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AUTHOR	Geigel, Joan; And Others
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ABSTRACT

A self-paced program designed to integrate the use of computers and physics courseware into the regular classroom environment is offered for physics high school teachers in this module on projectile and circular motion. A diversity of instructional strategies including lectures, demonstrations, videotapes, computer simulations, laboratories, and small group discussions are employed in the four-week plan for the unit. Suggestions for instruction include: (1) description of materials and equipment (emphasizing the role of the Apple II microcomputer in instruction); (2) flow sheet (diagramming instructional options and procedures); (3) materials list (indicating relevant textbooks, courseware, videotapes, and film loops); (4) student learning objectives outline (stating desired behaviors related to projectiles, circular motion, satellites, and the solar system); (5) lesson plan (providing a list of 39 activities for a period of 17 school days); (6) grading suggestions (advocating opportunities for student recognition); (7) hints on use of computers (offering suggestions for classroom management); (8) self-paced consideration (discussing class size, scheduling and teacher monitoring); (9) field test conclusions (containing the student evaluation form and results); and (10) student worksheets (including all activities, quizzes, and information sheets as well as an article from "NASA Facts" (March, 1981) concerning the shuttle era. (ML)

PROJECTILE AND CIRCULAR MOTION

A Model Four-Week Unit of Study for a High School Physics Class Using Physics Courseware

Department of Physics
North Carolina State University
Raleigh, NC 27650

PROJECTILE AND CIRCULAR MOTION

A Model Four-Week Unit of Study for a High School Physics Class Using Physics Courseware

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Joan Geigel, John S. Risley, Karen L. Johnston

Physics Courseware Laboratory
Department of Physics
North Carolina State University
Raleigh, NC 27695-8202

September, 1985

Introduction

This four-week unit of study is designed to help physics high school teachers present projectile and circular motion to a class of 20 to 40 students. The purpose of the teaching module is to integrate the use of computers and physics courseware into a regular classroom environment. The daily schedule calls for lectures, demonstrations, videotapes, film loops, laboratories, and reading assignments that a teacher would usually provide. However, at various times throughout the four-week period there are activities incorporating computers. Included are classroom demonstrations using large screen monitors, individual tutorials, drill and practice, games, and computer simulations for groups of two to three students.

Since students spend vastly differing amounts of time on computer activities, the study unit was self-paced. The self-paced instruction, however, reduces the number of lectures. Alternative learning activities are used: small group discussions, group laboratories, and small group computer lessons. To help the students and teacher visualize the options during the self-paced activities, a flow sheet is provided, see the *figure* on the next page. The daily lesson plan provides deadlines for the students. Brighter students do not spend as much time on drill and practice while poorer students can be "retaught" with unlimited patience by the computer until they master the required concept before moving on.

If a student fails a quiz, remedial work in the form of drill and practice on the computer can be offered to the student. The option of playing a game is used as a "reward" for the students who move at a faster pace or who exceed the minimum requirements.

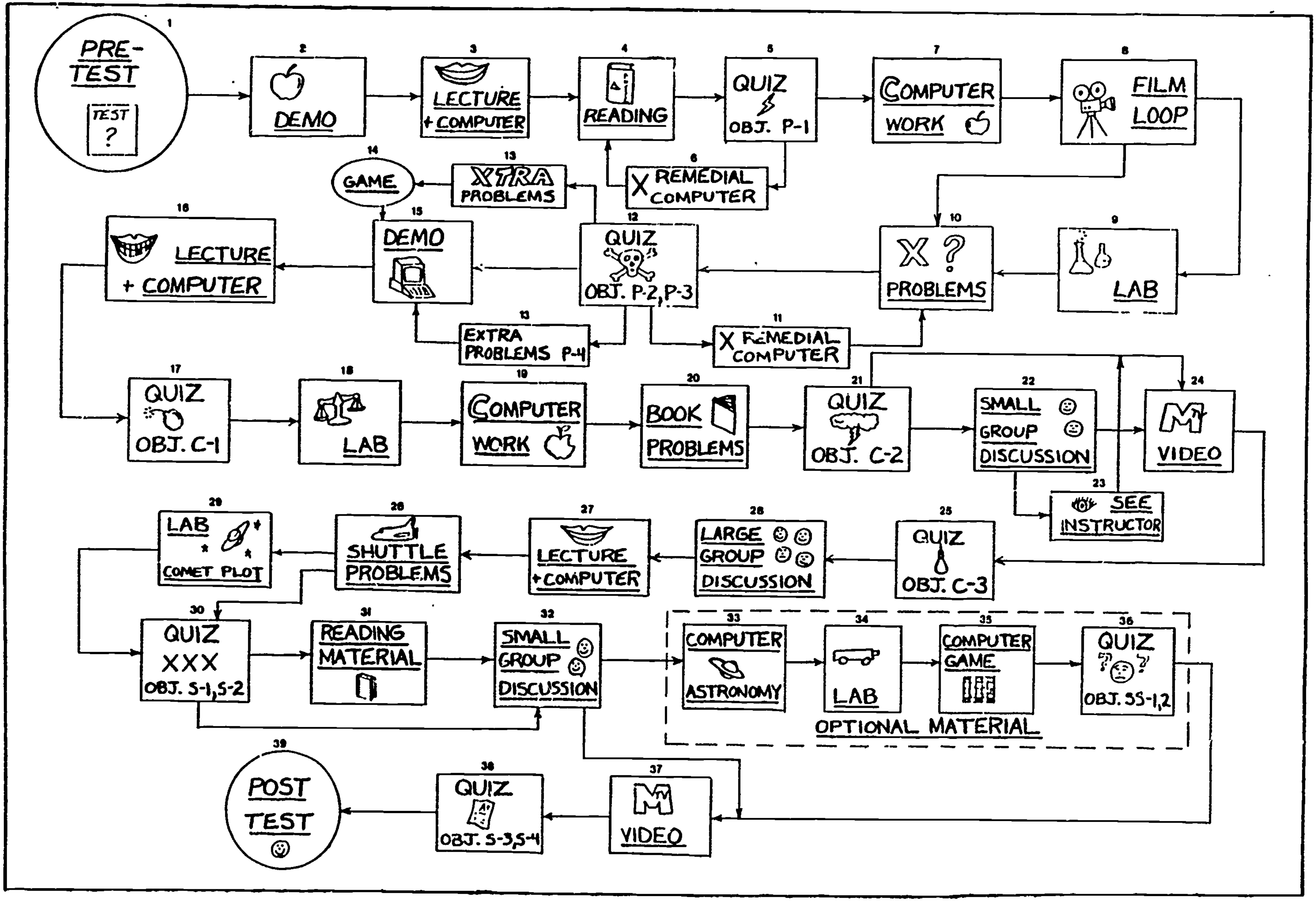
Materials and Equipment

Implementing computer instructions in today's school environment is not an easy task. Most physics high school teachers do not have access to enough microcomputers. If all of the students in one classroom work together on the same material at the same time, then 10 to 20 microcomputers are needed with one computer for each pair of students. However, the four-week study unit can be successfully implemented with only one computer—used only for demonstrations and perhaps a couple of small-group activities. A workable number of computers is six. Half the class can do computer activities with three students to each computer.*

Apple II microcomputers are utilized in this teaching module because of the vast amount of physics courseware available for Apple II's. The software for this study unit includes nine software packages or diskettes from seven commercial publishers. As yet, no computer-based laboratories or experiments are part of this study unit. Five video-tapes and four film loops are part of the lesson plan. Any high school physics textbook and a laboratory book can be used for this study unit. References to text are keyed to *Modern Physics* (Holt).

*As many as six (6) students have been spread around one computer. Only a few students in such a group seem to gain much understanding of the courseware materials, though.

FLOW SHEET



1 PRE-TEST
TEST ?
2 DEMO
3 LECTURE + COMPUTER
4 READING
5 QUIZ OBJ. P-1
6 X REMEDIAL COMPUTER
7 COMPUTER WORK
8 FILM LOOP
9 LAB
10 X ? PROBLEMS
11 X REMEDIAL COMPUTER
12 QUIZ OBJ. P-2, P-3
13 XTRA PROBLEMS
13 EXTRA PROBLEMS P-4
14 GAME
15 DEMO
16 LECTURE + COMPUTER
17 QUIZ OBJ. C-1
18 LAB
19 COMPUTER WORK
20 BOOK PROBLEMS
21 QUIZ OBJ. C-2
22 SMALL GROUP DISCUSSION
23 SEE INSTRUCTOR
24 VIDEO
25 QUIZ OBJ. C-3
26 LARGE GROUP DISCUSSION
27 LECTURE + COMPUTER
28 SHUTTLE PROBLEMS
29 LAB COMET PLOT
30 QUIZ XXX OBJ. S-1, S-2
31 READING MATERIAL
32 SMALL GROUP DISCUSSION
33 COMPUTER ASTRONOMY
34 LAB
35 COMPUTER GAME
36 QUIZ OBJ. SS-1,2
OPTIONAL MATERIAL
37 VIDEO
38 QUIZ OBJ. S-3, S-4
39 POST TEST

2

Materials List

1. Textbooks

Modern Physics, Williams, Trinklein, and Metcalfe (Holt, Reinhardt, and Winston Publishers, New York, 1976).
Laboratory Physics, Murphy (Charles E. Merrill Publishing Company, Columbus, OH, 1980).
Project Physics Handbook, (Holt, Reinhardt, and Winston Publishers, New York, 1981).

2. Courseware

CROSS EDUCATIONAL SOFTWARE: *Volume 5 - Circular Motion*
EDUCATIONAL MATERIALS AND EQUIPMENT: *Projectile and Circular Motion*
EDUTECH: *Physics Demos: Mechanics*
FOCUS MEDIA, INC.: *Nonlinear Motion*
J&S SOFTWARE: *Circular Motion* and *Free Fall*
VERNIER SOFTWARE: *Orbit II* and *Projectiles II*
John WILEY: *Concentrated Physics Concepts: Part I*

3. Videotapes

Space Shuttle: A Remarkable Flying Machine (28 min.) F/26 NASA
Space Shuttle Propulsion (7 min.) SS/09 NASA
Space Shuttle: Mission and Payloads, 1980 (13 min.) SS/05 NASA
The Kinetic Karnival and *Rotation* - Jearl Walker, N. C. Department of Public Instruction

4. Film Loops

Galilean Relativity I: Ball Dropped from the Mast of a Ship (80-3494)
Galilean Relativity II: Object Dropped from an Aircraft (80-3510)
Galilean Relativity III: Projectile Fired Vertically (80-3528)
(The National Film Board of Canada)

Human Momenta (NASA - Skylab)

Student Learning Objectives

The learning objectives of the module are the mastering of two-dimensional kinematics, projectile motion, circular motion, rotational kinematics, centripetal force, satellite motion, Kepler's laws, and the solar system. Numerous quizzes are given after new material is introduced to test the student's understanding and mastering of the learning objectives.

Projectiles:

P-1 Identify and give definitions of the following terms or phrases: projectile, trajectory, range, and the independence of the x- and y-components of the motion.
P-2 Calculate the range, time of flight and maximum height of a projectile given the initial velocity and firing angle.

P-3 Describe the motion of a projectile in terms of its velocity, acceleration, position, and the forces acting on it.
P-4 Given a required height or range, calculate the necessary initial conditions for the projectile.

Circular Motion:

C-1 Define or identify in a schematic diagram: curvilinear motion, centripetal force, circular motion, centripetal acceleration, rotary motion, rotational velocity, frequency, period, moment of inertia, tangential velocity, radial velocity, and critical velocity.
C-2 Given the frequency and mass of a body in a circular orbit of known radius, calculate the period of rotation, the centripetal acceleration, and the centripetal force.
C-3 Define and give examples of a frame of reference, fictitious forces, and inertial and non-inertial frames of reference.

Satellites:

S-1 Define artificial and natural satellites, escape velocity, geosynchronous orbit, and artificial gravity.
S-2 Identify at least two artificial and four natural satellites by name and identify their orbit, periods, and center of motion.
S-3 Identify the forces and provide the equations that describe the motion of satellites. Be capable of offering a physical explanation for various kinds of motion that might occur in space.
S-4 Given the period or orbiting distance of a satellite, calculate the other variable.

Solar System (Optional):

SS-1 Briefly explain and illustrate Kepler's three Laws of Planetary Motion.
SS-2 Briefly describe the planets in the solar system.

Lesson Plan

The lesson plan has 39 activities covering a period of 17 school days. See the flow sheet for a detailed overview. Many of the activities require a worksheet for the student to fill out. Original copies of these handouts are included with this module which can be duplicated as needed.

Day	Activity	Description
1	1*	Pretest
2	2	Introduction with projectile motion Demonstration

*A student worksheet has been prepared which can be duplicated.

	3	Lecture and Computer on projectile motion with distance formula a) EDUTECH: *Physics Demos: Mechanics* (Monkey and the Hunter with and without gravity) b) VERNIER: *Projectile II* (Challenge 3)
	4	Reading assignment: pp. 90-103.
3	5*	Quiz (Objective P-1)
	6	Remedial Computer Work WILEY: *Concentrated Physics Concepts Part I* (Work sections 1 - 3, keep notes)
	7*	Individual Computer Work
4	8*	Film Loop on Galilean Relativity with questions a) *Object Dropped from an Aircraft* b) *Projectile Fired Vertically* c) *Ball Dropped From the Mast of a Ship*
	9*	Laboratory on the Path of a Projectile pp. 61-63 *(Modern Physics)*
5	10*	Problem Set
	11	Remedial Computer work. Do more problems in activity #7
	12*	Quiz (Objectives P-2, P-3, and P-4))
	13*	Extra problems at blackboard (5)
	14	Computer Games VERNIER: *Projectile II* (Any of the Challenges) J&S: *Free Fall* (Any Section)
6	15	Demonstration of circular motion. Projection of the shadow of a pencil standing upright on a record player.
	16	Lecture and Computer a) Derive formulas on circular motion b) Discuss terminology c) Computer demonstration - Focus Media: *Non-linear motion* (Circular & SHM demonstration)
7	17	Quiz (Objective C-1)
	18*	Laboratory on *Centripetal Force*, pp. 67-68 *(Modern Physics)*
8	19*	Computer Work
	20	Book Problems p. 9, #1-7

	21*	Quiz (Objective C-2)
9	22*	Small Group Discussions
10	23	See Instructor
	24*	Video tape: *Rotation*
11	25*	Quiz (Objective C-3)
	26*	Film Loop: *Human Momenta* : Large Group Discussion
12	27	Lecture and Computer on the period of a satellite a) Derivation of the formula for the period of a satellite b) Examples c) Discussion of the shuttle environment
	28*	Shuttle Problems
13	29	Laboratory on the "Stepwise approximation to an orbit," pp. 114-118, *Project Physics Handbook*
	30*	Quiz (Objectives S-1 and S-2)
	31*	Reading Material *Space Shuttle* brochure from NASA
14	32*	Small Group Discussions
15	33*	Computer Work Astronomy (optional)
	34*	Computer Laboratory (optional)
	35	Computer Game (Optional) CROSS: *Vol. 5 - Circular Motion*
16	36*	Quiz (Objectives SS-1 and SS-2)
	37*	Video tapes on the NASA *Space Shuttle* a) A Remarkable Flying Machine b) Propulsion c) Mission and Payloads
	38*	Quiz (Objectives S-3 and S-4)
17	39	Post-test (See Pre-Test)

Grading

A grading system should be used that allows students ample opportunity to gain "full credit" on their activities. The system should also encourage the brighter students to put forth more effort yet not discourage the slow learner. If the students are aware that they are a part of a field study in which a new, "experimental" instructional unit is being used, adequate explanation must be given concerning their participation and generous consideration should be made in giving them credit for their work.

Use of the Module

The module is designed to be a self-contained study unit. With the optional material in astronomy, it will take four weeks. Teachers using the module will probably modify the material to suit their particular teaching priorities and student population.

Use of Computers in the Classroom

When computers are used in the classroom, the teacher is presented with a variety of new logistical problems.

1) Borrowing computers from other classrooms or institutional organizations is often necessary. Each computer should be checked for all of its components, especially the power cords and monitor cables which seem to be missing at the most inappropriate times.

2) If the teacher has not borrowed microcomputers before, the computers should be set up and tested a couple of days before they are needed to insure that everything will work when the students arrive.

3) Before beginning the unit, time should be set aside to instruct the students on some of the basic operating instructions of the computer, such as learning where the on-off switch is located.

4) The ideal ratio of students to computers is two or three to one. It is workable to have four or five students per computer.

5) One computer diskette can be used for several computers; however, the classroom environment would be less chaotic if several copies of the software exist.

6) The teacher must monitor the students at the computers periodically. Students will often bring non-physics software to the classroom from home.

7) When students are working at the computer, it is vital that they keep notes of their work. It is all too easy to go through a courseware activity and forget everything once the computer is turned off.

Self-paced Consideration

The module was designed as a set of self-paced activities because of the lack of sufficient computers for a normal-sized physics classroom i.e., 30-40 students. Class size, therefore, is an important issue in self-paced instruction. The instructor must be available as a resource for the students while they are working. A good size for such a class is 15-20 students. Certain students need continuous monitoring by the teacher in a self-paced environment. The teacher should publish a suggested schedule and set many "in-between" due dates to keep the students on track. Grading the large number of quizzes and activities is very time consuming. Some type of self-evaluation and peer grading could be improvised.

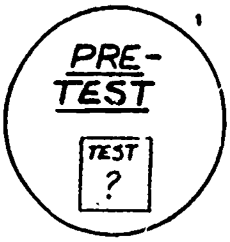
Conclusions Based on the First Field Test

The first field test of this unit of study was conducted by Joan Geigel at Sanderson High School during January, 1985.

Despite the success the students had in learning the material, they disliked the self-paced aspect of the module. The basic reason for their dislike is the reluctance and indeed the inability of the students to plan and carry through a self-chosen sequence of activities during their class time. The average student cannot function in an unstructured atmosphere. As one student related, "I've been spoon fed for twelve years, and I want to continue to be until I graduate in June." Many other comments can be summarized in the complaint that the module was "too much work." A self-paced structure is not necessary for incorporation of computers into the classroom. A structured sequence of activities could be arranged. However, it seemed that a self-paced class would capitalize on the flexibility of the computer. The students were asked to evaluate the use of the computer itself, aside from their prejudices about self-paced learning. Generally the computer was well received. The most common complaint was "too many people on one computer."

Student Evaluation of Four-Week Study from the 1st Field Test
(January, 1985)

	never again	mildly dislike	no opinion	OK	really like
1. Teacher gives a written set of objectives at the beginning of the unit.	3	3	24	28	40
2. Have many quizzes so that you can drop the lowest grades.	0	2	8	27	63
3. Use many different activities instead of just regular laboratories.	7	20	8	29	35
4. Have the opportunity to do extra work so that you can get a 100% on "laboratories."	0	3	7	27	63
5. Work at your own pace with only general due dates.	7	13	15	31	34
6. Have small group discussions with a group report, as opposed to regular lecture.	12	17	20	31	22
7. Turn in group laboratory reports.	5	9	25	37	23
8. Use this type of classroom structure for another topic.	19	13	27	24	13
9. Videos: Jearl Walker	2	5	15	35	42
Space Shuttle	2	8	15	43	30
10. Computer-assisted lecture demonstrations.	16	16	18	35	16
11. Computer homework assignments (as opposed to problems from the book)	9	23	27	28	10
12. Computer classroom assignments (supplemental problems)	8	20	25	38	8
13. Computer laboratories (taking the data from the computer display as in the astronomy laboratory.	10	16	27	34	15
14. Make-up work (if absent, get lecture from computer.	5	13	27	39	18
15. Remedial (extra computer instruction if you're having problems.	7	10	25	39	18
16. Rewards (class time for "physics games")	3	6	29	31	29



PRETEST

Answer Sheet

NAME: ______________________________ PERIOD: ________________

1. Speed = ____________________

   Angle = ____________________

2. Force = ____________________

3. ____

   ____

   ____

   ____

4. Range = ____________________

5. T = ____________________

6. Altitude = ____________________

1. ______	6. ______	11. ______	16. ______
2. ______	7. ______	12. ______	17. ______
3. ______	8. ______	13. ______	18. ______
4. ______	9. ______	14. ______	19. ______
5. ______	10. ______	15. ______	20. ______

Projectile And Circular Motion

$G = 6.7 \times 10^{-11}$ nt m^2/kg^2
$M_e = 6.0 \times 10^{24}$ kg
$R_e = 6.4 \times 10^6$m

SHOW ALL WORK

1. On level ground, a ball of mass 3 kg is thrown forward and upward. The ball is in the air for a total of 2 sec and strikes the ground 100 m from the thrower. What was the original speed and angle of the ball?

2. A fly of mass 2 gm is sunning itself on a turntable (4 cm from the center). The turntable is playing a "45" record (45 revolutions per min). What is the centripetal force on the fly?

3. When a car makes a sharp right turn, which side of the car do you lean toward and why?

4. A ball is shot from a muzzle with a velocity of 60 m/sec and an angle of 37 degrees. What is the range?

5. A girl is on a swing. At the bottom of her path, she is moving at 10 m/sec. She has a mass of 50 kg. What is the tension in each rope?

6. Calculate the altitude of a geosynchronous satellite.

PRETEST (cont.)

Projectile and Circular Motion

PUT ANSWERS IN BLANKS

In questions 1 through 4, a missile is fired horizontally at 30 m/sec. Neglect friction.

_____ 1. After two seconds, what is the x-component of the velocity of the missile?

(a) 0 m/sec (c) 30 m/sec
(b) 15 m/sec (d) 60 m/sec

_____ 2. Which forces are acting on the missile?

(a) gravity (d) a and b
(b) momentum (e) a and b and c
(c) inertia and initial velocity

_____ 3. After two seconds what is the acceleration of the missile?

(a) 0 m/sec (c) - 9.8 m/sec
(b) 9.8 m/sec (d) need more information

_____ 4. What is the trajectory of the missile?

(a) a straight line down
(b) a straight line at a 45 degree angle
(c) a half of a parabola
(d) a sine wave

_____ 5. The period of the earth around its focus is

(a) 24 hrs. (c) 365 days.
(b) 29 days. (d) 26,000 years.

_____ 6. The planet with the most eccentric orbit is

(a) Mercury. (c) Earth.
(b) Venus. (d) Mars.

_____ 7. A Martian year is approximately

(a) 1/2 earth year. (c) 2 earth years.
(b) ؛ earth. (d) 4 earth years.

Projectile and Circular Motion

_____ 8. When the space shuttle is in orbit, the force holding it in orbit is

(a) gravity.
(b) inertia.
(c) centrifugal.
(d) no force is needed since it is weightless.

_____ 9. If a space ship in the shape of a doughnut makes artificial gravity out in deep space, which way will be "up" for the passengers?

(a) out
(b) in
(c) perpendicular to the plane of rotation
(d) you cannot tell unless you know if the rotation is is clockwise or counterclockwise.

_____ 10. Why do astronauts from in the shuttle float on a spacewalk?

(a) they have no atmosphere pressing on them
(b) they are weightless
(c) they are in free fall
(d) they are rotating around the earth, opposite of the earth's spin so they appeared as if they were standing still.

_____ 11. The earth is closest to the sun in

(a) winter.
(b) spring.
(c) summer.
(d) fall.

_____ 12. Centripetal force

(a) produces circular motion.
(b) is the opposite of inertia.
(c) is always equal to weight minus tension.
(d) is always equal to tension minus weight.

_____ 13. During the barrel ride at the fair, you are in

(a) an inertial frame of reference.
(b) a non-inertial frame of reference.

Projectile And Circular Motion

____ 14. An ice skater spinning faster as she pulls in her arms is an example of

(a) f = ma (the force from the tips of the skate).
(b) conservation of energy.
(c) inertial balancing.
(d) conservation of angular momentum.

____ 15. A body travels about the earth in a circular path. The tangential velocity is

(a) relatively constant.
(b) always changing.

____ 16. As the moon moves about the earth, the acceleration of the moon is always

(a) toward the earth.
(b) aways from the earth.
(c) tangent to the path.
(d) zero.

____ 17. Halley's comet has a period of

(a) 5 years.
(b) 100 years.
(c) 47 years.
(d) 76 years.

____ 18. The earth's precession will eventually cause Polaris to no longer be the north star.

(a) True
(b) False

____ 19. If you ride on a merry-go-round, there is a centripetal force acting on you.

(a) True
(b) False

____ 20. When going down in an elevator, the force of gravity is

(a) much larger.
(b) much smaller.
(c) essentially the same.

QUIZ
OBJ. P-1

QUIZ

Objective P-1

NAME: ______________________________ PERIOD: ________________

1. Draw the trajectory of a projectile fired from ground level.

2. Why did the monkey get hit in the "Monkey & the Hunter" simulation?

3. Indicate the range on your answer to question #1.

4. Indicate the maximum altitude on your answer to question #1.

COMPUTER WORK

COMPUTER WORK

Projectile Motion

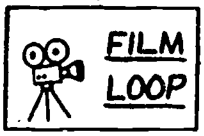
NAME: ______________________________ **PERIOD:** ________________

1. **Wiley: Concentrated Physics**

   Select #4 on the menu. This program prompts you for answers. Work at least 4 problems. Show all your work and calculations below.

2. **J & S: Free Fall**

   Select SHOOTING ARROWS, #3 on the menu. All of these examples have an initial velocity of 48 m/sec. You can choose the angle. The program gives you the range, maximum height, and the time of flight. Predict the answer ahead of time. Choose at least 3 angles, i.e., 30°, 60°, 45°. Show all your work and calculations below.



FILM LOOP

Projectile Motion

NAME: ______________________________ **PERIOD:** ________________

I. "OBJECT DROPPED FROM AIRCRAFT"

1. In the frame of reference of the airplane, is the motion vertically downward?

2. Is the motion a straight line? (You do <u>not</u> have to make a graph!)

3. What is the effect of air resistance? How would this show up in your graph of the motion?

4. Can you detect any evidence of air resistance?

5. Does the path of the object pass through the origin? Where is the origin?

II. "PROJECTILE FIRED VERTICALLY"

SCENE 1: If ski-doo is stationary relativity to the Earth, how does the flare move?

SCENE 2: If the ski-doo moves at an uniform velocity relative to the Earth, describe the flare's motion relative to the Earth.

SCENE 3 & 4: The speed of the ski-doos changes after the shot is fired. For each of the above cases, describe the motion of the ski-doo and describe the flare's motion relative to the Earth and relative to the ski-doo. In which case is the motion a parabola?

III. "Ball Dropped from the Mast of a Ship"

1. How do the events shown in this film illustrate the principle of Galilean relativity?

2. In which frame of reference does the ball behave the way you would expect it to behave, knowing that the force is constant and assuming that Newton's laws of motion apply?

3. In which reference systems do Newton's laws fail to predict the correct motion?

PROBLEMS

Projectiles and Circular Motion

NAME:______________________________ **PERIOD:**________________

(When the British system of units is used, e.g. ft/sec, use a_g = 32 ft/sec.)

P-1. A rifle is aimed horizontally at the bull's-eye of a target 500 meters away. The initial horizontal velocity of the bullet is 1,000 meters per second. How far below the bull's - eye will the bullet strike?

P-2. An arrow is shot at an angle of 30 degrees to the horizontal and with a velocity of 160 ft/sec.

a) How high will the arrow go?

b) How far will the arrow go horizontally?

P-3. An object is projected horizontally with a speed of 8 m/sec. from the top of a cliff 122.5 m high. How far from the base of the cliff will the object strike the ground?

P-4. A bomber is flying at an altitude of 32,000 ft. and at a speed of 300 mi/hr. (440 ft/sec.). How far in front of the target must the pilot release the bomb to score a hit?

13

XTRA PROBLEMS

EXTRA PROBLEMS

NAME: ______________________________ **PERIOD:** ________________

1. A body 400 m above ground is projected downward at an angle of 30 degrees to the horizontal with an initial speed of 10.0 ft/s. How many seconds will it take for the body to reach the ground? How far will it strike from the projection of the release point on the ground?

2. A cannon on a level plain is aimed 30 degrees above the horizon. A shell is fired with a muzzle velocity of 1200 ft/s toward a vertical cliff 3200 ft away. How far above the bottom of the cliff does the shell strike the cliff?

3. A World Series batter hits a home run ball with a velocity of 132 ft/s at an angle of 26 degrees above the horizontal. A fielder who has a reach of 7 ft above the ground is backed up against the bleacher wall which is 386 ft from home plate. The ball was 3 ft above the ground when it was hit. How high above the fielder's glove does the ball pass?

PROBLEMS (cont.)

Projectiles and Circular Motion

P-5. A golf ball is hit at an angle of 45 degrees with the horizontal and reaches a height of 190 ft. How far from the golfer will the ball land?

C-1. A 20-kg body moves at 4 cycles per second in a circular path of radius 5 m. Calculate

a) the linear speed,

b) the acceleration, and

c) the centripetal force acting on the body.

C-2. A body rests in a pail which is swung in a vertical circle with a 2 ft radius. What is the slowest speed the body can have so as not to fall out of the pail when it is at the top of the path?

C-3. A 100-ton train rounds a level curve of radius 550 ft at 30 mph. Determine the horizontal force against the rails.

C-4. The human body can safely stand an acceleration that is 9 times that due to gravity. What is the minimum radius of curvature that a pilot may safely turn his plane upward at the end of a nose dive? The plane travels at a speed of 480 mph?

QUIZ
OBJ. P-2, P-3

QUIZ

Objectives P-2 and P-3

NAME: ______________________________ **PERIOD:** ____________________

VERSION 1

A projectile is fired at 50 m/sec at 45 degrees.

a) Draw a FBD after it is fired.
b) What is the range?

---------------------------cut here----------------------------

NAME: ______________________________ **PERIOD:** ____________________

VERSION 2

A projectile is fired at 30 m/sec at 60 degrees.

a) What is the acceleration on the projectile?
b) What is the maximum height?

QUIZ (cont.)

Objective P-2 and P-3

NAME: ______________________ **PERIOD:** ______________

VERSION 3

A projectile is fired at 50 m/sec and 10 degrees.

a) What is the total time of flight and the range?
b) What is the y-component of the velocity at 1 sec?
c) What is the y-component of the acceleration at 1.5 sec?

---------------------------cut here---------------------------

NAME: ______________________ **PERIOD:** ______________

VERSION 4

A projectile is fired at 20 degrees and 100 m/sec.

a) What is the maximum height and the total time of the flight?
b) What is the force (if any) on the projectile in the x-direction while the projectile is in flight?

EXTRA PROBLEMS (cont.)

4. A highjumper whose center of gravity is 3.5 ft above the ground has been clearing 6.0 ft using a Western Roll in which the take-off velocity is at an angle of 60 degrees with the horizontal. With what speed must he take off? How far back from the bar must he take off?

5. Prove that a gun will shoot three times as high but just as far horizontally when its angle of elevation is 60 degrees compared to 30 degrees.

QUIZ (cont.)

Objective P-2 and P-3

NAME: ______________________ **PERIOD:** ______________

VERSION 5

A projectile is fired at 70 m/sec at 30 degrees.

a) What is the acceleration in the horizontal direction?
b) What is the range?

---------------------------cut here---------------------------

NAME: ______________________ **PERIOD:** ______________

VERSION 6

A projectile is fired at 40 degrees and 120 m/sec.

a) What is the range?
b) What is the x-component of the velocity after 1 sec?

QUIZ
OBJ. C-1

QUIZ

Objective C-1

NAME: ______________________________ **PERIOD:** ________________

VERSION 1

a) Draw a sketch of a body in a circular path and show the direction of the centripetal force.

b) A planet circles a sun 10 times in 5 years. What is the period of the planet.

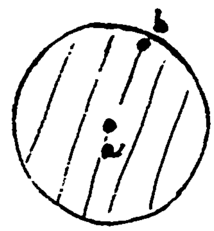
c) Give an example of rotary motion.

---------------------------cut here---------------------------

NAME: ______________________________ **PERIOD:** ________________

VERSION 2

a) This solid disk is rotating clockwise. Two dots **a** and **b** on the disk.



Which dot is in circular motion?

Draw the velocity vector of the outer dot at the instant shown.

b) What provides the centripetal force on the moon?

c) What is the frequency of the moon's rotation about the earth, if it takes 29 days from full moon to full moon?

QUIZ (cont.)

Objective C-1

NAME: ______________________________ **PERIOD:** ________________

VERSION 3

a) Halley's comet circles the sun once every 76 years. What is the comet's period and frequency?

b) Draw the path of earth around the sun and show the direction of the velocity and centripetal force at a particular instant in time.

c) Give an example of rotary motion.

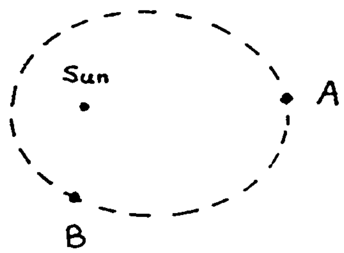
----------------------------cut here----------------------------

NAME: ______________________________ **PERIOD:** ________________

VERSION 4

a) What is the frequency of the earth around the sun?

b) Here is a comet around our sun. Show the direction of centripetal force at **A** and the centripetal acceleration at **B**.



c) Give an example of rotary motion.

QUIZ (cont.)

Objective C-1

NAME: ______________________________ **PERIOD:** ________________

VERSION 5

C-1 a) Define and sketch centripetal acceleration and frequency.

b) Give an example of circular motion and rotary motion and distinguish between the two.

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LAB

LABORATORY

Centripetal Force

Instructions:

The purpose, materials; and procedure for this laboratory are found in Laboratory Physics (Murphy) pg. 67, Investigation #13. The laboratory has been extended as indicated below.

You may use the program STOPWATCH on the disk **EDUCATIONAL COURSEWARE: Free Fall** instead of using a conventional stopwatch. Choose EXIT on the menu and STOPWATCH appears as a submenu item.

The laboratory report must include:

- Purpose
- Methods and Procedures
- Data Sheet
- Analysis of Data
- Sample calculation of the frequency
- Graphs
  - a) Plot T vs f, T vs m, and T vs R. The period T is the ordinate in each graph.
  - b) Plot T vs f, f vs m on semi-log paper.

For plotting you may use the program **EDUCATIONAL COURSEWARE: Lab Plot** and print a copy of the computer graph.)

LABORATORY (cont.)

Student Discussion Form

NAME: ______________________ PERIOD: ______________

1. What theory (laws, relationships, etc.) does this experiment illustrate?

2. Were you able to verify the theory? Why or why not?

3. How does your data substantiate theory? Refer to your graphs and charts and to your data and calculations when making comments.

4. What are the sources of error is this experiment?

5. How could the experiment be improved?

6. What conclusions did you form from this experiment?

COMPUTER WORK

Circular Motion

NAME: ______________________________ **PERIOD:** ________________

Instructions:

Work assignments A and B or B and C. Show your work and calculations in the space provided.

A) **EME: Projectile and Circular Motion**

Select menu item "C" Circular Motion Constant Speed (Answer <u>all</u> questions in full sentences).

B) **J&S: Circular Motion**

Select menu item "1" Circular Motion. Work at least 10 problems out of the 14 possible.

C) **Focus: Non-linear Motion**

Select menu item "2" Angular Momentum. Go through both parts of this section. Answer the following:

1. What is the law of conservation of angular momentum? How does this conservation law explain what you saw?

2. What is the moment of inertia (see text)?

3. What is the formula for the moment of inertia I for the two cases shown?

4. Explain how an ice skater does a spin?

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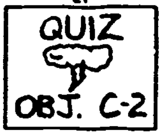

QUIZ

Objective C-2

NAME: ______________________________ **PERIOD:** ________________

VERSION 1

A boy swings a 3 kg ball around his head at a radius of 0.5 m 30 times in 15 sec. What is T and F_c?

----------------------------cut here----------------------------

NAME: ______________________________ **PERIOD:** ________________

VERSION 2

A 200 kg race car goes around a circular race track of radius 30 m 3 times in 10 minutes. What is T and F_c?

Objective C-2

NAME: ______________________ **PERIOD:** ______________

VERSION 3

A bird flys around a bug in a 1 m radius circle. The bird circles the bug 10 times in 100 seconds. What is T of bird? What is a_c of bird?

----------------------------cut here----------------------------

NAME: ______________________ **PERIOD:** ______________

VERSION 4

It takes a car 0.1 hr. to circle a track. (R = 50 M). The mass of the car is 200 kg. What is v?

SMALL GROUP DISCUSSION

SMALL GROUP DISCUSSION

Inertial and Non-Inertial Frames of Reference

Discuss these statements in groups of four people. You may use your text book for supplemental material. You may also consult with the instructor. Write up one set of answers in full sentences per discussion group. The grade on the paper is the grade for everyone in the group. **ONLY 4 NAMES PER PAPER ARE ALLOWED.**

SG-1 When you ride in a car in a tight circle you experience what is called a centrifugal force. Explain the sensation from the viewpoint of someone on the street watching the turning car and passenger.

SG-2 What are the real forces acting on you if you are riding a loop-de-loop at the fair and you are at the top of the loop? Is this an inertial frame of reference? Are there any fictitious forces? If so, describe them.

SG-3 If you are standing on a pair of fast roller skates (no friction) in the aisle of an airplane and suddenly the plane accelerates down the runway.

- a) What happens to you from the point of view of another passenger on the plane?
- b) What happens to you from the point of view of someone outside the plane?
- c) Draw a Free Body Diagram for each.

SG-4 What does it feel like at the bottom of a large drop in a roller coaster? Why? Is this an inertial frame of reference (at that point in the ride)?

SG-5 Define an inertial and non-inertial frame of reference and give an original example of each.

VIDEO

VIDEOTAPE

"Rotation"

NAME: ____________________ PERIOD: ____________

1. What is the difference between "centripetal" and "centrifugal" forces?

2. What is the relationship between torque and the force creating the torque?

3. Several people are riding on a merry-go-round. Compare the moments of inertia of the system of people and merry-go-round for two situations: if the people are near the center of the merry-go-round, and if they are out on the rim.

4. Explain why a brief touch on a spinning egg can aid in distinquishing a hard-boiled egg from a fresh one. When the fresh egg begins spinning again, from where did it receive its angular momentum?

5. When a diver pulls in his arms and legs during a somersault, what happens to his angular speed?

QUIZ (cont.)

Objective C-3

NAME:______________________________ PERIOD:________________

VERSION 3

Give an example of a non-inertial frame of reference (explain fully).

QUIZ
OBJ. C-3

QUIZ

Objective C-3

NAME: ______________________ PERIOD: ____________

VERSION 1

The following are non-inertial frame of reference. True or false (T/F).

_____ merry-go-round

_____ car traveling at a constant velocity 30 mph

_____ plane standing still

_____ a go-cart riding at a constant speed in a circle

---------------------------cut here---------------------------

NAME: ______________________ PERIOD: ____________

VERSION 2

Label the following as either an inertial I or non-inertial NI reference frame.

_____ earth

_____ loop-de-loop

_____ a boy on roller skates traveling at a constant velocity of 3 m/sec.

_____ a bee circling a flower

LARGE GROUP DISCUSSION

LARGE GROUP DISCUSSION

On Film Loop "HUMAN MOMENTA"

1. What is translational and rotational equilibrium?

2. Why does the astronaut with a beginning rotary movement, speed up and slow down? Explain the physics principle.

3. Al, the Astronaut

Description:

Al, the astronaut, is cruising along in deep, outer space minding his own business when he spies a bag of gold floating in space. He quickly fires his retro-rockets to stop his space cruiser, puts on his space suit, ties himself to the cruiser with a rope, and pushes off toward the bag of gold. Just as he reaches the bag of gold, he also reaches the end of his rope and comes to rest next to the gold. Unfortunately for Al, the rope also comes untied from the space cruiser. It is even more unfortunate that Al has been on a solo mission and there is no one to rescue him.

Problem:

Your mission--should you choose to accept it--is to figure out how Al can save himself and return to the ship with as much gold as possible. For 10 extra points estimate how much gold Al gets to keep. Show calculations.

Assumptions: The effects of gravity can be ignored. Al is wearing a standard EVA spacesuit.

Data: The mass of Al is 80 kg, the space suit has a mass of 40 kg, the 100-m rope has a mass of 10 kg, the bag of gold has 100 pieces and each piece is 20 grams, the bag itself is 100 gram. The oxygen supply will last 30 minutes.

SHUTTLE PROBLEMS

SHUTTLE PROBLEMS

Life in the Space Shuttle

Questions:

1. Is life in the space shuttle, while it is orbiting earth, any different than life in the transport ship heading for Bernard's Star? Explain your answer in terms of the physics that we have already studied.

2. What are the conditions necessary to put the space shuttle into a circular orbit around the earth? We will begin this study with a discussion of projectile motion and how it can be used to illustrate the concept of an orbit.

3. How do we calculate the period of the space shuttle for an earth orbit of arbitrary size? Does it depend on the mass of the space shuttle? What is the speed of the space shuttle when it is in an orbit around earth?

Problems:

1. STA-1 was placed in a nearly circular orbit with an altitude of 275 km (172 statute miles). What are its period and speed?

2. What are the period and speed of a satellite in a circular orbit at an altitude equal to the earth's radius?

3. What is the altitude of a geosynchronous satellite, that is, one which has a period equal to 24 hours?

4. What is the orbital period of the moon? Why does it not agree with the time between consecutive full moons?

DATA:

$G = 6.7 \times 10^{11}$ N-m^2/kg^2

$M = 6.0 \times 10^{24}$ kg

$GM = 4.0 \times 10^{14}$ N-m^2/kg $= 9.6 \times 10^4$ miles^3/s^2

R (earth) = 6400 km = 4000 miles

d (moon) = 380,000 km = 240,000 miles

1 statute mile = 1.6 km

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QUIZ
XXX
OBJ. S-1, S-2

QUIZ

Objective S-1, S-2

NAME: ______________________ **PERIOD:** ______________

VERSION 1

Answer Here.

______________ 1. What is the period of a geosynchronous orbit?

______________ 2. What is the earth's natural satellite?

______________ 3. What is the focus of the earth's orbit?

______________ 4. What keeps Pluto in orbit?

--------------------------cut here--------------------------

NAME: ______________________ **PERIOD:** ______________

VERSION 2

Answer Here.

______________ 1. What is the frequency of a geosynchronous orbit?

______________ 2. What artificial satellite (if any) does the earth have?

______________ 3. What is the focus of the moon's orbit?

______________ 4. Why doesn't a planet go directly into the sun if gravity pulls on it? What keeps it "out"?

QUIZ (cont.)

Objective S-1, S-2

NAME: ______________________ **PERIOD:** ______________

VERSION 3

1. What keeps a satellite in orbit?

2. What is the period of Halley's Comet?

3. Does the mass of a satellite affect its acceleration?

----------------------------cut here----------------------------

NAME: ______________________ **PERIOD:** ______________

VERSION 4

1. Give the names of two natural satellites.

2. What is the focus of the space shuttle orbit when it is in "space"?

NASA Facts

An Educational Publication
of the
National Aeronautics and
Space Administration
NF-127/3-81

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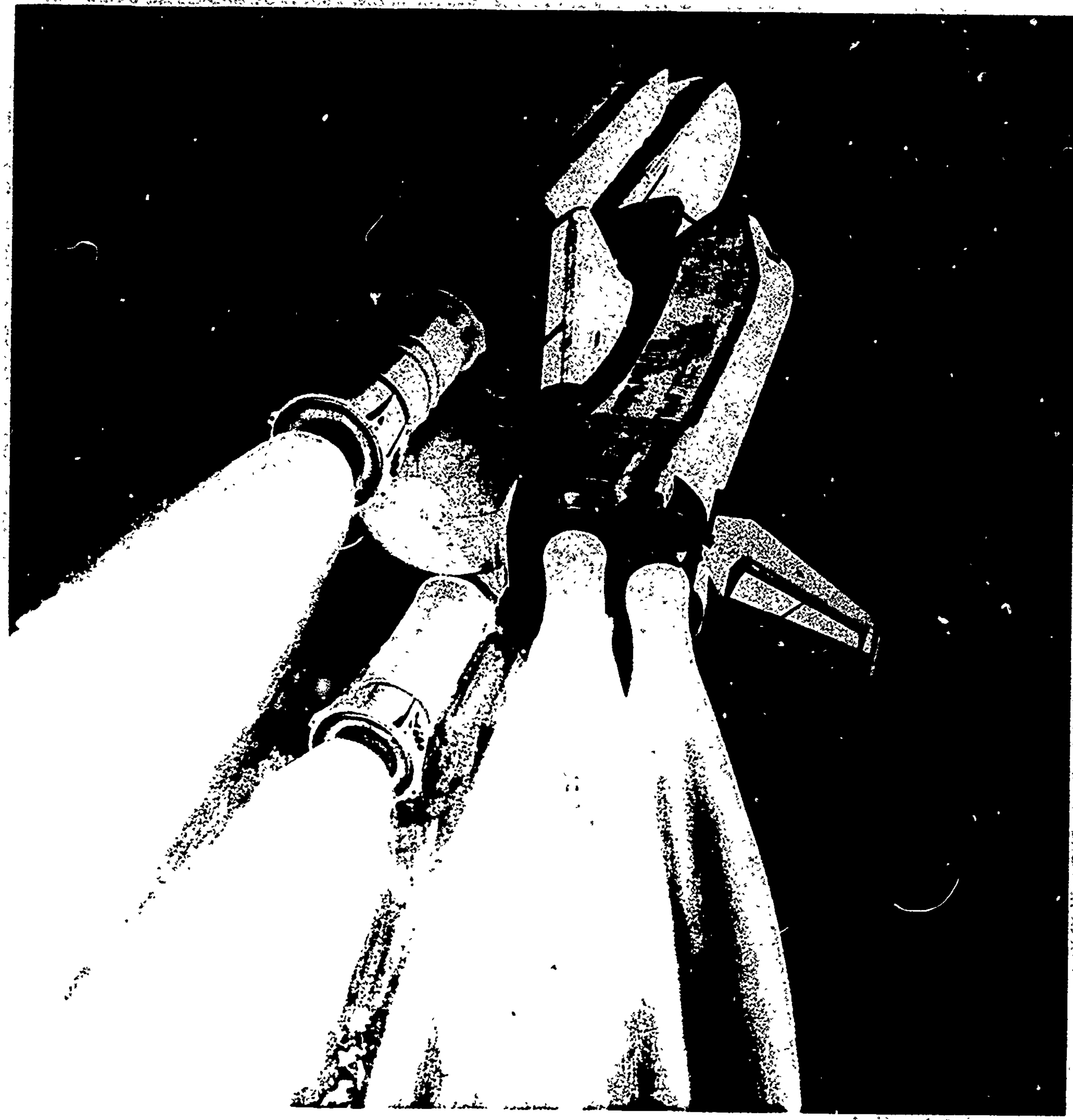
READING MATERIAL

The Shuttle Era



The Space Shuttle launch vehicle, with the Orbiter attached to the external tank and a pair of solid rocket boosters, climbs upward to begin its route to Earth orbit (artist's concept). This is a low-angle view indicating that the solid rocket boosters will soon be jettisoned. The external tank will also be jettisoned before the Orbiter enters an Earth-orbital configuration.

Cover

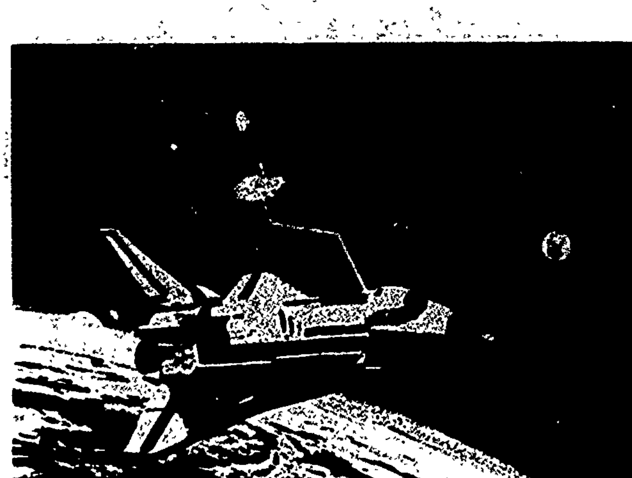
A unique high-angle view of the Space Shuttle (artist's concept). The Orbiter, still attached to the external tank as the solid rocket boosters are jettisoned, climbs upward to begin its Earth orbital mission.

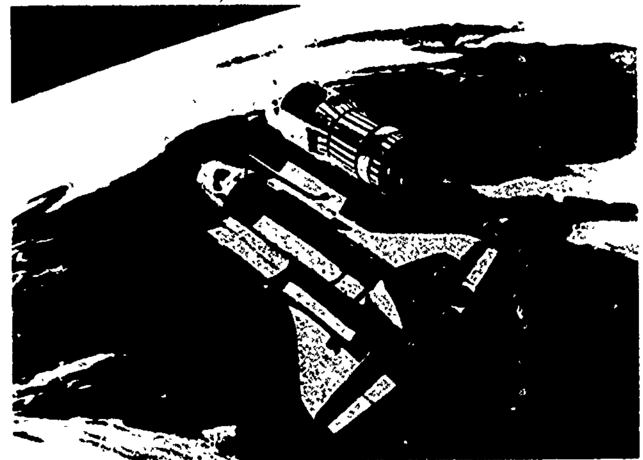
The Shuttle Era

On December 17, 1903, Orville and Wilbur Wright successfully achieved sustained flight in a power-driven aircraft. The first flight that day lasted only 12 seconds over a distance of 37 meters (120 feet), which is about the length of the Space Shuttle Orbiter. The fourth and final flight of the day traveled 260 meters (852 feet) in 59 seconds. The initial notification of this event to the world was a telegram to the Wrights' father.

Sixty-six years later, a man first stepped on the lunar surface and an estimated 500 million people around the world watched the event on television or listened to it on radio as it happened.

Building upon previous achievements, new plateaus in air and space transportation have been reached — military aviation, airmail, commercial passenger service, the jet age, and manned space flight. Now a new era nears. The beginning of regularly scheduled runs of NASA's Space Shuttle to and from Earth orbit in the 1980's marks the coming of age in space. The Shuttle turns formidable and costly space missions into routine and economical operations that generate maximum benefits for all people. Shuttle opens space to men and women of all nations who are reasonably healthy and have important work to do there.





The Inertial Upper Stage (IUS) is deployed from open payload bay of Shuttle Orbiter into space by the Orbiter's remote manipulator (artist's concept). The IUS can rocket spacecraft to geosynchronous orbits or into interplanetary trajectories. The IUS is one of two expendable, low-cost propulsion vehicles that are being considered for the Space Transportation System.

A Versatile Vehicle

Space Shuttle is a true aerospace vehicle. It takes off like a rocket, maneuvers in Earth orbit like a spacecraft, and lands like an airplane. The Space Shuttle is designed to carry heavy loads into Earth orbit. Other launch vehicles have done this. But unlike the other launch vehicles which were used just once, each Space Shuttle Orbiter may be used again and again.

Moreover, Shuttle permits checkout and repair of unmanned satellites in orbit, or return of the satellites to Earth for repairs that could not be done in space. This will result in considerable savings in spacecraft costs. Satellites that the Shuttle can orbit and maintain include those involved in environmental protection, energy, weather forecasting, navigation, fishing, farming, mapping, oceanography, and many other fields useful to man.

Spacecraft destined for geosynchronous orbit will be boosted from low Earth orbit by either a Solid Spinning Upper Stage (SSUS) or by the Inertial Upper Stage (IUS) that is being developed by the United States Air Force. Interplanetary spacecraft will be propelled by a variation of the Centaur upper stage that has been used with the Atlas and Titan expendable launch vehicles.

With its manipulator arm extended, the Space Shuttle Orbiter prepares to retrieve a satellite (artist's concept).

The large Space Telescope is being designed as an optical telescope observatory to be used in Earth orbit, unhindered by atmospheric distortion. Here, it is shown being deployed in orbit by the Space Shuttle.

Unmanned satellites, such as the Space Telescope, which can multiply our view of the universe, and the Long Duration Exposure Facility (LDEF), which can demonstrate the effects on materials of long exposure to the space environment, can be placed in orbit, erected, and returned to Earth by the Space Shuttle. Shuttle crews can also perform such services as replacing the Space Telescope's film packs and lenses. The Space Telescope program is managed by NASA's Marshall Space Flight Center, Huntsville, Alabama and the LDEF is a project of the NASA Langley Research Center, Hampton, Virginia.

The Shuttle is a manned spacecraft, but unlike manned spacecraft of the past such as Mercury, Gemini, and Apollo, it touches down like an airplane on a landing strip. Thus, the Shuttle eliminates the need for the expensive sea recovery force required for Mercury, Gemini, and Apollo. In addition, unlike the previous manned spacecraft, the Shuttle is reusable. It can be refurbished and ready for another journey into space in a comparatively short turnaround time.

The Shuttle can quickly provide a vantage point in space for observations of transient astronomical events or of sudden weather, agricultural, or environmental crises. Information from Shuttle observations could contribute to sound decisions for countries dealing with such problems.

The Shuttle is scheduled to carry a complete scientific laboratory called "Spacelab" into Earth orbit. Developed by the European Space Agency (ESA), Spacelab is similar to earthbound laboratories but is adapted to operate in zero gravity (weightlessness). It provides a shirt-sleeve environment, suitable for working, eating, and sleeping without the encumbrance of special clothing or space suits.

Spacelab provides facilities for as many as four laboratory specialists to conduct experiments in such fields as medicine, manufacturing, astronomy, and pharmaceuticals. Spacelab remains attached to the Shuttle Orbiter throughout a mission. Upon return to Earth, Spacelab is removed from the Orbiter and outfitted for its next assignment. It can be reused about 50 times.

Spacelab personnel will be men and women of many nations, experts in their fields, and in reasonably good health. They will require only a few weeks of space-flight training.

Participating ESA nations are Belgium, Denmark, France, Italy, The Netherlands, Spain, Switzerland, United Kingdom, Austria, and the Federal Republic of Germany (West Germany). Spacelab is an example of international sharing of space costs and of worldwide interest in the study of science in a space environment.

Projects that only recently were considered impracticable become feasible with Space Shuttle. Shuttle can carry into orbit the building blocks for large solar power stations that would convert the abundant solar heat and sunlight of space into unlimited supplies of electricity for an energy-hungry world. These building blocks would be assembled by specialists, transported, and supported by Space Shuttle.

The Shuttle can also carry the building blocks for self-sustaining settlements into Earth orbit. Inhabitants of these settlements could be employed in such vital occupations as building and maintaining solar power stations and manufacturing drugs, metals, glass for lenses, and electronic crystals. Manufacturing in weightless space could reduce costs of certain drugs, create new alloys, produce drugs and lenses of unusual purity, and enable crystals to grow very large. Drugs, metals, glass, and electronic crystals will also be manufactured during Spacelab missions, long before the establishment of any space settlement.

Space Shuttle System and Mission Profile (Principal Components)

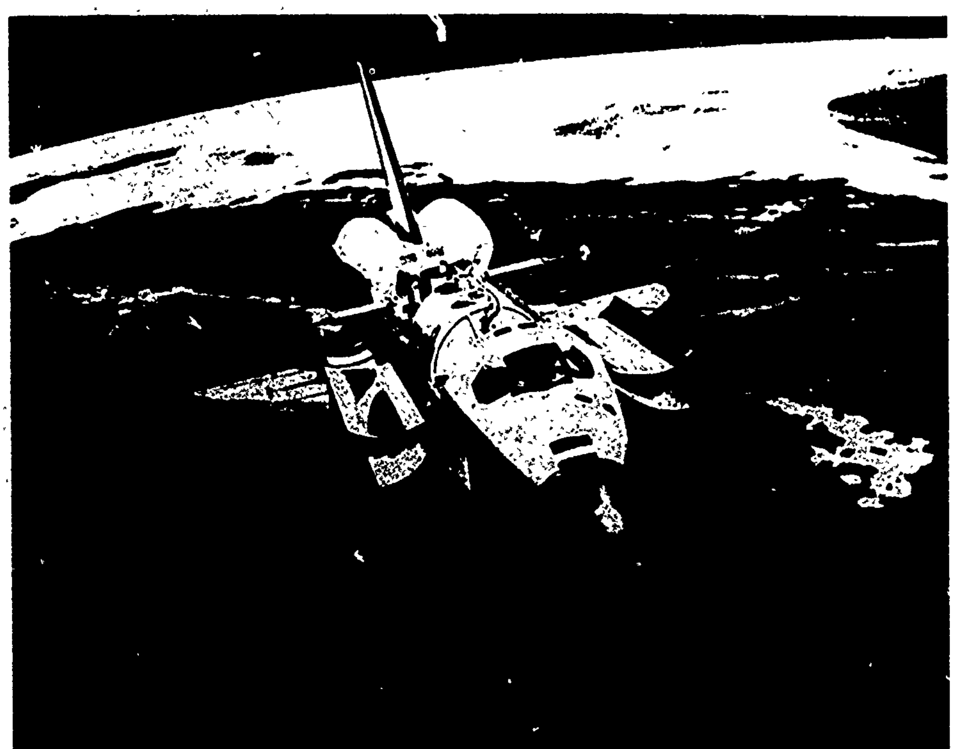
The Space Shuttle flight system is composed of the Orbiter, an external tank (ET) that contains the ascent propellant to be used by the Orbiter main engines, and two solid rocket boosters (SRB's). Each booster rocket has a sea level thrust of 11.8 million newtons (2.65 million pounds). The Orbiter and the SRB's are reusable; the external tank is expended on each launch.

The Orbiter is the crew and payload carrying unit of the Shuttle system. It is 37 meters (122 feet) long and 17 meters (57 feet) high, has a wingspan of 24 meters (78 feet), and weighs about 68000 kilograms (150000 pounds) without fuel. It is about the size and weight of a DC-9 commercial air transport.

The direction of Earth rotation has a significant bearing on the payload launch capabilities of the Shuttle. A due east launch from the Kennedy Space Center in Florida, using the Earth's easterly rotation as a launch assist, will permit a payload of up to 29500 kilograms (65000 pounds) to be carried into orbit. A polar orbit launch from Vandenberg Air Force Base in California, where the Earth's rotation neither assists nor hinders the Shuttle's capabilities, will permit a payload of up to 18000 kilograms (40000 pounds) to be carried into orbit. The most westerly launch from Vandenberg will allow a payload up to only 14500 kilograms (32000 pounds) to be transported to orbit since the Earth's rotation is counter to the westerly launch azimuth. The Orbiter carries its cargo in a cavernous payload bay 18.3 meters (60 feet) long and 4.6 meters (15 feet) in diameter. The bay is flexible enough to provide accommodations for unmanned spacecraft in a variety of shapes and for fully equipped scientific laboratories.

Each of the Orbiter's three main liquid-rocket engines has a thrust of 2.1 million newtons (470000 pounds) at sea level. They are fed propellants from the external tank, which is 47 meters (154 feet) long and 8.7 meters (28.6 feet) in diameter.

At lift-off the tank holds 720000 kilograms (1580000 pounds) of propellants, consisting of liquid hydrogen (fuel) and liquid oxygen (oxidizer). The hydrogen and oxygen are in separate pressurized compartments of the tank. The external tank is the only part of the Shuttle system that is not reusable.



A high-angle front view of the Orbiter vehicle in Earth orbit carrying Spacelab hardware as the primary cargo in its payload bay (artist's concept). A crewmember is seen performing extravehicular operations outside the pressurized laboratory in the payload bay.

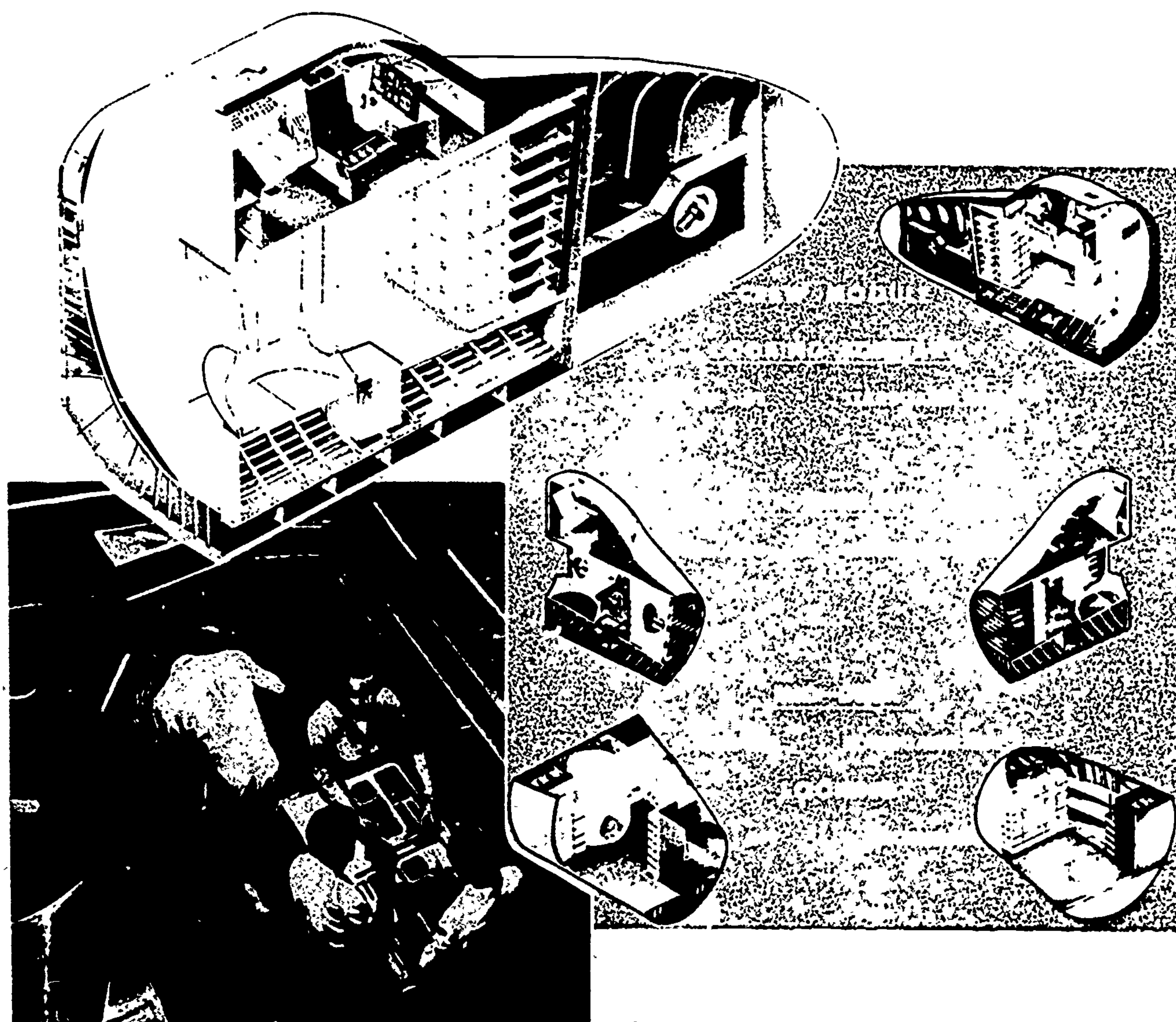
Crew and Passenger Accommodations

The crew and passengers occupy a two-level cabin at the forward end of the Orbiter. The crew controls the launch, orbital maneuvering, atmospheric entry, and landing phases of the mission from the upper-level flight deck. Payload handling is accomplished by crewmen at the aft cabin payload station. Seating for passengers and a living area are provided on the lower deck. The cabin will have maximum utility; mission flexibility is achieved with minimal volume, complexity, and weight. Space flight will no longer be limited to intensively trained, physically perfect astronauts but will now accommodate experienced scientists and technicians.

Crewmembers and passengers will experience a designed maximum gravity load of only 3g during launch and less than 1.5g during a typical reentry. These accelerations are about one-third the levels experienced on previous manned flights. Many other features of the Space Shuttle, such as a standard sea level atmosphere, will welcome the nonastronaut space worker of the future.

Typical Shuttle Mission

The Space Shuttle mission begins with the installation of the mission payload into the Orbiter payload bay. The payload will be checked and serviced before installation and will be activated on orbit. Flight safety items for some payloads will be monitored by a caution and warning system.

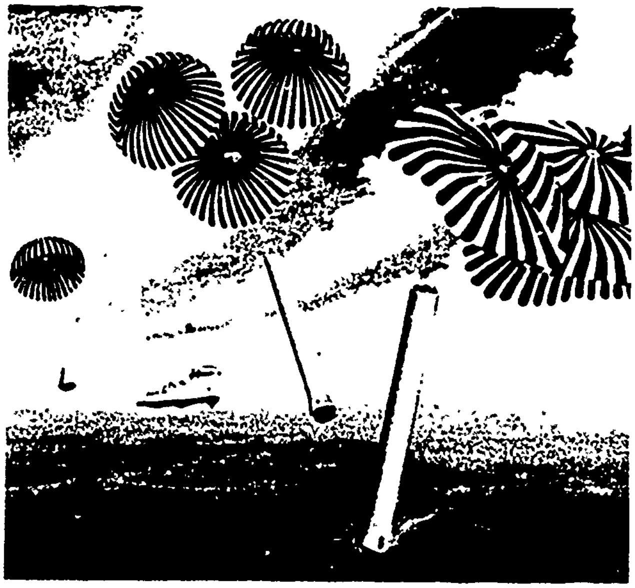


Space Shuttle Orbiter working and living areas.

In a typical Shuttle mission, which lasts from 7 to 30 days, the Orbiter's main engines and the booster ignite simultaneously to rocket the Shuttle from the launch pad. Launches are from the John F. Kennedy Space Center in Florida for east-west orbits or from Vandenberg Air Force Base in California for polar or north-south orbits.

At a predetermined point, the two unmanned solid rocket boosters separate from the Orbiter and parachute to the sea where they are recovered for reuse. The Orbiter continues into space. It jettisons its external propellant tank just before orbiting. The external tank enters the atmosphere and breaks up over a remote ocean area.

In orbit, the Orbiter uses its orbital maneuvering subsystem (OMS) to adjust its path, for rendezvous operations, and, at the end of its mission, for slowing down so as to head back toward Earth. The orbital speed is nearly 8000 meters per second (18 000 miles per hour). It takes approximately 90 minutes for an orbit of the Earth by the Space Shuttle, whether launched from NASA's Kennedy Space Center or, for some later flights, from Vandenberg Air Force Base in California. The first four orbital flight tests will be launched from Pad 39 at the Kennedy Space Center and land at Edwards Air Force Base, California



Solid rocket boosters landing at sea, where they will be picked up for reuse.

Facilities on a part of the huge Edwards Air Force Base in the desertland of Southern California form the backdrop for the Shuttle Orbiter 101 "Enterprise" as it heads for a landing during the fourth Approach and Landing Test (ALT) free flight. Note that the tail cone is removed from the Enterprise for this flight, which featured a 2-minute 34-second unpowered phase after the Orbiter separated from NASA 905, a 747 carrier aircraft. Crewmen for the flight were Astronauts Joe H. Engle, commander, and Richard H. Truly, pilot.

BEST COPY AVAILABLE

The OMS propellants are monomethyl hydrazine as the fuel and nitrogen tetroxide as the oxidizer. They ignite on contact, eliminating the need for ignition devices.

The Orbiter does not necessarily follow a ballistic path to the ground as did predecessor manned spacecraft. It has a crossrange capability (can maneuver to the right or left of its entry path) of about 2045 kilometers (1 270 miles).

The Orbiter touches down like an airplane on a runway at Kennedy Space Center or Vandenberg Air Force Base. Landing speed is about 341 to 364 kilometers per hour (212 to 226 miles per hour). After refurbishing, the Shuttle is ready for another space mission.

Space Shuttle Vehicle Crew

The Shuttle crew can include as many as seven people: the commander, the pilot, the mission specialist who is responsible for management of Shuttle equipment and resources supporting payloads during the flight, and one to four payload specialists who are in charge of specific payload equipment. The commander, pilot, and mission specialist are NASA astronauts. Payload specialists conduct the experiments and may or may not be astronauts. They are nominated by the payload sponsor and certified for flight by NASA.

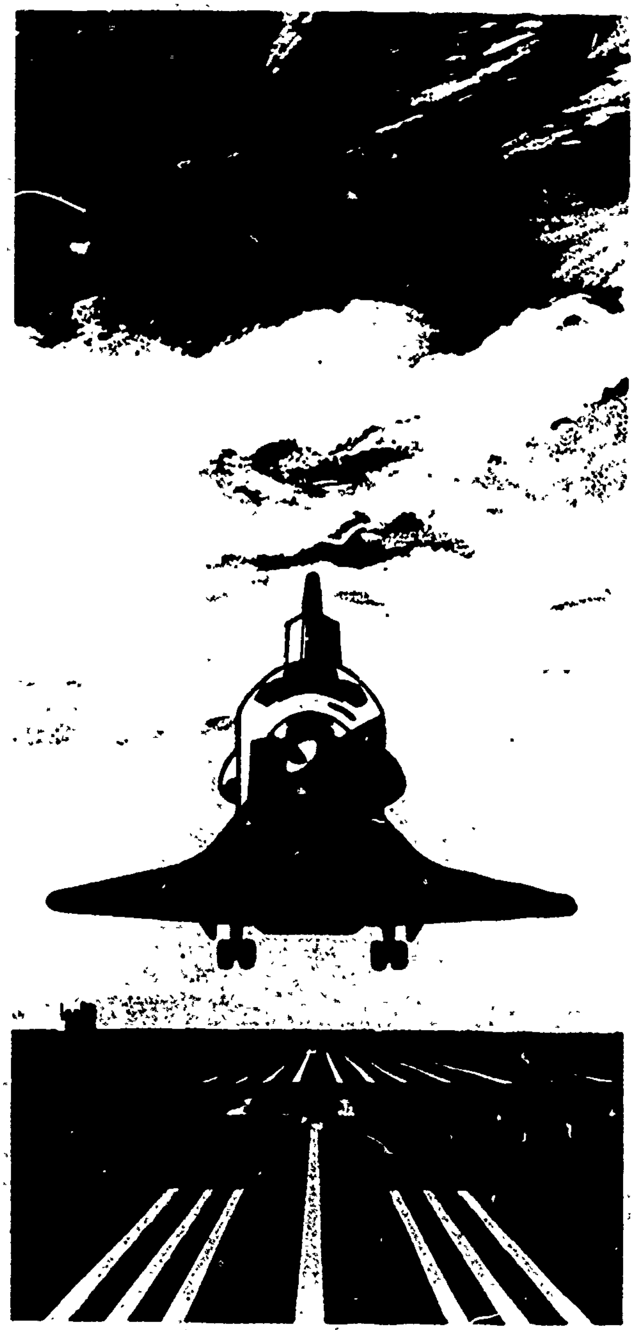
Shuttle Management Team

NASA's Lyndon B. Johnson Space Center, Houston, Texas, manages the Space Shuttle program and is also responsible for development, production, and delivery of the Orbiter.

NASA's George C. Marshall Space Flight Center, Huntsville, Alabama, is responsible for the development, production, and delivery of the solid rocket boosters, the external propellant tank, and the Orbiter main engines. Test firings of Shuttle engines are carried out at NASA's National Space Technology Laboratories, Bay St. Louis, Mississippi.

NASA's John F. Kennedy Space Center, Florida, is responsible for design and development of launch and recovery facilities and for operational missions requiring easterly launches.

Thousands of companies make up the Shuttle contractor team. They are located in nearly every state of the United States.



A head-on view of a Space Shuttle Orbiter landing at the Kennedy Space Center (artist's concept). The huge vehicle assembly building (VAB) is shown in the background.

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SMALL GROUP DISCUSSION

I. Life on the Moon

What is life like at reduced gravity? What kinds of interactions and motions would be the same and what kinds would be different at reduced gravity? Consider the following list of situations:

1. How is free fall affected? Does the hunter and the monkey demon stration still work?
2. What is the acceleration due to gravity on the moon?
3. What would it be like to walk on the moon's surface?
4. What would you expect to happen if you jump vertically upward?
5. How would you weigh something on the moon?
6. Why do some scientists advocate mining the moon to get material to build large space stations? What would be the advantages?

DATA:

M(moon) = 7.4×10^{22} kg
R(moon) = 1700 km
Earth-Moon distance = 380,000 km

II. A Medical Problem Arises

During the trip to Bernard's Star the health of the passengers starts to deteriorate because they are neglecting to do their exercises and consequently their hearts are growing weak. This will spell disaster upon arriving at the new planet. The commander has decreed that they must develop artificial gravity to correct this problem.

The transport ship has been built in the shape of a doughnut. Calculate the conditions necessary so that the artificial gravity at the outer rim will appear to be the same as on earth. Which way will be "up" for the passengers?

Is there any way for the passengers to distinguish this gravity from that on the surface of the earth? How will the gravitational force vary as a person moves toward the center of the ship?

DATA:

The transport ship has a radius of 1 km.
The acceleration due to gravity on earth is $9.8\ m/s^2$.
The centripetal force for circular motion is given by $F = mv^2/r$.

COMPUTER ASTRONOMY

COMPUTER WORK (Optional)

Astronomy

CROSS: Vol. 5 - Circular Motion (50 points)

Choose menu item "5" - Orbit Theory. Work all three sections including the quiz. Take notes and show calculations.

1. Why is explanation "2" better than explanation "1"?

2. What are the answers to the quiz?

CROSS: Vol. 11 - SOLAR SYSTEM ASTRONOMY (50 points)

Select any two items from the menu. Take notes and turn in a summary description for each.

LAB

COMPUTER ASTRONOMY

1. **FOCUS: Non-linear Motion (50 points)**

Go through the explanation and take notes on Kepler's 3 laws of planetary motion.

1. On the diagram below locate the other focus and label it.

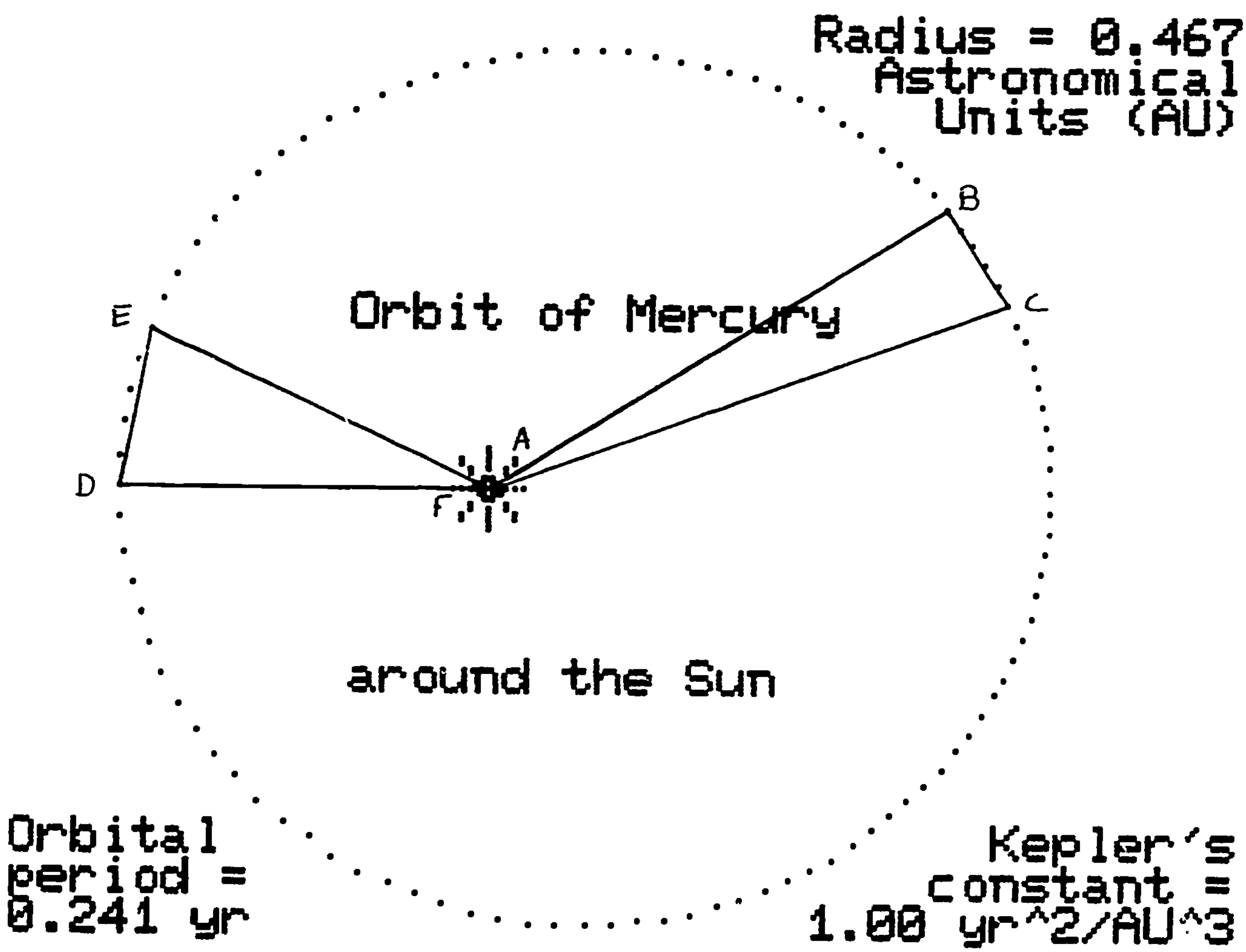
2. Calculate the eccentricity e for the orbit below.

3. Find the areas of the two triangles shown on the diagram.

   ABC =   DEF =

   Does your answer verify Kepler's 2nd law?

4. From measurements made on the diagram below calculate the gravitational constant G (use units of days and cm).



2. **EDUTECH: Mechanics Demos (50 points)**

Choose menu item #3 Planetary Motion. Let the computer plot the orbits for three planets of your choice. Measure the distances on screen and calculate the eccentricity and Kepler's constant T^2/R^3. Show your calculations and identify the three planets.

QUIZ
OBJ. SS-1,2

QUIZ

Objectives SS-1 and 2

NAME: ______________________ **PERIOD:** ____________

VERSION 1

Answer (a) or (b) depending on which optional material you studied.

a) Describe Kepler's second law and explain how this affects the velocity of a satellite.

b) Briefly describe the composition of our solar system.

---------------------------cut here---------------------------

NAME: ______________________ **PERIOD:** ____________

VERSION 2

Answer (a) or (b) depending on which optional material you studied.

a) What is Kepler's third law? Give the constant for any focus you choose. (You can use any unit you like).

b) Briefly describe any planet other than earth.

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VIDEO

VIDEOTAPES

NAME: ______________________________ **PERIOD:** ________________

I. Space Shuttle: "A Remarkable Flying Machine"

1. What impressed you most about the first flight of the space shuttle?

2. What are your opinions on space exploration? What should we pursue next? What do you envision as the eventual outcome of our pioneering in space?

II. "Mission and Payloads" and "Propulsion"

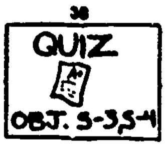
1. Describe the payload area.

2. What are some of the proposed missions for the shuttle?

3. Suggest three other possible uses for the shuttle.

4. What problems are unique to this new realm of "space" travel?

5. Why is re-entry so different for the shuttle? What accommodations has NASA made?



QUIZ

Objectives S-3 and S-4

NAME: ______________________ PERIOD: __________

VERSION 1

1. Why are people in the space shuttle floating?

2. What is the period of a satellite at an altitude of 3×10^5m?

-----------------------------cut here-----------------------------

NAME: ______________________ PERIOD: __________

VERSION 2

1. How could you compensate for lack of gravitational pull on a long deep space journey?

2. What is the period of a satellite at an altitude of 5×10^6 m (5000 km)?