NCERT solutions for class 11 physics chapter 8 Gravitation

Q: 8.1 (a) Answer the following questions:

(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?

Answer:

No, because gravitational force doesn't depend upon the material medium. It is independent of the presence of other materials.

Q: 8.1 (b) Answer the following :

(b)An astronaut inside a small space ship orbiting aroud the earth cannot detect gravity. If the space station orbiting around the earth has a large size, can he hope to detect gravity?

Answer:

Yes if the size of the space station is large then he can detect gravity.

Q: 8.1 (c) Answer the following:

(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 availble in the succeeding exercises). However, the tidal effect of the moon's pull is greater than the tidal effect of sun. Why?

Answer:

Apart from the gravitational pull, the tidal effect also depends upon the cube of the distance between the two. Since the distance between earth and sun is much larger than the distance between the sun and moon so it not also balances but is more than the effect of gravitational force. Thus the tidal effect of the moon's pull is greater than the tidal effect of the sun.

Q: 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 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 for the difference of potential energy $mg(r_2 - r_1)$ between two points and distance away from the centre of the earth r_2 r_1

Answer:

(a) Acceleration due to gravity **decrea es** with increasing altitude.

The relation between the two is given by :

$$g_h = \left(1 - \frac{2h}{R_e}\right) g$$

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

The relation is given below:

$$g_d = \left(1 - \frac{d}{R_e}\right) g$$

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

$g = \frac{GM}{R^2}$ Here M is the mass of the earth.

(d) The formula $-GMm(1/r_2 - 1/r_1)$ is **more** accurate than the formula for $mg(r_2 - r_1)$ the difference of potential energy between two points r_2 and r_1 distance away from the centre of the earth.

Q:8.3 Suppose there existed a planet that went around the sun was twice as fast as the earth. What would be its orbital size as compared to that of the earth?

Answer:

Time taken by planet to complete a revolution around sun = $\frac{1}{2}T_e$

Using Kepler's law of planetary motion we can write :

$$\left(\frac{R_p}{R_e}\right)^3 = \left(\frac{T_p}{T_e}\right)^2$$

or $$\frac{R_p}{R_e} = \left(\frac{\frac{1}{2}}{1}\right)^{\frac{2}{3}}$$

or $$\frac{R_p}{R_e} = 0.63$$

Thus the planet is 0.63 times smaller than earth.

Q: 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:

The orbital period in days is $= \ 1.769 \times 24 \times 60 \times 60 \ s$

Mass is given by :

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

Thus the ratio of the mass of Jupiter and mass of the sun is :

$$\frac{M_s}{M_j} = \frac{\frac{4\pi^2 R_e^3}{GT_e^2}}{\frac{4\pi^2 R_{io}^3}{GT_{io}^2}}$$

or

or ≈ 1045

Thus the mass of Jupiter is nearly one-thousandththat of the sun.

Q: 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:

We know that one light year is $9.45 \times 10^{15} \ m$.

The time period of rotation is given by :

$$T \ = \ \left(\frac{4\pi r^3}{GM}\right)^{\frac{1}{2}}$$

Putting all the value (in SI units) in the above equation we get :

or $= \ 1.12 \ \times 10^{16} \ s$

In years :

$$= \frac{1.12 \ \times 10^{16}}{365 \times 24 \times 60 \times 60} \ = \ 3.55 \times 10^{8} \ years$$

Q: 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) The total energy will be negative of its **kinetic energy** . Since at infinity potential energy is zero and total energy is negative.

(b) The energy required will be **less** as the stationary object on earth has no energy initially whereas the satellite has gained energy due to rotational motion.

Q: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 velocity from the earth is given by :

$$V_{esc} = \sqrt{2gR}$$

Since the escape velocity depends upon the reference (potential energy), so it only depends upon the height of location.

(i) No

(ii) No

(iii) No

(iv) Yes

Q: 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:

Among all only angular momentum and total energy of the comet will be constant other all factors given will vary from point to point.

Q: 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) In space we have state of weightlessness, so the swollen feet does not affect astronaut as there is no gravitational pull (so cannot stand).

(b) The swollen face will be affected as the sense organs such as eyes, ears etc. will be affected.

(c) It will affect the astronaut as it may cause mental strain.

(d) It will affect the astronaut as space has different orientations.

Q: 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 th direction indicated by the arrow (see Fig 8.12) (i) a, (ii) b, (iii) c, (iv) 0

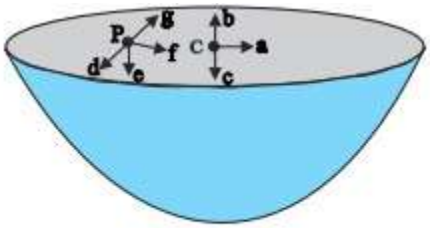

Fig. 8.12

Answer:

We know that the gravitational potential (V) in a sphere is constant throughout. Also, the gravitational intensity will act in the downward direction as its upper half is cut (gravitational force will also act in a downward direction). Hence the required direction of gravitational intensity is shown by arrow **C** .

Q:8.11 For the above problem, the direction of the gravitational intensity at an arbitrary point P is indicated by the arrow (i) d, (ii) e, (iii) f, (iv) g.

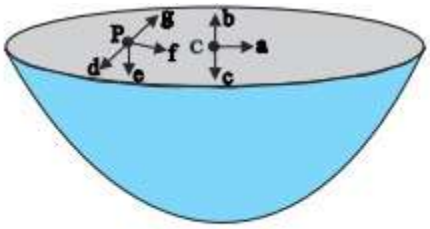

Fig. 8.12

Answer:

As stated in the previous question, the gravitational potential in a spherical shell is constant throughout. So the gravitational intensity will act in downward direction (as upper half is cut). So the required direction is shown by arrow **e** .

Q: 8.12 A rocket is fired from the earth towards the sun. At what distance from the earth's cntre is the gravitational force on the rocket zero? Mass of the sun $= 2 \times 10^{30}\ kg$, mass of the earth $= 6 \times 10^{24}\ kg$. Neglect the effect of other planets etc. (orbital radius $= 1.5 \times 10^{11}\ m$).

Answer:

Let the distance where the gravitational force acting on satellite P becomes zero be x from the earth.

Thus we can write :

$$\frac{GmM_s}{(r-x)^2} = \frac{GmM_e}{r^2}$$

or $$\left(\frac{r-x}{x}\right) = \left(\frac{2 \times 10^{30}}{60 \times 10^{24}}\right)^{\frac{1}{2}}$$

or $= \ 577.35$

Hence :

$$x = \frac{1.5 \times 10^{11}}{578.35} = 2.59 \times 10^{8}\ m$$ (Since r = 1.5×10^{11})

Q: 8.13 How will you 'weigh the sun', that is estimate its mass? The mean orbital radius of the earth around the sun is $1.5 \times 10^{8}\ km$.

Answer:

Mass of sun can be calculated by using the following formula:-

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

Putting the known values in the above formula, we obtain :

or $$= \frac{133.24 \times 10}{6.64 \times 10^4} = 2 \times 10^{30}\ Kg$$

Thus the mass of the sun is nearly $2 \times 10^{30}\ Kg$.

Q: 8.14 A saturn year is 29.5 times the earth year. How far is the saturn from the sun if the earth is $1.50 \times 10^8\ km$ away from the sun?

Answer:

Kepler's third law give us the following relation :

$$T = \left(\frac{\pi^2 r^3}{GM}\right)^{\frac{1}{2}}$$

Thus we can write :

$$\frac{r_s^3}{r_e^3} = \frac{T_s^2}{T_e^2}$$

or $$r_s = r_e \left(\frac{T_s}{T_e}\right)^{\frac{2}{3}}$$

or $= 1.5 \times 10^{11} \times \left(\frac{29.5T_e}{T_e}\right)^{\frac{2}{3}}$

or $= 14.32 \times 10^{11}\ m$

Thus the distance between the sun and Saturn is $14.32 \times 10^{11}\ m$.

Q: 8.15 A body weighs $63\ N$ on the surface of the earth. What is the gravitational force on it due to the earth at a height equal to half the radius of the earth?

Answer:

Acceleration due to gravity at height h from the surface of eath is :

$$g' = \frac{g}{\left(1 + \frac{h}{R}\right)^2}$$

For $h = \frac{R}{2}$ we have :

$$g' = \frac{g}{\left(1 + \frac{\frac{R}{2}}{R}\right)^2}$$

or $= \frac{4}{9}g$

Thus the weight of the body will be :

$$W = mg'$$

or $= m \times \frac{4}{9}g = \frac{4}{9}mg$

or $= 28\ N$

Q: 8.16 Assuming the earth to be a sphere of uniform mass density, how much would a body weigh half way down to the centre of the earth if it weighed $250\ N$ on the surface?

Answer:

Position of the body is (depth) :

$$= \frac{1}{2}R_e$$

Acceleration due to gravity at depth d is given by :

$$g' = \left(1 - \frac{d}{R_e}\right)g$$

or $$= \left(1 - \frac{\frac{R_e}{2}}{R_e}\right)g$$

or $$= \frac{1}{2}g$$

Thus the weight of the body is:-

$$W = mg'$$

or $$= m \times \frac{1}{2}g = \frac{mg}{2}$$

or $= 125\ N$

Thus the weight of the body is 125 N.

Q: 8.17 A rocket is fired vertically with a speed of 5 km s-1 from the earth's surface. How far from the earth does the rocket go before returning to the earth? Mass of the

earth $= 6.0 \times 10^{24}\ kg$; mean radius of the earth $= 6.4 \times 10^{6}\ m$; $G = 6.67 \times 10^{-11}\ Nm^2kg^{-1}$.

Answer:

The total energy is given by :

Total energy = Potential energy + Kinetic energy

$$= \left(\frac{-GmM_e}{R_e}\right) + \frac{1}{2}mv^2$$

At the highest point velocity will be zero.

Thus the total energy of the rocket is :

$$= \left(\frac{-GmM_e}{R_e + h}\right) + 0$$

Now we will use the conservation of energy :

Total energy initially (at earth's surface) = Total energy at height h

$$\left(\frac{-GmM_e}{R_e}\right) + \frac{1}{2}mv^2 = \left(\frac{-GmM_e}{R_e + h}\right)$$

or $\frac{1}{2}v^2 = \frac{gR_eh}{R_e + h}$

or $h = \frac{R_ev^2}{2gR_e - v^2}$

or $= \frac{6.4 \times 10^6 \times (5 \times 10^3)^2}{2g \times 6.4 \times 10^6 - (5 \times 10^3)^2}$

or $= 1.6 \times 10^6\ m$

Hence the height achieved by the rocket from earth's centre = R + h

$$= 6.4 \times 10^6 + 1.6 \times 10^6$$

or $= 8 \times 10^6 \ m$

Q: 8.18 The escape speed of a projectile on the earth's surface is $11.2 \ km \ s^{-1}$. A body is projected out with thrice this speed. What is the speed of the body far away from the earth? Ignore the presence of the sun and other planets.

Answer:

Let us assume the speed of the body far away from the earth is v_f .

Total energy on earth is :

$$= \frac{1}{2}mv_p^2 - \frac{1}{2}mv_{esc}^2$$

And the total energy when the body is far from the earth is :

$$= \frac{1}{2}mv_f^2$$

(Since the potential energy t fr from the earth is zero.)

We will use conservation of energy : -

$$\frac{1}{2}mv_p^2 - \frac{1}{2}mv_{esc}^2 = \frac{1}{2}mv_f^2$$

or $v_f = \sqrt{(v_p^2 - v_{esc}^2)}$

or $= \sqrt{((3v_{esc})^2 - v_{esc}^2)}$

or $= \sqrt{8} v_{esc}$

or $= 31.68 \ Km/s$

Q: 8.19 A satellite orbits the earth at a height of $400 \ km$ above the surface. How much energy must be expended to rocket the satellite out of the earth's gravitational influence? Mass of the satellite $= 200 \ kg$; ! mass of the earth $= 6.0 \times 10^{24} \ kg$; radius of the earth $= 6.4 \times 10^{6} \ m$; $G = 6.67 \times 10^{-11} \ Nm^2 kg^{-2}$.

Answer:

The total energy of the satellite at height h is given by :

$$= \frac{1}{2} m v^2 + \left(\frac{-GM_e m}{R_e + h} \right)$$

We know that the orbital speed of the satellite is :

$$v = \sqrt{\left(\frac{GM_e}{R_e + h} \right)}$$

Thus the total energy becomes :

$$= \frac{1}{2} m \times \left(\frac{GM_e}{R_e + h} \right) + \left(\frac{-GM_e m}{R_e + h} \right)$$

or $= -\frac{1}{2} \left(\frac{GM_e m}{R_e + h} \right)$

Thus the required energy is negative of the total energy :

nbsp; $E_{req} = \frac{1}{2} \left(\frac{GM_e m}{R_e + h} \right)$

or

or $= \ 5.9 \times 10^9 \ J$

Q: 8.20 Two stars each of one solar mass ($= 2 \times 10^{30} \ kg$) are approaching each other for a head on collision. When they are a distance $10^9 \ km$, their speeds are negligible. What is the speed with which they collide? The radius of each star is $10^4 \ km$. Assume the stars to remain undistorted until they collide. (Use the known value of G).

Answer:

The total energy of stars is given by :

$$E \ = \ \frac{-GMM}{r} \ + \ \frac{1}{2}mv^2$$

or $= \ \frac{-GMM}{r} \ + \ 0$

or $= \ \frac{-GMM}{r}$

Now when starts are just to collide the distance between them is 2R.

The total kinetic energy of both the stars is :

$$= \ \frac{1}{2}mv^2 \ + \ \frac{1}{2}mv^2 \ = \ mv^2$$

And the total energy of both the stars is :

$$= \ mv^2 \ + \ \frac{-GMM}{2r}$$

Using conservation of energy we get :

$$mv^2 + \frac{-GMM}{2r} = \frac{-GMM}{r}$$

or $$v^2 = GM\left(\frac{-1}{r} + \frac{1}{2R}\right)$$

or $$= 6.67 \times 10^{-11} \times 2 \times 10^{30}\left(\frac{-1}{10^{12}} + \frac{1}{2 \times 10^7}\right)$$

or $= 6.67 \times 10^{12}$

Thus the velocity is : $\sqrt{6.67 \times 10^{12}} = 2.58 \times 10^6\ m/s$

Q: 8.21 Two heavy spheres each of mass $100\ kg$ and radius $0.10\ m$ are placed $1.0\ m$ apart on a horizontal table. What is the gravitational force and potential at the mid point of the line joining the centres of the spheres? Is an object placed at that point in equilibrium? If so, is the equilibrium stable or unstable?

Answer:

Gravitational force at the midpoint will be zero. This is because both spheres are identical and their forces will be equal but opposite in direction.

The gravitational potential is given by :

$$= \frac{-GM}{\frac{r}{2}} - \frac{-GM}{\frac{r}{2}} = \frac{-4GM}{r}$$

$$= \frac{-4 \times 6.67 \times 10^{-11} \times 100}{1}$$

or $= -2.67 \times 10^{-8}\ J/Kg$

At the midpoint, we have equal forces in the opposite direction so it is in equilibrium but if we move the body slightly then the particle will move in one direction (as one force will be greater). So it is an unstable equilibrium.

NCERT solutions for class 11 physics chapter 8 gravitation additional exercise

Q: 8.22 As you have learnt in the text, a geostationary satellite orbits the earth at a height of nearly $36,000\ km$ from the surface of the earth. What is the potential due to earth's gravity at the site of this satellite? (Take the potential energy at infinity to be zero). Mass of the earth $= 6.0 \times 10^{24}\ kg$, radius $= 6400\ km$.

Answer:

Height of satellite from earth's surface : $3.6 \times 10^{7}\ m$

Gravitational potential is given by :

$$= \frac{-GM}{R\ +\ h}$$

or $$= \frac{-6.67 \times 10^{-11} \times 6 \times 10^{24}}{3.6 \times 10^{7}\ +\ 0.64 \times 10^{7}}$$

or $= -\ 9.4 \times 10^{6}\ J/Kg$

Thus potential due to earth gravity is $-\ 9.4 \times 10^{6}\ J/Kg$.

Q: 8.23 A star 2.5 times the mass of the sun and collapsed to a size of $12\ km$ rotates with a speed of 1.2 rev. per second. (Extremely compact stars of this kind are known as neutron stars.

Certain stellar objects called pulsars belong to this category). Will an object placed on its equator remain stuck to its surface due to gravity? (mass of the sun $= 2 \times 10^{30}\ kg$).

Answer:

A body will get stuck at the star's surface if the centrifugal force of star is less than the gravitational force.

The gravitational force is given by :

$$F_g = \frac{GMm}{r^2}$$

or $$= \frac{6.67 \times 10^{-11} \times 5 \times 10^{30} \times m}{(1.2 \times 10^4)^2} = 2.31 \times 10^{12}\ m\ N$$

The centrifugal force is given by :

$$F_c = mr\omega^2$$

or $= mr(2\pi v)^2 = m \times 1.2 \times 10^4 \times (2\pi \times 1.2)^2$

or $= 6.8 \times 10^5\ m\ N$

As we can see that the gravittional force is greater than the centrifugal force thus the body will remain at the star.

Q: 8.24 A spceship is stationed on Mars. How much energy must be expended on the spaceship to launch it out of the solar system? Mass of the space ship $= 1000\ kg$; mass of the sun $= 2 \times 10^{30}\ kg$; mass of mars $= 6.4 \times 10^{23}\ kg$; radius of mars $= 3395\ km$;radius of the orbit of mars $= 2.28 \times 10^8\ km$; $G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$

Answer:

Firstly, the potential energy of spaceship due to the sun is given by :

$$= \frac{-GMm_s}{r}$$

and the potential energy of spaceship due to mars is given by :

$$= \frac{-GMm_m}{R}$$

It is given that the spaceship is stationary so its kinetic energy is zero.

Thus the total energy of spaceship is :

$$= \frac{-GMm_s}{r} + \frac{-GMm_m}{R}$$

Thus the energy needed to launch the spaceship is :

$$= \frac{GMm_s}{r} + \frac{GMm_m}{R}$$

or

or $= 596.97 \times 10^9 \ J$

or $= 6 \times 10^{11} \ J$

Q: 8.25 A rocket is fired 'vertically' from the surface of mars with a speed of $2 \ km \ s^{-1}$. If 20% ??? of its initial energy is lost due to martian atmospheric resistance, how far will the rocket go from the surface of mars before returning to it? Mass of mars $= 6.4 \times 10^{23} \ kg$; radius of mars $= 3359 \ km$; $G = 6.67 \times 10^{-11} \ Nm^2kg^{-2}$.

Answer:

The kinetic energy of the rocket is (initial):-

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

And the initial potential energy is :

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

Thus total initial energy is given by :

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

Further, it is given that 20 per cent of kinetic energy is lost.

So the net initial energy is :

$$= 0.4mv^2 - \frac{GMm}{R}$$

The final energy is given by :

$$= \frac{GMm}{R + h}$$

Using the law of energy conservation we get :

$$0.4mv^2 - \frac{GMm}{R} = \frac{GMm}{R + h}$$

Solving the above equation we get :

$$h = \frac{R}{\frac{GM}{0.4v^2R} - 1}$$

or $$= \frac{0.4R^2v^2}{GM - 0.4v^2R}$$

or $= \dfrac{18.442 \times 10^{18}}{42.688 \times 10^{12} \; - \; 5.432 \times 10^{12}}$

or $= \; 495 \times 10^{3} \; m$

or $= \; 495 \; Km$

Thus the required distance is 495 Km.