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Gravitation

Chapter - 8

NCERT Exercise Solutions

1(a) No. Gravitational force is independent of medium. A body cannot be shielded from the gravitational influence of nearby matter.

(b) Yes. If the size of spaceship is very large then the variation in g is ~~d~~ detectable inside the spaceship. Therefore gravitational effect can be detected.

(c) $$\text{Tidal effect} \propto \frac{1}{(\text{distance})^3}$$

and

$$\text{Gravitational force} \propto \frac{1}{(\text{distance})^2}$$

The distance of moon from ocean water is very small as compared to the distance of sun. Therefore tidal effect of moon's pull is greater.

2(a) Acceleration due to gravity decreases with increasing altitude.

(b) Acceleration due to gravity decreases with increasing depth.

(c) Acceleration due to gravity is independent of mass of the body.

(d) $-GMm\left[\frac{1}{r_2}-\frac{1}{r_1}\right]$ is more accurate than the formula $mg(r_2-r_1)$.

3. $T_e = 1$ year

$T_p = \frac{1}{2}$ year

$r_e = 1 \text{ A.U} = 1.5\times10^{11}$ m

$r_p = ?$

By Kepler's III Law

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

$$T^2 = K r^3$$

Now

$$\left(\frac{T_e}{T_p}\right)^2 = \left(\frac{r_e}{r_p}\right)^3$$

$$r_p^3 = \left(\frac{T_p}{T_e}\right)^2 \cdot r_e^3$$

$$= \frac{(1/2)^2}{1} \times 1^3$$

$$r_p^3 = \frac{1}{4} \times \frac{2}{2}$$

$$r_p^3 = \frac{2}{8}$$

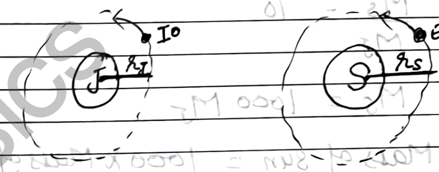
$$r_p = \frac{(2)^{1/3}}{2}$$

$$r_p = \frac{1.26}{2} = 0.63 \text{ A.U}$$

$$r_p = 0.63 \text{ A.U}$$

4. $T_J = 1.769$ days $r_J = 4.22\times10^8$ m

$T_s = 1$ year $= 365$ days, $r_s = 1 \text{ A.U} = 1.5\times10^{11}$ m



By Kepler's III Law

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

$$T^2 = K r^3$$

$$T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$$

$$M = \frac{4\pi^2}{GT^2}(r^3)$$

$$\frac{M_J}{M_s} = \left(\frac{r_J^3}{r_s^3}\right)\left(\frac{T_s^2}{T_J^2}\right)$$

$$= \left(\frac{\overset{2.8}{\cancel{4.22}}\times10^8}{\cancel{1.5}\times10^{11}}\right)^3 \times \left(\frac{365}{1.769}\right)^2$$

$$= (2.8)^3\times10^{-9}\times\left(\frac{\overset{206.21}{\cancel{365}}}{\cancel{1.77}}\right)^2$$

$$\simeq 7.84\times2.8\times10^{-9}\times(206)^2$$

$$= 22\times42436\times10^{-9}$$

$$= 22\times4.24\times10^{4}\times10^{-9}$$

$$= 93.28\times10^{-5}$$

$$= 0.93\times10^{-3}$$

$$\frac{M_J}{M_S} \simeq 1\times10^{-3}$$

$$\frac{M_S}{M_J} = 10^3$$

$$M_S = 1000\, M_J$$

Mass of sun = 1000 × Mass of Jupiter

Proved

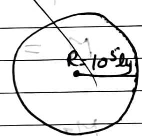
5. $M = 2.5\times10^{11}$ solar mass

$= 2.5\times10^{11} \times 2\times10^{30}$ kg [1 S.M $= 2\times10^{30}$ kg]

$M = 5\times10^{41}$ kg

$R = 10^5$ ly

$r =$



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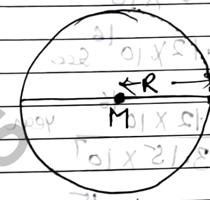

$D = 10^5$ ly

$R = \frac{D}{2} = \frac{10\times10^4}{2}$ ly

$R = 5\times10^4$ ly

$M = 2.5\times10^{11}$ solar mass

$= 2.5\times10^{11} \times 2\times10^{30}$ kg

$M = 5\times10^{41}$ kg

$r = 50,000$ ly

$= 5\times10^4$ ly

Given $R = r = 5\times10^4$ ly

$= 5\times10^4 \times 9.46\times10^{15}$ m

$= 47.3\times10^{19}$

$r = 4.73\times10^{20}$ m

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

$$T = \frac{39.44\times(4.73\times10^{20})^3}{6.67\times10^{-11}\times5\times10^{41}\text{ kg}}$$

$$= \frac{39.44\times105.82\times10^{60}}{33.35\times10^{30}}$$

$$= \frac{4173.54\times10^{30}}{33.35}$$

$$T^2 = 1.2514\times10^{32}\text{ s}$$

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$$T^2 = 1.25 \times 10^{32}$$

$$T = 1.12 \times 10^{16} \text{ sec}$$ Ans

$$T = \frac{1.12 \times 10^{16}}{3.15 \times 10^{7}} \text{ year}$$

$$= \frac{11.2 \times 10^{15}}{3.15 \times 10^{7}}$$

$$T = 3.55 \times 10^{8} \text{ years}$$ Ans

6. (a) If gravitational potential energy of a satellite is considered to be zero than its

$$K.E = \frac{1}{2} \frac{GMm}{r}$$

$$P.E = -\frac{GMm}{r}$$

and $$T.E = -\frac{1}{2} \frac{GMm}{r}$$

i.e the T.E is -ve of its K.E.

(b) An orbiting satellite has more energy than a stationary object at the same height. This additional energy is provided by the orbit. Therefore it requires lesser energy to make it move of the earth's influence than a stationary object.
i.e Ans is less.

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6 (a) Kinetic energy
For a satellite whose potential energy is taken zero at infinity -

$$K.E = \frac{1}{2} \frac{GMm}{r}$$

$$P.E = \frac{-GMm}{r}$$

$$T.E = -\frac{1}{2} \frac{GMm}{r}$$

i.e T.E is -ve of its K.E.

(b) Less
An orbiting satellite has more energy than a ~~sate~~ stationary object at the same height. This additional energy is provided by the orbit. Therefore it requires lesser energy to make it move out of the earth influence than stationary object.

7. The escape speed is given by

$$v_e = \sqrt{\frac{2GM_e}{R_e}} = \sqrt{2gR_e}$$

where $M_e \rightarrow$ Mass of earth
$R_e \rightarrow$ Radius of earth

(a) NO, because the escape speed does not depend on the mass of the body. It depends on mass of earth only.
(b) No. Escape speed does not depend on the location from where the body is projected.
(c) No, escape speed is independent of the direction of projection of the body.

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(d) Yes, because the escape speed depends upon the gravitational potential at a point.

8. (a) Linear speed is not constant. [By $L = mvr$, for constant angular momentum if r changes v is also get changed]
(b) Angular speed ω is not constant.
[By $L = mr^2\omega$]

(c) Angular momentum $L = mvr = constant$ as there is not external torque.
(d) K.E is not constant as v is not constant.
(e) By the conservation of energy
$$T.E = K.E + P.E$$
Since K.E is not constant, hence P.E is not constant.
(f) By the law of conservation of energy the total energy is constant.
i.e (c) and (f) are correct.

9. (a) The blood flow in feet would be lesser in zero gravity. So, the astronaut will not get swollen feet.
(b) In the conditions of weightlessness, the face gets more blood suppy. So the astronaut may develop swollen face.
(c) Due to more blood suppy to face, the astronaut may get headach.

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(d) We also have frame of references in space. Hence orientational problem will affect the astronaut.