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ABSTRACT

This high technology training module is an advanced course on computer-assisted design/computer-assisted manufacturing (CAD/CAM) for grades 11 and 12. This unit, to be used with students in advanced drafting courses, introduces the concept of CAD/CAM. The content outline includes the following seven sections: (1) CAD/CAM software; (2) computer numerical control (CNC) programming--control of machines by numbers, and advantages/disadvantages of CNC; (3) methods of programming; (4) the axis system--Cartesian coordinates, polar coordinates, and right-hand rule; (5) CAM software (post-processing)--advantages and applying software; (6) CNC machine operation--machine components, safety, selecting cutter tools, tools and fixtures, and controller operation; and (7) machine setup--entering offsets and program testing. A methodology section lists the following resource aids: three references, two videotapes, transparencies, demonstrations, worksheets, hardware and software, jig and fixtures, and unit evaluation. Unit evaluation consists of CNC pretest, two CNC worksheets, three assignments, and a posttest. Fourteen additional transparencies are provided. (NLA)

High-Technology Training Module

Module Title: CAD/CAM

Unit: CAM

Course: ADVANCED CAD/CAM

Grade Level (s): 11 - 12

Developed by: ROBERT ZULEGER

Date: MARCH, 1990

School: WAUSAU WEST HIGH SCHOOL

1200 WEST WAUSAU AVE., WAUSAU, WI 54401

Developed as a part of the High-Technology Training Model for Rural Based Business and Industry, Technical Colleges and Local and State Educational Agencies under Grant No. V199A90151.

HIGH - TECHNOLOGY

TRAINING MODULE

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This unit is designed to be used with students in an Advanced Drafting Course. It is assumed that the lab is equipped with MS-DOS CAD software, CAM software and a CNC milling machine. The materials could be altered to fit your needs.

The purpose of this unit is to introduce the concept of CAD/CAM. The student will become familiar with CNC and how CAD/CAM can save time and increase accuracy. It is assumed that the student has an understanding of coordinates.

Objectives: At the completion of the unit, the student will be able to:

1. identify the standard X, Y, Z axis using the "right hand rule".
2. compare the various methods for programming a CNC controller.
3. compare conversational input to coded input.
4. identify the major functions of a post-processor.
5. post-process a CAD drawing and download to a CNC milling machine.
6. operate a CNC milling machine after a part has been downloaded.

Content Outline

I. CAD/CAM
   A. C.A.D. Software
      1. store geometry
      2. extremely accurate
   B. C.A.M. Software
      1. intermediate step
      2. tool paths determined
      3. tool paths verified on screen
      4. can be saved or downloaded to CNC machine

II. What is Numberical Control Programming?
   A. Control of Machines by Numbers
   B. Advantages of CNC
      1. high degree of quality
      2. can machine difficult shapes economically
      3. reduced scrap
   C. Disadvantages of CNC
      1. high initial cost of machine
      2. increase in electrical maintenance
      3. retraining of existing personnel

III. Methods of Programming
   A. N/C Tape
   B. Direct Programming of Controller
   C. Post-processor Software

IV. The Axis System
   A. Cartesian Coordinates
      1. absolute
      2. incremental
   B. Polar Coordinates
   C. Right Hand Rule

V. CAM Software (Post-processing)
   A. Advantages
      1. verify tool paths on computer
      2. will generate codes of CNC controller
      3. can import CAD drawings
      4. geometry doesn't have to be recreated
   B. Applying Software
      1. loading part
      2. post-processing
      3. downloading to controller

VI. CNC Machine Operation
   A. Components of the Machine
   B. Safety
   C. Selecting Cutter Tools
   D. Tools and Fixtures
   E. Controller Operation

VII. Machine Setup
   A. Entering Offsets
   B. Testing the Program

Methodology

References:

1. Computer Numerical Controlled Simplified
   M. Fitzpatrick, Glencoe Publishing
2. Programming Manual
   Dyna Electronics
3. Post-processing Manual

Video Tapes:

1. Personal Computers in Manufacturing (Society of Manufacturing Engineers)
2. CAD/CAM (Society of Manufacturing Engineers)

Transparencies

Demonstrations

1. CNC Milling Machine
2. Post-processor Software

Worksheets

Hardware and Software

Jig and Fixtures

Evaluation

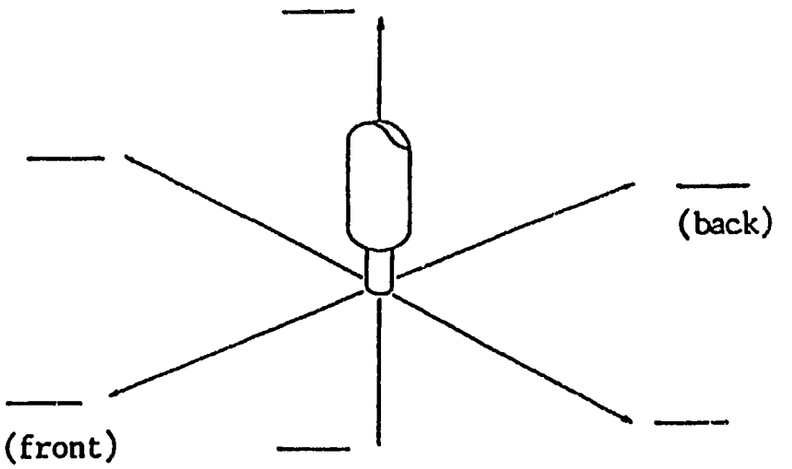
Unit Evaluation

CNC Worksheet No. 1	13 points
CNC Worksheet No. 2	12 points
Assignment No. 1	20 points
Assignment No. 2	25 points
Assignment No. 3	30 points
Post-Test	12 points

NAME _____

CNC PRE-TEST

1.- 6. Match each of the axis direction.



A. X+
B. X-
C. Y+
D. Y-
E. Z+
F. Z-

7.- 8. List two of four advantages of using CAM software.

A. _____

B. _____

9.- 11. Which three of the following are ways of programming a CNC controller?

9. _____
10. _____
11. _____

A. Using CAD software
B. N/C tape
C. Digitizer
D. Direct programming
E. Post-processor software
F. Using word processing software

12. Explain in your own words what conversational language means.

NAME _____

CNC WORKSHEET NO. 1

After reading Chapters 1, 3, and 6 in "Computer Numerical Control Simplified", answer the following questions.

1. List the four major differences between NC and CNC. (4 pts.)

2. If the thumb of your right hand points along the positive X axis, the first finger will point out the positive _____ axis and the second finger will identify the positive _____ axis. (2 pts.)

3. List the four major components in a CNC system. (4 pts.)

4. What are the ways a CNC controller may be programmed? (3 pts.)

NAME _____

CNC WORKSHEET NO. 2

After reading Chapters 22, 23, 24, and 25 in "Computer Numerical Control Simplified", answer the following questions.

1. What does "C.I.M." stand for? What are some of the duties of CIM? (4 pts.)

2. Explain what a work cell is. (4 pts.)

3. CAD units benefit the machinist in the following ways: (2 pts.)

Assignment No. 1

Objectives:

1. to understand the process of direct programming of the controller.

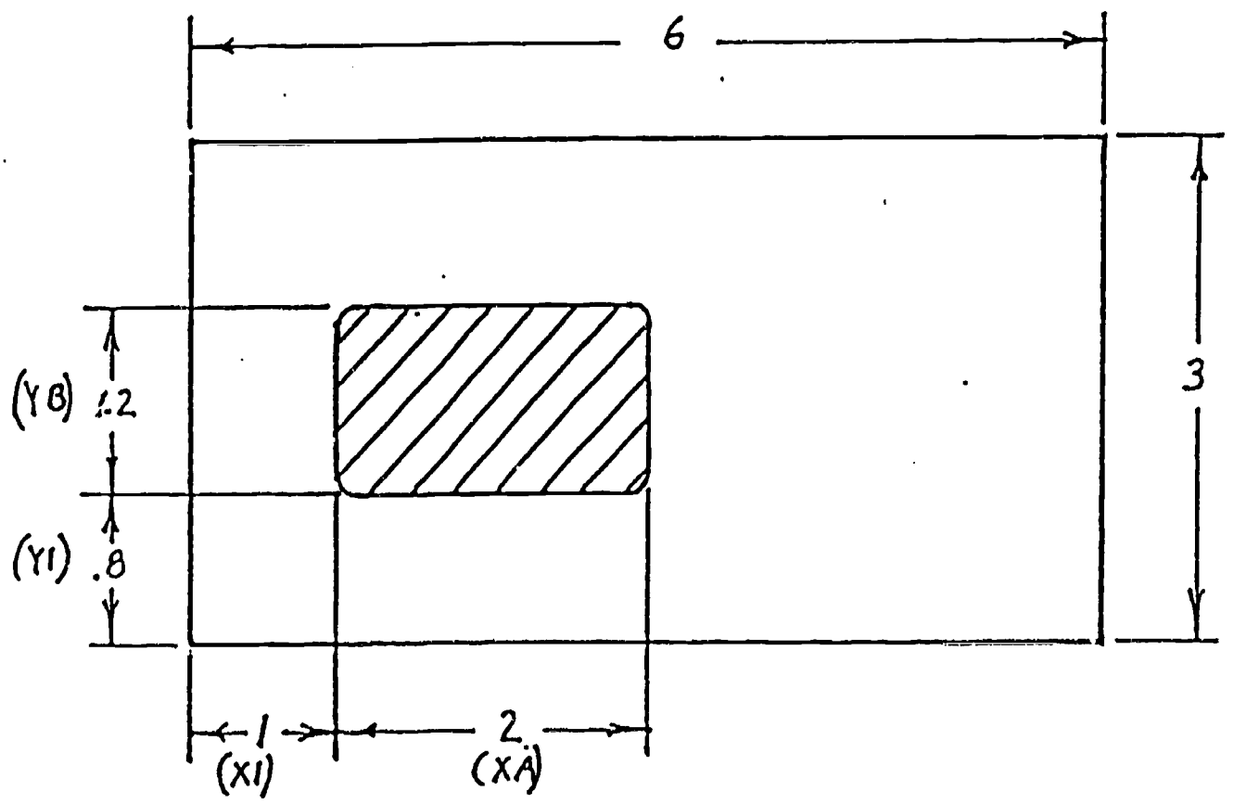
2. be able to apply cartesian coordinates.

After seeing the demonstration on programming, load the following program into the controller. After loading, have instructor check program before running.

Machine Set-up	5 pts.	_____
Machine Program	5 pts.	_____
Finished Part	10 pts.	_____
Total	20 pts.	_____

RECTANGLE POCKET - ASSIGNMENT NO. 1

```
001  START INS  01
002  TD = 0.2500
003  FR XYZ = 15
004  SETUP ⟶zcxyu
005  SPINDLE ON
006  RECT F 1 2% 050      (Rectangle pocket function.  F means finish cut.
                           1 means cut will be inside of dimension given.
                           2% 050 means that the depth will be no more
                           than 50% of tool diameter.)
007   XY CUT% 050         (Cutter will move over 50% of tool diameter for
                           each successive cut.)
008   ZH = 0.0000         (Z reference offset.  Should be 0 for programs.)
009   Zd = 0.0400         (Zd = depth that cutter will go.)
010   X1 = 1.0000 ⟶
                          (Location of lower left corner of frame cut.)
011   Y1 = 0.8000 ⟶
012   XA = 2.0000         (Length of rectangle along X axis.)
013   YB = 1.2000         (Length of rectangle along Y axis.)
014  SPINDLE OFF
015  END NEWPART
```



Assignment No. 2

Objectives:

1. be able to use CAM software to post-process a part drawn using CAD software.

2. be able to compare direct programming of controller with post-processing.

After seeing a demonstration of the CAM software, draw the part used in Assignment No. 1 on the CAD system and file. Then load the part into the CAM software and post-process. Down-load the program into controller and mill the part.

Drawing	10 pts.	_____
Post-Processing	10 pts.	_____
Milled Part	5 pts.	_____
Total	25 pts.	_____

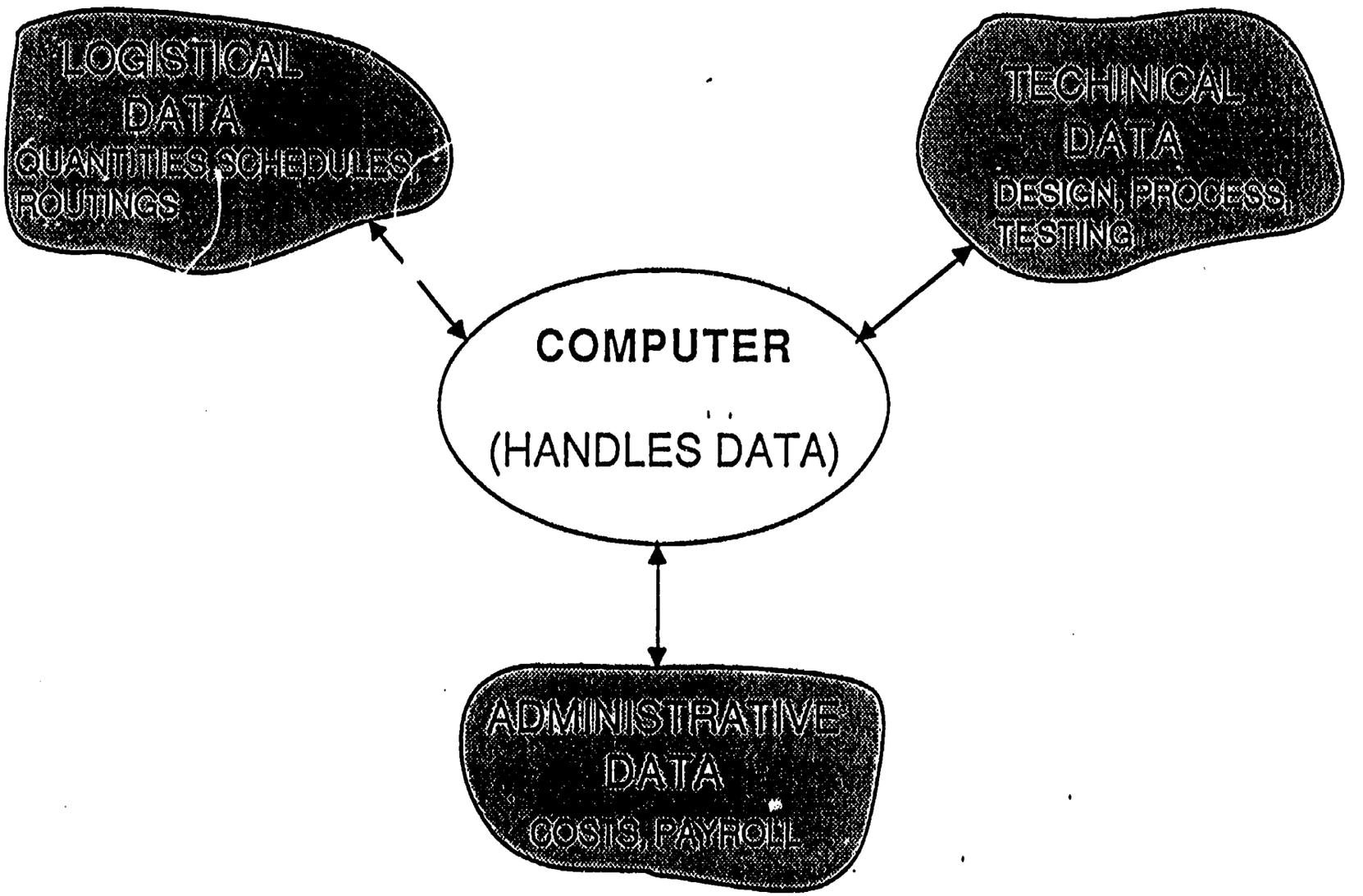
Assignment No. 3

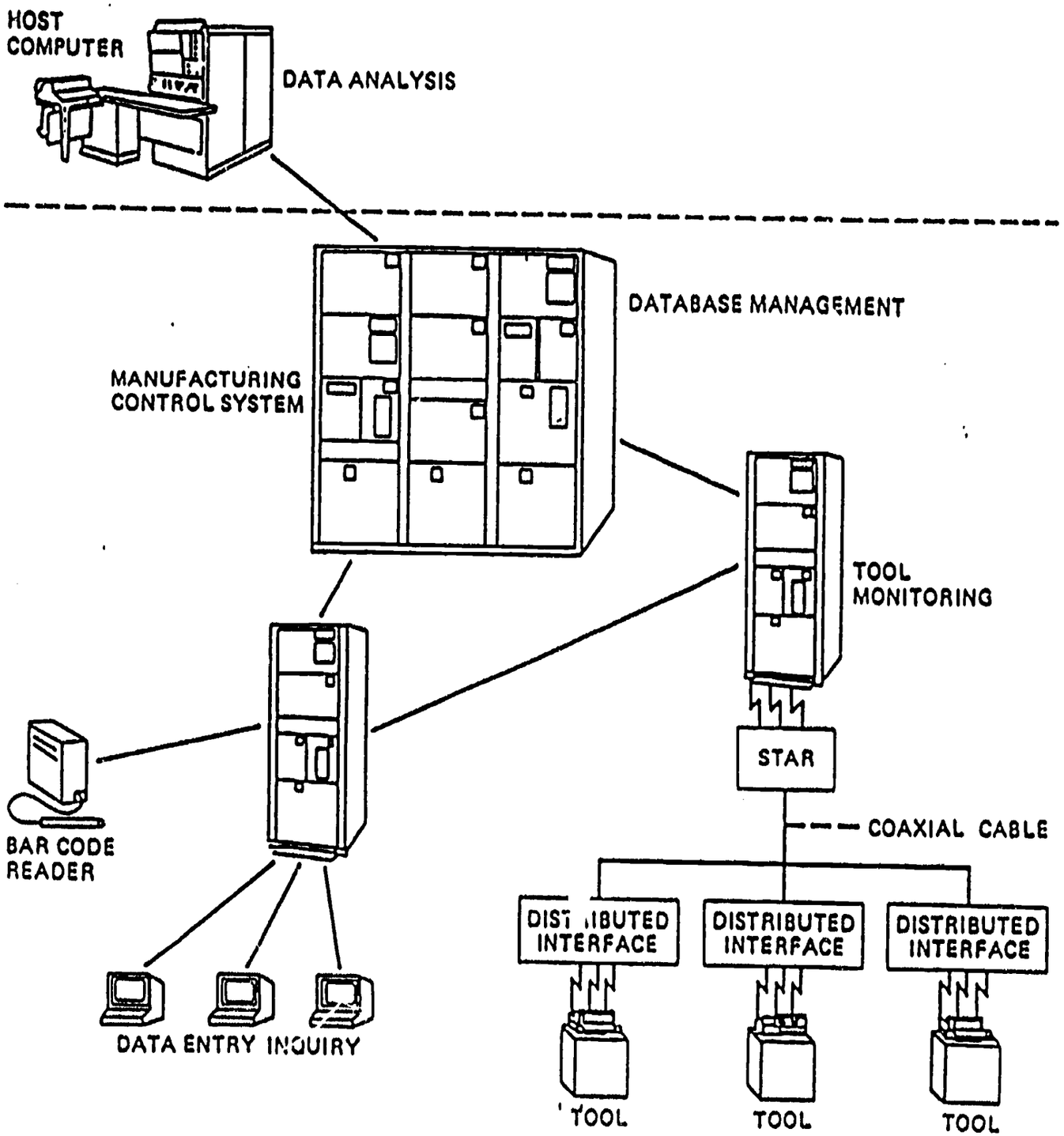
Design a part of your own choice. Then post-process and mill this part. Have instructor check design and program before milling.

Designed Part	10 pts.	_____
Post-Processing	10 pts.	_____
Finished Part	10 pts.	_____
Total	30 pts.	_____

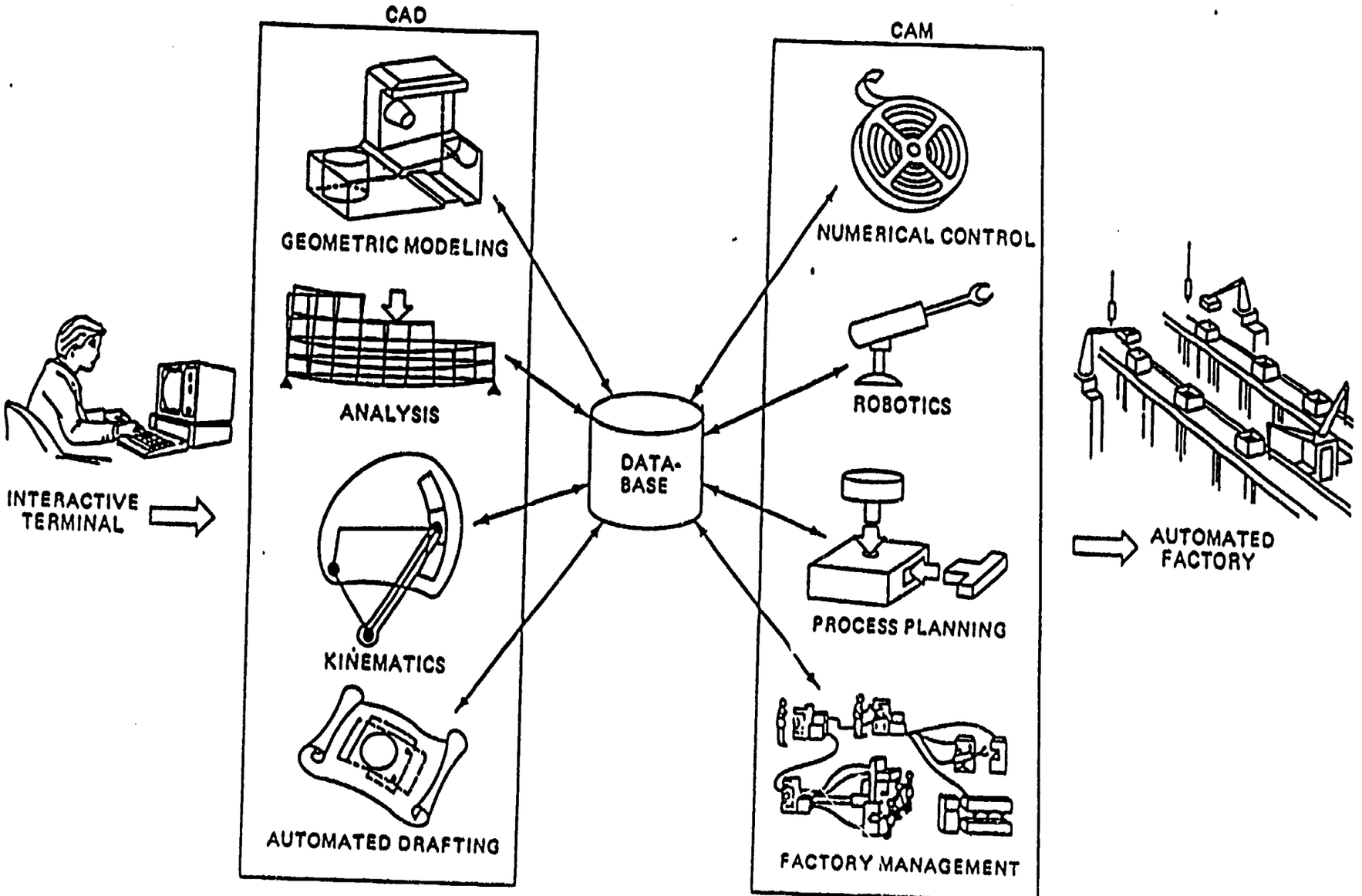
In addition to the transparencies included in this unit, the following transpararicies will also be used. Transparencies num'ered VM-1, and VM-9 from "Computer Numerical Control Simplified," instructors guide.

TYPES OF DATA USED IN MANUFACTURING





A DISTRIBUTED HEIRARCHICAL SYSTEM *(International Business Machines)*



Computer-aided engineering system. (*reprinted from John K. Krouse, What Every Engineer Should Know About Computer-Aided Design and Computer-Aided Manufacturing, by courtesy of Marcel Dekker Inc., New York, 1982*)

An NC or CNC machine is:

"A SYSTEM IN WHICH ACTIONS ARE CONTROLLED BY THE DIRECT INSERTION OF NUMERICAL DATA AT SOME POINT. THE SYSTEM MUST AUTOMATICALLY INTERPRET SOME PORTION OF THE DATA"

The Major System Components

NC

1. MACHINE TOOL

   SHAPES CUTS & FORMS MATERIAL AT THE DIRECTION OF THE PROGRAM (USUALLY PUNCHED TAPE)

2. CONTROLLER

   READS PROGRAM, DIRECTS MACHINE MOVEMENTS, ALLOWS LIMITED MANUAL MOVEMENT AND CONTROLS SET-UP.

3. TAPE READER

   USUALLY PART OF CONTROLLER READS TAPE AND FEEDS PROGRAM TO CONTROL MECHANISM.

4. TAPE PUNCH

   A TYPEWRITER-LIKE DEVICE THAT PUNCHES THE PROGRAM. THIS IS THE ONLY PLACE AN NC MACHINE MAY BE PROGRAMMED (USUALLY)

CNC

1. MACHINE TOOL

   SHAPES, FORMS & CUTS MATERIAL AT THE DIRECTION OF PROGRAM IN THE CONTROLLER MEMORY.

2. CONTROLLER - (microprocessor)

   A. DIRECTS MACHINE MOVEMENTS FROM PROGRAM STORED IN MEMORY.
   B. ALLOWS ACCESS TO PROGRAM MEMORY FOR WRITING OR EDIT.
   C. ALLOWS MANUAL OPERATION FOR SET-UPS

3. DATA STORAGE

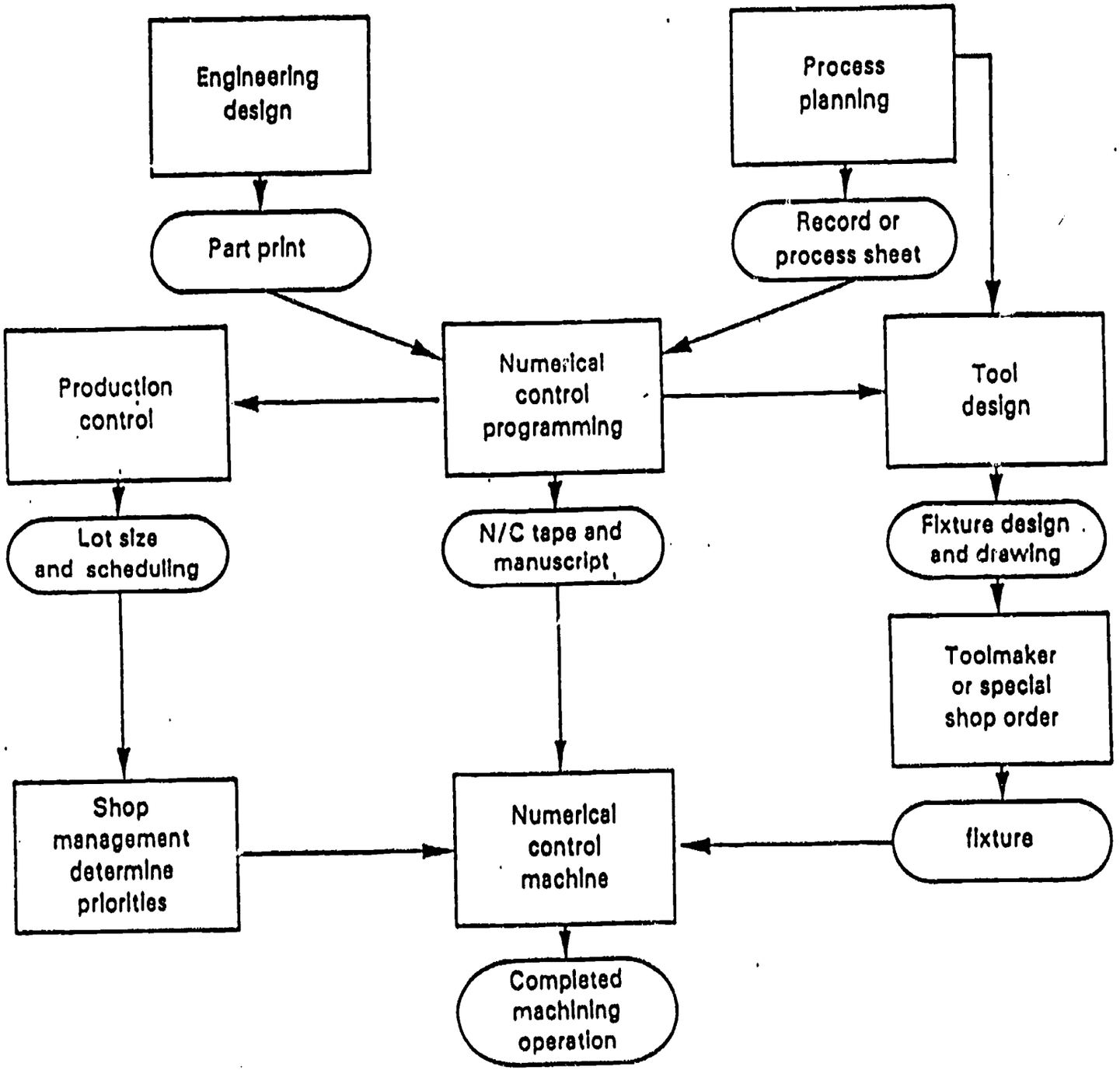
   A. STORES PROGRAMS NOT BEING USED ON PUNCHED TAPE, COMPUTER DISK OR CASSETTE TAPE.
   B. WILL PUT PROGRAM INTO CONTROL UNIT OR RECORD ONE INTO CONTROL This is called program storage & retrieval

4. OFFLINE PROGRAM UNIT

   A. PREPARES PROGRAMS
   B. AIDS PROGRAMMER WITH MATH AND GRAPHIC DISPLAY OF ACTUAL MACHINE MOVEMENTS.
   C. THIS IS USUALLY A MICROCOMPUTER

MAJOR DIFFERENCES

NUMERICAL CONTROLLED MACHINERY	COMPUTER NUMERICAL CONTROLLED MACHINERY
NO MEMORY FOR PROGRAM STORAGE	PROGRAMS MAY BE STORED WITHIN THE CONTROLLER MEMORY
CURVES ARE CONT. PATH APPROXIMATION	CURVES ARE EXACT
PROGRAMS CAN BE EDITED ONLY BY REPROGRAMMING TAPE	COMPUTER HAS RANDOM ACCESS MEMORY (RAM) ALLOWING OPERATOR EDITING ON SITE
CONTROLLER MAKES NO DECISIONS OR ADJUST-MENTS WHILE OPERATING	CONTROLLER CAN MAKE DECISIONS SUCH AS: IS PART TO TOLERANCE OR COMPENSATE BACKLASH TO AVOID CLIMBING IN INTERNAL POCKET CORNERS
MUST BE PROGRAMMED AWAY FROM MACHINE	MAY BE PROGRAMMED ON THE MACHINE (MDI) MANUAL DATA INSERT PROGRAMMING



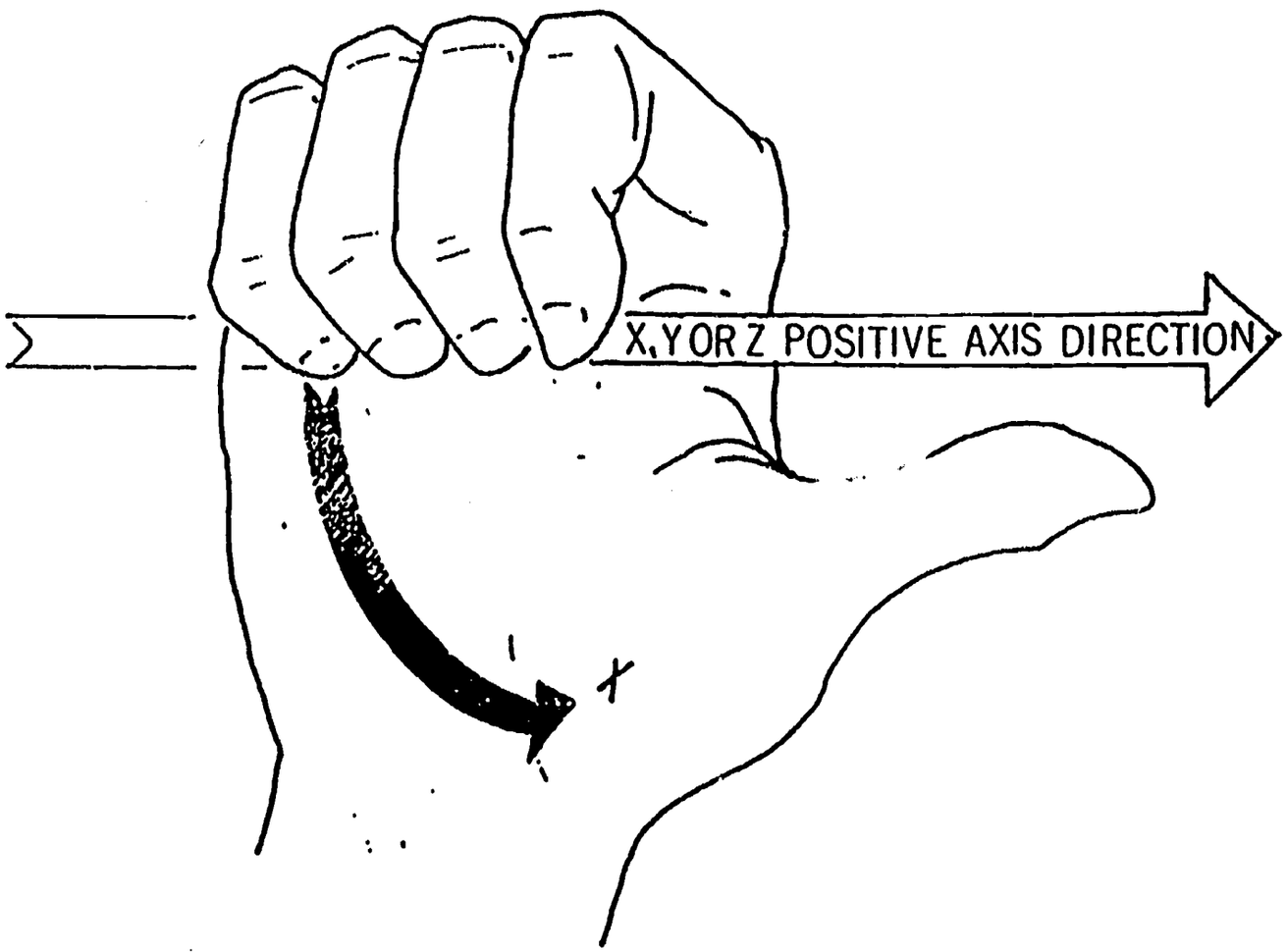
A FLOW DIAGRAM OF THE STEPS IN PROCESSING AN N/C PROGRAM

"RULE OF THUMB"

For Auxiliary Motion and Polar Arcs

To determine the sign of a rotary motion - positive or negative:

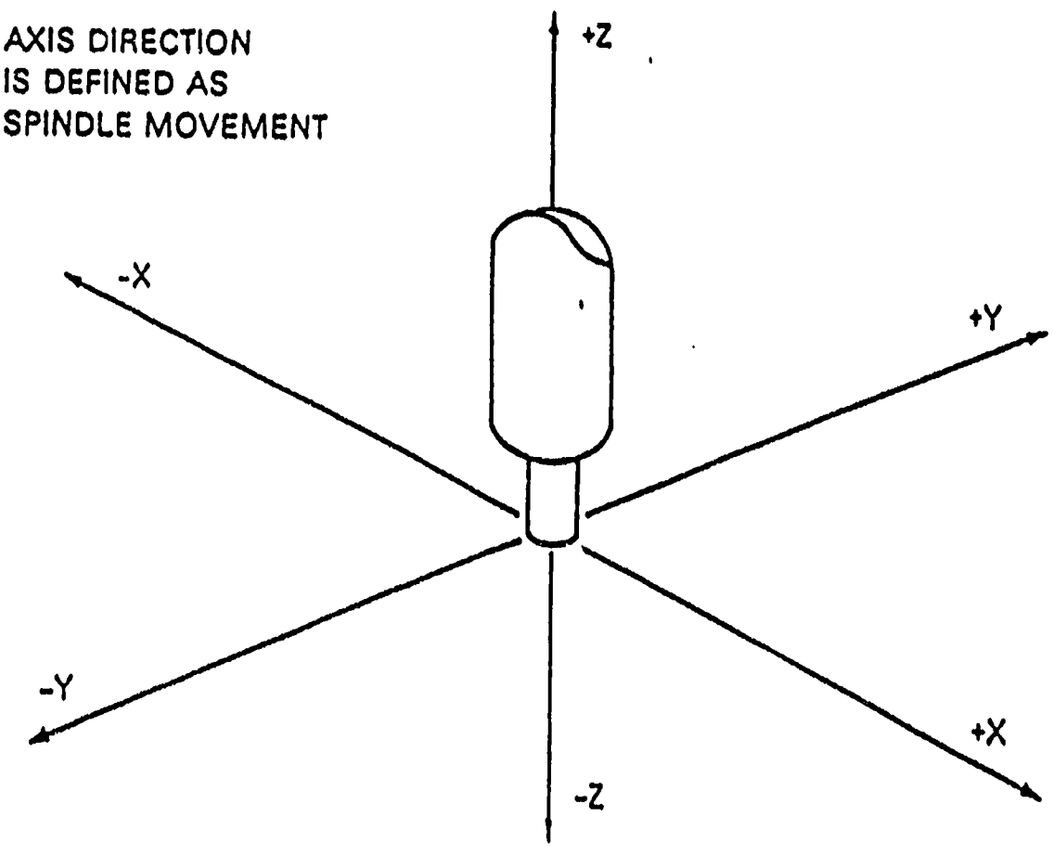
POINT THE THUMB OF YOUR RIGHT HAND IN THE DIRECTION OF THE POSITIVE AXIS OF ROTATION.

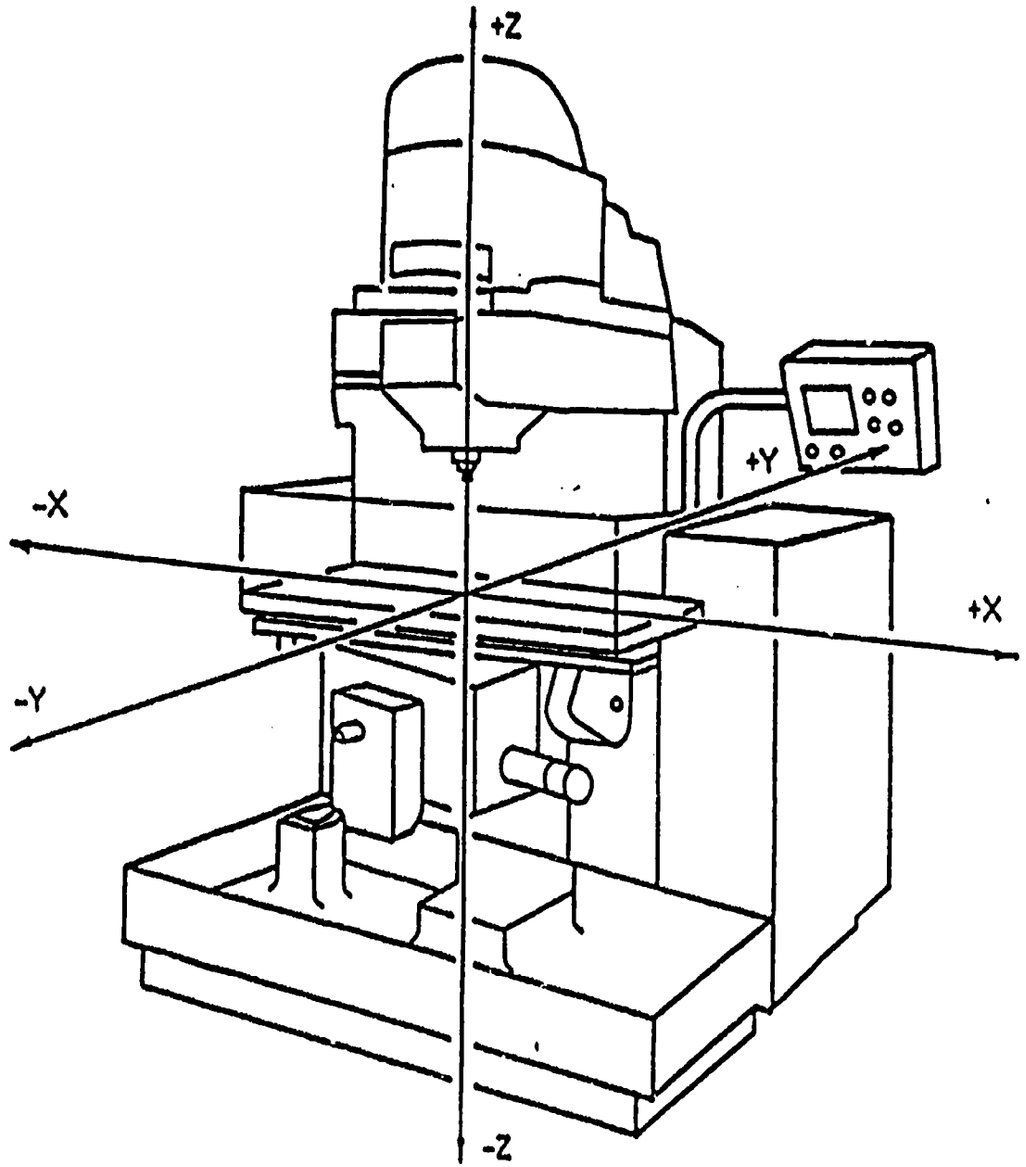


YOUR FINGERS WILL POINT IN THE POSITIVE ROTARY DIRECTION.

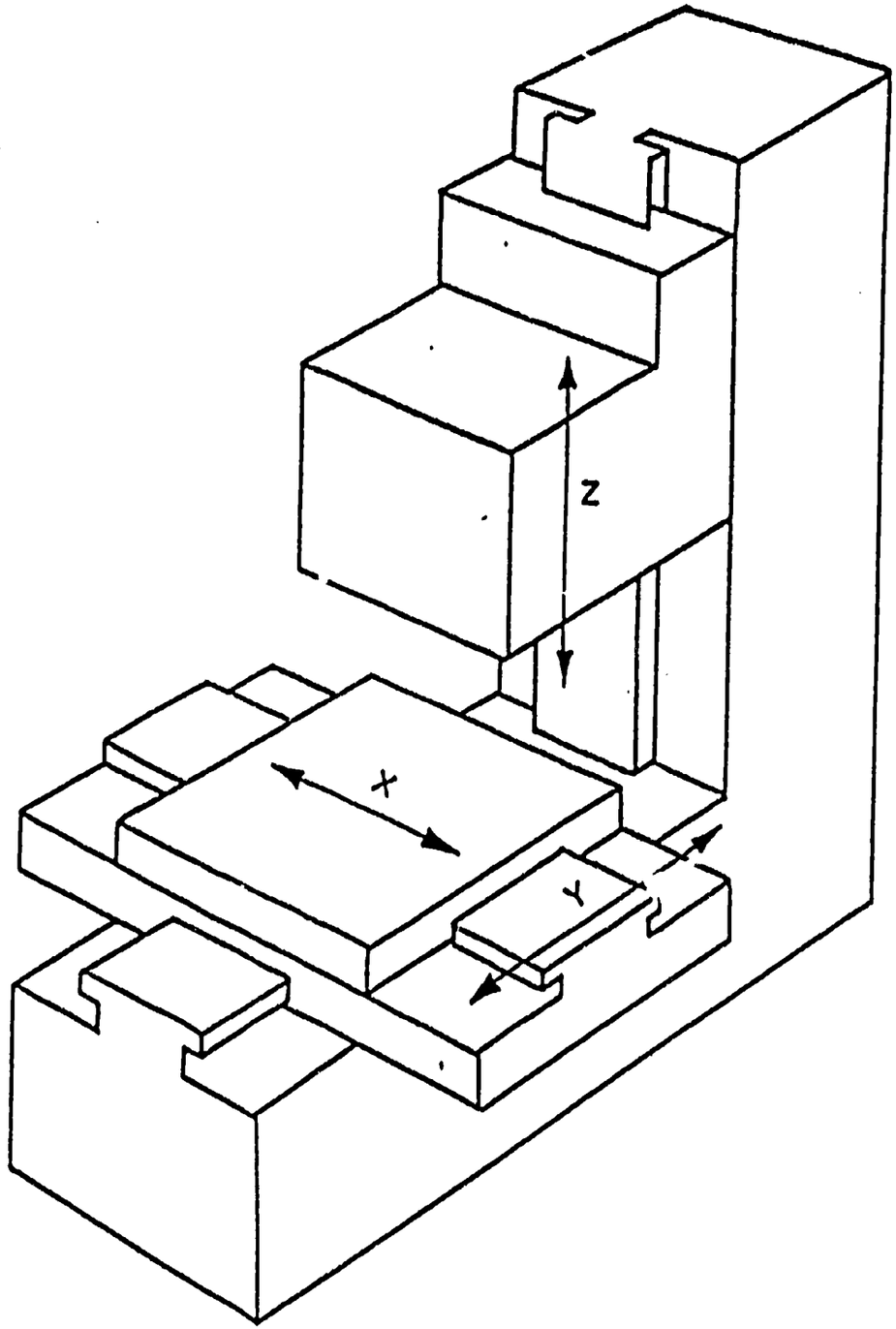
The rule of thumb works for polar arcs and for auxiliary axis motion. If we wish to call out an arc or a axial move of 20 degrees, we use the RULE OF THUMB to determine the sign of the entry.

AXIS DIRECTION
IS DEFINED AS
SPINDLE MOVEMENT

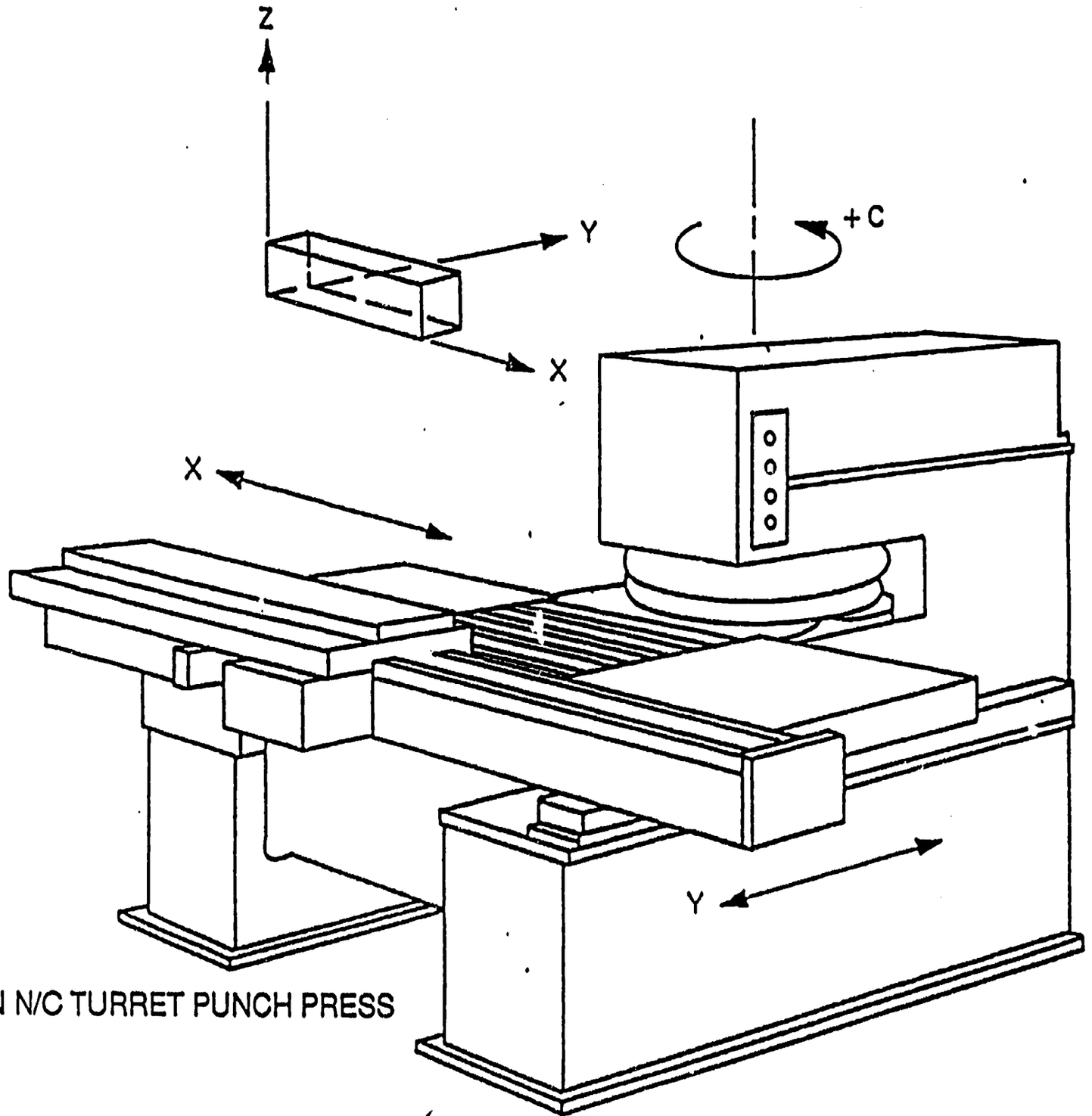




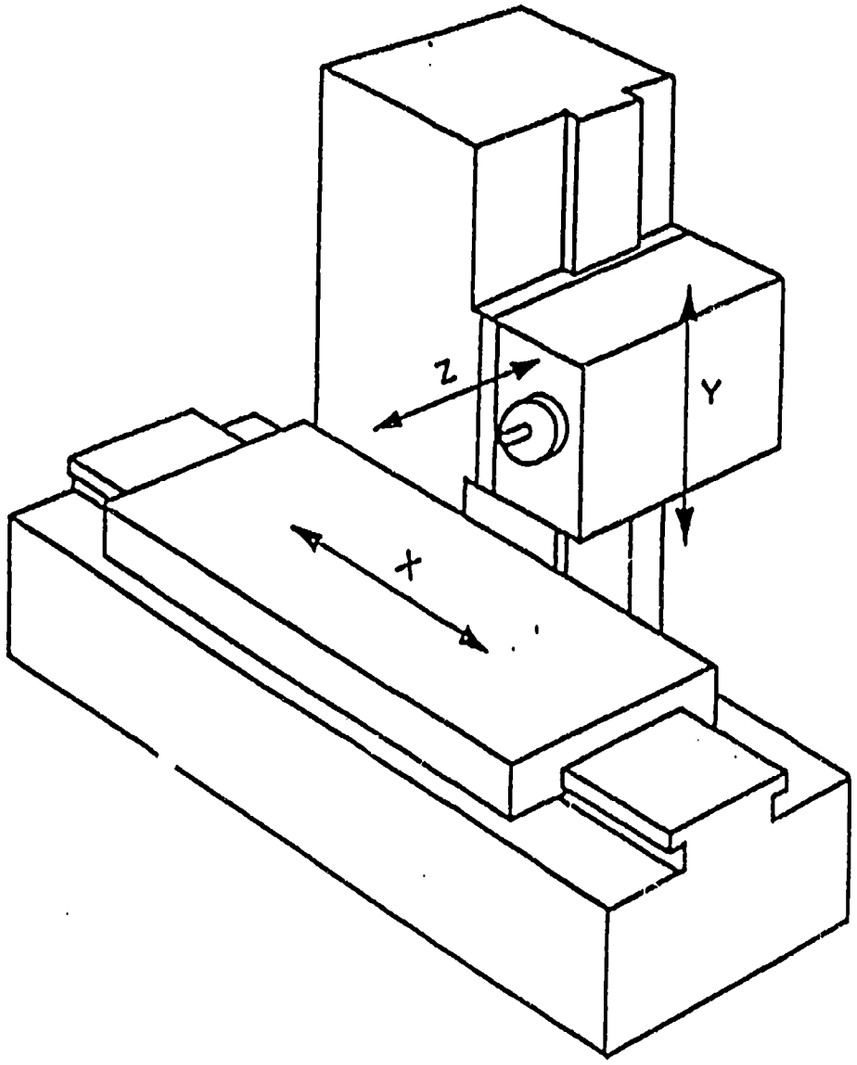
THREE-AXIS VERTICAL MILL



A VERTICAL N/C MACHINE



AN N/C TURRET PUNCH PRESS



A HORIZONTAL N/C MACHINE

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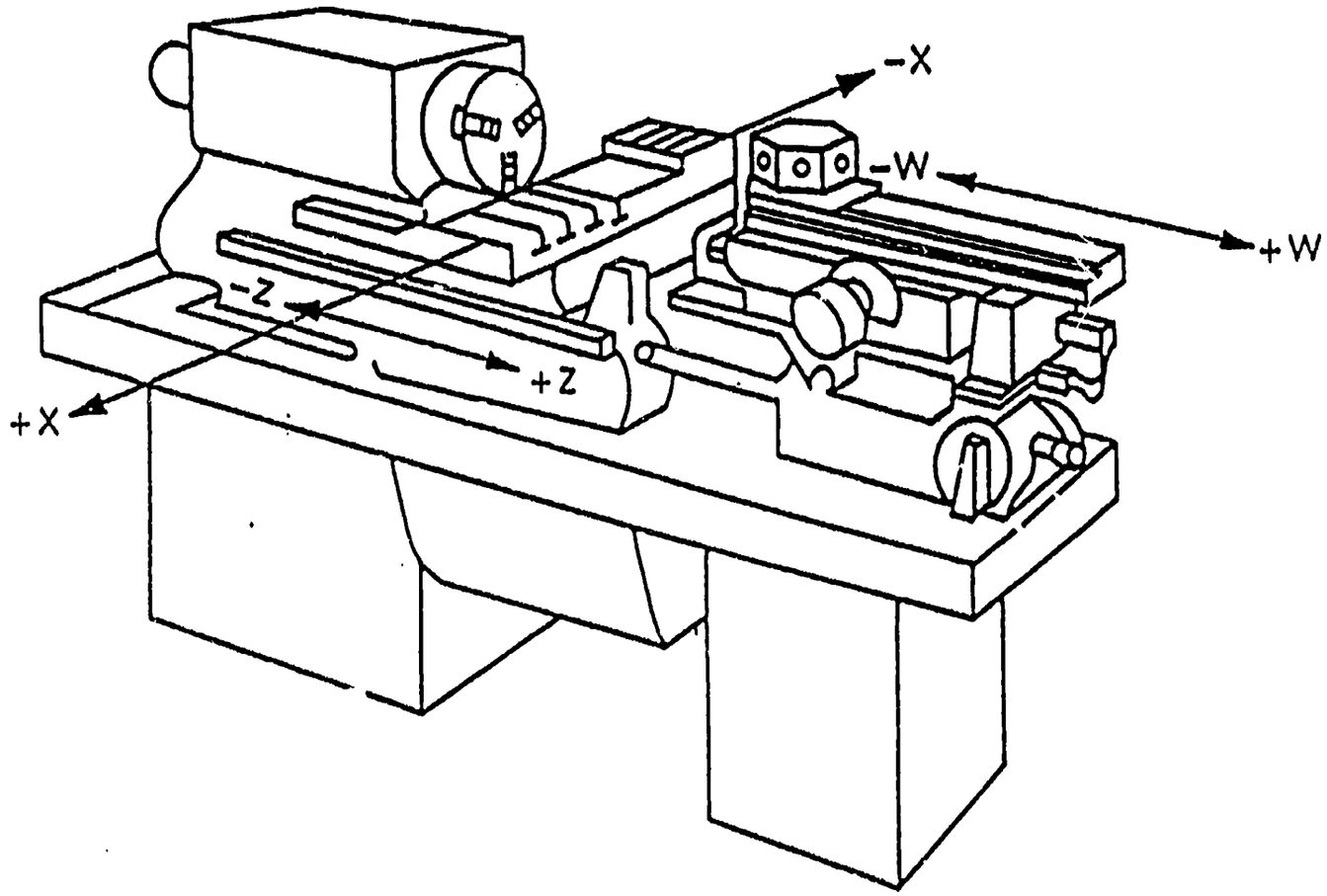
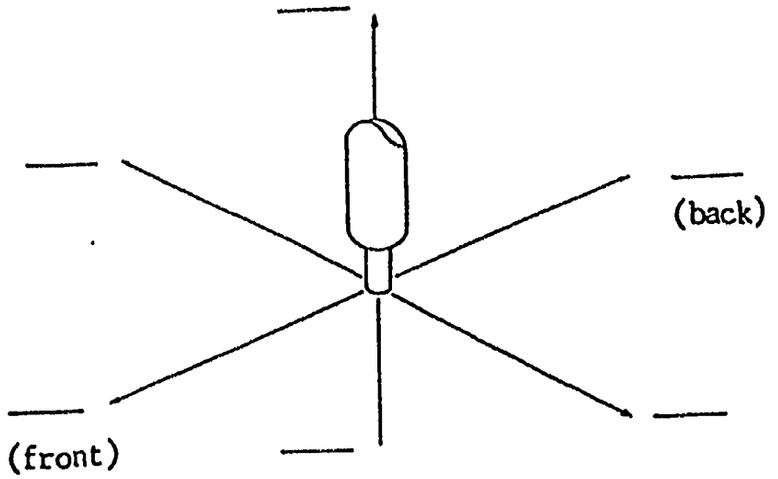


A N/C TURRET LATHE

NAME _____

CNC POST-TEST

1.- 6. Match each of the axis direction.



A. X+
B. X-
C. Y+
D. Y-
E. Z+
F. Z-

7.- 8. List two of four advantages of using CAM software.

A. _____

B. _____

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