DPP – 4 & 5 (Gravitation)

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Q 1. A Geostationary satellite is revolving around the earth. To make it escape from gravitational field of earth, its velocity must be increased by -
(a) 100 % (b) 41.4% (c) 50% (d) 59.6%

Q 2. If a satellite orbits as close to the earth's surface as possible-
(a) its speed is maximum
(b) time period of its rotation is minimum
(c) the total energy of the earth plus satellite system is minimum
(d) the total energy of the earth plus satellite system is maximum

Q 3. For a satellite to be geostationary, which of the following are essential conditions ?
(a) It must always be stationed above the equator.
(b) It must rotate from west to east
(c) It must be about 36,000 km above the earth
(d) Its orbit must be circular, and not elliptical

Q 4. A satellite is revolving round the earth in a circular orbit of radius a with velocity V_0. A particle is projected from the satellite in forward direction with relative velocity $v=\left(\sqrt{\frac{5}{4}}-1\right)V_0$. Calculate, during subsequent motion of the particle its minimum and maximum distance from earth's centre.
(a) a,5a/3
(b) 2a, 7a/3
(c) a,2a/3
(d) 2a/a/3

Q 5. Due to small air friction , height of a satellite from ground slowly decreases and it finally falls on ground. During motion of satellite
(a)Its speed increases
(b) Its speed decreases
(c) Its total mechanical energy increases
(d) Its total mechanical energy decreases

Q 6. A planet is revolving round the sun. Its distance from the sun at Apogee is r_A and that at Perigee is r_P . The mass of planet and sun is m and M respectively, V_A and V_P is the velocity of planet at Apogee and perigee respectively and T is the time period of revolution of planet round the sun. Then-
(a) $T^2 = \frac{\pi^2}{2GM}(r_A + r_P)^3$ (b) $T^2 = \frac{\pi^2}{2GM}(r_A + r_P)^3$
(c) $V_A r_A = V_P r_P$ (d) $V_A < V_P; r_A > r_P$

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Q 7. In elliptical orbit of a planet, as the planet moves from apogee position to perigee position, match the following table :

	Table I		Table II
(A)	speed of planet	(P)	remains same
(B)	distance of planet from centre of sun	(Q)	decreases
(C)	potential energy	(R)	increases
(D)	angular momentum about centre of sun	(S)	can not say

Q 8. A comet travels around the sun in elliptical orbit. Its mass is 10^8 kg .when 2.5×10^{11} m away(apogee position) its speed is 2×10^4 ms^{-1}. Find the change in KE when it has reached 5×10^{10} m(perigee position) away from the sun-

(a) 38×10^{16} J (b) 48×10^{16} J (c) 58×10^{16} J (d) 56×10^{16} J

Q 9. A planet of mass m is moving in an elliptical path about the sun. Its maximum and minimum distances from the sun are r_1 and r_2 respectively. If M_s is the mass of sun then the angular momentum of this planet about the centre of sun will be -

(a) $\sqrt{\frac{2GM_s}{(r_1+r_2)}}$ (b) 2GMsm $\sqrt{\frac{r_1r_2}{(r_1+r_2)}}$

(c) m $\sqrt{\frac{2GM_sr_1r_2}{(r_1+r_2)}}$ (d) $\sqrt{\frac{2GM_sm(r_1+r_2)}{r_1r_2}}$

Q 10. Suppose gravitational force varies $\left[F \propto \frac{1}{r^n}\right]$ inversely as nth power of distance. The square of time period of a planet in a circular orbit of radius r around the sun will be proportional to–

(a) $r^{\frac{n+1}{2}}$ (b) $r^{\frac{n-1}{2}}$

(c) $r^{\frac{n-2}{2}}$ (d) r^{n+1}

Q 11. A double star consists of two stars having masses m and 2 m separated by a distance r. Which of the following statement is correct?

(a) Radius of circular path of star of mass 2m is 2r/3

(b) Kinetic energy of 2 m mass star is double that of lighter star

(c) Time period of revolution of both are not same

(d) Angular momentum of lighter star is more

Q 12. A planet is moving around the sun in an elliptical orbit of semimajor axis a. Mass of sun is M and that of planet is m. Speed of planet at distance a from sun is

(a) $\sqrt{\frac{GM}{2a}}$ (b) $\sqrt{\frac{3GM}{2a}}$

(c) $\sqrt{\frac{GM}{a}}$ (d) $\sqrt{\frac{2GM}{a}}$

Q 13. A planet is moving around a sun in circular orbit of radius R. If we increase the velocity of the planet $\sqrt{2}$times. Find the path of the planet.

(a) ellipse

(b) circular

(c) Parabola

(d) hyperbola

Q 14. A satellite is revolving around a planet is an elliptical orbit under its gravitational field. It is seen that the linear momentum of the satellite varies with the radius vector as $R^{-1/2}$ then the angular momentum of the satellite is proportional to

(a) $R^{1/2}$

(b) R^1

(c) $R^{3/2}$

(d) R^0

Q 15 The minimum and maximum distances of a satellite from the centre of the Earth are 2R and 4 R respectively, where R is the radius of Earth and M is the mass of the Earth. Find radius of curvature at the point of minimum distance.

(a) 5R/3

(b) 6R/5

(c) 8R/3

(d) 8R/5

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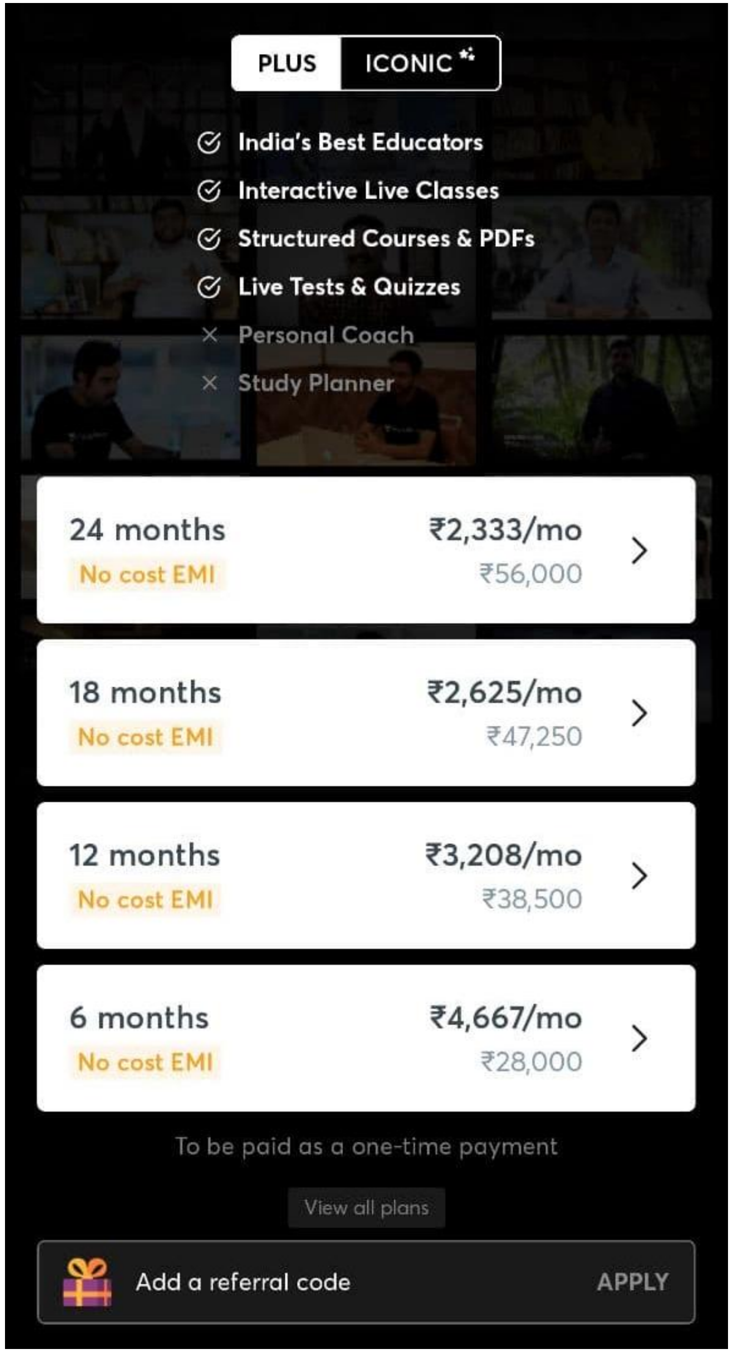
Answer Key

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

Q.7 A → R ; B → Q ; C → Q ; D → P



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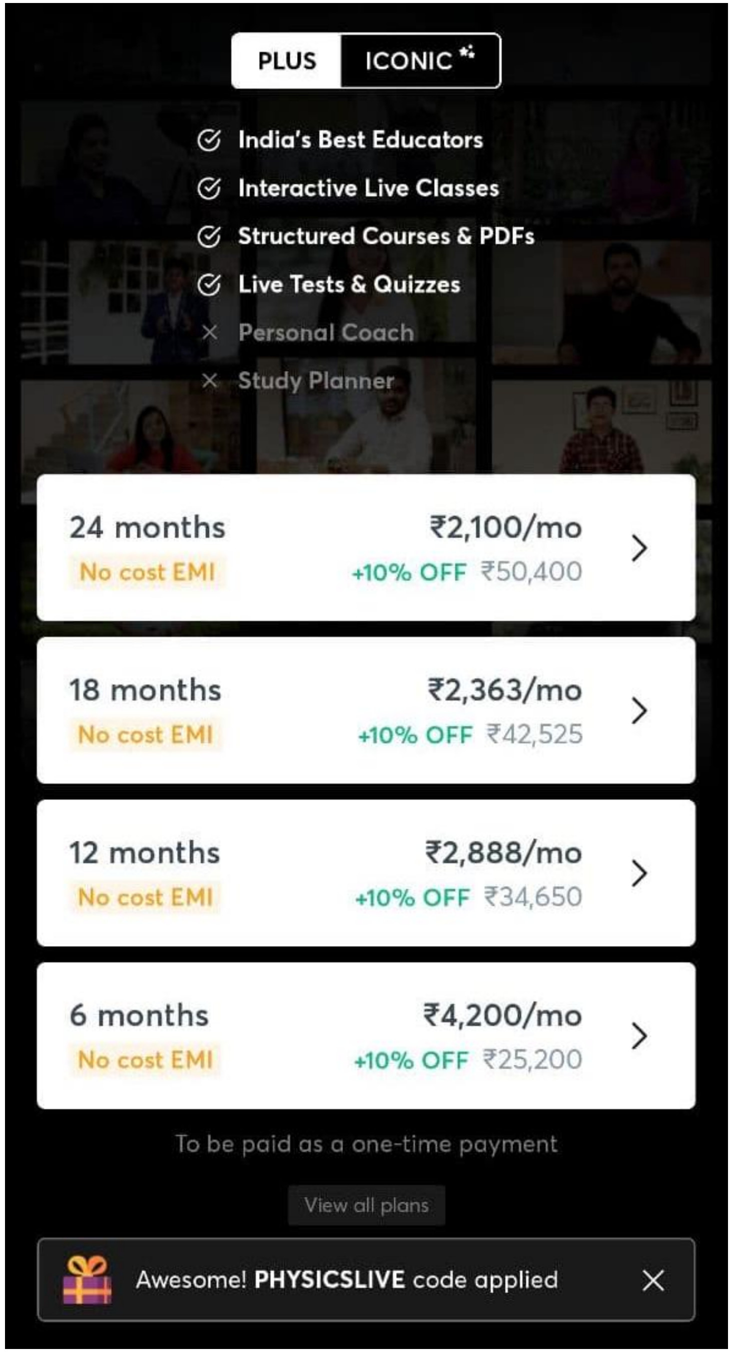

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Written Solution

DPP- 4&5 Gravitation- Escape Velocity, Orbital Velocity, Kepler's Law, Binary Star System

By Physicsaholics Team

Q.1) A Geostationary satellite is revolving around the earth. To make it escape from gravitational field of earth, its velocity must be increased by -

$V_0 = \sqrt{gR}$

$V_e = \sqrt{2gR} = \sqrt{2}\, V_0 = 1.414\, V_0$

$\Delta V = .414\, V_0$

% increment $= \frac{\Delta V}{V_0} \times 100 = 41.4\,\%$

(a) 100 % (b) 41.4% (c) 50% (d) 59.6%

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Q.2) If a satellite orbits as close to the earth's surface as possible-

(a) its speed is maximum

(b) time period of its rotation is minimum

(c) the total energy of the earth plus satellite system is minimum

(d) the total energy of the earth plus satellite system is maximum

$V_0 = \sqrt{\frac{GM}{r}} \Rightarrow V_0 \propto \frac{1}{\sqrt{r}}$

$T^2 \propto r^3 \Rightarrow T \propto r^{3/2}$

$E = -\frac{GMm}{2r} \Rightarrow E$ increases on increasing r

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Q.3) For a satellite to be geostationary, which of the following are essential conditions ?

$T = 24\,hr = 2\pi\sqrt{\dfrac{r^3}{GM}}$

$r = 42000\ Km$

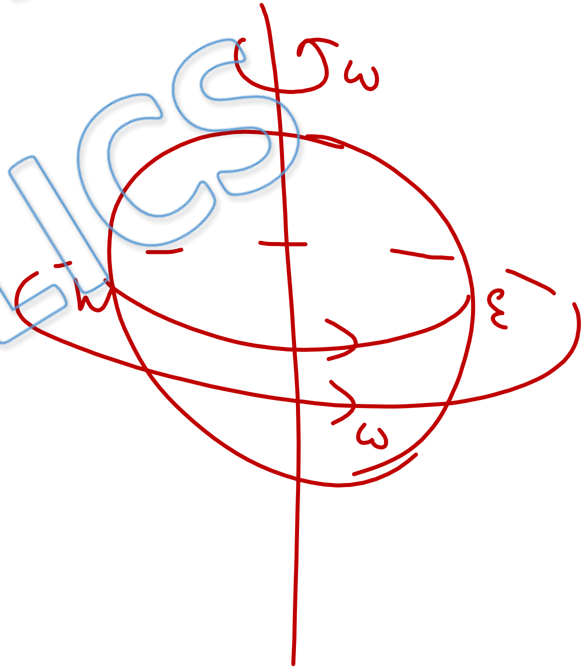
$h = 36000\ Km$

(a) It must always be stationed above the equator.

(b) It must rotate from west to east

(c) It must be about 36,000 km above the earth

(d) Its orbit must be circular, and not elliptical.



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Q.4) A satellite is revolving round the earth in a circular orbit of radius a with velocity V_0. A particle is projected from the satellite in forward direction with relative velocity $v=\left(\sqrt{\frac{5}{4}}-1\right)V_0$. Calculate, during subsequent motion of the particle its minimum and maximum distance from earth's centre.

(a) a,5a/3

(b) 2a, 7a/3

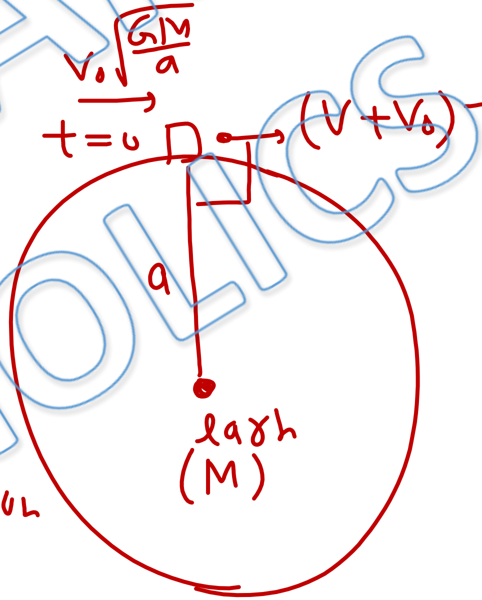
(c) a,2a/3

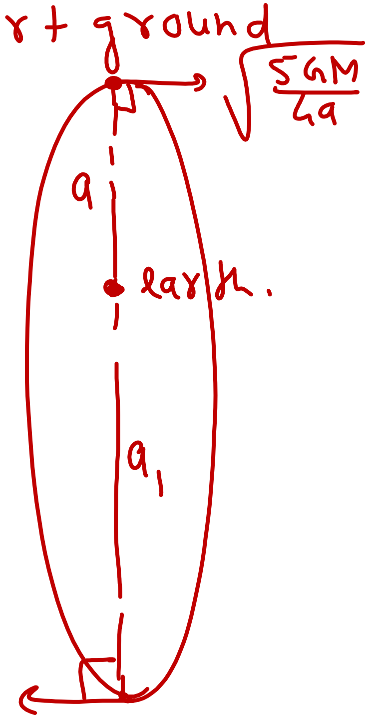
(d) 2a/a/3

at t=0

Velocity of particle $= V_0\sqrt{\frac{5}{4}}$

$= \sqrt{\frac{5GM}{4a}}$





Semimajor axis of elliptical motion

$r = \frac{a+a_1}{2}$

$TME = -\frac{GMm}{2r} = -\frac{GMm}{a+a_1}$

$-\frac{GMm}{a+a_1} = -\frac{GMm}{a} + \frac{1}{2}m\frac{5}{4}\frac{GM}{a} = -\frac{3}{8a}$

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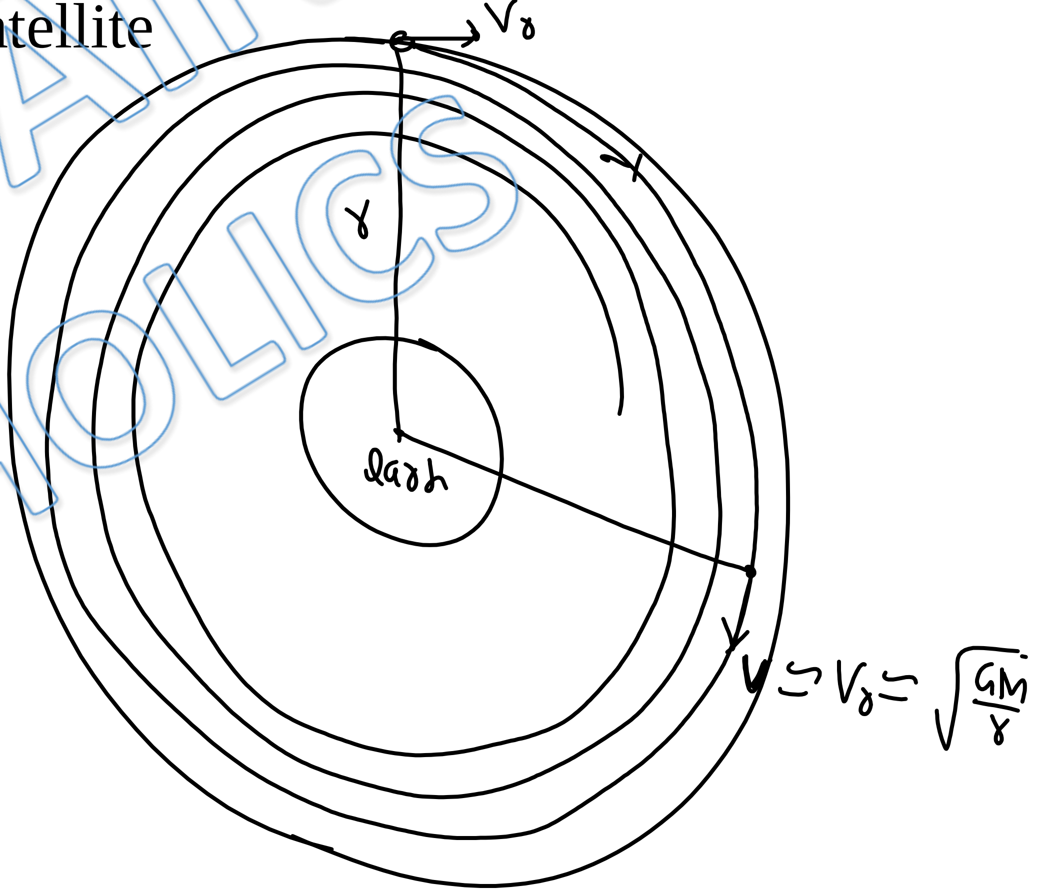
Q.5) Due to small air friction , height of a satellite from ground slowly decreases and it finally falls on ground. During motion of satellite

(a) Its speed increases

(b) Its speed decreases

(c) Its total mechanical energy increases

(d) Its total mechanical energy decreases



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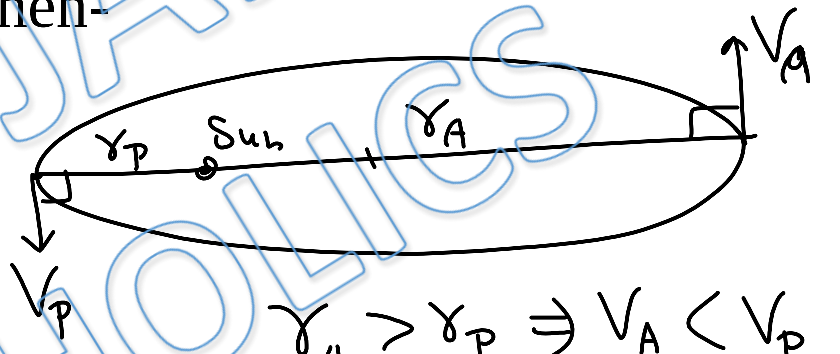
Q.6) A planet is revolving round the sun. Its distance from the sun at Apogee is r_A and that at Perigee is r_P . The mass of planet and sun is m and M respectively, V_A and V_P is the velocity of planet at Apogee and perigee respectively and T is the time period of revolution of planet round the sun. Then-

$$T^2 = 4\pi^2 \frac{r^3}{GM}$$

$$= 4\pi^2 \frac{(r_A + r_P)^3}{8GM}.$$



$r_A > r_P \Rightarrow V_A < V_P$ Since

$L = \text{Constant} \Rightarrow m V_P r_P = m V_A r_A$

(a) $T^2 = \frac{\pi^2}{2GM}(r_A + r_P)^3$

(b) $T^2 = \frac{\pi^2}{2GM}(r_A + r_P)^3$

(c) $V_A\, r_A = V_P\, r_P$

(d) $V_A < V_P; r_A > r_P$

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Q.7) In elliptical orbit of a planet, as the planet moves from apogee position to perigee position, match the following table :

	Table I		Table II
(A)	speed of planet	(P)	remains same
(B)	distance of planet from centre of sun	(Q)	decreases
(C)	potential energy	(R)	increases
(D)	angular momentum about centre of sun	(S)	can not say

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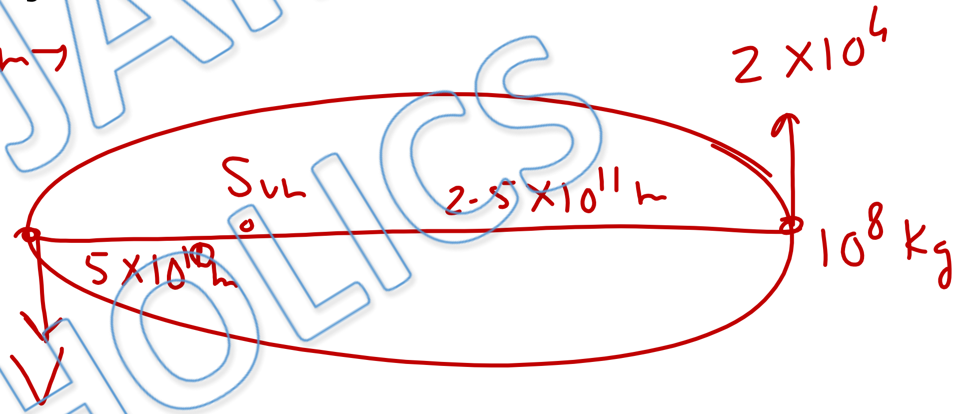
Q.8) A comet travels around the sun in elliptical orbit. Its mass is 10^8 kg .when 2.5×10^{11} m away(apogee position) its speed is 2×10^4 ms^{-1}. Find the change in KE when it has reached 5×10^{10} m(perigee position) away from the sun-

by Conservation of angular momentum →

$m v_1 r_1 = m v_2 r_2$

$\Rightarrow 2 \times 10^4 \times 2.5 \times 10^{11} = V \times 5 \times 10^{10}$

$V = 10^5$ m/sec



(a) 38×10^{16}J (b) 48×10^{16} J (c) 58×10^{16} J (d) 56×10^{16} J

$\Delta K = \frac{1}{2} \times 10^8 \left(10^{10} - 4 \times 10^8\right) = \frac{96}{2} \times 10^8 \times 10^8$

$= 48 \times 10^{16}$ J

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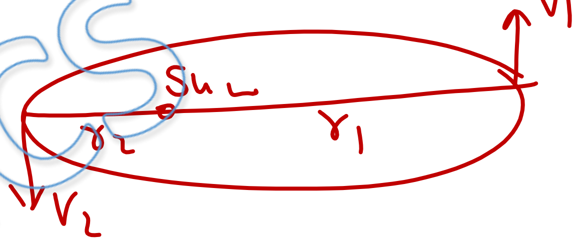
Q.9) A planet of mass m is moving in an elliptical path about the sun. Its maximum and minimum distances from the sun are r_1 and r_2 respectively. If M_s is the mass of sun then the angular momentum of this planet about the centre of sun will be -

$$\frac{1}{2}m^2v_1^2 - \frac{GMm^2}{r_1} = \frac{1}{2}m^2v_2^2 - \frac{GMm^2}{r_2}$$



(a) $\sqrt{\frac{2GM_s}{(r_1+r_2)}}$

(b) 2GMsm $\sqrt{\frac{r_1r_2}{(r_1+r_2)}}$

✓ (c) m $\sqrt{\frac{2GM_sr_1r_2}{(r_1+r_2)}}$

(d) $\sqrt{\frac{2GM_sm(r_1+r_2)}{r_1r_2}}$

$$L = mv_1r_1 = mv_2r_2 \quad \text{---(1)}$$

$$\frac{L^2}{2r_1^2} - \frac{L^2}{2r_2^2} = GMm^2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\frac{L^2}{2}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)\left(\frac{1}{r_1} + \frac{1}{r_2}\right) = GMm^2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$L^2 = \frac{2GMm^2r_1r_2}{r_1+r_2}$$

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Q.10) Suppose gravitational force varies $\left[F \propto \frac{1}{r^n}\right]$ inversely as n[th] power of distance. The square of time period of a planet in a circular orbit of radius r around the sun will be proportional to–

(a) $r^{\frac{n+1}{2}}$

(b) $r^{\frac{n-1}{2}}$

(c) $r^{\frac{n-2}{2}}$

(d) r^{n+1}

$mr\omega^2 = F \propto \frac{1}{r^n}$

$\omega^2 \propto \frac{1}{r^{n+1}}$

$\frac{4\pi^2}{T^2} \propto \frac{1}{r^{n+1}}$

$T^2 \propto r^{n+1}$

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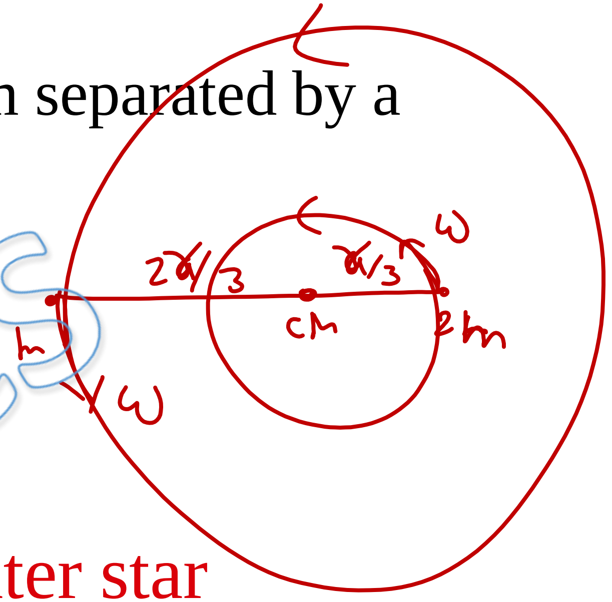
Q.11) A double star consists of two stars having masses m and 2 m separated by a distance r. Which of the following statement is correct?

$$KE_{heavy} = \frac{1}{2}\, 2m\left(\frac{r}{3}\right)^2 \omega^2 = \frac{mr^2\omega^2}{9}$$

$$KE_{light} = \frac{1}{2}\, m\left(\frac{2r}{3}\right)^2 \omega^2 = \frac{2mr^2\omega^2}{9}$$



(a) Radius of circular path of star of mass 2m is 2r/3

(b) Kinetic energy of 2 m mass star is double that of lighter star

(c) Time period of revolution of both are not same

(d) Angular momentum of lighter star is more

$$L_{light} = m\left(\frac{4r^2}{9}\right)\omega$$

$$L_{heavy} = 2m\left(\frac{r^2}{9}\right)\omega$$

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Q.12) A planet is moving around the sun in an elliptical orbit of semimajor axis a. Mass of sun is M and that of planet is m. Speed of planet at distance a from sun is

$TME = -\frac{GMm}{2a} = -\frac{GMm}{a} + \frac{1}{2}mv^2$

$\frac{1}{2}mv^2 = \frac{GMm}{2a}$

(a) $\sqrt{\frac{GM}{2a}}$

(b) $\sqrt{\frac{3GM}{2a}}$

(c) $\sqrt{\frac{GM}{a}}$

(d) $\sqrt{\frac{2GM}{a}}$

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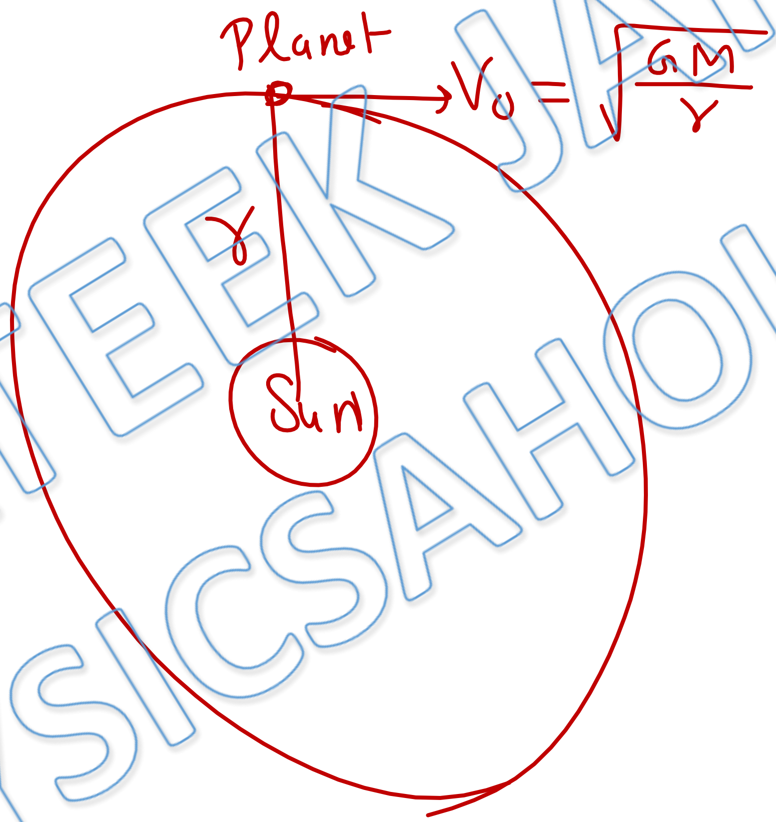
Q.13) A planet is moving around a sun in circular orbit of radius R. If we increase the velocity of the planet $\sqrt{2}$times. Find the path of the planet.



(a) ellipse

(b) circular

(c) Parabola ✓

(d) hyperbola

final velocity $= \sqrt{2}\, V_0$

$= \sqrt{\frac{2GM}{r}} = V_e$

$\Rightarrow$ parabolic

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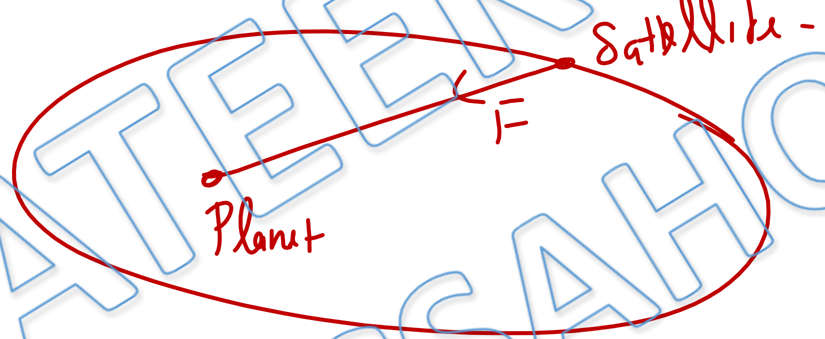
Q.14) A satellite is revolving around a planet is an elliptical orbit under its gravitational field. It is seen that the linear momentum of the satellite varies with the radius vector as $R^{-1/2}$ then the angular momentum of the satellite is proportional to



(a) $R^{1/2}$

(b) R^1

(c) $R^{3/2}$

(d) R^0

$\tau = 0 \Rightarrow L =$ Constant.

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Q.15) The minimum and maximum distances of a satellite from the centre of the Earth are 2R and 4 R respectively, where R is the radius of Earth and M is the mass of the Earth. Find radius of curvature at the point of minimum distance.

(a) 5R/3

(b) 6R/5

(c) 8R/3

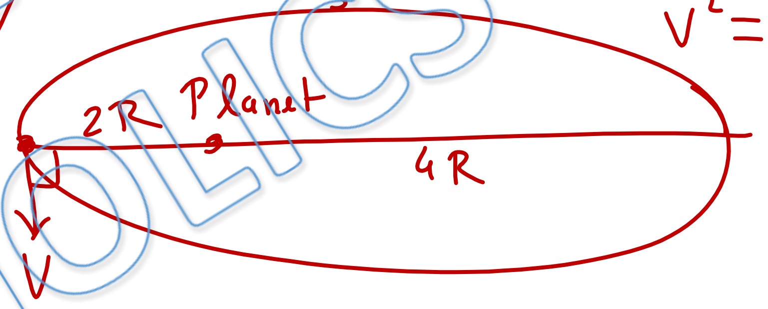
(d) 8R/5

Semimajor axis $= \frac{6R}{2} = 3R$

TME $= -\frac{GMm}{6R}$

$-\frac{GMm}{6R} = -\frac{GMm}{2R} + \frac{1}{2}mV^2$

$V^2 = \frac{2}{3}\frac{GM}{R}$



radius of curvature

$= \frac{V^2}{a_c} = \frac{mV^2}{F} = \frac{mV^2 \times 4R^2}{GMm} = \frac{4R^2V^2}{GM} = \frac{4R^2}{GM} \times \frac{2}{3}\frac{GM}{R}$

$= \frac{8R}{3}$

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