

Gravitation

Self- Assessment

Module 1 Kepler's Laws and Universal Law of Gravitation

Q.8.1.1 Particles of masses M , m and $2M$ are placed respectively at points A, B and C, where $AB = \frac{1}{2}(BC)$. $m \ll M$. At time $t = 0$, they are all at rest (Fig.Q.8.1.1).

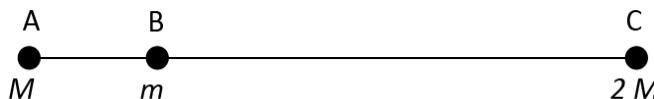


Fig.Q.8.1.1

At subsequent times before any collision takes place, which of the following options is correct ?

- (A) m will remain at rest.
- (B) m will move towards M .
- (C) m will move towards $2M$.
- (D) m will have an oscillatory motion.

Q.8.1.2 Gravitational force between two masses held at a distance r in air is F . When the two masses are inside a liquid with same separation, the gravitational force between them is F' . State which of the following options is correct?

- (A) $F'/F > 1$
- (B) $F'/F = 1$
- (C) $F'/F < 1$
- (D) F'/F will depend on the density of liquid

Q.8.1.3 Two identical heavy objects, each of mass M are located at P and Q, where $PQ = 2b$. An object of mass $m \ll M$ is placed at the midpoint of PQ. Then, the object of mass m is displaced by an infinitesimal distance a ($a \ll b$, such that $(\frac{a}{b})^2$ can be neglected) (i) along the line PQ and (ii) perpendicular to PQ. What is the ratio between the resultant forces experienced by m at the positions (i) and (ii) ?

- (A) 1:4
- (B) 1:2
- (C) 2:1
- (D) $a:b$

Q.8.1.4. Which of the following relations for speed(v) of the planet around the Sun for the positions in the diagram is true?(Fig.Q.8.1.2)

- (A) $v_A > v_B > v_D$
- (B) $v_A > v_D > v_B$
- (C) $v_A > v_C > v_P$
- (D) $v_A < v_D < v_P$

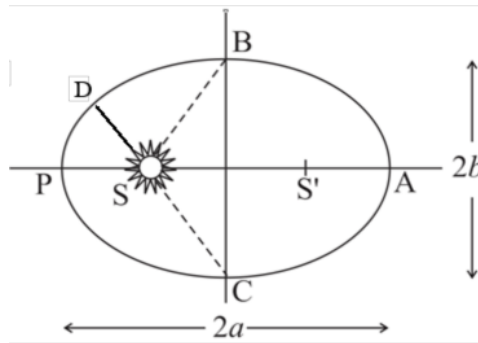


Fig.Q.8.1.2

Q.8.1.5. The areal velocity versus time graph for a planet around the Sun

- (A) is a straight line with zero intercept and positive slope.
- (B) is a straight line with non-zero intercept and positive slope.
- (C) is a straight line with zero intercept and negative slope.
- (D) is a straight line with non-zero intercept and negative slope.

Q.8.1.6 A satellite is in a circular orbit around the earth. Due to some reason it loses some of its energy. What is the new trajectory?

- (A) Follows a hyperbolic path and falls to earth.
- (B) Follows a parabolic path and falls to earth.
- (C) Follows new circular orbit of smaller radius.
- (D) Follows an elliptical orbit around earth with earth at one of the two focal points.

Q.8.1.7 A planet moves around the Sun. At point A in its orbit, it is closest to the Sun at a distance d_1 and has a speed v_1 . At another point B, when it is farthest from the Sun at a distance d_2 its speed will be

- (A) $\frac{d_1 v_1}{d_2}$
- (B) $\frac{d_2 v_1}{d_1}$
- (C) $\frac{d_1^2 v_1}{d_2^2}$

(D) $\frac{d_2^2 v_1}{d_1^2}$

Q.8.1.8 Mass M is divided into two parts xM and $(1-x)M$. For a given separation, the value of x for which the gravitational attraction between the two pieces becomes maximum is

- (A) $1/3$
- (B) $1/2$
- (C) $3/4$
- (D) 1

Q.8.1.9 A planet is revolving around the Sun in an elliptical path as shown in (Fig.Q.8.1.3).

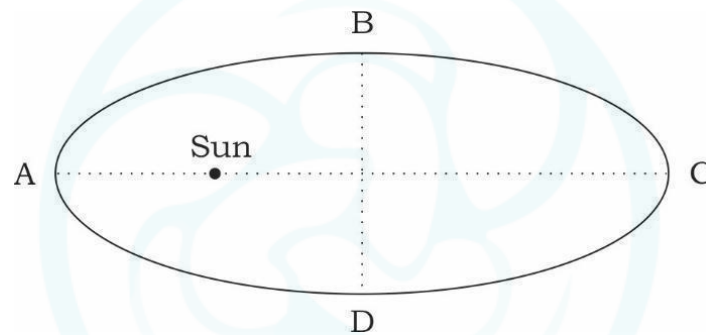


Fig.Q.8.1.3

- (A) The time in traveling DAB is less than that for BCD
- (B) The time in traveling DAB is greater than that for BCD
- (C) The time in traveling DAB is equal to that for BCD
- (D) The time in traveling CDA is greater than that for ABC

Q.8.1.10 A satellite is revolving in an elliptical orbit around the earth (Fig.Q.8.1.4). In order to make its orbit circular, we must fire a rocket

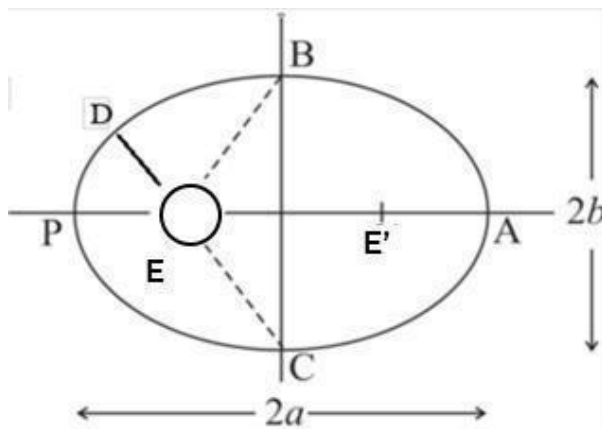


Fig.Q.8.1.4

- (A) at aphelion to increase its speed.
- (B) at aphelion to decrease its speed.
- (C) at perihelion to increase its speed.
- (D) at B so as to bring it to rest.



Module 2 Gravitational Field

Q.8.2.1. When an extended object is placed below the surface of earth, its center of mass will be

- (A) above its center of gravity.
- (B) below center of gravity.
- (C) coinciding with the center of gravity.
- (D) in the same horizontal line as the center of gravity.

Q.8.2.2. The time period of an artificial satellite orbiting around earth is proportional to the n th power of its orbital radius. What is the value of n ?

- (A) 0.5
- (B) -1
- (C) 1.5

(D) -2

Q.8.2.3. If the value of g at a height h above the surface of the earth is the same as at a depth d below it, then (both d and h being much smaller than the radius of the earth)

(A) $d = h/2$

(B) $d = h$

(C) $d = 2h$

(D) $d = h^2$

Q.8.2.4. Composition of the materials of the two planets are the same. Their radii are r_1 and r_2 . The ratio of the acceleration due to gravity g_1/g_2 at the surface of the two planets is

(A) $\frac{r_1}{r_2}$

(B) $\frac{r_2}{r_1}$

(C) $\left(\frac{r_1}{r_2}\right)^2$

(D) $\left(\frac{r_2}{r_1}\right)^2$

Q.8.2.5. The escape velocity from the earth surface is v . The escape velocity from the surface of another planet having a radius twice that of the earth and the same mean density will be

(A) v

(B) $\sqrt{2}v$

(C) $2v$

(D) $2\sqrt{2}v$

Q.8.2.6. A satellite is revolving around the Sun in a circular orbit with uniform velocity v . If the gravitational force suddenly disappears, the magnitude of the velocity of the satellite will be

(A) zero

(B) $v/2$

(C) v_1

(D) $2v$

Q.8.2.7. A satellite of mass m is moving in a circular orbit of radius R , close to the Earth's surface. Then the work required to be done, to move it to a circular orbit of radius $2R$ is (where M is the mass of the Earth) is

(A) $\frac{2GMm}{R}$

(B) $\frac{GMm}{R}$

(C) $\frac{GMm}{2R}$

(D) $\frac{GMm}{4R}$

Q.8.2.8. The escape velocity of a body from the surface of a planet of mean radius R and density ρ is

(A) $R \sqrt{\frac{2\pi G\rho}{3}}$

(B) $2R \sqrt{\frac{2\pi G\rho}{3}}$

(C) $2R \sqrt{\frac{4\pi G\rho}{3}}$

(D) $4R \sqrt{\frac{2\pi G\rho}{3}}$

Q.8.2.9. A body is projected from the earth's surface to infinity. The kinetic energy needed for the purpose is

(A) $\frac{1}{4}mgR$

(B) $\frac{1}{2}mgR$

(C) mgR

(D) $2mgR$

Q.8.2.10 The total energy ($KE + PE$) of an artificial satellite in a circular orbit around the Earth is E . Then its PE is equal to

- (A) $E/2$
- (B) $2E$
- (C) $-2E$
- (D) $-E$

Module 3 Earth Satellites and Weightlessness

Q.8.3.1. Which of the following is true in the context of motion of a geostationary satellite around the earth?

- (A) It moves around the earth's pole in a north-south direction.
- (B) It moves around the earth in an east-west direction.
- (C) It goes around the earth in a west-east direction.
- (D) It moves around the earth's pole in an east-west direction.

Q.8.3.2 Suppose a planet that goes around the Sun with angular speed equal to one-eighth of that of the earth. What would be its orbital size as compared to that of the earth?

- (A) 8 times that of earth
- (B) 4 times that of earth
- (C) $1/4^{\text{th}}$ of that of earth
- (D) $1/8^{\text{th}}$ of that of earth

Q.8.3.3. A satellite is to be projected for the purpose of communication. Which of the following is not true?

- (A) Its time period should be 24 hr.
- (B) It should be in an polar orbit
- (C) It should move from west to east
- (D) It should be at the same height above earth's surface as that of the other communication satellites

Q.8.3.4. A person with weight W on earth's surface is inside an elevator falling with acceleration $g/2$. He/She will feel himself/herself

- (A) weightless

- (B) having a weight equal to $W/2$
- (C) having weight equal to W
- (D) having weight equal to $3W/2$

Q.8.3.5. An astronaut in a space station orbiting earth experiences weightlessness. Which of the following is not the correct reason?

- (A) Earth's gravity at the space station is zero.
- (B) Space station is falling towards earth with acceleration g .
- (C) In the frame of reference of the space station the centrifugal force neutralizes the gravitational attraction.
- (D) g at the space station is the same as $\omega^2 r$.

Q.8.3.6. A saturn year is n times the earth year. Semi major axes of the earth orbit $= r_E$. What are the semi-major axes of saturn orbit?

- (A) nr_E
- (B) $\sqrt{nr_E}$
- (C) $n\sqrt{nr_E}$
- (D) $\sqrt[3]{n^2} r_E$

Q.8.3.7. Both earth and moon are subject to the gravitational force of the sun. As observed from the sun, the possibilities for the nature of the orbit of the moon are as under:

- (I) elliptical
- (II) not strictly elliptical because the total gravitational force on it is not ideally central.
- (III) not elliptical, but will essentially be a closed curve.

Which among the above is/are acceptable?

- (A) Only I
- (B) II and III
- (C) I and II
- (D) I and III

Q.8.3.8. During a rescue operation following a fire in a building, whose ground floor and staircase got badly damaged, a fire brigade personnel had to jump from the first floor with a heavy box of weight ' W ' on his head. Till such time he touched the ground, he experienced on his head a load

- (A) less than W
- (B) greater than W
- (C) equal to W
- (D) equal to zero

Q.8.3.9. An astronaut orbiting the earth in a circular orbit satellite above the surface of the earth gently drops an object out of the satellite. The object will

- (A) fall vertically down to the earth
- (B) move in an orbit around the earth
- (C) will move in an irregular way and fall down to the earth
- (D) will escape out of earth's gravity

Q.8.3.10. A satellite is revolving around earth in an elliptic orbit. An astronaut in such a satellite would have apparent weight

- (A) equal to Zero
- (B) equal to a non-zero constant
- (C) equal to a non-zero quantity varying in magnitude only
- (D) equal to a non-zero varying in magnitude as well as direction



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