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ABSTRACT

Twelve PLATO lessons are reproduced in this document to show the status of computer guided experimentation (CGE) instructional programs. The lesson topics include a description of the CGE-PLATO instructional laboratory, an introduction to CGE-PLATO tests and special software routines, router lesson for two electrical engineering courses, and an introduction to the CGE station. Lesson five is the operation and uses of the oscilloscope Analab 1120, and lesson six concerns the operation and uses of the audio oscillator, HP 200AB. Lessons seven, eight, and nine introduce the operation and use of the function generator Exact 251; the D.C. supply, Harrison 865B; and the vaccuum tube voltmeter, HP400D. Lesson ten is an experiment in the measurement of transients, lesson eleven is an experiment in measurements of impedance, and lesson twelve is an experiment in measurement of two-port networks. (CH)

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THE CGE—PLATO ELECTRONIC LABORATORY INSTRUCTIONAL PROGRAMS

J.P.Neal

Computer-based Education Research Laboratory

University of Illinois Urbana Illinois

December, 1974

2003 534

THE CGE-PLATO ELECTRONIC LABORATORY INSTRUCTIONAL PROGRAMS

By

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ABSTRACT

The twelve PLATO Lessons reproduced as Varian Prints in this report show the status of the CGE Instructional Programs as of August, 1974. This MTC Report supplements MTC Report #4, "The CGE-PLATO Electronic Laboratory Station Structure and Operation," and MTC Report #5, "Electronic Laboratory Instruction Using the CGE-PLATO Laboratory Station."

TABLE OF CONTENTS
and
TAB LESSON-LOCATOR

block 1a, cgeid

```
stop
****    For Neal, CGERL, Room 248 EEB.

One line description of this lesson --

    A Description of the CGE-PLATO Instructional Laboratory.

            Divisions of this Lesson:        Block     Unit

        Log of users of this lesson          cgeid     cgeida
        Description of cge                   cgem0a    cgem0a
        Recent userlog                       userlog
        Common for log of users of cge       uselog

        Final edit 26 aug 74 neal.

*list     info
*list     symbols
*list     varian,charset,cgeindex,cgechar
*********
start
ext       0
dataon
area      cge
course    n70
jump      n70='eecge',cgem0a,x
***

unit      cgeida              $$ logs all noncge users into uselog
common    cge,uselog,322
jump      nc2>315,cgem0a,x
calcs     nc1='cgedata',nc1⇐'cgedata','cgedata'+0(nc2⇐4)
name      nc(nc2)
calc      nc(nc2)⇐nc(nc2)+o55
calc      nc(nc2⇐nc2+1)⇐n70+o55
date      nc(nc2⇐nc2+1)
calc      nc(nc2⇐nc2+1)⇐(int(station÷320)+27)8^10
calc      nc(nc2⇐nc2+1)⇐nc(nc2⇐nc2+1)+(frac(int(station/32)/10)×10+27)8^8
calc      nc(nc2⇐nc2+1)⇐nc(nc2⇐nc2+1)+(o46)8^6
calc      nc(nc2)⇐nc(nc2)+(int(frac(v3⇐station÷32)×3.2)+27)8^4
calc      nc(nc2)⇐nc(nc2)+(frac((frac(v3⇐station÷32)×3.2))×10+27)8^2+o55
          nc2⇐nc2+2
jump      cgem0a
***

unit      cgeidb               $$ provides jumpout to sample
term      sample
at        1617
write     One moment please.....  returning to SAMPLE.
```

```
inhibit jumpchk
jumpout sample
next    cgeidb
```

-- part=1, block=b ----------

block 1b, cgem0a

```
unit    cgem0a
base
next    cgem0b
at      205
write   A Description of the CGE-PLATO Instructional Laboratory
             in CGERL, Room 248 EEB, University of Illinois


           As outlined herein, Computer-Guided Experimentation
        (CGE) instructional experiments are designed for use at
        a special CGE-PLATO laboratory station which has a CGE
        hardware interface linking sensors on adjacent electronic
        laboratory equipment with the PLATO console.

           For an operational demonstration of CGE, contact:

                Dr. J. P. Neal, Prof. Emeritus
                Department of Electrical Engineering
                University of Illinois,
                Urbana, Illinois 61801

                217-333-4351 or 333-3496 or 344-6116

           Or come visit the CGE Research Laboratory (CGERL) at:

        Room 248 EEB, University of Illinois, Urbana, Ill.


                        Press -NEXT- to proceed.
```

-- part=1, block=c ----------

block 1c, cgem0b

```
unit    cgem0b
back    cgem0a
next    cgem0c
at      804
write     The object of this CGE-PLATO research is to demonstrate
        that the Computer-Guided Experimentation-PLATO system will
        provide unique and worthwhile improvements in undergraduate
        or technician laboratory instruction, when properly used
```

```
                by competent instructors.

                   The CGE station consists of a PLATO IV console, a
                CGE-PLATO Interface Logic System, five rack-mounted
                electronic instruments, and various experimentation
                circuit boards for student use in learning electronic
                instrumentation and measurements.

                   Students presently active in CGE Research are:

                     Borth, David E.
                     Derrig, Daniel P.
                     Zanter, Douglas L.
        ***

        unit    cgem0c
        back    cgem0b
        next    cgem0d
        at      504
        write      The CGE-PLATO Interface Logic System enables any author
                to order the automatic sensing of the interconnections
                between 30 terminals on the rack-mounted equipment or on
                the currently-used circuit board and/or the settings of
                22 of the dials, knobs, or switches on the equipment.

                   The panel layout of the present CGE station is
                illustrated in the next display.  The present CGE
                rack-mounted instruments are:

                   Analab Dual-trace Scope Type 1120 and Plug-In Type 700
                   Exact Function Generator Type 251
                   Hewlett-Packard Audio Oscillator Model 200AB
                   HP Vacuum Tube Voltmeter Model 400D
                   Harrison Lab. Model 865B Power Supply

                   The CGE-PLATO Interface Logic System is mounted behind
                the instrument rack panel, beneath the Function Generator.

                   On the next display, the automatically-sensed terminals
                may be identified by T numbers, and the automatically-
                sensed dials may be identified by D numbers.
----------------------------------------------------- part=1, block=d ----------

           block 1d, cgem0d

        unit    cgem0d
        back    cgem0c
        define  panel
                switch=1
                trmnl=2
                ground=3
                dcsw=4
                solid=5
```

```
char      trmnl
          o000016,o000033,o000021,o000033,o000016,o000000,o000000,o000000
char      switch
          o000000,o000340,o000760,o001777,o001777,o000760,o000340,o000000
char      ground
          o000000,o100000,o120000,o124000,o124000,o120000,o100000,o000000
char      dcsw
          o000600,o000600,o000600,o000600,o001700,o003740,o003740,o001700
char      solid
          o177777,o177777,o177777,o177777,o177777,o177777,o177777,o177777
draw      509,133;0,133
zero      n5
zero      n6
calc      n7⇐1314
join      cges1a
join      cges1b
add1      n5
calc      n7⇐1534
join      cges1a
join      cges1c
add1      n5
calc      n7⇐1552
join      cges1a
join      cges1d
add1      n5
calc      n7⇐2212
join      cges1a
join      cges1e
add1      n5
calc      n7⇐2243
join      cges1a
join      cges1f
add1      n5
join      cges1a
join      cges1g
at        3117
write       Press -LAB-  for sensed dials.
          Press -DATA- for sensed terminals.

entry     cgem0de
pause
calc      n1⇐(key=next$or$key=back) - (key=lab) -2 (key=data)
join      n1,x,x,cges2a,cges3a,x
jump      (key=next) - (key=back),cgem0e,x,cgem0c
goto      key=o216,x,cgem0de,x
press     o216
***
```

-- part=1, block=e ----------

```
block 1e, cgem0e
```

```
unit      cgem0e
back      cgem0d
```

```
next    cgem0f
at      705
write      Actual laboratory experiments are programmmed by
        experienced laboratory instructors on the PLATO system.

           The instructor writing a program provides for the
        automatic sensing of terminal interconnections and/or
        dial settings wherever he deems necessary.

           The response of the program to the fedback information
        of the student's physical operations can be used in any
        manner the instructor devises for improving the student's
        learning.

           Each student can work independently at a CGE station
        and learn at his own rate how to use the equipment,
        and perform or devise meaningful experiments.
***

unit    cgem0f
back    cgem0e
next    cgem0g
at      903
write      CGE is an entirely new instructional system, and
        research is required to develop its teaching capabilities
        and demonstrate their superiorities in comparison with
        conventional laboratory instruction or training simulators.

           CGE is not simply a new Teaching Aid, it is a New Teaching
        Method with unexplored and unknown capabilities.

           The manner in which a student at a CGE station in a
        laboratory is provided ready access to laboratory facilities,
        theoretical material, computer assistance, and
        instructor assistance is visualized in the next display.
---------------------------------------------------------------- part=1, block=f ----------

        block 1f,  cgem0g

unit    cgem0g
back    cgem0f
next    cgem0h
calc    n1⇐.5
circle  129,256,368
at      427
write      Student
             in
          Laboratory
delay   n1
circle  129,256,144
at      2626
```

```
write     Student
             in
          Theory Course
delay   n1
circle  128,320,256
at      1746
write   Instructor
delay   n1-2
at      2238
write   Instructor
           Aid
at      1038
write   Instructor
           Aid
delay   n1
circle  128,192,256
at      1711
write   Computer
delay   n1-2
at      2219
write   Computer
          Aid
at      1019
write   Computer
          Aid
delay   n1÷2
at      244,192
write   CAI
delay   n1÷2
at      244,304
write   CGE
delay   n1-2
size    1
at      212,249
write   CGE Station
delay   n1-2
size    0
mode    rewrite
at      3007
write       The CGE Station provides the student with complete
        access to Computer Aid and Instructor Aid for both lab-
        oratory and theoretical learning.
mode    write
```

-- part=1, block=g ----------

block 1g, cgem0h

```
unit    cgem0h
back    cgem0g
next    cgem0i
at      204
write      All the PLATO lessons used by CGE are open for inspection
        by authors.  These lessons are:
```

```
        CGE-PLATO         TOPIC
         LESSON

        cge         A Description of the CGE-PLATO Instructional Lab.
        cgerl       CGE-PLATO Tests & Special Software Routines
        ee244       Student List for CGERL Course
        eecge       Author List for CGERL Course
        cgeindex    Router Lesson for Courses ee244 and eecge
        cgedata     Data File for courses ee244 and eecge
        eex00       An Introduction to the CGE Station
        eex01       The Oscilloscope
        eex02       The Audio Oscillator
        eex03       The Function Generator
        eex04       The Constant Voltage/Constant Current Supply
        eex05       The Vacuum Tube Voltmeter
        eex06       Measurements of Transients
        eex07       Measurements of Impedance
        eex08       Measurements of Two-Port Networks

           Note: Authors in the student mode can press -MICRO-
        to pass OK through a check. Students cannot do this.

           MTC Report #4, July 1974, CERL, is entitled
        "The CGE-PLATO Electronic Laboratory Station Structure
        and Operation", by J. P. Neal.
***

unit    cgem0i
back    cgem0b
next    cgeend
at      707
write   To review this Description of CGE-PLATO, press -BACK-.

        To access the CGE Experiments, press -NEXT-.
---------------------------------------------------------------- part=1, block=h ----------

    block 1h,   cgesla

unit    cgesla
at      n6
mode    erase
writec  n5-1,,Dual-Trace SCOPE,Audio Oscillator,VTVM,
        Function Generator,DC Supply,,
calc    n6⇐n7
at      n7
mode    write
writec  n5,,Dual-Trace SCOPE,Audio Oscillator,VTVM,
        Function Generator,DC Supply,,
***

unit    cges1b
```

```
draw    606;635;1235;1206;606
circle  35,103,369
circle  3,55,366
circle  6,55,396
circle  6,55,336
circle  6,149,336
at      146,360
plot    switch
at      165,327
plot    trmnl
at      165,335
plot    trmnl
at      179,327
plot    trmnl
at      191,327
plot    trmnl
at      260,327
plot    trmnl
at      248,327
plot    trmnl
at      236,327
plot    trmnl
at      260,335
plot    trmnl
circle  6,149,396
circle  3,181,392
circle  10,181,392
circle  3,213,392
circle  10,213,392
circle  3,245,392
circle  10,245,392
circle  6,255,352
circle  6,227,352
circle  6,199,352
circle  6,171,352
***

unit    cgesic
draw    637;647;1447;1437;637
circle  13,328,368
circle  35,328,368
circle  5,328,329
circle  10,353,311
circle  10,304,311
at      327,294
plot    trmnl
at      337,294
plot    trmnl
at      317,294
plot    trmnl
at      358,400
plot    switch
***

unit    cgesid
draw    649;659;1459;1449;649;skip;394,404;453,404;453,364;394,364;394,404
circle  44,424,334,135,46
```

```
draw    413,377;408,396
circle  13,424,327
at      452,339
plot    switch
at      452,309
plot    trmnl
at      452,295
plot    trmnl
at      393,295
plot    trmnl
at      393,309
plot    trmnl
***

unit    cgesle
draw    1606;1635;2135;2106;1606
circle  8,160,217
circle  25,160,217
circle  4,184,199
circle  10,224,227
circle  6,224,227
at      256,245
plot    trmnl
at      256,235
plot    trmnl
at      256,225
plot    trmnl
at      256,215
plot    trmnl
at      256,185
plot    trmnl
at      240,185
plot    trmnl
at      222,185
plot    trmnl
circle  5,201,185
circle  8,115,230
circle  8,83,230
at      51,237
plot    trmnl
at      51,227
plot    trmnl
at      51,217
plot    trmnl
at      88,188
plot    switch
***

unit    cgeslf
draw    2141;1841;1853;2153;2141
draw    357,218;325,218;325,194;357,194;357,218
circle  6,401,194
circle  6,401,213
circle  6,376,203
at      393,181
plot    trmnl
at      381,181
```

```
plot    trmnl
at      369,181
plot    trmnl
at      329,177
plot    dcsw
```

-- part=1, block=i ------------

block 1i, cgeslg

```
unit    cgeslg
at      2810
write   Location behind the panel of the complete and
        operable CGE-PLATO Interface Logic System
draw    272,171;40,171;40,138;272,138;272,171
draw    143,155;143,151;160,151;160,155;143,155
draw    248,78;194,132;skip;194,132;skip;192,134;178,148
        178,144;182,148;178,148
at      46,165
plot    trmnl
at      55,165
plot    trmnl
pause
mode    erase
draw    248,78;194,132;skip;194,132;skip;192,134;178,148
        178,144;182,148;178,148
draw    272,171;40,171;40,138;272,138;272,171
draw    143,155;143,151;160,151;160,155;143,155
at      46,165
plot    trmnl
at      55,165
plot    trmnl
at      2810
write   Location behind the panel of the complete and
        operable CGE-PLATO Interface Logic System
mode    write
```

-- part=1, block=j ------------

block 1j, cges2a

```
unit    cges2a
join    cges2b
join    cges2c
join    cges2d
join    cges2e
join    cges2f
***

unit    cges2b
draw    50,339;22,345
```

```
at      1101
write   D8
draw    243,397;243,427
at      227,427
write   D1
draw    211,397;211,427
at      195,427
write   D2
draw    179,397;179,427
at      163,427
write   D3
draw    169,352;153,442
at      137,442
write   D7
draw    197,352;191,442
at      175,442
write   D6
draw    226,352;226,452
at      210,452
write   D5
draw    254,352;270,452
at      254,452
write   D4
draw    146,333;127,310
at      111,290
write   D9
***

unit    cges2c
at      146,261
write   D12
draw    162,231;162,261
draw    224,227;240,267
at      224,267
write   D14
draw    218,237;202,277
at      186,277
write   D13
draw    198,180;182,160
at      166,140
write   D15
draw    81,237;81,267
at      65,267
write   D10
draw    113,237;113,267
at      97,267
write   D11
***

unit    cges2d
draw    353,304;370,283
at      354,263
write   D19
draw    300,303;292,279
at      276,259
write   D20
draw    327,386;327,436
```

```
at        311,436
write      D21
***

unit      cges2e
draw      425,333;474,378
at        474,368
write     D22
***

unit      cges2f
draw      374,204;374,234
at        358,234
write      D16
draw      399,214;415,234
at        399,234
write      D17
draw      399,194;431,194
at        431,184
write     D18
```

-- part=1, block=k ----------

block 1k, cges3a

```
unit      cges3a
join      cges3b
join      cges3c
join      cges3d
join      cges3f
join      cges3g
join      cges3h
***

unit      cges3b
draw      3044;2444;2423;3023;3044
at        3023
write          CIRCUIT BOARD
at        176,104
write      T1   T2   T3   T4   T5
at        2723
write      T6   T7   T8   T9   T10
at        176,56
write      T11  T12       T14  T15
***

unit      cges3c
draw      165,335;153,309
at        142,289
write     T16
draw      191,327;191,307
at        181,287
write     T18
draw      261,337;245,307
```

```
at      235,287
write   T17
***

unit    cges3d
draw    256,215;288,195
at      288,185
write   T22
draw    256,225;288,215
at      288,205
write   T21
draw    256,235;288,235
at      288,225
write   T20
draw    256,245;288,255
at      288,245
write   T19
draw    222,185;238,165
at      222,145
write   T23
draw    51,237;19,257
at      3,257
write   T24
draw    257,185;289,165
at      286,148
plot    ground
***

unit    cges3f
draw    327,294;311,274
at      295,254
write   T28
draw    337,294;349,270
at      333,250
write   T27
***

unit    cges3g
draw    393,309;409,279
at      393,259
write   T29
draw    452,309;468,289
at      468,279
write   T30
***

unit    cges3h
draw    369,181;353,161
at      337,141
write   T25
draw    381,181;389,161
at      373,141
write   T26
draw    393,181;402,168
at      398,152
plot    ground
```

```
--------------------------------------------------------------- part=1, block=l ----------

    block 11, cgeend

unit    cgeend
at      71Ø
write   Now jumping to an Index of CGE Experiments.
inhibit jumpchk
jumpout cgeindex
stop
--------------------------------------------------------------- part=1, block=m ----------
    user log

stop
cgedata
dØ
sellers arizona  Ø8/12/74 2
Ø

-
3Ø
imsss1 stan  Ø8/12/74 1
2

-
19
imsss1 stan  Ø8/12/74 1
2

-
19
eichmann e  Ø8/13/74 Ø
2

-
12
demo wright  Ø8/13/74 2
2

-
Ø8
eichmann e  Ø8/13/74 Ø
2

-
12
lachman uicc  Ø8/13/74 Ø
1

-
Ø3
sample cerl  Ø8/13/74 1
4
```

```
-
16
davis matha  Ø8/13/74 Ø
3

-
21
student cu  Ø8/14/74 Ø
2

-
ØØ
student cu  Ø8/14/74 Ø
2

-
ØØ
student cu  Ø8/15/74 Ø
2

-
ØØ
visitor ee244  Ø8/16/74 Ø
7

-
12
student cu  Ø8/16/74 Ø
2

-
ØØ
brown d siu  Ø8/16/74 Ø
2

-
18
wetstone conn  Ø8/16/74 2
3

-
Ø6
wetstone conn  Ø8/16/74 2
3

-
Ø6
sample cerl  Ø8/18/74 Ø
3

-
22
sample cerl  Ø8/18/74 Ø
3

-
```

```
22
smith arizona  Ø8/19/74 2
Ø

-
28
smith arizona  Ø8/19/74 2
Ø

-
28
cherub block  Ø8/19/74 Ø
2

-
11
becky cerl  Ø8/2Ø/74 Ø
3

-
26
becky cerl  Ø8/2Ø/74 Ø
3

-
26
paul phys  Ø8/2Ø/74 1
6

-
Ø3
ashworth siu  Ø8/22/74 Ø
7

-
27
ashworth siu  Ø8/23/74 Ø
3

-
13
ashworth siu  Ø8/23/74 Ø
3

-
13
dan mathk  Ø8/23/74 Ø
3

-
24
p mast p  Ø8/23/74 Ø
3

-
22
martin pdg  Ø8/26/74 Ø
```

767 1
768
769 -
770 16
771 start

cgeend	cgeend	607		284						
cgeida	cgeid	23								
cgeidb	cgeid	39		45						
cgem0a	cgem0a	47		21	25	37		69		
cgem0b	cgem0b	68		49	88	283				
cgem0c	cgem0b	87		70	111	160				
cgem0d	cgem0d	110		89	166					
cgem0de	cgem0d	156		161						
cgem0e	cgem0e	165		160	183					
cgem0f	cgem0e	182		167	198					
cgem0g	cgem0g	197		184	254					
cgem0h	cgem0h	253		199						
cgem0i	cgem0h	282		255						
cges1a	cges1a	289		132	136	~~140~~		144	151	148
cges1b	cges1a	300		133						
cges1c	cges1a	337		137						
cges1d	cges1a	353		141						
cges1e	cges1a	369		145						
cges1f	cges1a	402		149						
cges1g	cges1g	417		152						
cges2a	cges2a	444		159						
cges2b	cges2a	451		445						
cges2c	cges2a	480		446						
cges2d	cges2a	500		447						
cges2e	cges2a	511		448						
cges2f	cges2a	516		449						
cges3a	cges3a	527		159						
cges3b	cges3a	535		528						
cges3c	cges3a	546		529						
cges3d	cges3a	557		530						
cges3e	cges3a	580		531						
cges3g	cges3a	586		532						
cges3h	cges3a	596		533						
Back	panel	158	160							
data	panel	158								
dosw	panel	116	124	415						
inac	panel	32	34	35	35					
ground	panel	115	122	578	605					
int	panel	31	32	34						
key	panel	158	158	158	158	160		160		161
lab	panel	158								
nc	panel	27	28	28	29	30	32	31	33	32
		33	34	34	35	35				
nc1	panel	26	26							
nc2	panel	25	26	27	28	28	30	29	30	29
		31	31	32	32	32	33	32	33	33
		33	34	34	35	35		36		36
next	panel	158	160							
n1	panel	158	159	200	206	212	227	216	234	223
		237	240	244						
n5	panel	129	134	138	142	146		150	297	292
n6	panel	130	290	294						

n7	panel	131	135	139	143	147		294		295
n7Ø	panel	2Ø	21	29						
solid	panel	117	126							
station	panel	31	32	34	35					
switch	panel	113	12Ø	3Ø8	351	359		4ØØ		
trmnl	panel	114	118	31Ø	312	314	320	316	322	318
		324	345	347	349	361	367	363	377	365
		379	381	383	385	387	396	389	398	394
		4Ø9	411	413	426	428		436		438
v3	panel	34	35							

lesson information

lesson name = cge

starting date = Ø7/17/73

last edited on Ø8/26/74 at 11.31.45

by neal of course eecge

at site 7, station 27

author name = J. P. Neal

department = E.E.

telephone number = 333-4351

discipline = Elec. Engineering

grade level = Any

descripion of lesson = A Description of the CGE-PLATO Instructional Laboratory.

```
------------------------------------------------------------------ part=1, block=a ------------

        block 1a,   cgerlid

stop
****,   For Neal, CGERL, Room 248, EEB.

One line description of this lesson --.

    CGE-PLATO Tests & Special Software Routines

        Divisions of this Lesson:          Block      Unit

        Id for this lesson                 cgerlid
        Access from the student mode       rlm0a      rlm0a
        Cge index of lessons               rlm0a      rlm1a
        Listing of connections             rlm0a      rlm2a
        Cc test                            rlm3a      rlm3a
        Listing of dial settings           rlm3a      rlm4a
        Dc test                            rlm5a      rlm5a
        Transmit over ext channel          rlm5a      rlm6a
        Repeated check of 1 dial           rlm5a      rlm7a
        Cge checker authoring aids         rlm7b      rlm8a
        Slide display                      rlm9a      rlm9a
        Cge software.record-maintenance    rlm10a     rlm10a

        final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
*******
start
ext      0                      $$ clears cge hardware
dataoff

------------------------------------------------------------------ part=1, block=b ------------

        block 1b,  rlm0a.

unit     rlm0a
course   n51
jump     ((n51='eecge')$and$user='author'),x,rlm0b
back     rlmend
base
erase
at       711
write       Type the number of the following topic in
         which you are interested:
```

```
                1. Index to CGE Lessons and Stations
                2. Listing of Current Connections
                3. CC Test
                4. Listing of Current Dial Settings
                5. DC Test
                6. Transmit Data over External Channel
                7. Repeated Check of a Selected Dial
                8. CGE Checker Authoring Aids
                9. Slide Display
               10. CGE Software Record-Maintenance
arrow    2725
match    n150,1,2,3,4,5,6,7,8,9,10
jump     n150,x,rlm1a,rlm2a,rlm3a,rlm4a,rlm5a,rlm6a,rlm7a,rlm8a,rlm9a,rlm10a
***

unit     rlm0b
jumpout  plato
***

unit     rlm1a
base
back     rlm0a
next     rlm0a
at       305
write              CGE-PLATO LESSONS

         LESSON               TOPIC

         cge        A Description of the CGE-PLATO Instructional Lab.
         cgerl      CGE-PLATO Tests & Special Software Routines
         ee244      Student List for CGERL Course
         eecge      Author List for CGERL Course
         cgeindex   Router Lesson for Courses ee244 and eecge
         cgedata    Data File for courses ee244 and eecge
         eex00      An Introduction to the CGE Station
         eex01      The Oscilloscope
         eex02      The Audio Oscillator
         eex03      The Function Generator
         eex04      The Constant Voltage/Constant Current Supply
         eex05      The Vacuum Tube Voltmeter
         eex06      Measurements of Transients
         eex07      Measurements of Impedance
         eex08      Measurements of Two-Port-Networks
at       2603
write           CGE-PLATO stations in CGERL at 248 EEB:

         Site 7, Station 12, Console #118  w/o experimental equipment
         Site 7, Station 27, Console #324  w/CGE-PLATO I/O & exp. eqpt.
***

unit     rlm2a
base
back     rlm0a
next     rlm2a
join     rlm2b
at       3112
write    Press -NEXT- to check connections again.
```

```
              Press -BACK- when done.

-------------------------------------------------------------- part=1, block=c ---------

      block 1c,  rlm2b

unit      rlm2b
define    rlm2b
          cc=o4Ø
          check=n1          $$ marks a checked terminal
          start=n2          $$ first terminal in a node
          termc=n3          $$ marks terminal to be examined
          keytime=v4        $$ records time since last key
          datac=n5          $$ stores data from key
          namterm=n6        $$ name of terminal to be displayed
          screen=n7
          node=n8
at        31Ø
write     LISTING of CURRENT TERMINAL INTERCONNECTIONS
calc      check⇐oØ
          start⇐termc⇐1
          keytime⇐clock
          screen⇐32Ø
          node⇐Ø
time      1
enable
ext       cc+termc          $$ first request for terminal data

entry     rlm2c
pause
goto      (key=timeup)-(key=next$or$key=stop),rls2a,x,rls2b
goto      (key$mask$o1ØØØ)=Ø,rlm2c,x  $$ locks out keyboard
calc      datac⇐key$mask$o37     $$ bottom 5 bits are data bits
          check⇐check$union$(1$cls$(termc-1))  $$marks terminal
          keytime⇐clock
goto      datac=start,rls2c,x
goto      (termc=start)$and$node=6,rls2e,x
writec    n3=n2,<at,-5+n7⇐n7+2ØØ>Terminals Connected to NODE <a,o7ØØØ+n8⇐n8+1>,,
size      Ø
calc      namterm⇐termc
calcc     termc=start,screen⇐screen+1ØØ,screen⇐screen
at        screen
join      termc=start,rls2d,
calc      namterm⇐datac
at        screen⇐screen+1ØØ
join      rls2d
goto      where>3ØØØ,rls2e,x
calc      termc⇐datac
ext       cc+termc
goto      rlm2c
***

unit      rls2a
```

```
time      1
goto      (clock-keytime>1.5),x,rlm2c
calc      keytime⇐clock
ext       cc+termc
goto      rlm2c
***

unit      rls2b
pause

entry     rls2e
ext       0
writec    (bitcnt(check)<30)-(screen=320),<at,screen+198>* AND MORE *,
          <at,screen+200>* CHECK COMPLETED *,
          <at,screen+394>* Terminals are not interconnected *
size      0
***

unit      rls2c
goto      start≥30,rls2e,x
calc      start⇐start+1
calc      termc⇐start
goto      (check$ars$(start-1)$mask$1)=0,x,rls2c
ext       cc+termc
goto      rlm2c
***

unit      rls2d
writec    namterm,,,Term 1,Term 2,Term 3,Term 4,Term 5,Term 6,Term 7,
          Term 8,Term 9,Term 10,Term 11,Term 12,GROUND,Term 14,
          Term 15,Scope: A input,Scope: B input,Scope: Trigger,
          Fun-gen: Sqr-wave output,Fun-gen: Trng-wave output,
          Fun-gen: Sine-wave output,Fun-gen: Ramp output,
          Fun-gen: Atten'd output,Fun-gen: Trigger output,
          DC-sup: (+)term.,DC-sup: (-)term,Aud-osc: Right output,
          Aud-osc: left output,VTVM: input,VTVM: output
```

-- part=1, block=d ----------

block 1d, rlm3a

```
unit      rlm3a
define    rlm3a
          cc=o40
          termc=n1-9
at        227
write     CC Test
at        318
write     (Press -DATA- to restart)
at        604
write     term  octal  decimal
at        634
write     term  octal  decimal
calc      n1⇐10
```

```
calc     v5Ø⇐v52⇐clock
         n51⇐Ø
time     1
enable
ext      cc+termc

entry    rlm3b
pause
goto     (key=timeup)-(key=next$or$key=stop),rlm3c,x,rlm3d
calc     n(n1)⇐key
         n1⇐n1+1
         v5Ø⇐clock
goto     termc>3Ø,rlm3d,x
ext      cc+termc
goto     rlm3b
***

unit     rlm3c
time     1
goto     clock-v5Ø>1.5,x,rlm3b
calc     v5Ø⇐clock
         n51⇐n51+1
ext      cc+termc
goto     rlm3b
***

unit     rlm3d
ext      Ø
calc     v53⇐clock
at       3Ø1Ø
write    Number of DATA Transmission Repeats =
showt    n51
at       311Ø
write    Total DATA Transmission Time =
showt    v53-v52,4,3
write      seconds.
calc     n4⇐Ø
         n3⇐6Ø5
do       rlm3f,n2⇐1,(n1-1Ø)÷2
calc     n3⇐635
do       rlm3f,n2⇐((n1-1Ø)÷2+1),n1-1Ø

entry    rlm3e
pause
jump     (key=next$or$key=back)-(key=data),rlmØa,x,rlm3a
goto     rlm3e
***

unit     rlm3f
calc     n3⇐n3+1ØØ
         n145⇐n2
at       n3
showt    n2,2
write
showo    n(n2+9),4
at       n3+9
calc     n99⇐n(n2+9)$mask$o77
```

```
showt    n99
***

unit     rlm4a
base
back     rlmØa
next     rlm4a
join     rlm4b
at       3115
write    Press -NEXT- to check dials again.
         Press -BACK- when done.
```

--- part=1, block=e ----------

```
     block 1e,  rlm4b

unit     rlm4b
define   rlm4b
         dc=o1ØØ
         dial=n1
         code=n2
         screen=n3
         keytime=v4
calc     n22⇐nc2⇐nc2+1
do       rlm4c
calc     screen⇐511
         dial⇐1
         keytime⇐clock
time     1
enable
ext      dc+dial

entry    rlm4d
pause
goto     (key=timeup)-(key=next$or$key=stop),rlm4e,x,rlm4f
goto     (key$mask$o1ØØØ)=Ø,rlm4d,x       /$$ locksout keyboard
calc     code⇐key$mask$o37
         keytime⇐clock
do       rlm4g                            $$ generates display
calc     dial⇐dial+1
goto     dial>22,rlm4f,x
ext      dc+dial
goto     rlm4d
***

unit     rlm4e
time     1
goto     clock-keytime>1.5,x,rlm4d
calc     keytime⇐clock
ext      dc+dial
goto     rlm4d
***

unit     rlm4f
```

```
ext      Ø
exit     1
***

unit     rlm4g
at       screen+1ØØ
writec   dial,,,PLUG-IN,,,,,,,SCOPE,,FUN-GEN,,,,,,
         DC-SUP,,,AUD-OSC,,,VTVM
at       screen+8
writec   dial,,,B VOLTS,TIME,A VOLTS,B PREAMP,
         SWEEP MODE,TRIGGER SOURCE,A PREAMP,
         Y DISPLAY FUNC,X DISPLAY FUNC,
         TRIGGER,MULTIPLIER,CYCLES/SEC,
         OUTPUT,ATTENUATOR,DC LEVEL,METER,
         VOLTAGE,CURRENT,AMPLITUDE,
         RANGE,FREQUENCY,RANGE
at       screen+23
do       dial,x,x,d1,d2,d1,d4,d5,d6,d4,d8,d9,d1Ø,x
do       dial-1Ø,x,x,d11,d12,d13,d14,d15,d16,d17,d18,d19,d2Ø,d21,d22
***

unit     d1
writec   code,-,Ø,1 m,2 m,5 m,1Ø m,2Ø m,5Ø m,Ø.1 ,Ø.2 ,Ø.5 ,
         1.Ø ,2.Ø ,5.Ø ,1Ø ,2Ø ,5Ø ,1ØØ ,2ØØ
write    V full scale
***

unit     d2
writec   code,-,Ø,1Ø u,2Ø u,5Ø u,1ØØ u,2ØØ u,5ØØ u,
         1 m,2 m,5 m,1Ø m,
         2Ø m,5Ø m,1ØØ m,2ØØ m,5ØØ m,1,2,5,1Ø,2Ø,5Ø,ext
write     sec. full scale
***

unit     d4
writec   code,-,Ø,-AC,+AC,+DC,-DC,OFF,BAL SET
***

unit     d5
writec   code,-,Ø,ARM - variable length,
         MAN - variable length,
         AUTO - variable length,
         DRIV - variable length,
         DRIV - variable sweep rate,OFF
***

unit     d6
writec   code,-,Ø,LINE,AC - ext ÷ 2Ø,DC - ext ÷ 2Ø,AC ÷ ext,
         DC - ext,AC - int,DC - int,,
writec   code-8,OFF,
------------------------------------------------------------- part=1, block=f --------

block 1f, rlm4g
```

```
unit    rlm4c
at      419
write   Dial          Current Setting
at      419
write   ----          ------- -------
***

unit    d8
writec  code,-,Ø,A,B,A & B (CHOP),A & B (ALT),A vs B
***

unit    d9
writec  code,-,Ø,SWP×5,SWP,EXT
***

unit    d1Ø
writec  code,-,Ø,INT ,EXT
***

unit    d11
write   times
writec  code,-,Ø,Ø.ØØ1,Ø.Ø1,Ø.1,1.Ø,1Ø,1ØØ,1ØØØ,
***

unit    d12
writec  code,-,Ø,1.1,1.5,1.9,2.3,2.7,3.2,3.6,4.1,4.5,
        5.Ø,5.4,5.9,6.3,6.8,7.2,7.7,8.Ø,8.5,9.Ø,9.4,9.9,1Ø.2
write    Hz (not incl. MULT.)
***

unit    d13
writec  code,-,Ø,RAMP,SINE,TRIANGLE,SQUARE,
***

unit    d14
writec  code,-,Ø,2.7,3.5,4.8,6.1,7.2,8.1,8.7,9.8,1Ø.4,11.1,11.5,
        12.Ø,12.5,13.Ø,13.3,13.5,14.Ø,14.1,14.4,14.8,15.Ø,15.1
write    volts
***

unit    d15
writec  code,-,Ø,Ø,Ø,Ø,-56.5,-55.5,-52.5,-48,-44,-39,-35,-31,-27,
        -24,-2Ø,-17,-14,-13,-13,-1Ø,2,3Ø,56
write    volts
***

unit    d16
writec  code,-,Ø,VOLTS,AMPS,
***

unit    d17
writec  code,-,Ø,Ø.1,Ø.9,3.3,5.6,8.2,11.Ø,13,15,17,2Ø,21,23,26,
        28,3Ø,32,34,36,38,4Ø,42,44
write    volts
***
```

```
unit     d18
writec   code,-,0,0.0,0.0,0.01,0.05,0.07,0.10,0.14,0.17,0.20,0.25,
         0.27,0.29,0.31,0.35,0.37,0.40,0.43,0.46,0.50,0.52,0.55,0.59
write    amperes
***

unit     d19
writec   code,-,0,0.04,1.0,2.0,4.0,6.0,8.0,9.0,10,11,12,14,15,17,
         19,20,21,23,25,26,28,29,30
write     volts rms
***

unit     d20
write    times
writec   code,-,0,1,10,100,200,
***

unit     d21
writec   code,-,0,17,19.2,20.5,21.8,23.4,25.4,28,31.2,35,
         40,46,53,61,71,82,
         94,108,122,140,160,185,210
write     Hz (not incl. RANGE)
***

unit     d22
writec   code,-,0,0.001,0.003,0.01,0.03,0.1,0.3,1.0,3.0,10,30,
         100,300
write     R.M.S. VOLTS full scale
---------------------------------------------------------------- part=1, block=g ----------

         block 1g,  rlm5a

unit     rlm5a
define   rlm5a
         dc=o100
         dial=n1-9
base
at       128
write    DC Test
at       218
write    (Press -DATA- to restart)
calc     n1⇐10
         n101⇐0          $$ counter for number of repeats
time     1               $$ time slice between repeats
calc     v100⇐clock
         v102⇐clock
ext      dc+dial
enable
goto     rlm5b

entry    rlm5c
ext      dc+dial
```

```
entry   rlm5b
pause
goto    key=timeup,rlm5f,x        $$ go to rlmrf for retry
calc    n(n1+1)⇐key
        n1⇐n1+1
        v100⇐clock
goto    key=next$or$dial>22,x,rlm5c
ext     0
calc    v103⇐clock
calc    n4⇐0
at      410
write    Dial   Alpha    Octal          Binary
do      rlm5d,n2⇐1,27
at      3010
write   Number of Repeats=
showt   n101
at      3110
write   Total Transmission Time=
showt   v103-v102,4.3
write     seconds.
back    rlm0a
next    rlm0a
data    rlm5a
***

unit    rlm5d
calc    n3⇐400+100*n2
at      n3+12
write   <t,n2,2>      <a,n(n2+10)$mask$o77>        <at,n3+28><o;n(n2+10),4>
at      where+7
do      rlm5e,n120⇐1,2
at      where
do      rlm5e,n120⇐3,10
exit    -(n2≥n1-10)
***

unit    rlm5e
showt   (n(n2+10)$ars$(10-n120))$mask$o1,1
***

unit    rlm5f                      $$ handles retries
time    1
goto    clock-v100>2,x,rlm5b
calc    v100⇐clock
        n101⇐n101+1
ext     do+dial
goto    rlm5b
***

unit    rlm6a
back    rlm0a
erase
at      510
write   Enter the code which you wish to transmit
        over the external channel.
next    rlm6a
arrow   910
```

```
store   n1
ok
at      1210
write   Press -NEXT- to transmit same code again.
        Press -BACK- to transmit a different code.
inhibit erase
jump    rlm6c
***

unit    rlm6b
at      1210
write   EXT OUTPUT
back    rlm6a
next    rlm6b
ext     n1
at      1510
showo   n1,5
***

unit    rlm6c
inhibit erase
ext     n1
back    rlm6a
next    rlm6c
***

unit    rlm7a
back    rlm0a
ext     0
at      510
write   Type the CGE number of the dial you wish to
        have checked repeatedly.
arrow   814
store   n20
ok
jump    rlm7b
------------------------------------------------------------------ part=1, block=h ----------

        block 1h,  rlm7b

unit    rlm7b
at      210
write             REPEATED CHECK of a SINGLE DIAL

              Press -STOP- to stop test.

              Then, press -NEXT- to chose another dial,
              or -BACK- to return to index.
at      914
write   Dial Number = <z,n20>
at      933
write   Code =
at      1139
```

```
write   Code     Time
at      1314
write   Total checks =
        Changes =
        Repeats =
at      1814
write   Total time =
        Time/Check =
mode    rewrite
enable
ext     o100+n20
pause
calc    n3⇐key$mask$o77
calc    n2⇐n6⇐0
        n1⇐1
        n11⇐0
        n12⇐0
        n13⇐1240
        v7⇐clock
        v5⇐clock
time    1
ext     o100+n20

entry   rlm7be
pause
calc    v10⇐clock
calc    n13⇐n13+100
goto    n13>3200,rlm7bf,x
at      n13
write   <a,n3>        <z,v10-v7>

entry   rlm7bf
goto    (key=stop$or$key=next),rlm7c,x
goto    key=timeup,rlm7d,x
goto    (key$mask$o1000)=0,rlm7be,x   $$ locks out keyboard
calcc   n3=key$mask$o77,n12⇐n12,n12⇐n12+1
calc    n3⇐key$mask$o77
at      940
showa   key$mask$o77
at      944
write   o<o,key,4>
calc    n1⇐n1+1
calc    v8⇐clock
at      1329
write   <z,n1>
         <z,n6>
         <z,n12>
at      1829
write   <z,v8-v7>
        <z,(v8-v7)÷n1>
calc    v5⇐clock
ext     o100+n20
goto    rlm7be
***

unit    rlm7c
calc    v8⇐clock
```

```
ext       Ø                                 $$ clears hardware
pause                                       $$ waits for last timeup key
mode      rewrite
at        1329
write     <z,n1>
          <z,n6>
          <z,n12>
at        1829
write     <z,v8-v7>
          <z,(v8-v7)+n1>
at        2214
write     CHECK COMPLETED

entry     rlm7ce
pause                                   $$ loop absorbs spurious keys
goto      key=next$or$key=back,x,rlm7ce
jump      key=next,rlm7a,rlmØa
***

unit      rlm7d
time      1
goto      clock-v5>1,x,rlm7be
calc      n6⇐n6+1
          v5⇐clock
ext       o1ØØ+n2Ø
goto      rlm7be

unit      rlm8a
erase
back      rlmØa
at        51Ø
write             CGE Checker Authoring Aids

             This demonstration is intended to give authors
          an opportunity to explore the use of the ckc and
          ckd series subroutines.

          Press  c  for connection check subroutine demo.

          Press  d  for dial check subroutine demo.
at        221Ø
write     NOTE: Authors in the student mode can press -MICRO-
          to pass OK through a check. Students cannot do this.
arrow     191Ø
long      1
answer    c
jump      rlm8b
answer    d
jump      rlm8e
---------------------------------------------------- part=1, block=i ---------

          block 11,  rlm8b
```

```
unit      rlm8b
erase
inhibit erase
back      rlm8a
next      rlm8b
at        510
write  -    Connection Check Subroutine Demonstration

          Current Author Codes
at        910
write     Author Code  n33= <a,n33,30>


          Best Match      = <a,n36,30>

          Hardware Code   =
at        1428
do        rlm8c,n75⇐1,30
at        1610
write     Press DATA to change Author Code
data      rlm8d
at        1910
write     Type the number of the ckc subroutine you wish to try.

          1) ckc          (performs a connection check)
          2) ckcw         (performs a CC and writes errors)
          3) ckc1         (counts errors of new pack vs ckc)
          4) ckc1w        (same as ckc1 and writes errors)
          5) ckc2         (counts errors of best match vs ckc)
          6) ckc2w        (same as ckc2 and writes results)
arrow     2810
long      1
specs     nookno
match     n51,1,2,3,4,5,6
join      n51,x,ckc,ckcw,ckc1,ckc1w,ckc2,ckc2w
at        3110
write     <s,-n47> Errors Found in Setup
back      rlm8b
***

unit      rlm8c
calc      n76⇐0
move      n30,n75,n76,10
calcs     ((n76=0)-(n76="0")),n76⇐"0",n76⇐n76,n76⇐"4"
showa     n76
***

unit      rlm8d
at        1010
write     Desired Code
arrow     1026
copy      n33,30
long      30
storea    n33,30
ok
jump      rlm8b
```

```
***

unit     rlm8e
erase
inhibit  erase
base
back     rlm8a
next     rlm8e
at       510
write          Dial Check Subroutine Demonstration

         Current Author Codes
at       910
write    Author Code  n33=
at       928
write    <a,n33,50>


at       1310
write    Best Match        = <a,n39,50>

         Hardware Code     = <a,n80,22>
at       1710
write    Press DATA to change Author Code.
data     rlm8f
at       1910
write    Type the number of the ckd subroutine you wish to try.

         1) ckd        (performs a dial check)
         2) ckdw       (performs a DC and writes errors)
         3) ckd1       (counts errors of new pack vs ckd)
         4) ckd1w      (same as ckd1 and writes errors)
         5) ckd2       (counts errors of best match vs ckd)
         6) ckd2w      (same as ckd2 and writes results)
arrow    2810
long     1
match    n51,1,2,3,4,5,6
join     n51,x,ckd,ckdw,ckd1,ckd1w,ckd2,ckd2w
at       3110
write     <z,-n47> Errors Found in Setup
back     rlm8e
***

unit     rlm8f
at       1110
write    Desired Code
arrow    1126
copy     n33,50
long     50
storea   n33,50
ok
end
```

--- part=1, block=j ---------

block 1j, rlm9a

```
unit    rlm9a
back    rlm0a
next    rlm9b
calcc   (station=251),n101⇐256,512
slide   noslide
at      107
write   SLIDE NO.     CGE SLIDE

           0          Test Slide
           1          CGERL Entrance
           2          The EE244 Laboratory
           3          CGE-PLATO System Description
           4          Orientation of the CGE Station
           5          Scope & Function Generator
           6          Aud. Osc., VTVM, & DC Supply
           7          Layout of Sensed Dials & Terminals
           8          List of Sensed Dials & Terminals
           9 - 18     Dial Setting Codes
          19          Resistor Color Code
          20 - 21     E E Symbols & Units
          22          Recommended Unit Prefixes
          23          Defined Physical Values
          24 - 26     Physical Constants
          27 - 32     SCOPE -     Use of Dials and Terminals
          33 - 35     SCOPE -     Manufacturer's Specifications
          36 - 44     PLUG-IN -   Use of Dials and Terminals
          45 - 50     PLUG-IN -   Manufacturer's Specifications
          51 - 53     FUN.GEN. -  Use of Dials and Terminals
          54 - 56     FUN.GEN. -  Manufacturer's Specifications
          57 - 60     AUD.OSC. -  Use of Dials and Terminals
          61 - 62     AUD.OSC. -  Manufacturer's Specifications

                  Press -NEXT- to see remainder of Slide List.
```

-- part=1, block=k ----------

block 1k, rlm9b

```
unit    rlm9b
back    rlm9a
next    rlm9c
calcc   (station=251),n101⇐256,512
slide   noslide
at      107
write   SLIDE NO.     CGE SLIDE

          63 - 66     VTVM -      Use of Dials and Terminals
          67 - 68     VTVM -      Manufacturer's Specifications
          69 - 71     DC SUPP -   Use of Dials and Terminals
          72 - 75     DC SUPP -   Manufacturer's Specifications
```

```
                76          Graph of a Transient
                81          CGE Station Picture

                88          Gunther Frank at CGE
                89          Doug Dowden & Frank at CGE
                9Ø          Dave Borth at CGE
                91          Doug Zanter & Borth at CGE
                92          Borth & Dan Derrig at CGE
                93-97       CGE-PLATO Interface

                Type slide no.        ,press -NEXT-, or -BACK- to return.
      arrow     3121
      store     n1ØØ
      ok
      erase
      goto      (n1ØØ≤255),rlm9c,rls9a
      ***

      unit      rls9a
      back      rlm9a
      next      rlm9a
      at        121Ø
      write     NO!  Type a number less than 256..
      ***

      unit      rlm9c
      back      rlm9a
      next      rlm9d
      at        32Ø4
      write        This is slide ⟨z,n1ØØ⟩.  Press -NEXT- for next slide
      slide     n1ØØ
      ***

      unit      rlm9d
      back      rlm9a
      next      rlm9a
      calc      n1ØØ⇐n1ØØ+1
      goto      (n1ØØ≤255),rlm9c,x
      slide     512
      at        121Ø
      write     You can't show a slide greater than 255.
      ***

      unit      rlm9e
      slide     n1ØØ+512
      back      rlmØa
      next      rlmØa
      goto      rlmØa
------------------------------------------------------------- part=1, block=1 ---------

          block 11,   rlm1Øa
```

```
unit     rlm10a
back     rlm0a
next     rlm0a
*calc     nc(1)⇐10033          $$ format for changing cc counter
*calc     nc(2)⇐11869          $$ format for changing dc counter
at       505
write                    CGE Software Record-Maintenance

         CAUTION: In order to avoid interference with automatic
         record-keeping and avoid loss of log records, the
         following tasks will only be performed by a CGE author
         specifically authorized by the Director of CGERL.

              If specifically authorized, select the operation
         you wish to perform:

         A. Record chronologically a remark in the cgedata record.

         B. Print and clear the uselog maintained in the common
         in lesson cge.

         C. Print and clear the statlog maintained in lesson
         cgeindex.
arrow    2810
long     1
specs    bumpshift
match    n150,a,b,c
jump     n150,x,rlm10b,rlm10c,rlm10d
***

unit     rlm10b
calc     n21⇐nc(4)
         nc(4)⇐nc(4)+3
         nc(n21)⇐'inst
at       907
write       At the beginning of each day of operation, type
         the present date or, to record a note about a student
         difficulty, type the student's name.
arrow    1311
long     8
storea   nc(n21+1)
ok
at       1509
write       Type the desired code or remark:

         ok      - CC and DC checked and new day started.

         pdn     - Plato down.

         cdn     - CGE hardware down.

         unxabs  - unexcused absence.

         xabs    - excused absence.
```

```
              or any other 8 character remark.
arrow         2911
long          8
storea        nc(n21+2)
ok
jumpout plato
***

unit          rlm10c
next          rlm0a
back          rlm0a
at            806
write            The uselog in cge should be printed when 300
              lines have been entered therein. Do this as follows:

              1. Copy the common, uselog, from cge into cgerl as
              block lb, rename it userlog, convert it to a source,
              and mark it so it will not be readin.

              2. Insert "*list label, user log (date)" as the
              first line in userlog and "*list off" as the last
              line in userlog in cgerl.

              3. Request a print of cgerl.

              4. Enter cge, convert the common uselog to a source,
              delete all entries, then reconvert uselog to a common,
              so it can continue to record users of lesson cge.

              5. After the print of the userlog in cgerl has been
              received, delete the block userlog from cgerl.
------------------------------------------------------------------- part=1, block=m. ---------


     block lm,  rlmend:

unit          rlm10d
help1         rlm10e
lab1          rlm10i
next          rlm0a
back          rlm0a
at            506
write            The statlog in cgeindex should be printed when 300
              lines have been entered therein. Do this as follows:

              1. Warning- this step must be done only once !!
              Convert the common, statlog, to printable form from
              here by pressing -HELP1-, once.

              2. Copy the common statlog into cgerl, convert it to
              a source, rename the block studstat, move it to
              block lb, and mark it not to be readin.

              3. Zero the original copy of the common by pressing
```

```
          -LAB1- while in here in the student mode.

          5. Enter *list  label,student statistics (date) as
          the first line in studstat, and "*list  off" as
          the last line in studstat.

          6. Request a print of lesson cgerl.

          7. After the print of studstat in cgerl has been
          received, delete the block studstat from cgerl.
***

unit      rlm1Øe
calc      n1⇐11                         $$ changes 6 to 11

entry     rlm1Øe1
calc      n15Ø⇐nc(n1-1)
calcc     n15Ø='inst',n1⇐n1+3,n1⇐n1
jump      n15Ø='inst',rlm1Øe1,x
itoa      nc(n1+1),nc(n1+1)
itoa      nc(n1+2),nc(n1+2)
itoa      nc(n1+3),nc(n1+3)
itoa      nc(n1+4),nc(n1+4)
itoa      nc(n1+6),nc(n1+6)
jump      rlm1Øg
***

unit      rlm1Øf
calc      n1⇐n1+8                       $$ next student
jump      n1≤322,rlm1Øe1,x
at        41Ø
write     Common is now printable.
pause
jumpout plato
***

unit      rlm1Øg
calc      v5Ø⇐vc(n1)    $$ chgd from n1+5 so counters prt.
calc      n51⇐int(v5Ø)
calc      n52⇐1ØØØØ×frac(v5Ø)
jump      n51≤9,rlm1Øg1,x
jump      n51≤99,rlm1Øg2,x
jump      n51≤999,rlm1Øg3,x

entry     rlm1Øg1
calc      n53⇐1
goto      rlm1Øh

entry     rlm1Øg2
calc      n53⇐2
goto      rlm1Øh

entry     rlm1Øg3
calc      n53⇐3
goto      rlm1Øh
***
```

```
unit    rlm10h
calc    n54⇐'.'
itoa    n51,n51
itoa    n52,n52
move    n54,1,n51,n53+1,1
move    n52,1,n51,n53+2,4
calc    nc(n1+5)⇐n51
jump    rlm10f
***

unit    rlm10i
calc    nc(4)⇐10
zero    nc5,318
calc    nc322⇐0
jump    rlm0a
***

unit    rlmend
press   next
end     lesson
***
use     eex00,ck1
use     ck2
use     ck3
use     ck4
use     ck5
        ckc            not found                    640
        ckcw           not found                    640
        ckc1           not found                    640
        ckc1w          not found                    640
        ckc2           not found                    640
        ckc2w          not found                    640
        ckd            not found                    694
        ckdw           not found                    694
        ckd1           not found                    694
        ckd1w          not found                    694
        ckd2           not found                    694
        ckd2w          not found                    694
        d1        rlm4b               299           296        296
        d10       rlm4c               337           296
        d11       rlm4c               340           297
        d12       rlm4c               344           297
        d13       rlm4c               349           297
        d14       rlm4c               352           297
        d15       rlm4c               357           297
        d16       rlm4c               362           297
        d17       rlm4c               365           297
        d18       rlm4c               370           297
        d19       rlm4c               375           297
        d2        rlm4b               304           296
        d20       rlm4c               380           297
        d21       rlm4c               384           297
        d22       rlm4c               390           297
        d4        rlm4b               310           296        296
        d5        rlm4b               313           296
        d6        rlm4b               320           296
        d8        rlm4c               331           296
```

d9	rlm4c	334	296						
rlmend	rlmend	94Ø	31						
rlmØa	rlmØa	2Ø	56	57	84	434	222	435	23Ø
			468	491	582	791	593	792	71Ø
			793	796	797	867	846	865	847
			938						
rlmØb	rlmØa	51	3Ø						
rlm1a	rlmØa	54	49						
rlm1Øa	rlm1Øa	795	49						
rlm1Øb	rlm1Øa	819	817						
rlm1Øc	rlm1Øa	845	817						
rlm1Ød	rlmend	864	817						
rlm1Øe	rlmend	887	865						
rlm1Øe1	rlmend	889	892	9Ø2					
rlm1Øf	rlmend	9ØØ	932						
rlm1Øg	rlmend	9Ø8	898						
rlm1Øg1	rlmend	915	912						
rlm1Øg2	rlmend	918	913						
rlm1Øg3	rlmend	921	914						
rlm1Øh	rlmend	925	917	92Ø	923				
rlm1Øi	rlmend	934	866						
rlm2a	rlmØa	82	49	85					
rlm2b	rlm2b	91	86						
rlm2c	rlm2b	112	115	133	137*		14Ø		157
rlm3a	rlm3a	169	49	222					
rlm3b	rlm3a	187	195	199	2Ø3				
rlm3c	rlm3a	197	189						
rlm3d	rlm3a	2Ø5	189	193					
rlm3e	rlm3a	22Ø	223						
rlm3f	rlm3a	225	217	219					
rlm4a	rlm3a	236	49	239					
rlm4b	rlm4b	245	24Ø						
rlm4c	rlm4c	325	253						
rlm4d	rlm4b	26Ø	263	27Ø	274		277		
rlm4e	rlm4b	272	262						
rlm4f	rlm4b	279	262	268					
rlm4g	rlm4b	283	266						
rlm5a	rlm5a	395	49	436					
rlm5b	rlm5a	414	411	453	457				
rlm5c	rlm5a	412	42Ø						
rlm5d	rlm5a	438	426						
rlm5e	rlm5a	448	443	445					
rlm5f	rlm5a	451	416						
rlm6a	rlm5a	459	49	465	478		487		
rlm6b	rlm5a	475	479						
rlm6c	rlm5a	484	473	488					
rlm7a	rlm5a	49Ø	49	5Ø2					
rlm7b	rlm7b	5Ø1	499						
rlm7be	rlm7b	535	545	563	586		59Ø		
rlm7bf	rlm7b	542	539						
rlm7c	rlm7b	565	543						
rlm7ce	rlm7b	579	581						
rlm7d	rlm7b	584	544						
rlm8a	rlm7b	591	49	614	665				
rlm8b	rlm8b	611	6Ø7	615	643		659		
rlm8c	rlm8b	645	624						
rlm8d	rlm8b	651	627						

rlm8e	rlm8b	661		609	666	697				
rlm8f	rlm8b	690		682						
rlm9a	rlm9a	709		49	742	768	781	769	782	774
rlm9b	rlm9b	741		711						
rlm9c	rlm9b	773		743	765	784				
rlm9d	rlm9b	780		775						
rlm9e	rlm9b	789								
rls2a	rlm2b	135		114						
rls2b	rlm2b	142		114						
rls2c	rlm2b	151		119	155					
rls2d	rlm2b	159		126	129					
rls2e	rlm2b	144		120	130	152				
rls9a	rlm9b	767		765						
back	rlm3a	222								
back	rlm5a	581								
bitcnt	rlm2b	146								
cc	rlm2b	93	111	132	139	156				
cc	rlm3a	171	186	194	202					
check	rlm2b	94	104	117	117	146		155		
clock	rlm2b	106	118	137	138					
clock	rlm3a	182	192	199	200	207				
clock	rlm4b	256	265	274	275					
clock	rlm5a	407	408	419	422	453	532	454	537	531
		553	561	566	586	588				
code	rlm4b	249	264	300	305	311	323	314	332	321
		335	338	342	345	350	363	353	366	358
		371	376	382	385	391				
data	rlm3a	222								
datac	rlm2b	98	116	119	127	131				
dc	rlm4b	247	259	269	276					
dc	rlm5a	397	409	413	456					
dial	rlm4b	248	255	259	267	267	276	268	285	269
		288	296	297						
dial	rlm5a	398	409	413	420	456				
frac	rlm5a	911								
int	rlm5a	910								
key	rlm2b	114	114	114	115	116				
key	rlm3a	189	189	189	190	222		222		222
key	rlm4b	262	262	262	263	264				
key	rlm5a	416	417	420	525	543	545	543	546	544
		547	549	551	581	581		582		
keytime	rlm2b	97	106	118	137	138				
keytime	rlm4b	251	256	265	274	275				
n	rlm3a	190	231	233						
n	rlm5a	417	441	441	449					
namterm	rlm2b	99	123	127	160					
nc	rlm5a	820	821	821	822	829	931	841	935	890
nc2	rlm4b	252	252							
nc322	rlm5a	937								
nc5	rlm5a	936								
next	rlm2b	114								
next	rlm3a	189	222							
next	rlm4b	262								
next	rlm5a	420	543	581	582	941				
node	rlm2b	101	108	120						
noslide	rlm5a	713	745							
nl	rlm2b	94								

n1	rlm3a	172	181	198	191	191		217	219	219
n1	rlm4b	240								
n1	rlm5a	398	404	417	418	418	480	446	482	467
		486	527	552	552	555	576	560	888	571
		890	891	891	891	891	902	901	909	901
		931								
n100	rlm5a	762	765	777	778	783		783	790	784
n101	rlm5a	405	429	455	455	712		744		
n11	rlm5a	528								
n12	rlm5a	529	546	546	546	546		557		573
n120	rlm5a	443	445	449						
n13	rlm5a	530	538	538	539	540				
n145	rlm3a	227								
n150	rlm2b	48	49							
n150	rlm5a	816	817	890	891	892				
n2	rlm2b	95	121							
n2	rlm3a	217	219	227	229	231		233		
n2	rlm4b	249								
n2	rlm5a	426	439	441	441	441		446	526	449
n20	rlm5a	497	509	523	534	562		589		
n21	rlm5a	820	822	829	841					
n22	rlm4b	252								
n3	rlm2b	96	121							
n3	rlm3a	216	218	226	226	228		232		
n3	rlm4b	250								
n3	rlm5a	439	440	441	525	541		546		547
n30	rlm5a	647	679							
n33	rlm5a	620	655	657	673	703		705		
n36	rlm5a	621								
n39	rlm5a	677								
n4	rlm3a	215								
n4	rlm5a	423								
n47	rlm5a	642	696							
n5	rlm2b	98								
n51	rlm2b	29	30							
n51	rlm3a	183	201	201	210					
n51	rlm5a	639	640	693	694	910	914	912	924	913
		930	931							
n52	rlm5a	911	930							
n53	rlm5a	916	919	922	929	930				
n54	rlm5a	926	929							
n6	rlm2b	99								
n6	rlm5a	526	556	572	587	587				
n7	rlm2b	100	121	121						
n75	rlm5a	624	647							
n76	rlm5a	646	647	648	648	648	648	648	649	648
n8	rlm2b	101	121	121						
n99	rlm3a	233	234							
screen	rlm2b	100	107	124	124	124	128	124	128	125
		146	146	147	148					
screen	rlm4b	250	254	284	284	287		295		
start	rlm2b	95	105	119	120	124	153	126	153	152
		154	155							
station	rlm5a	712	744							
stop	rlm2b	114								
stop	rlm3a	189								
stop	rlm4b	262								

stop	rlm5a	543								
termc	rlm2b	96	105	111	117	120	126	123	121	124
		132	139	154	156					
termc	rlm3a	172	186	193	194	202				
timeup	rlm2b	114								
timeup	rlm3a	189								
timeup	rlm4b	262								
timeup	rlm5a	416	544							
user	rlm2b	30								
vc	rlm5a	909								
v10	rlm5a	537	541							
v100	rlm5a	407	419	453	454					
v102	rlm5a	408	432							
v103	rlm5a	422	432							
v4	rlm2b	97								
v4	rlm4b	251								
v5	rlm5a	532	561	586	588					
v50	rlm3a	182	192	199	200					
v50	rlm5a	909	910	911						
v52	rlm3a	182	213							
v53	rlm3a	207	213							
v7	rlm5a	531	541	559	560	575		576		
v8	rlm5a	553	559	560	566	575		576		
where	rlm2b	130								
where	rlm5a	442	444							

lesson information

lesson name = cgerl

starting date = 11/20/73

last edited on 08/21/74 at 10.52.53

by neal of course eecge

at site 7, station 27

author name = J. P. Neal

department = Elec. Engg.

telephone number = 333-4351

discipline = E E

grade level = CGE authors

descripion of lesson = CGE-PLATO Tests & Special Software Routines.

-- part=1, block=a ----------

block 1a, cgeindexid

```
stop
****     For Neal, CGERL, Room 248, EEB.
One line description of this lesson --
 The Router Lesson for Courses ee244 and eecge.
           Divisions of this Lesson:            Block       Unit
         Router unit                            cgestart    cgestart
         Index of cge experiments               cgeind      cgeind
         End-exp questionaire                   quest1      quest1
         Table of plato characters              charplato
         Table of cge characters                charcge
         Chars for cge character set            cgechar
         Common for student statistics          statlog
         final edit 29 aug 74 neal.
*list    info
*list    symbols
*list    charset,(* )
*list    varian,charset,cgeindex,cgechar
*******
start
write    (at,1010) Loading the CGE Character Set
stop
doto     8loop,n3⇐0,127         $$ this sequence will insert
char     n3                     $$ blanks in all r/w charset
         0,0,0,0,0,0,0,0        $$ spaces before loading the
8loop                           $$ cge character set
start
charset cgeindex,cgechar
erase
dataon
ext      0
```

-- part=1, block=b ----------

block 1b, cgestart

```
unit     cgestart
common   cgeindex,statlog,322
name     n2
jump     n2='inst',instruct,x
jump     user='student'$and$station≠251,x,cgeind
```

```
jump    user='student'$and$station≠23Ø,x,cgeind
at      1214
write   At this time you may only have access to CGE-PLATO
        at the CGE Research Laboratory, Room 248 EEB.
pause   3
jumpout plato
***

unit    instruct
at      121Ø
write   One moment please
jumpout cgerl,inst
***

unit    cgeind3
next    cgeind3
at      51Ø
write   You are not at the CGE station in Room 248 EEB.

        Therefore, I will send you back to our title page.
pause   3
jumpout cge
at      1Ø1Ø
write     Please be patient.
***

unit    cgeind4
jump    n2≠'ee244',cont1,x
join    n3=nc(nc(4)-8)$and$rstart1=nc(nc(4)-7),old,new
*         $$ 8,7 instead of 6,5
calc    nc(n21)⇐n3
        nc(n21+1)⇐rstart1

entry   cont1
jumpout resume
***

unit    cgeind2
at      121Ø
write   You are not at the CGE Station.  You will be
        taken to Sample when you press next.  Press
        Shift-Stop if you want to leave.
pause
inhibit jumpchk
at      3224
write   One Moment Please!
jumpout sample
***

unit    skiper
at      51Ø
write   now going to lesson CGE
inhibit jumpchk
jumpout cge
```

block 1c, cgeind.

```
unit    cgeind
route   end lesson,cgeind
route   error,cgeind  $$ specify where to go on exec. error
term    index
at      207
write     COMPUTER-GUIDED EXPERIMENTS        REFERENCES

          0.  An Intro. to the CGE Station    Chap. 1,2,3
          1.  The Oscilloscope                Chap. 9
          2.  The Audio Oscillator            Chap. 13
          3.  The Function Generator          Chap. 14
          4.  The DC Supply                   Chap. 8
          5.  The Vacuum Tube Voltmeter       Chap. 4,12
          6.  Measurements of Transients      Chap. 14
          7.  Measurements of Impedance       Chap. 3
          8.  Two-Port Networks

            The above experiments should be completed in
        sequence.  Prior to attempting an experiment, you
        should have read the above references in:

            Guide to Electronic Measurements and Laboratory
        Practice, by S. Wolf, Prentice-Hall, 1973.

            While in any experiment:

        To return to this page, -TERM- index.
        To record  your comments, -TERM- comment.
        To read tech. data and spec., -TERM- slides.

            Select an experiment by typing its number, or
        reenter where you shift-stopped out by pressing r.
arrow   3010
long    1
match   n1,0,1,2,3,4,5,6,7,8,r
course  n2
jump    station=236$and$n2='ee244',cgeind2,x
jump    station=251$or$n2='eecge',x,cgeind3
jump    n1,x,cgeind1
judge   no
at      3110
write   Type the number  0,1,2 ... etc.
***

unit    cgeind1
course  n2
name    n3
calc    n3⇐n3$mask$o77777777777777770000
jump    n1,x,x,x,x,x,x,x,x,x,x,cgeind4
jump    n2≠'ee244',cont,x
calcs   n1,nc(3)⇐'x','eex00','eex01','eex02','eex03','eex04','eex05','eex06','eex07','eex08'
join    n3=nc(nc(4)-8)$and$nc(3)=nc(nc(4)-7),old,new
```

```
calc      nc(n21)⇐n3
          nc(n21+1)⇐nc(3)

entry     cont
at        510
write     Now going to experiment selected.
inhibit   jumpchk
jumpout   n1;x;eex00;eex01;eex02;eex03;eex04;eex05;eex06;eex07;eex08
***

unit      old
calc      n21⇐nc(4)-8   $$ 8 instead of 6
exit      1
***

unit      new
calc      n21⇐nc(4)
          nc(4)⇐nc(4)+8   $$ 8 instead of 6
exit      1

------------------------------------------------------------- part=1, block=d -----------

        block 1d,   quest1

*****     End of Experiment Questionaire    *****

unit      quest1
at        810
write        You have completed this experiment.

             Please complete the following questionaire,
          in order to bring your comments to date.

               Please type the number of the multiple-
          choice statement below which best reflects
          your present opinion.

          A.   I believe my last CGE experiment is worthwhile.

               1.   Strongly Agree
               2.   Agree
               3.   Undecided
               4.   Disagree
               5.   Strongly Disagree
arrow     2510
long      1
ok
***

unit      quest2
at        1210
write     B.   I would have learned more about the
          topic of this experiment in a conventional
          laboratory course.
```

```
                    1.   Strongly Disagree
                    2.   Disagree
                    3.   Undecided
                    4.   Agree
                    5.   Strongly Agree
arrow    2510
long     1
ok
***

unit     quest3
at       810
write    C.    How would you advise a friend who
         was considering taking a Computer-Guided
         Experimental section of the Introductory
         EE Laboratory course, EE244.

                   1.   Fight tooth and nail to get into CGE.
                   2.   Take the CGE section if reasonably possible.
                   3.   Take the CGE section only if convenient.
                   4.   Avoid the CGE section if convenient.
                   5.   Avoid CGE like a plague.
arrow    2510
long     1
ok
***

unit     quest4
at       1210
write    D.    Have you previously covered the topic of your
         last CGE experiment in any other laboratory course ?
arrow    1640
long     1
ok
--------------------------------------------------------------- part=1, block=e ---------

          block 1e,  comment1

unit     comment1
back     cgeind
at       510
write         You are invited to type any final comments you
         care to offer!

         Press -NEXT- to enter another line of comment.

         Press -BACK- when finished.
calc     n1⇐1110

entry    comment2
arrow    n1⇐n1+100
jkey     back
```

```
ok
endarrow
goto     key=next,comment2,x
press    back
--------------------------------------------------------------------- part=1, block=f -----------

         block 1f,  charplato

***  The following PLATO character sets are in use:

*id      Normal lower case (lc):

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*lc2      Ø 1 2 3 4 5 6 7 8 9 = + ⇐ - ÷ × ; , . /

*id      Normal upper case (uc):

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*uc1      A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

*lc2      Ø 1 2 3 4 5 6 7 8 9 = + ⇐ - ÷ × ; , . /
*uc2      < > [ ] $ % _ ' * ( ) Σ   Δ ∪ ∩ : " ! ?

*id      MICRO then key above the character:

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*char     α β   δ                 λ μ   ° π   ρ σ θ     ω

*lc2      Ø 1 2 3 4 5 6 7 8 9 = + ⇐ - ÷ × ; , . /
*char     { }       @ ≫ 7     ≠ &         ~ ‡   \

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*uc1      A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
*char     ←   →         |                             ↑ ↓

*lc2      Ø 1 2 3 4 5 6 7 8 9 = + ⇐ - ÷ × ; , . /
*uc2      < > [ ] $ % _ ' * ( ) Σ   Δ ∪ ∩ : " ! ?
*char     ≤ ≥ { } #             ≡     Δ

*id      ACCESS then key above the char (ACCESS = shift □):

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*char     α β   δ                 λ μ   ° π   ρ σ θ   ω
*lc2      Ø 1 2 3 4 5 6 7 8 9 = + ⇐ - ÷ × ; , . /
*char     { } 2 3 4 @ ≫ 7 8 9 ≠ &   - ÷ × ~ ‡ . \

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*uc1      A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
*char     ← B C → E F G H I J K L M N O P Q R S T U V ↑ ↓ Y Z

*lc2      Ø 1 2 3 4 5 6 7 8 9 = + ⇐ - ÷ × ; , . /
*uc2      < > [ ] $ % _ ' * ( ) Σ   Δ ∪ ∩ : " ! ?
*char     ≤ ≥ { } # % _ ' * ( ≡ Σ   Δ ∪   : " ! ?
```

```
***     End of PLATO Character listings.
----------------------------------------------------------------------- part=1, block=g ----------

        block 1g,  charcge

***  The following characters are in the CGE Character Set:
*id      FONT then key above the char (FONT ≡ shift MICRO):
**   Position numbers of cge characters (read down):
*         1 2 3 4 5 6 7 8 9 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2
*                           Ø 1 2 3 4 5 6 7 8 9 Ø 1 2 3 4 5 6
*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*char                                         ◆             ↑ ↓     Ω
**   Position numbers of cge characters (read down):
*         2 2 2 3 3 3 3 3 3 3 4 3 5 3 4 5 5 6 6 4
*         7 8 9 Ø 1 2 3 4 5 6 4 7 3 8 8 2 9 1 2 Ø
*lc2      Ø 1 2 3 4 5 6 7 8 9 = + ← - ÷ × ; , . /
*char                         ≈ +   -
**   Position numbers of cge characters (read down):
*         6 6 6 6 6 7 7 7 7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 9
*         5 6 7 8 9 Ø 1 2 3 4 5 6 7 8 9 Ø 1 2 3 4 5 6 7 8 9 Ø
*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*uc1      A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
*char     |   ┤   ∈ ∨ ⌐       ┘       ┌ L ┐ ┘   ⟩ ¯ /           ◆
**   Position numbers of cge characters (read down):
*                           1 1 1   1 1 1 1   1 1
*         9 9 9 9 9 9 9 9 9 Ø Ø Ø   Ø 1 1 2 6 2 Ø
*         1 2 3 4 5 6 7 8 9 Ø 8 1   2 2 6 3 Ø 4 4
*lc2      Ø 1 2 3 4 5 6 7 8 9 = +   - ÷ × ; , . /
*uc2      < > [ ] $ % _ ' * ( ) Σ   Δ ∩ ∪ : " ! ?
*char                         ∫ .   _         |
*id       FONT then shift □ then key above the character:
**   Position numbers of cge characters (read down):
*         3 4 4 4 4 4 4 4 5 5 5 5 5 5 5
*         9 1 2 3 5 6 7 9 Ø 1 4 5 6 7 8
*lc1      a b c d e f g h i j k l m n o
*char     □
```

```
285   **  Position numbers of cge characters (read down):

286   *        1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
287   *        Ø Ø Ø Ø Ø 1 1 1 1 1 1 1 2 2 2
288   *        3 5 6 7 9 Ø 1 3 4 5 8 9 Ø 1 2

289   *lcl     a b c d e f g h i j k l m n o
29Ø   *ucl     A B C D E F G H I J K L M N O
291   *char

292   ***          End of CGE Character listings.
```

```
cgeind      cgeind      86     37    38    87    88    2Ø5
cgeind1     cgeind      123    118
cgeind2     cgestart    69     116
cgeind3     cgestart    5Ø     51    117
cgeind4     cgestart    6Ø     127
cgestart    cgestart    33
comment1    comment1    2Ø4
comment2    comment1    213    218
cont        cgeind      133    128
cont1       cgestart    66     61
instruct    cgestart    45     36
new         cgeind      143    62    13Ø
old         cgeind      139    62    13Ø
quest1      quest1      149
quest2      quest1      167
quest3      quest1      181
quest4      quest1      196
skiper      cgestart    8Ø
back                    219
key                     218
inc                     62     62    62    62    64   13Ø   65   3Ø   129
                        13Ø    13Ø   13Ø   131   132  145   132  145  14Ø
                        145
next                    218
n1                      114    118   127   129   212        214       214
n2                      35     36    61    115   116        117  128  124
n21                     64     65    131   132   14Ø        144
n3                      23     24    62    64    125  13Ø   126  131  126
rstart1                 62     65
station                 37     38    116   117
user                    37     38
```

lesson information

lesson name = cgeindex

starting date = Ø1/29/73

last edited on Ø9/Ø3/74 at 11.28.26

by neal of course eecge

at site 7, station 27

author name = J.P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = The Router Lesson for Courses ee244 and eecge lesson eex00 at 5:11 am on friday, september 6, 1974

-- part=1, block=a ----------

block 1a, eex00id

```
stop
****     For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

     An Introduction to the CGE Station.

            Divisions of this Lesson:           Block      Unit

         Id for this file                       eex00id
         Experiment eex00:
           Description of cge station           x00m0a     x00m0a
           Conclusion                           x00m0g     x00m1a
         Cge s.r. and terms                     ck1-ck6

         Final edit 29 aug 74 neal.

*list    info
*list    symbols
*list    varian,charset,cgeindex,cgechar
****
start
finish   endunit
write    [illegible] Loading the CGE Character Set
charset  cgeindex,cgechar
[illegible]
[illegible]
[illegible]  [illegible]x00
[illegible]
```

-- part=1, block=b ----------

block 1b, x00m0a

```
unit     x00m0a
erase
name     n2
next     x00m0a1
help     x00s0a
calcc    n30-400,n30+400,0
jump     n20-400,x00m0a1,x
zero     n20
at       [illegible]
write         Hello (a,n2)

              This PLATO terminal is externally interfaced with the
```

```
        adjoining electronic experimentation equipment.

           At this CGE-PLATO station, PLATO can automatically
        determine the external interconnections between terminals
        of the experimentation equipment or check the settings
        of the dials on that equipment.

           This lesson will acquaint you with the uses of PLATO and
        the names of the panel controls and terminals of the
        instruments and circuit boards of the CGE station.

           Subsequent experiments will guide you to learn worthwhile
        methods for operating the electronic instruments and making
        electronic measurements.

           Experienced instructors have programmed connection
        checks and dial checks where necessary to sense your
        progress through the experiments and to provide you
        with additional assistance, if you seem to encounter
        undue difficulty or request help or information.

           If you are unacquainted with PLATO, press -HELP-,
        otherwise, press -NEXT-.
 ***

 unit   x00m0a1
 back   >00m0a
 next   x00m0a2
 zero   n30
 at     1210
 write    If you want to see a sample of the
        variety of lessons now programmed on PLATO,
        -TERM- sample. Otherwise, press -NEXT-.
 ***

 unit   x00m0a2
 back   x00m0a1
 next   x00m0b
 at     503
 write   Now that you are acquainted with the Plato operation, you
        are ready to proceed with the Computer Guided Experiments.

          If you are somewhat familiar with electronic instruments
        or are exceptionally alert, you will find that you can
        rapidly accomplish the sequential learning tasks presented
        to you in the subsequent experiments.

          Do not be dismayed if you encounter difficulties.  If you
        have no difficulties and breeze through the tasks presented
        to you, you may be learning very little.

         As Alice in Wonderland said,
           "Oh, a knot!  Do let's untie it!"

------------------------------------------------------------ part=1, block=c ----------
```

block 1c, x00m0b

```
unit     x00m0b
back     x00m0a
next     x00m0b1
name     n2
at       905
write       Hello again <a,n2>

            After this brief introduction you should be able to
         communicate with me and set the instruments in the
         "safe initial mode". This initial mode is specified
         and rechecked whenever you start a new experiment.
***

unit     x00m0b1
back     x00m0b
next     x00m0c
at       907
write       In front of you are five rack-mounted electronic
         instruments.

            Each instrument has a number of terminals between
         which you can make interconnections, and a number of
         knobs, switches, and dials by which you can adjust
         the instruments.

            I will list the names we use to refer to each of
         the instruments, terminals, and dials, and I suggest
         you locate each of them on the instrument panels.
***

unit     x00m0c
back     x00m0b1
next     x00m0c1
at       510
write      At the top left of the equipment rack is the
         Finalab DUAL-TRACE SCOPE Type 1120. Note that red
         labels pertain to red knobs, and black labels
         pertain to black dials.

           Important dials of the SCOPE are:

         BEAM FINDER (a black dial)        SCALE
         INTENSITY (a red knob)            FOCUS
         A & B SEPARATION                  Power
         Y DISPLAY                         X DISPLAY
         Y POSITION                        X POSITION
***

unit     x00m0c1
back     x00m0c
next     x00m0d
at       506
write          To the right of the SCOPE, in the same frame,
```

```
            is the Analab TYPE 700 PLUG-IN.
                Important dials of the PLUG-IN are:
            A VOLTS              TIME               B VOLTS
                           NULLs (red knobs)
            A PREAMP   TRIGGER SOURCE   SWEEP MODE   B PREAMP
                             TRIGGER SLOPE


                Important terminals of the PLUG-IN are:
            A INPUT         TRIGGER INPUT        B INPUT
---------------------------------------------------------- part=1, block=d ------------

        block 1d,   x00m0d

unit      x00m0d
back      x00m0c1
next      x00m0d1
at        [illegible]
write        Directly below the SCOPE and the PLUG-IN is the
          FUNCTION GENERATOR:

               On the FUN. GEN. there are:

                  Dials                         Terminals

               TRIGGER                        SQUARE
               MULTIPLIER                     TRIANGLE
               CYCLES/SEC.                    SINE
               OUTPUT (black knob)            RAMP
               ATTENUATOR (red knob)          OUTPUT (red terminal)
               DC LEVEL                       TRIG OUT
***

unit      x00m0d1
back      x00m0d
next      x00m0e
at        [illegible]
write        Directly to the right of the PLUG-IN is
          the AUDIO OSCILLATOR.

               The dials of the AUD. OSC. are:

          RANGE, Frequency, and AMPLITUDE. The frequency dial
          is the large one in the center.
```

```
        The terminals of the AUD. OSC. are:
        GROUND (black), and the left and right red OUTPUT
        terminals.
***
unit    x00m0e
back    x00m0d1
next    x00m0e1
at      807
write      Next to the AUD. OSC. is the VACUUM TUBE VOLTMETER.

           The RANGE dial is the only dial of the VTVM.

           INPUT terminals of the VTVM are red and black.

           OUTPUT terminals of the VTVM are red and black.

           In each case here, the black terminals are GROUND.
***
unit    x00m0e1
back    x00m0e
next    x00m0g
at      807
write      The CONSTANT VOLTAGE/CONSTANT CURRENT or
        DC SUPPLY is located below the AUD. OSC. and the VTVM.

           The dials of the DC SUP. are:

        METER, VOLTAGE, and CURRENT.

           The terminals of the DC SUP. are:

        + (red), - (black), and GROUND.

           Incidentally, the ground terminals of all of the
        instruments are interconnected at the power receptacles,
        so GROUND is essentially only one common terminal.
---------------------------------------------------------- part=1, block=e ----------

      block 1e,  x00m0g

unit    x00m0g
back    x00m0e1
next    x00m0h
lab     x00s0b
at      807
write      The CGE-PLATO system has the capability of
```

```
          automatically checking the interconnections between
          30 terminals and automatically checking the settings
          of ?? dials on the experimentation equipment.

             If you want to see a record of a present check,
          press -LAB-.

             Otherwise, press -NEXT-.
***

unit      x00m0h
join      inmodal

entry     icheck
join      inmodeck
jump      n47,icheck,x00m1a
***

unit      x00m1a
back      x00m0h
next      x00m1b
name      n2
at        ?07
write        Hello again  <a,n2>

             At any time during an experiment, you can reach a
          slide display showing descriptions of the purposes of
          the important dials and terminals, the manufacturer'a
          specifications for the instruments, and other generally
          useful information by the -TERM- slides.

             You can do the experiments listed later in any order.

             Consequently, if you attempt to perform the
          experiments out-of-sequence, and encounter too
          much difficulty, you may be automatically
          guided to stop your selected experiment and
          complete a prior-listed experiment, in order for
          you to learn how to properly use an instrument.
```

-- part=1, block=f ------------

```
      block 1f,   x00end

unit      x00m1b
next      x00end
back      x00m1a
at        ?09
write       You are now ready to explore physical reality
          using this Computer-Guided Experimentation
          station.

             Leave all dials and connections in the safe
          initial mode, then press -NEXT- to go to the
```

```
        Index of Experiments.
***

unit    xØØsØa
calc    n25⇐'eexØØ'
        n26⇐Ø
        n3Ø⇐4ØØ
join    jmpmes
jumpout help
end
***

unit    xØØsØb
base
back    xØØmØg
next    xØØsØc
join    rlm2b
***

unit    xØØsØc
back    xØØsØb
next    xØØmØh
join    rlm4b
***

unit    xØØend
course  n2
calcc   n2='ee244',
        nc(n21+1)⇐(nc(n21+1)$mask$o7777777770ØØØØØØØØØØ)+o46Ø3ØØØØØØ,
        nc(n21+1)⇐nc(n21+1)
course  n1
join    n1='ee244',endunit,x
join    jmpmes
jumpout cgeindex
***

unit    endunit
course  n2
jump    n2≠'ee244',leave,x
calc    nc(n21+7)⇐nc(n21+7)+ahelp
        vc(n21+6)⇐vc(n21+6)+atime/6ØØØØ

entry   leave
***gives this lesson use of talk routines on cgerl
use     cgerl,rlm4b
use     rlm4c
use     rlm2b
```

-- part=1, block=g ----------

block 1g, ck1

```
unit    +cc
common  cgeindex,statlog,322
```

```
define  ckc
        cc=o40
        authorc=n33
        ccdata=n30
        bestcod=n36     $$ author code for best match
        besterr=n39     $$ number of errors in best match
        segment,acode=authorc,6
        segment,ccode=ccdata,6
        errors=n47
        print=n49       $$ -1=print off    0=print on
        start=n1
        search=n2
        termc=n3
        keytim=v4
        datac=n5
        count=n6
        acod1=n4
        acod2=n5
        ccod1=n6
        ccod2=n7
        state=n8

unit    ckow
erase
calc    print⇐0
goto    cc1

unit    ckc
calc    print⇐-1
goto    cc1

unit    ckc1
calc    print⇐-1
goto    cc3

unit    ckc1w
erase
calc    print⇐0
goto    cc3

unit    cc1
******          Data Collection Routine.          *********
calc    n22⇐nc1⇐nc1+1
        n23⇐-1
mode    rewrite
do      comess
mode    write
pack    ccdata,++++++++++++++++++++++++++++++
calc    start⇐termc⇐1
        keytim⇐clock
        count⇐0
time    1
enable
ext     cc+termc

entry   cc1a
pause
```

```
goto    (key=timeup)-(key=micro$and$user='author'),cc1b,x,cc1out
goto    (key$mask$o1ØØØ)=Ø,cc1a,x  $$ throw out keyboard key
calc    keytim⇐clock
        datac⇐key$mask$o37
        count⇐count+1
calcc   termc=Ø,termc⇐1,termc⇐termc    $$stops array error
*       when hardware not turned on
goto    (datac≠start)-(count>31),cc1c,x,cc1e
calc    ccode(termc)⇐start
        termc⇐datac
ext     cc+termc
goto    cc1a

unit    cc1c
calc    ccode(termc)⇐Ø
goto    termc=start,cc1d,x
calc    ccode(termc)⇐start
goto    cc1d

unit    cc1d
calc    start⇐start+1
        datac⇐ccode(start)
goto    ((datac≠"+")$and$(start≤3Ø))-(start>3Ø),cc1d,x,cc2
calc    termc⇐start
ext     cc+termc
goto    cc1a

unit    cc1b
time    1
goto    clock-keytim>1.5,x,cc1a
calc    keytim⇐clock
ext     cc+termc
goto    cc1a

unit    cc1e
*       Error if more than 3Ø keys recieved!!
mode    rewrite
at      3123
write   An Error Has Occurred!

unit    cc1out
calc    n22⇐nc1⇐nc1-1
pack    authorc,++++++++++++++++++++++++++++++
goto    cc2

unit    cc2
ext     Ø
disable
calc    besterr⇐1ØØ    $$init errors
mode    erase
do      ccmess
mode    write
goto    cc3

unit    cc3
calc    errors⇐Ø
        start⇐termc⇐Ø
```

```
do      cc4
goto    n23<Ø,x,skipc
goto    nc(322)<Ø,skipc,x
goto    n21<5$or$n21>31Ø,skipc,x
calc    nc(n21+4)⇐nc(n21+4)+1
calcc   n47<Ø,nc(n21+5)⇐nc(n21+5)+1,nc(n21+5)⇐nc(n21+5)
zero    n23

entry   skipc
do      besterr+errors-1,x,cc9
exit    -print
do      cc8
exit    1
```

--- part=1, block=h ------------

Block 1h, ck2

```
unit    ckc2w
erase
calc    print⇐Ø
block   bestcod,authorc,3
goto    cc3

unit    ckc2
calc    print⇐-1
block   bestcod,authorc,3
goto    cc3

unit    cc4
calc    print⇐print     $$dummy calc to enter loop
1       start⇐start+1  $$next terminal number
        branch start>3Ø,4,x             $$branch out when done
        ccod1⇐ccode(start)              $$get cc code
        acod1⇐acode(start)              $$get author code
        state⇐(ccod1=Ø$and$acod1="Ø")$or$(acod1="+")
        branch state,1,x
        search⇐start    $$set search at present terminal
2       search⇐search+1                 $$increment term. num.
        branch search>3Ø,1,x            $$go away if too big
        ccod2⇐ccode(search)             $$get cc code
        acod2⇐acode(search)             $$get authors code
        state⇐(acod1=acod2$and$acod1≠"Ø")
        state⇐state-2(ccod1=ccod2$and$ccod1≠Ø)-4(acod2="+")
        branch state,x,2,2,x,2
        errors⇐errors-1  $$add 1 to number of errors
        branch print,1,x
4       print⇐print     $$dummy calc to exit loop
goto    (start>3Ø)-2((errors<-6)$and$print=Ø),cc5,x,cc6
at      501-2ØØ errors
calc    term⇐start
do      cc7
writec  state, should be connected to ,*** man you are in trouble ***,
         shouldn't be connected to ,
```

```
calc    termc⇐search
do      cc7
goto    cc4

unit    cc5
exit    1

unit    cc6
calc    errors⇐-7
at      521-200×errors
write   *** AND MORE ***
exit    1

unit    cc7
writec  termc,-,0,Term. 1,Term. 2,Term. 3,Term. 4,Term. 5,
        Term. 6,Term. 7,Term. 8,Term. 9,Term. 10,
        Term. 11,Term. 12,Ground,Term. 14,Term. 15,
        Scope: A volts,Scope: B volts,Scope: trigger,
        Fun-gen: sq. wave output,Fun-gen: triangle,
        Fun-gen: sine output,Fun-gen: ramp output,
        Fun-gen: attn'd output,Fun-gen: trigger out,
        DC supply: (+) ,DC supply(-),
        Aud-osc: right output,Aud-osc: left output,
        VTVM: input,VTVM: output,

unit    cc8
at      711-200n47
writec  errors,*** WIRING ERRORS *** (Press -NEXT-),,
exit    1

unit    cc9
block   authorc,bestcod,3
calc    besterr⇐errors

unit    ccmess
at      3219
write   CONNECTION CHECK IN PROGRESS

---------------------------------------------------------------- part=1, block=i --------

        block 1i,  ck3

unit    +dc
define  ckd
        dc=o100
        authorc=n33
        dcdata=n30
        bestcod=n39     $$ author code for best match
        besterr=n44     $$ number of errors in best match
        segment,acode=authorc,6
        segment,dcode=dcdata,6
        errors=n47      $$ errors= -(number of errors found)
        print=n49       $$ -1=print off    0=print on
        dial=n1
```

```
          keytim=v2
          match=n3
          acod=n4
          dcod=n5
          imb=n16
          cannot=n17
          acod1=n18
          dcod1=n19
          state=n6
          paren=n7
          search=n8
          screen=n9

unit      ckd0
erase
calc      print⇐0
goto      dc

unit      ckd
calc      print⇐-1
goto      dc

unit      ckd1
calc      print⇐-1
goto      dc1

unit      ckd1w
calc      print⇐0
erase
goto      dc1

unit      ckd2w
erase
block     bestcod,authorc,6
calc      print⇐0
goto      dc1

unit      ckd2
block     bestcod,authorc,6
calc      print⇐-1
goto      dc1

unit      dc
calc      n22⇐nc2⇐nc2+1
          n23⇐-1
mode      rewrite
do        dcmess
calc      dial⇐1
          keytim⇐clock
time      1
enable
ext       dc+dial

entry     dc0
pause
goto      (key=timeup)-(key=micro$and$user='author'),dc0a,x,dcout
goto      (key$mask$o1000)=0,dc0,x  $$throw out keyboard keys
```

```
calc    dcode(dial)⇐key$mask$o77
        dial⇐dial+1
        keytime⇐clock
goto    dial>2Ø,dcØb,x
ext     dc+dial
goto    dcØ

unit    dcØa
time    1
goto    clock-keytim<1.5,dcØ,x
calc    keytime⇐clock
ext     dc+dial
goto    dcØ

unit    dcØb
disable
ext     Ø
mode    erase
do      dcmess
mode    write
calc    besterr⇐1ØØØ  $$ init no. of errors in best match
goto    dc1

unit    dcout
calc    n22⇐nc2⇐nc2-1
pack    authorc,++++++++++++++++++++++
calc    n36⇐n37⇐n38⇐Ø  $$fill out rest of authorc with blank
goto    dcØb

unit    dc1
calc    dial⇐search⇐paren⇐errors⇐Ø
        screen⇐31Ø
do      dc2                         $$ go look for errors
goto    n23<Ø,x,skipd
goto    nc(n22)<Ø,skipd,x
goto    n21<5$or$n21>31Ø,skipd,x
calc    nc(n21+2)⇐nc(n21+2)+1
calcs   n47<Ø,nc(n21+3)⇐nc(n21+3)+1,nc(n21+3)⇐nc(n21+3)
goto    n21

entry   skipd
do      besterr+errors-1,x,dc5      $$ is this a best match?
goto    1+(print-Ø)
goto    1

unit    dc3
at      screen-1
write   These dials are incorrectly set
draw    3Ø2;349
calc    screen⇐screen+3ØØ
```

part=1, block=j

block ij, ck4

```
unit    dc2
calc    print⇐print      $$dummy calc to enter loop
1       dial⇐dial+1
        match⇐0       $$ set no match  found yet flag
        branch dial>22,999,x
        dcod⇐dcode(dial)
100     search⇐search+1                   $$ incr author loc.
        acod⇐acode(search)                $$ get author code
        state⇐(acod="(")-(acod=")")-2(acod="+")-3(acod="<")-4(acod=">")
        branch state,400,x,300,1,600,500
        branch carrot,700,x
        match⇐match+(acod=dcod)           $$ check for match
        branch paren,100,x              $$ branch for paren loop
        branch match,1,900                $$ was there a match?
300     paren⇐0       $$ clear paren loop flag
        branch match,1,900                $$ was there a match?
400     paren⇐-1      $$ set paren loop flag
        branch 100    $$ go look at next author code
500     ...⇐0
        branch match,1,900
600     carrot⇐-1
        dial⇐dial+1
        dcod1⇐dcode(dial)
        branch 100
700     ...⇐0
        search⇐search+1
        acod1⇐acode(search)
        ...⇐...+(acod1="(")-(acod1=")")
        ...⇐...+(acod=dcod and acod1=dcod1)
        branch ...,900,100,100
900     ...⇐error...+1                    $$ add to error count
        branch print,1,x                  $$ should we print?
        ...print      $$ dummy calc to exit loop
        ... quit when done
        screen⇐110,dc3,
        screen 1000,dc4,x
        ...
        ...-1110,Oscilloscope,Function generator,
        Function Generator,DC Power supply,
        ...oscillator,Vacuum tube voltmeter,
write
        ...,A volts, time,B volts,B preamp,
        ... mode,... ,B preamp,
        ... display func, ... func,
        trigger,multiplier,...,
        output,attenuator,DC level,meter,
        voltage,current,amplitude,
        range,frequency,range,
write
calc    screen⇐screen+200
...     ...

...     ...4
        screen⇐screen+100
write   *** END MORE ***
```

```
unit    dcs5
block   authorc,bestcod,6
calc    besterr⇐abs(errors)

unit    dcmess
at      3223
write   DIAL CHECK IN PROGRESS
```

-- part=1, block=k --------

block 1k, ck5

```
unit    comment
term    comment
dataon
erase
at      510
write   Please type your comment at the arrow.

        Press -NEXT- to enter another line of comment.
        Press -BACK- when finished.
calc    n1⇐1110

entry   comment1
arrow   n1⇐n1+100
ikey    back
ok
endarrow
goto    key=next,comment1,x
press   back

unit    sample
term    sample
at      710
write   Now returning you to SAMPLE!
inhibit jumpchk
jumpout sample

unit    cgerl
term    cgerl
do      jmpmes
jumpout cgerl

unit    index
term    index
do      jmpmes
jumpout cgeindex,cgeind

unit    jmpmes
write   (at,1516)One moment please
inhibit jumpchk

unit    comdeck
pack    n33,+++fhe++a+++a(abcd)+a(ab)a++1
```

```
join    ckd
join    n47,inmode,x
join    n47,x,inmodec

unit    inmodec
pack    n[illegible],000000000000a000000000000000a00
join    [illegible]cw
join    n47,inmodep,x

unit    inmodep
pause   .5
pause

unit    inmode
entry
at      1210
write   The equipment was not set in the initial mode.
pause   1.5
erase

entry   inmode1
term    imode
at      109
write   Please:  Remove all plugged-in connections
                 Securely fasten all ground links
                 Set the dials in this safe initial mode:

                  SCOPE:
                     INTENSITY          fully CCW

                  PLUG-IN:
                     NULLS              at zero
                     A and B PREAMPs    OFF
                     TRIGGER SOURCE     OFF
                     SWEEP MODE         OFF

                  FUN GEN:
                     TRIGGER            INT
                     ATTENUATOR         fully CCW
                     DC LEVEL           CCW and click

                  AUD OSC:
                     AMPLITUDE          zero

                  DC SUPPLY:
                     VOLTAGE            0
                     CURRENT            0

                  VTVM:
                     RANGE              300

                 ALL POWER SWITCHES ON

         When ready to proceed, press -NEXT-.
pause   .5
pause
```

```
unit    imode
erase
at      1007
write      Before proceeding, please return the equipment to
        the Safe Initial Mode.
pause
join    inmodeck
exit
```

--- part=1, block=1 ---------

block 11, ck6

```
unit    slides
next    slide1
term    slides
erase
calc    (station=251),n101⇐256,256
slide   n101
at      207
write   SLIDE NO.        CGE SLIDE

            1            CGERL Entrance
            2            The EE244 Laboratory
            3            The CGE-PLATO System Description
            4            Orientation of the CGE Station
            7            Layout of Sensed Dials and Terminals
            8            List of Sensed Dials and Terminals
            19           Resistor Color Code
            20 - 21      E E Symbols and Units
            22           Recommended Unit Prefixes
            23           Defined Physical Values
            24 - 26      Physical Constants
            27 - 32      SCOPE -     Use of Dials and Terminals
            33 - 35      SCOPE -     Manufacturer's Specifications
            36 - 44      PLUG-IN -   Use of Dials and Terminals
            45 - 50      PLUG-IN -   Manufacturer's Specifications
            51 - 53      FUN.GEN. -  Use of Dials and Terminals
            54 - 56      FUN.GEN. -  Manufacturer's Specifications
            57 - 60      AUD.OSC. -  Use of Dials and Terminals
            61 - 62      AUD.OSC. -  Manufacturer's Specifications
            63 - 66      VTVM -      Use of Dials and Terminals
            67 - 68      VTVM -      Manufacturer's Specifications
            69 - 71      DC SUPP -   Use of Dials and Terminals
            72 - 75      DC SUPP -   Manufacturer's Specifications
            76           Graph of a Transient
            95           CGE-PLATO Interface.

          ; Type slide no.       ,press -NEXT-, or -BACK- to return.
arrow   3021
store   n100
ok
erase
goto    (n100<96),slide1,slideno
```

```
754  ***

755  unit     slideno
756  back     slides
757  next     slides
758  at       1210
759  write    [illegible] Type  a number less than 96.
760  ***

761  unit     slide3
762  slide    n100+[illegible]12
763  ***

764  unit     slide1
765  back     slides
766  next     slides
767  at       [illegible]
768  write    This is slide <z,n100>.  Press -NEXT- for next slide
769  slide    n100
770  ***

771  unit     slide2
772  back     slides
773  next     slides
774  calc     n100⇐n100+1
775  goto     (n100[illegible]96),slide1,x
776  [illegible]  [illegible]
777  at       1210
778  write    [illegible]ou can't show a slide greater than 96.
```

[illegible]	[illegible]	455	319	374			
[illegible]	[illegible]	314	303	306			
[illegible]	[illegible]	328	331	341	353	356	359
[illegible]	[illegible]	354	330				
[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	344	346	350		
[illegible]	[illegible]	360	[illegible]				
[illegible]out	[illegible]	[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	368			
[illegible]	[illegible]	[illegible]	[illegible]	313	376	397	401
[illegible]	[illegible]	402	[illegible]	429			
[illegible]	[illegible]	430	421				
[illegible]	[illegible]	[illegible]	421				
[illegible]	[illegible]	[illegible]	424	428			
[illegible]	[illegible]	[illegible]	390				
[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]erl	[illegible]	[illegible]					
[illegible]	[illegible]	304					
[illegible]	[illegible]	300	667				
[illegible]	[illegible]	307					
[illegible]	[illegible]	310					
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]	662				
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	502					

ckd2w	ck3	497					
comment,	ck5	626					
comment1	ck5	636	641				
dc	ck3	5Ø6	486	489			
dcmess	ck4	622	51Ø	536			
dcout	ck3	54Ø	518				
dcØ	ck3	516	519	525	528	531	
dcØa	ck3	526	518				
dcØb	ck3	532	523	544			
dc1	ck3	545	492	496	5Ø1	5Ø5	539
dc2	ck4	565	548	615			
dc3	ck3	559	599				
dc4	ck4	616	6ØØ				
dc5	ck4	619	55[illegible]				
endunit	xØØend	266	18	262			
icheck	xØØmØg	2Ø3	2Ø5				
imode5	ck5	7Ø6					
index	ck5	653					
inmode	ck5	672	663				
inmodec	ck5	665	664				
inmodeck	ck5	66Ø	2Ø4	712			
inmodep	ck5	669	668				
inmodel	ck5	678	2Ø2				
jmpmes	ck5	657	241	263	651	655	
leave	xØØend	271	268				
rlm2b	not found		249				
rlm4b	not found		254				
sample	ck5	643					
skipc	ck1	387	381	382	383		
skipd	ck3	555	549	55Ø	551		
slideno	ck6	755	753				
slides	ck6	715	756	757	765	772	773
slide1	ck6	764	716	753	775		
slide2	ck6	771	766				
slide3	ck6	761					
xØØend	xØØend	256	227				
xØØmØa	xØØmØa	26	57	82			
xØØmØa1	xØØmØa	56	29	32	66		
xØØmØa2	xØØmØa	65	58				
xØØmØb	xØØmØb	81	67	93			
xØØmØb1	xØØmØb	92	83	1Ø7			
xØØmØc	xØØmØb	1Ø6	94	122			
xØØmØc1	xØØmØc	121	1Ø8	136			
xØØmØd	xØØmØd	135	123	151			
xØØmØd1	xØØmØd	15Ø	137	164			
xØØmØe	xØØmØd	163	152	174			
xØØmØe1	xØØmØd	173	165	188			
xØØmØg	xØØmØg	187	175	247			
xØØmØh	xØØmØg	2Ø1	189	2Ø8	253		
xØØm1a	xØØmØg	2Ø7	2Ø5	228			
xØØm1b	xØØend	216	2Ø9				
xØØsØa	xØØend	237	3Ø				
xØØsØb	xØØend	245	19Ø	252			
xØØsØc	xØØend	251	243				
+uc	ck1	277					
+dc	ck3	489					
abs	ckd	621					

acod	ckd	479	572	573	573	573	573	573	593
acode	ckd	285	407	414					
acode	ckd	466	572	591					
acodi	ckd	295	407	408	408	415	415		
acodi	ckd	477	591	592	592	593			
acodi2	ckd	296	414	415	416				
ahelp	ckd	269							
atime	ckd	270							
authorc	ckd	281	285	367	396	400	453		
authorc	ckd	462	466	499	503	542	620		
back	ckd	642							
badcod	ckd	283	396	400	453				
[illegible]	ckd	464	499	503	620				
besterr	ckd	284	372	[illegible]	454				
besterr	ckd	465	[illegible]	[illegible]	621				
[illegible]	[illegible]	476	575	583	585				
cc	[illegible]	280	327	340	352	358			
ccdata	ckd	282	286	321					
ccode	[illegible]	286	338	343	345	349	406	413	
ccodi	[illegible]	[illegible]	406	[illegible]	416	416			
ccodi2	[illegible]	[illegible]	[illegible]	416					
clock	[illegible]	[illegible]	332	356	357				
clock	[illegible]	512	[illegible]	528	529				
count	[illegible]	294	324	334	334	337			
[illegible]	[illegible]	293	[illegible]	337	339	349	350		
[illegible]	ckd	461	515	524	530				
dcdata	[illegible]	463	462						
dcodi	[illegible]	[illegible]	[illegible]	576	593				
dcode	[illegible]	467	[illegible]	570	587				
dcodi2	[illegible]	[illegible]	[illegible]	[illegible]					
dial	[illegible]	[illegible]	[illegible]	[illegible]	520	521	521	523	530
		[illegible]	567	567	569	570	586	586	598
		[illegible]	606						
error	[illegible]	[illegible]	[illegible]	388	418	418	421	422	434
		[illegible]	[illegible]						
errors	[illegible]	[illegible]	[illegible]	556	595	595	621		
imb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	594			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	519	[illegible]	641			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	357			
[illegible]	[illegible]	471	[illegible]	[illegible]	[illegible]	530			
match	[illegible]	[illegible]	[illegible]	576	576	578	580	584	593
micro	[illegible]	[illegible]							
micro	ckd	[illegible]							
nc	[illegible]	[illegible]	259	260	260	269	269	382	384
		[illegible]	385	385	[illegible]				
nc	ckd	550	[illegible]	[illegible]	553	553	553	553	
nc1	[illegible]	316	316	366	366				
nc2	[illegible]	507	507	541	541				
next	ckd	641							
ni	[illegible]	261	262	289					
ni	[illegible]	470	[illegible]	637	637				
ni00	[illegible]	760	[illegible]	[illegible]	768	769	774	774	
ni1	[illegible]	719	[illegible]						
[illegible]	[illegible]	475							
[illegible]	[illegible]	476							
[illegible]	[illegible]	477							

n19	ckd	478							
n2	ckc	28	35	84	86	210	212	257	267
		268	290						
n21	ckc	259	259	260	260	269	269	270	383
		383	384	384	385	385	385	385	
n21	ckd	551	551	552	552	553	553	553	
n22	ckc	316	366						
n22	ckd	507	541						
n23	ckc	317	381	386					
n23	ckd	506	549	554					
n25	ckc	238							
n26	ckc	239							
n3	ckc	291							
n3	ckd	472							
n30	ckc	31	31	32	33	59	240	282	
n30	ckd	463							
n33	ckc	281							
n33	ckd	487	661	666					
n36	ckc	283							
n36	ckd	543							
n37	ckd	543							
n38	ckd	543							
n39	ckc	284							
n39	ckd	464							
n4	ckc	295							
n4	ckd	473							
n44	ckd	465							
n47	ckc	205	287	385	449				
n47	ckd	468	553	663	664	668			
n49	ckc	280							
n49	ckd	469							
n5	ckc	293	296						
n5	ckd	474							
n6	ckc	294	297						
n6	ckd	479							
n7	ckc	298							
n7	ckd	480							
n8	ckc	299							
n8	ckd	481							
n9	ckd	482							
paren	ckd	480	546	577	579	581			
print	ckc	288	302	305	308	312	389	395	483
		403	419	420	420	421			
print	ckd	469	485	488	491	494	500	504	566
		566	596	597	597				
screen	ckd	482	547	560	563	563	599	600	614
		614	617						
search	ckc	290	410	411	411	412	413	414	
search	ckd	481	546	571	571	572	590	590	
segment	ckc	285	286						
segment	ckd	466	467						
start	ckc	289	322	337	338	344	345	348	349
		350	350	351	379	404	404	405	407
		410	421	423					
state	ckc	299	400	400	415	416	416	417	
state	ckd	479	573	574					
station	ckd	719							

termc	ckc	291	322	327	335	335	335	335	334
		340	343	344	345	351	352	358	423
		427	438						
timeup	ckc	330							
timeup	ckd	51[illegible]							
user	ckc	330							
user	ckd	518							
vc	ckc	270	270						
v?	ckd	471							
v4	ckc	292							

lesson information

lesson name = eex00

starting date = 10/07/72

last edited on 09/05/74 at 18.56.55

by borth of course eecge

at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = elect. engr. lab

grade level = Freshman

description of lesson .An Introduction to the CGE Station lesson eexØ1 at 2:23 am on tuesday, august 27, 1974

```
---------------------------------------------------------------- part=1, block=a -----------

     block 1a,  eexØ1id

stop
****     For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

   The Operation and Uses of the Oscilloscope, Analab 112Ø.

            Divisions of this Lesson:        Block     Unit

          Id for this file                   eexØ1id
          Experiment eexØ1;
            Objectives                       xØ1mØa    xØ1mØa
            Find crt spot                    xØ1m1a    xØ1m1a
            Measure constant v               xØ1m2a    xØ1m2a
            Measure v                        xØ1m3a    xØ1m3a
            Use null dials                   xØ1m4a    xØ1m4a
            Display 2 voltages               xØ1m5a    xØ1m5a
            Lissajous figure                 xØ1m5a    xØ1m6a
            Final test                       xØ1m7a    xØ1m7a

          final edit 21 aug 74 neal.

*list    info
*list    symbols
*list    varian,charset,cgeindex,cgechar
****
start
finish   endunit
write    tat,1Ø1Ø> Loading the CGE Character Set
charset  cgeindex,cgechar
erase
dataon
area     eexØ1
ext      Ø

---------------------------------------------------------------- part=1, block=b -----------

     block 1b,  xØ1mØa

unit     xØ1mØa
restart
base
next     xØ1m1a
join     imode
jump     n47,xØ1mØa,x
erase
```

```
at      5Ø8
write   THE OPERATION and USES of the OSCILLOSCOPE,

                ANALAB DUAL TRACE SCOPE TYPE 112Ø

                    with TYPE 7ØØ PLUG-IN


           When you have completed this experiment
        you should be able to :

         1) Find and Adjust a Spot on the CRT Screen.

         2) Measure Constant Voltages.

         3) Measure Time-Varying Voltages.

         4) Use the NULL dials.

         5) Display Two Voltages vs Time simultaneously.

         6) Display a Lissajous Figure.
------------------------------------------------------------ part=1, block=c ------------

      block 1c,  xØ1m1a


unit    xØ1m1a
base
erase
back    xØ1mØa
next    xØ1m1b
help    xØ1s1a
at      1Ø1Ø
write      Find the spot on the screen and position it at
        (Ø,Ø), i.e., the center of the CRT screen.

           CAUTION: Keep the INTENSITY only as high as
        you need to see the spot. Otherwise, damage to
        the screen may occur.
at      2Ø2Ø
write      -HELP- is available.
*

unit    xØ1m1b
base
back    xØ1m1a
next    xØ1m1c
help    xØ1s1a
at      14Ø5
write      The spot should be a sharp point of light with no halo.
```

```
               If it is not, adjust the INTENSITY and FOCUS
          controls to correct the condition of your spot.
at        3020
write        -HELP- is available.
***

unit      x01m1c
restart
base
back      x01m1b
next      x01m1c1
lab       x01s1d
help      x01s1g
at        1210
write           Now that the spot is centered, balance the
          A PRE AMP before proceeding. Press -LAB- for an
          explanation of the PRE AMP Balancing Procedure.

               When you have verified the balance of the A PRE
          AMP, set the dials so the spot will be deflected
          5 cm when a voltage of ± 10 volts is applied
          to the A INPUT of the SCOPE.
at        3020
write        -HELP- is available.
***

unit      x01m1c1
pack      n33,++n+fh(cd)(ae)++++++++++++++
join      ckd
jump      n47,x,x01m2a,x
pack      n33,++++++(cd)+++++++++++++++
join      ckd1
jump      n47,x01s1i,x01s1f
------------------------------------------------------------ part=1, block=d ----------

     block 1d,  x01m2a


unit      x01m2a
back      x01m1c
next      x01m2a1
help      x01s2a
at        1007
write        Great!  You correctly set the dials.

               Now, make connections and dial settings so you can
          display the voltage from the DC Supply on the A channel
          of the SCOPE.  A positive voltage should cause an
          upward deflecton.

               As usual, press -NEXT- when you finish.
```

```
                     -HELP-' is available.
      ***

      unit    xØ1m2a1
      jump    user='author'$and$station≠251,xØ1m2b,x
      pack    n33,++++++++++++a++bØØØØØØØØbaØ+ØØ
      join    ckc
      jump    n47,xØ1m2a2,xØ1m2a3
      ***

      unit    xØ1m2a2
      pack    n33,++++++++++++a++bØØØØØØØØabØ+ØØ
      join    ckc1
      jump    n47,xØ1s2a,xØ1m2a4
      ***

      unit    xØ1m2a3
      pack    n33,++n+fh+(ae)(ab)+++++++++++++
      join    ckd
      jump    n47,xØ1s2a1,x
      pack    n33,++++++c+++++++++++++++
      join    ckd1
      jump    n47,xØ1s2b,xØ1m2b
      ***

      unit    xØ1m2a4
      pack    n33,++n+fh+(ae)(ab)+++++++++++++
      join    ckd
      jump    n47,xØ1s2a1,x
      pack    n33,++++++d+++++++++++++++
      join    ckd1
      jump    n47,xØ1s2b,xØ1m2b
      ***

      unit    xØ1m2b
      back    xØ1m2a
      next    xØ1m2b1
      at      1207
      write   Without changing anything on the SCOPE, deflect
              the spot to Y = 5 cm.

                 HINT. To make the DC Supply function properly,
              you must set the CURRENT dial to about 100 ma then,
              adjust the VOLTAGE dial until the 5 cm deflection
              is achieved.
      ***

      unit    xØ1m2b1
      pack    n33,++n+fh(cd)(ae)++++++++(def)(bcdefghijklmnopqrstuv)++++
      join    ckd
      jump    n47,xØ1s2c,xØ1m2c
      ***

      unit    xØ1m2c
      back    xØ1m2b
      next    xØ1m2d
      at      1210
```

```
write       Observe the effects of the A PREAMP control.

               How many centimeters deflection do you get
            using the AC settings?
arrow       1635
answer      (zero,0)
at          1810
write          The AC refers to the type of coupling. AC coupling
            implies that there is a capacitor in the input circuit,
            to block the dc or average component.
no
at          1810
write          If the spot is not at 0 you have done something
            wrong. Check your balancing again, and if that
            doesn't help call your instructor.
```

-- part=1, block=e ----------

block 1e, x01m2d

```
unit        x01m2d
base
back        x01m3c
next        x01m2d1
lab         x01s1e
help        x01s2d
at          1207
write          Similarly, the spot can be deflected horizontally.

               Balance the B PRE AMP, if you have not done so. You
            may review the balancing procedure by pressing -LAB-.

               Set the dials and make the connections necessary
            to deflect the spot 4 cm horizontally when a voltage
            of +8 volts is applied the B INPUT of the SCOPE. The
            Y DISPLAY must be set to Axis B.

               Set the B PRE AMP to DC+.

***

unit        x01m2d1
pack        n32,h++(cd)fh(cd)+++++++++(bcd)(bcdefghijklmnopqrstuv)++++
join        bkd
jump        n47,x01m2d3,x01m2d2
***

unit        x01m2d2
pack        n33,0000000000000g000a0000000ag0+00
join        cke
jump        n47,x01m2e,x01m2e
***
```

```
unit    xØ1m2d3
pack    n33,n++(cd)fhe+++++++++(bcd)(bcdefghijklmnopqrstuv)++++
join    ckd1
jump    n47,xØ1s2e,x
pack    n33,ØØØØØØØØØØØØgØØ+aØØØØØØØagØ+ØØ
join    ckc
jump    n47,xØ1s2e,xØ1m2e
***

unit    xØ1m2e
back    xØ1m2d
next    xØ1m2e1
at      507
write       Without changing A VOLTS or B VOLTS dials,
        deflect the spot to:

                              X=3cm   Y=3cm

            Try to do this and then press -NEXT-, as always.
        You will be guided automatically if you have difficulty.
***

unit    xØ1m2e1
jump    user='author'$and$station≠251,xØ1m2f,x
pack    n33,n+n(cd)++(cd)e+++++++++(bcd)(bcdefghijklmnopqrstuv)++++
join    ckd
jump    n47,x,xØ1m2e2
pack    n33,+++++++++++++++(bcd)(bcdefghijklmnopqrstuv)++++
join    ckd1
jump    n47,xØ1s2g,xØ1s2f
***

unit    xØ1m2e2
pack    n33,+++c++c++++++++++++++
join    ckd1
calcs   n47,n7Ø⇐Ø,-1
pack    n33,++++++++++++a++bbØØØØØØØbaØ+ØØ
join    ckc
jump    n47,xØ1m2e3,x
jump    n7Ø,xØ1m2f,xØ1s2h
***

unit    xØ1m2e3
pack    n33,++++++++++++a++bbØØØØØØØabØ+ØØ
join    ckc1
jump    n47,xØ1s2i,x
jump    n7Ø,xØ1s2h,xØ1m2f
***

unit    xØ1m2f
back    xØ1m2e
next    xØ1m3a
at      71Ø
write       GOOD!

            Do not change the dial settings on the SCOPE.
```

```
          Observe the effect of varying the VOLTAGE control
     of the DC SUPPLY.

-------------------------------------------------------------- part=1, block=f ----------

     block 1f,   x01m3a

unit      x01m3a
restart
base
back      x01m2f
next      x01m3a1
help      x01s3a
at        907
write        Apply a 20 Hz signal, with a peak-to-peak voltage
          of Vp-p = 12 V, from the AUDIO OSCILLATOR  to the
          A channel of the SCOPE.
at        3020
write     -HELP- is available
***

unit      x01m3a1
pack      n03,++++++++++++g++a00000000000a900
join      cks
jump      n47,x01s3d,x01m3a2
***

unit      x01m3a2
pack      n03,++n+fh(cd)e+++++++++++(cd)a(bc)+
join      ckd                 $$ Performs a complete dial check
jump      n47,x,x01m3b        $$ Jumps, if dial check correct
pack      n03,+++n+fh(cd)e+++++++++++++++
join      ckd1                $$ Checks PLUG-IN and SCOPE dials
jump      n47,x01s3e,x        $$ Help provided if incorrect
pack      n03,++++++++++++++++++++a(bc)+
join      ckd1                $$ Check the frequency dial setting
jump      n47,x01s3f,x        $$ Help provided if incorrect
pack      n03,+++++++++++++++++++(cd)+++
join      ckd1                $$ Checks the DC SUPPLY settings
jump      x01s3g              $$ Help provided if incorrect
***

unit      x01m3b
back      x01m3a
next      x01m3c
at        510
write        Now, what do you see displayed on the SCOPE ?
arrow     710
answer    <a,an,beautiful,clear>vertical,straight>line
at        1010
write     That's right. The dot is being deflected up and down
          sinusoidally.  But it's moving so fast that it
```

```
             appears as a vertical line.
no
at           1010
write        You should see a vertical line.
             If you don't, press -BACK- to go through
             this section again.
***

unit         x01m3c
back         x01m3b
next         x01m3c1
help         x01s3h
at           910
write           In order to make this waveform appear
             on the SCOPE as a sine wave, it is
             necessary to sweep the display horizontally:

                To do this, you must apply a periodic
             linearly-increasing voltage to the SCOPE's
             horizontal input for a timed sweep.

                Turn the A PRE-AMP to OFF and apply a 0.9 Hz
             non-adjustable RAMP wave from the FUNCTION
             GENERATOR to the B INPUT of the SCOPE.

                Set B VOLTS to 50 V.
at           3020
write        -HELP- is available.
```

-- part=1, block=g ----------

block 1g, x01m3c1

```
unit         x01m3c1
pack         n13,c+ncfhee+ac(rst)++(abcde)+++(cd)a(bc)+
join         ckd
jump         n47,x01s3j,x01m3c2
***

unit         x01m3c2
pack         n13,++++++++++++g++ab000b000ag00
join         ckd
jump         n47,x,x01m3d
pack         n13,++++++++++++g++a++++++++++ag++
join         ckd1
jump         n47,x01s3j,x
at           1410
write              You did not apply the non-adjustable
             RAMP wave correctly!
pause
jump         x01m3c
***

unit         x01m3d
```

```
back      x01m3c
next      x01m3d1
at        510
write        As you see, this makes the spot sweep across
          the screen as a linear function of time.

             Now, set the A PRE AMP to DC+ and the FUNCTION
          GENERATOR to 9 Hz.
***

unit      x01m3d1
pack      n33,o+ncfhce+ad(rst)++(abcde)+++++++
join      cld
jump      n47,x,x01m3e
at        1410
write        Read the problem carefully!!!  You
          were given only two dials to change.
pause
jump      x01m3d
***

unit      x01m3e
base
back      x01m3d
next      x01m3e1
help      x01s3k
at        307
write        Good! You should now have a sine wave
          displayed on the screen.
             However, there are 2 things wrong with this display:

             1) There is a visible retrace when the spot
          comes quickly back to the left.

             2) The display is not stable.

             To solve the first problem:

          The SWEEP system of the SCOPE can be used to internally
          generate a ramp wave and blank out the return trace.

             To solve the second problem:

          The TRIGGER SOURCE of the SCOPE can automatically
          start the SWEEP at the beginning of each period.


             Make the necessary adjustments to solve both these
          problems, and remove any unnecessary connections.
at        3020
write     -HELP- is available.
***

unit      x01m3e1
pack      n33,++n++(fg)+a++++++++++(cd)a(bc)+
join      chd
jump      n47,x01s31,x
```

```
pack      n33,++++++++++++g++a0000000000ag00
join      clc
jump      n47,x01s3m,x01m4a

------------------------------------------------------------------------- part=1, block=h ----

     block 1h,  x01m4a

unit      x01m4a
restart
join      imode
jump      n47,x01m4a,x01m4a0
***

unit      x01m4a0
base
back      x01m3e
next      x01m4a1
help      x01s4a
at        507
write        Display on the A channel of the SCOPE, a
          nonadjustable SINE wave having a frequency of
          200 Hertz from the FUNCTION Generator.

             Externally trigger the SCOPE from the FUNCTION
          GENERATOR.

                    -HELP- is available.
***

unit      x01m4a1
pack      n33,+++++++++++++++a+b00a00b000+00
join      clcw
next      n47,x01m4a0,x
jump      n47,x,x01m4a2
***

unit      x01m4a2
pack      n33,++++(cd)(de)(abdc)abaf(bcd)+++++++++
join      clcdw
next      n47,x01m4a0,x
jump      n47,x,x01m4b0
***

unit      x01m4b0
next      x01m4b
back      x01m4a
at        1210
write     Leave this waveform on the screen.  You will
          need it again later on.
***

unit      x01m4b
```

```
base
back      xØ1m4a
next      xØ1m4c
help      xØ1s4b
zero      n7Ø
at        12Ø7
write        The NULL dials, with the TIME and the A and B
          VOLTS dials, can be used in measuring values on the
          CRT display.  For this use, the NULL dials must be
          set at zero initially.

             The value of a voltage point is measured by
          rotating the associated NULL dial until the voltage
          point being measured is returned to the zero voltage
          level of the display.  The manner in which the value
          of the voltage is read will be discussed when you
          press -NEXT-.

             Press -HELP- if you do not understand the meaning
          of the phrase 'zero voltage level'.


unit      xØ1m4c
circle    144,248,256
circle    4Ø,248,256
at        237,368
size      1
write     Ø.Ø

          Ø.Ø

          Ø.Ø
size      1
rotate    -9Ø
at        358,269
write      2.Ø
at        328,27Ø
write      Ø.8
at        299,27Ø
write      Ø.4
rotate    18Ø
at        256,198
write     Ø.8
at        256,167
write     1.6
at        256,137
write     4.Ø
draw      1632;skip;1632
draw      192,389;134,447;skip;3Ø5,387;364,446
circle    212,248,268,57,122
draw      73Ø;215,417;skip;734;275,419
circle    116,233,3Ø3,99,119
circle    124,26Ø,296,83,61
circle    174,247,275,121,58
rotate    Ø
calc      n7Ø⇐Ø
at        243,4Ø3
```

```
write   'V
goto    x01m4d
rotate  0
size    0
```

-- part=1, block=i ----------

block 1i,   x01m4d'

```
unit    x01m4d
calc    n70⇐n70+1
jump    (n70=4),x01m4e,x,x
mode    erase
at      235,424
writec  n70,,,, 1, 2
mode    write
at      235,424
writec  n70,,, 1, 2, 5
rotate  180
join    n70,x,x,x01m4d1,x01m4d2,x01m4d3
rotate  0
size    0
mode    erase
join    n70,x,x,x,x01m4d4,x01m4d5
mode    write
join    n70,x,x,x01m4d4,x01m4d5,x01m4d6
size    1
pause
goto    x01m4d
***

unit    x01m4d1
at      222,312
write   ÷
***

unit    x01m4d2
mode    erase
at      222,312
write   ÷
mode    write
at      222,344
write   ÷
***

unit    x01m4d3
mode    erase
at      222,344
write   ÷
mode    write
at      222,375
write   ÷
***
```

```
unit    x01m4d4
at      2810
write      When either the A or B VOLTS dial is set at
        1, 10, or 100, read the NULL on the bottom scale.
***

unit    x01m4d5
at      2810
write      When the A or B VOLTS dial is set at
        2, 20, or 200, read the NULL on the middle scale.
***

unit    x01m4d6
at      2810
write      When the A or B VOLTS dial is set
        5, 50, or 500, read the NULL on the top scale.
***

unit    x01m4e
next    x01m4f
size    0
at      1410
write      Now that you know what scale to read on the NULL
        dial, you can measure a voltage point by taking the
        reading on the NULL and moving the decimal point
        to the right by the number of zeros in the number
        displayed in the FULL SCALE window.
***

unit    x01m4f
back    x01m4b
next    x01m4g
at      1210
write      If the A VOLTS dial was set at 100 mV and
        the NULL reading was .5 , what would be the voltage ?

                a.)      5 mV
                b.)      50 V
                c.)      50 mV
                d.)      500 mV
arrow   2215
specs   bumpshift
answer  c
wrong   b
at      2410
write      The answer is in mV not V.
wrong   (a,d)
at      2410
write      There are two zero's in the A Volts
        reading, and 10²×.5=50.
***

unit    x01m4g
next    x01m5a
back    x01m4f
help    x01m4b
pack    n33,+++++++++++++++a+b00a00b000+00
```

```
join      ckc
jump      n47,x01s4c,x
pack      n33,++++(cd)(de)(abdclabaf(bcd)++++++++++
join      ckd
jump      n47,x01s4c,x
at        1308
write       Measure the peak-peak voltage of the sine wave
          displayed on the Scope using the A VOLTS NULL DIAL.

              What is the measured voltage          volts
arrow     1640
ansv      41,10
```

part=1, block=j

block 1j, x01m5a

```
unit      x01m5a
restart
join      imode
jump      n47,x01m5a,x01m5a0
***

unit      x01m5a0
base
back      x01m4f
next      x01m5a1
lab       x01s1e
at        910
write       This oscilloscope is capable of displaying two
          waveforms at the same time, which is very useful
          in comparison measurements.

            Using the FUNCTION GENERATOR, apply a nonadjustable
          SINE wave to channel A and a nonadjustable SQUARE
          wave to channel B of the SCOPE.

            Trigger the SCOPE from the FUNCTION GENERATOR.

            Each time you begin a new series of measurements,
          it is advisable to recheck the dc balance of the
          A and B PRE AMPs, and rezero the traces.

            Press -LAB- to review the balancing procedure.
***

unit      x01m5a1
pack      n33,+++++++++++++++abcb0a00c000+00
join      ckcw
next      n47,x01m5a0,x
jump      n47,x,x01m5b
***

unit      x01m5b
```

```
back     x01m5a0
next     x01m5b1
at       510
write       Set the frequency at 40 Hertz, and display
         both traces simultaneously, with TIME FULL SCALE
         at 100 ms.
***

unit     x01m5b1
pack     n33,+m+(abcd) (cd) (de) (abcd) cbae (ghi) ++(abcd) +++++++
join     ckdw
jump     n47,x,x01m5c
next     x01m5b
***

unit     x01m5c
back     x01m5b
next     x01m5d
at       1207
write       For the most stable display of a low frequency
         signal the CHOP setting of the Y DISPLAY is desirable.
***

unit     x01m5d
back     x01m5c
next     x01m6a
at       1210
write       Experiment on your own for awhile.  Change
         the frequency of the wave and the TIME dial.

            Note which setting of the Y DISPLAY (ALT or CHOP)
         gives the best display.
***

unit     x01m6a
back     x01m5d
next     x01m7a
at       1314
write       Set the Y DISPLAY FUNCTION to A vs B.
pause
pack     n33,++++++++e++++++++++++++++
join     ckd
jump     n47,x01s6a,x
at       1610
write       The pattern you see on the SCOPE is called
         a LISSAJOUS figure.  Change the wave INPUTS to
         the SCOPE (SQUARE,SINE,TRIANGLE,RAMP) to get
         different patterns.
----------------------------------------------- part=1, block=k ----------

block k, x01m7a

unit     x01m7a
```

```
restart
join    umode
jump    n47,x01m7a,x01m7aa
***

unit    x01m7aa
base
back    x01m6a
next    x01m7a1
*       [illegible]
write      Set the FUNCTION GENERATOR at 4000 Hz and connect
        the nonadjustable SQUARE wave to channel B.

           Connect the AUDIO OSCILLATOR to the A channel
        with a frequency of 3000 Hz, and adjust the AMPLITUDE
        to a comfortable level.

           Trigger the SCOPE from the FUNCTION GENERATOR.

           Adjust the display until both voltages appear.
        The A*B SEPARATION knob, to the left of the CRT
        screen, adjusts the separation of the zero base lines
        of the A and B traces.

           You may superpose the traces by reducing the
        separation of the zero base lines to zero. Or, you
        may separate them by raising the A zero base line
        to [illegible] +2 and lowering the B zero base line to
        [illegible] -2. If you turn both the PRE AMPs to OFF while
        doing this, your adjustments will be more accurate.
***

unit    x01m7a1
next    x01m7a1
pause   [illegible]
join    [illegible]
jump    n47,x,x01m7a2
***

unit    x01m7a2
next    x01m7aa
back    [illegible]
join    [illegible]
jump    n47,x,x01m7b
***

unit    x01m7b
back    x01m7a
next    x01m7c
at      [illegible]
write   Are both traces stable?
arrow   [illegible]
answer  (n,no)
at      [illegible]
write   The SCOPE is being triggered by the FUNCTION GENERATOR.
        Which is the stable trace? (square or sine)
```

```
no      :
at      710
write   If they are, then you aren't!!!
arrow   1037
specs   bumpshift
answer  (square)<wave>
***     :

unit    xØ1m7c
back    xØ1m7b
next    xØ1m7d
at      5Ø7
write   Set the TRIGGER SOURCE so that both traces are stable.
***     :

unit    xØ1m7d
back    xØ1m7c
pack    n33,+++++(fg)+++++++++++++++
join    ckd
jump    n47,xØ1s7a,x
at      1Ø1Ø
write   Correct!  On the INT trigger settings,the
        traces trigger independently.
next    n47,xØ1m7c,xØ1end
---------------------------------------------------------- part=1, block=1 ----------

        block 11,  xØ1s1a

unit    xØ1s1a
next    xØ1s1b
back    xØ1s1c
at      1ØØ7
write      Adjust the INTENSITY and FOCUS controls so that
        the spot is a sharp point of light with no halo.

           The X POSITION and Y POSITION controls are used
        to move the spot around the screen.

           If no spot appears on the screen, even at full
        INTENSITY, use the BEAM FINDER control to locate it.

           Press -NEXT- for information on use of BEAM FINDER.

           Set the SCALE illumination control at 8.Ø.

           When the spot is properly adjusted, press -BACK-.
***     :

unit    xØ1s1b
back    xØ1s1a
next    xØ1s1c
at      5Ø7
write             USE OF THE BEAM FINDER:
```

```
        1) Turn and hold the black BEAM FINDER knob fully CW.

        2) The spot should appear on the screen. Center it,
        using the red X and Y POSITION knobs.

        3) Release the BEAM FINDER when the spot is within
        a few cm of the center, and the spot should remain.
at      3005
write   If you still can't locate the spot call your instructor.
end
***

unit    x01s1c
press   next
end
***

unit    x01s1d
back    x01m1c
next    x01s1e
at      1007
write      Before using the SCOPE for any investigation,
        the A and B preamplifiers must be balanced.  This
        is essentially an adjustment of the linearity of
        their dc amplifiers.

           Balance the A PRE AMP using the procedure you
        will see when you press -NEXT-.
***

unit    x01s1e
at      510
write              BALANCING PROCEDURE

        For the preamplifier you want to balance:

        1) Set PRE AMP to OFF.

        2) Set VOLTS FULL SCALE to 1mv, and center the trace.

        3) Set PRE AMP to BAL SET and use the BAL screw
           to center the spot. Use the beam finder if
           needed. ( BAL Screw has both fine and coarse
           adjustment. Adjust slightly past center and
           then back for finer control )

        4) Check to see that the preamplifier is balanced by
           switching the PRE AMP between OFF and BAL SET.
           If the spot moves, repeat the balancing procedure.

        5) Return VOLTS FULL SCALE to desired setting.
           Call your instructor if you are unable to
           properly balance the PRE AMPs !
end
```

block 1m, xØ1s1f1

```
unit     xØ1s1f
back     xØ1s1g
next     xØ1s1g
at       121Ø
write       Something is wrong with your setup.
         You will be given information on the dials
         before you are allowed to try again.  Press
         -NEXT- for this information.
***

unit     xØ1s1g
next     xØ1s1h
at       51Ø
write       The number in the window of the
         A VOLTS FULL SCALE dial represents the voltage
         required for a full scale deflection of 1Ø cm.

            With  A VOLTS FULL SCALE set at 2Ø volts, the
         sensitivity (volts/cm.) would be
arrow    1Ø43
answer   <volts,volt,cm> (2)
at       12Ø7
write       What is the minimum number of cm needed to deflect
         the spot to the edge of full scale from (Ø,Ø) ?
arrow    153Ø
answer   <cm> (5)
at       2ØØ7
write       Setting A VOLTS FULL SCALE to 1Ø volts provides
         a deflection of 1Ø cm for a 1Ø volt signal.  However,
         since the spot is now at (Ø,Ø), a setting of 2Ø V
         will allow the spot to remain on the screen when a
         1Ø volt signal is applied.
wrong    1Ø
at       171Ø
write     If the spot were centered at the bottom of
         the screen, full scale deflection would be 1Ø.
         Try again remembering the spot is at (Ø,Ø)
***

unit     xØ1s1h
at       111Ø
write       When applying a constant voltage to one of
         the channels, the Y DISPLAY must be set to that
         channel, or to the A vs B position.

            The TRIGGER SOURCE and the SWEEP MODE
         should be set in the OFF position for constant
         signals.
end
```

```
/***

unit    x01s11
back    x01m1c
next    x01m1c
at      1210
write      You cannot deflect the spot with the A PRE AMP
        in the OFF position.


           To what position should the A PRE AMP be set
        to deflect the spot ?
arrow   1240
specs   bumpshift
answer  (dc)
wrong   (ac)
at      1410
write   NO  You are applying a dc or constant voltage.
```

-- part=1, block=n ----------

```
        block in,  x01s2a1,

unit    x01s2a
back    x01m2a
next    x01m2a
at      1207
write      Connect the "+" terminal of the DC SUPPLY to the
        A INPUT of the SCOPE and the "-" terminal to ground.

           The DC SUPPLY generator circuit is not internally
        grounded, that is, it is floating.  However, there
        is a common-ground terminal to the right of the +
        and - terminals to which an external ground
        connection can be made.
***

unit    x01s2a1
next    x01m2a
back    x01m2a
at      1206
write      You have unnecessarily changed some of the dials.
        The only dials you may have needed to change were
        the A PRE AMP and the X DISPLAY. Return all other
        dials to where they were before.
***

unit    x01s2b
back    x01m2a
next    x01m2a
at      1410
write      You did not set the A PRE AMP to allow
        a positive voltage to cause upward deflection.
***
```

```
unit     xØ1s2c
base
back     xØ1m2b
next     xØ1m2b1
lab      xØ1s1e
at       131Ø
write         You did not deflect the spot 5 cm properly.
         On the DC SUPPLY, verify that you have set the CURRENT
         to at least 1ØØ mA and the VOLTAGE to provide a 5
         cm deflection.  Press -LAB- if you want to
         rebalance a PRE AMP.
***

unit     xØ1s2d
at       121Ø
write         The B channel deflects the spot in
         a manner similar to that of the A channel.

              The A channel deflects vertically and the B channel
         deflects horizontally with A vs B.

              After you return to the task statement,
         you can repeat the A channel again by pressing -BACK-.
end
------------------------------------------------------------ part=2, block=a --------

         block 2a,  xØ1s2e!

unit     xØ1s2e
back     xØ1m2a
next     xØ1m2d
at       121Ø
write         You seem to have trouble deflecting the spot
         horizontally. You should have turned the A PRE AMP to
         OFF or should have disconnected the connection to
         the A INPUT.  Press -NEXT- to try again.

         Press -BACK- to repeat the vertical deflection task.
***

unit     xØ1s2f
back     xØ1m2e
next     xØ1m2e
at       121Ø
write         You incorrectly set the dials.
pause
erase
at       81Ø
write         The vertical deflection is controlled
         by the       channel with Y DISPLAY at A vs B.
arrow    917
specs    bumpshift
```

```
answer  a
at      1210
write      The horizontal deflection is controlled
        by the          channel with the Y DISPLAY at A vs B.
arrow   1317
specs   bumpshift
answer  b
at      1610
write      Then to control both the A and the B
        channels, the Y Display should be set to
arrow   1750
specs   bumpshift
answer  (a) (vs,versus,vs) (b)
at      2010
write      Both the A and the B PREAMPs should
        be set in the            position to deflect
        the spot.
arrow   2124
specs   bumpshift,
answer  dc
at      2410
write      Set the A and B VOLTS FULL SCALE dials to 20 V.
***

unit    x01s2g
back    x01m2e
next    x01m2e
at      1210
write      You incorrectly set the DC SUPPLY. Make
        sure that a 3 cm deflection is obtained.
***

unit    x01s2h
back    x01m2e
next    x01m2e
at      1210
write      You did not set the A and B PRE AMPs so
        a positive voltage would cause upward deflection.
***

unit    x01s2i
back    x01m2e
next    x01m2e
at      1210
write      You incorrectly connected the DC SUPPLY to
        the SCOPE!
```

-- part=2, block=b ----------

```
block 2b,   x01s3a

unit    x01s3a
base
back    x01m3a
```

```
next     x01m3a
lab      x01s3b
data     x01s3c
at       1210
write         Press the desired key for the information
         you want;

                  -LAB-   Voltage peak to peak or Vp-p.
                  -DATA-  Connections.
                  -NEXT-  To return to the task.
***

unit     x01s3b
back     x01m3a
next     x01m3a
origin   72,352
axes     0,-101,300,100
scalex   2π
scaley   10
markx    π,π/4
labely   10,2.5
delta    .2
funct    10sin(v77),v77
at       2510
write    What is the peak to peak voltage of this wave?
arrow    2556
ansv     20,2
no
at       2710
write    The peak to peak voltage is the voltage between
         Vmax  and  Vmin.
hbar     372,10,-
graph    372,10,Vmax
hbar     372,-10,-
graph    372,-10,Vmin
vector   9π/4,0,9π/4,9.6
vector   9π/4,0,9π/4,-9.6
at       1054
write    Vp-p
write
end
***

unit     x01s3c
next     x01m3a
at       1210
write         Shown below are the three terminals
         of the AUDIO OSCILLATOR.  To apply a sine
         wave to the A INPUT of the SCOPE,
         the A INPUT must be connected to what
         terminal of the AUDIO OSCILLATOR. (A,B, or C)
circle   8,160,192
circle   8,192,192
circle   8,224,192
draw     2026;200,178;194,172;157,172;152,177;152,191
         skip;167,191;167,183;184,183;184,191
at       157,184
```

```
write   A  B  C
arrow   1740
specs   bumpshift
answer  c
at      2410
write      This is the only connection you need since
        the SCOPE and the AUDIO OSCILLATOR are internally
        grounded.
wrong   (a,b)
at      2410
write   No! Terminal B is connected to ground.
        Notice the ground strap between A and B.
no
at      2410
write   NO!!! Type the letters A, B, or C.
end
***

unit    x01s3d
next    x01s3c
at      1210
write      You incorrectly connected the AUDIO OSCILLATOR
        to the SCOPE.  Press -NEXT- for help.
***

unit    x01s3e
next    x01m3a
at      1010
write     You were not to change the dials on the SCOPE!
        Reset them in these positions:

             A VOLTS FULL SCALE     .20 V
             SWEEP MODE             OFF
             TRIGGER SOURCE         OFF
             A PRE AMP              +DC
             Y DISPLAY              A vs B
***

unit    x01s3f
next    x01m3a
at      1210
write      The output frequency of the AUDIO OSCILLATOR is
        incorrectly set.  Remember the output frequency
        is the product of the RANGE dial and the frequency
        dial.
```

-- part=2, block=c ----------

```
     block 2c,  x01s3g

unit    x01s3g
base
next    x01m3a
```

```
help     x01s3b
at       1210
write       The AMPLITUDE of the AUDIO OSCILLATOR is
         incorrectly set.

         Press -NEXT- to try again.
         Press -HELP- if uncertain about Vp-p.
***

unit     x01s3b
define   switch=1
         trmnl=2
         ground=3
char     trmnl
         o000016,o000033,o000021,o000033,o000016,o000000,o000000,o000000
char     switch
         o000000,o000340,o000760,o001777,o001777,o000760,o000340,o000000
char     ground
         o000000,o100000,o120000,o124000,o124000,o120000,o100000,o000000
draw     1606;1635;2135;2106;1606
circle   8,160,217
circle   25,160,217
circle   4,184,199
circle   10,224,227
circle   6,224,227
at       256,245
plot     trmnl
at       256,235
plot     trmnl
at       256,225
plot     trmnl
at       256,215
plot     trmnl
at       256,205
plot     trmnl
at       256,185
plot     trmnl
at       240,185
plot     trmnl
at       222,185
plot     trmnl
circle   5,201,185
circle   8,115,230
circle   8,83,230
at       51,237
plot     trmnl
at       51,227
plot     trmnl
at       51,217
plot     trmnl
at       88,188
plot     switch
at       210
write       The nonadjustable outputs have fixed voltages.
            There is no way to alter this.
size     5
at       279,208
```

```
write    }
size     Ø
at       1839
write    Nonadjustable
            Outputs
pause
at       61Ø
write        The adjustable OUTPUT is controlled by the
         ATTENUATOR, the OUTPUT selector, and the DC LEVEL.
         The ATTENUATOR and DC LEVEL controls are interdependent.
draw     224,125;224,181;skip;228,179;224,183;22Ø,179
at       184,1Ø8
write     Adjustable
            OUTPUT
draw     14Ø,121;198,179;skip;198,174;198,179;193,179
at       48,117
write    DC LEVEL
draw     222,225;265,268;skip;222,23Ø;222,225;227,225
at       1534
write    ATTENUATOR
draw     18Ø,271;215,236;skip;211,235;216,235;216,24Ø
at       1515
write     OUTPUT
end
```

--- part=2, block=d -----------

block 2d,   xØ1s3i

```
unit     xØ1s3i
next     xØ1m3c
at       131Ø
write        You incorrectly set the dials.  Read the
         problem carefully.  You are given which dials
         you needed to change.
***

unit     xØ1s3j
next     xØ1m3c
at       131Ø
write        It is necessary to again drive the A channel from
         the AUDIO OSCILLATOR.
***

unit     xØ1s3k
back     xØ1m3e
next     xØ1m3e
at       7Ø5
write    The Y DISPLAY FUNCTION should be set to the
         position to display the sine wave on the A INPUT.
arrow    749
specs    bumpshift
answer   a
at       12Ø5
```

```
write       To internally trigger the SCOPE, the TRIGGER
            SOURCE should be set at
no
at          1005
write          The Y DISPLAY FUNCTION should be set to the A
            position to display the sine wave on the A channel.
arrow       1330
specs       bumpshift
answer      <ac,dc>(int,internal)
at          1810
write          The SWEEP MODE should be set to the DRIVEN -
            VARIABLE LENGTH position.

               Set the TIME at 50 ms (1/frequency), so that one
            period (T) of the sine wave appears on the screen.
no
at          1510
write          The TRIGGER SOURCE should be set to the INT
            position when you internally trigger the SCOPE.
end
***

unit        x01s3l
next        x01s3k
at          1210
write          You have incorrectly set the dials.

               Instructions on how to correct these errors
            will be given when you press -NEXT-.
***

unit        x01s3m
next        x01m3e1
at          1210
write          You don't need that wire connected to the B INPUT.
------------------------------------------------------------- part=2, block=e --------


      block 2e,  x01s4a!


unit        x01s4a
next        x01s3h
at          505
write          To what position must the TRIGGER SOURCE be set
            to permit the SCOPE to be externally triggered ?
arrow       653
specs       bumpshift
answer      <ac,dc>(ext,external)
at          1410
write          The  only connection needed to externally
            trigger the SCOPE from the FUNCTION GENERATOR
            is a connection from the _______________ terminal of
            the SCOPE to the_________________ terminal of the
            FUNCTION GENERATOR.
```

```
no
at          1110
write           It should be set in an EXT position.
arrow       1634
specs       bumpshift
answer      <the,terminal>(trig,trigger) (in,input)
no
at          2410
write           The terminal on the SCOPE is the TRIGGER INPUT.
arrow       1726
specs       bumpshift
answer      <the,terminal>(trig,trigger) (out,output)
jump        x01s3h
no
at          2410
write           The terminal on the FUNCTION GENERATOR is
            the TRIG OUT.
```

--- part=2, block=f -----------

block 2f,   x01s4b1

```
unit        x01s4b
define      spot=1
char        spot
            o000014,o000036,o000077,o000077,o000036,o000014,o000000,o000000
join        x01s4b1
at          245,320
plot        spot
at          2510
write           To measure the voltage of this deflection
            move the NULL dial until the voltage point is at the
            zero base line.

                Press -NEXT- to see this done.
pause
mode        erase
at          245,320
plot        spot
at          2510
write           To measure the voltage of this deflection
            move the NULL dial until the voltage point is at the
            zero base line.

                Press -NEXT- to see this done.
mode        write
at          245,253
plot        spot
pause
erase
join        x01s4b1
funct       5sin(v77),v77<=2π,2π,.1π
at          2510
write           If you wanted to measure the zero to
```

```
             peak voltage (V0-p), move the trace to the
             zero level by adjusting the NULL.  Press
             -NEXT- to see this done.
    pause
    mode     erase
    funct    5sin(v77),v77⇐-2π,2π,.1π
    at       2510
    write         If you wanted to measure the zero to
             peak voltage (V0-p), move the trace to the
             zero level by adjusting the NULL.  Press
             -NEXT- to see this done.
    mode     write
    funct    5sin(v77)-5,v77⇐-2π,2π,.1π
    end
    ***

    unit     x01s4b
    origin   1632
    axes     -120,-120,120,120
    scalex   2π
    scaley   10
    markx    .4π,.4π,2
    marky    2,2,2
    markx    .4π,.08π
    ***

    unit     x01s4c
    next     x01m4a
    back     x01m4a
    at       1310
    write         You did not follow my instructions to leave
             the waveform displayed on the screen.  Press
             -NEXT- to display the waveform again.
    ***

    unit     x01s6a
    next     x01m6a
    at       1610
    write         Set the Y DISPLAY to A vs B.
    ***

    unit     x01s7a
    back     x01m7c
    next     x01m7c
    at       1310
    write         You did not set the TRIGGER SOURCE
             in the correct position!!
    end
--------------------------------------------------------------------- part=2, block=g ---------

         block 2g,  x01end!

    unit     x01end
```

```
1324  back      x01m7a
1325  join      imode
1326  jump      n47,x01end,x
1327  course    n2
1328  calcc     n2='ee244',
1329            nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
1330            nc(n21+1)⇐nc(n21+1)
1331  output    /// student has completed experiment ///
1332  join      endunit
1333  join      jmpmes
1334  jumpout   cseindex,quest1

1335  entry     leave
1336  end       lesson
1337  ***

1338  unit      endunit
1339  course    n2
1340  jump      n2≠'ee244',leave,x
1341  calc      nc(n21+7)⇐nc(n21+7)+ahelp
1342            vc(n21+6)⇐vc(n21+6)+atime/60000
1343  ***Incl.cse s.r. & terms sample,index,imode,comment,slides.
1344  use       ecs00,ck1
1345  use       ck2
1346  use       ck3
1347  use       ck4
1348  use       ck5
1349  use       ck6
      ckc               not found                     120       202      210  330  237  388  271
                                                      580
      ckcw              not found                     411       617      696
      ckcl              not found                     125       243
      ckd               not found                      98       130      138  226  157  276  197
                                                      325       352      385       583  731  658
      ckdw              not found                     417       631      702
      ckdl              not found                     101       133      141  234  207  279  229
                                                      282       285      333
      endunit     x01end              1338             23      1332
      imode             not found                      35       393      594       668       1325
      jmpmes            not found                    1333
      leave       x01end              1335           1340
      x01end      x01end              1323            735      1326
      x01m0a      x01m0a                31             36        54
      x01m1a      x01m1a                51             34        68
      x01m1b      x01m1a                66             55        81
      x01m1c      x01m1a                78             69       105      771       847       848
      x01m1c1     x01m1a                96             82
      x01m2a      x01m2a               104             99       145      864  977  865  985  876
                                                      886       914
      x01m2a1     x01m2a               117            106
      x01m2a2     x01m2a               123            121
      x01m2a3     x01m2a               128            121
      x01m2a4     x01m2a               136            126
      x01m2b      x01m2a               144            118       134      142       161       893
      x01m2cb     x01m2a               155            146       894
      x01m2c      x01m2a               160            158       181
      x01m2d      x01m2d               179            162       214      915
```

xØ1m2d1	xØ1m2d	195	182						
xØ1m2d2	xØ1m2d	2ØØ	198						
xØ1m2d3	xØ1m2d	2Ø5	198						
xØ1m2e	xØ1m2d	213	2Ø3	211	248	959	924	96Ø	925
			966	967	973		974		
xØ1m2e1	xØ1m2d	223	215						
xØ1m2e2	xØ1m2d	232	227						
xØ1m2e3	xØ1m2d	241	238						
xØ1m2f	xØ1m2d	247	224	239	245		259		
xØ1m3a	xØ1m3a	256	249	289	981	994	982	1Ø23	993
			1Ø6Ø	1Ø71	1Ø8Ø				
xØ1m3a1	xØ1m3a	269	26Ø						
xØ1m3a2	xØ1m3a	274	272						
xØ1m3b	xØ1m3a	288	277	3Ø6					
xØ1m3c	xØ1m3a	3Ø5	29Ø	339	342		1162		1169
xØ1m3c1	xØ1m3c1	323	3Ø7						
xØ1m3c2	xØ1m3c1	328	326						
xØ1m3d	xØ1m3c1	341	33[illegible]	358	362				
xØ1m3d1	xØ1m3c1	35Ø	343						
xØ1m3e	xØ1m3c1	36Ø	353	398	1175		1176		
xØ1m3e1	xØ1m3c1	36[illegible]	363	1212					
xØ1m4a	xØ1m4a	391	389	394	423		43Ø	1304	13Ø3
xØ1m4aØ	xØ1m4a	396	394	412	418				
xØ1m4a1	xØ1m4a	4Ø[illegible]	399						
xØ1m4a2	xØ1m4a	415	413						
xØ1m4b	xØ1m4a	436	422	555	578				
xØ1m4bØ	xØ1m4a	451	419						
xØ1m4c	xØ1m4a	448	431						
xØ1m4d	xØ1m4d	486	464	5Ø7					
xØ1m4d1	xØ1m4d	5Ø9	498						
xØ1m4d2	xØ1m4d	513	498						
xØ1m4d3	xØ1m4d	521	498						
xØ1m4d4	xØ1m4d	529	5Ø2	5Ø4					
xØ1m4d5	xØ1m4d	534	5Ø2	5Ø4					
xØ1m4d6	xØ1m4d	539	5Ø4						
xØ1m4e	xØ1m4d	544	49Ø						
xØ1m4f	xØ1m4d	554	545	577	599				
xØ1m4g	xØ1m4d	575	556						
xØ1m5a	xØ1m5a	582	576	595					
xØ1m5aØ	xØ1m5a	597	595	618	622				
xØ1m5a1	xØ1m5a	615	6ØØ						
xØ1m5b	xØ1m5a	621	619	639	636				
xØ1m5b1	xØ1m5a	629	623						
xØ1m5c	xØ1m5a	635	632	643					
xØ1m5d	xØ1m5a	642	637	652					
xØ1m6a	xØ1m5a	651	644	673	1311				
xØ1m7a	xØ1m7a	666	653	669	7Ø6		1324		
xØ1m7aØ	xØ1m7a	671	669	694	7ØØ				
xØ1m7a1	xØ1m7a	693	674						
xØ1m7a2	xØ1m7a	699	697						
xØ1m7b	xØ1m7a	7Ø5	7Ø3	723					
xØ1m7c	xØ1m7a	722	7Ø7	729	735		1316		1317
xØ1m7d	xØ1m7a	728	724						
xØ1s1a	xØ1s1a	737	56	7Ø	752				
xØ1s1b	xØ1s1a	751	738						
xØ1s1c	xØ1s1a	766	739	753					
xØ1s1d	xØ1s1a	77Ø	83						

xØ1s1e	xØ1s1a	781		183	6Ø1	772		895		
xØ1s1f	xØ1s1f	8ØØ		1Ø2						
xØ1s1g	xØ1s1f	8Ø9		84	8Ø1	8Ø2				
xØ1s1h	xØ1s1f	836		81Ø						
xØ1s1i	xØ1s1f	846		1Ø2						
xØ1s2a	xØ1s2a	863		1Ø7	126					
xØ1s2a1	xØ1s2a	875		131	139					
xØ1s2b	xØ1s2a	884		134	142					
xØ1s2c	xØ1s2a	891		158						
xØ1s2d	xØ1s2a	9Ø3		184						
xØ1s2e	xØ1s2e	913		2Ø3	2Ø8	211				
xØ1s2f	xØ1s2e	923		23Ø						
xØ1s2g	xØ1s2e	958		23Ø						
xØ1s2h	xØ1s2e	965		239	245					
xØ1s2i	xØ1s2e	972		244						
xØ1s3a	xØ1s3a	979		261						
xØ1s3b	xØ1s3a	99[illegible]		983	1Ø81					
xØ1s3c	xØ1s3a	1Ø22		984	1Ø54					
xØ1s3d	xØ1s3a	1Ø53		272						
xØ1s3e	xØ1s3a	1Ø59		28Ø						
xØ1s3f	xØ1s3a	1Ø7Ø		283						
xØ1s3g	xØ1s3g	1Ø78		286						
xØ1s3h	xØ1s3g	1Ø88		3Ø8	1217	1242				
xØ1s3i	xØ1s3i	1161		326						
xØ1s3j	xØ1s3i	1168		334						
xØ1s3k	xØ1s3i	1174		364	12Ø5					
xØ1s3l	xØ1s3i	12Ø4		386						
xØ1s3m	xØ1s3i	1211		389						
xØ1s4a	xØ1s4a	1216		4ØØ						
xØ1s4b	xØ1s4b	1248		43[illegible]						
xØ1s4b1	xØ1s4b	129[illegible]		125[illegible]	1274					
xØ1s4c	xØ1s4b	13Ø[illegible]		581	584					
xØ1s6a	xØ1s4b	131Ø		659						
xØ1s[illegible]	xØ1s4b	1315		73[illegible]						
ahelp		1341								
atime		134[illegible]								
ground		1Ø91	1Ø96							
nc		13[illegible]	1329	133Ø	133Ø	1341		1341		
next		78[illegible]								
n2		1327	1328	1339	134Ø					
n21		1329	1329	133Ø	133Ø	1341		1341	1342	1342
n33		97	1ØØ	119	124	129	140	132	156	137
		196	2Ø1	2Ø6	2Ø9	225	236	228	242	233
		27Ø	275	278	281	284	332	324	351	329
		384	387	41Ø	416	579	630	582	657	616
		695	7Ø1	73Ø						
n47		96	99	1Ø3	121	126	134	131	142	134
		158	198	2Ø3	2Ø8	211	235	227	238	23Ø
		244	273	277	28Ø	283	334	326	333	331
		386	389	394	412	413	781	418	584	419
		595	618	619	632	659	703	669	732	697
		735	1326							
n7Ø		235	239	245	433	481	490	489	493	489
		496	498	5Ø2	5Ø4					
sin		1ØØ[illegible]	117[illegible]	118[illegible]	13ØØ					
spot		1249	125[illegible]	1254	126[illegible]	1271				
station		118	[illegible]4							

switch		1089	1094	1130						
trmnl		1090	1092	1105	1107	1109	115	1111	117	1113
		1119	1124	1126	1128					
user		118	224							
vc		1342	1342							
v[illegible]		1002	1002	1275	1275	1283		1283	1290	1290
V_{ma}	1012									
V_{mi}	1014									
π		997	999	999	1275	1275	1283	1275	1283	1283
		1290	1290	1290	1296	1298		1298	1300	1300

lesson information

lesson name = eex01

starting date = 09/23/72

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by neal of course eecge

at site 7, station 12

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = elec. eng. lab

grade level = Freshman

description of lesson = The Operation and Uses of the Oscilloscope, Analab 1120.

```
----------------------------------------------------------- part=1, block=a ----------

     block 1a,  eex02id

stop
****    For Neal, CGERL, Room 248 EEB.

One line description of this lesson --

    The Operation and Uses of the Audio Oscillator, HP 200AB.

              Divisions of this Lesson:          Block      Unit

          Id for this file                       eex02id
          Experiment eex02:
            Objectives                           x02m0a     x02m0a
            Frequency adjustments                x02m0a     x02m1a
            Amplitude adjustment                 x02m0a     x02m2a
            Compare w/function generator         x02m2a2    x02m3a
            Floating mode                        x02m4a     x02m4a
            Superposition of waves               x02m5a     x02m5a
            Final test                           x02m5j     x02m6a

          final edit 21 aug 74 neal

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   at,1010 Loading the CGE Character Set
charset cgeindex,cgechar
erase
[illegible]
[illegible]     eex02
[illegible]     [illegible]

----------------------------------------------------------- part=1, block=b ----------

     block 1b,  x02m0a

unit    x02m0a
restart
join    imode
jump    n47,x02m0a,x
base
next    x02m1a
zero    n50
zero    n51
```

```
at      704
write   THE OPERATION AND USES OF THE AUDIO OSCILLATOR, HP 200AB
at      1005
write     The purpose of this experiment is to experimentally
        study the operation of the Audio/Oscillator as a
        sine-wave voltage generator, and use it in various modes.

          The specific tasks of this experiment are to examine:

        1)  Frequency adjustments.
        2)  Amplitude adjustment and measurement.
        3)  Comparisons with the Function Generator.
        4)  The floating mode of the Audio Oscillator.
        5)  Superposition of waveforms.
***

unit    x02m1a
restart
base
next    x02m1b
back    x02m0a
at      807
write       The Audio Oscillator produces a sine-wave voltage
        over a range of frequencies which nearly coincides
        with the range of audible acoustical frequencies.

          The parameters of the generated sine-wave voltage
        are its frequency and its amplitude. These parameters
        can be varied by adjustments of the dials on the front
        panel of the Audio Oscillator.

          The output frequency in Hertz is designed to be
        within 2 percent of the product of the settings of the
        large frequency dial and the RANGE dial.

          The output amplitude is adjusted by the AMPLITUDE
        dial. This dial is not calibrated in volts.

***

unit    x02m1b
back    x02m1a
next    x02m1c
at      808
write     Adjust the Audio Oscillator to generate a
        frequency of approximately 5000 Hertz.
***

unit    x02m1c
pack    n33,++++++++++++++++++++,<c(kI)df>+
join    ckd
jump    n47,x02s01a,x02m2a
***

unit    x02m2a
restart
```

```
base
back      x02m1b
next      x02m2a1
help      x02s02a
at        708
write        Now that you have set the Audio Oscillator
          frequency properly, turn up the AMPLITUDE dial all
          the way and display one period of the Audio Oscillator
          output waveform on the A channel of the Scope so you
          can most accurately measure the peak-to-peak value.

             Set the Sweep Mode to the Driven Variable Length
          Position.  This is the most stable and recommended
          mode of operation for most signals.

             Internally Trigger the scope for this setup.
at        2920
write     -HELP- is available
***

unit      x02m2a1
pack      n33,000000000000c00b0000000000bc00
join      ckc
jump      n47,x02s03a,x02m2a2
```

-- part=1, block=c --------

block 1c, x02m2a2

```
unit      x02m2a2
pack      n33,+ep+d(fg)(abcd)a++++++++++v(cd)(f1)+
join      ckd
calcc     n47,n60⇐n60+1,n60⇐0
jump      n60,x,x,x02s04a,x02s05a,x02s05b
jump      n47,x02s04a,x02m2b
***

unit      x02m2b
back      x02m2a
next      x02m2c
at        1007
write        Measure Vp-p of the sine wave.

             Hint:    Peak-to-peak expanse is easiest to observe
          when the SWEEP is turned OFF.

             What peak-to-peak voltage did you read?

                 Vp-p =
arrow     1720
ansv      85,5
no
at        2110
write     Your voltage measurement is too inaccurate.
```

```
            Check your measurements!
***

unit        x02m2c
back        x02m2b
next        x02m3a
at          607
write          Good.

               Without moving the AMPLITUDE control on the
            Audio Oscillator, observe the amplitude of the
            output sine wave voltage on the Scope while you
            vary the frequency of the Audio Oscillator over
            its entire operating range.
pause       3
at          1407
write          Does the amplitude of the output vary with frequency ?
arrow       1626
answer      (y,yes,Y,Yes)
at          1707
write          Right!  The amplitude does vary somewhat.
wrong       (n,no,No)
at          1707
write          Look at it more carefully, while you vary the
            frequency from the lowest to the highest settings.
***

unit        x02m3a
restart
base
back        x02m2b
next        x02m3b
at          807
write          The Function Generator is also capable of producing
            a sinusoidal waveform of adjustable frequency and
            amplitude.

               We will now use the Scope to compare the adjustable
            SINE output of the Function Generator with the output
            of the Audio Oscillator.
***

unit        x02m3b
back        x02m3a
next        x02m3c
at          1507
write          Connect the adjustable SINE output of the Function
            Generator to the B channel of the Scope.

               The Function Generator is grounded by the links
            between the lower right terminals on its front panel,
            so only one connection from the Function Generator
            is necessary.
***

unit        x02m3c
pack        n33,+++++++++++++++bc+++++c+++b+++
```

```
join    ckc
jump    n47,x02s06a,x02m3d
***

unit    x02m3d
restart
back    x02m3b
next    x02m3e
at      807
write      Set the Function Generator to produce a sine
        wave with a frequency of 5000 Hz. and with a
        maximum amplitude.

           (If you would like to review the operation
        of the Function Generator, press -LAB-.)

           Now, set the Scope to display the A and B
        channels alternately, with both the A and B VOLTS
        at 100 volts and with internal triggering.
lab     x02s07a
```

-- part=1, block=d --------

block 1d, x02m3e

```
unit    x02m3e
pack    n39,p+p(bc)d(fg)(bc)db+g(ijk)bv+++++++++
join    ckd
jump    n47,x02s08a,x02m3f
***

unit    x02m3f
back    x02m3d
next    x02m3g
at      807
write      Use the Scope to compare the output waveshapes
        of the Function Generator and the Audio Oscillator.

           As you experiment with various controls, make any
        observations necessary to answer the following questions.
do      x02s09a
at      1407
write      Which instrument has the greater maximum output
        amplitude?
arrow   1536
answer  a
at      1607
write      RIGHT! The Audio Oscillator is capable of
        producing the largest amplitude sine wave.
***

unit    x02m3g
back    x02m3f
next    x02m3h
```

```
at      807
write      Which instrument has the higher maximum frequency?
at      1307
write      Which instrument has the lower minimum frequency?
do      x02s09a
arrow   930
bump
answer  a
wrong   b
at      1007
write      Look at both the frequency dial and the
        MULTIPLIER(range) dial.
arrow   1430
answer  b
wrong   a
at      1507
write      Look at both the frequency dial and
        the MULTIPLIER(range) control
***

unit    x02m3h
back    x02m3g
next    x02m3i
at      707
write      With both sine waves at about the same frequency
        you may be able to notice that one of the generators
        produces a better quality sine wave.

           Which generator is it?
arrow   1135
specs   nookno,bumpshift
match   n51,a,b
at      1140
writec  n51,no,ok,no
endarrow
at      1308
write      The Audio Oscillator produces a pure sine wave
        in its internal oscillator circuit.

           The Function Generator produces its sine wave
        by means of waveshaping circuits.
at      1807
write      Thus the Function Generator 'sine wave' is not as
        pure a sine wave as that of the Audio Oscillator.
        It has noticeable imperfections.
***

unit    x02m3i
back    x02m3h
next    x02m4a
at      1007
write      In experiments which require the use of
        a sinusoidal source, it is generally desirable
        to use the Audio Oscillator and not the
        Function Generator because of the Audio Oscillator's
        purer quality output and greater range.
```

block 1e, xØ2m4a

```
unit    xØ2m4a
join    imode
jump    n47,xØ2m4a,x
base
restart
back    xØ2m3i
next    xØ2m4b
at      807
write      As mentioned before, the Audio Oscillator is
        normally grounded by the ground link at its terminals.

           As you might suspect, it is also possible to operate
        the Audio Oscillator in its ungrounded or floating mode.

           Now prepare the Audio Oscillator for operation
        in its floating mode by disconnecting its left
        output terminal from ground.
***

unit    xØ2m4b
pack    n32,++++++++++++Ø+++++++++++++++Ø++
join    ckc
jump    n47,xØ2s1Øa,xØ2m4c
***

unit    xØ2m4c
next    xØ2m4d
at      1007
write      With the Audio Oscillator set to operate in its
        floating mode, it can be connected in series
        with other generators or the DC SUPPLY. The net
        output voltage of the series combination would
        then be the sum of the individual output voltages.
***

unit    xØ2m4d
back    xØ2m4c
next    xØ2m4e
help    xØ2s11a
at      707
write      Let's use the Function Generator with the Audio
        Oscillator in its floating mode and add a square
        wave to a sine wave.

           Connect the adjustable SQUARE output of the Function
        Generator to one of the terminals of the Audio
        Oscillator.

           Then connect the other terminal of the Audio
        Oscillator to the A INPUT of the Scope.
```

```
               Trigger the Scope from the Function Generator.
at         3125
write      Help is available.
***

unit       x02m4e
pack       n33,0000000000000000a0c0000bc00ba00
join       ckc
jump       n47,x,x02m4f
pack       n33,0000000000000000a0c0000bc00ab00
join       ckc1
jump       n47,x02s11a,x02m4f
***

unit       x02m4f
back       x02m4d
next       x02m4g
at         1007
write          Good! Now set the frequency of the Function
           Generator to 5000 Hz and the frequency of the
           Audio Oscillator to twice that frequency.

               Display one period of the square wave on the Scope.
***

unit       x02m4g
pack       n33,+e++d(de)(cd)a+ag(ijk)d+(abcd)++++<e(pqr)d(klm)>+
join       ckdw
jump       n47,x,x02m4h
pause
jump       x02m4f
***

unit       x02m4h
back       x02m4f
next       x02m5a
at         1007
write          Notice how turning up the amplitudes of the Function
           Generator and the Audio Oscillator voltages influences
           the display of the sum of the two waveforms.

               Experiment a bit. Change the frequency of the
           Audio Oscillator and see what happens.

------------------------------------------------------------- part=1, block=f ----------

      block 1f,   x02m5a

unit       x02m5a
join       imode
jump       n47,x02m5a,x
base
restart
```

```
back     x02m4h
next     x02m5b
zero     n95
at       707
write       You have seen how the Audio Oscillator and the
         Function Generator can be used to add two waveforms.

            As you should have noticed, in that case it is
         difficult to obtain  a stable display because the
         two frequencies are not synchronized.

            Let's try a different method to superpose two
         waveforms.

------------------------------------------------------------ part=1, block=g----------

      block 1g,  x02m5b

unit     x02m5b
back     x02m5a
next     x02m5c
at       707
write       You will need the SUPERPOSITION BOARD,
         ITEM 38. Please get it from the shelf below.

            The theory for the method you are about to use
         is based on Kirchhoff's Current law.

            The theory states that the current leaving a
         node is the sum of the currents entering the node.

            Let me demonstrate this with a few diagrams.
***

unit     x02m5c
back     x02m5b
next     x02m5d
at       407
write       Below is a node with three branches.

            The node is labled  A  and the branches are
         labled 1 through 3.
at       1632
write    o
at       1613
write    o
at       1651
write    o
at       2632
write    o
draw     251,260;251,105;skip;254,262;400,262;skip
         248,262;102,262
at       1532
write    A
```

```
at      1552
write   2
at      1512
write   1
at      2732
write   3
pause
mode    rewrite
at      607
write     Now let's assume a current reference direction
        for each branch, and label the diagram accordingly.
pause   1
mode    rewrite
at      1515
write   i1
draw    135,278;174,278;170,282;skip;174,278;170,274
at      1548
write   i2
draw    369,278;328,278;332,282;skip;328,278;332,274
draw    1835;2235;276,164;skip;272,160;268,164
at      2238
write   i3
pause
mode    rewrite
at      607
write     According to Kirchhoff's Current Law, the current
        leaving node A is equal to the sum of the currents
        entering node A.
pause
mode    erase
at      607
write     According to Kirchhoff's Current Law, the current
        leaving node A is equal to the sum of the currents
        entering node A.
mode    write
at      607
write     Therefore i3 is equal to the sum of i1 and i2
        or i3 = i1 + i2

pause   1
at      2241
write   = i1 + i2
pause
mode    erase
at      407
write     Below is a node with three branches.

          Therefore i3 is equal to the sum of i1 and i2
        or i3 = i1 + i2

mode    write
at      407
write     If the currents, i1 and i2, are two waveforms,
        then i3 will be the sum of the two waveforms.
```

block 1h, x02m5d

```
unit     x02m5d
back     x02m5c
next     x02m5e
at       507
write      Now that we have reviewed how two currents can be
         superposed, let's go to the SUPERPOSITION BOARD.
***

unit     x02m5e
back     x02m5d
erase
draw     1314;2514;2552;1352;1314
circle   12,132,284
circle   11,380,284
circle   11,132,131
draw     144,283;166,283;166,275
draw     153,243;153,210;158,205;148,195;158,185
         153,180;153,130;skip;143,130;357,130
draw     153,243;166,243;166,251
draw     357,130;357,180;352,185;362,195;352,205;357,210
         357,243
draw     369,284;347,284;347,276;skip;357,243;347,243
         347,251
draw     288,130;288,134;293,139;283,149;293,159;288,164
         288,168
circle   11,288,179
draw     288,189;288,199;skip;283,199;293,199;skip
         288,199;283,204;293,204;288,199
draw     288,204;288,228;skip;278,228;298,228;skip
         298,233;278,233;skip;288,233;288,286;293,281
         303,291;313,281;318,286;318,268
draw     277,179;259,179;244,204;skip;259,204;259,212
         288,212
draw     259,212;246,240;skip;259,240;259,246;288,246
circle   11,245,286
draw     288,286;255,286
draw     234,286;229,286;224,291;214,281;204,291;199,286
         199,268
draw     166,263;199,263;199,271
draw     347,263;318,263;318,268
at       1414
write     1          R1      3       R2        5
                  sw1                sw2
                      2              4

                     sw4        C
                             7
             R4      sw3        Di        R5
                                8

                                R3

```

```
        11    SUPERPOSITION BOARD
inhibit erase
jump    n95,x,x02m5f
***

unit    x02m5f
back    x02m5e
at      307
write      This is the board you will be using to
        to superimpose the wave forms.

           This board contains more components than
        you will need to use for this experiment
pause
mode    erase
at      307
write      This is the board you will be using to
        to superimpose the wave forms.

           This board contains more components than
        you will need to use for this experiment
mode    write
at      307
write      The components that you will not need are
        the capacitor and the diode.  These must be shorted
        out by closing switches sw3 and sw4 for this experiment.
mode    erase
draw    259,179;244,204;skip;259,212;246,240
mode    write
draw    259,212;259,240;skip;259,179;259,205
inhibit erase
```

-- part=1, block=1 ----------

block 11, x02m5g

```
unit    x02m5g
next    x02m5h
mode    erase
at      307
write      The components that you will not need are
        the capacitor and the diode.  These must be shorted
        out by closing switches sw3 and sw4 for this experiment.
mode    write
at      207
write      Now, make sure the board is connected to the CGE
        Interface by plugging the board's sensor cable into the
        jack in the center of the panel below the Function
        Generator. In addition to closing sw3 and sw4:

           Set sw1 so that terminals 1 and 2 are connected
        (sw1 in the up position).

           Set sw2 so that terminals 5 and 4 are connected
```

```
               (sw2 in the up position).
inhibit erase
***

unit     x02m5h
pack     n33,aadbb0dd0000c00000000000000c00
join     ckc
inhibit erase
jump     n47,x,x02m5i
next     x02m5j
***

unit     x02m5i
back     x02m5g
next     x02m5j
help     x02s13a
jump     n51,x02m5j,x
mode     erase
at       202
write       Now, make sure the board is connected to the CGE
         Interface by plugging the board's sensor cable into the
         jack in the center of the panel below the Function
         Generator. In addition to closing sw3 and sw4:

            Set sw1 so that terminals 1 and 2 are connected
         (sw1 in the up position).

            Set sw2 so that terminals 5 and 4 are connected
         (sw2 in the up position).
mode     write
at       107
write       Connect the non-adjustable SQUARE wave output
         from the Function Generator to terminal 5 and
         the non-adjustable sine wave output from the
         Function Generator to terminal 1.
            Connect the common input of the board (terminal 11)
         to Ground.
            Connect the A INPUT of the Scope to Terminal 8
         of the SUPERPOSITION BOARD to display the waveform
         of the total current.
            Trigger the Scope from the Function Generator.
at       2914
write    Press -HELP- to see a circuit diagram of setup
                             or
         Press -NEXT- to have your connection checked.
inhibit erase

---------------------------------------------------------------- part=1, block=j --------

      block 1j,  x02m5j

unit     x02m5j
next     x02m5i
help     x02s14a
```

```
data     x02s15a
erase
pack     n33,aacdd0cc+0k0k00c0rd0a00r000k00
join     ckc
jump     n47,x,x02m5k
calc     n95⇐-1
at       1007
write       You have some errors in your setup.

         Press -NEXT- to try again.

         Press -DATA- to see the correct circuit.

         Press -HELP- to see a list of your errors.
***

unit     x02m5k
back     x02m5i
next     x02m5l
at       1007
write       Set the frequency of the Function Generator to
         5000 Hertz and display two periods of the wave
         on the Scope.
***

unit     x02m5l
pack     n33,+f++(cd)(de)+abag(jk)++(abcd)+++++++
join     ckd
jump     n47,x02s16a,x02m5m
***

unit     x02m5m
back     x02m5k
next     x02m6a
at       1007
write       Experiment with the SUPERPOSITION BOARD for
         a while if you wish.

            When you press -NEXT- you will be taken to
         a short review covering the Audio Oscillator.
***

unit     x02m6a
base
restart
join     imode
jump     n47,x02m6a,x
back     x02m5m
next     x02m6b
at       607
write     - You are ready for a short review covering your
         experimental examination of the Audio Oscillator.

***

unit     x02m6b
back     x02m6a
```

```
next    x02m6c
at      607
write     Set the  Audio Oscillator to:

        Operate at a frequency of about 20,000 Hertz.

        Be in the nonfloating mode.

        Generate a peak-to-peak voltage of about 40 volts.
***

unit    x02m6c
calc    n51⇐n51+1
pack    n33,++++++++++++++++++<d(pq)c(uv)>+
join    ckdw
jump    n47,x,x02m6ca
next    x02s18a
***

unit    x02m6ca
pack    n33,++++++++++++c++a+++++++++++ac++
join    ckcw
jump    n47,x,x02m6d
next    x02s18a
***

unit    x02m6d
back    x02m6b
next    x02end
at      707
write          Great!

          Experiment on your own for a few minutes if you wish.
***

unit    x02s01a
next    x02m1b
at      1007
write     The frequency setting of the Audio Oscillator
        is not quite right.

          Recall, that the frequency of the generated output
        is the product of the frequency dial setting and
        the RANGE dial setting.

          If the frequency dial is set at 40 and the RANGE
        dial is set at 200, the generated frequency should
        be __________ Hz.
arrow   1911
ansv    8000.,1
end
```

-- part=1, block=k --------

block 1k, x02s02a

```
unit     x02s02a
next     x02s02b
at       1007
write       In order to display a specific waveform on the Scope
         so the amplitude can be most accurately read:

           . The Y DISPLAY FUNCTION must be set to the pertinent
         INPUT channel.

            Recall that every reading from the CRT screen has
         a possible error of 0.1 cm.  Therefore, the calibrated
         VOLTS FULL SCALE must be set as low as possible in order
         to give maximum vertical traverse to the displayed
         waveform.

           . The TIME FULL SCALE of the Scope must be
         set to display the desired number of periods of
         the waveform.

            Press -BACK- if you are ready to proceed,

                           or

         press -NEXT- if you need more help on the Time setting.
***

unit     x02s02b
at       507
write       Let T represent the time duration in seconds of
         the period of the waveform.

            One period of a sine wave is shown below.
origin   1618
axes     0,-100,256,100
scaley   1
scalex   2π
labelx   1,.25
markx    π,π/4
write    (at,1731)T/2(at,1748)T
funct    sin(v57),v57⇐0,2π,.02π
at       1507
write      . If the frequency of the sine wave is 4000 Hz,
         the period T of the wave expressed in milliseconds is
         T = 1000/frequency = ______________ ms.
arrow    2329
answ     .25
mode     rewrite
write    (at,2910)Right! and T/2=.125(at,1730).125(at,1747).25(at,1650)msec
mode     write
no
endl
***

unit     x02s03a
next     x02m1a
```

```
at      1007
write     Both the Scope and the Audio Oscillator circuit
        commons are normally grounded  by links on their
        front panels.  Then, in this case, only one connection
        is required between the ungrounded output of the Audio
        Oscillator and the INPUT of the Scope.

          CHECK your connections again.
end
***

unit    x02s04a
next    x02m2a
at      707
write     Remember that the period (in seconds) of a waveform
        is the reciprocal of the frequency.  T = 1/f.

          To observe only one complete cycle of a waveform,
        the TIME FULL SCALE of the Scope must be set to
        one period.

          Also check the setting of the dials relating to
        the A channel on the Scope.
```

--- part=1, block=1 ---------

block 11, x02s05a

```
unit    x02s05a
back    x02m2a
next    x02s05b
at      1017
write       Having problems?

        Press -BACK- to try again, or,

        press -NEXT- to see your errors.
***

unit    x02s05b
join    ckd2w
next    n47,x02m2a,x02m2b
***

unit    x02s06a
next    x02m3b
at      807
write   Hint!

          The red adjustable-output jack of the Function
        Generator is located directly below the red
        ATTENUATOR knob.
```

```
                 Verify that the Audio Oscillator remains
               connected to the A channel of the Scope.
     ***

     unit      x02s07a
     at        807
     write        The frequency of the Function Generator output
               is the product of the CYCLES/SEC dial setting and
               the MULTIPLIER dial setting.

                  The black OUTPUT knob selects the shape of
               the adjustable-output waveform at the red output
               jack directly below it.

                  The red ATTENUATOR knob controls the amplitude
               of the waveform at the red output jack. As usual,
               maximum amplitude is fully clockwise.
     end
     ***

     unit      x02s08a
     next      x02m3d
     at        1007
     write        You had better check your dial settings again.
     end
     ***

     unit      x02s09a
     at        1907
     write        To answer Audio Oscillator,   type-   a
                  To answer Function Generator, type-   b
     end
     ***

     unit      x02s10a
     next      x02m4a
     at        1007
     write        HINT!  The left red output terminal of the Audio
               Oscillator is normally connected to the black ground
               terminal by a metal ground link.
     end
     ***

     unit      x02s11a
     next      x02s12a
     at        1007
     write     The Function Generator and the Audio Oscillator
               should be connected in series, that is they should
               form a single continuous loop to the Scope.
     circle    32,152,208
     draw      1924;1936;2236;2242;2142;skip;304,169;1739;1746
               360,169;304,169;skip;2144;2744;2729;2829;skip
               2933;2633;2614;2914;2933;skip;2831;240,40;skip
               250,40;230,40;skip;235,35;246,35;skip;243,31
               238,31;skip;1916;1912;2012;skip;102,192;74,192
               skip;80,186;96,186
     draw      ;skip;92,180;85,180
```

```
at        120,203
write     SCOPE
at        1940
write     A.O.
at        2818
write     F.G.
circle    3,328,176
circle    3,344,176
circle    3,314,176
circle    3,240,64
circle    3,224,64
inhibit   erase
```

--- part=1, block=m -----

```
        block 1m,  x02s12a

unit      x02s12a
next      x02m4d
mode      erase
at        1007
write     The Function Generator and the Audio Oscillator
          should be connected in series, that is they should
          form a single continuous loop to the Scope.
mode      write
at        1007
write     The best source for the external trigger of the
          Scope is the TRIG OUT of the Function Generator.
circle    3,115,84
draw      115,84;115,128;155,128;155,176
at        2703
write     TRIG OUT
end
***

unit      x02s13a
back      x02m5f
calc      n5⇐1
mode      erase
at        1007
write       Connect the non-adjustable SQUARE wave output
          from the Function Generator to terminal 5 and
          the non-adjustable sine wave output from the
          Function Generator to terminal 1.
            Connect the common input of the board (terminal 11)
          to Ground.
            Connect the A INPUT of the Scope to Terminal 8
          of the SUPERPOSITION BOARD to display the waveform
          of the total current.
            Trigger the Scope from the Function Generator.
at        2914
write     Press -HELP- to see a circuit diagram of setup
                              or
          Press -NEXT- to have your connection checked.
```

```
entry    x02s13ae
next     x02m5j
draw     199,263;166,263;skip;318,263;347,263
mode     write
circle   32,96,448
draw     209;228;628;609;209;skip;236;256;656;636;236
at       213
write    SCOPE                          F. G.
draw     199,263;166,275;skip;318,263;347,276
circle   3,432,464
circle   3,432,441
circle   3,166,422
circle   3,143,434
circle   3,290,461
circle   3,383,424
draw     287,461;256,461;256,400;166,400;166,419;skip
         143,431;143,367;47;367;47,160;144,160
circle   8,152,160;180,0
draw     160,160;272,160;278,174
         skip;435,463;459,463;459,283;390,283;skip
         434,440;450,440;450,324;132,324;132,205
         skip;383,421;383,346;80,346;80,130;121,130
at       318
write                        T.O.           SQ

            A                              SIN
                T.I.                 GRD
at       2910
write    After you have made your connections, press -NEXT-
end
```

-- part=1, block=n -----------

```
.block in,  x02s15a

unit     x02s14a
join     chelw
next     x02m5j
help     x02s15a
at       2907
write    Press -HELP- to see a circuit diagram of the setup

                              or

         Press -NEXT- to have your connections checked.
***

unit     x02s15a
do       x02m5e
mode     erase
draw     259,179;244,204;skip;259,212;246,240
mode     write
draw     259,212;259,240;skip;259,179;259,205
```

```
mode      erase
goto      x02s13ae
end
***

unit      x02s16a
next      x02m5k
help      x02s17a
at        1007
write     One or more of your dial settings are wrong.

          Press -NEXT- to have your dials rechecked

                                  or

          Press -HELP- for a listing of your dial errors.
***

unit      x02s17a
pack      n33,+f++(cd)(de)+abag(jk)++(abcd)+++++++
join      ckdlw
end
***

unit      x02s18a
help      x02m4a
at        810
write     You seem to have had difficulty with the review.

            Press the number you want to do:

            1.  Repeat the review quiz.

            2.  Repeat this experiment.

            3.  Review frequency and amplitude.

            4.  Review floating or grounded operation.
arrow     1045
long      1
storen    n1
answer    (1,2,3,4)
jump      n1,x,x,x02m6a,x02m0a,x02m1a,x02m4a
***

unit      x02end
back      x02m6b
join      imode
jump      n47,x02end,x
course    n2
calcs     n2='ee244',
          nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
          nc(n21+1)⇐nc(n21+1)
erase
output    /// student has completed experiment ///
join      endunit
join      jmpmes
```

```
966  jumpout cgeindex,questx
967  entry   leave
968  end     lesson
969  ***
970  unit    endunit
971  course  n2
972  jump    n2≠'ee244',leave,x
973  calc    nc(n21+7)⇐nc(n21+7)+ahelp
974          vc(n21+6)⇐vc(n21+6)+atime/60000
975  ***Incl.cge s.r. & TERMs sample,index,imode,comment,slides.
976  use     eex00,ck1
977  use     ck2
978  use     ck3
979  use     ck4
980  use     ck5
981  use     ck6
```

ckc		not found		103	177	292	323	684	560
ckcw		not found		664					
ckc1		not found		326					
ckc1w		not found		906					
ckd		not found		79	108	197	623		
ckdw		not found		340	658				
ckd1w		not found		936					
ckd2w		not found		765					
endunit	x02end		970	22	964				
imode		not found		32	275	356	638		956
jmpmes		not found		965					
leave	x02end		967	972					
x02end	x02end		954	670	957				
x02m0a	x02m0a		30	33	55	952			
x02m1a	x02m0a		51	35	71	952			
x02m1b	x02m0a		70	54	85	676			
x02m1c	x02m0a		77	72					
x02m2a	x02m0a		82	80	114	735	746	766	757
x02m2a1	x02m0a		101	86					
x02m2a2	x02m2a2		106	104					
x02m2b	x02m2a2		113	111	130	154	766		
x02m2c	x02m2a2		129	115					
x02m3a	x02m2a2		151	131	165				
x02m3b	x02m2a2		164	155	182	769			
x02m3c	x02m2a2		175	166					
x02m3d	x02m2a2		180	178	201	792			
x02m3e	x02m3e		195	183					
x02m3f	x02m3e		200	198	219				
x02m3g	x02m3e		218	202	241				
x02m3h	x02m3e		240	220	265				
x02m3i	x02m3e		264	242	279				
x02m4a	x02m4a		274	266	276	804	940		952
x02m4b	x02m4a		290	280					
x02m4c	x02m4a		295	293	305				
x02m4d	x02m4a		304	296	330	839			
x02m4e	x02m4a		321	306					
x02m4f	x02m4a		329	324	327	343	346		
x02m4g	x02m4a		338	331					
x02m4h	x02m4a		345	341	360				

xØ2m5a	xØ2m5a	355		347	357	373				
xØ2m5b	xØ2m5b	382		361	385					
xØ2m5c	xØ2m5b	384		374	458					
xØ2m5d	xØ2m5d	457		386	465					
xØ2m5e	xØ2m5d	464		459	513	915				
xØ2m5f	xØ2m5d	512		51Ø	856					
xØ2m5g	xØ2m5g	539		566						
xØ2m5h	xØ2m5g	558		54Ø						
xØ2m5i	xØ2m5g	565		562	599	614				
xØ2m5j	xØ2m5j	598		563	567	569		875		9Ø7
xØ2m5k	xØ2m5j	613		6Ø5	627	925				
xØ2m5l	xØ2m5j	621		615						
xØ2m5m	xØ2m5j	626		624	64Ø					
xØ2m6a	xØ2m5j	635		628	639	647		952		
xØ2m6b	xØ2m5j	646		641	669	955				
xØ2m6c	xØ2m5j	655		648						
xØ2m6ca	xØ2m5j	662		659						
xØ2m6d	xØ2m5j	668		665						
xØ2sØ1a	xØ2m5j	679		68Ø						
xØ2sØ2a	xØ2sØ2a	69Ø		687						
xØ2sØ2b	xØ2sØ2a	7Ø9		691						
xØ2sØ3a	xØ2sØ2a	734		1Ø4						
xØ2sØ4a	xØ2sØ2a	745		11Ø	111					
xØ2sØ5a	xØ2sØ5a	756		11Ø						
xØ2sØ5b	xØ2sØ5a	764		11Ø	758					
xØ2sØ6a	xØ2sØ5a	768		178						
xØ2sØ7a	xØ2sØ5a	778		193						
xØ2sØ8a	xØ2sØ5a	791		198						
xØ2sØ9a	xØ2sØ5a	797		2Ø8	225					
xØ2s1Øa	xØ2sØ5a	8Ø3		293						
xØ2s11a	xØ2sØ5a	811		3Ø7	327					
xØ2s12a	xØ2s12a	838		812						
xØ2s13a	xØ2s12a	855		568						
xØ2s13ae	xØ2s12a	874		921						
xØ2s14a	xØ2end	9Ø5		6ØØ						
xØ2s15a	xØ2end	914		6Ø1	9Ø8					
xØ2s16a	xØ2end	924		624						
xØ2s17a	xØ2end	934		926						
xØ2s18a	xØ2end	939		66Ø	666					
ahelp		973								
atime		974								
nc		96Ø	96Ø	961	961	973		973		
n1		95Ø	952							
n2		958	959	971	972					
n21		96Ø	96Ø	961	961	973		973	974	974
n33		78	1Ø2	1Ø7	176	196	325	291	339	322
		559	6Ø3	622	657	663		935		
n47		33	8Ø	1Ø4	1Ø9	111	276	178	293	198
		324	327	341	357	562	634	6Ø5	659	624
		665	766	957						
n51		37	25Ø	252	569	656		656		857
n6Ø		36	1Ø9	1Ø9	1Ø9	11Ø				
n95		362	51Ø	6Ø6						
sin		721								
vc		974	974							
v57		721	721							
π		717	719	719	721	721				

lesson information

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by neal of course eecge

at site 7, station 27

author name = J P'Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = freshman

descripion of lesson = The Operation and Uses of the Audio Oscillator, HP 2ØØAB.

```
---------------------------------------------------------------- part=1, block=a ----------

block 1a,  eexØ3id

stop
****    For Neal, CGERL, Room 248 EEB.

One line description of this lesson --

   The Operation and Uses of the Function Generator, Exact 251.

           Divisions of this Lesson:          Block     Unit

          Id for this file                    eexØ3id
          Experiment eexØ3;
            Objectives                        xØ3mØa    xØ3mØa
            Measure wave parameters           xØ3m1a    xØ3m1a
            Oper. of function generator       xØ3m2a    xØ3m2a
            Development of equi. circuit      xØ3m3a    xØ3m3a

          final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   <at,1Ø1Ø> Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon
area    eexØ3
ext     Ø
---------------------------------------------------------------- part=1, block=b ----------

block 1b,  xØ3mØa

unit    xØ3mØa
restart
join    imode
jump    n47,xØ3mØa,x
at      4Ø8
write   THE OPERATION AND USES OF THE FUNCTION GENERATOR,
                     Exact 251.

             The learning objectives are:
```

1) To measure the period, amplitude, and average (dc) characteristics of a waveform.

2) To properly drive a two-terminal circuit with any periodic voltage having any adjustable or nonadjustable V_{max}, V_{min}, or V_{av}, and any frequency within the useful limits of the Function Generator, while triggering the Function Generator internally, externally, or manually.

3) To experimentally determine a practical equivalent circuit for the Function Generator as seen looking into its nonadjustable SQUARE wave output terminals.

```
------------------------------------------------------------------ part=1, block=c ----------

      block 1c,    x03m1a

unit      x03m1a
back      x03m0a
calc      n51⇐-1
zero      n60
          n61
          n62
          n63
          n64
at        1107
write        Here, you will be given an opportunity to
          review the physical properties of waveforms (i.e.,
          Vp-p, frequency, period, etc.). You should already be
          acquainted with these concepts. They will be used
          extensively in this experiment.
***

unit      x03m1b
next      x03m1c
back      x03m1a
at        210
write     From the waveform displayed below, measure
          the following quantities:
join      x03s1b
at        417
write     1) Period  _______________  sec.

          2) Frequency  ___________  Hertz.

          3) Vmax       ___________  volts.

          4) Vmin       ___________  volts.

          5) Vp-p       ___________  volts.

          6) V0-p       ___________  volts.
```

```
****            doto loop avoids repeat questions
calc      n1Ø1⇐233
doto      2line,n1ØØ⇐6Ø,64,1
calc      n1Ø1⇐n1Ø1+2ØØ
calcs     (n1ØØ-61),v1Ø2⇐.Ø5,2Ø,2Ø,-2Ø,4Ø
calcs     (n1ØØ-61),v1Ø3⇐1.2,2.Ø
at        n1Ø1
writec    n(n1ØØ),⟨z,v1Ø2,v1Ø3⟩,,
2line
join      n51,xØ3s1a,xØ3s1a1,xØ3s1a2,x,xØ3s1a4,xØ3s1a5
***

unit      xØ3m1c
next      xØ3m1d
back      xØ3m1b
calc      n51⇐15              $$ for first use of xØ3s1h
          n52⇐-15
          n53⇐Ø
at        1ØØ7
write     It is often desirable to know other characteristics
          of a wave in addition to the time - amplitude char-
          acteristics. One example would be the AVERAGE (DC)
          value of the wave.

          For now, let us concentrate our efforts on SYMMETRICAL
          waveforms; a later experiment will present a more
          mathematical approach for finding the average or dc
          value of any waveform.

------------------------------------------------------------ part=1, block=d ----

          block 1d,  xØ3m1d

unit      xØ3m1d
next      xØ3m1e
help      xØ3s1h
back      xØ3m1c
at        6Ø8
write     What is the average ( dc ) value of the symmetric
          square wave below ?     _________  volts

                      -HELP- is available
join      xØ3s1i
gdraw     Ø,15;1Ø,15;1Ø,-15;2Ø,-15;2Ø,15;3Ø,15;3Ø,-15;3Ø,Ø
arrow     732
ansv      Ø
***

unit      xØ3m1e
help      xØ3s1j
next      xØ3m2a
back      xØ3m1c
calc      n51⇐2Ø         $$ answers for second call to xØ3s1h
          n52⇐-1Ø
```

```
        n53◆5
at      6Ø8
write   Now suppose we were to change the average or dc
        level such that the waveform is symmetrical about
        a non-zero value. Observe the effect on the wave-
        form below; what is the average (dc) value ?

                          __________ volts

                       -HELP- is available
join    xØ3s1i
gdraw   Ø,2Ø;1Ø,2Ø;1Ø,-1Ø;2Ø,-1Ø;2Ø,2Ø;3Ø,2Ø;3Ø,Ø
arrow   1126
ansv    5
***
```

--- part=1, block=e -----------

block 1e, xØ3m2a

```
unit    xØ3m2a
restart
at      9Ø7
write   The Function Generator produces different signals
        over a continuous range of frequencies. The para-
        meters of these outputs are adjusted by three
        groups of dials:

                  1) OUTPUT
                  2) TIMING
                  3) TRIGGERING

        If you wish to see what any of these groups does,
        type in the number of that group. If not, just
        press -NEXT-.
pause
keytype n7Ø,1,2,3,back
jump    n7Ø,xØ3m2b,xØ3s2a1,xØ3s2a2,xØ3s2a3,xØ3m1d
***

unit    xØ3m2b
restart
base
back    xØ3m2a
next    xØ3m2c
help    xØ3s2b
at      11Ø5
write      Set up the Function Generator for a nonadjustable
        RAMP Wave having a period of 2 ms.

           Display this wave on channel A of the SCOPE, using
        the Function Generator as the trigger source.
```

```
                              -HELP- is available.

------------------------------------------------------------ part=1, block=f ----------

         block ff,  x03m2c

unit     x03m2c
zero     n62
         n63
         n64
         n65
         n66
         n67
pack     n33,++(op)+(acd)(de)(abcd)a+af(ijk)++++++++++
join     ckd
calc     n55⇐n47                     $$ n55=-1 if dials wrong
jump     n47,x,x03m2c1
pack     n33,++++++++++f(ijk)++++++++++
join     ckd1
calc     n62⇐n47                     $$ n62=-1 if freq. wrong
pack     n33,+++++(de)+++a++++++++++++
join     ckd1
calc     n63⇐n47                     $$ checks trigger
pack     n33,++++(acd)+(abcd)a++++++++++++++
join     ckd1                        $$ checks dials 5,7,8
calc     n67⇐n47
pack     n33,++(op)++++++++++++++++++
join     ckd1
calc     n64⇐n47                     $$ n64⇐-1 if a-volts wrong

entry    x03m2c1
pack     n33,0000000000000000n0a000n0a000+00
join     ckc
jump     n55,x03s2c,x                $$ falls thru if dials ok
jump     n47,x03s2c,x03m2d           $$ x03s2c jumps to helps
***

unit     x03m2d
restart
base
back     x03m2b
next     x03m2d1
help     x03s2i
at       1407
write    Now set up the Function Generator for a sine wave
         with a Vp-p = 10 V and having a frequency of 1
         kHz. Trigger the Scope from the Function Generator
         and display the waveform on channel A of the Scope.

                              -HELP- is available

------------------------------------------------------------ part=1, block=g ----------
```

block 1g, xØ3m2d1

```
unit     xØ3m2d1
zero     n6Ø                        $$ pre-set for use in xØ3s2j
         n61
         n62
         n63
pack     n33,++(mno)++(de)+a+a<f(tuv)g(ab)>b(cdef)++++++++
join     ckd
calc     n55⇐n47
jump     n47,x,xØ3m2d1e
pack     n33,++(mno)++++a++++b(cdef)++++++++
join     ckd1
calc     n6Ø⇐n47
pack     n33,+++++(de)+++a+++++++++++++
join     ckd1
calc     n61⇐n47
pack     n33,++++++++++<f(tuv)g(ab)>++++++++++
*                             dial 11 on f and 12 on t,u,v
*                          or dial 11 on g and 12 on a or b

join     ckd1
calc     n62⇐n47

entry    xØ3m2d1e
pack     n33,ØØØØØØØØØØØØØØØØnØaØØØØnaØØØ+ØØ
join     ckc
jump     n55,xØ3s2j,x
jump     n47,xØ3s2j,xØ3m2e
***

unit     xØ3m2e
base
help     xØ3s2q
back     xØ3m2d
restart
at       14Ø6
write    Next set up the system for an adjustable square wave
         having a period of 1 ms. with a Vp-p of 1Ø volts. Set
         up the Function Generator to be manually triggered
         and display the waveform on channel A.

                           -HELP- is available
***

unit     xØ3m2g
zero     n6Ø                        $$ pre-set for xØ3s2r
         n61
pack     n33,++(mnop)++(defg)+(ae)+v<f(tuv)g(ab)>d(abc)++++++++
join     ckd
calc     n55⇐n47
jump     n47,x,xØ3m2g1
pack     n33,+++++++a+++<f(tuv)g(ab)>++++++++++
join     ckd1
calc     n6Ø⇐n47
```

```
pack     n33,++(mnop)++++(ae)++++d(abc)++++++++
join     ckd1
calc     n61⇐n47

entry    x03m2g1
pack     n33,0000000000000000n0+0000n+000+00
join     ckc
jump     n55,x03s2r,x
jump     n47,x03s2t,x03m2h
***

unit     x03m2h
restart
base
help     x03s2w
back     x03m2e
at       1206
write    Finally, set up a 20 Vp-p triangle wave at a frequency
         of 500 Hz. and a DC LEVEL of -5 volts. Display this
         waveform on channel A of the scope, which should be
         triggered from the Function Generator.

                          -HELP- is available'
***

unit     x03m2i
base
zero     n60                          $$ pre-set for x03s2x
         n61
         n62
pack     n33,++(nop)++(de)c(acd)+af(ijk)c(cde)(st)+++++++
join     ckd
calc     n55⇐n47
jump     n47,x,x03m2i1
pack     n33,++++++++++f(ijk)++++++++++
join     ckd1
calc     n60⇐n47
pack     n33,+++++(de)+++a++++++++++++
join     ckd1
calc     n61⇐n47

entry    x03m2i1
pack     n33,0000000000000000n0a0000na000+00
join     ckc
jump     n55,x03s2x,x
jump     n47,x03s2x,x03m3a

---------------------------------------------------------------- part=1, block=h ---------

         block 1h,  x03m3a

unit     x03m3a
base
term     equiv
```

```
restart
join    imode
jump    n47,xØ3m3a,x
back    xØ3m2h
at      12Ø5
write   When you finish this section you should be able to:

        1) Describe and characterize the circuit model of the
           Function Generator that has been developed.

        2) Establish the applicability of this model to the
           Function Generator for any given circuit conditions.
***

unit    xØ3m3b
back    xØ3m3a
at      3Ø6
write   The Function Generator must be represented by a model
        consisting of voltage sources, resistors, and other
        circuit elements useful in circuit theory calculations.
        A logical first choice would be an IDEAL voltage source
        as illustrated below.
join    xØ3s3a
draw    937;1237;284,3Ø5;274,3Ø1;256,[illegible];261,3Ø6;256,3Ø1
        261,296
at      1138
write   iL(t)
at      18Ø6
write   An ideal voltage source, vs(t) is defined as a circuit
        element whose circuit voltage is a prescribed function
        of time and is independent of the circuit current. In
        other words, in the suggested equivalent circuit, vs(t)
        is independent of iL(t).
***

unit    xØ3m3c
back    xØ3m3b
join    xØ3s3a
at      17Ø7
write   vs(t) is the open circuit voltage of the Function
        Generator. If this were the correct model, would
        you expect the amplitude or waveshape of the volt-
        age between points A and B to vary when a resistor
        is placed across the output?  (yes/no)
arrow   241Ø
specs   nookno,bumpshift
match   n51,yes,no
at      2417
writec  n51,no,no,ok
at      26Ø7
write   The output voltage will not be affected when a
        resistance is placed across the outputs; it should
        be independent of the load, as specified.
***

unit    xØ3m3d
back    xØ3m3c
```

```
at      1006
write   We now have a model of the Function Generator to help
        us predict its performance in a given circuit applica-
        tion. Let us now consider a specific case and see how
        accurately this first model predicts the behavior of
        the Function Generator.
------------------------------------------------------------ part=1, block=i ---------

        block 1i,  x03m3e

unit    x03m3e
next    x03s3b
back    x03m3d
at      405
write   According to Kirchoff's Voltage Law, VL = Vs on
        open circuit. Since our model is an ideal voltage
        source, Vs should not change when a resistor is
        placed across the output. Let's see if this is
        the case.
join    x03s3a
draw    841;845;843;942;843;944;843;1043;skip;1243;1443
        1441;1445
at      328,330
write   VL
at      2107
write   Set up the Function Generator to produce a non -
        adjustable square wave at a frequency of 800 hz.
        Display this waveform on channel A of the Scope
        and trigger the Scope from the Function Generator.
------------------------------------------------------------ part=1, block=j ---------

        block 1j,  x03m3f

unit    x03m3f
back    x03m3e
help    x03s3d
next    x03s3g
at      308
write   Our model predicts that the voltage will not be
        affected when a resistor is placed across the
        output.
join    x03s3a
draw    838;296,360;285,353;296,346;285,339;296,332
        285,325;296,318;296,288
at      1708
write   Using the RESISTOR BOARD, ITEM 32, place a 500 ohm
        resistor across the output of the Function Generator
        (nodes A and B) as shown above.
```

```
                   Press -NEXT- when you have done so.
at       2308
write    **NOTE: You should still be displaying a non-
                 adjustable square wave at a frequency
                 of 800 Hz.

                          -HELP- is available
***

unit     x03m3g
back     x03m3f
at       1009
write    Our ideal voltage source model predicted that the
         voltage would not be affected when a resistor is
         placed across the output. Can the Function Generator
         be represented as an ideal voltage source?
                       _______________ (yes/no)
arrow    1422
specs    nookno,bumpshift
match    n51,yes,no
at       1431
writec   n51,no,no,ok
at       1709
write    An ideal voltage source implies that the voltage
         will not be affected when a resistor is placed
         across the output. Hence, the Function Generator
         cannot be represented by a model consisting only
         of an ideal voltage source.
***

unit     x03m3h
base
next     x03m3i
back     x03m3g
at       206
write    It would appear that the ideal voltage source model
         for the Function Generator is not adequate.
         Consider the following model.
join     x03s3e
at       2109
write    This model consists of an ideal source and an
         unknown R,L, or C element in series with it.
         If a resistor were now connected between nodes
         A and B, VAB would... (increase,decrease,not change)
at       2523
write    _________________
arrow    2524
specs    bumpshift,okextra
wrong    (increase,not change,notchange)
draw     2605;2660
at       2709
write    No. The output would decrease because RL (=500Ω)
         and the unknown R,L,or C element would form a
         voltage divider. Therefore, VAB would be only
         a fraction of Vs.
answer   decrease
at       2808
```

```
write   Yes, and our earlier observation (VAB decreased)
        would tend to support this model.
endarrow
at      31Ø9
write   ----Hereafter, let us refer to VAB as VL ----
                        press -NEXT-
pause
join    xØ3s3k1
```

--- part=1, block=k ----------

block 1k, xØ3m3i

```
unit    xØ3m3i
back    xØ3m3h
at      1ØØ7
write      We remember that the open circuit voltage of the
        Function Generator was a square wave. With an RL of
        5ØØ ohms connected, is the output still a square
        wave?
                   ___________( yes/no )
arrow   142Ø
specs   bumpshift
answer  yes
wrong   no
at      16Ø7
write      If the output of the generator doesn't look like
        a square wave, no conclusions can be made about the
        unknown elements at this time. However, you should
        have found that the resistive load did not alter the
        waveshape and answered "yes" instead of "no".
***

unit    xØ3m3j
back    xØ3m3i
at      12Ø7
write   The output of the generator with RL connected is
        exactly proportional to VS and would appear to be
        independent of time. This would lead to the con-
        clusion that the unknown element has a V/I relation
        that is independent of time. The only element that
        satisfies this condition is a _______________.
arrow   1738
specs   bumpshift,okspell
answer  (resistor,resistance)
***

unit    xØ3m3k
back    xØ3m3j
at      4Ø7
write   Can the Function Generator be represented by an ideal
        source and a resistor if the open circuit voltage is
        a square wave with a resistor across the output, and
        the following waveform results? ___________(yes/no)
```

```
at      1640
write   time
draw    1648;1609;1209;1418;2018;1827;1227;1436;2036;1845
        1645
arrow   740
specs   nookno,bumpshift
match   n51,yes,no
at      748
writec  n51,no,no,ok
at      2208
write   Since the output is not a square wave, the relation
        between V and I is not constant.
***

unit    x03m31
back    x03m3k
calc    n51⇐-2              $$pre-set for x03m3m
at      307
write   A simple equivalent circuit for an actual
        controlled - source driving a resistive load may
        be assumed as shown below, where vs(t) is the
        voltage of an ideal voltage source and Rg is an
        internal resistance.
join    x03s3e1
join    x03s3k
join    x03s3f
at      2010
write   where vs(t) = vg(t) + vL(t) = Rg iL(t) + RL iL(t)

        or

        vs(t) - Rg iL(t) = RL iL(t)
at      2403
write   Eq. (1)
at      2707
write   We will limit this task to determining experiment-
        ally whether an equivalent circuit of this type is
        applicable, and, if so, evaluating Rg.
```

-- part=1, block=1 ----------

block 11, x03m3m

```
unit    x03m3m
back    x03m31
add1    n51                 $$writec in x03s31 and x03s3n
join    x03s3e1
join    x03s3k
join    x03s3f
at      2111
write   In our setup only RL and VL are known
        Noting the given reference direction,
        write an equation for IL.

```

```
                    IL=_|____________________
arrow   2524
specs   bumpshift,nookno
put     +=/
        l=l
        s=s
        g=g
storea  n60,30
ok
search  'vs',2,n60,30,1,n61
jump    n61,x,x03s31
search  'rg',2,n60,30,1,n61
jump    n61,x,x03s31
search  'vl/rl',5,n60,30,1,n61
jump    n61,x03s3n,x03s3m
***

unit    x03m3n
base
back    x03m3m
calc    n58⇐1             $$used in x03m3p
        n51⇐-1
at      508
write   In order to experimentally measure a current, IL,
        with the scope, we measure the voltage, VL, produced
        across a known resistance, RL, by that current and
        calculate
                          VL
                    IL = -----
                          RL


        Observe IL with RL = 500 ohms. Is the waveshape of
        IL identical to the waveform you observed for Vs ?
                __________(yes/no)
at      2308
write   Is the point at which IL crosses zero and is positive
        going at the same point on the display as it was for
        Vs ?
                ______________(yes/no)
specs   bumpshift
arrow   1616
answer  yes
wrong   no
at      1808
write   Once again the waveform is a square wave
draw    1808;1848
specs   bumpshift
arrow   2616
answer  yes
***

unit    x03m3o
base
back    x03m3n
next    x03m3p
erase
```

```
catchup
at       505
write    Eq(1)    vs(t) - RgiL(t) = RLiL(t)
at       1007
write    Excellent, you have now shown that Eq. (1) for the
         proposed circuit is not violated for the value
         RL = 500 ohms, in that

              vs(t) = 500 iL(t) + RgiL(t) = (500 + Rg) iL(t)

         where Rg may be a positive real number.
at       1405
write    Eq(2)
at       2207
write    The above equation could not apply with Rg being a
         positive real number if the waveshapes of vs(t) and
         iL(t) differed, particularly, if iL(t) ≠ 0 when
         vs(t) = 0.
```

-- part=1, block=m ------------

block 1m, x03m3p

```
unit     x03m3p
inhibit  erase
lab      x03s2e2
back     x03m3o
help     x03s3o
data     x03s3q
next     x03m3p2
at       207
write        You have not shown that Eq(1) applies for all
         values of RL with a specific value of Rg. To do so
         tabulate VL p-p and IL p-p for the specified values
         of RL.
             When you have satisfactorily tabulated values
         for five different resistive loads, PLATO will plot
         VL p-p versus IL p-p.

                   REMEMBER: IL = VL / RL
size     2
at       1213
write    Data point no.
calc     n57⇐n58-5
at       1240
showt    n58,3
size     0
at       1412
write    Choose RL =_____________(ohms)

         Enter VL =____________(Volts) (measured)

         Enter IL = ____________(Amps) (calculated)
at       3222
```

```
write   -HELP- is available
at      1426
writec  n51,500,1000,250,100,50         $$resistor
calcs   n51,v130⇐500,1000,250,100,50
calcs   n51,v52⇐17.6,24.5,10.4,4.65,2.55      $$voltage
arrow   1623
store   v131
ansv    v52,10%
no
at      2707
write   Your readings for V_L must be as accurate as possible.
        Be sure you are displaying the largest possible
        waveform on the Scope. Press -LAB- for an explanation.
endarrow
calc    v132⇐(v131/v130)
join    x03s3p
pause
join    key=data,x03s3q,x

entry   x03m3p1
next    x03m3p2
at      1824
erase   10
catchup
at      1822
write   ____________
inhibit erase
data    x03s3q
arrow   1822
store   v56
ansv    v132
no
draw    2803;2862
at      2913
write   Thought I wasn't looking, didn't you? Let's
        try that division again. I_L (=V_L/R_L) =?
endarrow
***

unit    x03m3p2
erase
join    n58,x,x,x03s3r,x03s3r1
add1    n58
        n51
at      1521
write   Press -NEXT-
next    n57,x03m3p,x03m3q
```

-- part=1, block=n ----------

blockmn, x03m3q

```
unit    x03m3q
base
```

```
next      x03m3r
back      x03m3n
at        310
write     For any range of I_L where the graph is a straight
          line, the negative of the value of the slope can
          be used as the value of R_g and for that range the
          assumed equivalent circuit is applicable.
origin    100,100
axes      300,240
scalex    .08
scaley    30
labelx    .02,.01
labely    10,2
size      2
graph     -.02,20,V_L
locate    .02,-7
write     I_L (amps)
size      0
gdraw     ;v142,v143;v140,v141;v144,v145;v146,v147;v148,v149
doto      1line,n100⇐140,148,2
locate    v(n100),v(n100+1)
write     (n100-142)/2,5000Ω,1000Ω,250Ω,100Ω,50Ω
1line
locate    .045,25
write     slope = -R_g
***

unit      x03m3r
next      x03end
back      x03m3q
at        409
write     Thus you have experimentally shown that this
          circuit is an acceptable equivalent circuit
          model for the function generator for a range
          of 0 < R_L < ( ≈ 1000) ohms.
join      x03s3e1
at        1624
write     R_g
at        2109
write     where R_g is the assumed internal resistance of
          the function generator and V_s a voltage source.
          Beyond this range, however, the model is not
          applicable and other circuit elements must be
          included to account for variations in the slope
          of V_L/I_L.
```

-- part=2, block=a ----------

block 2a, x03s1a

```
unit      x03s1a
arrow     431
store     v52
ansv      .05
```

```
calc     n51⇐0
         n60⇐-1
no
jump     x03s1c

entry    x03s1a1
arrow    631
ansv     20
calc     n51⇐1
         n61⇐-1
no
jump     x03s1d

entry    x03s1a2
arrow    831
store    n54
ansv     20
calc     n51⇐2
         n62⇐-1
no
jump     x03s1e

entry    x03s1a3
arrow    1031
ansv     -20
calc     n51⇐3
         n63⇐-1

entry    x03s1a4
arrow    1231
ansv     40
calc     n51⇐4
         n64⇐-1
no
jump     x03s1f

entry    x03s1a5
arrow    1431
ansv     20
no
jump     x03s1g
***

unit     x03s1b
origin   75,130
axes     0,-100,300,100
scalex   100
scaley   20
labelx   25,5
labely   10,5
gdraw    0,0;12.5,20;37.5,-20;62.5,20;87.5,-20;100,0
graph    106,-3,msecs
graph    -5,23,volts
frame    -40,-130,375,140
***

unit     x03s1c
```

```
next    x03m1b
back    x03m1b
at      505
write   No, the period of this waveform is not <s,v52> secs.
        Observe the waveform below ~~and, remembering that~~ the
        period is the time required for the waveform to begin
        repeating itself, determine the period.

        Note that your answer should be in units of seconds.
        (1 msec = .001 sec.)
join    x03s1b
***

unit    x03s1d
next    x03m1b
at      1005
write   N[illegible], frequency (f) is the reciprocal of the period (T).
        [illegible]ou have determined that the period of this waveform
        is .05 secs. Thus, since f = 1/T and T = .05 secs.:

                         f =  1     = ?? hz
                             ---
                             .05

                Press -NEXT- to enter your answer
***

unit    x03s1e
next    x03m1b
at      806
write   [illegible]ou incorrectly specified Vmax as being <z,n54> volts.
        Observe how Vmax is noted on the waveform below, then
        press -NEXT- to enter the correct answer.
join    x03s1b
graph   [illegible],10,Vmax

entry   x03s1e1
gdraw   [illegible];40,20
gdraw   [illegible];31,7
gdraw   [illegible],15;31,20
***

unit    x03s1f
next    [illegible]m1b
at      806
write   The peak-to-peak value is Vmax - Vmin. Observe this
        on the waveform below, then press -NEXT- to enter
        the correct answer.
join    x03s1b
join    x03s1e1
gdraw   31,0;31,-20
gdraw   [illegible],-20;40,-20
graph   [illegible],10,V(p-p)
***

unit    x03s1g
next    x03m1b
at      [illegible]
```

```
write   For this waveform V(Ø-p) is V(max). Observe this on
        the figure below, then press -NEXT- to enter the
        correct answer.
join    xØ3s1b
join    xØ3s1e1
graph   28,1Ø,V(Ø-p)
```

-- part=2, block=b ----------

block 2b, xØ3s1h

```
unit    xØ3s1h
join    xØ3s1i
gdraw   Ø,15;1Ø,15;1Ø,-15;2Ø,-15;2Ø,15;3Ø,15;3Ø,-15;3Ø,Ø

entry   xØ3s1h1
at      214
write     Since this is a symmetrical waveform,
        the average value is the line about which
        the waveform is symmetrical.
                  -OR-
         ...taking a different approach...

          V(max)+V(min)   = AVERAGE VALUE
                2
        Enter V(max) = __________ volts

        Enter V(min) = __________ volts

        The average value is then= __________ volts
arrow   1Ø28
ansv    n51
arrow   1238
ansv    n52
arrow   1442
ansv    n53
no
at      1536
write    (<z,n51>) + (<z,n52>) = ???
               2
end
***

unit    xØ3s1i
origin  75,15Ø
axes    Ø,-1ØØ,3ØØ,1ØØ
scalex  35
scaley  2Ø
labelx  1Ø,5
graph   -2,22,Volts
graph   38,Ø,Time
***

unit    xØ3s1j
```

```
join     x03s1i
gdraw    0,20;10,20;10,-10;20,-10;20,20;30,20;30,0
join     x03s1h1
end
***

unit     x03s2a1
next     x03m2a
output   //output help reviewed//
at       708
write    The adjustable output of the Function Generator
         is affected by:

           1) The Attenuator- The red dial of the OUTPUT
              group. This dial varies the voltage of the output
              waveform.

           2) Output Selector- This is the dial behind the
              attenuator. It is used to select the periodic
              signal to be controlled.

           3) ± DC Level - This dial changes the Vav
              of the adjustable output.

           4) Terminals- The only terminal affected by the
              above dials is the one directly below the
              attenuator. The terminals to the right of the
              attenuator have a constant magnitude and DC level.
end
***

unit     x03s2a2
next     x03m2a
output   //timing help reviewed//
at       1008
write      The time it takes a periodic signal to complete
         one cycle is known as the period of the waveform.
         The number of these periods that occur in one second
         is known as the frequency of the signal. The Timing
         section of the Function Generator allows the
         variation of the signal's frequency. The output
         frequency is the product of the MULTIPLIER and the
         CYCLES/SEC dials.
end
----------------------------------------------------------- part=2, block=c ----------

     block 2c,  x03s2a3

unit     x03s2a3
output   //trigger reviewed//
next     x03m2a
at       809
write      To trigger means to initiate or start a cycle.
```

```
        This Function Generator has two ways of being
        triggered. The INT setting causes the generator
        to be on continuously. The EXT setting allows
        the Function Generator to be triggered by an
        external voltage or event. This station is not
        equipped to externally trigger the Function
        Generator ( other than manual triggering); thus
        you should use the INT setting unless you are
        instructed to do otherwise.

         The TRIG OUT terminal is used to trigger
        other instruments synchronously with the
        Function Generator.
end
***

unit    x03s2b
back    x03m2b
at      1107
write   Remember that F= 1/T where:

                    F= frequency in Hertz

                    T= period in seconds

        Also, use the output terminal to the right of the
        attenuator.
end
***

unit    x03s2c
pack    n33,000000000000000n0+000n0+000+00
join    ckcl
calc    n65⇐n47
jump    n67,x03s2e,x
jump    n65,x03s2h,x
jump    n62,x03s2d,x
jump    n63,x03s2g,x
jump    n64,x03s2e1,x03s2g
***

unit    x03s2d
next    x03m2c
help    x03s2f
back    x03m2b
at      1105
write    No, you seem to be having a problem with the timing
        aspect: You were asked to set it for a period of 2 ms.

           Press -NEXT- if you understand your error and
        have corrected it.

           Press -HELP- if you would like some assistance.

           Press -BACK- to reread the problem statement.
***
```

```
unit    x03s2e
next    x03m2c
back    x03m2b
at      705
write      Unless you properly set the SWEEP MODE and A
        PRE AMP dials, you cannot display this waveform
        on the SCOPE. You should have mastered the use
        of these dials in the first experiment.

           If you need assistance, it would be best for
        you to review Experiment 1 (Operation and Use
        of the Oscilloscope ) before continuing this
        experiment.

                       -OTHERWISE-

           Press -NEXT- if you understand your error and
        have corrected it.

           Press -BACK- to reread the problem statement.
----------------------------------------------------------- part=2, block=d ----------


    block 2d,  x03s2e1


unit    x03s2e1
back    x03m2b
next    x03m2c
help    x03s2e3
at      805
write      The waveform which you are displaying is not acceptable.

           Reset the A VOLTS dial so that the waveform is as
        large as possible without exceeding the boundaries
        of the Oscilloscope screen.

           Press -NEXT- when you have correctly set the
        A VOLTS dial.

           Press -BACK- if you would like to reread the
        problem statement.

           Press -HELP- for further assistance.
***

unit    x03s2e2
erase                            $$ x03m3p has inhibit erase
catchup
at      1008
goto    x03s2e3                  $$ x03m3p avoids first paragraph

entry   x03s2e3
at      605
write      At this point of the experiment the size of the
```

```
             waveform is somewhat of a triviality. However,
             the final task of this experiment requires that
             you be able to accurately read the peak-to-peak
             voltage of the displayed waveform. As you increase
             the size of the displayed waveform, your accuracy
             improves. The reason for this is as follows:
      at     1405

      entry  x03s2e4
      write     The normally specified tolerance is ≈ ± 3 %
             of the FULL SCALE voltage setting. Thus if you are
             displaying a 10 volt peak-to-peak signal on a
             FULL SCALE setting of 10 volts, you are reading
             10 volts ± 3 %, or 10 volts ± 0.3 volts.

                Now, suppose you were to decrease the size of
             the waveform by changing A VOLTS to 100 VOLTS FULL
             SCALE. Once again the tolerance is ± 3 % or
             ± 3 volts. Thus, attempting to read a 10 volt peak-
             to-peak signal on a 100 volt FULL SCALE would
             produce an answer of 10 volts ± 3 volts, an
             unacceptable reading.
      end
      ***

      unit   x03s2f
      next   x03m2c
      help   x03s2a2
      back   x03m2b
      base
      at     605
      write     You were asked to set the timing dials so as to
             obtain a period T of 2 ms.

                1 ms (millisecond) = .001 second = 10^-3 second.

                Therefore, T (= 2 ms) = 2×10^-3 sec.

                Frequency f is the reciprocal of the period; i.e.,
             f = 1/T

             Thus the frequency when T = 2 ms. is
                                   1
                          f= ------------ = 500 Hz
                               2×10^-3
      at     2205
      write     Press -HELP- if you would like further assistance.

                Press -NEXT- when you have set the timing dials to
             500 Hz.

                Press -BACK- to reread the problem statement.
```

-- part=2, block=e ----------

block 2e, xØ3s2g

```
unit     xØ3s2g
next     xØ3s2g1
at       2Ø5
write       No, the system is not triggered as requested. Let's
         try a different approach.

            Beginning with the SCOPE.

            Suppose you wish to trigger the SCOPE from another
         source, such as the Function Generator, where would
         you position the SCOPE's TRIGGER SOURCE dial?

                        _______________ (ext/int)

            Now, in order to obtain that external triggering signal
         from the Function Generator which output of the
         Function Generator would you connect to the SCOPE's
         TRIGGER INPUT ?

                        _______________(Trig out/ Ext)
arrow    1118
specs    bumpshift
answer   (ext,external)
wrong    (int,internal)
draw     2Ø6Ø;2ØØ5;25Ø5;256Ø;2Ø6Ø
at       21Ø7
write    No...
               the INT setting triggers the SCOPE internally
         internally. You want to trigger the SCOPE externally.
arrow    1618
specs    bumpshift,okextra
answer   (trig out,trigout)
draw     2Ø6Ø;2ØØ5;25Ø5;256Ø;2Ø6Ø
at       21Ø7
write    Great... Once you have made the connection and/or
         dial setting adjustments as specified above you will
         have the SCOPE properly triggered. Press -NEXT- when
         you have done so.
wrong    (ext,external)
draw     2Ø6Ø;2ØØ5;25Ø5;256Ø;2Ø6Ø
at       21Ø8
write    No...
           The EXT TRIGGER is for externally triggering
           the FUNCTION GENERATOR. You want to externally
           trigger the SCOPE from the FUNCTION GENERATOR.
***

unit     xØ3s2g1
back     xØ3m2b
next     xØ3m2c
help     xØ3s2a3
at       5Ø8
write       Now that you know how to properly trigger the
         SCOPE, let's turn our attention to the Function
```

```
          Generator...

          You have already noted that a connection should
          be made between the SCOPE's TRIGGER INPUT and
          the Function Generator's TRIG OUT.  As noted,
          this connection allowed the Scope to be triggered
          externally. Thus far we have not stabilized the
          FUNCTION GENERATOR.
at        1808
write     Press  -HELP- for a description of how to trigger
                        the Function Generator.

          Press  -NEXT- if you know how to properly trigger
                        the Function Generator and have set
                        the dials accordingly.

          Press  -BACK- to reread the problem statement.
------------------------------------------------------------- part=2, block=f --------
```

block 2f, xØ3s2h

```
unit      xØ3s2h
zero      n55                  $$ avoids first jump in xØ3m2d1
next      xØ3m2c1
back      xØ3m2b
help      xØ3s2h1
at        8Ø5
write        You are not displaying a nonadjustable RAMP
          wave as requested.

             Press -NEXT- if you understand your error and
          have corrected it.

             Press -HELP- for assistance.

             Press -BACK- to reread the problem statement.
***

unit      xØ3s2h1
base
next      xØ3m2c1
lab       xØ3s2a1
at        6Ø5
write        The nonadjustable RAMP wave output is
          located to the right of the OUTPUT dial.

             Before changing your set-up, vary the
          setting of the ATTENUATOR. You should find
          that doing so changes the peak-to-peak value
          of the displayed waveform.

             Now connect the nonadjustable RAMP wave
          output terminal to the SCOPE's a INPUT. You
```

```
                should now find that varying the ATTENUATOR
                setting does not change the peak-to-peak
                value of the waveform.

                   Press -NEXT- when you have connected the
                nonadjustable RAMP output to the SCOPE's A INPUT.

                   Press -LAB- for a further discussion of the
                Function Generator's features output features.
        ***

        unit    xØ3s2i
        back    xØ3m2d
        at      1Ø1Ø
        write      Make sure that the OUTPUT selector is
                in the SINE wave position. Also be sure the
                adjustable OUTPUT terminal is connected to
                the SCOPE.
        end
        ***

        unit    xØ3s2j
        pack    n33,ØØØØØØØØØØØØØØØØnØ+ØØØØn+ØØØ+ØØ
        join    ckc1
        calc    n63⇐n47
        jump    n6Ø,xØ3s2k,x
        jump    n61,xØ3s2m,x
        jump    n62,xØ3s2l,x
        jump    n63,xØ3s2k,xØ3s2m
        ***

        unit    xØ3s2k
        next    xØ3m2d1
        help    xØ3s2n
        back    xØ3m2d
        at      1ØØ9
        write   You are not properly displaying an adjustable
                SINE wave with a peak-to-peak voltage of 1Ø volts.

                   Press -NEXT- if you understand your error and
                have corrected it.

                   Press -HELP- for assistance.

                   Press -BACK- to reread the problem statement.
        ***

        unit    xØ3s2l
        next    xØ3m2d1
        help    xØ3s2p
        back    xØ3m2d
        at      7Ø5
        write      Caught you day-dreaming a little, right?
                Let's set that timing dial at 1ØØØ Hz.
```

```
               Press -NEXT- when you have done so.

               Press -HELP- if you need assistance.

               Press -BACK- to reread the problem statement.
```

-- part=2, block=g ------

block 2g,   xØ3s2m:

```
unit     xØ3s2m
next     xØ3m2e
back     xØ3m2d
at       1ØØ5
write       You should still be triggering the SCOPE from the
         Function Generator just as you did in the previous
         exercise.

            Press -NEXT- when you have triggered the SCOPE
         from the Function Generator.

            Press -BACK- to reread the problem statement.
***

unit     xØ3s2n
base
next     xØ3s2n1
lab      xØ3s2a1
at       811
write       The adjustable output terminal is located
         directly below the ATTENUATOR dial. Find this
         terminal now and connect it to A INPUT on the SCOPE!

            Press -NEXT- when you have done so.

            Press -LAB- for a further discussion of the
         Function Generator's features.
***

unit     xØ3s2n1
pack     n33,ØØØØØØØØØØØØ+ØØnØ+ØØØØn+ØØØ+ØØ
join     ckc
jump     n47,x,xØ3s2o
pack     n33,ØØØØØØØØØØØØ+ØØnØ+ØØØØn+ØØØ+ØØ
join     ckclw
pause
jump     xØ3s2n
***

unit     xØ3s2o
next     xØ3s2o1
back     xØ3m2d
at       1ØØ5
write       Good, now set the OUTPUT selector to the SINE
```

```
         wave position. Adjust the ATTENUATOR setting until
         the peak-to-peak voltage is 10 volts. Of course the
         SCOPE's dials should be set so that you can properly
         display this waveform on channel A.

            Press -NEXT- when you have set these dials correctly.

            Press -BACK- to reread the problem statement.
***

unit     x03s2o1
pack     n33,++(mno)++++a++++b(cdef)++++++++
join     ckd
jump     n47,x,x03m2d1
pack     n33,++(mno)++++a++++b(cdef)++++++++
join     ckd1w
pause
jump     x03s2o
***

unit     x03s2p
next     x03m2d1
base
at       1108
write       The frequency of the waveform to be displayed is
         the product of the settings of the CYCLES/SEC dial
         and the MULTIPLIER dial.

            Since you want a frequency of 1000 Hz, you should
         set the MULTIPLIER dial on 1000 and the CYCLES/SEC
         dial on ______________

arrow    1716
specs    bumpshift
answer   (1,one)
at       2008
write                   or.....

            You could set the MULTIPLIER dial on 100 and the
         CYCLES/SEC dial on ______________
arrow    2327
specs    bumpshift
answer   (10,ten)
at       2709
write       Press -NEXT- when you have properly set the
         CYCLES/SEC and MULTIPLTER dials at 1000 Hz.
```

-- part=2, block=h ----------

block 2h, x03s2q

```
unit     x03s2q
help     x03s2v
back     x03m2e
```

```
at      1005
write      Don't forget to put the Function Generator's
        TRIGGER dial to the MANUAL position.

           Also, f=1/T (The frequency of the Function Generator
        is the product of the MULTIPLIER and the CYCLES/SEC dials.
at      2005
write      If you would like more information on the MANUAL
        TRIGGER, press -HELP-.  Otherwise, press -NEXT- to
        continue.
end
***

unit    x03s2r
jump    n60,x03s2s,x
jump    n61,x03s2t,x03s2u
***

unit    x03s2s
next    x03m2g
at      905
write      As in the last exercise, you should have a frequency
        of 1000 Hz. Set the frequency dials at 1000 Hertz.

           Then...

        Press -NEXT-

        Press -BACK- to reread the problem statement
***

unit    x03s2t
next    x03m2g
back    x03m2e
at      905
write      Once again you are displaying an adjustable wave-
        form, this time a 10 Vp-p square wave. Carefully,
        adjust the ATTENUATOR and check the SCOPE's dial
        settings (such as A VOLTs, Y DISPLAY, etc.).

           Press -NEXT- when you are properly displaying the
        waveform.

           Press -BACK- to reread the problem statement.
***

unit    x03s2u
next    x03m2g
help    x03s2v
back    x03m2e
at      811
write      You appear to be having trouble with the
        manual trigger. Before we go further, you
        should be aware that PLATO does not sense when
        the MANUAL button is being pressed; thus, it
        is not necessary that you be pressing the
        MANUAL button when the dial check is in
```

```
            progress.  You only need to have the system
            set up to be manually triggered, press the
            MANUAL button once or twice to assure your-
            self that you have the proper set-up, then:

               Press -NEXT- for PLATO to check.

               Press -HELP- for further assistance.

               Press -BACK- to reread the problem statement.
     ***

     unit   x03s2v
     at     605
     write     When the Function Generator's TRIGGER selection
            dial is set to the EXT position, the Function
            Generator may be triggered by an external voltage
            or event.  Pressing the MANUAL button may be
            considered an external event.

               You may trigger the SCOPE either internally or
            from the Function Generator.
     end
----------------------------------------------------------- part=2, block=i ----------

        block 2i,  x03s2w

     unit   x03s2w
     at     1105
     write     The DC LEVEL control is below the ATTENUATOR.

               Carefully set this dial. Also, since this dial
            interacts with the ATTENUATOR dial, you may find it
            necessary to re-adjust the ATTENUATOR setting.

               (Since you are putting a dc component into the
            waveform, to what position should the A PRE AMP be set?)
     end
     ***

     unit   x03s2x
     pack   n33,0000000000000000+0a0000+a000+00
     join   ckc1
     calc   n62⇐n47
     jump   n60,x03s2y,x
     jump   n61,x03s2z,x
     jump   n62,x03s2z,x03s2z1
     ***

     unit   x03s2y
     next   x03m2i
     back   x03m2h
     at     905
```

```
write       If you've gotten this far, the timing dials should
            be causing you problems now. However, the Function
            Generator's CYCLES/SEC and MULTIPLIER dials, which
            should be set at a frequency of 500 Hz, are not set
            properly.

               Press -NEXT- when you have set these dials properly.

               Press -BACK- to reread the problem statement.
***

unit        x03s2z
next        x03m2i
back        x03m2h
at          805
write          You are not triggering the SCOPE from the Function
            Generator.

               Press -NEXT- when you have made the necessary dial
            and/or connection corrections.

               Press -BACK- to reread the problem statement.
***

unit        x03s2z1
next        x03m2i
help        x03s2z2
back        x03m2h
at          905
write          You are not displaying a triangle wave with a peak-to-
            voltage of 20 volts and a dc level of -5 volts.

               Press -NEXT- if the understand your error and
            have corrected it.

               Press -HELP- for assistance with the DC LEVEL.

               Press -BACK- to reread the problem statement.
***

unit        x03s2z2
next        x03m2i
at          505
write          Before attempting to set the DC LEVEL at -5 Volts,
            you must set the 0 Volts level on the SCOPE. To do so,
            turn the A PRE AMP to OFF, and position the trace on
            the center horizontally by means of the Y POSITION knob.

pause
write          Now that you have positioned the zero voltage level
            on the SCOPE, do not move the Y POSITION knob.  Doing
            so will dislocate the zero voltage level on the screen.

               Return the A PRE AMP from OFF to its previous setting.
```

```
        Adjust the Function Generator's DC LEVEL until the
wave is centered about -5 V. Then readjust the
ATTENUATOR and the DC LEVEL as necessary to obtain the
20 Vp-p waveform with a dc level of -5 volts.

---------------------------------------------------------------- part=2, block=j ----------

        block 2j,  xØ3s3a

unit    xØ3s3a
draw    837;824;1Ø24;1Ø26;1226;1222;1Ø22;1Ø24;skip;1224
        1424;1437
at      2ØØ,2Ø2
write   c B
at      2ØØ,376
write   c A
at      112Ø
write   +
        vg(t)
***

unit    xØ3s3b
pack    n33,++(op)++(de)+a+af(pqr)++++++++++
join    ckd
jump    n47,x,xØ3s3c
join    ckdlw
pause
jump    xØ3m3e
***

unit    xØ3s3c
pack    n33,ØØØØØØØØØØØØ+ØØnØanØØØØaØØØ+ØØ
join    ckc
jump    n47,x,xØ3m3f
join    ckclw
pause
jump    xØ3m3e
***

unit    xØ3s3d
at      12Ø7
write      Connect the (+) output terminal of the Function
        Generator to terminal 7 on the RESISTOR BOARD. Also,
        connect terminal 7 to (+) A-input of the Scope.

           Now connect the (-) output terminal of the
        Function Generator to terminal 8 on the resistor
        board. Terminal 8 should also be connected to the
        A INPUT of the Scope.
end
***

unit    xØ3s3g
pack    n33,++(no)++(de)+a+af(pqr)++++++++++
```

```
join    ckd
jump    n47,x,xØ3s3j
pack    n33,++(no)++++++++++++++++++
join    ckdl
jump    n47,xØ3s3h,xØ3s3i
***

unit    xØ3s3h
help    xØ3s2e3
next    xØ3s3g
back    xØ3m3f
at      905
write      The waveform you are displaying is too small. You
        cannot measure it very accurately.

           Press -NEXT- when you have reset A VOLTS so that the
        waveform is as large as possible without exceeding
        the boundaries of the screen.

           Press -HELP- for a further explanation.

           Press -BACK- to reread the problem statement.
***

unit    xØ3s3i
next    xØ3s3g
pack    n33,++(no)++(de)+a+af(pqr)++++++++++
join    ckdlw
***

unit    xØ3s3j
pack    n33,ØØØØØØabØØØØaØØbØcbØØØØcØØØ+ØØ
join    ckc
jump    n47,x,xØ3m3g
pack    n33,ØØØØØØabØØØØbØØaØcaØØØØcØØØ+ØØ
join    ckcl
jump    n47,x,xØ3m3g
join    ckclw
pause
jump    xØ3m3f
***

unit    xØ3s3l
next    xØ3m3m
at      1315
write   vg(t) and Rg are unknowns. Write your
        equation in terms of known parameters
        only.

           press -NEXT- to try again
at      2111
writec  n51,,,ASK YOUR INSTRUCTOR FOR ASSISTANCE.......
***

unit    xØ3s3m
next    xØ3m3n
at      1416
```

```
write   Your equation will work!!

              press -NEXT-
***

unit    xØ3s3n
next    xØ3m3m
at      1615
write   No, your equation will not work

            press -NEXT- to try again.
at      2411
writec  n51,,,ASK YOUR INSTRUCTOR FOR ASSISTANCE.......
------------------------------------------------------------------ part=2, block=k ----------

        block 2k,  xØ3s3e

unit    xØ3s3e
at      1524
write   Unknown
        R,L,or C
        element
at      3Ø4,36Ø
write   o  A
at      3Ø4,218
write   o  B

entry   xØ3s3e1
at      3Ø4,36Ø
write   o
at      3Ø4,218
write   o
draw    939;921;1121;112Ø;122Ø;1222;1122;1121;skip;1221
        1421;142Ø;162Ø;1622;1422;1421;skip;1621;1821;1839
at      192,336
write   +
at      184,318
write   vs(t)
***

unit    xØ3s3f
draw    94Ø;114Ø;32Ø,328;312,32Ø;32Ø,312;312,3Ø4;32Ø,296
        312,288;32Ø,28Ø;312,272;32Ø,264;312,256;184Ø
at      1342
write   RL
draw    1235;1535;1733;173Ø;238,246;232,24Ø;238,234
at      1436
write   IL
***

unit    xØ3s3k
at      1416
write   -
```

```
         Vg
         +
at       1624
write    Rg

entry    x03s3ki
at       308,360
erase    7
at       308,218
erase    7
draw     945;950;skip;947;1046;947;1048;947;1247;skip
         1447;1847;1845;1850
at       353,299
write    VL
***

unit     x03s3o
back     x03m3p
erase
catchup
at       1010
write    For each of the five data points place the
         specified value of RL across the output of
         the Function Generator (just as you have
         done previously). The peak-to-peak voltage
         which you read from the SCOPE is VL. You
         have already determined that IL = VL/RL.
         Since you know VL and RL, the calculation
         of IL is simple division; a calculator has
         been provided for your convenience.
end
***

unit     x03s3p
draw     2111;2154;2754;2711;2111
at       2217
write     PLATO CALCULATOR
at       2312
write    Enter expression such as 5/7, 4.3/75, etc.
                   EXPRESSION:
                  PLATO CALCULATES:
at       1904
write    Press -DATA- if you would like to use the calculator to
         calculate IL. Otherwise press -NEXT- to enter IL directly.
***

unit     x03s3q
at       1822
erase    2
at       2432
erase    12
at       2539
erase    6
catchup
inhibit erase
arrow    2432
store    v70
```

```
ok
endarrow
calc     v71⇐v7Ø
at       2539
show     v71
at       2612
write    Press -NEXT- to enter I_L above
pause
jump     xØ3m3p1
***

unit     xØ3s3r
calc     n1ØØ⇐14Ø

entry    xØ3s3r1
calc     v(n1ØØ)⇐v56
add1     n1ØØ
calc     v(n1ØØ)⇐v131
add1     n1ØØ
```

--- part=2, block=1 ----------

block 21, xØ3end

```
unit     xØ3end
back     xØ3m3r
join     imode
jump     n47,xØ3end,x
course   n2
calcc    n2='ee244',
         nc(n21+1)⇐(nc(n21+1)$mask$o7777777777ØØØØØØØØØØ)+o46Ø3ØØØØØØ,
         nc(n21+1)⇐nc(n21+1)
erase
output   /// student has completed experiment ///
join     endunit
join     jmpmes
jumpout  cgeindex,quest1

entry    leave
end      lesson
***

unit     endunit
course   n2
jump     n2≠'ee244',leave,x
calc     nc(n21+7)⇐nc(n21+7)+ahelp
         vc(n21+6)⇐vc(n21+6)+atime/6ØØØØ
***Incl.cge s.r. & terms sample,index,imode,comment,slides.
use      eevØØ,ck1
use      ck2
use      ck3
use      ck4
use      ck5
use      ck6
```

ckc	not found		194 234 266 1477 300 1523 1263
ckc1	not found		981 1201 1399 1526
ckc1w	not found		1266 1479 1528
ckd	not found		177 218 255 1469 289 1497 1285
ckd1	not found		181 184 187 225 190 230 222
			259 262 293 296 1500
ckd1w	not found		1288 1471 1519
endunit	x03end	1679	19 1673
imode	not found		29 308 1665
jmpmes	not found		1674
leave	x03end	1676	1681
x03end	x03end	1663	735 1666
x03m0a	x03m0a	27	30 49
x03m1a	x03m1a	40	65
x03m1b	x03m1a	63	90 807 808 844 820 856 831
x03m1c	x03m1a	88	64 107 121
x03m1d	x03m1d	104	89 154
x03m1e	x03m1d	118	105
x03m2a	x03m2a	139	120 159 911 935 950
x03m2b	x03m2a	156	154 201 968 1019 992 1066 1003
			1127 1154
x03m2c	x03m2c	169	160 990 1002 1020 1129 1064
x03m2c1	x03m2c	19[illegible]	179 1153 1169
x03m2d	x03m2c	198	196 241 1191 1238 1211 1272 1225
x03m2d1	x03m2d1	21[illegible]	202 1209 1223 1286 1293
x03m2d1e	x03m2d1	232	220
x03m2e	x03m2d1	238	236 274 1237 1319 1364 1346
x03m2g	x03m2d1	251	1336 1345 1358
x03m2g1	x03m2d1	264	257
x03m2h	x03m2d1	2[illegible]	268 310 1407 1419 1430
x03m2i	x03m2d1	[illegible]	1406 1418 1428 1440
x03m2i1	~~x03m2d1~~	29[illegible]	291
x03m3a	x03m3a	30[illegible]	302 309 321
x03m3b	x03m3a	[illegible]	341
x03m3c	x03m3a	[illegible]	360
x03m3d	x03m3a	[illegible]	370
x03m3e	x03m3e	36[illegible]	389 1473 1481
x03m3f	x03m3f	38[illegible]	412 1478 1506 1530
x03m3g	x03m3f	411	434 1524 1527
x03m3h	x03m3f	431	468
x03m3i	x03m3i	467	483 487
x03m3j	x03m3i	4[illegible]	500
x03m3k	x03m3i	49[illegible]	520
x03m3l	x03m3i	51[illegible]	545
x03m3m	x03m3m	544	573 1533 1551
x03m3n	x03m3m	571	607 709 1544
x03m3o	x03m3m	60[illegible]	632
x03m3p	x03m3p	629	608 704 1607
x03m3p1	x03m3p	67[illegible]	1653
x03m3p2	x03m3p	69[illegible]	655 679
x03m3q	x03m3q	70[illegible]	704 736
x03m3r	x03m3q	734	708 1664
x03s1a	x03s1a	75[illegible]	86
x03s1a1	x03s1a	761	86
x03s1a2	x03s1a	76[illegible]	86
x03s1a3	x03s1a	77[illegible]	
x03s1a4	x03s1b	781	86

xØ3s1a5	xØ3s1a	788	86				
xØ3s1b	xØ3s1a	794	69	817	836	849	861
xØ3s1c	xØ3s1a	8Ø6	76Ø				
xØ3s1d	xØ3s1a	819	767				
xØ3s1e	xØ3s1a	83Ø	775				
xØ3s1e1	xØ3s1a	838	85Ø	862			
xØ3s1f	xØ3s1a	843	787				
xØ3s1g	xØ3s1a	855	792				
xØ3s1h	xØ3s1h	865	1Ø6				
xØ3s1h1	xØ3s1h	868	9Ø7				
xØ3s1i	xØ3s1h	895	113	133	866	9Ø5	
xØ3s1j	xØ3s1h	9Ø4	119				
xØ3s2a1	xØ3s1h	91Ø	154	117Ø	1252		
xØ3s2a2	xØ3s1h	934	154	1Ø65			
xØ3s2a3	xØ3s2a3	948	154	1129			
xØ3s2b	xØ3s2a3	967	161				
xØ3s2c	xØ3s2a3	979	195	196			
xØ3s2d	xØ3s2a3	989	985				
xØ3s2e	xØ3s2a3	1ØØ1	983				
xØ3s2e1	xØ3s2e1	1Ø18	987				
xØ3s2e2	xØ3s2e1	1Ø33	631				
xØ3s2e3	xØ3s2e1	1Ø38	1Ø21	1Ø37	15Ø4		
xØ3s2e4	xØ3s2e1	1Ø48					
xØ3s2f	xØ3s2e1	1Ø63	991				
xØ3s2g	xØ3s2g	1Ø85	986	987			
xØ3s2g1	xØ3s2g	1126	1Ø86				
xØ3s2h	xØ3s2h	1151	984				
xØ3s2h1	xØ3s2h	1167	1155				
xØ3s2i	xØ3s2h	119Ø	2Ø3				
xØ3s2j	xØ3s2h	1199	235	236			
xØ3s2k	xØ3s2h	12Ø8	12Ø3	12Ø6			
xØ3s2l	xØ3s2h	1222	12Ø5				
xØ3s2m	xØ3s2m	1236	12Ø4	12Ø6			
xØ3s2n	xØ3s2m	1249	121Ø	1268			
xØ3s2n1	xØ3s2m	1261	1251				
xØ3s2o	xØ3s2m	127Ø	1264	129Ø			
xØ3s2o1	xØ3s2m	1283	1271				
xØ3s2p	xØ3s2m	1292	1224				
xØ3s2q	xØ3s2q	1317	24Ø				
xØ3s2r	xØ3s2q	1331	267				
xØ3s2s	xØ3s2q	1335	1332				
xØ3s2t	xØ3s2q	1344	268	1333			
xØ3s2u	xØ3s2q	1357	1333				
xØ3s2v	xØ3s2q	1376	1318	1359			
xØ3s2w	xØ3s2w	1387	273				
xØ3s2x	xØ3s2w	1397	3Ø1	3Ø2			
xØ3s2y	xØ3s2w	14Ø5	14Ø1				
xØ3s2z	xØ3s2w	1417	14Ø2	14Ø3			
xØ3s2z1	xØ3s2w	1427	14Ø3				
xØ3s2z2	xØ3s2w	1439	1429				
xØ3s3a	xØ3s3a	1456	328	342	377	396	
xØ3s3b	xØ3s3a	1467	369				
xØ3s3c	xØ3s3a	1475	147Ø				
xØ3s3d	xØ3s3a	1483	39Ø				
xØ3s3e	xØ3s3e	1559	439				
xØ3s3e1	xØ3s3e	1568	528	547	742		
xØ3s3f	xØ3s3e	158Ø	53Ø	549			

x03s3g	x03s3a	1495		391	1505	1517				
x03s3h	x03s3a	1503		1501						
x03s3i	x03s3a	1516		1501						
x03s3j	x03s3a	1521		1498						
x03s3k	x03s3e	1589		529	548					
x03s3k1	x03s3e	1596		465						
x03s3l	x03s3a	1532		565	567					
x03s3m	x03s3a	1543		569						
x03s3n	x03s3a	1550		569						
x03s3o	x03s3e	1606		633						
x03s3p	x03s3e	1622		675						
x03s3q	x03s3e	1634		634	677	686				
x03s3r	x03s3e	1655		699						
x03s3r[illegible]	x03s3e	1657		699						
ahelp		1682								
atime		1683								
data		677								
key		677								
msecs		802								
n		84								
nc		1669	1669	1670	1670	1682		1682		
n100		79	81	82	84	727	729	728	1656	728
		1658	1659	1660	1661					
n101		78	80	80	83					
n2		1667	1668	1680	1681					
n21		1669	1669	1670	1670	1682		1682	1683	1683
n33		176	180	183	186	189	221	193	224	217
		227	233	254	258	261	292	265	295	288
		299	980	1200	1262	1265	1348	1284	1468	1287
		1476	1496	1499	1518	1522		1525		
n47		30	178	179	182	185	196	188	219	191
		220	223	226	231	236	260	256	263	257
		268	290	291	294	297	982	302	1202	309
		1264	1286	1400	1470	1478	1524	1498	1527	1501
		1666								
n51		58	86	91	122	351	429	353	512	421
		514	521	546	575	662	701	663	757	664
		764	772	779	784	884		891	1557	1541
n52		92	123	886	891					
n53		93	124	888						
n54		770	833							
n55		178	195	219	235	256	301	267	1152	290
n57		649	704							
n58		574	649	651	699	700				
n60		51	213	223	252	260	562	285	564	294
		566	568	758	1203	1332		1401		
n61		52	214	226	253	263	564	286	565	297
		566	567	568	569	765		1204	1402	1333
n62		53	170	182	215	231	985	287	1205	773
		1400	1403							
n63		54	171	185	216	780		986	1206	1202
n64		55	172	191	785	987				
n65		173	982	984						
n66		174								
n67		175	188	983						
n70		153	154							
p		853	853	863						

v	728	728	1658	1660
vc	1683	1683		
volts	803			
v102	81	84		
v103	82	84		
v130	683	674		
v131	666	674	1660	
v132	674	689		
v140	726			
v141	726			
v142	726			
v143	726			
v144	726			
v145	726			
v146	726			
v147	726			
v148	726			
v149	726			
v52	664	667	755	810
v56	688	1658		
v70	1644	1647		
v71	1647	1649		
%	667			
Time	902			
V	853	863		
Volts	901			
V_{ma}	837			
V_L	722			

lesson information

lesson name = eex03

starting date = 05/18/73

last edited on 08/21/74 at 11.18.26

by neal of course eecge

at site 7, station 27

author name = J.P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = The Operation and Uses of the Function Generator, Exact 251.

```
---------------------------------------------------------------- part=1, block=a --------

block 1a,  eexØ4id

stop
****    For Neal, CGERL, Room 248, EEB.
One line description of this lesson --
     The Operation and Uses of the DC Supply, Harrison 865B.
          Divisions of this Lesson:          Block      Unit
          Id for this file                    eexØ4id
          Experiment eexØ4;
            Objectives                         xØ4mØa     xØ4mØa
            Uses of dc supply                  xØ4mØa     xØ4m1a
            Constant v / constant i opn.       xØ4m2a     xØ4m2a
            Operation in floating mode,        xØ4m3a     xØ4m3a
            Practical applications             xØ4m3h     xØ4m4a
            Optional studies                   xØ4m4d     xØ4m5a
          Final edit 21 aug 74 neal.
*list    info
*list    symbols
*list    varian,charset,cgeindex,cgechar
****
start
finish   endunit
write    (at,1Ø1Ø) Loading the CGE Character Set
charset  cgeindex,cgechar
erase
dataon
area     eexØ4
ext      Ø
---------------------------------------------------------------- part=1, block=b --------

block 1b,  xØ4mØa

unit     xØ4mØa
restart
join     imode
jump     n47,xØ4mØa,x
base
next     xØ4mØb
calc     n59⇐(-1)
at       5Ø5
write    The Operation and Uses of the Constant Voltage/Constant
```

```
                Current Supply, Harrison Laboratories 865B
at          1010
write          When you have completed this experiment
            you should be able to:

            1) Determine the cases in which the DC SUPPLY
            can be used.

            2) Adjust the DC SUPPLY for constant current/
            voltage operation.

            3) Connect the DC SUPPLY in either a floating
            or a grounded mode, as the particular application
            may require.

            4) Use the DC SUPPLY in practical applications.
***

unit        x04m0b
back        x04m0a
next        x04m1a
lab         x04m4a
data        x04m5a
at          1210
write       Press -NEXT- for a CGE learning experience,

                  -LAB-  if you know all about this device,

                  -DATA- for a do-it-yourself CGE sequence.
***

unit        x04m1a
back        n59,x04m0b,x04m3h,x04m5b
next        n59,x04m1b,x04m3h,x04m5b
join        n59-3,x04s1a,x
goto        n59,x,x04s0a,x04s0a,x
at          1611
write          Do you think that this device could be used
            to generate the 60 Hz. alternating current
            that is available from wall outlets?
arrow       1849
answer      (n,no,nope,NO,No)
at          2211
write       Right!  60 Hz. current is a periodic function of
            time.
wrong       (y,yes,YES,Yes)
at          2211
write       60 Hz current is not constant, it's a periodic
            function of time.
wrong
at          2211
write       y or n will suffice as an answer.
```

--- part=1, block=c ---------

block 1c, xØ4m1b

```
unit     xØ4m1b
back     n59,xØ4m1a,xØ4m3h,xØ4m5b
next     n59,xØ4m1c,xØ4m3h,xØ4m5b
join     n59-3,xØ4s1b,x
goto     n59,x,xØ4sØa,xØ4sØa,x
at       1611
write    Can this supply be used to ...
at       1811
write    Generate a constant (dc) voltage of 15 V ?
         Produce 1Ø volts across a 15 ohm resistor?
         Generate a constant current of Ø.Ø1 amp?
arrow    1854
answer   (YES,Yes,yes,y)
wrong    (NO,No,no,n,nope)
at       2211
write    Nope, it'll work.  Try it!
arrow    1954
answer   (NO,no,No,n)
wrong    (YES,Yes,yes,y)
at       2211
write    1Ø volts ÷ 15 ohms = Ø.667 amp.  That's too much!
arrow    2Ø54
answer   (no,NO,No,n)
wrong    (YES,Yes,yes,y)
at       2211
write    Ø.Ø1 amp is below the minimum current of Ø.1 amp
***

unit     xØ4m1c
back     n59,xØ4m1b,xØ4m3h,xØ4m5b
next     n59,xØ4m2a,xØ4m3h,xØ4m5b
join     n59-3,xØ4s1c,x
goto     n59,x,xØ4sØa,xØ4sØa,x
at       1211
write    The DC SUPPLY should be "ON".
         Is the pilot light glowing?
arrow    1339
answer   (yes,y,Yes,YES)
wrong    (no,NO,No,n)
at       1511
write    Call the lab assistant to check your supply.
```

-- part=1, block=d ----------

block 1d, xØ4m2a

```
unit     xØ4m2a
back     n59,xØ4m1c,xØ4m3g,xØ4m5b
next     xØ4m2b
jump     n59=3,xØ4m2b,x
```

```
at      611
write   The DC SUPPLY will operate as a constant voltage
        source if the load current remains less than the
        setting of the CURRENT dial.
at      1011
write   Or the DC SUPPLY will operate as a constant current
        source so long as the load voltage is less than the
        setting of the VOLTAGE dial.
at      1411
write   In any case, the load current (IL) will never be
        greater than the CURRENT dial setting; and
        the load voltage (VL) will never be greater than
        the VOLTAGE dial setting.  The mode of operation
        of the DC SUPPLY is determined by the setting
        of these dials and the load resistor only!!
        The setting of the METER switch has no effect on
        this operation!!!
```

-- part#1, block=e ----------

```
        block 1e, x04m2b

unit    x04m2b
back    x04m2a
next    n59,x04m2c,x04m2h,x04m5b,x04m2c
join    n59-1,x04s2a,x
[illegible]  n59,x,x04s0a,x04s0a,x
at      1411
write   If the DC SUPPLY is set at 20 volts and
        0.15 amp., and then a 100 ohm load is placed
        on the output, what will be the resultant load
        current and voltage?
at      2011
write   IL=__________amp.     VL=__________volts.
arrow   2014
[illegible]  [illegible]
ansv    0.15,1%
at      [illegible]
write   Right!  The DC SUPPLY will not allow the load
        current to become greater than the dial setting.
store   v55
no
join    v55-0.15,x04s2b,x04s2c
arrow   2035
ansv    15,.1
at      2611
write   Right!  The DC SUPPLY is in constant current mode!
store   v56
no
at      2611
write   You got IL right; now just use Ohm's law!
[illegible]

unit    x04m2c
```

```
help     x04s2d
next     x04m2d
goto     n59,x,x04s0a,x04s0a,x
at       810
write    Let's try to show this by experimentation.
at       1210
write    Set up the DC SUPPLY for 20 volts and 0.15 amperes.
at       3110
write    -HELP- is available.
***

unit     x04m2d
pack     n83,+++++++++++++++++(hi)(fghijk)+++++
join     cld
jump     n47,x04s2e,x
goto     n59-10+n47,x04m3a,x04m3h,x04m5b,x04m5b,x04m5b,x04s2f
```

--------------------------------------- part=1, block=f ---------

block 1f, x04m3a

```
unit     x04m3a
back     n59,x,x04m3h,x04m5b
next     n59,x04m3b,x04m3h,x04m5b,x04m3b
join     n89-3,x04s3a,x
goto     n59,x,x04s0a,x04s0a,x
at       1511
write        Connect the sensor cable of the RESISTOR BOARD,
         and then drive the 100 ohm resistor from the
         DC SUPPLY in the following fashion:

             Connect the (+) output to Terminal 3.

             Connect the (-) output to GROUND.

             Connect the (-) output to Terminal 4.
***

unit     x04m3b
pack     n33,00120000000002000000000000120+00
join     chc
jump     n47,x04m3a,x04m3c
***

unit     x04m3c
back     n59,x04m3a,x04m3h,x04m3a
next     n59,x04m3d,x04m3h,x04m5b
at       811
write        With the 100 ohm resistor connected the current
         will not exceed 0.15 amp, at any voltage setting.
         Also, the voltage will never exceed the 20 volts
         despite the current setting.

             Experiment with this until you can verify these
```

```
              statements.

                    Can you verify the above ?
  arrow     1642
  answer    (YES,yes,yes,y)
  wrong     no
  write     Call the lab instructor.
  join      imode
  jump      n59-4*n47,x04m3d,x04m3h,x04m5b,x04m3c
----------------------------------------------------------- part=1, block=g -----

         block 1g,  x04m3d

  unit      x04m3d
  back      n59,x04m3c,x04m3h,x04m5b
  next      n59,x04m3e,x04m3h,x04m5b
  join      n59-3,x04s3b,x
  goto      n59,x,x04s0a,x04s0a,x
  at        2311
  write     If you had as many power supplies of this type
            as you wanted could you generate a 1.5 ampere
            current ?
  arrow     2421
  answer    (NO,NO,no,n)
  ***

  unit      x04m3e
  back      n59,x04m3d,x04m3h,x04m5b
  next      n59,x04m3f,x04m3h,x04m5b,x04m3f
  join      n59-3,x04s3c,x
  goto      n59,x,x04s0a,x04s0a,x
  jump      n59=3,x04m3f,x
  ***

  unit      x04m3f
  back      x04m3e
  at        809
  write     Set the METER dial to display the load current.
  pause
  pack      n33,++++++++++++++++v++++++++
  join      cbd
  jump      n59-10*n47,x04m3g,x04m3h,x04m5b,x04m5b,x04m5b,x04m3f
  ***

  unit      x04m3g
  term      test
  zero      n59
  jump      x04m3h
----------------------------------------------------------- part=1, block=h -----
```

block 1h, x04m3h

```
unit    x04m3h
at      1311
write   To review any of these topics press the
        following keys:

        a)  Definitions of direct current (dc).
        b)  Power supplies and glowing lights.
        c)  Constant voltage and constant current mode.
        d)  Power supply load connections.
        e)  Multiple power supply operations.
        f)  Functions of the METER dial.
        g)  Voltage and current limitations.
        h)  Operation of the VOLTAGE and CURRENT controls.

        You will be automatically returned to this
        page after each review unit.

        Topic ?

        When you are finished press -DATA- for the final test.
data    x04m4a
goto    n60,x,x,x04s0a
base
arrow   2319
long    1
match   n60,a,b,c,d,e,f,g,h
jump    n60,x,x04m1a,x04m1c,x04m2a,x04m3a,x04m3d,x04m3e,x04m1b,x04s2d
at      2511
write   Just type the letter.
***

unit    x04m4a
base
join    imode
jump    n47,x04m4a,x
calc    n60⇐2
jump    x04m4b
***

unit    x04m4b
back    x04m0a
at      810
write   Set the DC SUPPLY to produce the following output:

           A 15V dc signal across the 500 ohm resistor
        on the resistor circuit board.

           The DC voltage generated should be negative
        (-) with respect to ground.

           The resistor itself should be connected
        such that terminal 7 is connected to ground.

           Set the meter on the DC supply to monitor the
```

```
        load voltage.
pause
pack    n33,ØØØØØØabØØØØaØØØØØØØØØØØØabØ+ØØ
join    ckd
jump    n47,x,x04m4b1
next    x04m4b
***

unit    x04m4b1
pack    n33,+++++++++++++++(fg)+++++
join    ckd
jump    n47,x04s4a,x
jump    x04m4c
***

unit    x04m4c
join    [illegible]
jump    n47,x04m4c,x
at      511
write     Can the power supply be used to generate:

        1)  A 48 volt dc signal ?            (yes/no)

        2)  How about 17 volts ac ?

        3)  A constant current of Ø.4 amperes ?
arrow   1039
answer  (NØ,No,no,n)
wrong   (YES,yes,y,Yes)
add1    n60
arrow   1241
answer  (NO,No,no,n)
wrong   (YES,Yes,yes,y)
add1    n60
arrow   14[illegible]
answer  (YES,Yes,yes,y)
next    n60,x,x,x04s4d
wrong   (NO,No,no,n)
add1    n60
```

--- part=1, block=i ------------

block 1i, xØ4m4d

```
unit    x04m4d
at      810
write     Set the DC SUPPLY to generate 2Ø V dc
        with the current limited to Ø.3 A.

          Set the METER to measure output voltage.
pause
pack    n33,+++++++++++++++a(hi)(Imn)+++++
join    ckd
jump    n47,x04s4b,x
```

```
jumr      n47,x04s4c,x
jump      x04m4e
***

unit      x04m4e
join      imode
jump      n47,x04m4e,x
at        411
write        If you were to set the dials of the supply to
          the following positions-

          1)  METER        - volts
          2)  VOLTAGE      - 20 volts
          3)  CURRENT      - 0.1 amperes

             Would the supply be in constant voltage or
          constant current operation with a load of
          100 ohms ?               (type letter)

                          a)  Constant current
                          b)  Constant voltage
arrow     1322
answer    (A,a)
wrong     (B,b)
addl      n60
***

unit      x04m4f
at        920
write        If you required more current than the DC SUPPLY
          could furnish, could you connect two DC SUPPLIES
          in parallel ?

             If you required more voltage than the DC SUPPLY
          could furnish, could you connect two DC SUPPLIES
          in series ?
next      n60,x04end,x04end,x04s4d
arrow     1034
answer    (NO,No,no,n)
wrong     (YES,yes,Yes,y)
addl      n60
arrow     1434
answer    (YES,Yes,yes,y)
wrong     (NO,No,no,n)
addl      n60
***

unit      x04m5a
back      x04m0a
base
at        620
write     Do it your self study
at        811
write     Choose any method of study you wish!!

          Enter   i   for only information
                  q   for only questions,  or
```

```
                       b    for both information and questions
arrow     1411
long      1
answer    (I,i)
calc      n59⇐1
answer    (Q,q)
calc      n59⇐3
answer    (B,b)
calc      n59⇐2
***

unit      x04m5b
back      x04m5a
base
at        611
write     (Press -BACK- to change study mode.)
join      x04m3h
arrow     2019
long      1
match     n60,a,b,c,d,e,f,g,h,
next      n60,x,x04m1a,x04m1c,x04m2a,x04m3a,x04m3d,x04m3e,x04m1b

------------------------------------------------------------------- part=1, block=j ------------

          block 1j,   x04s0a

unit      x04s0a
*         dummy unit to end goto's
***

unit      x04s1a
at        711
write        The DC SUPPLY is used to generate direct
          current; that is, the current (or voltage)
          generated is constant for a given load, i.e.
          it is not a periodic function of time.

             Of course the output of the device is
          adjustable, but for any setting it will not
          generate anything but a constant voltage and
          current, if the load is constant.
***

unit      x04s1b
at        711
write     Note that this supply can only generate voltages
          up to 40 volts dc.  Also, the maximum current
          capacity of this supply is 0.5 amperes.
          Voltages or currents greater than these limits
          cannot be produced.

          However, the supply will not operate at all if
          the CURRENT dial is set less than about 0.1 amp.
***
```

```
unit     x04s1c
at       811
write  *   Turn on the DC SUPPLY by throwing the
         small toggle switch on the left of the supply.
         The small, red pilot light should glow.
***

unit     x04s2a
at       611
write    Calculating I_L and V_L is easy.  Just assume that
         the supply is in either constant voltage or
         constant current operation.  Then, use R_L to
         calculate the remaining V_L or I_L.  If the V or
         I is not greater than it's limit, you have the
         solution.  If not, the supply is operating in
         the other mode.
***

unit     x04s2b
at       2311
write    I_L cannot be greater than the current limit.
***

unit     x04s2c
at       2311
write    No, if I_L were really that, what would V_L be?
         Find which parameter (I or V) would be limiting?
```

-- part=1, block=k ----------

block 1k,   x04s2d

```
unit     x04s2d
back     n59,x04m2c,x04m3h,x04m5b
next     n59,x04s2d2,x04m3h,x04m5b,x04s2d2,x04m5b
join     n59-3,x04s2d1,x
goto     n59,x,x04s0a,x04s0a,x
jump     n59=3,x04s2d2,x
***

unit     x04s2d1
at       810
write      To set the power supply to a given voltage and
         current limit output, first short the +(red)
         and -(black) terminals of the DC SUPPLY
         with a test lead.

           With the METER switch on AMPS, adjust the
         CURRENT control to the desired current limit.

           Remove the test lead from the DC SUPPLY
         terminals and turn the METER switch to VOLTS.
         Then adjust the VOLTAGE control to the desired
```

```
            output voltage limit.

                One additional note: Be sure you are reading
            the correct meter scale when setting the
            current and voltage limits.
    ***

    unit    x04s2d2
    back    n59-3,x04s2d,x04m5b
    next    n59,x04m2c,x04m3h,x04m5b
    at      410
    write   To set the output current limit of the DC SUPPLY,
            which of the following is necessary?

            a) The + output terminal of the supply should
            be grounded.

            b) The + and - terminals of the supply should
            be shorted together.

            c) The + and - terminals of the supply should
            be left open circuited.
    arrow   1520
    specs   nookno
    answer  (b,B)
    at      1705
    write       Right! But remember to disconnect the short when
            setting the output voltage limit.
    wrong   (a,A)
    at      1705
    write       No! The DC SUPPLY is a floating supply and hence
            neither the + or - terminals are internally
            connected to ground.
    wrong   (c,C)
    at      1705
    write       No! Only when you are setting the voltage limit
            is it necessary that the output terminals be
            open circuited.
    no
    at      1705
    write   Just type the letter of your response.
    ***

    unit    x04s2e
    next    x04m2c
    pack    n38,+++++++++++++++++ij++++
    join    ckd1
    jump    n47,x04s2f,x
    at      1116
    write   You are reading the wrong meter scale!!
    ***

    unit    x04s2f
    next    x04s2d
    at      1005
    write       You have incorrectly set the VOLTAGE and/or
            CURRENT dials. You will receive help when you
```

```
        you press -NEXT-.
------------------------------------------------------------ part=1, block=1 ----------

     block 11,   x04s3a

unit      x04s3a
at        811
write        The output of the DC SUPPLY is available
          at the red and black jacks in the lower right
          area of the panel.  The silver jack at the far
          right is a chassis ground and may be connected
          to either the red or black jack as required.
***

unit      x04s3b
at        809
write        Note carefully that two DC SUPPLIES cannot
          be connected in parallel to achieve a greater
          current capability.  The reason for this is
          simple but important:

             If two DC SUPPLIES are connected in parallel,
          one supply will try to drive the other and a
          large current will flow along the low resistance
          wires between the supplies.  This does not
          happen when two DC SUPPLIES are connected in series
          with a current limiting load; thus, they can be
          connected in series to generate larger voltages
          than either supply acting alone.
***

unit      x04s3c
at        811
write        Note the METER switch located just right of
          the panel meter.  This switch controls the
          indications of the meter.  The meter will
          measure either load current or load voltage,
          depending upon the position of the switch.

             Note that this switch has NO EFFECT on the
          operation of the supply, it simply indicates the
          actual terminal voltage or current.
***

unit      x04s4a
at        1011
write     Remember...

                Set the output voltage to 15 V dc.

             (It will be necessary for you to increase
          the output current limit until the voltage
          across the 500 ohm resistor is 15 V dc.)
```

```
                Monitor the output voltage!
next      xØ4m4a
***

unit      xØ4s4b
pack      n33,+++++++++++++++a(ijk)q+++++
join      ckd1
jump      n47,xØ4s4c,x
at        1116
write     You are reading the wrong meter scale!!
next      xØ4m4d
***

unit      xØ4s4c
join      xØ4s2f
pause
erase
join      xØ4s2d1
pause
jump      xØ4m4d

---------------------------------------------------------- part=1, block=m ----------

          block 1m,  xØ4end

unit      xØ4s4d
at        1211
write        You appear to be having some trouble.

             Press -NEXT- for a chance to review.
c         A student failing the prof. test has n59⇐-1.
next      n59,xØ4m5a,xØ4m3h,xØ4m5a
***

unit      xØ4end
back      xØ4m5a
join      imode
jump      n47,xØ4end,x
course    n2
calcc     n2='ee244',
          nc(n21+1)⇐(nc(n21+1)$mask$o7777777777ØØØØØØØØØØ)+o46Ø3ØØØØØØ,
          nc(n21+1)⇐nc(n21+1)
erase
output    /// student has completed experiment ///
join      endunit
join      jmpmes
jumpout   cgeindex,quest1

entry     leave
end       lesson
***

unit      endunit
```

```
course  n2
jump    n2≠'ee244',leave,x
calc    nc(n21+7)⇐nc(n21+7)+ahelp
        vc(n21+6)⇐vc(n21+6)+atime/60000
***Incl.cge s.r. & terms sample,index,imode,comment,slides.
use     eex00,ck1
use     ck2
use     ck3
use     ck4
use     ck5
use     ck6
```

```
ckc        not found           208
ckcw       not found           309
ckd        not found           189   254   315   348
ckd1       not found           528   586
endunit    x04end      623     21    617
imode      not found           31    226   290   320  609  354
jmpmes     not found           618
leave      x04end      620     625
x04end     x04end      607     380   380   610
x04m0a     x04m0a      29      32    52    296   391
x04m0b     x04m0a      51      34    62
x04m1a     x04m0a      61      53    84    284   418
x04m1b     x04m1b      83      63    111   284   418
x04m1c     x04m1b      110     85    125   284   418
x04m2a     x04m2a      124     112   147   284   418
x04m2b     x04m2b      146     126   127
x04m2c     x04m2b      176     148   148   471   495         526
x04m2d     x04m2b      187     178
x04m3a     x04m3a      193     191   209   212   212   418   284
x04m3b     x04m3a      206     195   195
x04m3c     x04m3a      211     209   227   230
x04m3d     x04m3d      229     213   227   242   284         418
x04m3e     x04m3d      241     231   249   284   418
x04m3f     x04m3d      248     243   243   246   255
x04m3g     x04m3d      257     125   255
x04m3h     x04m3h      262     62    63    84  112   85  148   111
                               191   194   195 227  212  230   213
                               231   242   243 414  255  471   260
                               472   495   605
x04m4a     x04m3h      288     54    278   291   582
x04m4b     x04m3h      295     293   311
x04m4b1    x04m3h      313     310
x04m4c     x04m3h      319     317   321
x04m4d     x04m4d      341     590   598
x04m4e     x04m4d      353     351   355
x04m4f     x04m4d      372
x04m5a     x04m4d      390     55    410   605   605         608
x04m5b     x04m4d      409     62    63    84  112   85  125   111
                               148   191   191 125  191  213   194
                               227   230   231 255  242  255   243
                               255   471   472       472  495   494
x04s0a     x04s0a      420     65    65    87  114   87  130   114
                               150   179   179 233  197  233   197
                               245   245   279        474        474
x04s1a     x04s0a      423     64
x04s1b     x04s0a      434     86
```

xØ4s1c	xØ4sØa	445		113						
xØ4s2a	xØ4sØa	451		149						
xØ4s2b	xØ4sØa	461		166						
xØ4s2c	xØ4sØa	465		166						
xØ4s2d	xØ4s2d	47Ø		177	284	494		534		
xØ4s2d1	xØ4s2d	477		473	596					
xØ4s2d2	xØ4s2d	493		472	472	475				
xØ4s2e	xØ4s2d	525		19Ø						
xØ4s2f	xØ4s2d	533		191	529	593				
xØ4s3a	xØ4s3a	54Ø		196						
xØ4s3b	xØ4s3a	548		232						
xØ4s3c	xØ4s3a	563		244						
xØ4s4a	xØ4s3a	574		316						
xØ4s4b	xØ4s3a	584		349						
xØ4s4c	xØ4s3a	592		35Ø	587					
xØ4s4d	xØ4end	6ØØ		337	38Ø					
ahelp		626								
atime		627								
nc		613	613	614	614	626		626		
n2		611	612	624	625					
n21		613	613	614	614	626		626	627	627
n33		188	2Ø7	253	3Ø8	314		347	585	527
n47		32	19Ø	191	2Ø9	227	310	255	316	291
		321	349	35Ø	355	529		587		61Ø
n59		35	62	63	64	65	86	84	87	85
		111	112	113	114	125	149	127	150	148
		179	191	194	195	196	213	197	227	242
		23Ø	231	232	233	242	245	243	246	244
		255	259	279	4Ø3	4Ø5	472	4Ø7	473	471
		474	475	~~494~~	495	6Ø5				
n6Ø		283	284	292	33Ø	334	370	337	380	339
		384	388	417	418					
vc		627	627							
v55		164	166	171						
%		16Ø								

lesson information

lesson name = eexØ4

starting date = Ø3/29/73

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by neal of course eecge

at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = The Operation and Uses of the DC Supply, Harrison 865B.

block 1a, eex05id

```
stop
***     For Neal, CGERL, Room 248, EEB.
One line description of this lesson --
   The Operation and Uses of the Vacuum Tube Voltmeter, HP400D.
            Divisions of this Lesson:          Block      Unit
          Id for this file                     eex05id
          Experiment eex05;
            Objectives                         eex05id    x05m0a
            Properly set range dial            x05m1a     x05m1a
            Properly connect vtvm              x05m1a     x05m2a
            Determine uses of vtvm             x05m2d     x05m3a
            Convert rms to p-p                 x05m2d     x05m4a
            Predict vtvm indications           x05m4h     x05m5a
            Final test                         x05m5n     x05m6a
         Final edit 21 aug 74 neal.
*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   <at,1010> Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon
area    eex05
ext     0
***
unit    x05m0a
base
restart
next    x05m1a
join    imode
jump    n47,x05m0a,x
at      507
write   THE OPERATION AND USES OF THE VACUUM TUBE VOLTMETER,
                      Hewlett Packard Model 400D
            In this experiment, you should learn to:
          1)     Adjust the RANGE dial of the VTVM to measure
          voltages accurately.
```

2) Properly connect the VTVM to the terminal whose voltage-to-ground is to be measured.

3) Determine those voltages which can and cannot be accurately measured on the VTVM.

4) Convert V_{rms} to V_{pp}, and understand the relationship between the two for sinusoidal waveforms.

5) Predict the VTVM indication for simple non-sinusoidal periodic waveforms.

-- part=1, block=b --------

block 1b, x05m1a

```
unit     x05m1a
back     x05m0a
next     x05m1b
at       510
write       Voltage measurements are displayed on the
         large panel meter.  The RANGE switch (below the
         meter) is used to scale the input voltage to
         allow more accurate readings.

            The setting of the RANGE switch determines the
         largest rms voltage voltage that can be measured
         at that setting.  For most accurate measurements,
         the pointer should indicate in the range between
         30 to 100 % of full scale.
***

unit     x05m1b
back     x05m1a
next     x05m1b1
help     x05s1a
at       1010
write       Set the RANGE dial to accurately measure a
         45 rms volt signal.


                   -HELP- is available.
***

unit     x05m1b1
help     x05s1a
pack     n33,+++++++++++++++++++++k+
join     ckdw
jump     n47,x,x05m2a
next     x05m1b
***

unit     x05m2a
```

```
back      x05m1b
next      x05m2b
at        510
write        The voltage applied between the RED and BLACK
          jacks on the left side of the voltmeter marked
          INPUT is the voltage that will be measured by
          the voltmeter.  The BLACK jack is internally
          connected to ground.  The RED jack is connected
          to the point of interest.  Note that the
          resultant voltage is always measured with
          respect to ground, because the BLACK jack is
          internally grounded.
***

unit      x05m2b
back      x05m2a
next      x05m2c
at        1010
write        If you were to measure a voltage with respect
          to ground at some point "X" , which color terminal
          on the VTVM would you connect to "X" ?
arrow     1610
specs     bumpshift
answer    red
at        2010
write        RIGHT ! And that's the only connection required.

             However, if you were to measure a voltage in an
          UNGROUNDED circuit you would have to connect the
          black terminal of the VTVM to the circuit also.
wrong     black
at        1310
write        The black jack is already connected to ground.
no
at        1610
write        You only need to write the color of the jack.
***

unit      x05m2c
back      x05m2b
next      x05m2d
at        510
write        Connect the VTVM to display an indication for
          the 0.1V P-P CAL OUT  jack on the SCOPE.
------------------------------------------------------------- part=1, block=c -------

     block 1c, x05

unit      x05m2d
back      x05m2c
next      x05m3a
help      x05s1a
at        510
```

```
write      Adjust the RANGE switch to accurately measure
           the output from the 0.1V P-P  CAL OUT  jack.

              What indication do you read ?
at         1429
write      -HELP- is available
arrow      843
specs      nookno
ansv       0.056,.002
at         1015
write      Excellent !  A very close reading.
ansv       0.056,.01
at         1015
write      That's a good reading.
wrongv     0.056,.04
at         1015
write      Try to get a little closer reading.
wrongv     0.0056,.001
at         1015
write      You've got the wrong jack !
no
at         1015
write      You're way off, better try again.
***

unit       x05m3a
back       x05m2d
next       x05m4a
at         305
write         The nonsinusoidal voltage from the SCOPE that you just
           measured was at a frequency of 1000 Hz. Furthermore, the
           scale reading was equal to or less than the voltage label.

              Only frequencies greater than 10 Hz but less than
           4 MHz ( 4 x 10^6 ) can be measured accurately.

              Also, only indications larger than about 0.001 and
           less than 300 can be read accurately.
at         1508
write         Can the VTVM be used to measure:

           1)  A .17 V p-p 1000 Hz signal ?            (yes/no)

           2)  The 115 volt ac output of a wall receptacle ?

           3)  A 43 volt dc signal ?
arrow      1739
specs      bumpshift
answer     yes
arrow      1957
specs      bumpshift
answer     yes
arrow      2133
specs      bumpshift
answer     no
no
at         2422
```

```
write     REMEMBER: dc is 0 Hz.
***

unit      x05m4a
restart
base
join      imode
jump      n47,x05m4a,x
at        507
write       This task will examine the relationship between
          the peak-to-peak voltage measurement on the SCOPE,
          and the R.M.S. SINE indication on the VTVM, for the
          same ac signal.

            In electrical engineering, the term ac for
          alternating current usually refers to a sinusoidal
          current with a zero average value.

            To begin our experiment, we need an ac source.
          Hence, set the AUDIO OSCILLATOR to an output frequency
          of 2000 Hz.
pause
jump      key=back,x05m3a,x

entry     x05m4a1
pack      n33,++++++++++++++++++<b(uv)c(bc)>+
join      ckd
jump      n47,x05s4a,x05m4b
***

unit      x05m4b
at        1007
write       Measure this signal with the VTVM, as follows:

            First, set the VTVM range to allow the most accurate
          measurement of a 25 rms volt sinusoidal signal.
pause
jump      key=back,x05m4a,x
pack      n33,++++++++++++++++++++j
join      ckd
jump      n47,x05s4b,x05m4c
------------------------------------------------------------ part=1, block=d ----------


          block 1d,  x05m4c


unit      x05m4c
at        510
write       Connect the output of the AUDIO OSCILLATOR
          to the VTVM.

            The VTVM is internally grounded and only
          requires one connection.
```

```
              Be sure that the AUDIO OSCILLATOR ground link
          is connected and tightened.
pause
jump      key=back,x05m4b,x
pack      n33,000000000000b00000000000000aba
join      ckcw
jump      n47,x,x05m4d
next      x05m4c
***

unit      x05m4d
back      x05m4c
next      x05m4d1
at        510
write         Carefully adjust the output AMPLITUDE of the
          AUDIO OSCILLATOR to cause a 25 rms volt indication
          on the VTVM.
***

unit      x05m4d1
pack      n33,+++++++++++++++++(rs) (bc) (bcuv) j
join      ckd
jump      n47,x,x05m4e
pack      n33,+++++++++++++++++(tu) (bc) (bcuv) j
join      ckd1
goto      n47,x,x05s4c
pack      n33,+++++++++++++++++(pq) (bc) (bcuv) j
join      ckd1
goto      n47,x,x05s4d
at        510
write         You're way off! The frequency should still
          be 2000 Hz. The VTVM should be set to measure
          25 RMS volts. The Audio Oscillator AMPLITUDE
          should be adjusted to cause an indication of
          25 rms volts on the VTVM.
pause
jump      x05m4d1
***

unit      x05m4e
back      x05m4d
next      x05m4f
erase
catchup
at        1510
write         Now that you have set the AUDIO OSCILLATOR
          correctly, do not change any of its controls unless
          specifically directed.
***

unit      x05m4f
back      x05m4e
next      x05m4g
at        510
write         The ac voltage you have set is measured
          on the VTVM in rms (root-mean-square) volts.
```

```
                Root-mean-square volts are defined as follows:
at      1019
write   Vrms = [ (1/T) ∫0^T (v(t))^2 dt ]^1/2

at      1210
write   where T = the period of v(t), and v(t) is in volts.
pause
at      1410
write     Note that root-mean-square is descriptive
        of the above formula, as follows:

        ROOT = square root of the bracketed expression

        MEAN = 1/T × ∫0^T (     ) dt of the following integrand

        SQUARE = squared time function = (v(t))^2
***

unit    x05m4g
back    x05m4f
at      706
write     Set the SCOPE to measure an ac voltage on the A
        channel with A VOLTS at 100 V FULL SCALE.

          Of course, the A PREAMP should be AC coupled and
        the SWEEP should be internally triggered by AC signals.

        RECALL: DO NOT TOUCH THE AUDIO OSCILLATOR DIALS!
pause
pack    n33,44p++f+ab+++++++++++++
join    ckd
jump    n47,x05s4e,x05m4h
```

-- part=1, block=e ----------

```
     block 1e,   x05m4h

unit    x05m4h
at      710
write     Connect the output of the AUDIO OSCILLATOR
        to the A INPUT of the SCOPE.

          The SCOPE is grounded by ground links and also
        requires only one connection.
pause
pack    n33,0000000000000a00b0000000000ba+0
join    ckcw
jump    n47,x,x05m4i
next    x05m4h
***

unit    x05m4i
base
back    x05m4e
```

```
next     x05m5a
calc     n120⇐-1
at       510
write    What is Vpp (from the SCOPE)?  ____   volts
arrow    540
store    v55
ansv     70,4
endarrow
calc     v56⇐25.0/v55
at       710
write    On the basis of your measurements:

                   Vrms =   -----   × Vpp
join     x05s4f

entry    x05m4i1
inhibit  erase
data     x05s4f
back     x05m4e
arrow    922
ansv     v56,10%
no
at       1110
write    Vrms = VTVM indication = 25

         Vpp = Scope Reading = ⟨s,v55⟩ volts

         Vrms = ?? × Vpp

         Press -NEXT- to clear your answer; then...
         ...Press -DATA- to re-use the calculator.
endarrow
calc     n120⇐0
at       1110
write    And  Vpp =   -----   × Vrms
join     x05s4f

entry    x05m4i2
inhibit  erase
data     x05s4f
back     x05m4e
arrow    1122
ansv     v55/25,2%
no
at       1315
write    Press -NEXT- to clear your answer then ...
         ... press -DATA- to re-use the calculator
endarrow
at       1310
write    NOTE:  These conversion factors are only valid
         for a sinusoidal wave symmetric about 0 volts.

         Let's take a look at what the theoretical values
         are for these conversion factors.
***

unit     x05m5a
```

```
term     rms
back     x05m4i
next     x05m5b
erase
catchup
at       .210
write       NOTE: Study this sequence carefully.
         You'll be asked a problem based on this method.
at       715
write       Consider an ac or simple sine wave:

                        v(t) = sin(ωt)
join     x05s5b
delta    .1
funct    (sin(v55)),v55
***

unit     x05m5b
back     x05m5a
next     x05m5c
at       305
write       Now let's square v(t):

                (v(t))² = (sin(ωt))²
join     x05s5b
delta    .1
funct    (sin(v55))²,v55
pause
join     x05s5b1
pause
calc     v60⇐sqrt(v59)
at       2219
write    V_rms = √Y1  = <z,v60,3.3>
hbar     2π,.707,-
graph    2.1π,.707,V_rms
pause
at       2505
write       The average of the squared wave is 0.5

            The square root of 0.5 is 0.707

            The value of V_rms = 0.707 for v(t) = sin ωt compares
         with V_pp = 2.0 which is read on the Scope for v(t).
```

-- part=1, block=f ----------

block 1f, x05m5c

```
unit     x05m5c
back     x05m5b.
next     x05m5d
at       709
write       Generally, as applies for any simple sine wave,
         the following ratios are established:
```

```
                 Vpp / Vrms = 2√2 = 2.828
                 VØp / Vrms = 2√2 / 2 = √2 = 1.414
               Or, inversely:
                 Vrms / Vpp = √2 /4 = Ø.354
                 Vrms / VØp = 1/√2 = √2/2 = Ø.7Ø7
***

unit    xØ5m5d
back    xØ5m5a
next    xØ5m5e
at      2Ø5
write      The rms value of a periodic voltage is the square
        root of the average of the squared voltage.

           Calculate Vrms for the following wave:

        Vrms =          rms volts    (Press -BACK- to review)
at      1235
write   v(t) =  1      Ø < t < T/2
             = -1    T/2 < t < T
join    xØ5s5b
gdraw   Ø,1;π,1
gdraw   ;π,-1
gdraw   ;2π,-1
gdraw   ;2π,Ø
arrow   712
ansv    1.Ø
no
at      25Ø5
write      1² is the same as (-1)², the average over one
        period of the constant 1.Ø volt is 1.Ø volt, and
        the square root of 1. is 1.
***

unit    xØ5m5e
restart
back    xØ5m5d
next    xØ5m5e1
join    imode
jump    n47,xØ5m5e,x
at      5Ø5
write      Although the VTVM scales are calibrated in the unit
        R.M.S. VOLTS for a simple SINE wave, the VTVM does not
        indicate the root-mean-square voltage for any signal.

           The actual indication on the VTVM is related to the
        input signal by the following formulae:
at      12Ø7
join    xØ5s5a
***

unit    xØ5m5e1
```

```
back      x05m5e
next.     x05m5e2
at        707
write      As noted, the VTVM indication for a pure sine wave
          is its rms voltage, and this is not true generally
          for every non-sinusoidal waveshape.

             The relation between the waveshape of a periodic
          voltage applied at the INPUT of the VTVM, the responsive
          position of the pointer of the VTVM, and the scale
          reading indicated by the pointer can be understood
          more clearly by tracing the effects of the INPUT voltage
          through a schematic diagram of the VTVM.
```

-- part=1, block=g ---------

block 1g,   x05m5e2

```
unit      x05m5e2
back      x05m5e1
next      x05m5e3
join  -   x05s5e2
at        1605
write        The signal at the INPUT terminals of the VTVM is:

          vAA' = v(t)
pause
mode      erase
at        1605
write        The signal at the INPUT terminals of the VTVM is:

          vAA' = v(t)
mode      write
at        1605
write     vAA' = v(t)

             The capacitor blocks the average value so at BB'
          only the ripple remains:

          vBB' = v(t) - Vav, where Vav = 1/T ∫0^T v(t) dt
at        190,456
write     B
at        190,344
write     B'
pause
mode      erase
at        1805
write        The capacitor blocks the average value so at BB'
          only the ripple remains:

          vBB' = v(t) - Vav, where Vav = 1/T ∫0^T v(t) dt
mode      write
at        1805
write     vBB' = v(t) - Vav, where Vav = 1/T ∫0^T v(t) dt
```

```
           The full-wave rectifier converts all negative values
         to positive values, so the fully-rectified ripple
         at CC' is:

         vCC' = |v(t) - Vav|
size     7
at       352,382
write    }
size     0
at       384,400
write    Full-wave
         Rectifier
at       235,321
write    C
at       333,321
write      C'
pause
mode     erase
at       2005
write      The full-wave rectifier converts all negative values
         to positive values, so the fully-rectified ripple
         at CC' is:

         vCC' = |v(t) - Vav|
mode     write
at       292,319
write    M
at       2005
write    vCC' = |v(t) - Vav|

           The d'Arsonval mechanism (M), because of its inertia,
         cannot respond to a frequency greater than 3 Hz, so
         the pointer responds to the average value of vCC' :

         VTVM response = 1/T ∫0^T |v(t)-Vav|dt

pause
mode     erase
at       2205
write      The d'Arsonval mechanism (M), because of its inertia,
         cannot respond to a frequency greater than 3 Hz, so
         the pointer responds to the average value of vCC' :

         VTVM response = 1/T ∫0^T |v(t)-Vav|dt

mode     write
at       2205
write    VTVM response = 1/T ∫0^T |v(t)-Vav|dt

           The manufacturer marked this VTVM meter scale to
         indicate R.M.S. volts when a simple sine wave is
         applied to the INPUT. Therefore, the VTVM indication is:

         VTVM indication = 1.11/T ∫0^T |v(t)-Vav|dt
```

block 1h, xØ5m5e3

```
unit    xØ5m5e3
back    xØ5m5e2
next    xØ5m5f
at      5Ø5
write     In general, the value indicated by the VTVM pointer
        is 1.11 times the average of the fully-rectified
        ripple of the INPUT voltage.  This is mathematically
        expressed by the following previously-mentioned formula:
at      12Ø7
join    xØ5s5a
***

unit    xØ5m5f
back    xØ5m5e
next    xØ5s5b
calc    nr2Ø⇐1
erase
catchup
at      5Ø5
write     Let's look at some non-sinusoidal waveforms from
        the Function Generator and see how this applies:

          Accomplish this task:

          On the A channel of the oscilloscope:

        Display two cycles of a square wave with Vpp = 2Ø V,
        and Vav = Ø.

        Set the A PREAMP at +DC.

        Use a generator frequency of 1 kHz.

        Connect the VTVM to measure this same signal, starting
        with the 3ØØ RANGE and reducing the RANGE until you
        display the reading most accurately.
***

unit    xØ5m5g
base
back    xØ5m5f
at      31Ø
write   What is the reading on the VTVM ?

                   Vindicated =
at      535
writec  n12Ø,,,,<s,v51>
goto    n12Ø,x,x,x,xØ5m5gØ
arrow   533
store   v51
```

```
ansv      11.Ø,1
endarrow

entry     xØ5m5gØ
at        81Ø
write     On the basis of your measurement:
at        11Ø5
write     Vindicated = ______   Vpp for a symmetrical square wave.
calc      v56⇐v51/2Ø
at        1125
writec    n12Ø,,,,<s,v56>
goto      n12Ø,x,x,x,xØ5m5gØa
join      xØ5s4f

entry     xØ5m5g1
inhibit   erase
back      xØ5m5f
data      xØ5s4f
arrow     1119
ansv      v56,1Ø%
no
at        13Ø8
write     Vpp = 2Ø V.
          Vindicated = <s,v51>
          thus, Vindicated = ?? × Vpp
          Press -NEXT- to clear your answer then...
          ... press -DATA- to re-use the calculator
endarrow

entry     xØ5m5gØa
calc      n12Ø⇐2
at        13Ø7
write        For a square wave symmetrical about Ø V:

                        Vpp = 2 VØp = 2 Vrms .

          therefore your conversion factor is:

             Vrms = VØp = ______   × the VTVM indication.
at        32Ø4
write     -HELP- is available
help      xØ5s5f
join      xØ5s4f

entry     xØ5m5g2
inhibit   erase
back      xØ5m5f
data      xØ5s4f
help      xØ5s5f
arrow     2Ø25
ansv      .9Ø91,.1
no
at        221Ø
write     Press -NEXT- to erase your answer,
```

```
        then, press -DATA- to re-use the calculator.
endarrow

------------------------------------------------------------- part=1, block=i ---------

        block 1i, x05m5h

unit    x05m5h
back    x05m5g
next    x05m5h1
erase
catchup
at      1010
write   Now adjust the ± dc level adust on the  func-
        tion generator to produce a sq. wave such that:

        V+pk = 20 volts and V-pk = 0 volts as measured

        on the scope. The frequency is left at 1 kHz.

        NOTE: the dc level adjust interacts with the
        amplitude, therefore, you must adjust them both
        to obtain the desired signal.
at      3007
write                   Press -NEXT- when ready.

unit    x05m5h1
pack    n33,+(ghi)(no)+(cd)(defg)caba<f(tuv)g(ab)>d(defghi)(stu)++++++j
join    cbdu
jump    n47,x,x05m5i
next    x05m5h
***

unit    x05m5i
back    x05m5h
next    x05m5j
at      1010
write   What is the VTVM indication ?

             ____ volts
arrow   1210
ansv    11.0,1
at      1410
write   That's correct! Note that changing Vav
        changes Vrms as well as V0-p , however,
        Vpp and the indication on the VTVM are
        the same.
***

unit    x05m5j
back    x05m5i
at      1010
write   You could therefore conclude that the
```

```
              VTVM indication for a given waveform
              is directly proportional to the
              _    voltage of that waveform.  (A,B,C,D)
at            2110
write         A)   RMS
              B)   AVERAGE
              C)   0-PEAK
              D)   PEAK-PEAK
arrow         1310
answer        (D,d)
***

unit          x05m5k
back          x05m5j
at            210
write         NOTE: Study this sequence carefully. You'll
              be asked a problem based on this method.
at            522
write         Consider this waveform:
at            722
size          2
write            v(t)
size          0
join          x05s5e
gdraw         0,1;2,2;6,0;8,1
pause
at            2010
write                   Vav = 1/T ∫0^T v(t) dt
pause
hbar          0,1,-
at            1148
write         * Vav = 1
***

unit          x05m5l
back          x05m5k
at            522
write         Performing the operation:

                     v(t) - Vav
join          x05s5e
gdraw         0,0;2,1;6,-1;8,0
***

unit          x05m5m
back          x05m5l
at            522
write         Next finding the magnitude:

                     | v(t) - Vav |
join          x05s5e
gdraw         0,0;2,1;4,0;6,1;8,0
pause
at            1818
write         calculating: V1 = 1/T ∫0^T |v(t) -Vav| dt
pause
hbar          8,.5,-
```

```
at        1348
write     ⇐ V1 = .5
pause
at        2110
write     The VTVM should therefore indicate :

          1.11072 × V1   or approximately .555 volts
```

-- part=1, block=j ---------

block 1j, x05m5n

```
unit      x05m5n
term      test
back      x05m5k
at        1010
write     If you would like to repeat the last graphical
          sequence explaining the VTVM response......

          press -BACK-. Otherwise press -NEXT-.
***
unit      x05m5o
back      x05m5n
erase
catchup
at        1010
write     At this time you might want to experiment
          with some waveforms other than the square
          wave from the function generator. See if
          you can predict what they should indicate
          on the VTVM for a given amplitude, then
          verify this by measuring it with the VTVM.


          When you are ready for a challenge to your
          prowess...........PRESS -NEXT-.
at        2110
write                       REMEMBER
at        2310
join      x05s5a
***
unit      x05m6a
calc      n12043
next      x05end
back      x05m5o
base
help      x05s6a
at        3210
write     HELP is available........
join      x05s5e
gdraw     ;0,0.5;2,1.5;4,1.5;4,0.5;6,-.5;8,-.5;8,.5
at        410
```

```
write   On the basis of what you have learned in this
        experiment, what would the VTVM indicate for
        this waveform? ____     volts
at      1918
join    x05s5a
join    x05s4f

entry   x05m6a1
inhibit erase
data    x05s4f
help    x05s6a
next    x05end
back    x05m5o
arrow   625
ansv    .833,.01
no
at      718
write   Press -NEXT- to clear you answer then...
        ...press -DATA- to re-use the calculator
***

unit    x05s1a
at      505
write      The RANGE setting indicates the largest rms volt
        signal that the voltmeter can measure. Thus, if
        you wanted to measure a signal of approximately
        15 rms volts, you would not set the RANGE dial to
        10.0, but rather, to 30.0 to obtain a readable
        indication.
end
***

unit    x05s4a
next    x05m4a1
back    x05m4a
at      510
write   I caught you daydreaming, didn't I !
at      710
write   Come on now, you can do better than that
        I asked for 2000 Hz. In case it slipped your
        mind....

              Freq.out = Freq. setting × Multiplier.

        Let's set it carefully and continue on.
              Press -NEXT- when ready.
***

unit    x05s4b
at      510
write   Surely you're not nervous!
        Let's try that again.

        Just set the range switch to 30  and then ...

        Press -NEXT-
pause
```

```
pack    n33,+++++++++++++++++++++++++j
join    ckd
jump    n47,xØ5s4b,xØ5m4c
```

--- part=1, block=k ---------

block 1k, xØ5s4c

```
unit    xØ5s4c
at      51Ø
write   Not bad. You're just a little high.
        In order to get good results we need
        to be a little more precise.

        I want that needle right on Ø25 VRMS.
        When you've got it, press -NEXT-.
pause
jump    xØ5m4d1
***

unit    xØ5s4d
at      51Ø
write   You're just a little low. To get good
        results we must be precise as possible.

        Set the amplitude as close to .25 VRMS
        as you can and then press - NEXT - .
pause
jump    xØ5m4d1
***

unit    xØ5s4e
at      61Ø
write   Are you sure that you know all that ?

        The A channel should be
        AC coupled at 1ØØ volts
        full scale. Internally
        trigger the sweep from
        AC levels in the AUTO mode.
        Display only the A channel
        and sweep it normally (not
        times 5).

        Then, press -NEXT-.
pause
pack    n33,++p++f+ab+++++++++++++
join    ckdw
jump    n47,x,xØ5m4h
next    xØ5s4e
***

unit    xØ5s4f
inhibit erase
```

```
calcs   n12Ø,n121⇐922,1122,1123,2Ø25,625
mode    erase
at      3Ø19
write   Press -NEXT- to enter your answer above
        Press -BACK- to recalculate
at      n121
write   >
mode    write
at      2737
erase   2Ø
at      2838
erase   15
catchup
draw    2617;2657;2957;2917;2617
at      2719
write   CGE Calculator
        Enter Expression:

arrow   2837
store   v1ØØ
ok
endarrow
at      2938
show    v1ØØ
at      3Ø19
write   Press -NEXT- to enter your answer above
        Press -BACK- to recalculate
pause
goto    key=back,xØ5s4f,x
jump    n12Ø,xØ5m4i1,xØ5m4i2,xØ5m5g1,xØ5m5g2,xØ5m6a1
***

unit    xØ5s5a
write   V_indicated = (π√2 / 4) · (1/T) ∫_Ø^T | v(t) - V_av | dt

         where V_av = (1/T) ∫_Ø^T v(t) dt.

        Here:  π√2 / 4  =  √2 / 2 / 2 / π  = 1.11 for a sine.
***

unit    xØ5s5b
origin  151Ø
axes    Ø,-1ØØ,3ØØ,1ØØ
scalex  2π
scaley  1
markx   π,π/4
labely  1,.25
```

-- part=1, block=1 ----------

block 11, xØ5s5b1

```
unit     x05s5b1
at       705
write    and calculate the average of the squared wave as Y1:
at       2019
write    Y1 = 1/T ∫0^T ( v(t) )^2 dt =
mode     rewrite
at       1828
write    Plato is computing Y1 by increments.
calc     v59⇐0
doto     2line,v70⇐1,50
calc     v57⇐(sin(2πv70/50))^2
         v58⇐(sin(2π(v70-1)/50))^2
         v59⇐v59+(v57+v58)/100
         v71⇐πv70/25
gdraw    v71,0;v71,v57
at       2044
showt    v59
2line
mode     erase
at       1828
write    Plato is computing Y1 by increments.
mode     write
hbar     2π,.5,-
graph    2.1π,.5,Y1
end
***

unit     x05s5c
pack     n33,000000000000a00b0+++++b+000ab0
join     ckcw
jump     n47,x,x05s5d
next     x05m5f
***

unit     x05s5d
pack     n33,+(ghi)(nop)+(cd)(defg)(bc)aba<f(tuv)g(ab)>d(efghi)(abcd)++++++j
join     ckdw
jump     n47,x,x05m5g
next     x05m5f
***

unit     x05s5e
origin   1515
axes     0,-128,256,128
scalex   8
scaley   2
markx    4,1
labely   1,.25
at       1730
write    T/2
at       1747
write    T
***

unit     x05s5e2
at       117
write    HP 400D VACUUM TUBE VOLTMETER
```

```
draw     117;146
at       1413
write    Internal Schematic Diagram of the VTVM
draw     1413;1451
at       70,431
write     +

          v(t)

          -
draw     88,448;138,448;skip;138,453;138,443
circle   7,150,448,135,225
draw     143,448;193,448;193,428;197,424;189,416;197,408
         189,400;197,392;193,388;193,368;88,368;skip;193,448;293,448;skip;193,368;293,368
draw     293,448;276,431;skip;271,426;254,409;271,392
         skip;276,387;295,368;314,387;skip;319,392
         336,409;319,426;skip;314,431;297,448
draw     276,431;276,424;269,431;276,431;skip;280,427
         272,435
draw     276,387;276,394;269,387;276,387;skip;280,391
         272,383
draw     319,391;319,384;312,391;319,391;skip;315,395
         323,387;skip;319,426;319,433;312,426;319,426
         skip;323,430;315,422
draw     254,409;254,374
circle   6,254,368,90,270
draw     254,361;254,329;280,329
circle   15,295,329
draw     309,329;336,329;336,409
at       85,456
write    A
         ◆
at       85,360
write    ◆
         A'
at       190,440
write    ◆
at       190,360
write    ◆
at       292,440
write    ◆
at       251,401
write    ◆
at       333,401
write    ◆
at       292,360
write    ◆
at       251,321
write    ◆
at       333,321
write    ◆
end
```

-- part=1, block=m ----------

block 1m, x05s5f

```
unit      x05s5f
erase
catchup
at        811
write     Vpp = 2 V0p = 2 Vrms

          Vindicated =  <s,v51>       x  Vpp
                        ------
                          20

          Vpp =      20       x  Vindicated
                   ------
                   <s,v51>

          thus, Vrms =  Vpp  =     20        x  Vindicated
                        ---    ------------
                         2     <s,v51> x 2
pause
jump      x05m5g
***

unit      x05s6a
back      x05m6a
erase
catchup
join      x05s5e
gdraw     0,0.5;2,1.5;4,1.5;4,0.5;6,-0.5;8,-0.5;8,0.5
hbar      8.25,.5,-
at        525
write     Vav = ∫0^T v(t) dt
locate    8.5,.4
write     ← Vav = 1/2
***

unit      x05s6b
back      x05s6a
at        525
write     Performing the operation:
               v(t) - Vav
join      x05s5e
gdraw     0,0;2,1;4,1;4,0;6,-1;8,-1;8,0
***

unit      x05s6c
back      x05s6b
at        522
write     Next, finding the magnitude
            | v(t) - Vav |
join      x05s5e
gdraw     0,0;2,1;4,1;4,0;6,1;8,1;8,0
***

unit      x05s6d
back      x05s6c
help      x05s6e
next      x05m6a
join      x05s5e
```

```
gdraw   Ø,Ø;2,1;4,1;4,Ø;6,1;8,1;8,Ø
at      321
write   Recalling the formula:

        V_indicated = (π√2/4) · (1/T) ∫_Ø^T |v(t) - V_av| dt
        where π√2/4 = 1.11
at      2ØØ5
write     Note that the area to the left of t=T/2 is identical
        to the area to the right.

          Thus, you only need to integrate from t = Ø to
        t = T/2 and multiply by two.

          Press -NEXT- to enter your answer.

          Press -HELP- for further assistance.
***

unit    xØ5s6e
back    xØ5s6d
next    xØ5s6f
help    xØ5s6g
at      7Ø9
write     To find the area under the curve |v(t)-V_av|:

        Press -NEXT- for a geometric approach.

        Press -HELP- to solve the integral directly.
***

unit    xØ5s6f
help    xØ5s6g
back    xØ5s6a
next    xØ5m6a
join    xØ5s5e
gdraw   Ø,Ø;2,1;4,1;4,Ø;6,1;8,1;8,Ø
at      2Ø8
write   Note that the figure to the left of t=T/2 is:

        (rectangle of area 1/2)
doto    3line,n1Ø1⇐1,8,1
calc    v1Ø2⇐n1Ø1 × Ø.25
calc    v1Ø3⇐n1Ø1 × Ø.125
hbar    v1Ø2,v1Ø3,-
3line
at      432
write   - (shaded triangle 1/2 × 1/4 × 1)
at      622
write   = 1/2 - 1/8 = 3/8
at      1924
write   Recall that the total area is twice
        as large ( = 2 × 3/8 = 3/4)

        and V_indicated = 1.11Ø72 × 3/4
write   (at,26Ø8)Press -NEXT- to enter your answer
```

```
                         -BACK- to review this sequence

                         -HELP- to see the integral approach

--------------------------------------------------------------part=1, block=n ---------

    block in,  xØ5end:

unit     xØ5s6g
help     xØ5s6f
back     xØ5s6a
next     xØ5m6a
join     xØ5s5e
gdraw    Ø,Ø;2,1;4,1;4,Ø;6,1;8,1;8,Ø
at       321
write    V_indicated = π√2/4  1/T ∫_Ø^T |v(t)-V_av| dt
pause
at       621
write    = 1.11Ø72 × 1/T × 2 × ∫_Ø^(T/4) 4/T tdt + ∫_(T/4)^(T/2) dt
at       541
write
         [                         ]
pause
at       921
write    = 1.11Ø72 × 1/T × 2 ×  4/T  t²/2 |^(T/4) + (T/2 - T/4)
at       841
write
         [                         ]
pause
at       2Ø21
write    = 1.11Ø72 × [ 2 ×          ]
calc     v61⇐-.1
zero     v62
mode     rewrite
at       1821
write    Plato Computing Integral
doto     1line,v6Ø⇐Ø,2Ø
calcs    v6Ø-11,v61⇐v61+Ø.1,1
gdraw    Ø.2×v6Ø,Ø;Ø.2×v6Ø,v61
gdraw    (Ø.2×v6Ø)+4,Ø;(Ø.2×v6Ø)+4,v61
calcc    v6Ø-11,v63⇐Ø.Ø125×v6Ø×v61,v62⇐v63+(Ø.Ø25×v6Ø×v61)-Ø.25
at       2Ø38
writec   v6Ø-11,<t,v63>,<t,v62>
1line
at       1821
write
mode     write
at       26Ø8
write    Press -NEXT- to enter your answer

                  -BACK- to review this sequence

                  -HELP- for the geometrical approach.
***
```

```
1172  unit     x05end
1173  back     x05m6a
1174  join     imode
1175  jump     n47,x05end,x
1176  course   n2
1177  calcc    n2='ee244',
1178           nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
1179           nc(n21+1)⇐no(m21+1)
1180  erase
1181  output   /// student has completed experiment ///
1182  join     endunit
1183  join     jmpmes
1184  jumpout  cgeindex,quest1

1185  entry    leave
1186  end      lesson
1187  ***

1188  unit     endunit
1189  course   n2
1190  jump     n2≠'ee244',leave,x
1191  calc     nc(n21+7)⇐nc(n21+7)+ahelp
1192           vc(n21+6)⇐vc(n21+6)+atime/60000
1193  ***Incl.cge s.r. & terms sample,index,imode,comment,slides,
1194  use      eex00,ck1
1195  use      ck2
1196  use      ck3
1197  use      ck4
1198  use      ck5
1199  use      ck6
```

ckcw	not found		226	307	957		
ckd	not found		201	212	240	296	838
ckdw	not found		77	659	878	963	
ckd1	not found		243	246			
endunit	x05end	1188	22	1182			
imode	not found		34	184	446	1174	
jmpmes	not found		1183				
leave	x05end	1185	1190				
x05end	x05end	1172	775	794	1175		
x05m0a	eex05id	30	35	52			
x05m1a	x05m1a	51	33	66			
x05m1b	x05m1a	65	53	79	82		
x05m1b1	x05m1a	74	67				
x05m2a	x05m1a	81	78	96			
x05m2b	x05m1a	95	83	118			
x05m2c	x05m1a	117	97	125			
x05m2d	x05m2d	124	119	153			
x05m3a	x05m2d	152	126	198			
x05m4a	x05m2d	181	154	185	210	815	
x05m4a1	x05m2d	199	814				
x05m4b	x05m2d	204	202	224			
x05m4c	x05m4c	215	213	228	231	839	
x05m4d	x05m4c	230	227	258			
x05m4d1	x05m4c	238	232	255	850	860	
x05m4e	x05m4c	257	241	268	313	330	351
x05m4f	x05m4c	267	259	287			

xØ5m4g	xØ5m4c	286		269						
xØ5m4h	xØ5m4h	299		297	3Ø9	879				
xØ5m4i	xØ5m4h	311		3Ø8	368					
xØ5m4i1	xØ5m4h	327		913						
xØ5m4i2	xØ5m4h	348		913						
xØ5m5a	xØ5m4h	366		314	383	419				
xØ5m5b	xØ5m4h	382		369	4Ø7					
xØ5m5c	xØ5m5c	4Ø6		384						
xØ5m5d	xØ5m5c	418		4Ø8	444					
xØ5m5e	xØ5m5c	442		42Ø	447	458		56Ø		
xØ5m5e1	xØ5m5c	457		445	472					
xØ5m5e2	xØ5m5e2	471		459	549					
xØ5m5e3	xØ5m5e3	548		473						
xØ5m5f	xØ5m5e3	559		55Ø	58Ø	6Ø3		631	965	959
xØ5m5g	xØ5m5e3	578		643	964	1Ø45				
xØ5m5gØ	xØ5m5e3	591		586						
xØ5m5gØa	xØ5m5e3	618		599						
xØ5m5g1	xØ5m5e3	6Ø1		913						
xØ5m5g2	xØ5m5e3	629		913						
xØ5m5h	xØ5m5h	642		661	664					
xØ5m5h1	xØ5m5h	657		644						
xØ5m5i	xØ5m5h	663		66Ø	679					
xØ5m5j	xØ5m5h	678		665	694					
xØ5m5k	xØ5m5h	693		715	746					
xØ5m5l	xØ5m5h	714		724						
xØ5m5m	xØ5m5h	723								
xØ5m5n	xØ5m5n	744		754						
xØ5m5o	xØ5m5n	753		776	795					
xØ5m6a	xØ5m5n	773		1Ø48	1Ø78	11Ø5		1131		1173
xØ5m6a1	xØ5m5n	79Ø		913						
xØ5s1a	xØ5m5n	8Ø3		68	75	127				
xØ5s4a	xØ5m5n	813		2Ø2						
xØ5s4b	xØ5m5n	828		213	839					
xØ5s4c	xØ5s4c	841		244						
xØ5s4d	xØ5s4c	852		247						
xØ5s4e	xØ5s4c	862		297	88Ø					
xØ5s4f	xØ5s4c	882		326	329	347	6Ø4	35Ø	628	6ØØ
				632	789	792		912		
xØ5s5a	xØ5s4c	915		455	557	771		788		
xØ5s5b	xØ5s4c	921		378	388	429				
xØ5s5b1	xØ5s5b1	929		392						
xØ5s5c	xØ5s5b1	955		561						
xØ5s5d	xØ5s5b1	961		958						
xØ5s5e	xØ5s5b1	967		7Ø4	72Ø	729	1Ø64	781	1Ø72	1Ø51
				1Ø79	11Ø6	1132				
xØ5s5e2	xØ5s5b1	979		474						
xØ5s5f	xØ5s5f	1Ø33		627	633					
xØ5s6a	xØ5s5f	1Ø47		778	793	1Ø6Ø		11Ø4		113Ø
xØ5s6b	xØ5s5f	1Ø59		1Ø68						
xØ5s6c	xØ5s5f	1Ø67		1Ø76						
xØ5s6d	xØ5s5f	1Ø75		1Ø94						
xØ5s6e	xØ5s5f	1Ø93		1Ø77						
xØ5s6f	xØ5s5f	11Ø2		1Ø95	1129					
xØ5s6g	xØ5end	1128		1Ø96	11Ø3					
ahelp		1191								
atime		1192								
back		198	21Ø	224	912					

key	198	210	224	912					
nc	1170	1170	1179	1179	1191		1191		
n101	1111	1112	1113						
n120	315	344	562	585	586	619	590	774	599
	804	913							
n121	804	889							
n2	1176	1177	1189	1190					
n21	1178	1178	1179	1179	1191		1191	1192	1192
n33	76	200	211	225	289	295	242	306	245
	650	837	877	956	962				
n47	35	76	185	1202	213	244	227	247	241
	297	308	447	660	839	964	879	1175	958
sin	380	390	939	940					
sqrt	394								
vc	1192	1192							
v100	903	907							
v102	1112	1114							
v103	1113	1114							
v51	585	586	596	611	1038		1041		1043
v55	319	322	337	353	380		380	390	390
v56	322	332	596	598	606				
v57	939	941	943						
v58	940	941							
v59	394	937	941	941	945				
v60	394	396	1156	1157	1158	1159	1158	1160	1159
	1160	1160	1162						
v61	1151	1157	1157	1158	1159		1160		1160
v62	1152	1160	1162						
v63	1160	1160	1162						
v70	938	940							
v71	942	943	943						
%	332	353	606						
V_{rms}	398								
Y_1	952								
	397	710	735	951	1053		1114		
π	397	398	430	431	432	926	433	926	924
	940	951	952						
πv70	939	942							

lesson information

lesson name = eex05

starting date = 06/01/73

last edited on 08/21/74 at 11.23.41

by neal of course eecge

at site 7, station 27

author name = J. P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = The Operation and Uses of the Vacuum Tube Voltmeter, HP 400D.

lesson eex06 at 2:43 am on tuesday, august 27, 1974

```
----------------------------------------------------------- part=1, block=a ----------

        block 1a,   eex06id

stop
****    For Neal, CGERL, Room 248, EEB.

One line description of this lesson

    Measurements of Transients.

        Divisions of this Lesson:        Block     Unit

        Id for this file                 eex06id
        Experiment eex06;
          Objectives                     x06m0a    x06m0a
          Measure transient waveshapes   x06m0a    x06m1a
          Measure and calc. time const.  x06m1q0   x06m2a

        Final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   <at,1010> Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon
area    eex06
ext     0
calc    n99⇐1               $$ used for restart skipping
----------------------------------------------------------- part=1, block=b ----------

        block 1b,   x06m0a

unit    x06m0a
restart
join    imode
jump    n47,x06m0a,x
next    x06m0b
calc    n99⇐0
at      407
write               MEASUREMENTS OF TRANSIENTS

           This is an experimental study of transients in a
```

```
         series circuit which contains resistors and a single
         energy-storage element, such as a capacitor or an
         inductor.

            The principal objectives of this experiment are:

         1. To measure and compare the waveshapes of the input
         and element voltages, currents, powers, and energies
         in a series RC circuit, when the source voltage is
         constant.

         2. To measure the time constant of the current of a
         series RC circuit and compare it with the value
         calculated from the nominal parameters of the circuit
         devices.
***

unit     x06m0b
back     x06m0a
next     x06m1a
at       707
write       A square-wave voltage is constant during each
         half-period.  Consequently, when a square-wave
         voltage drives a series RC or RL circuit, the
         circuit's response to a constant voltage can be
         studied by examining its response to the square-
         wave voltage during any half-period.  Furthermore,
         being repetitive, the input and element voltages
         can be displayed on the Scope.
pause
at       1907
write       Hence, the response of an RC circuit to a constant
         voltage applied when the capacitor is INITIALLY
         DISCHARGED can be studied experimentally by driving
         the RC circuit with a square-wave voltage having a
         zero value during each alternate half-period, and
         a frequency sufficiently low for the transients to
         decay practically to zero during each half-period.
***

unit     x06m1a
back     x06m0b
next     x06m1a1
help     x06s1a
at       707
write       Display one period of the adjustable SQUARE OUTPUT
         of the Function Generator on channel A of the Scope.

            Trigger the Scope from the Function Generator.

            Accurately adjust the open-circuit SQUARE-wave
         OUTPUT of the Function Generator to:

            Vmax = 20 V,  Vmin = 0,  and  f = 1000 Hz.

         Use A VOLTS FULL SCALE at 20 V for greatest accuracy,
         and lower the zero volts base line of the display
```

to the bottom line, 5 cm below the center of the CRT screen.

Disregard any small peak at the start of the trace.

Recall that the possible error with the Scope is ± 3 % of the VOLTS FULL SCALE setting, so you should avoid introducing further errors due to inaccuracies in your settings, readings, or calculations.

-- part=1, block=c ----------

block 1c, x06m1a1

```
unit    x06m1a1
pack    n33,0000000000000a00b0c0000bc000a00
join    ckcw
next    n47,x06m1a,x
jump    n47,x,x06m1a2
***

unit    x06m1a2
pack    n33,+gne(cd)(de)caba<f(rstuv)g(ab)>d(ef)(tu)+aaa++1
join    ckdw
next    n47,x06m1a,x
jump    n47,x,x06m1b
***

unit    x06m1b
at      1007
write      The Scope is the most accurate of the rack-
        mounted instruments.  Consequently, please readjust
        the frequency of the Function Generator, so the
        swept length of one period, as observed on the Scope,
        is exactly 10 cm, for the period of 1 ms and the
        frequency of 1000 Hz.
***

unit    x06m1b1
pack    n33,0000000000000a00b0c0000bc000a00
join    ckcw
next    n47,x06m1a,x
jump    n47,x,x06m1b2
***

unit    x06m1b2
pack    n33,+gne(cd)(de)caba<f(stu)g(ab)>d(ef)(tu)+aaa++1
join    ckdw
next    n47,x06m1a,x
jump    n47,x,x06m1c
***

unit    x06m1c
back    x06m1a
```

```
next    xØ6m1d
jump    n99,x,x,xØ6m1i1,xØ6m1qØa $$ units added for retarts
at      8Ø7
write      DO NOT readjust any dial or knob on the Function
        Generator during the remainder of this task.  You
        have correctly set the open-circuit voltage vg of the
        Function Generator and it will automatically try
        to maintain the terminal voltage constant.

           However, the terminal voltage will still vary with the
        load current, as was observed in a previous experiment
        where it was found that the Function Generator with
        the controls at a fixed setting could be approximately
        represented theoretically by an ideal voltage source
        vg in series with an internal resistance Rg.
***

unit    xØ6m1d
back    xØ6m1c
next    xØ6m1d1
help    xØ6s1a
at      7Ø7
write,     Connect the sensor cable of the RC BOARD, ITEM 33,
        to the CGE Interface.

           Ground Terminal 4 of the RC BOARD.

           Drive Terminal 1 of the series resistor-capacitor
        circuit with the adjusted SQUARE-wave OUTPUT of the
        Function Generator. Note how the display of vin changes !

           Observe the input voltage vin on channel A with
        A VOLTS FULL SCALE at 5Ø V, and observe the input
        current i on channel B with B VOLTS FULL SCALE at
        2 V.  Return the zero base line to the center of
        the screen.


                -HELP- is available.
***

unit    xØ6m1d1
pack    n33,aØbcØØØØØØØØcØØabdØØØØadØØØcØØ
join    ckcw
next    n47,xØ6m1d,x
jump    n47,x,xØ6m1d2
***

unit    xØ6m1d2
pack    n33,kgoc(cd)(de)cdba<f(stu)g(ab)>d(ef)(tu)+aaa++1
join    ckdw
next    n47,xØ6m1d,x
jump    n47,x,xØ6m1e
```

--- part=1, block=d ----------

block id, xØ6m1e

```
unit      xØ6m1e
base
back      xØ6m1d
next      xØ6m1f
define    x⇐n12Ø
          y⇐n121
          xmax⇐n122
          ymax⇐n123
calc      x⇐398
          y⇐425
          ymax⇐2Ø
          xmax⇐1Ø
join      xØ6s1b
gdraw     -1Ø,Ø;-1Ø,16;Ø,16;Ø,Ø;1Ø,Ø
graph     2,2Ø,vg(t)
at        661
write     t
at        4Ø5
write       The voltage source of the
          RC circuit is a square wave
          having:

                 Vmax =          volt.

                 Vmin =          volt.
arrow     818
long      2
answer    2Ø
no
at        12Ø5
write        If you have not change the Function Generator
          controls, Vmax of vg should be 2Ø volt.  The Scope
          is displaying the input voltage of the RC circuit.

             The source voltage is theoretically internal to
          Function Generator and cannot be displayed under load.
arrow     1Ø18
answer    Ø
long      1
inhibit   erase
no
at        12Ø5
write        If you have not changed the generator controls,
          Vmin of vg should be Ø volt.
endarrow
***

unit      xØ6m1f
back      xØ6m1e
next      xØ6m1g
calc      y⇐255
join      xØ6s1b
```

```
calc     n95⇐1
doto     x06m1f1,n94⇐-10,5,10
gdraw    n94,0;n94,n95(20)
graph    2,20,i(t)
at       1561
write    t
funct    n95(20)exp(-.5(v100-n94)),v100⇐n94,n94+10,.5
calc     n95⇐n95×-1
x06m1f1
at       1305
write       Without changing any
         connections, turn the A PRE AMP
         to OFF and by adjusting the
         A*B SEPARATION knob, use the
         undeflected channel A trace
         for a zero baseline of the
         current display.
pause
mode     erase
at       1305
write       Without changing any
         connections, turn the A PRE AMP
         to OFF and by adjusting the
         A*B SEPARATION knob, use the
         undeflected channel A trace
         for a zero baseline of the
         current display.
inhibit erase
jump     x06m1f1
***

unit     x06m1f1
pack     n33,a0bc00000000c00abd0000ad000c00
join     ckd
inhibit erase
jump     n47,x06s1c,x06m1f2
***

unit     x06m1f2
pack     n33,kgoc(cd)(de)edba<f(rstu)g(ab)xd(ef)(tu)?aaa++1
join     ckd
inhibit erase
jump     n47,x06s1c,x06m1g
```

-- part=1, block=e ----------

block 1e, x06m1g

```
unit     x06m1g
back     x06m1e
next     x06m1h
at       1305
write       The exponential current
         of the RC circuit, read
```

```
          experimentally has:

                    Imax =           mA

                    Imin =           mA
arrow     1718
ansv      8.4,1
no
at        2205
write        You can read the amplitude
          more accurately by momentarily
          going to a smaller FULL SCALE
          setting on B VOLTS.
arrow     1918
ansv      -8.Ø,1
inhibit   erase
no
at        22Ø5
write        You can read the amplitude
          more accurately by momentarily
          going to a smaller FULL SCALE
          setting on B VOLTS.
endarrow
inhibit   erase
***

unit      xØ6m1h
back      xØ6m1e
next      xØ6m1h1
calc      y⇐85
          ymax⇐2ØØ
join      xØ6s1b
graph     2,2ØØ,pg(t)
graph     1Ø,-2Ø,t
doto      Ø6m1h1,n94⇐-1Ø,-2,1Ø
gdraw     n94,Ø;n94,2Ø(8.8)
funct     2Ø(8.8)exp(-1(v1ØØ-n94)),v1ØØ⇐n94,n94+1Ø,.5
Ø6m1h1
at        25Ø5
write        The power delivered by the
          source can be calculated
          by simply multiplying the
          source voltage (2Ø or Ø V) by
          the current for each point in
          time.
***

unit      xØ6m1h1
next      xØ6m1h1
at        1ØØ7
write        Now, in order to read i(t) versus t more accurately
          for the next tabulation, please set the Scope TIME
          at 5ØØ µs and B VOLTS at 1 V.
             Turn the A PRE-AMP to +DC.
pause
pack      n33,aØbcØØØØØØØØcØØabdØØØØadØØØcØØ
join      ckcw
```

```
jump    n47,x,xØ6m1h2
***

unit    xØ6m1h2
next    xØ6m1h1
pack    n33,jfoc(cd)(de)(cd)dba<f(rtu)g(ab)>d(ef)(tu)+aaa++l
join    ckdw
jump    n47,x,xØ6m1i

------------------------------------------------------------------------ part=1, block=f ----------

        block 1f,  xØ6m1i

unit    xØ6m1i
base
help    xØ6s1f
back    xØ6m1e
at      2Ø7
write      Enter the values of the source voltage vg, and
        measure on the Scope display and enter the values of
        of the circuit current i, in the table below.  As you
        properly enter each pair of values, I will then
        calculate and enter pg = vg×i within 6 %.

                  t              vg           i           pg

                 (ms)            (V)         (mA)        (mW)

                 Ø.Ø2

                 Ø.1+

                 Ø.2+

                 Ø.3+

                 Ø.4+

                 Ø.5+

                 Ø.6+

                 Ø.7+

                 Ø.8+

                 Ø.9+

                                 Help is available
goto    key=back,replot,x
calc    n1ØØ⇐1224
        n1⇐1Ø4
        v1Ø1⇐2Ø
        v1Ø2⇐8.4
```

```
join      x06s1d
calc      v102⇐3.3
join      x06s1d
calc      v102⇐1.2
join      x06s1d
calc      v102⇐.5
join      x06s1d
calc      v102⇐.2
join      x06s1d
calc      v102⇐-7.6
          v101⇐0
join      x06s1d
calc      v102⇐-3.6
join      x06s1d
calc      v102⇐-1.2
join      x06s1d
calc      v102⇐-.5
join      x06s1d
calc      v102⇐-.2
join      x06s1d
pause

entry     replot
next      x06m1i0
jump      key=back,x,x06m1i0
at        1223
write          20          ‹s,v80›      ‹s,v105›

               20          ‹s,v81›      ‹s,v106›

               20          ‹s,v82›      ‹s,v107›

               20          ‹s,v83›      ‹s,v108›

               20          ‹s,v84›      ‹s,v109›

               0           ‹s,v85›      0

               0           ‹s,v86›      0

               0           ‹s,v87›      0

               0           ‹s,v88›      0

               0           ‹s,v89›      0
***

unit      x06m1i0         $$ this is a dummy unit for restart
restart
jump      n99,x,x,x06m1a

entry     x06m1i1
zero      n99
jump      x06m1j
***

unit      x06m1j
```

```
back     x06m1i
next     x06m1k
at       807
write       The input power pg, calculated above,
         will be plotted versus time t, when you press -NEXT-.
calc     ymax⇐200
         xmax⇐10
         x⇐248
         y⇐160
pause

entry    power
join     x06s1b
gdraw    -10,0;-10,v105;-8,v106;-6,v107;-4,v108;-2,v109;0,0
graph    2,200,pg(t)
graph    10,-20;t
exit
calc     n149⇐104
doto     06m1j1,n150⇐1,5,1
graph    -12+2(n150),v(n149+n150),•
06m1j1
doto     06m1j2,n150⇐1,6,1
graph    2(n150-1),0,•
06m1j2
```

-- part=1, block=g ------------

```
     block  g,  x06m1k

unit     x06m1k
base
term     work
back     x06m1i
next     x06m1l
at       405
write       The energy wg(t) supplied to the circuit by the
         voltage source vg is

                             wg(t)  =  ∫0^t pg(t) dt.

            When you press -DATA-, I will calculate and
         plot wg(t) versus t for one period, using your data.

calc     ymax⇐50
         x⇐248
         y⇐160
         xmax⇐10
pause

entry    work
join     x06s1b
graph    2,50,wg(t)
graph    10,-5,t
```

```
calc    n111⇐1Ø4
        v112⇐v134⇐Ø
        n13Ø⇐1
        n132⇐-1Ø

entry   xØ6m1k1
calc    v131⇐(v(n111+n13Ø)-v(n111+n13Ø+1))/4
doto    Ø6m1k2,v14Ø⇐.25,1,.25
calc    v133⇐v(n111+n13Ø+1)+(1-v14Ø+.25)4(v131)
calc    v112⇐v112+.Ø25×v133
gdraw   2(v14Ø-.25)+n132,v134;2(v14Ø)+n132,v112
calc    v134⇐v112
Ø6m1k2
calc    n13Ø⇐n13Ø+1
        n132⇐n132+2
goto    n132≤-2,xØ6m1k1,x
gdraw   Ø,v112;1Ø,v112
exit
at      2912
write   wg(t) = ∫Ø^T pg(t) dt. =⟨z,v112⟩ μJ (within 9%)
***

unit    xØ6m11
base
term    resis
back    xØ6m1k
next    xØ6m1m
at      3Ø5
write     While the energy was being supplied to the RC
        circuit by the source, energy was being dissipated in
        the resistances of the circuit. The total resistance
        of the RC circuit includes the generator internal
        resistance well as the resistances of the various
        circuit elements on the RC BOARD. Hence, in the
        equivalent circuit below;

                         R = Rg + R1 + R2

draw    2Ø23;2Ø3Ø;1931;2133;1935;2Ø36;2Ø44;2344;skip
        2341;2347;skip;344,136;2Ø44;2744;2723;2523
circle  36,343,1Ø1,132,48
draw    2523;176,122
draw    176,149;2Ø23
circle  14,176,136
at      1933
write   R
at      2449
write   C
at      2229
write   i
draw    235,164;271,164
at      2318
write   +
        vg
        -
pause
at      13Ø5
```

```
write     As you may verify, the manufacturer's rated
        equivalent resistance values for the Function
        Generator and the circuit board resistors give
        R = 200 + 2000 + 100 = 2300 ohms.
```

-- part=1, block=h ----------

```
*block 1h,  x05m1m

unit    x06m1m
back    x06m1l
next    x06m1n
at      507
write     Let's check this with your experimental
        measurements.

          As we mentioned previously, the
        capacitor voltage is zero when v_g jumps from 0 to
        20 volts at the beginning of each period. Therefore,
        at that instant the only opposition to the flow of
        current is the resistance voltage v_R = iR.  Using
        this relation and your previously-measured current
        in milliamperes:

          R = 20/(.001× <s,v80>) = <s,20/(v80×.001)> ohms  (within 6%)
          When you press -NEXT-, I will use your value of R
        with the values you read for i to calculate and
        display the power dissipation p_R = i²R versus t.
pause
erase
at      210
write     An estimate of the power being dissipated at any
        instant t in the circuit resistance R is

                     p_R(t) = i²(t) R
calc    y⇐350
        x⇐248
        y_max⇐200
        x_max⇐10

entry   resisp
join    x06s1b
graph   1.5,200,p_r(t)
graph   10,-20,t
calc    v1⇐20/v80
gdraw   -10,0;-10,v1(v80)²;-8,v1(v81)²;-6,v1(v82)²;-4,v1(v83)²;-2,v1(v84)²;0,0
gdraw   0,0;0,v1(v85)²;2,v1(v86)²;4,v1(v87)²;6,v1(v88)²;8,v1(v89)²;10,0
exit
pause
at      1610
write     An estimate of the energy w_R(t) dissipated in R
        during the interval t = 0 to t = t is

                  w_R(t) = ∫_0^t p_R(t) dt.
```

```
calc      y⇐115
          ymax⇐50

entry     resisw
join      x06s1b
graph     1.5,50,wr(t)
graph     10,-5,t
calc      n111⇐79
          v112⇐v134⇐0
          n130⇐1
          n132⇐-10

entry     x06m1m1
calc      v131⇐(v(n111+n130)-v(n111+n130+1))/4
doto      06m1m2,v140⇐.25,1,.25
calc      v133⇐v(n111+n130+1)+(1-v140+.25)4(v131)
calc      v112⇐v112+.025(v133)^2v1
gdraw     2(v140-.25)+n132,v134;2(v140)+n132,v112
calc      v134⇐v112
06m1m2
calc      n130⇐n130+1
          n132⇐n132+2
goto      n132≤-4,x06m1m1,x
gdraw     -2,v112;0,v112
calc      n111⇐84
          n130⇐1
          n132⇐0

entry     x06m1m3
calc      v131⇐(v(n111+n130)-v(n111+n130+1))/4
doto      06m1m4,v140⇐.25,1,.25
calc      v133⇐v(n111+n130+1)+(1-v140+.25)4(v131)
calc      v112⇐v112+.025(v133)^2 2.353
gdraw     2(v140-.25)+n132,v134;2(v140)+n132,v112
calc      v134⇐v112
06m1m4
calc      n130⇐n130+1
          n132⇐n132+2
goto      n132≤6,x06m1m3,x
gdraw     8,v112;10,v112
exit
at        3112
write     wr(t) = ∫0T pr(t) dt. =⟨z,v112⟩ μJ
```

-- part=1, block=i ----------

block ii, x06mln

```
unit      x06mln
base
back      x06m1m
next      x06mln1
at        705
write        Let's examine the voltage across the capacitor
```

in the experimental RC circuit, and relate it to the current i.

For this purpose, please return the Scope TIME to 1 ms, B VOLTS to 2 V, and A VOLTS to 50 V, and raise the base line to the center of the screen.

Since v_{34} across the current-sensing resistor is insignificant in comparison, v_{24} is like v_C.

Therefore, monitor Terminal 2 on the A channel to display $v_C(t)$.

```
***

unit    x06mln1
next    x06mln
pack    n33,aebc00000000c00ebd0000ad000c00
do      ckcw
jump    n47,x,x06mln2
***

unit    x06mln2
next    x06mln
pack    n33,kgoc(cd)(de)(cd)dba<f(rtu)g(ab)>d(e0)(tu)+aaa+1
do      ckdw
jump    n47,x,x06mlo
***

unit    x06mlo
back    x06mln
next    x06mlp
jump    n99,x,x,x,x06mlq0
calc    x⇐356
        y⇐425
        ymax⇐20
        xmax⇐10
join    x06s1b
graph   8,20,vC(t)
graph   10,-2,t
calc    n95⇐1
doto    1lasta,n94⇐-10,5,10
funct   n95(20-20exp(-.5(v100-n94)))+(n95-1)²(20exp(-.5(v100-n94))),v100⇐n94,n94+10,.5
calcc   n95=1,n95⇐0,n95⇐1
1lasta
at      505
write      The voltage vC across the
        capacitor is exponentially
        increasing towards 20 when
        vg = 20, and is exponentially
        decreasing towards 0 when vg = 0.
***

unit    x06mlp
back    x06mlo
term    try
next    x06mlq0
at      105
```

```
write     For this analysis, please read from the Scope and
          properly enter each value of vC(t), I will then
          calculate and enter pC = vC×i.

                  t           vC          i          pC

                 (ms)         (V)        (mA)       (mW)

                 0.0-

                 0.1-

                 0.2-

                 0.3-

                 0.4-

                 0.5-

                 0.6-

                 0.7-

                 0.8-

                 0.9-
goto      key=back,replotv,x
calc      n100⇐922
          n1⇐80
          v102⇐0
join      x06sle
calc      v102⇐12
join      x06sle
calc      v102⇐16
join      x06sle
calc      v102⇐18
join      x06sle
calc      v102⇐19
join      x06sle
calc      v102⇐20
join      x06sle
calc      v102⇐8
join      x06sle
calc      v102⇐3
join      x06sle
calc      v102⇐1.8
join      x06sle
calc      v102⇐.4
join      x06sle
pause

entry     replotv
next      x06m1q0
jump      key=back,x,x06m1q0
calc      n100⇐922
          n1⇐80
```

```
doto      lplot,n15Ø⇐Ø,9,1
at        n1ØØ+2
show      v(n1+n15Ø-3Ø)
at        n1ØØ+1Ø
show      v(n1+n15Ø)
at        n1ØØ+21
show      v(n1+n15Ø-2Ø)
calc      n1ØØ⇐n1ØØ+2ØØ
lplot
```

-- part=1, block=j ----------

block 1j, x Ø6m1qØ

```
unit      xØ6m1qØ
restart
calcc     n99=1,n99⇐2,n99⇐Ø
jump      n99,x,x,x,xØ6m1a

entry     xØ6m1qØa
jump      n99,x,x,x,xØ6m1n
jump      xØ6m1q
***

unit      xØ6m1q
next      xØ6m2a
at        5Ø5
write       At any instant, p_g(t) = p_R(t) + p_C(t).

            Over any period Ø < t < T:
          w_g(t) = w_R(t) + w_C(t).

            Graphs of p_C(t), w_C(t), p_G(t), w_G(t), p_R(t), and
          w_R(t) will be shown when you press -NEXT-.
pause
erase
calc      y⇐85
          x⇐12Ø
          x_max⇐1Ø
          y_max⇐2ØØ
join      xØ6s1b
graph     1.5,2ØØ,p_c(t)
graph     1Ø,-2Ø,t
gdraw     -1Ø,Ø;-1Ø,v6Ø;-8,v61;-6,v62;-4,v63;-2;v64;Ø,Ø;Ø,v65;2,v66;4,v67;6,v68;8,v69;1Ø,Ø
calc      y⇐85
          x⇐398
          y_max⇐5Ø
join      xØ6s1b
graph     1.5,5Ø,w_c(t)
graph     1Ø,-5,t
calc      n111⇐6Ø
          v112⇐v134⇐Ø
          n13Ø⇐1
          n132⇐-8
```

```
calc     v131⇐(v(60)-v(61))/4
doto     06m1q1a,v140⇐.25,1,.25
calc     v133⇐v(61)+(1-v140)4(v131)
calc     v112⇐v112+.025v133
gdraw    2(v140-.25)-10,v134;2(v140)-10,v112
calc     v134⇐v112
06m1q1a

entry    x06m1q1
calc     v131⇐(v(n111+n130)-v(n111+n130+1))/4
doto     06m1q2,v140⇐.25,1,.25
calc     v133⇐v(n111+n130+1)+(1-v140+.25)4(v131)
calc     v112⇐v112+.025v133
gdraw    2(v140-.25)+n132,v134;2(v140)+n132,v112
calc     [illegible]
06m1q2
calc     n130⇐n130+1
         n132⇐n132+2
goto     n130=8,x06m1q1,x
gdraw    0,v112;10,v112

entry    x06m1q3
calc     x⇐120
         y⇐255
         y_max⇐200
join     resisp
calc     x⇐398
         y_max⇐50
join     resisw
calc     x⇐120
         y_max⇐200
         y⇐425
join     power
calc     y_max⇐50
         x⇐398
join     work

unit     x06m2a
back     x06m1p
next     x06m2b
at       507
write       Transients occur whenever a stable system is
         disturbed, so it behooves us to relate the wave-
         shapes you have just observed to the values of R
         and C in the equivalent circuit.

            As with any dissipative system containing a single
         type of storage element, the differential equation
         which applies during any half-period in which the
         source voltage v_g is constant is

                                 1   t
               v_g(t)  =  R i(t) + -- ∫  i(t) dt + V_C0
                                 C   0

         where V_C0 is the capacitance voltage at t = 0, the
         the beginning of that half-period.

            Differentiating with respect to t gives the
```

```
        first-order differential equation:

                          di     1
                        R --  +  - i = Ø
                          dt     C
        or
                         di       1
                         --  = -  -- i
                         dt       RC
```

-- part=1, block=k ------

block 1k, xØ6m2b:

```
unit  :  xØ6m2b
back     xØ6m2a
next     xØ6m2c
at    :  5Ø7
write       The differential equation i

                          di     1
                        R --  +  - i = Ø
                          dt     C
            or
                         di       1
                         --  = -  -- i
                         dt       RC
            Solves to
                                       t
                                    -  --
                                       RC
                        i = I_Ø ε

            where I_Ø is the current at t = Ø and ε = 2.71828,
            the base of natural logarithms.

               Any variable, whose rate of change at any instant
            is proportional to the value of that variable at that
            instant is of the natural exponential form, like i.
***   :

unit  :  xØ6m2c
back  :  xØ6m2b
next     xØ6m2d
at       5Ø7
write       Consider the term
                         ε^(- t/RC)

            RC is called the time constant τ = RC.

            When t = Ø, ε^(-t/RC) = ε^(- Ø/τ) = ε^Ø  = 1.ØØ

            When t =  τ, ε^(- t/RC) = ε^(- τ/τ) = ε^(-1) = Ø.37
```

When $t = 2\tau$, $\epsilon^{-t/RC} = \epsilon^{-2\tau/\tau} = \epsilon^{-2} = 0.14$

When $t = 3\tau$, $\epsilon^{-t/RC} = \epsilon^{-3\tau/\tau} = \epsilon^{-3} = 0.05$

When $t = 4\tau$, $\epsilon^{-t/RC} = \epsilon^{-4\tau/\tau} = \epsilon^{-4} = 0.02$

When $t = 5\tau$, $\epsilon^{-t/RC} = \epsilon^{-5\tau/\tau} = \epsilon^{-5} = 0.01$

Note that for any time $t_2 = t_1 + \tau$,

$$\epsilon^{-t_2/RC} = \epsilon^{-1} \times \epsilon^{-t_1/RC} = 0.37\, \epsilon^{-t_1/RC}$$

In other words, during any time interval $\Delta t = \tau$ the exponential function concerned will decrease to 37 % of its value at the beginning of that interval.

```
***

unit    xØ6m2d
term    test2
back    xØ6m2c
next    xØ6m2d1
at      1ØØ5
write      Let's apply the above theory to measure the time
        constant τ for the experimental RC circuit.

           Turn the A PRE AMP to OFF, to provide a baseline
        as we did before.  Also, set TIME at 5ØØ µs and
        B VOLTS at 1 V, so you display one half-period of
        the current i.
***

unit    xØ6m2d1
pack    n33,aØbcØØØØØØØØcØØ+bdØØØØadØØØcØØ
join    ckc
goto    n47,xØ6s1c1,xØ6m2d2
***

unit    xØ6m2d2
pack    n33,jfoc(cd)(de)edba<f(rtu)g(ab)>d(ef)(tu)+aaa++l
join    ckd
jump    n47,xØ6s1c1,xØ6m2e
```

-- part=1, block=1 --------

block 11, xØ6m2e

```
unit    xØ6m2e
back    xØ6m2d
next    xØ6m2f
at      1ØØ7
write      Recall that 1 cm horizontally on this display
        is now equivalent to 5Ø microseconds, and, beginning
        at any point on the exponential curve, measure the
        time interval in which the current i decreases
```

```
        to 37 % of its initial value.

                            Time constant = τ =        μs
arrow   1642
long    2
ansv    92,10
no
at      1705
write     If the period of the current
        is still 1 ms, your measurement
        of τ should be in the range of
        80 to 100 μs.

          Try again, perhaps starting from some
        other initial time on the smooth curve.
***

unit    x06m2f
back    x06m2e
next    x06m2g
at      505
write     Another feature is significant for any first-order
        exponential curve. Recall that

                                                   t
                            di      1       1    - -
                            -- = - -- i = + - I ε  τ
                            dt     RC       τ  0

          At any time t1, the tangent to the current curve is
                            Δi
                            -- = -
                            Δt

          Consequently, if a tangent to the current curve is
        extend from time t = t1 to t = t1 + τ, the tangent
        line should end at i = 0.

          Since this should apply at any point on the
        decreasing curve, you now have another method of
        graphically checking whether the curve represents a
        first-order decreasing exponential function.
***

unit    x06m2g
back    x06m2f
term    test
at      205
write     You should now be able to answer the following
        questions pertinent to this experiment.

          1. What element supplies the energy dissipated in R
        during the second half-period when vg = 0 ?

          2. During the second half-period, i = I0 ε t/τ,
        wherein I0 =            mA

arrow   650
specs   bumpshift
```

```
answer   (c,cap,capacitor)
wrong    (v_g, generator, source)
arrow    918
ansv     -7.8,.5
inhibit erase
jump     x06m2g1
***

unit     x06m2g1
next     x06end
at       1105
write       3. During any half-period, the curve of p_R(t)
         versus t is a first-order exponential function.

            What is the time constant of p_R(t)?
calc     x⇐248
         y⇐205
         y_max⇐20
         x_max⇐10
join     x06s1b
graph    1.5,20,p_r (t)
graph    1.5,-2,40
graph    9,-2,200 µsec.
funct    (20) exp (-.6 (v100)) ,v100⇐0,10,.5
at       1451
write    µsec
arrow    1444
ansv     40,5
wrong    .
join     x06s2c
```

-- part=1, block=m ----------

```
      block 1m,  x06s1a

unit     x06s1a
at       1010
write       The output voltage is displayed as it was in
         earlier experiments.  Just connect the adjustable
         SQUARE OUTPUT of the Function Generator to A INPUT.

            The circuit current is not as easy to measure.
         The Scope is only capable of displaying a voltage
         not a current.  Using the basic equation v=iR,
         the current can be measured by interpreting each
         volt across the 100 ohm sampling resistor as
         10 milliampere.  Therefore, monitor the voltage
         at Terminal 3 and multiply it by 10 to read the
         current in mA.
end
***

unit     x06s1b
origin   x,y
```

```
axes     -75,-75,75,75
scalex   x_max
scaley   y_max
markx    2x_max,x_max/5
marky    2y_max,y_max/5
end
***

unit     x06s1c
next     x06m1e
erase
at       1007
write        You have not followed my suggestions carefully.

                          Try again please..
***

unit     x06s1c1
next     x06m2d
erase
at       1007
write        You have not followed my suggestions carefully.

                          Try again please..
***

unit     x06s1d
back     x06m1e
arrow    n100
store    v103
ansv     v101
arrow    n100+13
store    v(n1-24)
ansv     v102,.5
at       n100+26
showt    v103×v(n1-24)
calc     n1⇐n1+1
         v(n1)⇐v103×v(n1-25)
         n100⇐n100+200
***

unit     x06s1e
arrow    n100
store    v(n1-30)
ansv     v102,2
at       n100+10
showt    v(n1)
at       n100+21
showt    v(n1-30)×v(n1)
calc     v(n1-20)⇐v(n1+30)×v(n1)
         n1⇐n1+1
         n100⇐n100+200
***

unit     x06s1f
next     x06s1g
at       510
```

```
write     The graph you see below should look similar
        to the traces displayed on the oscilloscope.
        If it doesn't ask your instructor for assistance.

entry   graph
origin  248,15Ø
axes    -14Ø,-14Ø,14Ø,14Ø
scalex  1Ø
scaley  1Ø
markx   2
marky   2
exit
funct   1Øexp(-.25(1Ø+v15Ø)),v15Ø⇐-1Ø,1Ø,.5
gdraw   -1Ø,Ø;-1Ø,1Ø;1Ø,1Ø;1Ø,Ø
pause
mode    erase
at      51Ø
write     The graph you see below should look similar
        to the traces displayed on the oscilloscope.
        If it doesn't ask your instructor for assistance.
mode    write
at      51Ø
write     You can obtain five of the needed data points
        from this display read the voltage values at
        the ◆ on the horizontal axis.  Each data point
        has a current and a voltage reading.
          Slide the base line up or down to read any
        value that is off the screen.  When you read
        that value do not forget that the voltage is
        from the new base line.
```

-- part=1, block=n ---------

block 1n, xØ6end

```
entry   points
graph   -9.8,Ø,◆
graph   -6,Ø,◆
graph   -2,Ø,◆
graph   2,Ø,◆
graph   6,Ø,◆
exit
***

unit    xØ6s1g
at      51Ø
write     For the other 5 data points the Trigger
        Slope slide switch is used.  Switch the
        Trigger Slope to trigger on the negative
        side of the wave.  This will give you the
        second cycle of the wave.  The traces seen
        on the scope should resemble the below graph.
join    graph
gdraw   -1Ø,Ø;-1Ø,-1Ø,
```

```
funct   -10exp(-.25(10+v150)),v150⇐-10,10,.5
pause
mode    erase
at      510
write      For the other 5 data points the Trigger
        Slope slide switch is used.  Switch the
        Trigger Slope to trigger on the negitive
        side of the wave.  This will give you the
        second cycle of the wave.  The traces seen
        on the scope should resemble the below graph.
mode    write
at      510
write      You can obtain the final five data points
        from this display read the voltage and current
        values at the • on the horizontal axis.
           As before the base line can be moved up or
        down to read values off the screen.
join    points
end
***

unit    x06s2c
at      2105
write   Known equations:
           pr(t)=Rt×[ic(t)]2
           ic(t)=Imax×exp[-t/τ1]
at      2505
write      Rearranging the equations:   pr(t)=Rt×Imax2×exp[-2t/τ1]

           Now a different time constant, τ2, can be defined as τ1/2
        This new time contant is the time constant for pr(t).

                             pr(t)=Rt×Imax2×exp[-t/τ2]
gdraw   0,20;2.2,0
end
***

unit    x06end
back    x06m2g
join    imode
jump    n47,x06end,x
course  n2
calcc   n2='ee244',
        nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
        nc(n21+1)⇐nc(n21+1)
*erase
output  /// student has completed experiment ///
join    endunit
join    jmpmes
jumpout cgeindex,quest1

entry   leave
end     lesson
***

unit    endunit
course  n2
```

```
1106  jump   n2='ee244',leave,x
1107  calc   nc(n21+7)⇐nc(n21+7)+ahelp
1108         vc(n21+6)⇐vc(n21+6)+atime/60000
1109  ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1110  use    eex00,ck1
1111  use    ck2
1112  use    ck3
1113  use    ck4
1114  use    ck5
1115  use    ck6
```

ckc	not found		252	846			
ckcw	not found		94	115	162	320	603
ckd	not found		258	851			
ckdw	not found		100	121	168	326	609
endunit	x06end	1104	18	1098			
graph	x06sla	1009	1052				
imode	not found		29	1090			
jmpmes	not found		1099				
leave	x06end	1101	1106				
points	x06end	1036	1071				
power	x06m1i	411	760				
replot	x06m1i	378	352				
replotv	x06m1n	679	655				
resisp	x06m1m	530	753				
resisw	x06m1m	545	756				
work	x06m1k	441	763				
x06end	x06end	1088	918	1091			
x06m0a	x06m0a	27	30	50			
x06m0b	x06m0a	49	31	72			
x06m1a	x06m0a	71	51	95	101 126	116 395	122
			697				
x06m1a1	x06m1a1	92	73				
x06m1a2	x06m1a1	98	96				
x06m1b	x06m1a1	104	102				
x06m1b1	x06m1a1	113					
x06m1b2	x06m1a1	119	117				
x06m1c	x06m1a1	125	123	143			
x06m1d	x06m1a1	142	127	163	169	174	
x06m1d1	x06m1a1	160	144				
x06m1d2	x06m1a1	166	164				
x06m1e	x06m1e	172	170	216	263 964	292 978	332
x06m1f	x06m1e	215	175				
x06m1f1	x06m1e	250	248				
x06m1f2	x06m1e	256	254				
x06m1g	x06m1g	262	217	260			
x06m1h	x06m1g	291	264				
x06m1h1	x06m1g	311	293	312	324		
x06m1h2	x06m1g	323	321				
x06m1i	x06m1i	329	327	401	428		
x06m1i0	x06m1i	393	379	380			
x06m1i1	x06m1i	396	128				
x06m1j	x06m1i	400	398				
x06m1k	x06m1k	425	402	468			
x06m1k1	x06m1k	449	459				
x06m1l	x06m1k	465	429	504			
x06m1m	x06m1m	503	469	586			
x06m1m1	x06m1m	553	563				

xØ6m1m3	xØ6m1m	568		578						
xØ6m1n	xØ6m1n	584		5Ø5	6Ø1	6Ø7		613		699
xØ6m1n1	xØ6m1n	6ØØ		587						
xØ6m1n2	xØ6m1n	6Ø6		6Ø4						
xØ6m1o	xØ6m1n	612		61Ø	636					
xØ6m1p	xØ6m1n	635		614	765					
xØ6m1q	xØ6m1qØ	7Ø2		7ØØ						
xØ6m1qØ	xØ6m1qØ	694		615	638	688		681		
xØ6m1qØa	xØ6m1qØ	698		128						
xØ6m1q1	xØ6m1qØ	737		747						
xØ6m1q3	xØ6m1qØ	749								
xØ6m2a	xØ6m1qØ	764		7Ø3	792					
xØ6m2b	xØ6m2b	791		766	814					
xØ6m2c	xØ6m2b	813		793	834					
xØ6m2d	xØ6m2b	832		815	855	971				
xØ6m2d1	xØ6m2b	844		835						
xØ6m2d2	xØ6m2b	849		847						
xØ6m2e	xØ6m2e	854		852	877					
xØ6m2f	xØ6m2e	876		856	899					
xØ6m2g	xØ6m2e	898		878	1Ø89					
xØ6m2g1	xØ6m2e	917		915						
xØ6s1a	xØ6s1a	939		74	145					
xØ6s1b	xØ6s1a	954		184	219	296	531	412	546	442
				62Ø	716	723		927		
xØ6s1c	xØ6s1a	963		254	26Ø					
xØ6s1c1	xØ6s1a	97Ø		847	852					
xØ6s1d	xØ6s1a	977		357	359	361	368	363	370	365
				372	374	376				
xØ6s1e	xØ6s1a	991		659	661	663	669	665	671	667
				673	675	677				
xØ6s1f	xØ6s1a	1ØØ3		331						
xØ6s1g	xØ6end	1Ø44		1ØØ4						
xØ6s2c	xØ6end	1Ø74		937						
ahelp		11Ø7								
atime		11Ø8								
back		352	38Ø	655	681					
exp		226	3Ø1	625	625	931		1Ø17		1Ø54
i		223								
key		352	38Ø	655	681					
nc		1Ø94	1Ø94	1Ø95	1Ø95	11Ø7		11Ø7		
ni		354	657	683	686	688	986	69Ø	987	983
		987	988	988	993	996	999	998	999	998
		999	1ØØØ	1ØØØ						
n1ØØ		353	656	682	685	687	691	689	979	691
		982	985	989	989	992	1001	995	1001	997
n111		445	45Ø	45Ø	452	549	556	554	565	554
		569	569	571	726	738		738		74Ø
n12Ø		176								
n121		177								
n122		178								
n123		179								
n13Ø		447	45Ø	45Ø	452	457	554	457	554	551
		556	561	561	566	569	576	569	576	571
		728	738	738	74Ø	745		745		
n132		448	454	454	458	458	558	459	558	552
		562	562	563	567	573	577	573	578	577
		729	742	742	746	746		747		

n149	417	419							
n150	418	419	419	421	422	688	684	690	686
n2	1092	1093	1105	1106					
n21	1094	1094	1095	1095	1107		1107	1100	1108
n33	93	99	114	128	161	251	167	319	251
	325	602	608	845	850				
n47	38	95	96	101	102	122	116	123	117
	163	164	169	170	254	327	268	604	321
	610	847	852	1091					
n94	221	222	222	226	226	300	226	340	299
	301	301	301	624	625		625	625	625
n95	220	222	226	227	227	625	620	626	625
	626	626							
n99	25	32	128	395	397	696	615	696	696
	697	699							
Pc	717								
Pe	297	414							
Pr	532	928							
t	186	223	297	298	414	444	415	532	443
	533	547	548	621	622	724	717	725	718
	928								
v	419	450	450	452	554	569	554	569	556
	571	686	688	690	730	734	730	736	732
	740	983	986	988	988	998	993	998	996
	999	999	999						
vc	1100	1100							
v1	534	535	535	535	535	536	535	536	536
	536	536	557						
v100	226	226	301	301	625	931	625	931	625
v101	355	367	981						
v102	356	358	360	362	364	371	366	373	369
	375	658	660	662	664	670	666	672	668
	674	676	984	994					
v103	[illegible]	986	988						
v105	382	413							
v106	383	413							
v107	384	413							
v108	385	413							
v109	386	413							
v112	446	453	453	454	455	463	460	550	460
	557	557	558	559	564	572	564	573	572
	574	579	579	582	727	734	733	735	733
	741	741	742	743	748		748		
v131	450	452	554	556	569	732	571	738	730
	740								
v133	452	453	556	557	571	733	572	740	732
	741								
v134	446	454	455	550	558	574	559	727	573
	734	735	742	743					
v140	451	452	454	454	555	558	556	570	558
	571	573	573	731	732	739	734	740	734
	742	742							
v150	1017	1017	1054	1054					
v60	719								
v61	719								
v62	719								
v63	719								

v64	719								
v65	719								
v66	719								
v67	719								
v68	719								
v69	719								
v80	382	516	516	534	535				
v81	383	535							
v82	384	535							
v83	385	535							
v84	386	535							
v85	387	536							
v86	388	536							
v87	389	536							
v88	390	536							
v89	391	536							
v_g	186								
v_C	621								
ω_c	724								
ω_g	443								
ω_r	547								
x	176	188	408	437	527	721	616	750	713
	754	757	762	923	955				
x_{max}	178	183	407	439	529	926	619	957	714
	959	959							
y	177	181	218	294	409	543	438	617	526
	712	720	751	759	924		955		
y_{max}	179	182	295	406	436	618	528	715	544
	722	752	755	758	761	960	925	960	958
•	419	422	1037	1038	1039		1040		1041
μsec	930								

lesson information

lesson name = eex06

starting date = 03/29/73

last edited on 08/21/74 at 11.26.37

by neal of course eecge

at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = Measurements of Transients.

```
block 1a,  eex07id

stop
****    For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

   Measurements of Impedance.

          Divisions of this Lesson:        Block     Unit

        Id for this file                   eex07id
        Experiment eex07;
          Objectives                       eex07id   x07m0a
          Measure impedance magnitude      x07m1a    x07m1a
          Time displacement method         x07m1d    x07m2a
          Lissajous figure method          x07m2e    x07m3a
          Calc.impedance from components   x07m4a    x07m4a

        final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   <at,1010> Loading the CGE Character Set
charset cgeindex,cgechar
erase
zero    n99              $$ used for restart skipping
dataon
area    eex07
ext     0
***

unit    x07m0a
restart
join    imode
jump    n47,x07m0a,x
calc    n55⇐-1          $$ used in review seq.
calc    n99⇐-1          $$ n99 = 0 if restart
at      509
write             MEASUREMENTS OF IMPEDANCE

        When you have completed this experiment, you
        should be able to:

        1)   Experimentally measure the magnitude of an
        impedance.
```

```
          2)    Measure the time-phase relation between two
          waveforms by the time-displacement method.

          3)    Measure the time-phase relation between two
          waveforms by the Lissajous-figure method.

          4)    Calculate the theoretical impedance of a
          series circuit and compare this value with the
          actual laboratory measurement.
```

-- part=1, block=b ----------

```
      block 1b,  xØ7m1a

unit      xØ7m1a
base
back      xØ7mØa
next      n55,xØ7m1b,xØ7m3e
at        3Ø7
write        Consider a two-terminal electrical device driven
          by a single-frequency sinusoidal power source and
          having an input voltage v and input current i:

                                  i
                                   →
draw      198,391;248,391
circle    8,227,375
draw      166,375;219,375;skip;234,375;284,375
at        921
write     ◆          Z
          +          v
at        12Ø5
write        When displayed on the SCOPE, the convenient
          measures of a sine wave are Vpp and the time angle
          after t = Ø at which the wave is positive-going
          through v = Ø.  We will use the input current i
          as the time reference, and thus show it by

                i = IØp sin ωt = Ø.5Ipp sin ωt

             Now, the input voltage leads or lags the input
          current by a time-angle equal to or less than π/2
          or 9Ø°.  Hence, the expression for the input voltage
          can be shown by

                v(t) = VØp sin (ωt + θ) = Ø.5Vpp sin (ωt + θ)

          where -9Ø° ≤ θ ≤ 9Ø°.

unit      xØ7m1b
back      xØ7m1a
next      xØ7m1b1
at        5Ø5
write        In terms of the input voltage and current of a
```

```
        two-terminal circuit element, we will define the
        impedance of that element by

                       Z = |Z| ∠θ

        where          |Z| = Vpp / Ipp

                       θ = the angle by which the voltage
        leads the current, as shown in the equations on the
        preceding display.

           Our present task is to measure |Z|, the magnitude
        of the impedance of an inductive two-terminal circuit.

           Select the IMPEDANCE BOARD, ITEM 35 from the
        shelf below, and connect the sensor cable securely
        in the panel connector below the Function Generator.

           When you have connected the circuit-board sensor cable,
        connect the circuit diagrammed on the next display.
***

unit    x07m1b1
back    x07m1b
next    x07m1b
join    x07s1a
pause
pack    n33,a0a0000000b0c0caba00000+00ba00
join    ckc
jump    n47,x,x07m1c
pack    n33,a0a0000000b0c0caba00000+00ba00
join    ckc2w
***

unit    x07m1c
back    x07m1b
join    x07s1b
at      2007
write    The connection diagram requires the display of
        the voltage across the switch-selected impedance
        on A channel of the SCOPE, and the voltage of the
        current-sensing resistor on B channel, so

                     |vB| = |iZ| × 100

           Therefore : |iZ| = 10 × |vB|   (milliamperes)
           As connected, vB = -iZ × 100.  In order to display
        +iZ, set the B PRE AMP at AC-.

----------------------------------------------------------- part=1, block=c --------

    block 1c,  x07m1d

unit    x07m1d
```

```
back     x07m1c
next     x07m1d1
at       707
write       Set the equipment so that:

            Two periods of a 2 kHz sine wave with Vpp = 20 V
         are displayed on channel A of the SCOPE.

            Externally trigger the SCOPE from the A INPUT
         for a stable display and use the AC EXT setting.

            Set the A PRE AMP at DC+, and the B PRE AMP at -DC.
***

unit     x07m1d1
next     x07m1d
pack     n33,+(gh) (nop) d (cd) dc (ad) b++++++++++ (fg) <c (bc) b (uv) >+
join     ckdw
jump     n47,x,x07m1e
***

unit     x07m1e
back     x07m1d
at       708
write       What is the value of Ipp ?

                            milliamperes (mA)
arrow    908
ansv     2.9,.15
wrongv   .29,.015
at       1510
write    For the current-sensing resistor

         |Ipp| (milliamperes) = |VB pp| x 10
wrongv   -2.9,.15
at       1510
write    A peak-to-peak value cannot be a negative number.
no
at       1507
write       You should recall that iZ = -10 x vB , where
         iZ is in milliamp and VB is the voltage displayed
         on channel B. Be sure to set B VOLTS so that a
         large-size waveform is displayed on the CRT.
endarrow
at       1307
write       Recalling that Z = V/I , what is the magnitude

         of the impedance?

         |Z| =                       kΩ
at       1906
write    NOTE: As this experiment requires numerous calculations,
         a calculator is provided for your convenience.

            Simply enter the expression you need to evaluate.
join     x07s4e
arrow    1713
```

```
ansv     7,14,.7
***

unit     xØ7m2a
back     xØ7m1e
at       5Ø5
write       Now that you have seen how to measure the magnitude
         of an impedance, we will next measure the angle of
         that impedance.

            As stated earlier v and i have certain time angles
         with respect to t = Ø.  We selected the time-reference
         angle of the current as Ø.  Consequently, the time-
         reference angle of the voltage is θ, the angle by which
         the voltage leads or lags the current, that is, the
         angle of the impedance.
```

-- part=1, block=d --------

block 1d,   xØ7m2b

```
unit     xØ7m2b
back     xØ7m2a
next     n55,xØ7m2c,xØ7s2b
at       5Ø5
write       We will now measure θ for the selected impedance
         on the circuit board, by the time-displacement method.

            If Δt is the time interval by which the voltage leads
         the current, or the current lags the voltage, on the SCOPE
         display, we can calculate θ using the following relations

                 i(t) = IØp sin ωt

                 v(t) = VØp sin ω(t + Δt) = VØp sin (ωt + θ)

         where θ = ωΔt = 2πfΔt = 2π(Δt/T)

            In the sinusoidal expressions, angles are in radians
         and ωT = 2π.  However, in circuit calculations it is most
         convenient to use angles in degrees, where 2π radians
         is equivalent to 36Ø°.  Hence, to measure θ on the SCOPE
         simple determine the fraction of the period T by which
         the voltage leads the current and multiply that fraction
         by 36Ø° to evaluate θ.  Incidentally, to type the
         degree sign, simply press -MICRO- and type o.
***

unit     xØ7m2c
next     xØ7s2a
back     xØ7m2b
at       4Ø5
write       Set the equipment so that:
```

```
            The SCOPE is triggered externally by the A INPUT.

            Both the A and B INPUTs are displayed in the ALternate
            mode, with the A PRE AMP at DC+ and the B PRE AMP at -DC.
            With the B PRE AMP set in this manner, i(t) will be
            displayed rather than -i(t).

               The AUDIO OSCILLATOR should still supply Vpp = 20 V
            at a frequency of 2 kHz to the A channel of the SCOPE.

               It is not necessary to change any connections.
      ***
      unit     x07m2d
      base
      jump     n99,x,x07m3a
      back     x07m2c
      next     x07m2e
      help     x07s2b
      at       2410
      write    -HELP- is available.
      at       505
      write       By what time interval does the current lag the voltage.

                          milliseconds.
      arrow    705
      store    v60
      ansv     0.08,0.02
      at       905
      write       What is the period T of the sine waves, as
               displayed on the SCOPE ?

                          milliseconds.
      arrow    1205
      store    v61
      ansv     .5,.02
      endarrow
      at       1305
      write       Recalling that θ = (Δt/T) × 360°, what is θ ?
      join     x07s4e
      arrow    1710
      ansv     (v60/v61)*360,2
```

-- part=1, block=e ----------

6

block 1e, x07m2e

```
      unit     x07m2e
      calc     n51⇐-1           $$ used in x07m2f goto and writec
      base
      back     x07m2d
      next     x07m2f
      join     x07s2c
      join     x07s2d
```

```
at       1126
write    ◆ LEADING waveform
at       1531
write    ◆ LAGGING waveform
pause
mode     erase
join     x07s2d
mode     write
join     x07s2e
pause
mode     erase
join     x07s2e
mode     write
join     x07s2f
***

unit     x07m2f
base
back     x07m2e
lab      x07s2d
help     x07s2e
at       805
write       Set the impedance-selector switch to position 5.
         Is v(t) for this circuit leading or lagging?
         ____________
at       1011
writec   n51,,lagging          $$ inserts previous response
goto     n51,x,x07m2f1
arrow    1010
answer   lagging
no
at       1205
write       Remember, v(t) is display on channel A; i(t)
         on channel B. Press -LAB- to review the
         definitions of leading and lagging.
endarrow
add1     n51

entry    x07m2f1
at       1410
write    Is θ positive or negative? ____________
at       1438
writec   n51,,,negative
goto     n51,x,x,x07m2f2
arrow    1438
answer   negative
no
at       1610
write    θ for a a lagging v(t) is negative
endarrow
add1     n51

entry    x07m2f2
at       1710
write    Thus, this circuit is: ____    (type a,b,or c)

                     a) inductive
```

```
                            b) capacitive
                            c) resistive
arrow     1733
answer    b
no
at        23Ø9
write     Press -HELP- for assistance and/or an explanation.
endarrow
at        24Ø9
write     Return the impedance selector switch to position
          3 before proceeding.
***

unit      xØ7m3a
restart
base
back      xØ7m2e
next      xØ7m3b
help      n99,x,xØ7s1a
data      n99,x,xØ7m2c
at        1ØØ5
write        The next method for measuring phase angles is
          the Lissajous figure method. Before continuing,
          however, recheck the balance of both SCOPE
          channels and the positioning of the Ø,Ø point
          on the SCOPE grid.
at        2Ø1Ø
writec    n99• •Press -HELP- to see the circuit diagram

          Press -DATA- for dial settings.
```

-- part=1, block=f ------------

block 1f, xØ7m3b

```
unit      xØ7m3b
zero      n52                 $$ needed for proper use of xØ7s3a
back      xØ7m3a
next      xØ7s3c
at        3Ø5
write        To obtain a Lissajous figure from your
          present circuit, set the Y DISPLAY FUNCTION
          to A vs B and turn OFF the SWEEP MODE.

             Press -NEXT- when you have finished.

             Press -DATA- to see a typical Lissajous figure.
pause
keytype n51,data,next,back
goto      n51,x,xØ7s3a,x
jump      n51,x,x,xØ7s3c,xØ7m3a
***

unit      xØ7m3c
```

```
next      n55,x07m3d,x07m3e
back      x07m3b
at        205
write        The Lissajous figure on display is a plot of

          y = Vm sin (ωt + Θ)   versus   x = Im sin ωt.

             Θ can be evaluated from the ratio of M = 2V(t) at t = 0,
          to N = Vpp.   Thus:

entry     x07m3c1
at        1007
write     2Vm sin(ωt+Θ)|ωt=0       2Vm sin(0+Θ)
                               =  ------------- = sin Θ  =  M
          ------------------                                 -
          2Vm sin ωt|ωt=π/2        2Vm sin 90°               N
join      x07s3a
join      x07s3b
***

unit      x07m3d
base
next      x07m3e
back      x07m3c
help      x07m3c1
calc      n52⇐-1                          $$ needed for x07s3a
at        305
write        From the Lissajous pattern displayed on the SCOPE,
          measure:

                        M (t = 0)           __________ Volts

                        N (at Vmax)         __________ Volts

                        Θ (=arcsin M/N)     __________ °


                               -HELP- is available
arrow     630
store     v120
ansv      8.4,.6
arrow     630
store     v121
ansv      10,1.1
no
at        1605
write        A convenient method for measuring N is to turn
          the B PRE AMP to OFF.
endarrow
join      x07s3f
arrow     1030
ansv      v102,5%
***

unit      x07m3e
base
at        405
```

```
write      Recall our definition of impedance Z:

                          Z = |Z| ∠θ

              You should now be able to calculate the
           magnitude, |Z|, and its phase angle θ.

           Press -HELP- to review measurements of magnitude.

           Press -DATA- to review the use of the time displacement
           method in calculating θ.

           Press -LAB-  to review the use of the Lissajous
           figure in determining θ.

           Press -NEXT- to continue.
pause
keytype n55,next,back,help,data,lab
jump    n55,x07m4a,x07m4a,x07m3d,x07m1a,x07m2b,x07m3c
---------------------------------------------------------- part=1, block=g -----------

     block 1g,  x07m4a

unit      x07m4a
imain     x07s4g
at        405
write        Thus far we have expressed impedance in the
          polar form, Z = |Z| ∠θ. Another representation is
          the rectangular or complex form:

                    Z = R + jX      where j = √-1

          in this expression, R is termed the resistive component
          and X is called the reactive component.

             For converting from the polar form to the rectangular
          from, use of Euler's identity gives:

              R = |Z| cos θ  and  X = |Z| sin θ

             Similarly, to convert from the rectangular form
          to the polar form, use the identities:

             |Z| = √(R² + X²)    and  θ = arctan (X/R )

             Since these identities will be useful in the
          remainder of this experiment, you may obtain
          this display hereafter by pressing -SHIFT-DATA-.

                Press -NEXT- to continue.
end
next      x07m4b
***
```

260

```
unit    x07m4b
back    x07m4a
at      505
write     For a SERIES circuit, R is the sum of the
        resistances in the circuit. (Caution: this is
        not true for a parallel circuit).

          Individual series-element reactances are related
        to the element parameters, i.e., capacitance and
        inductance, and the frequency by the formulas:

             X_L = ωL = 2πfL   (recall ω = 2πf)

                       1        1
             X_C = - ---- = - -----
                      ωC      2πfC

             X = X_L + X_C

          These formulas will also be useful in the
        remainder of this experiment, you may obtain this
        display hereafter by pressing -SHIFT-LAB-.
end
next    x07m4c
***

unit    x07m4c
base
back    x07m4c
next    x07m4c1
at      605
write     In a given circuit, one may measure either
        R and X, or |Z| and θ_Z, and expect the results
        to be in agreement with one another.

          Set the Impedance Selector Switch to position 2.
***

unit    x07m4c1
pack    n33,aa000000000b0c0caba00000+00ba00
join    ckc
jump    n47,x07m4c,x07m4d
pack    n33,aa000000000b0c0caba00000+00ba00
join    ckc2w
***

unit    x07m4d
zero    n59                 $$ used in next goto and writec
base
back    x07m4c
next    x07m4e
help    x07s4b
at      705
write     Using the same 20 V p-p, 2 kHz signal from the
        AUDIO OSCILLATOR, determine the magnitude of this
        new impedance, Z.
```

```
                |Z| = ____________ kΩ

                         -HELP- is available
join      x07s4e
arrow     1118
store     v50
ansv      3.5,10%
```

-- part=1, block=h ----------

block 1h, x07m4e

```
unit      x07m4e
base
back      x07m4d
next      x07m4f
help      x07s4d
lab       x07s2e
at        705
write        To complete this calculation of Z in the polar
          form, Z = |Z| ∠θ , determine θ by the time-
          displacement method.

             Recall that θ = Δt/T

          enter T  = ___________ milliseconds

          enter Δt = ___________ milliseconds
at        2420
write     -HELP- is available
at        1318
writec    n59,⟨s,v61⟩,,
at        1518
writec    n59,⟨s,v60⟩,,
goto      n59,x07m4e1,x
arrow     1316
store     v61
ansv      .5
no
at        1722
write     Set the frequency so T =.5 ms.
endarrow
arrow     1516
store     v60
ansv      .04,.05
endarrow
calc      n59⇐-1

entry     x07m4e1
at        1910
write     enter θ = ___________
join      x07s4e
arrow     1922
store     v51
```

```
ansv     -(v60/v61)×360,1
wrongv   (v60/v61)×360,1
at       2105
write       Recall that θ for a capacitive circuit is negative.
         Press -LAB- for an explanation.
***

unit     x07m4f
base
back     x07m4e
next     x07m4g
calc     v52⇐sin(v51°)
calc     v53⇐cos(v51°)
at       410
write       You have calculated Z in the polar form as

                 Z = |⟨s,v50⟩ kΩ| ∠⟨s,v51⟩°

            Using the identities available by pressing
         -SHIFT-DATA- , express Z in the rectangular
         form as Z = R + jX:

                 R = ____________  kΩ
at       1616
write    sin (⟨s,v51⟩°) = ⟨s,v52⟩

         cos (⟨s,v51⟩°) = ⟨s,v53⟩
at       1223
writec   n59,,⟨s,v54⟩
goto     n59,x,x07m4f1
join     x07s4e
arrow    1221
store    v54
ansv     v53×v50,10%
no
at       1237
write    Units of Z and R are kΩ.
endarrow
zero     n59

entry    x07m4f1
at       1416
write    jX = ______________ kΩ
join     x07s4e
arrow    1421
store    v55
ansv     v52×v50,10%
wrongv   -(v52×v50),10%
at       1437
write    You need a minus sign.
no
at       1437
write    Units of Z and X are kΩ.
```

--- part=1, block=i --------

block 1i, x07m4g

```
unit      x07m4g
base
back      x07m4f
next      x07m4h
help      x07s4f
join      x07s1b
at        144,428
erase     4
at        144,428
write     ◆
at        520
write     ↗
catchup
at        2005
write        Using the reactance equations which are available
          by pressing -SHIFT-LAB-, calculate the theoretical
          value of the impedance of circuit 2, and express
          Z in rectangular form, R + jX.

             R = __________ kΩ
at        2514
writec    n59,,,⟨s,v56⟩
goto      n59,x,x,x07m4g1
arrow     2511
store     v56
ansv      3.3
wrongv    3.4
at        2705
write        Voltage is measured between Terminal 15 and ground
              Note that the 100Ω resistor is not included in
          this measurement.  It is used only for sensing the
          impedance current.
no
at        2708
write     For a series circuit, R is the sum of resistors.
endarrow
calc      n59⇐1  $$ avoids rewriting after branching key hit

entry     x07m4g1
at        3203
write     -HELP- is available
at        2532
write     X = __________ kΩ
join      x07s4e
arrow     2536
store     v57
ansv      -1.6,10%
wrongv    -1600,10%
at        2631
write     Check your units.
wrongv    1.6,10%
at        2631
write     Almost! You forgot the minus sign ..
```

```
***

unit    x07m4h
base
back    x07m4g
next    x07end
at      509
write   "   You have measured the impedance of circuit
        2 and expressed it in polar form as:

                Z = |<s,v50> kΩ| ∠<s,v51> °

           You converted Z to the rectangular form and expressed
        Z as:

        1)      Z = <s,v54> kΩ + j (<s,v55>) kΩ

           Finally, you calculated the theoretical value of
        Z in rectangular form and found:

        2)      Z = <s,v56> kΩ + j (<s,v57>) kΩ

           If the measured value of Z, equation 1, differs
        greatly from the theoretical value, equation 2,
        you may wish to discuss the discrepancy with your
        instructor. Bear in mind, however, that the values
        of the components used to obtain equation 2 are rated
        at ± 10%. Also, recall the inherent ± 3% error en-
        countered when reading oscilloscope measurements.
------------------------------------------------------------ part=1, block=j --------


        block 1j,  x07s1a

unit    x07s1a
draw    313;337;737;713;313
circle  29,157,432
draw    341;349;849;841;341
circle  29,352,432
circle  8,352,432
circle  3,352,390
circle  3,340,390
circle  3,363,390
at      336,373
write   I
circle  3,200,416
circle  3,264,416
draw    1719;1741;2341;2319;1719
circle  3,160,208
circle  3,160,160
circle  3,304,176
circle  3,208,406
circle  3,264,406
at      261,385
```

```
write   ↓
at      205,388
write   ↓
draw    1921;1221;1224;624;627;skip;208,406;224,406
        224,319;352,319;352,176;304,176;skip;352,390
        352,353;104,353
at      101,349
write   ◆
draw    2221;2421;skip;363,389;363,128;2421;skip;634;639
        1139;363,336
at      360,332
write   ◆
at      2322
write   IMPEDANCE BOARD
at      2137
write   15
at      2221
write   11
at      1922
write   1
at      526
write
at      633
write
draw    2221;2233
at      256,156
write   -^^-
draw    2237;2239;2139
at      248,163
write   100Ω
at      1623
write   current-sensing
        resistor ___
at      368,228
write   |
        |
        |
        ↓
draw    1921;1924;1824;1830;2030;2024;1924;skip;1930;1939
        2139
at      1905
write   set switch to
        connect
        Term. 1 to 3
draw    109,197;160,197
at      159,193
write   →
at      950
write   NOTE:
        AUDIO OSC.
        ground strap
        should be dis-
        connected.
draw    949;345,368
at      342,368
write   ↑
draw    123,432;187,432;skip;520;152,460;152,403
```

```
at       1016
write      vA →
at       929
write      vB →
circle   3,232,406
draw     232,406;630;627
at       427
write    trigger
         input
           ↓
at       221
write    SET UP THIS CIRCUIT
at       2819
write    Press -NEXT- when finished
end
```

-- part=1, block=k ----------

block lk, 0, x07s1b

```
unit     x07s1b
circle   8,104,432
draw     515;519
at       144,428
write    ◆——→
at       176,428
write    ◆
at       172,444
write    ◆
at       173,412
write    ◆
at       161,400
write    ◆
at       144,396
write    ◆
at       419
write
draw     147,397;147,368
at       1019
write    ,
         |
         |
at       1013
write    3.3kΩ
at       1021
write    .05μF
draw     168,404;216,404;928
at       213,352
write    ╪
         |
         |
at       1030
write    .5H
draw     623;635;835
```

```
at      269,368
write   |
        8
        |
        |
draw    524;530
at      232,428
write   -ooo-
draw    534;543;943
at      333,352
write   <
        <
        |
at      1037
write   3.3kΩ
at      630
write   .5H
draw    423;325;334
at      264,460
write   -||-
draw    336;351;951
at      397,352
write   <
        
        |
at      1045
write   3.3kΩ
at      256,444
write   .05µF
circle  8,400,304
draw    1251;400,311
draw    1350;147,304;147,321
at      213,304
write   |
at      269,304
write   |
at      333,304
write   |
draw    400,296;1551;1545
at      320,268
write   -/\/\-
draw    1541;1515
circle  8,104,272
at      320,276
write   100Ω
at      1352
write   15
at      1413
write   11
at      413
write   1
at      425
write   2
at      525
write   3
at      625
write   4
```

```
at        180,402
write     5
at        155,391
write     6
at        1724
write     IMPEDANCE   ITEM 35
draw      1810;1855;155;110;1810
at        1422
write     current-sensing
          resistor ———→
at        1712
write     VA
at        312
write     VA
draw      1352;1356
at        440,300
write     —
at        452,288
write     ⊥
```

-- part=1, block=1 --------

block 11,   x07s2a

```
unit      x07s2a
next      x07m2c
pack      n33,(ij)(fgh)(no)d(cde)(de)cdb+++++++++(fg)<b(uv)c(bcd)>+
join      ckd
jump      n47,x,x07s2a1
pack      n33,(ij)(fgh)(no)d(cde)(de)cdb+++++++++(fg)<b(uv)c(bcd)>+
join      ckdtw
***

unit      x07s2a1
next      x07m2c
pack      n33,a0a000000b0c0caba0000+00ba00
join      ckcw
jump      n47,x,x07m2d
***

unit      x07s2b
next      n55,x,x07m3e
at        507
write        In order to measure the time delay between
          two sine waves, you must measure the distance
          between a given position on the reference wave
          and the same relative position on the displaced
          wave.
                                   Note that both waveforms
                                   are adjusted to be symmetrical
                                   about zero volts.
join      x07s2c
~~catchup~~
vbar      π/4,1,1
```

```
hbar     π/2,1,-
hbar     3π/2,-1,-
hbar     3π/4,.5,-
hbar     7π/4,-.5,-
.locate  Ø,.8
write    ←Δt→
.end
***

unit     x07s2c
origin   1815
axes     Ø,-128,256,128
scalex   2π
scaley   1
labely   1,.25
markx    π,.25π
funct    sin(v7Ø),v7Ø⇐Ø,2π,.Ø2π
funct    sin(v7Ø-.25π)×.5,v7Ø⇐Ø,2π,.Ø2π
***

unit     x07s2d
at       3Ø5
write       The following convention has been adopted
         regarding the sign of θ.  Consider the
         positive going slopes of the two waveforms.
         The waveform whose peak appears on the left
         is said to LEAD the other. Correspondingly,
         the sinusoid whose peak appears on the right
         is said to LAG the other.
end
***

unit     x07s2e
at       3Ø5
write       The impedance angle θ is defined as the
         angle of the voltage wave with respect to
         the current wave. Thus, if v(t) is leading,
         θ is positive (inductive circuit); if v(t) is
         lagging, θ is negative (capacitive circuit);
         if v(t) is neither leading nor lagging, θ
         is zero (resistive circuit).
end
***

unit     x07s2f
at       3Ø5
write       Note that the voltage waveform (displayed
         on channel A) for this circuit leads the
         current waveform; thus, θ is positive, i.e.,
         an inductive circuit.
***

unit     x07s3a
calc     v141⇐5Ø
calc     v141⇐(v141)°
calc     v141⇐abs(v141)+.ØØØØØ1°
calc     v141⇐cos(v141)/sin(v141)
```

```
origin  2132
axes    -120,-120,120,120
scalex  5
scaley  5
markx   1,.5
marky   1,.5
calc    v142⇐4/(sqrt(16-16(v141²/(v141²+1)))+4v141sqrt(v141²/(v141²+1)))
funct   v142×(   sqrt(16-v140²)+v141×(v140)),v140⇐-4,+4,.1
funct   -v142×(sqrt(16-v140²)-v141×(v140)),v140⇐-4,+4,.1
goto    n52,x07s3b,x
end
```

--- part=1, block=m ---------

block 1m,   x07s3b

```
unit    x07s3b
gdraw   -8,-3;0,-3
gdraw   -7.25,-2.75;-7.25,0.75
gdraw   -7.25,2;-7.25,2.75
gdraw   -8,3;0,3
gdraw   -2,-4;8,-4
gdraw   3,4;8,4
gdraw   7.25,-3.75;7.25,0.75
gdraw   7.25,2;7.25,3.75
size    2
gnaph   -9,1.2,2 A
        5:7,1.2,2 B
size    0
end
***
unit    x07s3c
pack    n33,(ij)+(no)d+(de)ce+++++++++++(fg)<c(bcd)b(uv)>+
join    ckd
jump    n47,x07s3d,x
pack    n33,a0a00000000b0c0caba00000+00ba00,
join    ckcw
jump    n47,x,x07m3c
pause
jump    x07m3b
***
unit    x07s3d
base
next    x07m3b
help    x07s3e
at      309
write   You have incorrectly set the dials.

        Press -NEXT- to try again

        Press -HELP- for a listing of your errors
```

```
            Press -DATA- to see a typical Lissajous figure.
pause
keytype n51,data,next,help
goto    n51,x,x07s3a,x
jump    n51,x,x,x07m3b,x07s3e
***

unit    x07s3e
pack    n33,(ij)+(no)d+(de)ce++++++++++(fg)<c(bcd)b(uv)>+
join    ckd1w
pause
jump    x07m3b
***

unit    x07s3f
at      2510
write   ARCSIN CALCULATOR ( enter M/N )
arrow   2720
store   v109
ansv    v120/v121,5%
endarrow
calc    v102⇐45°
calc    v101⇐0°
calc    v103⇐90°

entry   x07m3d1
calc    v110⇐v109-sin(v102)
goto    .0000001>abs(v110),x07m3d2,x
calcc   0>v110,v103⇐v102,v101⇐v102
calc    v102⇐(v101+v103)/2
goto    x07m3d1

entry   x07m3d2
calc    v102⇐(180/π)×v102
at      2920
write   θ = <t,v102>
at      3110
write   Press -NEXT- to enter θ above
pause
***

unit    x07s4b
base
at      705
write      Recall that the Y Display Function must be
        set to A & B ALT.   Also, |Z| = |Vpp| ,  where
                                        -----
                                        |Ipp|
           v is displayed on channel A, and channel B
        displays .1|i| where i is in milliamps.
at      1610
write   Press -NEXT- when you have correctly set then dials.
pause
pack    n33,(ij)(fgh)(no)d(cde)(de)cdb+++++++++(fg)<b(uv)c(bcd)>+
join    ckdw
next    n47,x07s4b,x
```

```
jump      n47,x,x07s4c
***

unit      x07s4c
next      x07m4e
at        707
write     |Ipp| = ____________ milliamps
arrow     715
ansv      5.7,10%
no
at        907
write     Recall that |i| = 10 |vB|, where i is in milliamps.
endarrow
at        1011
write     |Z| = ____________ kΩ
join      x07s4e
arrow     1018
store     v50
ansv      3.5,10%
```

-- part=1, block=n ------

```
        block in,  x07end

unit      x07s4d
next      x07m4e
help      x07s4dl
data      x07s2b
at        1108
write     Press -HELP- for explanations on setting the dials.
          Press -DATA- for assistance in determining θ.
***

unit      x07s4dl
base
next      x07s4d
join      x07m2c
pause
pack      n33, (ij) (fgh) (no)d (cde) (de) cdb+++++++++ (fg) <b (uv) c (bcd) >+
join      ckdw
jump      n47,x,x07m4e
***

unit      x07s4e
mode      erase
at        3219
write     Press -NEXT- to enter your answer above.
mode      write
at        3837
erase     20
at        2938
erase     15
catchup
```

```
draw      2717;2757;3057;3017;2717
at        2819
write      CGE Calculator.
          Enter Expression:

arrow     2837
store     v100
ok
endarrow
at        3038
show      v100
at        3219
write     Press -NEXT- to enter your answer above
pause
***

unit      x07s4f
at        511
write        The important equation for use in calculating
          the reactance, X, is:

                  jXc =  1    = j  (-   1   )
                        jωC            2πfC

          where f = 2,000 Hz.

          'π', if you would prefer to use the symbol,
          is obtained by pressing -MICRO- then pressing -p-.

             Note that your answer is requested in units
          of kΩ, where k = 10^3. The capacitance shown on
          the diagram is rated in units of µF, where µ= 10^-6.
end
***

unit      x07s4g
data1     x07m4a
lab1      x07m4b
***

unit      x07end
back      x07m4a
join      imode
jump      n47,x07end,x
course    n2
calcc     n2='ee244',
          nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
          nc(n21+1)⇐nc(n21+1)
erase
output    /// student has completed experiment ///
join      endunit
join      jmpmes
jumpout   cgeindex,quest1

entry     leave
end       lesson
***
```

```
1126  unit      endunit
1127  course    n2
1128  jump      n2≠'ee?44',leave,x
1129  calc      nc(n21+7)⇐nc(n21+7)+ahelp
1130            vc(n21+6)⇐vc(n21+6)+atime/6ØØØØ
1131  ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1132  use       eexØØ,ck1
1133  use       ck2
1134  use       ck3
1135  use       ck4
1136  use       ck5
1137  use       ck6
      ckc             not found           1Ø4    1466
      ckcw            not found           866    967
      ckc2w           not found           1Ø7    469
      ckd             not found           858    964
      ckdw            not found           136    1Ø28   1Ø63
      ckd1w           not found           861    988
      endunit   xØ7end        1126        2Ø     112Ø
      imode           not found           31     1112
      jmpmes          not found           1121
      leave     xØ7end        1123        1128
      xØ7end    xØ7end        111Ø        632    1113
      xØ7mØa    eexØ7id       29          32     51
      xØ7m1a    xØ7m1a        49          79     411
      xØ7m1b    xØ7m1a        78          52     99     1ØØ    11Ø
      xØ7m1b1   xØ7m1a        98          8Ø
      xØ7m1c    xØ7m1a        1Ø9         1Ø5    123
      xØ7m1d    xØ7m1d        122         134    14Ø
      xØ7m1d1   xØ7m1d        133         124
      xØ7m1e    xØ7m1d        139         137    173
      xØ7m2a    xØ7m1d        172         186
      xØ7m2b    xØ7m2b        185         2Ø8    411
      xØ7m2c    xØ7m2b        2Ø6         187    223    327    856   1Ø64   864
      xØ7m2d    xØ7m2b        2[illegible]  251    867
      xØ7m2e    xØ7m2e        248         224    272    324
      xØ7m2f    xØ7m2e        27Ø         252
      xØ7m2f1   xØ7m2e        294         281
      xØ7m2f2   xØ7m2e        3Ø4         296
      xØ7m3a    xØ7m2e        321         222    339    35Ø
      xØ7m3b    xØ7m3b        337         325    354    97Ø    974   99Ø    984
      xØ7m3c    xØ7m3b        352         371    411    968
      xØ7m3c1   xØ7m3b        36Ø         372
      xØ7m3d    xØ7m3b        368         353    411
      xØ7m3d1   xØ7s3b        1ØØ2        1ØØ7
      xØ7m3d2   xØ7s3b        1ØØ3        1ØØ4
      xØ7m3e    xØ7m3b        396         52     353    37Ø    87Ø
      xØ7m4a    xØ7m4a        413         411    411    436    11Ø7   1111
      xØ7m4b    xØ7m4a        435         433    11Ø8
      xØ7m4c    xØ7m4a        454         452    456    467    474
      xØ7m4c1   xØ7m4a        464         457
      xØ7m4d    xØ7m4a        471         467    49Ø
      xØ7m4e    xØ7m4e        488         475    534    1Ø33   1Ø5Ø   1Ø64
      xØ7m4e1   xØ7m4e        52Ø         5Ø7
      xØ7m4f    xØ7m4e        532         491    578
      xØ7m4f1   xØ7m4e        562         552
```

x07m4g	x07m4g	576		535	631						
x07m4g1	x07m4g	613		598							
x07m4h	x07m4g	629		579							
x07s1a	x07s1a	651		101	326						
x07s1b	x07s1b	744		111	581						
x07s2a	x07s2a	855		207							
x07s2a1	x07s2a	863		859							
x07s2b	x07s2a	869		187	225	1052					
x07s2c	x07s2a	891		253	880						
x07s2d	x07s2a	901		254	261	273					
x07s2e	x07s2a	912		263	266	274		493			
x07s2f	x07s2a	923		268							
x07s3a	x07s3a	930		349	365	983					
x07s3b	x07s3b	947		366	941						
x07s3c	x07s3b	962		340	350						
x07s3d	x07s3b	972		965							
x07s3e	x07s3b	986		975	984						
x07s3f	x07s3b	992		392							
x07s4b	x07s3b	1016		476	1029						
x07s4c	x07s3b	1032		1030							
x07s4d	x07end	1049		402	1059						
x07s4d1	x07end	1057		1051							
x07s4e	x07end	1066		168	244	483	565	523	610	553	
				1044							
x07s4f	x07end	1091		580							
x07s4g	x07end	1106									
abs		933	1004								
ahelp		1129									
atime		1130									
gos		537	934								
nc		1116	1116	1117	1117	1129		1129			
n2		1114	1115	1127	1128						
n21		1116	1116	1117	1117	1129		1129	1130	1130	
n33		103	106	135	465	468	865	857	963	860	
		966	967	1027	1062						
n47		34	105	137	467	859	968	867	1024	965	
		1030	1064	1143							
n51		280	280	281	290	295	348	296	349	303	
		959	982	983	984						
n52		35	373	944							
n55		35	52	167	353	410		411		870	
n59		472	504	506	507	519	561	551	597	552	
		598	612								
n99		[illegible]	[illegible]	322	326	327		335			
sin		536	898	899	934	1003					
sqrt		941	942	943							
vc		1130	1130								
v100		1082	1086								
v101		1000	1005	1006							
v102		394	999	[illegible]	1005	1005	1009	1006	1011	1009	
v103		1001	1005	1006							
v109		996	1003								
v110		1003	1004	1005							
v120		382	997								
v121		385	997								
v140		942	942	942	943	943		943			
v141		931	932	932	933	933	934	934	941	934	

	941	941	941	942	943				
v141sqr	941								
v142	941	942	943						
v5Ø	405	54Ø	556	568	569	636	1Ø46		
v51	525	54Ø	547	549	636				
v51°	536	537							
v52	536	547	568	569					
v53	537	549	556						
v54	551	555	639						
v55	567	639							
v56	597	6ØØ	642						
v57	[illegible]	642							
v6Ø	[illegible]	246	5Ø6	516	526	527			
v61	239	246	5Ø4	5Ø9	526	527			
v7Ø	898	898	899	899					
	394	466	556	568	569	625	621	797	622
	1Ø[illegible]	1Ø47							
A	957								
B	958								
-	883	884	885	886					
|	892								
^	[illegible]	933	999	1ØØØ	1ØØ1				
π	882	883	884	885	886	897	894	898	897
	898	899	899	899	1ØØ9				

lesson information

lesson name = eexØ7

starting date = Ø4/11/73

last edited on Ø8/28/74 at 22.32.47

by neal of course eecge

at site 17, station 18

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = Measurements of Impedance.

lesson eex08 at 10:39 pm on wednesday, august 28, 1974

-- part=1, block=a ----------

block 1a,   eex08id

```
stop
****      For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

    Measurements of Two-Port Networks.

              Divisions of this Lesson:        Block     Unit

          Id for this file                     eex08id
          Experiment eex08
            Objectives                         x08m0a    x08m0a
            Definition of two-port network     x08m1a    x08m1a
            Voltage gain of a two-port         x08m2a    x08m2a
            Frequency response of two-port     x08m3a    x08m3a
            Final test                         x08m4a    x08m4a

          final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   tgt,1010> Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon
area    eex08
ext     0
```

-- part=1, block=b ----------

block 1b,   x08m0a

```
unit    x08m0a
next    x08m1a
define  x08def
        err=n50
        errmess=n51
        it=n52      $$ specifies input terminal of two port
        ot=n53      $$ specifies output terminal of two port
        fc=v55
        fo=v56
zero    err
```

```
restart
join      imode
jump      n47,x08m0a,x
at        417
write     MEASUREMENTS OF TWO-PORT NETWORKS
at        705
write        When you have completed this experiment, you should
          be able to:

             1. Understand the definition of a two-port network.

             2. Measure the voltage-gain transfer function of a
          two-port network.

             3. Measure the frequency response of the voltage
          gain of a two-port network.

             4. As a final test, measure the frequency response
          of the voltage gain of a band-pass filter.
```

-- part=1, block=c ----------

block 1c,   xØ8m1a

```
unit      xØ8m1a
back      xØ8mØa
next      xØ8m1b
at        707
write        Throughout this lesson we will represent a network
          by a box which may be thought of as containing the
          network.

             Leads brought out of the box indicate that
          certain terminals or nodes of the network are
          externally accessible.  That is, we can connect to
          or measure between these terminals or nodes.
draw      1723;1742;2342;2323;1723;2123;2117;skip;1923;1917
          skip;1942;1948;skip;2142;2148;skip;2335;2735
          skip;2730;2330
at        219,187
write     NETWORK
circle    3,128,208
circle    3,128,176
circle    3,376,176
circle    3,376,208
circle    3,232,80
circle    3,272,80
vector    252,41;272,80
vector    252,41;232,80
at        206,21
write     TERMINALS
***

unit      xØ8m1b
```

```
term    m1b
back    x08m1a
next    x08m1c
at      307
write   A pair of terminals is called a port. A two-port
        network is, therefore, a network with two pairs of
        external terminals.

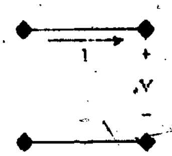
           In a two-port network, one of the ports is usually
        connected to a source, and the other port is usually
        connected to a load.

           For the arrangement shown below, the following
        four electrical quantities can be measured:

                          I1, V1, I2, & V2.
join    x08s1a
join    x08s1b
join    x08s1c
at      2705
write      Throughout this experiment, we will assume that the
        impedance ZL is a very high impedance, i.e., that the
        magnitude of I2 is small compared to the magnitude of I1.
----------------------------------------------------------- part=1, block=d ----------

     block 1d,    x08m1c

unit    x08m1c
back    x08m1b
next    x08m1d
at      307
write      Consider any port, or pair of terminals, in a network
        driven by a single-frequency sinusoidal power source.
        Conventions used here for the voltage and current are:
```




```
           When displayed on the SCOPE, the convenient measures
        of a voltage are Vpp and the time angle øv after t = 0,
        where the voltage is positive-going through v = 0.

           Then, the voltage is expressed mathematically by:

        v (t) = 0.5Vpp sin (wt + øv) = Vop sin (wt + øv)

           Here, this voltage is expressed as a phasor by:

        V = |V| ∠øv where |V| = 0.707 Vpp
```

```
          Similarly, the current representations are:

          i (t) = Iøp sin (ωt + øi), I = |I| ∠øi, |I| = 0.707 Ipp.
***

unit      x08m1d
back      x08m1c
next      x08m2a
at        505
write       A transfer function is a relation between two
          activities at two different ports in a network.  This
          contrasts with an impedance function which is a relation
          between two activities at the same port in a network.

            The transfer function called the voltage gain is
          of interest in this experiment.  We will refer to it
          hereafter simply as the gain G and define it by:

          G = |G| ∠øG = V2 / V1 = (|V2| / |V1|) ∠(øV2 - øV1)

            The gain is a complex quantity and can also be
          written in complex form, like we did for impedances
          in the impedance experiment, as:

                          G = Gre + j Gim
```

-- part=1, block=e ----------

block 1e, x08m2a

```
unit      x08m2a
back      x08m1d
next      x08m2b
at        405
write       Now consider the two-port shown below, where port 1
          is the driven port, and port 2 is the load port.

            If V1 = 15 V dc and V2 = 3 V dc, what is the gain G ?
join      x08s1a
join      x08s1c
join      x08s1b
arrow     926
at        926
write
ansv      .20,.05
wrong     3
at        1110
write     No, the gain of the two port is defined as the
          ratio V2/V1.
***

unit      x08m2b
back      x08m2a
next      x08m2c
```

```
help    x08s2a
at      305
write       Now suppose you are given another two-port network.

                V1pp = 10 /0° V drives port 1.

                V2 is then measured as V2pp = 5 /+31°.

            What is the voltage gain G of the two-port in polar form,
        i.e., in the form |G|/α°? (Press -MICRO- then o for °.)
join    x08s1a
join    x08s1c
join    x08s1b
at      1210
write   Magnitude ____   Phase angle ____
at      3122
write   -HELP- is available.
arrow   1220
ansv    .5
arrow   1240
answer  <degrees,deg,°>31
wrong   <degrees,deg,°>-31
*

unit    x08m2c
back    x08m2b
next    x08m2d
help    x08s2b
at      405
write       Consider the resistive two port network shown below.

            If V1 = 10 V dc, what is V2 and G.

            V2 =
at      817
write   ____ V dc.
at      830
write   G = ____
join    x08s1d
join    x08s1a
join    x08s1c
at      3122
write   HELP is available
arrow   817
ansv    5
no
at      1005
write     Hint: Think of the two-port network as a simple
        voltage divider. Note also that -HELP- is available.
arrow   833
ansv    .5
no
at      1011
write   You got V2 correct, now simply use the formula
        G = V2/V1 to find the voltage gain.
```

--- part=1, block=f ---

block 1f, x08m2d

```
unit      x08m2d
back      x08m2c
next      x08m2e
calc      it⇐1
          ct⇐3
at        405
write        Let's try to verify this last result experimentally.
          The resistive two-port just studied is part of the
          the superposition circuit. Plug in the sensor cable
          of the SUPERPOSITION BOARD, ITEM 38, and place all
          the switches on the board (SW1 through SW4) in the
          up position.

             You should now have the following two-port network:
join      x08s11
join      x08s1a
join      x08s1c
at        1817
write     1
at        1843
write
at        2316
write     11
at        2347
write     11
pause
at        2320
write     1
at        405
write        In this experiment, terminal 1 is used as the
          common grounded terminal.
***

unit      x08m2e
back      x08m2d
next      x08m2f
calc      errmess⇐0
memo      err
join      x08s2h
end
***

unit      x08m2f
pack      n33,+++efhe++a++a(abcd)+aaa++1
join      ckd
jump      n47,x08s2c,x

entry     x08m2g
pack      n33,aacdd0cc00k0k00ac000000000akc0
join      chc
calc      errmess⇐0
```

```
         err⇐n47
   jump  n47,x08s2d,x08m2h
   ***

   unit      x08m2h
   erase
   catchup
   back      x08m2d
   next      x08m2j
   zero      err
   at        405
   write     Measure the gain of the two-port by setting the
          following dials:

               1) Set the OSCILLOSCOPE to display a 1 kHz sine
          wave with an amplitude in the range 5 ≤ Vpp ≤ 10 V.
          Set the Y DISPLAY to A, the A PRE AMP to +AC,
          the TRIGGER SOURCE to AC INT, and the SWEEP MODE to
          AUTO.

               2) Set the RANGE control of the VACUUM TUBE VOLTMETER
          to 3 RMS VOLTS.

               3) Adjust the frequency controls of the AUDIO
          OSCILLATOR to produce a 1 kHz sine wave output.
          Temporarily connect the VTVM INPUT to terminal
          <z,it> of the two-port network and then
          adjust the AMPLITUDE dial of the AUDIO
          OSCILLATOR to give a 2 rms V reading on the VTVM.

               4) Now reconnect the VTVM INPUT to terminal <z,ot> of
          the two-port network.
   end
   join      x08m2i
   ***

   unit      x08m2i
   at        2805
   write     After setting these dials, press -NEXT-.
   ***

   unit      x08m2j
   pack      n33,+(gh)mecfbab+++++++++(bc)b(pq)h
   join      ckd
   calc      errmess⇐0
             err⇐n47
   jump      n47,x08s2f,x08m2k
```

-- part=1, block=g ----------

block 1g, x08m2k

```
   unit      x08m2k
   back      x08m2h
```

```
next      x08m2l
at        405
write        You have now correctly set up the two-port network
          for gain measurements. Without changing the
          AMPLITUDE dial of the AUDIO OSCILLATOR at all,
          measure the output port voltage (terminal 3) on the VTVM.

             What is value that you read on the VTVM?

arrow     1110
at        1110
write     ____ rms V
store     v52
ansv      1,5%
at        1605
write        The input voltage V1 to the two-port network was
          set above to 2 rms V.

             The output voltage V2 that you obtained was
          <s,v52> rms V.

             What is the voltage gain of the two port?
arrow     2417
ansv      v52/2,5%
wrongv    2*v52,5%
at        2605
write        Remember the voltage gain of a two-port is defined
          as V2/V1, not V1/V2!!!
no
at        2605
write        You have miscalculated the voltage gain G.
          Check again to make sure that V1 is 2 rms V,
          and remeasure the output port voltage, V2.

unit      x08m2l
write
setshup
back      x08m2k
next      x08m2n
at        805
write        Now vary the frequency of the AUDIO OSCILLATOR, making
          sure to keep the input voltage V1 constant as you do this.

entry     x08m2m
at        1005
write        It may be helpful to first set V1 to 2 rms V, at a
          particular frequency (e.g. 1 kHz). Then, with A VOLTS
          FULL SCALE set to 5 V, take the A PRE AMP off of
          calibration. This is done by rotating the red knob
          marked VARIABLE GAIN counter-clockwise.

             By adjusting the VARIABLE GAIN, set the peak-to-peak
          deflection on the SCOPE to exactly 10 divisions and leave
          it there.
```

```
         Thereafter, as you rotate the frequency dial of the
     AUDIO OSCILLATOR, readjust only the AUDIO OSCILLATOR
     AMPLITUDE control to maintain a constant peak-to-peak
     deflection on the SCOPE.
end
```

-- part=1, block=h ----------

```
     block 1h,    x08m2n

unit      x08m2n
back      x08m2l
next      x08m2o
lab       x08m2m
at        805
write        Do you notice any change in the amplitude of the
          output voltage  on the VTVM, as the input frequency
          to the two-port is varied?
arrow     1220
answer    (n,no,N,No)
at        1405
write        Right! As long as the input amplitude to a resistive
          two-port is held constant, the output voltage
          amplitude will not vary as a function of frequency.
          This is because the impedance of a resistor is
          independent of frequency and hence the voltage
          gain of a resistive two-port is independent of
          frequency.
wrong     (y,yes,Y,Yes,some)
at        1405
write        Make sure that you keep the input voltage
          to the two-port constant as you vary the frequency.
          Press -LAB- if you need a hint on how to do this.
***

unit      x08m2o
at        805
write        If you have taken the A VOLTS off of calibration
          by adjusting the red VARIABLE GAIN knob, place
          the A VOLTS back into calibration by rotating
          the red VARIABLE GAIN dial fully clockwise until
          it clicks.

             When the A channel is in its calibrated mode,
          the A VOLTS window will be lit.
pause

entry     x08m2p
join      imode
jump      n47,x08m2p,x08m3a
```

-- part=1, block=i ----------

```
block 1i,   x08m3a

unit      x08m3a
back      x08m2n
next      x08m3b
base
at        405
write      Plug the sensor cable of the TWO PORT NETWORK BOARD,
          ITEM 36, into the interface.

             In this part of the experiment, the two port
          concerned consists of a series capacitor and a
          shunt resistor. The input port is terminals 1 & 2
          and the output port is terminals 3+ 2. Terminal 2
          will be used as the ground terminal. Locate these
          terminals on the board now.
***

unit      x08m3b
zero      [illegible]
back      x08m3a
next      x08m3c
join      [illegible]
end

----------------------------------------------------- part=1, block=j ----------

block 1j,   x08m3c

unit      x08m3c
pack      n3?,abc000000000b00ac000000000abe0
join      ckc
calc      errmess⇐1
          erren47
jump      n47,x08s2d,x08m3d
***

unit      x08m3d
back      x08m3a
next      x08m3e
data      x08m2h
[illegible]
[illegible]
at        [illegible]
write        Set the equipment dials to the same positions
          you previously used for measuring the gain of the
          resistive two port.

             Press -DATA- to review the dial settings necessary

                          OR
```

```
               . Press -NEXT- after you have properly set the dials.
***

unit      x08m3e
pack      n33,++m+cfbab+ttt+++++bb(pq)h
join      ckd
calc      errmess⇐1
          err⇐n47
jump      n47,x08s2f,x08m3f
***

unit      x08m3f
back      x08m3d
next      x08m3g
data      x08m2m
at        405
write        Now, monitoring the output port with the VTVM,
          vary the AUDIO OSCILLATOR frequency over the range
          of 20 Hz to 100 Hz, while keeping the voltage
          amplitude at the input port constant.
at        905
write        Press -DATA- for a hint on keeping the input
          port voltage amplitude constant.
at        1405
write        Does the output voltage vary as a function of
          frequency?
arrow     1524
answer    (y,Y,yes,Yes)
at        1705
write        Right! If the input port voltage V1 is held
          constant, the output port voltage V2 will vary as
          a function of frequency.

             Our next goal will be to predict the frequency response
          of the gain of a simple two-port RC network.

             Leave your equipment setup alone, as it will be
          used later.
wrong     (n,N,no,No)
at        1710
write        Make sure that you are keeping the input
          port voltage constant and that you are varying
          the AUDIO OSCILLATOR over the correct frequency
          range.
***

unit      x08m3g
back      x08m3f
next      x08m3h
lab       x08s2b
at        405
write        The gain G of the two port you have just connected
          may be analyzed easily by using the voltage-divider
          concept, where impedances are used instead of resistances.

             When I2 is negligible with respect to I1, the gain
          of the two-port under study is approximated by:
```

```
        G(jω) = V1 =   jωRC
                V2   1 + jωRC

where R = 2 kΩ, C = .1 μF, and ω = 2πf.

    Note that the gain is now a function of frequency,
and may be designated by G(jω).

    To review the voltage divider concept, press -LAB-.

    We will now measure G(jω) as a function of frequency.
------------------------------------------------------ part=1, block=k ----------

        block  k,    xØ8m3h

unit     xØ8m3h
back     xØ8m3g
next     xØ8m3i
at       405
write        The magnitude of G(jω) in deciBels (abbreviated dB)
         is defined by |G(jω)|dB = 2Ø × log1Ø |G(jω)| dB

             The advantage of using the deciBel or logarithmic
         notation is that it permits the easy computation
         of the magnitude of a product of gain functions, by
         simply adding the individual deciBel values, i.e.:

         |G1(jω)G2(jω)|dB = |G1(jω)|dB + |G2(jω)|dB

             It may also be noted that the phase angle of the
         product of two gains is simply the sum of their angles:

         ∠G1(jω)G2(jω) = ∠G1(jω) + ∠G2(jω)

             The measurement of |G|dB is facilitated by the
         use of the VTVM's dB scale. The use of this scale
         in measuring |G|dB will be covered next.
***

unit     xØ8m3i
back     xØ8m3h
next     xØ8m3j
at       204
write            USE OF THE dB SCALE ON THE HP4ØØD VTVM

             A deciBel is defined as 2Ø log1Ø a/b, i.e., 2Ø times
         the log to the base 1Ø of the ratio of two numbers.

             For our use (finding the gain of a two-port), the
         dB scale on the VTVM makes gain measurements easy.
```

```
          The dB scale on the VTVM is calibrated in terms of the
       ratio of the measured voltage Vx to the reference voltage.
       The reference voltage used on the VTVM is Vr = 0.775 rms V.
       Hence, the dB reading on the VTVM of any voltage is

       |Vx|dB = 20 log10 |Vx/Vr| = 20 log10 |Vx| - 20 log10 |0.775|

          In making a gain measurement, it is convenient to set
       the VTVM to the proper voltage scale to read |V2|, but
       before reading it, readjust V1 so the pointer indicates
       0 dB on the dB scale.  Then the value of |V2|dB is that
       value , 0 dB, plus the label on the RANGE dial setting.

          Next, without further adjusting V1, measure V1 on
       the dB scale, adjusting the RANGE switch so as to give
       the most accurate reading. Then, |V1|dB is the sum of
       the [illegible] reading and the [illegible] RANGE label.  Finally

              |V2/V1|dB = |V2|dB - |V1|dB
end
------------------------------------------------------------ part=1, block=1 -----

       block 11,   x08m3j

unit   x08m3j
base
back   x08m3i
next   x08m3k
lab    x08m m
at     405
write     Now measure the frequency response of |G|dB:

       1) At 5 kHz, adjust the A.O. AMPLITUDE dial so that
       the VTVM, which is currently displaying V2, reads
       0 dB , when the RANGE dial is set to +10 dB.

       2) Now keeping V1 constant, decrease the frequency
       of the A.O. until the gain is down 3 dB from its
       5 kHz value.

          Press -LAB- for a suggestion on keeping V1 constant.

          At what frequency is the gain down 3 dB?         Hz.
arrow  1649
store  fc
ansv   66,5,5%
wrong
at     1805
write     The frequency at which |G|dB is down 3 dB from its
       high frequency value is known as the corner frequency,
       fc, of the two port.
***
```

```
unit     x08m3k
back     x08m3j
at       410
write    Measure |G|dB at .5,.7,1,2,3,5,& 10 times fo.
                FREQUENCY (Hz)                      |G|dB

         .5×fo =<e,.5×fc>   Hz

         .7×fo =<e,.7×fc>   Hz

          1×fo =<e,1×fc>   Hz

          3×fo =<e,3×fc>   Hz

          5×fo =<e,5×fc>   Hz

         10×fo =<e,10×fc>   Hz
calc     n60⇐640
         n61⇐61

entry    x08m3l
calc     n61⇐n61+1
calcs    (n61-63),v70⇐-6.5,-4.7,-3,-.5,-.3,0
arrow    (n60⇐n60+200)
store    v(n61)
ansv     v70,.3
endarrow
inhibit erase
goto     (n61>66),x08m3m,x08m3l
***

unit     x08m3m
next     x08m3n
back     x08m3k
at       2105
write      To make evaluation of your data more meaningful,
         the data above will be plotted when you press -NEXT-.
***

unit     x08m3n
back     x08m3k
erase
origin   100,100
axes     300,300
lscalex  10000,10
scaley   0,-10
markx    20,10,2
labely   2,1,0
gdraw    (.5×fc),v62;(.7×fc),v63;fc,v64;(2×fc),v65;(3×fc),v66;(5×fc),v67;(10×fc),v68
write    <at,2713>10^1      10^2    Hz     10^3         10^4
write    <at,1606>dB
at       205
write      The graph below is known as a Bode plot of the
         gain. Note that the vertical scale is a linear plot
         of logarithmic values, and the horizontal scale is
         a logarithmic plot of frequency values.
```

```
at      2805
write      Note also that at low frequencies (below fo), the
        gain is low, while at high-frequencies, the gain is
        approaching unity (0 dB = 1). Hence, this two port
        network is called a high-pass filter.
```

-- part=1, block=m ----------

```
        block 1m,    x08m3o

unit    x08m3o
back    x08m3k
next    x08m3p
at      405
write      We will now measure the frequency response of the
        voltage gain for another type of two port network.

           Leave the two port network board plugged in, but
        remove all connections to the board and to the
        instruments.
pause
pack    n13,a0a00000000b000000000000000b00
join    cke
jump    n47,x08m3o,x08m3p
***

unit    x08m3p
back    x08m3o
next    x08m3q
lab     x08s2h
zero    err
at      405
write      The next two port network to be studied consists
        of terminals 4,5, & 2 on the TWO PORT NETWORK BOARD.

           The input port is between terminals 4 & 2, and the
        output port is between terminals 5 & 2, with the common
        terminal 2 used as the ground terminal.

           Make the necessary connections to this two port to
        enable you to measure |G|dB as a function of frequency.

           These connections are the same as those used for
        the last 2 two-ports. Press -LAB- to review the
        necessary connections.
end
***

unit    x08m3q
pack    n33,0a0bc0000000a00bc000000000bac0
join    cke
calc    errmess⇐0
        err⇐n47
jump    n47,x08s2d,x08m3n
```

```
------------------------------------------------------------------------------ part=1, block=n ----------

        block in,   x08m3r

        unit    x08m3r
        back    x08m3p
        next    x08m3s
        data    x08m2h
        calc    it⇐4
                ot⇐5
        at      405
        write      Set the dials on the equipment to measure |G|dB
                of this two port network. Use the same dial settings
                that you used to measure |G|dB of the high pass filter.

                   Press -DATA- to review the needed dial settings.
        ***

        unit    x08m3s
        pack    n33,++m+cfbab+++++++++bb(pq)h
        join    ckd
        calc    errmess⇐2
                err⇐n47
        jump    n47,x08s2f,x08m3t
        ***

        unit    x08m3t
        back    x08m3r
        next    x08m3u
        lab     x08m2l
        at      405
        write      Now measure the frequency response of |G|dB as follows:

                1) At 100 Hz, adjust the A.O. AMPLITUDE dial so that
                the VTVM (which is currently displaying V2) reads 0 dB,
                when the RANGE dial is set to the +10 dB scale.

                2) Now keeping V1 constant, increase the frequency of the
                A.O. until the gain is down 3 dB from its 100 Hz value.

                   Press -LAB- for a suggestion on keeping V1 constant.

                   At what frequency is the gain down 3 dB?        Hz.
        arrow   1549
        store   fo
        ansv    1820,3%
        wrong
        at      1805
        write      The frequency at which |G|dB is down 3 dB from its
                low frequency value is known as the corner frequency
                fo of this network.
------------------------------------------------------------------------------ part=2, block=a ----------
```

block 2a, x08m3u

```
unit      x08m3u
back      x08m3t
lab       x08m3l
base
at        403
write       Measure |G|dB of this two port as indicated below.

            Press -LAB- to review the measurement procedure.
at        810
write       FREQUENCY                               |G|dB

          .1×fo =<e,.1×fo>   Hz

          .2×fo =<e,.2×fo>   Hz

          .5×fo =<e,.5×fo>   Hz

          .7×fo =<e,.7×fo>   Hz

           1×fo =<e,1×fo>    Hz

           2×fo =<e,2×fo>    Hz

           3×fo =<e,3×fo>    Hz

           5×fo =<e,5×fo>    Hz

          10×fo =<e,10×fo>   Hz
calc      n60⇐240
          n61⇐99

entry     x08m3v
calc      n61⇐n61+1
calcs     (n61-101),v70⇐0,-.2,-1,-1.9,-3,-7.2,-10.1,-14,-20
arrow     (n60⇐n60+200)
store     v(n61)
ansv      v70,.3
no
endarrow
inhibit erase
goto      (n61>107),x08m3w,x08m3v
***

unit      x08m3w
back      x08m3u
next      x08m3x
at        2005
write       To make evaluation of your data more meaningful,
          the data above will be plotted when you press -NEXT-.
***
```

```
unit      xØ8m3x
back      xØ8m3u
next      xØ8m4a
erase
origin    1ØØ,1ØØ
axes      3ØØ,3ØØ
lscalex   1ØØØØØ,1ØØ
scaley    Ø,-25
markx     2Ø,1Ø,2
labely    5,1,Ø
gdraw     (.1×fo),v1ØØ;(.2×fo),v1Ø1;(.5×fo),v1Ø2;(.7×fo),v1Ø3;fo,v1Ø4
gdraw     fo,v1Ø4;(2×fo),v1Ø5;(3×fo),v1Ø6;(5×fo),v1Ø7;(1Ø×fo),v1Ø8
write     <at,2713>1Ø^2        1Ø^3    Hz    1Ø^4        1Ø^5
write     <at,16Ø6>dB
at        2Ø5
write        The graph below is the Bode plot of |G|dB for the two
          port network you currently have set up.

             Note that the plot differs from the Bode plot of the
          high-pass filter previously studied.
at        28Ø5
write        Since low frequencies are passed and high frequencies
          are attenuated, this two port network is known as
          a low-pass filter.
```

--- part=2, block=b ------------

block 2b,   xØ8m4a

```
unit      xØ8m4a
restart
base
back      xØ8m3x
next      xØ8m4b
erase
catchup
at        4Ø5
write        The great utility of the Bode-plot method of
          recording G vs f is easily demonstrated.

             Consider the two gains you have evaluated experimentally
          for the high-pass and low-pass filters. The gain for
          a filter consisting of those two filters cascaded is
          simply the product of the gains of the individual filters.

             The 2 two-ports are cascaded simply by connecting
          Terminal 3 to Terminal 4. The input port is then Terminals
          1 & 2, and the output port is Terminals 5 & 2. Note
          that Terminal 2 is the common ground terminal.

             The gain |G|dB of this composite filter, using
          your calculated values, is shown in the next display.
***
```

```
unit    x08m4b
origin  75,100
axes    350,300
lscalex 1000000,10
scaley  0,-25
markx   20,10,2
labely  5,1,0
write   <at,2709>10^1           10^2           10^3           10^4           10^5
write   <at,28,241>|G|dB
write   <at,2831>f (Hz)
gdraw   (.5×fc),v62;(.7×fc),v63;fc,v64;(2×fc),v65;(3×fc),(v66+v100);
gdraw   (3×fc),(v66+v100);(5×fc),(v67+v101);(10×fc),v68
gdraw   (10×fo);v68;(.5×fo),v102;(.7×fo),v103;fo,v104;(2×fo),v105;(3×fo),v106;
gdraw   (3×fo),v106;(5×fo),v107;(10×fo),v108
```

-- part=2, block=c ----------

```
* block 2c,    x08m4c

unit    x08m4c
base
back    x08m4a
data    x08m2h
lab     x08s2i
help    x08m21
calc    it⇐1
        ct⇐5
at      405
write      Check the preceding display experimentally, by measuring
        and entering |G|dB in the table below:

              FREQUENCY                    |G|dB

                 50 Hz

                100 Hz

                200 Hz

                500 Hz

                  1 kHz

                  2 kHz

                  5 kHz

                 10 kHz

                 15 kHz
at      2808
write   Press -DATA- to review the dial settings.
              -LAB- to review the connections.
```

```
                      -BACK- for the terminal numbers of the two-port.
                      -HELP- for a hint on keeping V_1 constant.
calc      n60⇐839
          n61⇐110

entry     x08m4d
calc      n61⇐n61+1
calcs     (n61-112),v70⇐-4.3,-1.8,-.75,-.6,-1.3,-3.8,-9.5,-15,-18.2
arrow     (n60⇐n60+200)
store     v(n61)
ansv      v70,.5
no
endarrow
inhibit erase
goto      (n61>118),x08m4e,x08m4d
***

unit      x08m4e
next      x08m4f
mode      rewrite
at        2805                 $$ blank lines needed for rewrite
write        Press -NEXT- to see your experimental values
          superimposed as *'s on the calculated Bode plot.


***

unit      x08m4f
erase
origin    75,100
axes      350,300
lscalex   1000000,10
scaley    0,-25
markx     20,10,3
labelx    5,1,0
write     <at,2709>10^1          10^2          10^3          10^4          10^5
write     <at,26,241>|G|_dB
write     <at,2831>f (Hz)
gdraw     (.5×f_c),v62;(.7×f_c),v63;f_c,v64;(2×f_c),v65;(3×f_c),(v66+v100);
gdraw     (3×f_c),(v66+v100);(5×f_c),(v67+v101);(10×f_c),v68
gdraw     (10×f_c),v68;(.5×f_o),v102;(.7×f_o),v103;f_o,v104
gdraw     f_o,v104;(2×f_o),v105;(3×f_o),v106;(5×f_o),v107
gdraw     (5×f_o),v107;(10×f_o),v108
graph     50,v111,*
graph     100,v112,*
graph     200,v113,*
graph     500,v114,*
graph     1000,v115,*
graph     2000,v116,*
graph     5000,v117,*
graph     10000,v118,*
graph     15000,v119,*
at        2905
write        Note that this two port network attenuates frequencies
          greater than 600 Hz and less than 200 Hz. Because of this
          characteristic, this network is known as a band-pass filter.
pause
```

```
jump    x08end
```

-- part=2, block=d ----------

```
        block 2d,    x08s1a

unit    x08s1a
draw    1723;1742;2342;2323;1723
draw    1823;1817;skip;2223;2223;2217
circle  3,128,160
circle  3,128,224
at      1917
write   +
at      128,168
write   _
at      128,188
write   V1
at      1719
write   I1
at      1819
write   →
draw    1842;1848
circle  3,376,224
at      373,207
write   +
draw    2242;2248
circle  3,376,160
at      375,171
write   _
at      372,184
write   V2
at      348,224
write   →
at      348,240
write   I2
***

unit    x08s1b
draw    1848;426,224
at      423,208
write   |
        >
        <
        |
draw    426,160;2248
at      440,188
write   ZL
***

unit    x08s1c
draw    1817;1811
circle  16,80,192
draw    1911;1811;skip;2111;2211;2217
at      76,192
```

```
write   +
        _
***

unit    xØ8s1d
at      2ØØ,22Ø
write   -^^^-
draw    183Ø;1834
at      261,2Ø8
write   |
        }
        }
draw    2223;2242;2234;2134;skip;1834;1834;1842;skip;1826;1823
at      192,2Ø3
write   33ØØΩ
at      272,188
write   33ØØΩ
***

unit    xØ8s2a
at      5Ø5
write      Complex numbers may be written in two forms;

        rectangular form (A+jB) and polar form (|C|∠α°).

           The two forms are interrelated by the following
        equations:

at      1Ø1Ø
write
             |C| = √(A² + B²)

               α = tan⁻¹ (B/A)
at      1135
write   A=|C|cos α

        B=|C|sin α
at      16Ø5
write      To divide two complex numbers, first put both
        numbers into polar form. Then divide the magnitudes
        and subtract the phase angles.

              For example: A∠α  =  A ∠(α - β)
                           B∠β     B
end
```

-- part=2, block=e ----------

block 2e,   xØ8s2b

```
unit    xØ8s2b
at      4Ø5
write      The network below is known as a voltage divider network,
        when I₂ is negligible with respect to I₁:
```

```
at      192,380
write   -^^-
         R1
at      735
write     I2
        ------>
at      1034
write   >
        >
draw    820;825;skip;829;267,384;267,368;skip;267,384
        842;skip;1220;1242;skip;267,335;267,320
at      280,348
write   R2
at      152,346
write   V1
at      320,346
write   V2
at      920
write   +
at      152,326
write   -
at      318,327
write   -
at      318,368
write   +
draw    1023;1031;1131;1126;204,340;skip;204,332;200,336
at      1124
write   I1
at      1405
write      From the above network, the following equations
        can be derived:
at      1626
write   1) V2 = R2I1

        2) I1 = V1/(R1 + R2)
at      2005
write      Substituting eq. 1) into eq. 2), the following equation
        is obtained:                  V2 = R2V1 / (R1+R2)

           The output voltage V2 is just that part of the input
        voltage V1 appearing across R2. Hence the name 'voltage
        divider'.

           It can be shown that this voltage divider idea holds
        in general for impedances Z1 and Z2 in place of R1 and
        R2, and also holds for ac voltages.
end
***

unit    x08s2c
next    x08m2f
at      405
write      At this point, you have not yet been asked to set
        any dials. Set all dials back to their initial mode
        positions, and then press -NEXT- to proceed.
***
```

```
unit    x08s2d
help    errmess,x,x08m2e,x08m3b,x08m3p
next    errmess,x,x08m2g,x08m3c,x08m3q
join    (err<0),x08s2e,x
at      605
write      Press -NEXT- if you know and have corrected your error.

        or, press -HELP- to review the needed connections.
***

unit    x08s2e
at      408
write   There is something wrong with your connections.
```

-- part=2, block=f --------

block 2f,   x08s2f

```
unit    x08s2f
next    errmess,x,x08m2i,x08m3e,x08m3s
help    x08m2h
join    (err<0),x08s2g,x
at      1005
write      Press -NEXT- if you know and have corrected your
        errors.

           Press -HELP- if you wish to review the needed dial
        settings.
***

unit    x08s2g
at      810
write   You have incorrectly set (z,-n47) dials(s).
***

unit    x08s2h
at      405
write      Now make the following connections:

        1) Connect the input port of the two port network to
        the AUDIO OSCILLATOR.

        2) Also connect the input port to the A INPUT of the
        OSCILLOSCOPE.

        3) Connect the output port of the two port network
        to the INPUT of the VACUUM TUBE VOLTMETER.

        4) Finally, connect the output port of the two port
        network to the B INPUT of the OSCILLOSCOPE.
at      2105
write      Did you remember to correctly connect all grounds.
```

```
                Press -BACK- to review the terminal numbers of the
             two port under study.
at           2605
write           When you are through making the above connections,
             press -NEXT-.
end

unit         x08s2i
erase
catchup
at           405
write           Now make the following connections:

             1) Connect the input port of the two port network
             to the AUDIO OSCILLATOR.

             2) Also connect the input port to the A INPUT of the
             OSCILLOSCOPE.

             3) Connect the output port of the two port network
             to the INPUT of the VACUUM TUBE VOLTMETER.

             4) Finally, connect the output port of the two port
             network to the B INPUT of the OSCILLOSCOPE.
at           2105
write           Did you remember to correctly connect all grounds.
end
------------------------------------------------------------ part=2, block=g ----------

          block 2g,     x08end

unit         x08end
back         x08m3a
join         imode
jump         n47,x08end,x
course       n2
calcc        n2='ee244',
             nc(n21+1)⇐(nc(n21+1)$mask$o777777777700000000000)+o46030000000,
             nc(n21+1)⇐nc(n21+1)
erase
output       /// student has completed experiment ///
join         endunit
join         jmpmes
jumpout      cgeindex,quest1

entry        leave
end          lesson
***

unit         endunit
course       n2
jump         n2≠'ee244',leave,x
calc         nc(n21+7)⇐nc(n21+7)+ahelp
```

```
1Ø98         vc(n21+6)⇐vc(n21+6)+atime/6ØØØØ
1Ø99  ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
11ØØ  use     eexØØ,ck1
11Ø1  use     ck2
11Ø2  use     ck3
11Ø3  use     ck4
11Ø4  use     ck5
11Ø5  use     ck6
      ckc             not found              259     419     627     65Ø
      ckd             not found              255     297     44Ø     669
      endunit   xØ8end         1Ø94           2Ø    1Ø88
      imode           not found               39     393    1Ø8Ø
      jmpmes          not found             1Ø89
      leave     xØ8end         1Ø91         1Ø96
      xØ8end    xØ8end         1Ø78          872    1Ø81
      xØ8mØa    xØ8mØa           28           4Ø      55
      xØ8m1a    xØ8m1a           54           29      83
      xØ8m1b    xØ8m1a           81           56     1Ø4
      xØ8m1c    xØ8m1c          1Ø3           84     126
      xØ8m1d    xØ8m1c          125          1Ø5     143
      xØ8m2a    xØ8m2a          142          127     162
      xØ8m2b    xØ8m2a          161          144     185
      xØ8m2c    xØ8m2a          184          163     215
      xØ8m2d    xØ8m2d          214          186     246     267
      xØ8m2e    xØ8m2d          245          216    1Ø17
      xØ8m2f    xØ8m2d          253          247    1Ø1Ø
      xØ8m2g    xØ8m2d          257         1Ø18
      xØ8m2h    xØ8m2d          264          262     3Ø3     427     658  Ø3Ø  797
      xØ8m2i    xØ8m2d          291          289    1Ø29
      xØ8m2j    xØ8m2d          295          268
      xØ8m2k    xØ8m2k          3Ø2          3ØØ     337
      xØ8m2l    xØ8m2k          334          3Ø4     359     677     799
      xØ8m2m    xØ8m2k          342          361     448     543
      xØ8m2n    xØ8m2n          358          338     397
      xØ8m2o    xØ8m2n          382          36Ø
      xØ8m2p    xØ8m2n          392          394
      xØ8m3a    xØ8m3a          396          394     412     425    1Ø79
      xØ8m3b    xØ8m3a          41Ø          398    1Ø17
      xØ8m3c    xØ8m3c          417          413    1Ø18
      xØ8m3d    xØ8m3c          424          422     446
      xØ8m3e    xØ8m3c          438          426    1Ø29
      xØ8m3f    xØ8m3c          445          443     478
      xØ8m3g    xØ8m3c          477          447     496
      xØ8m3h    xØ8m3h          495          479     514
      xØ8m3i    xØ8m3h          513          497     541     698
      xØ8m3j    xØ8m3j          539          515     564
      xØ8m3k    xØ8m3j          563          542     588     594     617
      xØ8m3l    xØ8m3j          576          584
      xØ8m3m    xØ8m3j          586          584
      xØ8m3n    xØ8m3j          593          587
      xØ8m3o    xØ8m3o          616          628     631
      xØ8m3p    xØ8m3o          63Ø          618     628     656    1Ø17
      xØ8m3q    xØ8m3o          648          632    1Ø18
      xØ8m3r    xØ8m3r          655          653     675
      xØ8m3s    xØ8m3r          667          657    1Ø29
      xØ8m3t    xØ8m3r          674          672     697
      xØ8m3u    xØ8m3u          696          676     728     735
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xØ8m3v	xØ8m3u	716		725						
xØ8m3w	xØ8m3u	727		725						
xØ8m3x	xØ8m3u	734		729	761					
xØ8m4a	xØ8m4a	758		736	796					
xØ8m4b	xØ8m4a	779		762						
xØ8m4c	xØ8m4c	794								
xØ8m4d	xØ8m4c	822		831						
xØ8m4e	xØ8m4c	833		831						
xØ8m4f	xØ8m4c	842		834						
xØ8s1a	xØ8s1a	874		95	149	171		197		228
xØ8s1b	xØ8s1a	9Ø4		96	151	173				
xØ8s1c	xØ8s1a	915		97	15Ø	172		198		229
xØ8s1d	xØ8s1a	923		196	227					
xØ8s2a	xØ8s1a	937		164						
xØ8s2b	xØ8s2b	959		187	48Ø					
xØ8s2c	xØ8s2b	1ØØ9		256						
xØ8s2d	xØ8s2b	1Ø16		262	422	653				
xØ8s2e	xØ8s2b	1Ø24		1Ø19						
xØ8s2f	xØ8s2f	1Ø28		3ØØ	443	672				
xØ8s2g	xØ8s2f	1Ø38		1Ø31						
xØ8s2h	xØ8s2f	1Ø42		25Ø	414	633				
xØ8s2i	xØ8s2f	1Ø61		798						
ahelp	xØ8def	1Ø97								
atime	xØ8def	1Ø98								
err	xØ8def	31	37	249	261	269	421	299	442	411
		634	652	671	1Ø19	1Ø31				
errmess	xØ8def	32	248	26Ø	298	42Ø	670	441	1017	651
		1Ø18	1Ø29							
f_c	xØ8def	35	555	568	569	57Ø	573	571	602	572
		6Ø2	6Ø2	6Ø2	6Ø2	6Ø2	784	6Ø2	784	789
		789	789	79Ø	79Ø	79Ø	853	791	853	853
		853	853	854	854	854		855		
f_o	xØ8def	36	688	7Ø5	7Ø6	7Ø7	710	7Ø8	711	7Ø9
		712	713	744	744	744	745	744	745	744
		745	745	745	791	791	791	791	792	791
		792	792	855	855	855	856	856	856	856
		857	857							
it	xØ8def	33	217	283	428	659		8ØØ		
nc	xØ8def	1Ø84	1Ø84	1Ø85	1Ø85	1Ø97		1Ø97		
n2	xØ8def	1Ø82	1Ø83	1Ø95	1Ø96					
n21	xØ8def	1Ø84	1Ø84	1Ø85	1Ø85	1Ø97		1Ø97	1098	1Ø98
n33	xØ8def	254	258	296	418	439		626	668	649
n47	xØ8def	4Ø	256	261	262	299	421	3ØØ	422	394
		442	443	628	652	653	[illegible]040	671	1081	672
n5Ø	xØ8def	31								
n51	xØ8def	32								
n52	xØ8def	33								
n53	xØ8def	34								
[illegible]	xØ8def	574	579	579	714	719	825	719	825	82Ø
[illegible]	xØ8def	575	577	577	578	58Ø	717	584	717	715
		718	72Ø	725	821	823	826	823	831	824
ot	xØ8def	34	218	286	429	66Ø		8Ø1		
v	xØ8def	58Ø	72Ø	826						
vc	xØ8def	1Ø98	1Ø98							
v1ØØ	xØ8def	744	789	79Ø	853	854				
v1Ø1	xØ8def	744	79Ø	854						
v1Ø2	xØ8def	744	791	855						

v1Ø3	xØ8def	744	791	855			
v1Ø4	xØ8def	744	745	791	855	856	
v1Ø5	xØ8def	745	791	856			
v1Ø6	xØ8def	745	791	792	856		
v1Ø7	xØ8def	745	792	856	857		
v1Ø8	xØ8def	745	792	857			
v111	xØ8def	858					
v112	xØ8def	859					
v113	xØ8def	86Ø					
v114	xØ8def	861					
v115	xØ8def	862					
v116	xØ8def	863					
v117	xØ8def	864					
v118	xØ8def	865					
v119	xØ8def	866					
v52	xØ8def	314	32Ø	323	324		
v55	xØ8def	35					
v56	xØ8def	36					
v62	xØ8def	6Ø2	789	853			
v63	xØ8def	6Ø2	789	853			
v64	xØ8def	6Ø2	789	853			
v65	xØ8def	6Ø2	789	853			
v66	xØ8def	6Ø2	789	79Ø	853	854	
v67	xØ8def	6Ø2	79Ø	854			
v68	xØ8def	6Ø2	79Ø	791	854	855	
v7Ø	xØ8def	578	581	718	721	824	827
%	xØ8def	315	323	324	556	689	

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