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ABSTRACT

The booklet contains information about an experimental space science survey course which explores the tools and methods used to study space. Included are a list of 22 performance objectives, an outline of the content in the course, lists of experiments, demonstrations, and projects for the course and the books in which these are to be found, a list of report topics, a list of 16mm films related to space, references, and other information. (PR)

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

SPACE SCIENCE

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SCIENCE
(Experimental)

SPACE SCIENCE

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Written by Richard Huffman
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
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1971

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SPACE SCIENCE

COURSE DESCRIPTION:

Space Science is a survey course exploring the tools and methods scientists use to study space. Astronomical measurement, inter-relationships, theories of the origin of the universe, star descriptions, space travel and oddities of space are included.

ENROLLMENT GUIDELINES:

None

STATE ADOPTED TEXT BOOKS

1. Brown, F. Martin, Kemper, Grace, and Lewis, John. Earth Science. New Jersey: Silver Burdett, 1970.

2. Earth Science Curriculum Project, Investigating the Earth. Boston: Houghton Mifflin Company, 1967.

3. Hibbs, Albert and Eiss, Albert. The Earth-Space Sciences. River Forest, Illinois: Laidlaw Brothers, 1971.

4. Thurber, Walter and Kilburn, Robert. Exploring Earth Science. Boston: Allyn and Bacon, 1970.

PERFORMANCE OBJECTIVES

1. Given a diagram of a telescope, the student will label the principal parts.

2. The student will compare the refractor and reflector telescopes.

3. Given certain desired outcomes the student will decide which telescope is best suited for the job.

4. The student will describe how a star's spectrum can help the astronomer.

5. The student will explain how the Doppler effect leads astronomers to infer the universe is expanding.

6. Given a number in the trillions the student will express it in scientific notation.

7. Given distances to various locations in space, the student will select the best unit of measurement, astronomical unit, light year, or parsec.

8. Given the names and terms Ptolemy, Kepler, heliocentric, elliptical, circular, Copernicus, and geocentric the student will discuss orbital motion using each.

9. The student will explain how Bode's theory helped astronomers discover asteroids.

10. The student will relate Newton's three laws of motion to a rocket launch.

11. After studying the theories of the origin of the universe the student will cite the strength and weaknesses of each theory.

12. Given pictures of various types of galaxies the student will be able to classify them as to elliptical, spiral or barred spiral types.

13. The student will contrast apparent and absolute magnitudes.

14. Given a H-R diagram the student will be able to place the sun, white dwarf, and red giant type stars.

15. The student will arrange these colors in increasing star temperature, blue-white, orange, red, yellow, and white.

16. Given characteristics of various star types the student will classify them as to binary, nova, supernova, and Cepheid variables.

17. Given diagrams of some of the common constellations, the student will name them.

18. The student will distinguish between primary and secondary cosmic rays.

19. The student will state the relationship between meteors and comets.

20. Draw a graph representing your idea of how the amount of energy released from a star changes with time. Use the vertical axis for the amount of energy released and the horizontal axis for the time.

21. Give a hypothesis to explain either quasars or pulsars.

22. Plan a space trip to any location in space, and list possible problems and solutions, the type of personnel needed and why, special instruments and why.

COURSE OUTLINE

I. Basic Tools and Methods

A. Telescopes
1. Types
a. Reflector
b. Refractor
c. Schmidt
d. Radio
2. How they work

B. Spectrograph

C. Photometry

D. Doppler Effect
1. Red shift
2. Blue shift

II. Astronomical Measurement

A. Scientific Notation

B. Astronomical Unit

C. Light Year

D. Parsec--3.26 light years

E. Parallax--triangulation method of measuring astronomical distance

III. Space Relationships

A. Kepler's Laws

B. Bode's theory

C. Newton
   1. Gravity
   2. Laws of motion

D. The nature of orbits

IV. The Universe

A. Theories of origin
   1. Big bang
   2. Oscillating-universe
   3. Steady state

B. Galaxies
   1. Classification
   2. Clusters
   3. Milky way

C. Intergalactic gas

V. Stars

A. Magnitude
   1. Apparent
   2. Absolute---luminosity
   3. Inverse square law

B. Stellar energy
   1. Proton-proton cycle
   2. Carbon-nitrogen cycle

C. H-R diagram
   1. Color
   2. Luminosity
   3. Temperature

D. Double or binary

E. Cepheid variables

F. Novae and Super nova

G. Evolution of a star

H. Constellations

I. Satellites of stars
   1. Planets
   2. Asteroids
   3. Comets

VI. Visitors from space

A. Cosmic rays

B. Meteors
1. Never reach earth
2. Called shooting stars

C. Meteorites

VII. Noise from space

A. Quasars

B. Pulsars

VIII. Space travel

A. Why?

B. Training

C. Problems

D. Instruments and equipment needed

E. Future

EXPERIMENTS

Brandwein, Paul, Beck, Alfred, Strahler, Violet, Brennen, Matthew, and Turner, Daniel. The Earth: Its Changing Form. New York: Harcourt, Brace and World, 1970.

1. How light travels (p. 493)
2. How the refracting telescope works (pp. 495-496)
3. The reflection of light (p. 497)
4. Diagram orbits of three different planets (Making predictions #1, p. 516)
5. Newton's first law of motion (pp. 530-531)

Brown, F. Martin, Kemper, Grace, and Lewis, John. Laboratory Investigations in Earth Science. New Jersey: Silver Burdett, 1970.

6. Shapes of impact craters (pp. 133-135)
7. Finding the Latitude of the North Star (pp. 71-74)
8. Orbiting Masses (pp. 5-8)
9. Apparent Retrograde Motion (pp. 9-12)

Earth Science Curriculum Project. Investigating the Earth. Boston: Houghton Mifflin Company, 1967.

10. Investigating motions in the sky, p. 84 (4-1)
11. Investigating the behavior of a falling object, p. 107 (5-2)
12. Apparent motion of Mars, p. 496 (activity)
13. Motions and phases of Planet X, p. 497 (23-2)
14. Creating a model of the solar system, p. 501 (23-4)
15. Estimating brightness and color of stars, p. 519 (activity)
16. Calculate time of orbit for a double star, p. 525 (activity)
17. Investigating spectra, p. 527 (24-7)
18. Comparing the sun with other stars, p. 529 (24-9)
19. Measuring the diameter of the sun, p. 520 (24-10)
20. Investigating galaxies, p. 547 (25-7)
21. Investigating the motion of galaxies, p. 556 (26-3)

Hibbs, Albert and Eiss, Albert. The Earth-Space Sciences. River Forest, Illinois: Laidlaw Brothers, 1971.

22. Observe stars using a star map (pp. 46-47)
23. Time exposure photographs (p. 48)
24. Effects of nebulae on our observations of stars (p. 56)
25. Observe the Milky Way and the Andromeda galaxy (p. 62)
26. Estimate the number of stars shown in a photograph of a portion of the Milky Way, p. 65 (some things to do #1)
27. Observe the brightness of different stars (p. 67)
28. Infrared radiation-comparing two irons (p. 70)
29. Examination of a spectrum (p. 73)
30. Observe a double star (p. 77)
31. Observe two types of star clusters (p. 81)
32. Observe scintillations of a luminous watch (p. 83)

33. Select 10 brightest stars and find their names on a star map, p. 87 (some things to do #3)
34. Relationship between distance and brightness (p. 90)
35. Chart - computation of the radius, distance, or the apparent magnitude of a star (p. 92)
36. Observe parallax (p. 93)
37. Comparing units of distance (p. 98)
38. Wave motion showing the Doppler Effect (p. 102)
39. Movement about the center of mass (p. 105)
40. How the baseline affects parallax, p. 109 (some things to do #1)
41. Finding the center of the mass of the earth-moon system, p. 109 (challenges in science #2)
42. Construction of H-R diagram
43. Observe a red giant and a main sequence star
44. Model of the expanding universe
45. Scale drawing of the solar system (p. 161)
46. Draw and compare ellipses (p. 166)
47. Observe a meteor shower (p. 174)
48. Measuring centripetal force (p. 183)
49. Comparing a rotating mass to the rotating mass of a gas (p. 202)

National Aeronautics And Space Administration. Space Resources For Teachers Space Science. Washington D. C.: NASA, 1969.

50. Measuring the height of the school flagpole, p. 26 (I-8)
51. The H-R diagram, p. 56 (II-10)

Navarra, John and Strahler, Arthur. Our Planet in Space: The Earth Sciences Investiguide. New York: Harper and Row, 1969.

52. The changing stars (pp. 75-82)
53. Using a star finder (pp. 124-129)
54. Making a star map (p. 131)
55. Difference between star magnitude and luminosity (pp. 131-135)

Thurber, Walter and Kilburn, Robert. Exploring Earth Science. Boston: Allyn and Bacon, 1970.

56. Measuring angles of elevation (p. 33)
57. Finding true north (p. 340)
58. Magnitude of common stars (p. 341)
59. Locate the true horizon (p. 342)
60. Changes in star elevations (p. 343)
61. The sky clock (p. 344)
62. Star trails (pp. 344-345)
63. Make a model sky (p. 347)
64. Locate sky equator (p. 348)
65. Circumpoler Constellations (p. 349)
66. Effect of latitude (p. 349)
67. Scale model solar system (p. 354)

68. Count the number of stars in the sky, p. 366 (#11)
69. Parallax (p. 393)
70. A model of the earth's precession and change in the north star (p. 396)
71. Kepler's second law of planetary motion (p. 405)
72. Orbits of planets (p. 406)
73. Putting an object in motion (p. 407)
74. Chart on Bode's theory (p. 408)
75. Falling bodies (p. 416)
76. Projectiles (p. 417)
77. Effect of force on velocity (p. 418)
78. Effect of mass (p. 418)
79. One and two stage rockets (p. 420)

DEMONSTRATIONS

Brandwein, Paul, Beck, Alfred, Strahler, Violet, Brennen, Matthew, and Turner, Daniel. The Earth: Its Changing Form. New York: Harcourt, Brace and World, 1970.

1. Sun's spectrum using a prism (p. 470)
2. Magnitude and distance (p. 478)
3. Difficulty of sending a spacecraft to another planet, p. 490 (a search for patterns #2)
4. Light refraction (p. 494)

Hibbs, Albert and Eiss, Albert. The Earth-Space Sciences. River Forest, Illinois: Laidlaw Brothers, 1971.

5. Detect cosmic rays using a Geiger counter (p. 41)
6. Electroscope discharge (p. 531)
7. Comparing 200 inches in diameter to 1/8 inch in diameter (T-32)*
8. Apparent shapes of galaxies with pie plates (T-32)
9. Relationship between a star's temperature and color (T-37)
10. Relationship between the size of the angle of parallax and the distance to the object being observed (T-44)
11. Compare student's mass to something 1/332,000 of his mass for relationship of the sun to earth (T-63)
12. Use a candle to show difficulty in measuring the sun (T-63)
13. Nichrome wire to show colors of various elements (T-64)
14. Density (T-68)
15. Features of an orbit using a rubber ball and string (T-69)
16. Inertia (T-77)
17. Radiometer showing decrease of radiation as distance increases (T-83)
18. Estimate of number of meteors on one part of the earth (T-178)
19. Spinthariscope showing production of secondary particles (T-183)

* T refers to pages in Teacher's Edition

National Aeronautics and Space Administration. Space Resources For Teachers Space Science. Washington D. C.: NASA, 1969.

20. The effect of vibration on human performance and reaction (pp. 75-76)
21. Sensory and perceptual problems (pp. 120-122)
22. The vestibular effects of acceleration and rotation on human performance (pp. 126-129)
23. The method of trigometric stellar parallax, p. 29 (1-4)
24. Apparent and absolute magnitude, p. 33 (1-5)
25. The inverse-square law, p. 33 (1-6)
26. Energy and the color of light, p. 50 (11-9)
27. Continuous spectra and the measurement of color intensity p. 50 (11-3)
28. Behavior of falling bodies, p. 123 (VI-I)
29. Newton's three laws of motion (pp. 123-124)

RESOURCE MATERIALS FOR ADDITIONAL DEMONSTRATIONS

30. Reflecting telescope
31. Refracting telescope
32. Cloud chamber
33. Doppler effect apparatus
34. Radiometer
35. Electroscope
36. Spectroscope
37. Geiger counter

PROJECTS

Brandwein, Paul, Beck, Alfred, Strahler, Violet, Brennen, Matthew, and Turner, Daniel. The Earth-Its Changing Form. New York: Harcourt, Brace and World, 1970.

1. Build an altazimuth scope and use it (p. 516)
2. Keeping up to date on space satellites (p. 545)

Haggerty, James. Man's Conquest of Space. Vistas of Science 12. New York: Scholastic Book Services, 1966.

3. Solar cell (p. 118)
4. Water rocketry (pp. 119-120)
5. Simulated space flights (pp. 121-124)

Hibbs, Albert and Eiss, Albert. The Earth-Space Sciences. River Forest, Illinois: Laidlaw Brothers, 1971.

6. Prepare a skit to illustrate the steps taken by man in accumulating his knowledge of the solar system (p. 23)
7. Record of the apparent motion of a bright planet (p. 141).
8. Conduct a study on relativity (p. 191)
9. Repeat some of Galileo's experiments (p. 195)
10. Make your own Geiger counter (p. 509)
11. Can plant life live on another planet? (p. 177)
12. How the gravitational constant was determined (p. 181)
13. Collect micrometeorites (T 184)

Houston, Walter, ed. Star Atlas and Workbook of the Heavens. Columbus, Ohio: American Education Publications, 1967.

14. The double stars (p. 8)
15. Nebulae and clusters (p. 12)
16. Variables and meteors (p. 16)
17. Deep sky photography (p. 20)
18. Observe Jupiter's satellites (p. 29)
19. The Messier club (p. 29)
20. Lunar crater drawings (p. 29)

Hynek, J. Allen and Anderson, Norman. Challenge of the Universe Vistas of Science 4. New York: Scholastic Book Services, 1965.

21. A modified theodolite (pp. 117-124)
22. Observing objects and phenomena of space (p. 134)

National Aeronautics and Space Administration. Space Resources For Teachers Biology. Washington D. C: NASA, 1969.

23. Space nutrition (p. 26)
24. Gas exchange and waste management (pp. 35-49)
25. Oxygen consumption (pp. 50-55)
26. Temperature stress (pp. 58-62)
27. Weightlessness (pp. 63-71)
28. Acceleration and vibration stress (pp. 72-74)
29. Problems of isolation and confinement (pp. 131-142)

National Aeronautics and Space Administration. Space Resources For Teachers Space Science. Washington D. C.: NASA, 1969.

30. Build and calibrate a spectroscope (p. 52)

Thurber, Walter and Kilburn, Robert. Exploring Earth Science. Boston: Allyn and Bacon, 1970.

31. Make and use a simple two lens telescope (p. 363)
32. Take star trails using high speed Ektachrome film and explain the results, p. 366 (#10)
33. Make a small planetarium, p. 366 (#19)
34. Effect of launching angle, p. 430 (#8)
35. Models of paths of objects traveling through space, p. 431 (#9)
36. Amount of force exerted by different balloon rockets, p. 431 (#10)

REPORTS

1. Importance of radio astronomy
2. Quasars
3. How stars are named
4. Prepare a report on one of the scientists for whom a moon crater is named
5. Report on the accomplishments of any one of the following:
   a. Copernicus
   b. Galileo
   c. Halley
   d. Kepler
   e. Bode
   f. Brahe
   g. Newton
   h. Ptolemy
   i. Goddard
   j. Von Braun
   k. Einstein
6. Famous comets
7. Meteors
8. Star oddities

FIELD TRIPS

1. Planetarium at the Museum of Science.
   At present there are special programs for junior and senior high schools. However, they will present a program on any area if requested. Normal programs are $.35 per student. Special programs are $1.00 per student.
2. Observatory at the Museum of Science.
   Reflector and refractor telescopes, spectrograph, star cameras, and a coronagraph are used.
3. Cape Kennedy

RESOURCE PEOPLE

1. Meteorologist to explain how satellites are used in weather forecasting.
2. Southern Cross Astronomical Society at the Museum of Science.
3. Amateur Astronomer to explain how to make a telescope.
4. Planetarium Education - Jack Horkheimer, Museum of Science.

MATHEMATICAL PROBLEMS

1. The closest visible star is Alpha Centauri. It is 25,240,000,000,000 miles away. How many astronomical units (AU) is this?
2. Alpha Centauri is how many light years away from the earth?
3. Use scientific notation to give the distance from earth to Alpha Centauri in miles.
4. Light travels at 186,272 miles per second. What distance does it travel in one year?
5. If it takes seven seconds for the information sent by a space probe satellite to reach the earth, how far from the earth is the satellite?
6. A star is 652 light years away, what is this in parsecs?
7. The Doppler effect can be expressed as

$$\frac{\text{change in wavelength}}{\text{normal wavelength}} = \frac{\text{velocity of source}}{\text{velocity of light}}$$

Develop problems using the above formula.

8. Universal law of gravitation $F = \frac{GM_1 M_2}{d^2}$

Develop problems using the above formula.

9. Calculate time required to go to various places traveling at 25,000 M.P.H.
10. Kepler's third law $\frac{P^2}{p^2} = \frac{R^3}{r^3}$

P is the period of one planet, p is the period of the second planet, and R and r are the average orbital radii of the two planets respectively. Develop problems using the above formula.

11. A star's brightness, luminosity, and distance are related by the inverse square law.

$$B = \frac{L}{D^2} \qquad D = \sqrt{\frac{L}{B}}$$

Develop problems using the above formula.

DADE COUNTY 16MM FILMS

1. Biology in Space Science
   AV# 1-11468, 13½ min. C
2. Centrifugal Force
   AV# 1-10698, 13 min. BW
3. Centripetal Force and Satellite Orbits
   AV# 1-01784, 11 min. BW
4. Cosmic Rays
   AV# 1-30330, 29 min. C
5. Demonstrations With Light
   AV# 1-10728, 11 min. C
6. Earth Satellites (Explorers of Outer Space)
   AV# 1-11449, 17 min. BW
7. Elliptic Orbits (0310)
   AV# 1-10701, 18 min. BW
8. Exploring by Satellite
   AV# 1-30740, 28 min. C
9. Exploring Space
   AV# 1-30737, 25 min. C
10. Exploring the Universe
    AV# 1-01516, 11 min. BW
11. Force and Motion
    AV# 1-01748, 10 min. BW
12. Force of Gravity
    AV# 1-30285, 29 min. C
13. Galileo
    AV# 1-12494, 14 min. C
14. Gravity
    AV# 1-01787, 10 min. BW
15. Gravity: The Mighty Pull
    AV# 1-10705, 13½ min. C
16. How Many Stars?
    AV# 1-01524, 10 min. BW
17. How Vast is Space?
    AV# 1-10633, 18 min. C
18. How We Explore Space
    AV# 1-10621, 15 min. C
19. Jet and Rocket Engines
    AV# 1-03623, 10 min. C
20. Laws of Motion
    AV# 1-10682, 12 min. BW
21. Men in Space
    AV# 1-30742, 35 min. C
22. Mars and Beyond
    AV# 1-10682, 12 min. BW
23. Measuring Large Distances
    AV# 1-30252, 29 min. BW
24. Motion and Time
    AV# 1-10672, 13 min. C
25. Mystery of Time
    AV# 1-40017, 40 min. C

26. Nearest Star, The
AV# 1-30217, 29 min. C
27. Newton, Isaac
AV# 1-12468, 13½ min. BW
28. Nuclear Radiation: Detection
AV# 1-10798
29. Nuclear Radiation In Outer Space
AV# 1-11423
30. Realm of the Galaxies, The
AV# 1-10636, 19 min. C
31. Rockets: How They Work
AV# 1-11424, 16 min. C
32. Satellites: Stepping Stones to Space
AV# 1-11447
33. Science in Space
AV# 1-30746, 29 min. C
34. Strange Case of The Cosmic Rays, The (Part 1)
AV# 1-30243, 30 min. C
35. Strange Case of The Cosmic Rays, The (Part 2)
AV# 1-30246, 30 min. C
36. Understanding Our Universe
AV# 1-01534, 11 min. C

DADE COUNTY MODELS

1. Astronomy, Set 1 AV# 6-00162
2. Astronomy, Set 2 AV# 6-00163
3. Footsteps To The Moon AV# 6-00030
4. Planetarium Model AV# 6-00035

DADE COUNTY TRANSPARENCIES

1. Astronomy AV# 2-30028
2. Behavior of Light (Lens-Telescope) AV# 2-00160
3. Earth Science: Astronomy, Set 1 AV# 2-30000
4. Earth Science: Astronomy, Set 2 AV# 2-30146
5. Force and Motion, Unit 2: Centrifugal and Centripetal Force
6. Mechanics: Scientific Notation AV# 2-00186
7. Universe, The: Northern Star System AV# 2-00210

DADE COUNTY SLIDES

1. Astronomy: Stars and Planets. 30 (2x2) AV# 5-20097
2. Man in Space: The Cape Canaveral Story 36 (2x2); 1 tape recording, 600' 15' 7-½ IPS S-T; SG AV# 5-50031
3. Missiles At Cape Kennedy 10 (2x2) AV# 5-20170
4. Rocket Trip, A. 26 (2x2) AV# 5-20082

SUGGESTED DISCUSSION QUESTIONS

1. What has our understanding of nuclear energy revealed about the sun?
2. What information about the earth might be learned from studying meteorites?
3. Why would a manned exploration of the moon seem likely to accomplish more than a well-equipped unmanned capsule?
4. Why does the speed of Halley's Comet vary?
5. If the sun were a variable star, how would the earth be affected?
6. Why are retrorockets instead of parachutes used for landing on the moon?
7. What are some of the rights and obligations of men and nations in space research?
8. If a heavy object is to be placed in the same orbit as an object with less mass, which object would have to move with the greater velocity?
9. What problems are involved in making a trip lasting months or years to another star system?
10. You have 24 hours to collect samples from the planet Earth to carry back to planet X. You do not land near a city and do not see any earthlings. What would you collect if you could carry back only 100 pounds of substances? What kind of materials would give the best overview of what the earth is like?
11. Why are minus magnitudes used?
12. If you were an astronomer in another galaxy how would you describe the path of earth?
13. What will happen to earth when the sun becomes a red giant star?
14. How can lengths be expressed in terms of time?

SPECIAL INSTRUCTIONS

1. A variety of experiments are suggested at various levels of sophistication. It would be impossible to complete all of the labs within the nine weeks. The teacher should choose those labs which are best adapted to their student's ability levels, time schedules, and available facilities. Many experiments may be used as demonstrations and vice-versa.
2. The reference list is purposely short. Every school has an ample supply of excellent books on all aspects of space that should be used.
3. The books that are listed can be considered "musts".
4. The Universe a Life Nature Library book may be used as a text. A classroom should have at least 15 copies.
5. The Earth-Space Sciences published by Laidlaw is the state-adopted text with the most comprehensive coverage of space.
6. Planets, Stars and Galaxies published by John Wiley & Sons is an excellent teacher reference.
7. The only real way to learn about stars is to look at them. Hopefully, you can have night labs or give homework assignments and the students can compile the information the next day.
8. This course as written does not mandate the curriculum. It may be adapted to a variety of teaching strategies:
   a. A self-pacing, individualized learning approach
   b. Small group seminar-research type approach
   c. A structured situation in which all students participate in the same activities

REFERENCES

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9. National Aeronautics and Space Administration. From Here, Where? Washington D. C.: NASA, 1965.

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11. National Aeronautics and Space Administration. Space Resources For Teachers Space Science. Washington D. C.: NASA, 1969.

12. Navarra, John and Strahler, Arthur. Our Planet in Space The Earth Sciences. New York: Harper and Row, 1967.

MASTER SHEET - SPACE SCIENCE

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