Question 8. 1. Answer the following:
(a) You can shield a charge from electrical forces by putting it inside a hollow conductor. Can you shield a body from the gravitational influence of nearby matter by putting it inside a hollow sphere or by some other means?
(b) An astronaut inside a small spaceship orbiting around the Earth cannot detect gravity. If the space station orbiting around the Earth has a large size, can he hope to detect gravity?
(c) If you compare the gravitational force on the Earth due to the Sun to that due to the Moon, you would find that the Sun's pull is greater than the Moon's pull. (You can check this yourself using the data available in the succeeding exercises). However, the tidal effect of the Moon's pull is greater than the tidal effect of Sun. Why?
Answer:
(a) No. Gravitational forces are independent of medium. A body cannot be shielded from the gravitational influence of nearby matter.
(b) Yes. If the size of the spaceship is extremely large, then the gravitational effect of the spaceship may become measurable. The variation in g can also be detected.
(c) Tidal effect depends inversely on the cube of the distance, unlike force which depends inversely on the square of the distance. Since the distance of moon from the ocean water is very small as compared to the distance of sun from the ocean water on earth. Therefore, the tidal effect of Moon's pull is greater than the tidal effect of the sun.

Question 8. 2. Choose the correct alternative:
(a) Acceleration due to gravity increases/decreases with increasing altitude.
(b) Acceleration due to gravity increases/decreases with increasing depth (assume the Earth to be a sphere of uniform density).
(c) Acceleration due to gravity is independent of the mass of the Earth/mass of the body.
(d) The formula $- GMm (1/r_2 - 1/r_1)$ is more/less accurate than the formula $mg (r_2 - r_1)$ for the difference of potential energy between two points r2 and r1 distance away from the centre of the Earth.
Answer:
(a) decreases
(b) decreases
(c) mass of the body
(d) more

Question 8.3. Suppose there existed a planet that went around the Sun twice as fast as the Earth. What would be its orbital size as compared to that of the Earth?
Answer:

Here, $T_e = 1$ year; $T_p = \frac{T_e}{2} = \frac{1}{2}$ year; $r_e = 1$ A.U.

Using Kepler's third law, we have $r_p = r_e \left(\frac{T_p}{T_e}\right)^{2/3}$

$$\Rightarrow \qquad r_p = 1\left(\frac{1/2}{1}\right)^{2/3} = 0.63 \text{ AU}$$

Question 8.4. Io, one of the satellites of Jupiter, has an orbital period of 1.769 days and the radius of the orbit is 4.22×10^8 m. Show that the mass of Jupiter is about one-thousandth that of the Sun.
Answer. For a satellite of Jupiter, orbital period, T_1 = 1.769 days = 1.769 x 24 x 60 x 60 s Radius of the orbit of satellite, $r_1 = 4.22 \times 10^8$ m

Mass of Jupiter, M_1 is given by $M_1 = \frac{4\pi^2 r_1^3}{GT_1^2} = \frac{4\pi^2 \times (4.22 \times 10^8)^3}{G \times (1.769 \times 24 \times 60 \times 60)^2}$ ...(i)

We know that the orbital period of Earth around the sun,

T = 1 year = 365.25 × 24 × 60 × 60 s;

orbital radius, r = 1 A.U. = 1.496×10^{11} m.

Mass of sun is given by $M = \frac{4\pi^2 r^3}{GT^2} = \frac{4\pi^2 \times (1.496 \times 10^{11})^3}{G \times (365.25 \times 24 \times 60 \times 60)^2}$ ...(ii)

Dividing eqn. (ii) by (i), we get

$$\frac{M}{M_1} = \frac{4\pi^2 \times (1.496 \times 10^{11})^3}{G \times (365.25 \times 24 \times 60 \times 60)^2} \times \frac{G \times (1.769 \times 24 \times 60 \times 60)^2}{4\pi^2 \times (4.22 \times 10^8)^3} = 1046$$

or $$\frac{M_1}{M} = \frac{1}{1046} \simeq \frac{1}{1000} \Rightarrow M_1 = \frac{1}{1000} M.$$ **Proved**

Question 8.5. Let us assume that our galaxy consists of 2.5×10^{11} stars each of one solar mass. How long will a star at a distance of 50,000 ly from the galactic centre take to complete one revolution? Take the diameter of the Milky way to be 10^5 ly.
Answer:
Here, r = 50000 ly = 50000 x 9.46×10^{15} m = 4.73×10^{20} m
M = 2.5×10^{11} solar mass = $2.5 \times 10^{11} \times (2 \times 10^{30})$ kg = 5.0×10^{41}kg
We know that

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

or $$T = \left(\frac{4\pi^2 r^3}{GM}\right)^{1/2} = \left[\frac{4 \times (22/7)^2 \times (4.73 \times 10^{20})^3}{(6.67 \times 10^{-11}) \times (5.0 \times 10^{41})}\right]^{1/2}$$

$$= 1.12 \times 10^{16} \text{ s.}$$

Question 8. 6. Choose the correct alternative:
(a) If the zero of potential energy is at infinity, the total energy of an orbiting satellite is negative of its kinetic/potential energy.
(b) The energy required to launch an orbiting satellite out of Earth's gravitational influence is more/less than the energy required to project a stationary object at the same height (as the satellite) out of Earth's influence.
Answer:
(a) If the zero of potential energy is at infinity, the total energy of an orbiting satellite is negative of its kinetic energy.
(b) The energy required to launch an orbiting satellite out of Earth's gravitational influence is less than the energy required to project a stationary object at the same height (as the satellite) out of Earth's influence.

Question 8.7. Does the escape speed of a body from the Earth depend on

(a) the mass of the body,
(b) the location from where it is projected,
(c) the direction of projection,
(d) the height of the location from where the body is launched?
Answer:

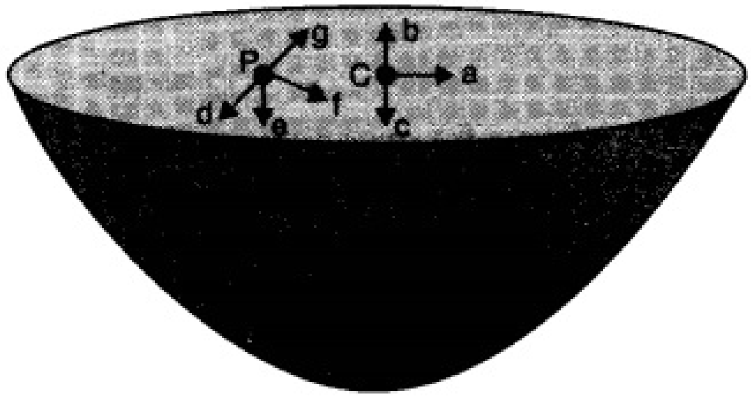
The escape speed $v_{es} = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$. Hence,

(a) The escape speed of a body from the Earth does not depend on the mass of the body.
(b) The escape speed does not depend on the location from where a body is projected.
(c) The escape speed does not depend on the direction of projection of a body.
(d) The escape speed of a body depends upon the height of the location from where the body is projected, because the escape velocity depends upon the gravitational potential at the point from which it is projected and this potential depends upon height also.

Question 8. 8. A comet orbits the Sun in a highly elliptical orbit. Does the comet have a constant
(a) linear speed
(b) angular speed
(c) angular momentum
(d) kinetic energy
(e) potential energy
(f) total energy throughout its orbit? Neglect any mass loss of the comet when it comes very close to the Sun.
Answer:
(a) The linear speed of the comet is variable in accordance with Kepler7s second law. When comet is near the sun, its speed is higher. When the comet is far away from the sun, its speed is very less.
(b) Angular speed also varies slightly.
(c) Comet has constant angular momentum.
(d) Kinetic energy does not remain constant.
(e) Potential energy varies along the path.
(f) Total energy throughout the orbit remains constant.

Question 8. 9.Which of the following symptoms is likely to afflict an astronaut in space (a) swollen feet, (b) swollen face, (c) headache, (d) orientational problem.
Answer:
(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 of the astronaut is expected to get more supply. Due to it, the astronaut may develop swollen face.
(c) Due to more blood supply to face, the astronaut may get headache.
(d) Space also has orientation. We also have the frames of reference in space. Hence, orientational problem will affect the astronaut in space.

Question 8. 10. In the following two exercises, choose the correct answer from among the given ones: The gravitational intensity at the centre of a hemispherical shell of uniform mass density has the direction indicated by the arrow (see Fig.)
(i) a, (ii) b, (iii) c, (iv) 0.



Answer: At all points inside a hollow spherical shell, potential is same. So, gravitational intensity, which is negative of gravitational potential gradient, is zero. Due to zero gravitational intensity, the gravitational forces acting on any particle at any point inside a spherical shell will be symmetrically placed. It follows from here that if we remove the upper hemispherical shell, the net gravitational force acting on a particle at P will be downwards. Since gravitational intensity is gravitational force per unit mass therefore, the direction of gravitational intensity will be along c. So, option (iii) is correct.

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