Name Period Date

Concept-Development Practice Page 14-1

Satellite Motion

1. Figure A shows "Newton's Mountain," so high that its top is above the drag of the atmosphere. The cannonball is fired and hits the ground as shown.

   a. You draw the path the cannonball might take if it were fired a little bit faster.

   b. Repeat for a still greater speed, but still less than 8 km/s.

   c. Then draw the orbital path it would take if its speed were 8 km/s.

   d. What is the shape of the 8 km/s curve?
   Circle

   e. What would be the shape of the orbital path if the cannonball were fired at a speed of about 9 km/s?
   Ellipse

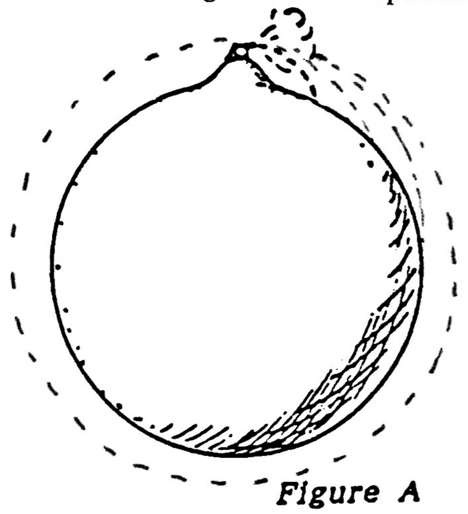


Figure A

2. Figure B shows a satellite in circular orbit.

   a. At each of the four positions draw a vector that represents the gravitational *force* exerted on the satellite.

   b. Label the force vectors *F*.

   c. Then draw at each position a vector to represent the *velocity* of the satellite at that position, and label it *V*.

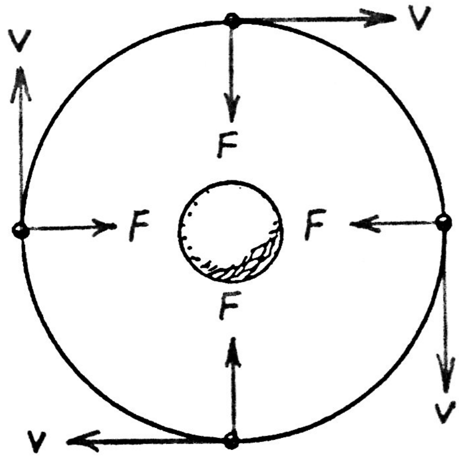


Figure B

   d. Are all four *F* vectors the same length? Why or why not?
   Yes, because the force is the same strength at equal distances from the earth.

   e. Are all four *V* vectors the same length? Why or why not?
   Yes, because there is no acceleration along the satellite's path.

   f. What is the angle between your *F* and *V* vectors? 90 degrees

   g. Is there any component of *F* along *V*? No, *F* and *V* are perpendicular to each other.

   h. What does this tell you about the work the force of gravity does on the satellite?
   The force of gravity does no work on the satellite.

   i. Does the KE of the satellite in Figure B remain constant, or does it vary? It remains constant.

   j. Does the PE of the satellite remain constant, or does it vary?
   It remains constant.

Conceptual PHYSICS

3. Figure C shows a satellite in elliptical orbit.

a. Repeat the procedure you used for the circular orbit, drawing vectors *F* and *V* for each position, including proper labeling. Show equal magnitudes with equal lengths, and greater magnitudes with greater lengths, but don't bother making the scale accurate.

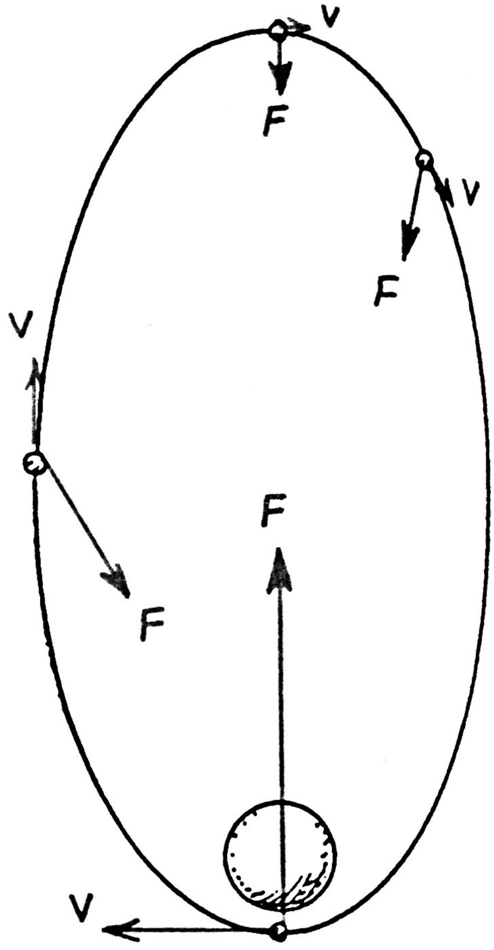


Figure C

b. Are your vectors *F* all the same magnitude? Why or why not?

No, the force decreases when the distance from the earth increases.

c. Are your vectors *V* all the same magnitude? Why or why not?

No. When the KE decreases (as the satellite moves farther from the earth), the speed decreases. When the KE increases (as the satellite moves toward the earth), the speed increases.

d. Is the angle between vectors *F* and *V* everywhere the same, or does it vary?

It varies.

e. Are there places where there is a component of *F* along *V*?

Yes, everywhere except at the apogee and the perigee.

f. Is work done on the satellite when there is a component of *F* along and in the same direction of *V* and if so, does this increase or decrease the KE of the satellite?

Yes. This increases the KE of the satellite.

g. When there is a component of *F* along and opposite to the direction of *V*, does this increase or decrease the KE of the satellite?

This decreases the KE of the satellite.

h. What can you say about the sum KE + PE along the orbit?

It is constant (in accord with conservation of energy).

Be very very careful when placing both velocity and force vectors on the same diagram. Not a good practice, for one may construct the resultant of the vectors -- ouch!

Mechanics Overview

1. The sketch shows the elliptical path described by a satellite about the earth. In which of the marked positions, A - D, (put S for "same everywhere") does the satellite experience the maximum

a. gravitational force? A

b. speed? A

c. momentum? A

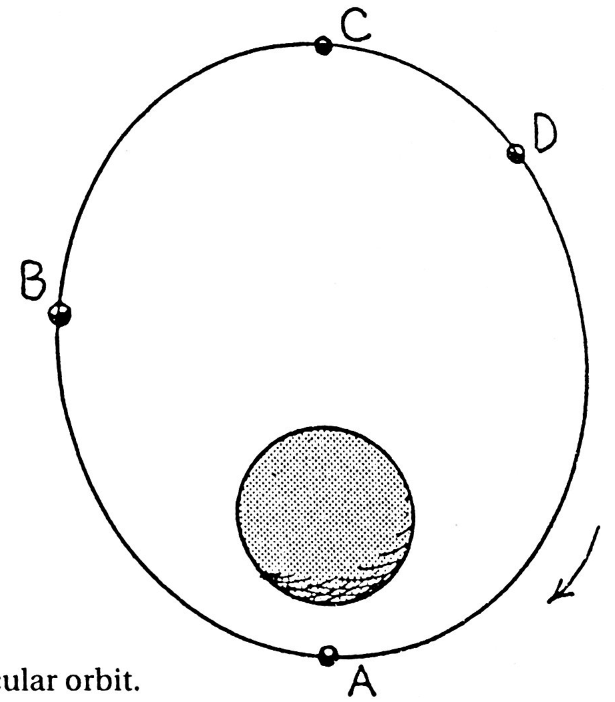
d. kinetic energy? A

e. gravitational potential energy? C

f. total energy (KE + PE)? S

g. acceleration? A

h. angular momentum? S



2. Answer the above questions for a satellite in circular orbit.

a. S b. S c. S d. S e. S f. S g. S h. S

3. In which position(s) is there momentarily no work being done on the satellite by the force of gravity? Why?

A and C because no force component in direction of motion.

4. Work changes energy. Let the equation for work, $W = Fd$, guide your thinking on these: Defend your answers in terms of $W = Fd$.

a. In which position will a several-minutes thrust of rocket engines pushing the satellite forward do the most work on the satellite and give it the greatest change in kinetic energy? (Hint: think about where the most distance will be traveled during the application of a several-minutes thrust?)

A, where force acts over longest distance.

b. In which position will a several-minutes thrust of rocket engines pushing the satellite forward do the least work on the satellite and give it the least boost in kinetic energy?

C, where force acts over shortest distance.

c. In which positon will a several-minutes thrust of a retro-rocket (pushing opposite to the satellite's direction of motion) do the most work on the satellite and change its kinetic energy the most?

A, most "negative work" and most KE occurs where force acts over the longest distance.