DPP – 5 (Gravitation)

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Q 1. A satellite is orbiting round the earth at a height h above the surface of the earth. If this distance h is increased, the period of satellite will

(a) decrease (b) increase
(c) remain unaffected (d) become zero

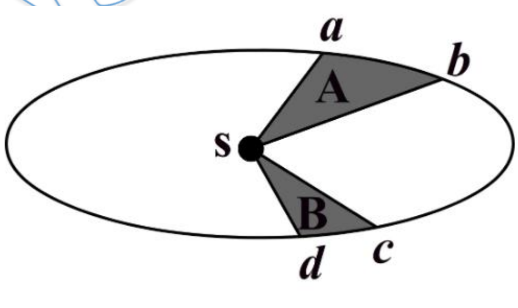
Q 2. The period of revolution of an earth's satellite close to the surface of earth is 60 minutes. The period of another earth's satellite is an orbit at a distance of three times earth's radius from its surface will be (in minutes)

(a) 90 (b) $90\sqrt{8}$
(c) 270 (d) 480

Q 3. A satellite takes $\frac{1}{8}$ years to move round the earth in its permissible orbit of radius R. The period when it revolves round the earth in an orbit of radius '2R' is

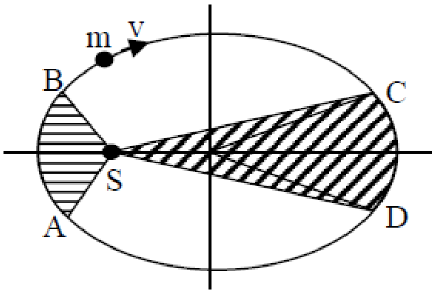
(a) $\frac{1}{2\sqrt{2}}$ years (b) $2\sqrt{2}$ years
(c) 4 years (d) $\frac{1}{4}$ years

Q 4. The figure shows the motion of a planet around the sun in an elliptical orbit with sun at the focus. The shaded areas A and B are also shown in the figure which can be assumed to be equal. If t_1 and t_2 represent the time for the planet to move from a to b and d to c respectively, then



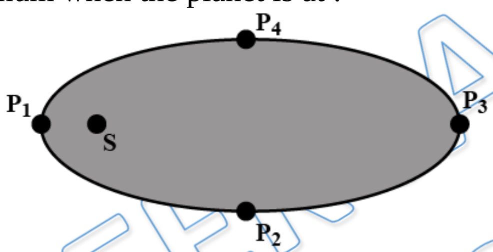
(a) $t_1 < t_2$
(b) $t_1 > t_2$
(c) $t_1 = t_2$
(d) From the given information, the relation between t_1 and t_2 cannot be determined.

Q 5. The figure shows elliptical orbit of a planet m about the sun S. The shaded area SCD is twice the shaded area SAB. If t_1 is the time for the planet to move from C to D and t_2 is the time to move from A to B then:



(a) $t_1 = t_2$ (b) $t_1 > t_2$
(c) $t_1 = 4t_2$ (d) $t_1 = 2t_2$

Q 6. The figure shows a planet in elliptical orbit around the sun S. The kinetic energy of the planet will be maximum when the planet is at :



(a) P_1 (b) P_2
(c) P_3 (d) P_4

Q 7. A planet moves around the sun. At a given point P, it is closest from the sun at a distance d_1 and has a speed V_1. At another point Q, when it is farthest from the sun at a distance d_2, its speed will be

(a) $\frac{d_1^2 V_1}{d_2^2}$ (b) $\frac{d_2 V_1}{d_1}$
(c) $\frac{d_1 V_1}{d_2}$ (d) $\frac{d_2^2 V_1}{d_1^2}$

Q 8. Kepler's second law regarding constancy of aerial velocity of a planet is a consequence of the law of conservation of
(a) Energy (b) Angular momentum
(c) Linear momentum (d) None of these

Q 9. A planet moves around the sun in an elliptical orbit. When earth is closest from the sun, it is at a distance r having a speed v. When it is at a distance 4r from the sun its speed will be:
(a) 4v (b) $\frac{v}{4}$
(c) 2v (d) $\frac{v}{2}$

Q 10. In a binary star system one star has thrice the mass of other. The stars rotate about their common center of mass then :
(a) Both stars have same angular momentum about common centre of mass

(b) Both stars have angular momentum of same magnitude about common center of mass
(c) Both stars have same angular speeds
(d) Both stars have same linear speeds

Q 11. A binary star system consists of two stars A and B which have time period T_A and T_B, radius R_A and R_B and mass M_A and M_B. Then
(a) If $T_A > T_B$ then $R_A > R_B$
(b) If $T_A > T_B$ then $M_A > M_B$
(c) $\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{R_A}{R_B}\right)^3$
(d) $T_A = T_B$

Q 12. The two stars in a certain binary star system move in circular orbits The first star α moves in an orbit of radius 1×10^9 km. The other star β moves in an orbit of radius 5×10^8 km. What is the ratio of masses of star β to the star α ?
(a) 1 (b) 2
(c) $\frac{5}{13}$ (d) $\frac{3}{7}$

Q 13. A planet revolves around sun whose mean distance is 1.588 times the mean distance between earth and sun. The revolution time of planet will be
(a) 1.25 years (b) 1.59 years
(c) 0.89 years (d) 2 years

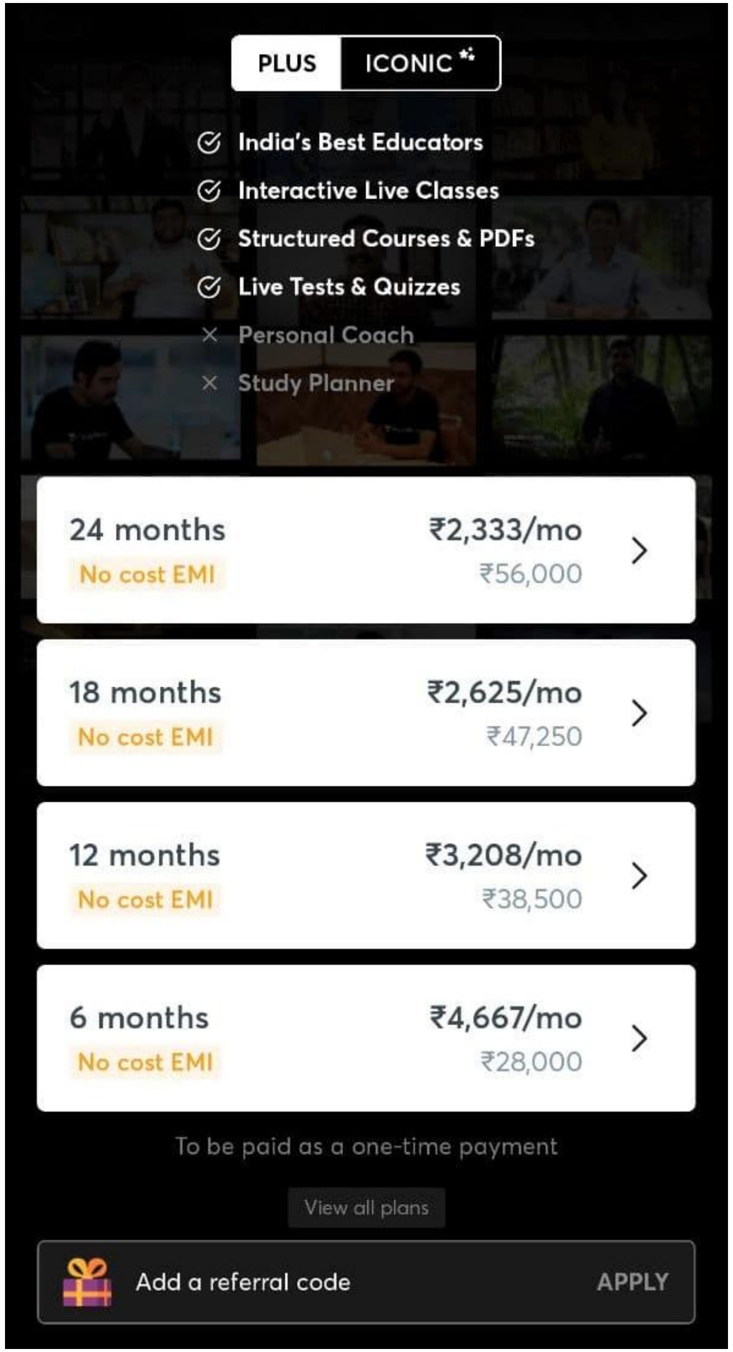
Q 14. If the radius of earth's orbit is made 1/4, the duration of an year will become
(a) 8 times (b) 4 times
(c) $\frac{1}{8}$ times (d) $\frac{1}{4}$ times

Q 15. A double star is a system of two stars of masses m and 2m, rotating about their center of mass only under their mutual gravitational attraction. If r is the separation between these two stars then their time period of rotation about their center of mass will be proportional to
(a) $r^{\frac{3}{2}}$ (b) r
(c) $m^{\frac{1}{2}}$ (d) $m^{-\frac{3}{2}}$

Q 16. A satellite which is geostationary in a particular orbit is taken to another orbit. Its distance from the center of earth in new orbit is 2 times that of the earlier orbit. The time period in the second orbit is
(a) 4.8 hours (b) $48\sqrt{2}$ hours
(c) 24 hours (d) $24\sqrt{2}$ hours

Answer Key

Q.1 b	Q.2 d	Q.3 a	Q.4 c	Q.5 d
Q.6 a	Q.7 c	Q.8 b	Q.9 b	Q.10 c
Q.11 d	Q.12 b	Q.13 d	Q.14 c	Q.15 a
Q.16 b				



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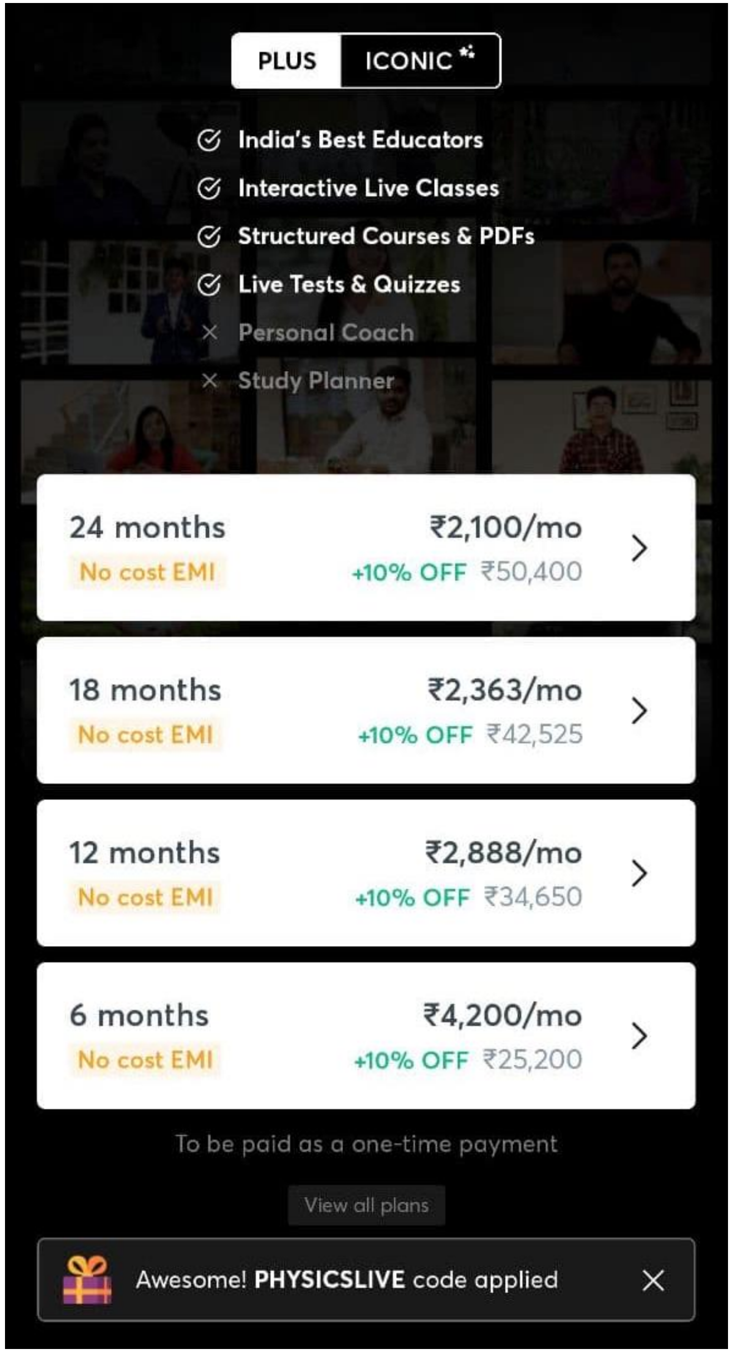

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Written Solution

DPP-5 Gravitation: Kepler's Law, Binary Star System

By Physicsaholics Team

Solution: 1

$\because T^2 \propto r^3$

if $r \uparrow \Rightarrow T \uparrow$

so; if height of satellite is increased

$\Rightarrow$ Time period will increase.

Ans. b

Solution: 2

$\because T^2 \propto r^3$

$\Rightarrow \dfrac{T_1^2}{T_2^2} = \dfrac{r_1^3}{r_2^3}$

$\dfrac{(60\,min)^2}{T_2^2} = \dfrac{R^3}{(R+3R)^3} = \dfrac{R^3}{(4R)^3}$

$T_2^2 = 4^3 \times (60\,min)^2 = 64 \times (60\,min)^2 = 8^2\,(60\,min)^2$

$T_2 = 8 \times 60\,min$

$T_2 = 480\,min$ Ans.

Ans. d

Solution: 3

$\because T^2 \propto r^3$

$\Rightarrow \frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3}$

$\frac{\left(\frac{1}{8}\text{ year}\right)^2}{T_2^2} = \frac{R^3}{(2R)^3}$

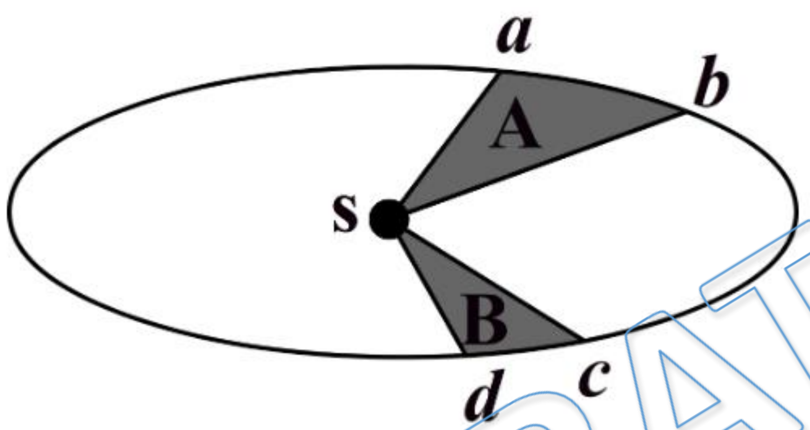
$T_2^2 = (2)^3\left(\frac{1}{8}\text{ years}\right)^2 = 8 \times \frac{1}{64_8}(\text{years})^2$

$\boxed{T_2 = \frac{1}{2\sqrt{2}}\text{ years}}$ Ans

Ans. a

Solution: 4

second law of Kepler states that radius vector from sun to the planet swaps equal area in equal time.

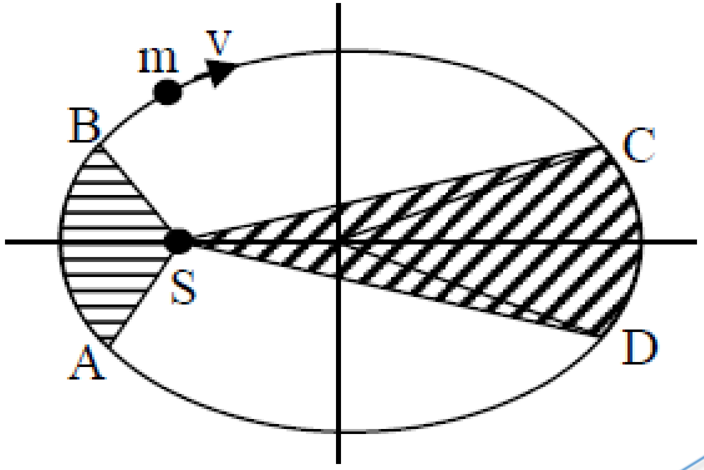


if A = B

then $t_1 = t_2$

Ans. c

Solution: 5



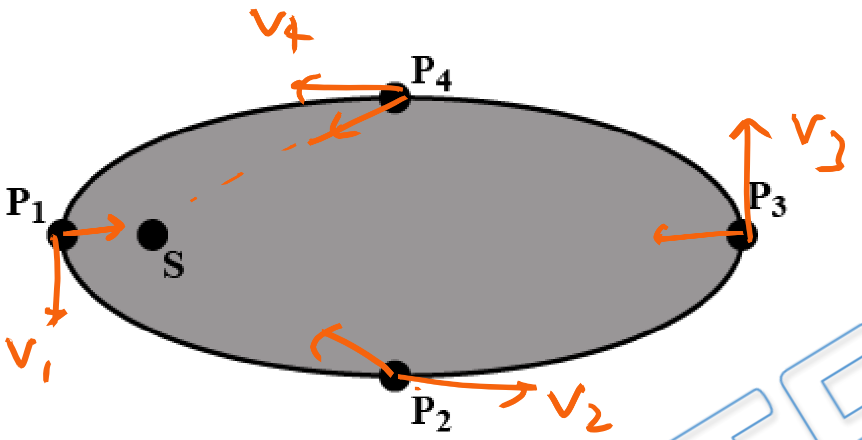
$\because$ Area(SCD) = 2 Area(SAB)

then t(SCD) = 2 t(SAB)

$\Rightarrow$ $t_1 = 2t_2$ Ans

Ans. d

Solution: 6



$\because KE = \frac{1}{2}mv^2$

$(KE)_{max} \Rightarrow$ when $(v)_{max}$.

$\because F_c = max$ at P_1

$[\because r = min]$

so; $\Rightarrow v_{max}$ at P_1

so; $(KE)_{max}$ at P_1 Ans

Ans. a

Solution: 7

$\because \quad d_1 < d_2$

$\because \quad L = \text{constant}$

[L = Angular momentum]

$m v_1 d_1 = m v_2 d_2$

$$\Rightarrow \boxed{v_2 = \frac{v_1 d_1}{d_2}} \text{ Ans}$$

Ans. c

Solution: 8

"The areal velocity is constant" is kepler's second Law.

$$\left(\frac{dA}{dt}\right) = \frac{L}{2m} = \text{constant}$$

where ; L = Angular momentum

& m = mass of planet

Hence; this Law is derived from Law of conservation of angular momentum.

Ans. b

Solution: 9

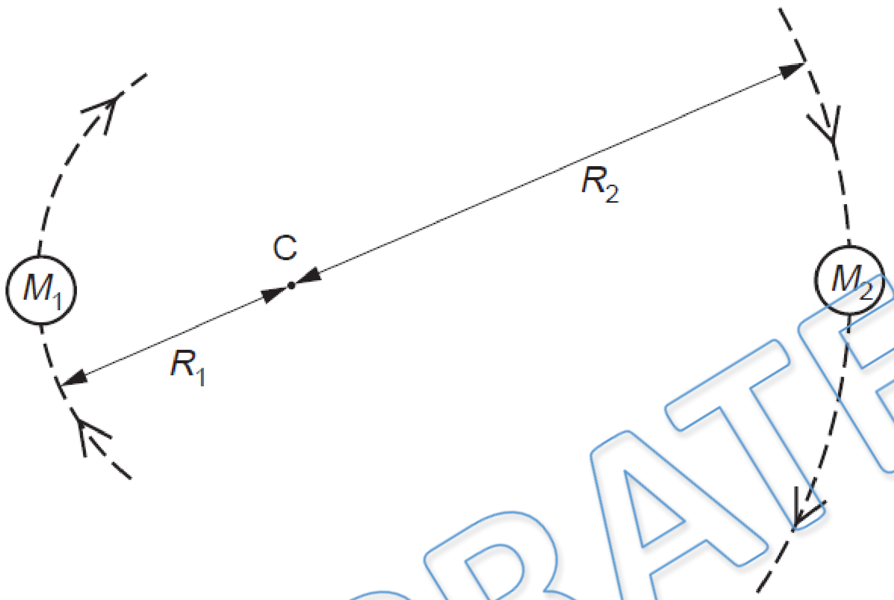
$\because L = \text{constant}$

$$mvr = mv_2(4r)$$

$$\Rightarrow \boxed{v_2 = \frac{v}{4}} \text{ Ans.}$$

Ans. b

Solution: 10

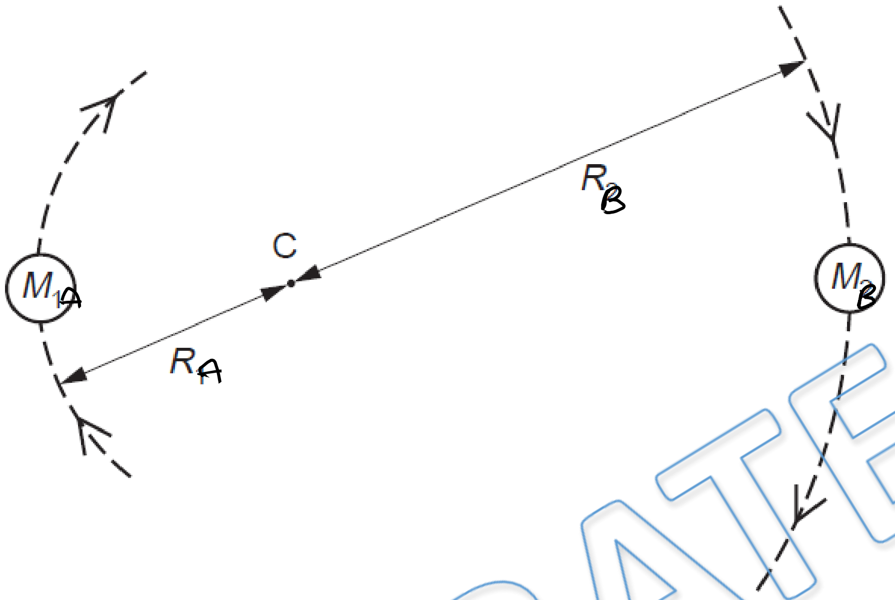


Angular speed of both stars in a binary star system is equal

so, $\boxed{\omega_1 = \omega_2 = \omega}$

Ans. c

Solution: 11



Angular speed of both stars in a binary star system is equal

so, $\boxed{\omega_A = \omega_B = \omega}$

$$T = \frac{2\pi}{\omega}$$

$$T_A = \frac{2\pi}{\omega_A}$$

$$T_B = \frac{2\pi}{\omega_B}$$

if $\omega_A = \omega_B$

then; $\boxed{T_A = T_B}$ Ans

Ans. d

Solution: 12

∵ c = com of both star system

so; $m_\alpha R_\alpha = m_\beta r_\beta$

$$m_\alpha (1\times10^9) = m_\beta (5\times10^8)$$

$$\frac{m_\alpha}{m_\beta} = \frac{5\times10^8}{10\times10^8} = \frac{1}{2}$$

$$\boxed{\frac{m_\alpha}{m_\beta} = \frac{1}{2}} \Rightarrow \boxed{\frac{M_\beta}{m_\alpha} = \frac{2}{1}} \text{ Ans}$$

Ans. b

Solution: 13

If radius of earth orbit = R

then radius of planet's orbit = 1.588 R

$$\frac{T_e^2}{T_p^2} = \frac{R^3}{(1.588R)^3} = \frac{1}{(1.588)^3}$$

$$T_p^2 = T_e^2 (1.588)^3$$

$$T_p^2 = (1 \text{ year})^2 (1.588)^3$$

$$T_p^2 = (1 \text{ year})^2 (4)$$

$$T_p = (1 \text{ year}) \times 2$$

$$\boxed{T_p = 2 \text{ years}}$$ Ans

Ans. d

Solution: 14

$\because \; T^2 \propto r^3$

$$\frac{T_1^2}{T_2^2} = \left(\frac{R_1}{R_2}\right)^3$$

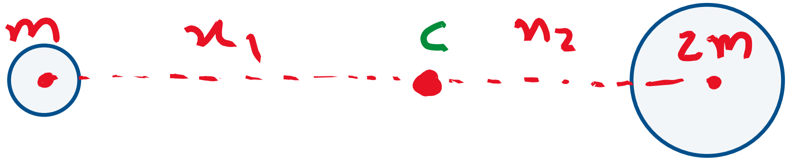
$$\frac{T_1^2}{T_2^2} = \left(\frac{R_1}{R_1/4}\right)^3 = (4)^3 = 64$$

$$T_2^2 = \frac{T_1^2}{64}$$

$$\boxed{T_2 = \frac{T_1}{8}} \text{ Ans}$$

Ans. c

Solution: 15



$x_1 + x_2 = r \quad \text{—(1)}$

$m x_1 = 2m x_2$

$x_1 = 2 x_2$

Put in eq^n (1)

$2x_2 + x_2 = r$

$3x_2 = r$

$\boxed{x_2 = \frac{r}{3}}$ & $\boxed{x_1 = \frac{2r}{3}}$

$F_c = \frac{m\omega^2}{R}$

$\frac{G(m)(2m)}{r^2} = m\omega^2 x_1 = m\omega^2\left(\frac{2r}{3}\right)$

$\frac{2Gm^2}{r^2} = m\omega^2\left(\frac{2r}{3}\right) \Rightarrow \omega^2 = \frac{3GM}{r^3}$

$\boxed{\omega = \sqrt{\frac{3GM}{r^3}}}$

$\Rightarrow T = \frac{2\pi}{\omega}$

$\boxed{T = 2\pi\sqrt{\frac{r^3}{3GM}}}$

$\boxed{T \propto r^{3/2}}$ & $\boxed{T \propto m^{-1/2}}$

Ans. a

Solution: 16

$T^2 \propto r^3$

$$\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3}$$

$$\frac{T_1^2}{T_2^2} = \frac{r_1^3}{(2r_1)^3} = \frac{1}{8}$$

$$T_2^2 = 8T_1^2$$

$$T_2 = 2\sqrt{2}\,T_1 = 2\sqrt{2} \times (24 \text{ hours})$$

$$\boxed{T_2 = 48\sqrt{2} \text{ hours}}$$ Ans

Ans. b

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