PHYSICS

BOOKS - GK PUBLICATIONS PHYSICS (HINGLISH)

GRAVITATION

Illustrative Example

1. Three points A , B and C each of mass are placed in a line with AB=BC=d. Find the gravitational force on a fourth particle P of same mass placed at a distance d from the particle B on the perpendicular bisector of the line AC.

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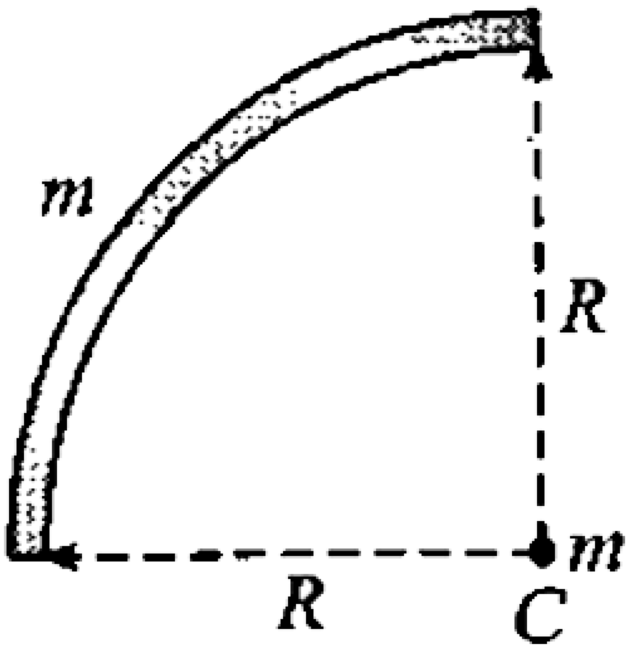
2. Find the force of attraction on a particle of mass m placed at the centre of a quarter ring of mass mand radius R as shown in figure.



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3. Two balls of mass m each are hung side by side by side by two long threads of equal

length l. If the distance between upper ends is r, show that the distance r' between the centres of the ball is given by $gr'^2(r-r')=2lGm$

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4. A ring of radius R is made from a thin wire of radius r. If ρ is the density of the material of wire then what will be the gravitational force exerted by the ring on the material particle of mass m placed on the axis of ring of ring at a distance x from its centre. Shown that the force will be maximum when $x = R / \sqrt{2}$ and the maximum value of force will be given as

$$F_{\max} = \frac{4\pi^2 G r^2 \rho m}{(3)^{3/2} R^2}$$

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5. Find the distance of a point from the earth's centre where the resultant gravitational field due to the earth and the moon is zero. The mass of the earth is $6.0 \times 10^{24} kg$ and that of the moon is $7.4 \times 10^{22} kg$. The distance between the earth and the moon is $4.0 \times 10^5 km$.

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6. A uniform ring of mas m and radius a is placed directly above a uniform sphere of mass M and of equal radius. The centre of the ring is at a distance $\sqrt{3}$ a from the centre of the sphere. Find the gravitational force exerted by the sphere on the ring.

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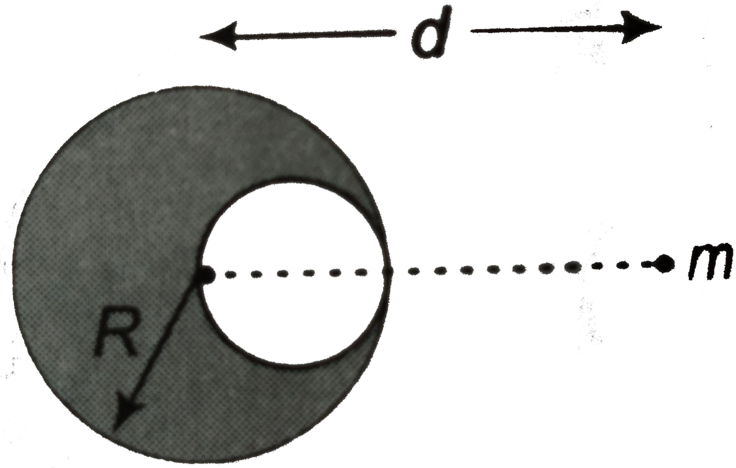
7. Figure shows a spherical cavity inside a lead sphere. The surface of the cavity passes through the centre of the sphere and touches the right side of the sphere. The mass of the sphere before hollowing was M. With what gravitational force does the hollowed out lead sphere attract a particle of mass m that lies at a distance d from the centre of the lead sphere on the straight line connecting the centres of the spheres and of the cavity.



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8. A uniform solid sphere of mass M and radius a is surrounded symmetrically by a uniform thin spherical shell of equal mass and radius 2a. Find the gravitational field at a distance a).

3/2 a from the centre , b). 5/2 as from the centre.

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9. The small dense stars rotate about their common centre of mass as a binary system, each with a period of 1 year. One star has mass double than that of the other, while mass of the lighter star is one-third the mass of the Sun. The distance between the two stars is r

and the distance of the earth from the Sun is R, find the relation between r and R.

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10. Calculate mass of earth taking it to ne a sphere of radius 6400 km. given $g = 9.8 m/s^2$ and $G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$

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11. If the radius of the earth were to shrink by one percent its mass remaining the same, the acceleration due to greavity on the earth's surface would

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12. At what rate should the earth rotate so that the apparent g at the equator becomes zero? What will be the length of the day in this situation?

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13. Two equal masses each in are hung from a balance whose scale pans differ in vertical height by h. The error in weighing in terms of density of the earth ρ is

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14. Calculate the apparent weight of a body of mass m at a latitude λ when it is moving with speed v on the surface of the earth from west to east at the same latitude.

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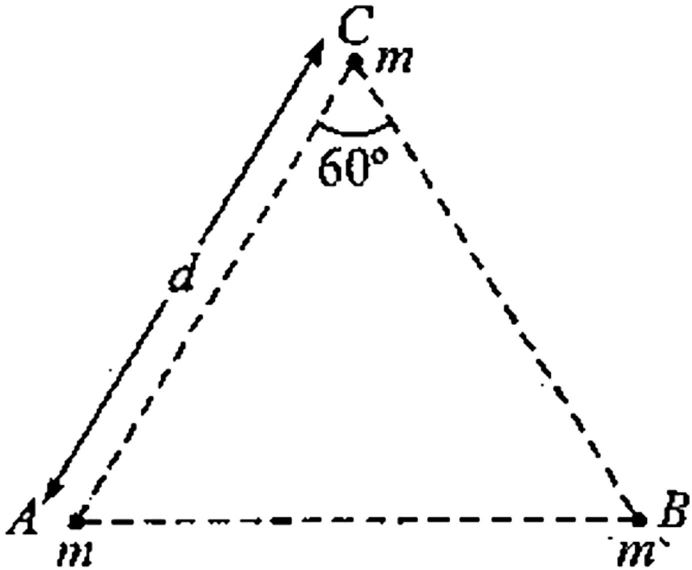
15. Three particle each of mass m are placed at the corners of an equilateral at the corners of an equilateral triangle of side d as shown in figure. Calculate (a) the potential energy of the system, (b) work done on this system if the side of the traingle is changed from d to 2d.



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16. Two particles m_1 and m_2 are initially at rest

at infinite distance. Find their relative velocity of approach due to gravitational attraction when their separation is d.

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17. Two particles A and B of masses 1 kg and 2 kg respectively are kept 1 m apart and are released to move under mutual attraction. Find The speed A when that of B is 3.6 cm/hour. What is the separation between the particles at this instant?

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18. Find work done in shifting a body of mass m from a height h above the earth's surface to a height 2h above the earth's surface.

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19. A circular ring of mass M and radius R is placed in YZ plane with centre at origin. A particle of mass m is released from rest at a point x = 2R. Find the speed with which it will pass the centre of ring .

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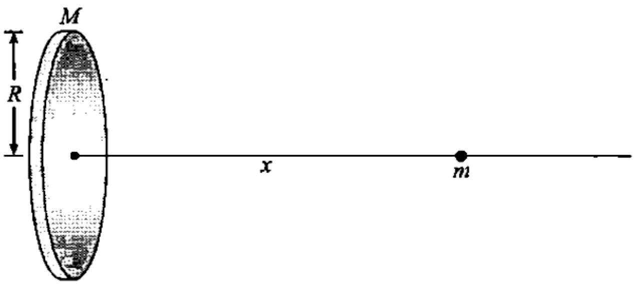
20. Find the gravitational interaction energy of system consisting of a disc of mass M, radius R and a small mass m dituated at a distance x from disc centre on its axis as shown in figure.



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21. A small mass m is transferred from the centre of a hollow sphere of mass M to infinity. Find work done in the process. Compare this with the situation if instead of a hollow sphere, a solid sphere of same mass were there.

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22. Given a thin homogenous disc of radius a and mass m_1. A particle of mass m_2 is placed at a distance l from the disc on it's axis of symmetry. Initially both are motionless in free space but they ultimately collide because of gravitational attraction. find the relative velocity at the time of collision. assume $a < < 1$.

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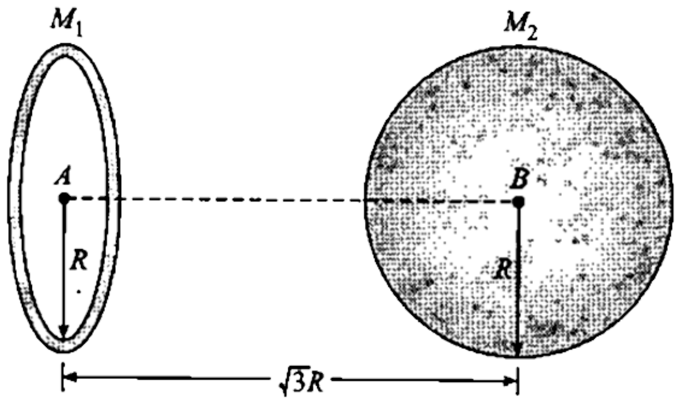
23. Figure. Shown a ring of mass M_1 ans a sphere of mass M_2 separated by a distance $\sqrt{3}R$. A small object of mass m is displaced from A to B. Find the work done by gravitational forces.



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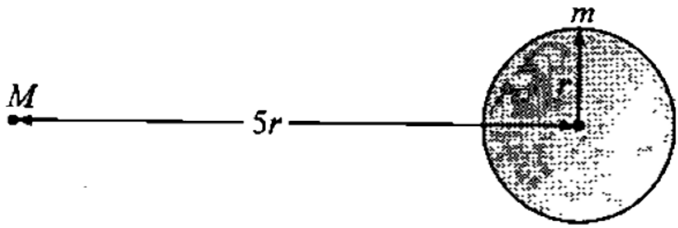
24. A solid sphere of mass m and radius r initially placed at a distance 5r from the centre of a point mass M as shown in figure. Now During displacement, it is also uniformly expanded to a radius 2 r so that its density decreases uniformly throughout its volume. Find the work required in this process.



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25. A particle of mass m was transferred from the centre of the base of a uniform hemisphere of mass M and radius R into infinity.

What work was performed in the process by the gravitational force exerted on the particle by the hemisphere?

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26. On the pole of the Earth a body is imparted velocity v_0 directed vertically up. Knowing the radius of the Earth and the free-fall acceleration on its surface, find the height to which the body will ascend. The air drag is to be neglected.

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27. Estimate the mass of the sun, assuming the orbit of Earth around the sun to be a circle. The distance between the sun and the Earth is $1.49 \times 10^{11} m$, and $G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$.

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28. If Earth be at one half its present distance from the sun, how many days will there be in a year?

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29. An artificial satellite of the earth is to be established in the equatorial plane of the earth and to an observer at the equator it is required that the satellite will move eastward, completing one round trip per day. The distance of the satellite from the centre of the earth will be - (The mass of the earth is

6.00×10^{24} kg and its angular velocity = 7.30×10^{-5} rad/sec.)

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30. A satellite revolving in a circular equatorial orbit of radius $R = 2.0 \times 10^4$ km from west to east appears over a certain point at the equator every $11.6h$. From these data, calculate the mass of the earth. $(G = 6.67 \times 10^{-11} Nm^2)$

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31. An artificial satellite is describing an eqatorial orbit at 1600 km above the surface of the earth. Calculate its orbital speed and the period of revolution. If the satellite is travelling in the same direction as the rotateion of the earth (i.e., from west to east), calculate the interval between two successive times at which it will appear vertically overhead to an observer at a fixed point on the equator. Radius of earth = 6400km.

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32. A satellite of mass m is in a circular orbit of radius r round the Earth. Calculate its angular momentum with respect to the centre of the orbit in terms of the mass M of the Earth and G.

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33. A satellite ils launched into a circular orbit $1600km$ above the surface of the earth. Find the period of revolution if the radius of the earth is $R = 6400 km$ and the acceleration due to gravity is $9.8 ms^{-2}$. At what height from the ground should it be launched so that it may appear stationary over a point on the earth's equator?

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34. Two Earth's satellites move in a common plane along circular orbits. The orbital radius of one satellite $r = 700 km$ while that of the other satellite is $\Delta r = 70 km$ less. What time interval separates the periodic approaches of the satellites to each other over the minimum distance?

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35. The moon revolves round the earth 13 times in one year. If the ratio of sun-earth distance to earth-moon distance is 392, then the ratio of masses of sun and earth will be

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36. A satelite revolves around a planet in an elliptical orbit. Its maximum and minimum distances from the planet are 1.5×10^7 m and 0.5×10^7 m respectively. If the speed of the satellite at the farthest point be 5×10^3 m/s, calculate the speed at the nearest point.

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37. Imagine a light planet revolving around a very massive star in a circular orbit of radius r with a period of revolution T. On what power of r will the square of time period will depend if the gravitational force of attraction between the planet and the star is proportional to $r^{-5/2}$.

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38. A meteorite approaching a planet of mass M (in the straight line passing through the centre of the planet) collides with an automatic space station orbiting the planet in a circular trajectory of radius R. The mass of the station is ten times as large as the mass of the meteorite. As a result of the collision, the meteorite sticks in the station which goes over to a new orbit with the minimum distance R/2 from the planet. Speed of the meteorite just before it collides with the planet is : .

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39. Halley's comet has a period of 76 years and in the year 1986, had a distance of closest approach to the sun equal to 8.9×10^{-10} m.

What is the comet's farthest distance from the sun if the mass of sun is 2×10^{30}kg and $G = 6.67 \times 10^{-11}$ MKS units?

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40. A satellite is revolving round the earth in a circular orbit of radius r and velocity v_0. A particle is projected from the satellite in forward direction with relative velocity $v = \left(\sqrt{5/4} - 1\right)v_0$. Calculate its minimum and maximum distances from earth's centre during subsequent motion of the particle.

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41. A sky lab of mass $2 \times 10^3 kg$ is first launched from the surface of earth in a circular orbit of radius $2R$ and then it is shifted from this circular orbit to another circular orbit of radius $3R$. Calculate the energy required

(a) to place the lab in the first orbit,

(b) to shift the lab from first orbit to the second orbit. $(R = 6400km, g = 10m/s^2)$

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42. If a satellite is revolving around a planet of mass M in an elliptical orbit of semi-major axis a. Show that the orbital speed of the satellite when it is a distance r from the focus will be given by

$$v^2 = GM\left[\frac{2}{r} - \frac{1}{a}\right]$$

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43. A planet of mass m moves along an ellipse around the sun so that its maximum and minimum distance from the sun are equal to r_1 and r_2 respectively. Find the angular momentum of this planet relative to the centre of the sun. mass of the sun is M.

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44. A planet A moves along an elliptical orbit around the Sun. At the moment when it was at the distance r_0 from the Sun its velocity was equal to v_0 and the angle between the radius vector r_0 and the velocity vector v_0 was equal to α. Find the maximum and minimum distances that will separate this planet from the Sun during its orbital motion.

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45. A spaceship is launched into a circular orbit close to the earth's surface . What additional velocity has now to be imparted to the spaceship in the orbit to overcome the gravitational pull. Radius of earth $= 6400 km$, $g = 9.8 m / s^2$.

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46. A spaceship approaches the Moon (mass $= M$ and radius $= R$ along a parabolic path which is almost tangential to its surface. At the moment of the maximum approach, the brake rocket is fired to convert the spaceship into a satellite of the Moon. Find the change in speed.

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47. A particle is fired verticaly upward with a speed of 9.8 kms^{-1}. Find the maximum height attained by the particle. Radius of earth =6400 k,m and g at the surface $= 9.8 ms^2$. Consider only earth's gravitation.

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48. A satellite of mass M_S is orbitting the earth in a circular orbit of radius R_S. It starts losing energy slowly at a constant rate C due to friction if M_e and R_e denote the mass and radius of the earth respectively show that the satellite falls on the earth in a limit time t given by $t = \frac{GM_SM_e}{2C}\left(\frac{1}{R_e} - \frac{1}{R_S}\right)$

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49. An artificial satellite is moving in a circular orbit around the earth with a speed equal to half the magnitude of escape velocity from the earth.

(i) Determine the height of the satellite above the earth's surface.

(ii) If the satellite is stopped suddenly in its orbit and allowed to fall freely onto the earth, find the speed with which it hits the surface of the earth.

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50. An artificial satellite (mass m) of a planet (mass M) revolves in a circular orbit whose radius is n times the radius R of the planet in the process of motion the satellite experiences a slight resistance due to cosmic dust. Assuming the force of resistance on satellite to depend on velocity as $F = av^2$ where 'a' is a constant caculate how long the satellite will stay in the space before it falls on to the planet's surface.

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51. A satellite is revolving around the earth in an orbit of radius double that of the parking orbit and revolving in same sense. Find the periodic time duration between two instants when this satellite is closest to a geostationary satellite.

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52. find the minimum coaltitude which can directly receive a signal from a geostationary satellite.

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53. a.Find the radius of the circular orbit of a satellite moving with an angular speed equal to the angular speed of earth\'s rotation. b). If the satellite is directly above the north pole at some instant find the time it takes to come over the equatorial plane. Mass of the earth $= 6 \times 10^{24} kg$

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54. A satellite is orbiting around the earth in an orbitin equatorial plane of radius $2R_e$ where R_e is the radius of earth. Find the area on earth, this satellite covers for communication purpose in its complete revolution.

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Particle Exercise

1. Two spherical balls of mass 10 kg each are placed 10 cm apart. Find the gravitational force of attraction between them.

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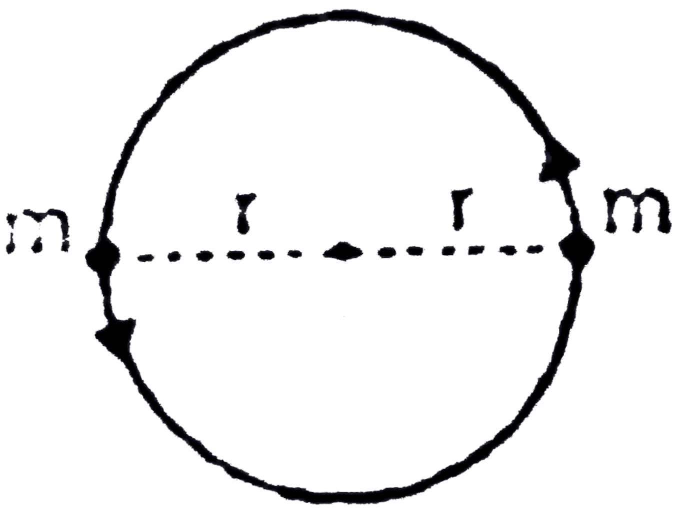

2.

Two particles of equal mass (m) each move in a circle of radius (r) under the action of their mutual gravitational attraction find the speed of each particle.

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3. For particles of equal masses M that move along a circle of radius R under the action of their mutual gravitational attraction. Find the speed of each particle.

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4. Mass M is split into two parts m and $(M-m)$, which are then separated by a certain distance. What is the ratio of (m/M) which maximises the gravitational force between the parts ?

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5. In a double star, two stars (one of mass m and the other of mass $2m$) distance d apart rotate about their common centre of mass., Deduce an expressioin for the period of revolution. Show that te ratio of their angular momenta about the centre of mass is the same as the ratio of their kinetic energies.

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6. Two concentric spherical shells have masses m_1, m_2 and radii R_1,R_2($R_1 < R_2$). Calculate the force by this system on a particle of mass m, if it is placed at a distance $\frac{(R_1 + R_2)}{2}$ from the centre.

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7. The distance between the centres of the Moon and the earth is D. The mass of the earth is 81 times the mass of the Moon. At what distance from the centre of the earth, the gravitational force will be zero?

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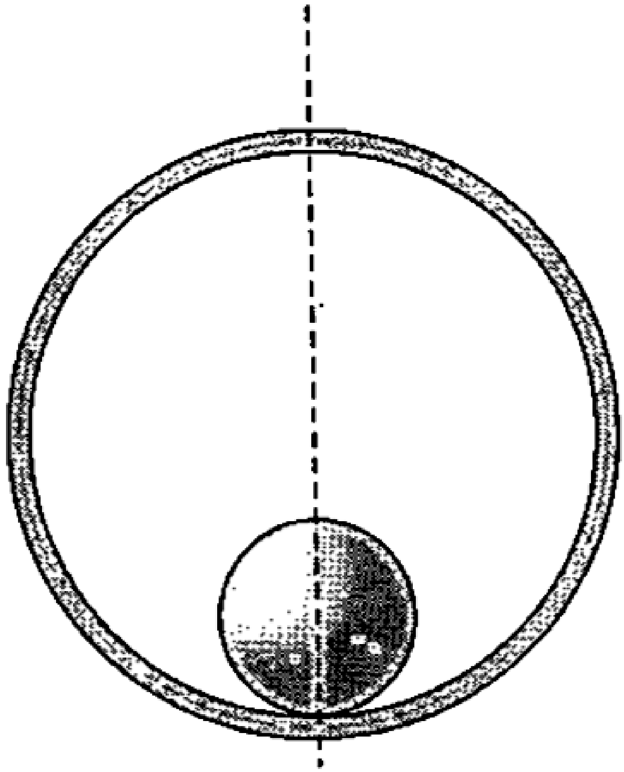
8. A solid sphere of mass m and radius r is placed inside a hollow thin spherical shell of mass M and radius R as shown in figure-6.30.

A particle of mass m' is placed on the line joining the two centres at a distance x from the point of contact of the sphere and the shell. Find the magnitude of the resultant gravitational force on this - particle due to the sphere and the shell if (a)

$r < x < 2r, (b) 2r < x < 2R \text{ and } (c) x > 2R.$



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9. The gravitational field in a region is given by $\left(2\hat{i}+2\hat{j}\right)$ N/kg. What is the work done by an external agent in slowly shifting a particle of mass 10 kg from origin to point (5,4).

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10. Inside a uniform sphere of density ρ there is a spherical cavity whose centre is at a distance l from the centre of the sphere. Find the strength of the gravitational field inside the cavity.

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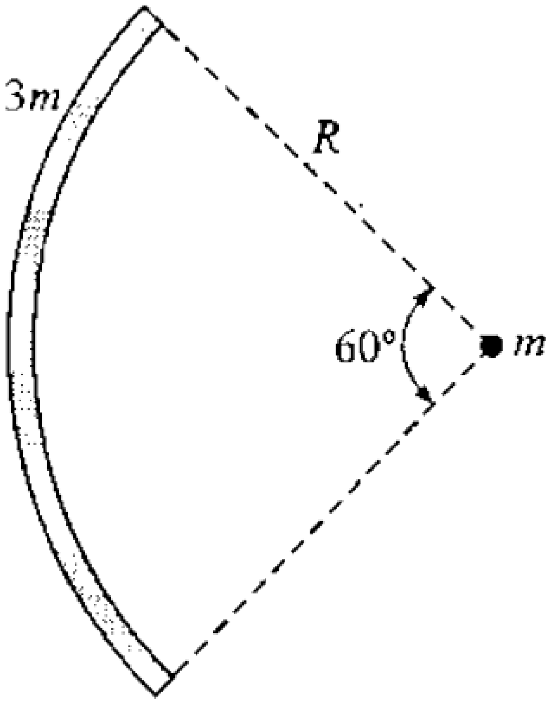
11. A small point mass m is placed at the centre of curvature of acircular are of radius R and mass 3 m as shown in figure-6.31. Find the net gravitational force acting on the point mass.



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12. A small point mass m is to be thrown with such a speed at a distance x from the axis of a long cylinder of radius R and density ρ, so that m starts revolving around the cylinder in a circular orbit of radius x with centre on the axis of cylinder. Find the speed with which point mass is thrown.

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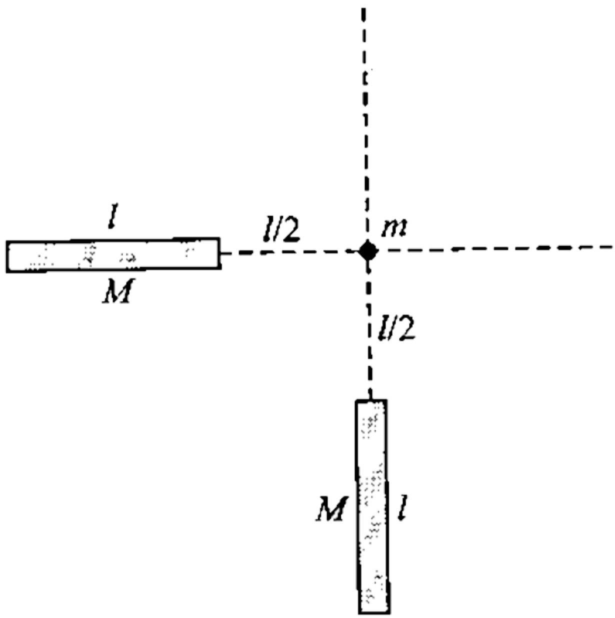
13. Figure shows two uniform rods of mass M and length l placed on two perpendicular lines. A small point mass m is placed on the point of intersection of the two lines. Find the net gravitational force experienced by m.



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14. What will be acceleration due to gravity on the surface of the moon if its radius were

$(1/4)^{th}$ the radius of earth and its mass $(1/80)^{th}$ the mass of earth? What will be the escape velocity on the surface of moon if it is $11.2 km/s$ on the surface of the earth? (given that $g = 9.8 m/s^2$)

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15. The diameter of a planet is four times that of the earth. Find the time period of a pendulum on the planet, if it is a second pendulum on the earth. Take the mean density of the planet equal to that of the earth,

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16. Imagine a new planet having the same density as that of earth but 3 times bigger than the earth in size. If the acceleration due to gravity on the surface of earth is g and that on the new plane is g, then :

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17. Weight fo a body of a mass m decreases by 1% when it is raised to height h above the earth's surface. If the body is taken to depth h in a mine, change in its weight is

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18. A tunnel is dug along a chord of the earth. a perpendicular distance $\frac{R}{2}$ from the earth\'s centre is dropped. The wall of the tunnel may be assumed to be frictionless. Find the force exerted by the wall on a particle of mass m when it is at a distance x from the centre of the tunnel.

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19. Find the height over the earth\'s surface at which the weight of a body becomes half of its value at the surface.

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20. A body is weighted by a spring balance to be 1.000 kg at the north pole. How much will it weight at the equator. Account for the earth\'s rotation only.

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21. A body suspended on a spring balance in a ship weighs W_0 when the ship is at rest. When the ship begins to move along the equator with a speed v, show that the scale reading is very close to $W_0(1 \pm 2\omega V / g)$, where ω is the angular speed of the earth.

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22. The kinetic energy needed to project a body of mass m from the eath surface (radus R) to infinity is

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23. How much work is done in circulating a small object of mass m around a sphere of mass m in a circle of radius R.

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24. Distance between the centres of two stars is 10α. The masses of these stars are M and 16M and their radii a and 2a, respectively. A body of mass m is fired straight form the surface of the larger star towards the smaller star. What should be its minimum inital speed to reach the surface of the smaller star? Obtain the expression in terms of G,M and a.

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25. Find the gravitational potential due to a hemispherical cup of mass M and radius R, at its centre of curvature.

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26. Two particle each of mass M are fixed at positions (0, a) and $(0, \ -a)$. Another particle of mass $M/2$ is thrown from origin along + z axis so that it is just able to reach a point $(0, 0, 2\sqrt{3}a)$. Find the soeed with which it was projrcted.

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27. The gravitational field in a region is given by $E = \left(2\hat{i} + 3\hat{j}\right)N/kg.$

Find the work done by the gravitational field when a particle of mass $1kg$ is moved on the line $3y + 2x = 5$ from $(1m, 1m)$ to $(-2m, 3m)$.

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28. Find the gravitational potential energy of a system consisting of a uniform rod AB of mass M, length l and a point mass m as shown in figure.

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29. Two satellites A and B of the same mass are orbiting the earth at altitudes R and $3R$ respectively, where R is the radius of the earth. Taking their orbit to be circular obtain the ratios of their kinetic and potential energies.

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30. As satellite of mass 1000 kg is supposed to orbit the earth at a height of 2000 km above the earth\'s surface. Find a). its speed in the orbit b). its kinetic energy. c). The potential energy of the earth satelilte system and d). its time period. Mass of the earth $= 6 \times 10^{24} kg$.

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31. A satellite is to revolve around the earth in a circle of radius 8000 km. With what speed should this satellite be projected into orbit? What will be the time period?

Take g at the surface $= 9.8ms^{-2}$ and radius of the earth =6400 km.

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32. Assume the radius of the earth to be

$6.4 \times 10^6 m$

a. Calculate the time period T of a satellite on equational orbit at $1.4 \times 10^{e} m$ above the surface of the earth.

b. What is the speed of the satellite in this orbit?

c. If the satellite is travelling in the same direction as the rotation of the earth i.e. west to east, what is the interval between two successie times at which it will appear vertically overhead to an observed at a fixed point on the equator?

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33. A satellite of mass $2 \times 10^3 kg$ has to be shifted from an orbit of radius 2R to another of radius 3R, where R is the radius of the earth. Calculate the minimum energy required. Take mass of earth $= 6 \times 10^{24} kg$, radius of earth $= 6.4 \times 10^6 m.$

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34. A double star is a system of two starts moving around the centre of inertia of the system due to gravitation. Find the distance between the components of the double star, if its total mass equals M and the period of revolution T.

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35. If a planet was suddenly stopped in its orbit supposed to be circular, show that it would fall onto the sun in a time $\frac{\sqrt{2}}{8}$ times the period of the plant's revolution.

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36. A particle takes a time t_1 to move down a straight tunnel from the surface of earth to its centre. If gravity were to remain constant this time would be t_2 calculate the ratio $\frac{t_1}{t_2}$

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37. A planet of mass M moves around the Sun along an ellipse so that its minimum distance from the Sun is equal to r and the maximum distance to R. Making use of Kepler's laws, find its period of revolution around the Sun.

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38. Suppose we have made a model of the Solar system scaled down in the ratio η but of materials of the same mean density as the actual materials of the planets and the Sun. How will the orbital periods of revolution of planetary models change in this case?

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39. Two Earth's satellites move in a common plane along circular orbits. The orbital radius of one satellite $r = 700 km$ while that of the other satellite is $\Delta r = 70 km$ less. What time interval separates the periodic approaches of the satellites to each other over the minimum distance?

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40. A satellite is put in an orbit just above the earth's atmosphere with a velocity $\sqrt{1.5}$ times the velocity for a circular orbit at the that height. The initial velocity imparted is horizontal. What would be the maximum distance of the satellite from the earth, when it is in the orbit.

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41. A cosmic body A moves to the sun with velocity v_0(when far from the sun) and aiming parameter l, the arm of the vector v_0, relative to the centre of the sun. find the minimum distance by which this body will get to the sun. mass of the sum is M.

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42. Two satellites S_1 and S_2 revolve round a planet in coplaner circular orbit in the same sense. Their period of revolution are 1 hour and 8 hour respectively. The radius of the orbit of S_1 is $10^4 km$. When S_2 is closest to S_1, find

(a) The speed of S_2 relative to S_1,

(b) The angular speed of S_2 actually observed by an astronaut is S_1

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43. If a planet revolve around the sun in an elliptical orbit such that its minimum distance from sun is r_1 and maximum distance is r_2.

Find the distance of planet from sun when it is at a position where the line joining the planet and sun is perpendicular to the major axis of ellipse.

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44. For a low altitude orbit if $r \cong r_p$, where r_p is planet radius, show that for a given average planetary density, the orbital period of satellite is independent of the size of the planet. Calculate its value average density is ρ.

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45. What should be the orbit radius of a communication satellite that it can cover 75% of the surface area of earth during its revolution.

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46. The radius of a planet is $R_1$and a satellite revolves round it in a circle of radius R_2. The time period of revolution is T. find the acceleration due to the gravitational force of the plane at its surface.

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47. The small dense stars rotate about their common centre of mass as a binary system, each with a period of 1 year. One star has mass double than that of the other, while mass of the lighter star is one-third the mass of the Sun. The distance between the two stars is r

and the distance of the earth from the Sun is R, find the relation between r and R.

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48. An artificial satellite is moving in a circular orbit around the earth with a speed of equal to half the magnitude of escape velocity from earth.

(i). Determine the height of the satellite above the earth's surface

(ii). If the satellite is stopped suddenly in its orbit and allowed to fall freely on the earth. Find the speed with it hits and surface of earth. Given `M="mass of earth & R "="Radius of earth"

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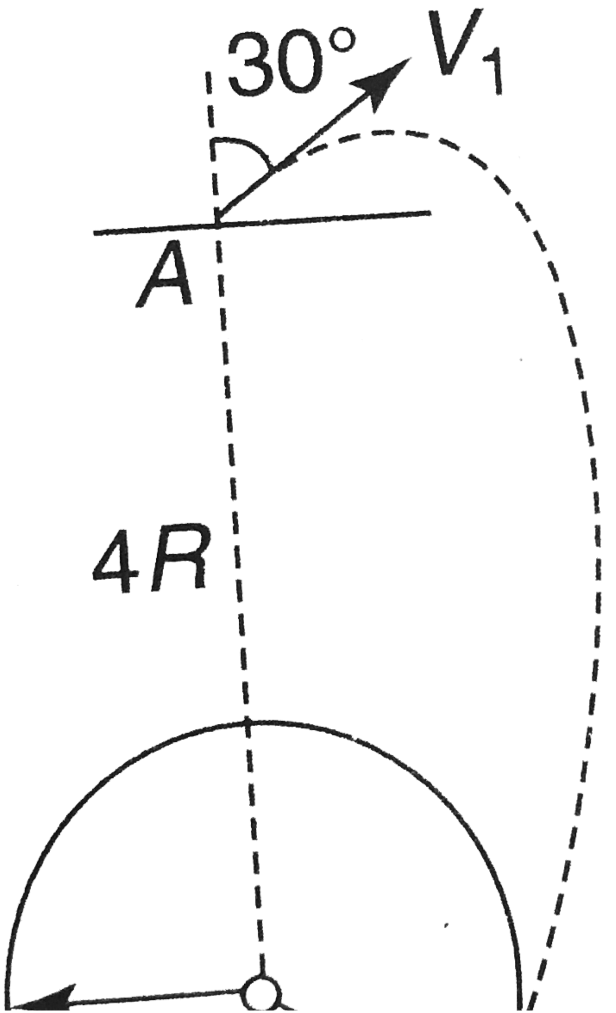
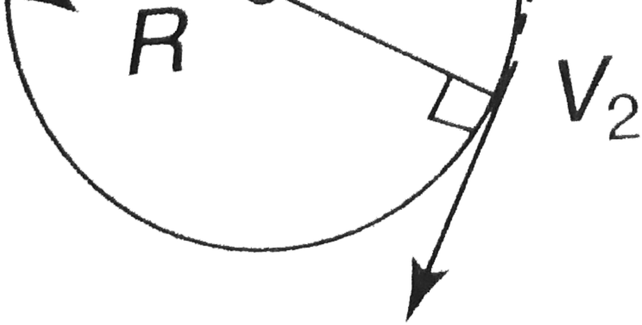
49. A particle is projected from point A, that is at a distance $4R$ form the centre of the earth, with speed V_1 in a direction making 30° with the line joining the centre of the earth and point A, as shown. Consider gravitational interaction only between thesetwo. (Use $\frac{GM}{R} = 6.4 \times 10^7 m^2 / s^2$). The speed V_1 if particle pasess grazing the surface of the earth is





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50. A mass of $6 \times 10^{24} kg$ is to be compressed in a sphere in such a way that the escape velocity from its surface is $3 \times 10^{8} m / s$. Find the radius of the sphere (in mm).

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Discussion Qns

1. The Sun's tide-raising power is only half as great as that of the Moon. The direct pull of the Sun on the earth, however, is about 175 times that of the Moon. Why is it then that the Moon causes larger tides?

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2. At noon, the sun and the earth pull the objects on the earth's surface in opposite directions. At midnight, the sun and the earth pull these objects in same direction. Is the weight of an object as measured by a spring balance on the earth's surface , more at midnight as compared to its weight as noon?

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3. As measured by an observer on the earth, be any difference in the periods of two satellites, each in a circular orbit near the earth in an equatorial Plane but one moving eastward and the other westward?

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4. Does a rocket really need the escape speed of $11.2 km/s$ initially to escape from the Earth?

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5. If an artificial statellite is orbiting the earth, it it possible for the plane of the orbit to not pass through the center of the earth? On what property of the gravitational force is your answer based?

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6. If a planet of given density were made larger, its force of attraction for an object on its surface would increase because of the greater distance from the object to the centre of the planet. Which effect predominates?

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7. An astronaut orbiting the earth in a circular orbit $120km$ above the surface of earth, gently drops a spoon out of space-ship. The spoon will

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8. Can two particles be in equilibrium under the action of their mutual gravitational force? Can three particle be? Can one of the three particles be?

Watch Video Solution

9. If the gravitational force on an object depends linearly on its mass, why is the accleration of a freely falling object independent of its mass?

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10. A satellite revolves around the earth in a circular orbit. What will happen to its orbit if universal gravitational constant start decreasing with time.

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11. Gravitational force acts on all objects in properties to their masses. Why then, a heavy object does not fall faster than a light object?

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12. The weight of an object is more at the poles than at the equator. Is it beneficial to purchase goods at equator and sell them at the pole? Does it matter whether a spring balance is used or an equal beam balance is used?

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13. Objects at rest on the earth's surface move in circular paths with a period of $24h$. Are they in 'orbit' in the sense that an earth satellite is in orbit? Explain.

Watch Video Solution

14. A satellite is revolving around a planet in a circular orbit. What will happen, if its speed is increased from v_0 to

(a) $\sqrt{1.5}v_0$ (b) $2v_0$

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15. Because the earth bulges near the equator, the source of Mississippi River, althorugh high above sea level, is nearer to the centre of the earth than its month. How can a river flow $'u\phi ll'$?

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16. The astronauts in a satellite orbiting the Earth feel weightlessness. Does the weightlessness depend upon the distance of the satellite from the Earth ? If so how ? Explain your answer.

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17. The total energy of the earth + Sun system is negative. How do you interpret the negative energy of a system?

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18. Two air bubbles with radius r are present in water. Are these bubbles attracted or repelled?

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19. Suppose an earth satellite, revolving in a circular orbit experiences a resistance due to cosmic dust. Then

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20. Objects at rest on the earth's surface move in circular paths with a period of $24h$. Are they in 'orbit' in the sense that an earth satellite is in orbit? Explain.

Watch Video Solution

21. When a train moves from west to east at high speed, does its wight incrase or decrease?

Watch Video Solution

22. A spacecraft spins about its axis. What would be the feeling of an astronaut inside it?

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23. Can a satellite move in a stable orbit in a plane not passing through the earth's centre ? Explain.

Watch Video Solution

24. An apple falls from a tree. An insect in the apple finds that the earth is falling towards it with an acceleration g. Who exerts the force needed to accelerate the earth with this acceleration?

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25. A spacecraft consumes more fuel in going the earth to moon than it takes for a return trip. Comment on this statement.

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26. The planet Egabbac (in another solar system) has a radius twice that of the earth's but an average mass density which is the same as the earth. Would the weight of an object on Egabbac's surface to be the same as on the earth's greater than on the earth's or less than on the earth's ? If greater or less than on the earth's then by how much?

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27. As measured by an observer on the earth, be any difference in the periods of two satellites, each in a circular orbit near the earth in an equatorial Plane but one moving eastward and the other westward?

Watch Video Solution

28. Can a satellite move in a stable orbit in a plane not passing through the earth's centre ? Explain.

Watch Video Solution

29. What will happen to an orbiting planet if all a sudden (a) it comes to stand still in the orbit (b) the gravitational force caases to act on it?

Watch Video Solution

30. Describe the way the mass of an astronaut and the gravitational force on the astronaut very during a trip from the earth to the moon.

Watch Video Solution

31. Describe the way the mass of an astronaut and the gravitational force on the astronaut very during a trip from the earth to the moon.

Watch Video Solution

Concetual Mcq

1. If the gravitational force were potential to $\frac{1}{r}$, then a particle in a circular orbit under such a force would have its original speed:

A. Indepdent of r

B. $\propto \frac{1}{r}$

C. $\propto \frac{1}{r^2}$

D. $\propto r^2$

Answer: A

Watch Video Solution

2. The ratio of accleration due to gravity at a depth h below the surface of earth and at a height h above the surface of earth for h $<<$ radius of earth:

A. Is constant

B. Changes linearly with h

C. Changes parabolically with h

D. Decreases

Answer: B

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3. A uniform spherical shell gradually shrinks maintainig its shape. The gravitational potential at the centre

A. Increases

B. Decreases

C. Remains consatant

D. Oscillates

Answer: B

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4. If both the mass and radius of the earth decrease by 1% the value of

A. 1% decrease

B. 1.5% increase

C. 1% increase

D. 2% decrease

Answer: C

Watch Video Solution

5. Escape velocity on a planet is e v . If radius of the planet remains same and mass becomes 4 times, the escape velocity becomes

A. Be doubled

B. Be halved

C. Be tripled

D. Not change

Answer: D

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6. The magnitude of gravitational potential energy of the moon earth system is U with zero potential energy at infinite separation. The kinetic energy of the moon with respect to the earth is K.

A. $K = 2U$

B. $K = \frac{U}{2}$

C. $K = U$

D. $K = 4U$

Answer: B

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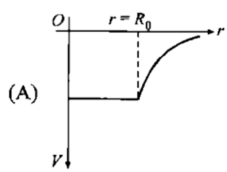
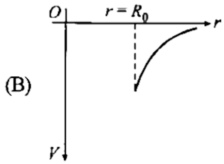
7. P is a point at a distance r from the centre of a solid sphere of radius a. The gravitational potential at P is V. IF V is plotted as a function of r, which is the correct curve ?

A. 



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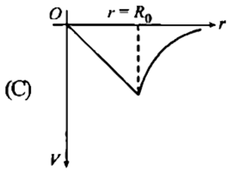
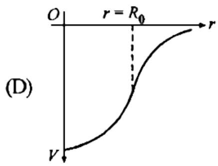


C.



D.

Answer: D

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8. A system consits of n identical particles each of mass m. The total number of interactions between particles possible are :

A. $n(n+1)$

B. $\frac{1}{2}n(n+1)$

C. $n(n-1)$

D. $\frac{1}{2}n(n-1)$

Answer: D

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9. A satellite going round the earth in a circular orbit loses some energy due to a collision. Its speed is v and distance from the earth is d.

A. Velocity increases and distance decreases

B. Both velocity and distance increase

C. Both velocity and distance decrease

D. Velocity decreases and distance increases

Answer: A

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10. A particle on earth's surface is given a velocity euqal to its escape velocity. Its total mechanical energy with zero potential energy reference at infinite separation will be:

A. Negative

B. Positive

C. Zero

D. Infinite

Answer: C

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11. If the gravitational potential energy of a body at a distance r from the centre of the earth is U, then it's weight at that point is

A. Ur

B. $\frac{U}{r}$

C. Ur^2

D. Ur^3

Answer: B

Watch Video Solution

12. A thin spherical shell of mass M and radius R has a small hole. A particle of mass m released at its mouth. Then

A. The particle wil execute simple harmonic motion inside the shell

B. The particle will oscillate inside the shell, but the oscillations are not simple harmonic

C. The particle will not oscillate, but the speed of the particle will go on increasing

D. None of these

Answer: D

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13. Two identical trains A and B move with equal speeds on parallel tracks along the equator. A moves from east to west and B moves from west to east. Which train will exert greater force on the track?

A. Train P exerts greater force on tracks

B. Train Q exerts greater force on tracks

C. Both exert euqal force on track

D. Data is insufficient to arrive at a conclusion

Answer: A

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14. Two satellites A and B of the same mass are orbiting the earth at altitudes R and $3R$ respectively, where R is the radius of the earth. Taking their orbit to be circular obtain the ratios of their kinetic and potential energies.

A. $2:1$

B. $1:2$

C. $3:1$

D. $2:3$

Answer: B

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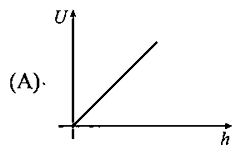
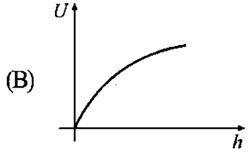
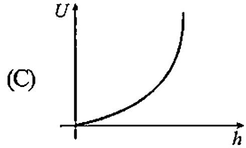
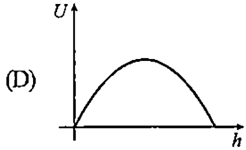
15. A particle of mass an charge q is projected vertically upwards .A uniform electric field $\overrightarrow{E}$ is acted vertically downwards.The most appropriate graph between potential energy U (gravitation plus electrostatic) and height h($< <$ radius of earth) is :(assume U to be zero on surface of earth)

A. 

B. 

C. 

D. 

Answer: A

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16. A satellite is to be stationed in an orbit such that it can be used for relay purpose (such a satellite is called a Geostationary satellite). The conditions such a satellite should fulfill is/are :

A. Its orbit must lie in equatorial plane.

B. Its sense of rotation must be from east to west

C. Its orbital raius must be $44900km$.

D. It orbital must be elliptical

Answer: A

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17. Consider a planet in some solar system which has a mass double the mass of the earth and density equal to the average density of the earth. An object weighing W on the earth will weigh

A. W

B. 2W

C. $W/2$

D. $2^{1/3}W$

Answer: D

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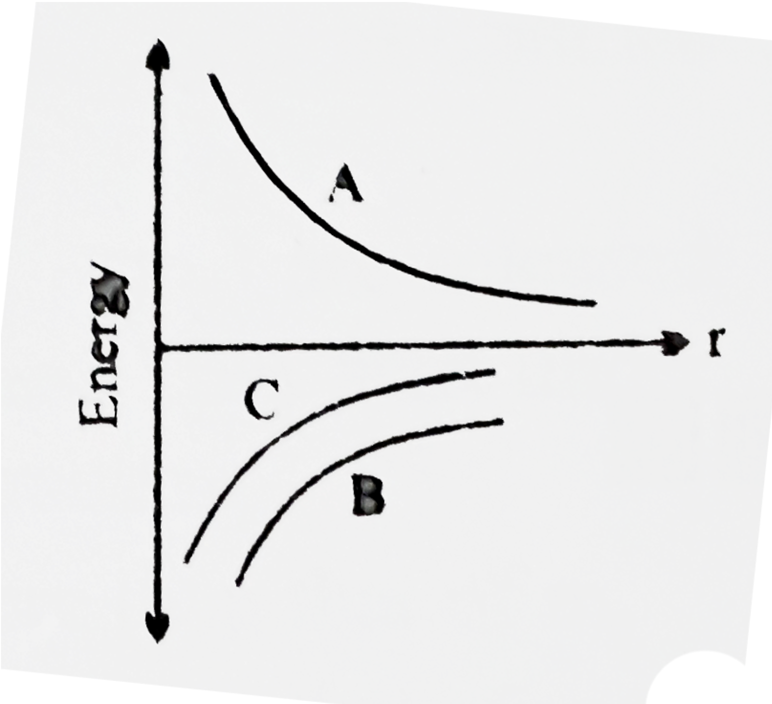
18. The figure shows the variation of energy with the orbit radius of a body in circular planetary motion. Find the correct statements about the curves A, B and C



A. C shows the total energy, B the kinetic energy and A the potential energy of the satellite

B. A shows the kinetic energy, B the total energy and C the potential energy of the satellite

C. A and B are the kinetic and potential energies and C the total energy of the satellite

D. C and A are the kinetic potential energies respectively and B the total energy of the satellite

Answer: C

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19. Let the acceleration due to gravity be g_1 at a height h above the earth's surface g_2 at a depth d below the earth's surface. If $g_1 = g_2, h < < R$ and $d < < R$ then

A. $d = h$

B. $d = 2h$

C. $h = 2d$

D. Date is insufficicent to arrive at a conclusion.

Answer: B

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20. A particle is placed in a field characterized by a value of gravitational potential given by $V = -kxy$, where k is a constant. If $\overrightarrow{E}_g$ is the gravitational field then

A. $\overrightarrow{E}_g = k\left(x\overrightarrow{i} + y\overrightarrow{j}\right)$ and is conservation in nature

B. $\overrightarrow{E}_g = k\left(y\overrightarrow{i} + x\overrightarrow{j}\right)$ and is conservation in nature

C. $\overrightarrow{E}_g = k\left(x\overrightarrow{i} + y\overrightarrow{j}\right)$ and is non-conservative in nature

D. $\overrightarrow{E}_g = k\left(y\overrightarrow{i} + x\overrightarrow{j}\right)$ and is non-conservative in nature

Answer: B

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21. Which of the following statement is wrong ?

A. A ship moving from west to east, along the equator , shall have more less as compared to when its is at rest at the equator

B. A ship moving from east to west, along the equator, shall have more weight as compared to when it is at rest

C. Earth has retained its atmosphere because the value of $\sqrt{\frac{3kT}{m}}$ for air molecules is larger than escape velocity

D. The time period of a simple pendulum of infinite length is the same as the time period of SHM of a ball in a tunnei along the diameter of earth

Answer: C

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22. If the period of revolution of an artificial satellite just above the earth be T second and the density of earth be ρ, kg/m^3 then

(G $= 6.67 \times 10^{-11} m^3/kg.\text{ second}^2$)

A. Is a universal constant whose value is

$$\frac{3\pi}{G}$$

B. Is a universal constant whose value is

$$\frac{3\pi}{2G}$$

C. Is proportioanal to radius of earth R

D. Is propotional to squre of the radius of earth R^2 Here $G =$ universal gravitational constant

Answer: A

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23. A planet is revolving round the sun in an elliptical orbit. Of the following the property which is a constant during the motion of the planet is :

A. The force of attraction between the planet and sun.

B. The total energy of the planet plus sun system.

C. The linear momentum of the planet.

D. The kinetic energy of the planet about the sun.

Answer: B

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24. Two air bubble in water ina continer in gravity free space:

A. move toward each other

B. move away from each other

C. Do not move if system is left indisturbed.

D. May move toward or away from each other depending upon the distance between them

Answer: B

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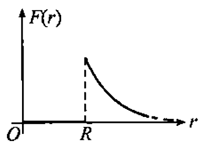
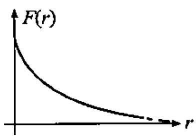
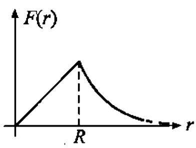
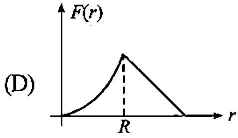
25. A particle of mass m is ocated at a distance r from the centre of shell of mass M and radius R. The force between the shell and mass $F(r)$. The plot of $F(r)$ ve r is :

A. (A) 

B. (B) 

C. (C) 

D. 

Answer: A

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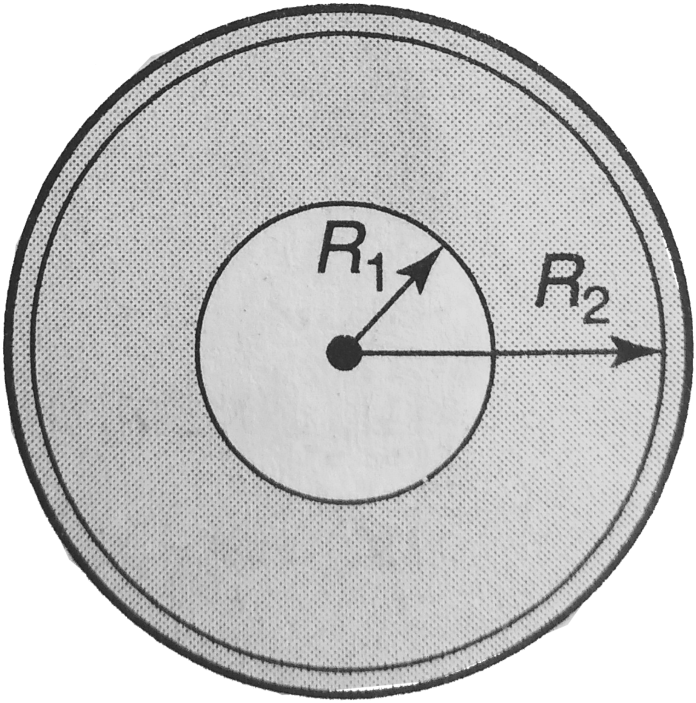
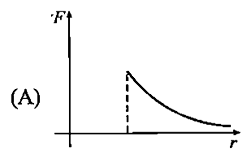
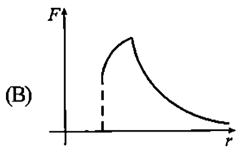
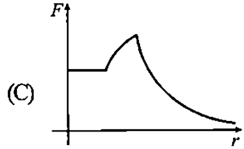
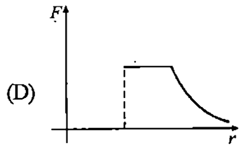
26. A sphare of mass M and $radius R_2$ has a concentric cavity of radius R_1 as shown in figure The force F exerted by the sphere on a particle of mass m located at a distance r from the centre of sphere veries as $(0 \leq r \leq \infty)$.



A. 

B. 

C. 

D. 

Answer: B

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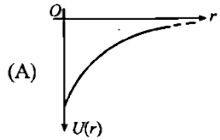
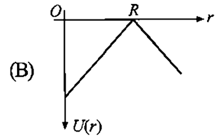
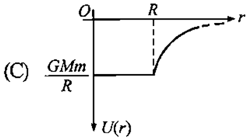
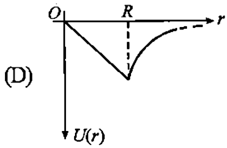
27. A shell of mass M and radius R has point mass m placed at a distance r from its centre. The gravitational potential energy U(r) vs r will be

A. 

B. 

C. 

D. 

Answer: C

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28. A satellite is orbiting round the earth. While in orbit a small part separates from the satellite. The separated part.

A. Falls directly to the earth

B. Moves in a spiral path and reaches the earth after few revolutions about the earth.

C. Continuous to move in the same orbit.

D. Moves gradually father from the earth.

Answer: C

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29. A satellite S is moving in an elliptical orbit around the earth. The mass of the satellite is very small compared to the mass of the earth.

A. The acceleration of S is always directed towards the centre of the earth

B. The angular momentum of S veries periodically with time

C. The total mechanica energy of S veries periodically with time

D. The linear momentum of S remains constant in magnitude

Answer: A

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30. A planet of mass m is moving around the sun in an elliptical orbit of semi-major axis a :

A. The total mechanical energy of the planet is varying periodically with time

B. The total energ of the planet is constant and equals $-\dfrac{GmM_s}{2a}$, N_s is mass of sun

C. Total mechanical energy of the planet is constant and equals $-\dfrac{GmM_s}{a}$, M_2 is mass of sun

D. Date is insufficient of arrice at a conclusion

Answer: B

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31. Two stars of masses m_1 and m_2 distance r apart, revolve about their centre of mass. The period of revolution is :

A. $2\pi\sqrt{\dfrac{r^3}{2G(m_1+m_2)}}$

B. $2\pi\sqrt{\dfrac{r^3(m_1+m_2)}{2Gm_1m_2}}$

C. $2\pi\sqrt{\dfrac{2r^3}{G(m_1+m_2)}}$

D. $2\pi\sqrt{\dfrac{r^3}{G(m_1+m_2)}}$

Answer: D

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32. A satellite in an equatorial orbit has a time period of 6 hrs, At a certain instant, it is directly overhead an observer on the equator of the earth. It is directly overhead the observer again after a time T. The possible value(s) of `T is/are :

A. 8 hr

B. 4.8 hr

C. both (A) and (B)

D. none of these

Answer: C

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33. 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. $\frac{v_1}{d_1} . d_2$

B. $v_1 . \frac{d_1}{d_2}$

C. $v_1 . \sqrt{\frac{d_2}{d_1}}$

D. $v_1 . \sqrt{\frac{d_1}{d_2}}$

Answer: B

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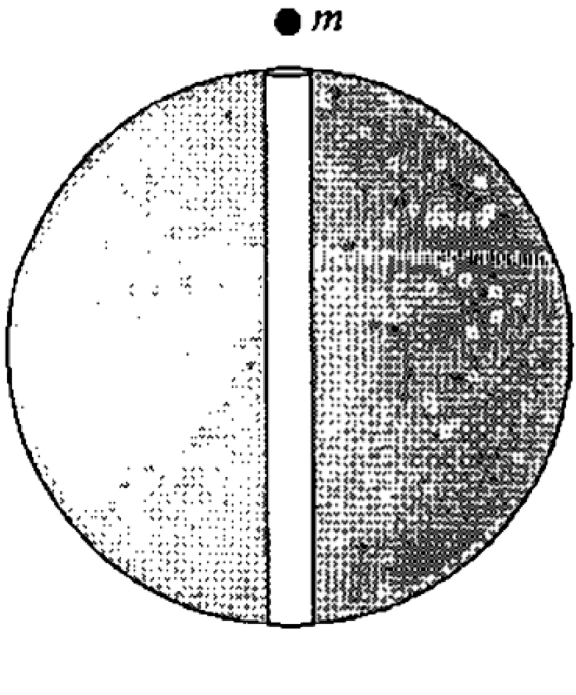
34. A tunnel is made inside earth passing throgh centre of earth. A particle is dropped from the surface of earth. Select the correct statement :



A. Kinetic energy of particle is maximum at centre and its potential energ is zero at center

B. Velocity of particle is proportional to x [where x is distance of particle from center of earth

C. Kinetic energy of particle is maximum when it reaches on the other side of tunnel

D. Kinetic energy of particle is maximum at center

Answer: D

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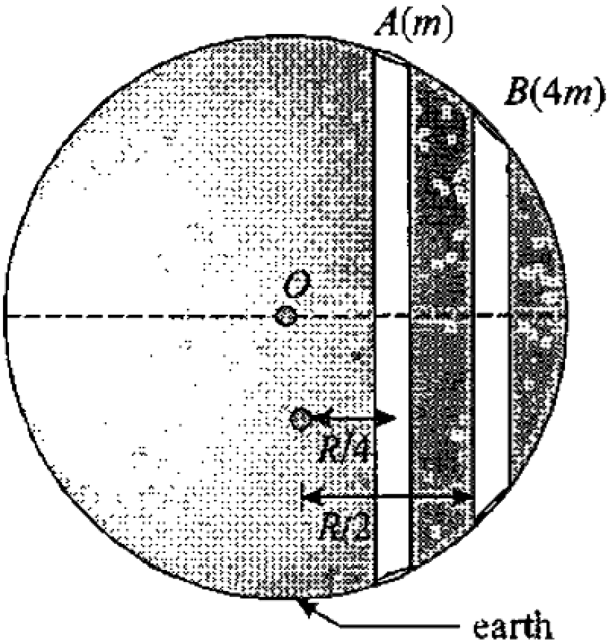
35. Two particle A and B (of masses m and $4m$) are released from rest in the two tunnels as shown in the figure-6.93. Which particle will cross the equatorial plane first?



A. A

B. B

C. Both simultaneously

D. Data insufficient

Answer: C

View Text Solution

36. Identify the correct defination of gravitationa potential at a point.

A. It is defined in term fo the force required to displaced a unit mass from infinity to that point

B. It is defined in term of the force required to move a unit mass from the surface of earth to that point

C. It is defined in terms of the force required to displace a unit mass from that point to infinity

D. none of these

Answer: D

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37. Tidal waves in the sea are primarily due to

A. The gravitational effect of the moon on the earth

B. The gravitational effect of the sun on the earth

C. The gravitational effect of Venus on the earth

D. The atmophere effect of the earth itself

Answer: A

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38. If the sun were suddenly replaced by a block hole of one solar mass, what would happen to the earth's orbit immediately after the replacement ?

A. The earth would sprial into the black hole

B. The radius of the earth's orbit would be unchanged, but the period of the earth's motion would increase

C. The radius of the earth's orbnit would be unchanged, but the period of the earth's motion would decrease

D. Neither the radius of the orbit nor the period would change

Answer: B

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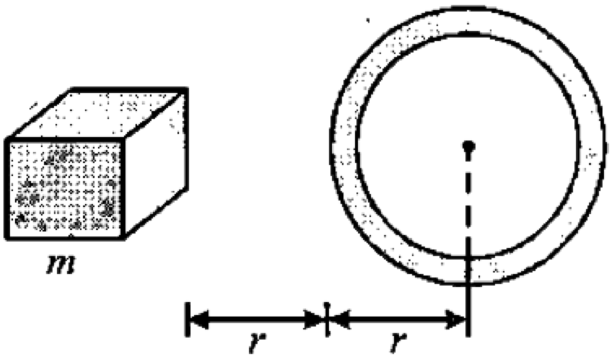
39. A block of mass m is lying at a distance r from a spherical shell of mass m and radius r, then :



A. Only gravitational field inside the shell is zero

B. Gravitational field and gravitational potential both are zero inside the shell

C. Gravitational potential as well as gravitational field inside the shell are not zero

D. Can't be ascertained.

Answer: C

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Numerial Mcqs

1. The ratio of the time period of a simple pendulum of length l_0 with a pendulum of infinite length is :

(Where, R is the radius of earth)

A. zero

B. $\sqrt{\dfrac{l_0}{R}}$

C. $\sqrt{\dfrac{l_0 + R}{R}}$

D. $\sqrt{\dfrac{R}{I_0 + R}}$

Answer: B

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2. The rotation of the earth radius R about its axis speeds upto a value such that a man at latitude angle 60° feels weightless. The duration of the day in such case will be

A. $2\pi\sqrt{\frac{R}{g}}$

B. $4\pi\sqrt{\frac{R}{g}}$

C. $2\pi\sqrt{\frac{g}{R}}$

D. $4\pi\sqrt{\frac{g}{R}}$

Answer: B

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3. At what height the gravitationa field reduces by 75% of the gravitational field at the surface of earth?

A. R

B. $2R$

C. $3R$

D. $4R$

Answer: A

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4. In a certain region of space, the gravitational field is given by $-\frac{k}{r}$ where r is the distance and k is a constant. If the gravitaional potential at $r = r_0$ be V_0, then what is the expression for the gravitaional potential (V)-

A. $V = K\text{In}\left(\frac{r}{r_0}\right) + v_0$

B. $V = K\text{In}\left(\frac{r}{r_0}\right) - v_0$

C. $V = K\text{In}\left(\frac{r_0}{r}\right) + v_0$

D. $V = K\text{In}\left(\frac{r_0}{r}\right) - v_0$

Answer: C

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5. If different planets have the same density but diferent radii then the acceleration due to gravity (g) on the surface of the planet will depend on its radius (R) as

A. $g \propto \frac{1}{R^2}$

B. $g \propto R^2$

C. $g \propto \frac{1}{R}$

D. $g \propto R$

Answer: D

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6. A shell of mass M and radius R has another point mass m placed at a distance r from its centre $(r > R)$. The force of attraction between the shell and point mass is :

A. $F = \frac{GMm}{r}$

B. $F = \frac{GMm}{r^2}$

C. $f = \text{Zero}$

D. None of these

Answer: B

Watch Video Solution

7. Let the acceleration due to gravity be g_1 at a height h above the earth's surface g_2 at a depth d below the earth's surface. If $g_1 = g_2, h < < R$ and $d < < R$ then

A. $d = h$

B. $d = 2h$

C. $h = 2d$

D. Date is insufficient of arrive at a conclusion.

Answer: B

Watch Video Solution

8. A satellite is revolving round the earth in an orbit of radius r with time period T. If the satellite is revolving round the earth in an orbit of radius $r + \Delta r (\Delta r < < r)$ with time period $T + \Delta T (\Delta T < < T)$ then.

A. $\frac{\Delta T}{T} = \frac{3}{2} \frac{\Delta r}{r}$

B. $\frac{\Delta T}{T} = \frac{2}{3} \frac{\Delta r}{r}$

C. $\frac{\Delta T}{T} = \frac{\Delta r}{r}$

D. $\frac{\Delta T}{T} = -\frac{\Delta r}{r}$

Answer: A

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9. Consider an infinite plane sheet of mass with surface mass density σ. The gravitational field intensity at a point P at perpendicular distance r from such a sheet is :

A. Zero

B. $-\sigma G$

C. $2\pi\sigma G$

D. $-4\pi\sigma G$

Answer: C

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10. Two identical thin ring, each of radius R meters, are coaxially placed a distance R metres apart. If Q_1 coulomb, and Q_2 coulomb, are repectively the charges uniformly spread on the two rings, the work done in moving a charge q from the centre of one ring to that of the other is

A. zero

B. $\dfrac{Gm(m_1 - m_2)\left(\sqrt{2} - 1\right)}{\sqrt{2}R}$

C. $\dfrac{Gm\sqrt{2}(m_1 + m_2)}{R}$

D. $\dfrac{Gmm_1\left(\sqrt{2} - 1\right)}{m_2 R}$

Answer: B

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11. A point P $\left(R\sqrt{3}m, 0, \right)$ lies on the axis of a ring of mass M and radius R. The ring is located in $y - z$ plane with its centre at origin. A small particle of mass m start from P and reaches O under gravitational attraction only. Its speed at O will be.

A. $\sqrt{\frac{GM}{R}}$

B. $\sqrt{\frac{Gm}{R}}$

C. $\sqrt{\frac{GM}{\sqrt{2}R}}$

D. $\sqrt{\dfrac{Gm}{\sqrt{2}R}}$

Answer: A

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12. An artificial satellite moving in circular orbit around the earth has total (kinetic + potential) energy E_0. Its potential energy and kinetic energy respectively are :

A. $2E_0$ and $-2E_0$

B. $-2E_0$ and $3E_0$

C. $2E_0$ and $-E_0$

D. $-2E_0$ and $-E_0$

Answer: C

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13. The ratio of the earth's orbital angular momentum (about the Sun) to its mass is $4.4 \times 10^{15} m^2 s^{-1}$. The area enclosed by the earth's orbit is approximately-__________m^(2).

A. $1 \times 10^{22} m^2$

B. $3 \times 10^{22} m^2$

C. $5 \times 10^{22} m^2$

D. $7 \times 10^{22} m^2$

Answer: D

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14. A particle is projected vertivally upwards from the surface of earth $(radius R_e)$ with a kinetic energy equal to half of the minimum value needed for it to escape. The height to which it rises above the surface of earth is ......

A. R_e

B. $2R_e$

C. $3R_e$

D. $4R_e$

Answer: A

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15. A satellite of mass $5000 kg$ is projected in space with an intial speed of $400 m / s$ making an angle of 30° with the radial direaction from a distance $3.6 \times 10^7 m$ away from the center of the earth.

The angular momentum of satellite :

A. $3.6 \times 10^7 J - s$

B. $4.9 \times 10^7 J - s$

C. $9.2 \times 10^7 J - s$

D. $3.6 \times 10^{14} J - s$

Answer: D

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16. A satellite of mass $5000kg$ is projected in space with an intial speed of $400m/s$ making an angle of 30° with the radial direaction from a distance $3.6 \times 10^7 m$ away from the center of the earth.

The energy of satellite :

A. $1.6 \times 10^7 \text{Joule}$

B. 4.9×10^7 Joule

C. 0.2×10^7 Joule

D. -1.5×10^{10} Joule

Answer: D

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17. A satellite of mass $5000kg$ is projected in space with an intial speed of $400m/s$ making an angle of 30° with the radial direaction from a distance $3.6 \times 10^7 m$ away from the center of the earth.

The minimum distance of state

The minimum distance of satellite from earth :

A. $66.6 \times 10^7 m$

B. $14.9 \times 10^7 m$

C. $1.29 \times 10^7 m$

D. $1.6 \times 10^4 m$

Answer: C

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18. A satellite of mass $5000kg$ is projected in space with an intial speed of $400m/s$ making an angle of 30° with the radial direaction from a distance $3.6\times10^{7}m$ away from the center of the earth.

The maximum distance of satellite from earth.

A. $6.6\times10^{7}m$

B. $24.9\times10^{7}m$

C. $11.9\times10^{7}m$

D. $1.6\times10^{4}m$

Answer: C

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19. A satellite of mass $5000kg$ is projected in space with an intial speed of $400m/s$ making an angle of 30° with the radial direaction from a distance $3.6\times10^{7}m$ away from the center of the earth.

The semi-major axis of the orbit of satellite :

A. $6.6\times10^{7}m$

B. $14.9 \times 10^7 m$

C. $19.2 \times 10^7 m$

D. $1.6 \times 10^4 m$

Answer: A

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20. Semi-major axis of the orbita of satellite :

A. $16.6 \times 10^7 m$

B. $3.92 \times 10^7 m$

C. $10.2 \times 10^{17} m$

D. $2.6 \times 10^{4} m$

Answer: B

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21. Imagine a light planet revolving around a very massive star in a circular orbit of radius r with a period of revolution T. On what power of r will the square of time period will depend if the gravitational force of attraction between the planet and the star is proportional to $r^{-5/2}$.

A. T^2 is propotional to R^2

B. T^2 is propotional to $R^{7/2}$

C. T^2 is propotional to $R^{3/2}$

D. T^2 is propotional to $R^{3.75}$

Answer: B

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22. A projectile is fired from the surface of earth of radius R with a velocity kv_e (where v_e is the escape velocity from surface of earth and $k < 1$). Neglecting air resistance, the maximum height of rise from centre of earth is

A. $\frac{R}{k^2}$

B. $\frac{2R}{1-k^2}$

C. $\frac{2R}{k^2}$

D. $\frac{R}{1-k^2}$

Answer: D

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23. Two satellites S_1 and S_2 revolve around a planet in coplanar circular orbits in the same sense their periods of revolution are 1 hour and 8hours respectively the radius of the orbit of S_1 is 10^4 km when S_1 is closest to S_2 the angular speed of S_2 as observed by an astronaut in S_1 is :

A. $10^4\pi$

B. $2 \times 10^4\pi$

C. $\frac{1}{2}10^4\pi$

D. $4 \times 10^4\pi$

Answer: A

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24. In previous problem what is the angular speed of S_2 is the observed by an astronaut in S_1 when they are closet :

A. $\frac{\pi}{2}$

B. $\frac{\pi}{3}$

C. $\frac{\pi}{4}$

D. $\frac{\pi}{6}$

Answer: B

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25. Two particles of masses m_1 and m_2 initially at rest a infinite distance from each other, move under the action of mutual gravitational pull. Show that at any instant therir relative velocity of approach is $\sqrt{2G(m_1 + m_2)/R}$

where R is their separation at that instant.

A. $\sqrt{\frac{G(m_1 + m_2)}{r}}$

B. $\sqrt{\frac{2G(m_1 + m_2)}{r}}$

C. $\sqrt{\frac{Gm_1m_2}{(m_1 + m_2)r}}$

D. $\sqrt{\frac{G(m_1 + m_2)}{2r}}$

Answer: B

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26. A body is imparted a velocity v from the surface of the earth. If v_0 is orbital velocity and v_e be the escape velocity then for :

$v = v_0$ the body follows a circular track around the earth.

(B). $v > v_0$ but $< ve$, the body follows elliptical path around the earth.

(C). $v < v_0$, the body follows elliptical path and return to surface of earth.

(D). $v > v_e$, the body follows hyperbolic path and escape the gravitational pull of the earth.

A. A, B

B. B, C

C. A, B, C

D. A, B, C, D

Answer: D

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27. The escape velocity for a planet is v_e. A particle is projected from its surface with a speed v. For this particle to move as a satellite around the planet.

A. $\frac{v_e}{2} < v < v_e$

B. $\frac{v_e}{\sqrt{2}} < v < v_e$

C. $v_e < v < \sqrt{2v_e}$

D. $\frac{v_e}{\sqrt{2}} < v < \frac{v_e}{2}$

Answer: B

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28. Two bodies of masses m and M are placed at distance d apart. The gravitational potential (V) at the position where the gravitational field due to them is zero V is

A. $V = -\frac{G}{d}(m+M)$

B. $V = -\frac{Gm}{d}$

C. $V = -\frac{GM}{d}$

D. $V = -\frac{G}{d}\left(\sqrt{m}+\sqrt{M}\right)^2$

Answer: D

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29. Suppose we have made a model of the Solar system scaled down in the ratio η but of materials of the same mean density as the actual materials of the planets and the Sun. How will the orbital periods of revolution of planetary models change in this case?

A. ηT_0

B. $\eta^2 T_0$

C. $\eta^3 T_0$

D. T_0

Answer: D

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30. A geostationary satellite orbits around the earth in a circular orbit of radius 36,000 km. then the time period of a spy satellite orbiting a few hundred km (600 km) above the earth's surface (R=6400 km) will approximately be

A. $\frac{1}{2}h$

B. $1h$

C. $2h$

D. $4h$

Answer: C

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31. Consider a thin uniform spherical layer of mass M and radius R. The potential energy of gravitational interaction of matter forming this shell is :

A. $-\frac{GM^2}{R}$

B. $-\frac{1}{2}\frac{GM^2}{R}$

C. $-\frac{3}{5}\frac{GM^2}{R}$

D. $-\frac{2}{3}\frac{GM^2}{R}$

Answer: B

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32. Find the proper potential energy of gravitational interaction of matter forming

(a) a thin uniform spherical layer of mass m and radius R,

(b) a uniform sphere of mass m and radius R(make use of the answer to Problem)

A. $-\frac{GM^2}{R}$

B. $-\frac{1}{2}\frac{GM^2}{R}$

C. $-\frac{3}{5}\frac{GM^2}{R}$

D. $-\frac{2}{3}\frac{GM^2}{R}$

Answer: C

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33. What should be the period of rotation of earth so as to make any object on the equator weig half of its present value?

A. 2hrs

B. 24 hrs

C. 8hrs

D. 12hrs

Answer: A

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34. An artificial satellite is describing an equatorial orbit at $3600km$ above the earth's surface. Calculate its period of revolution? Take earth radius $6400km$.

A. 8.71 hrs

B. 9.71 hrs

C. 10.71 hrs

D. 11.71 hrs

Answer: A

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35. In previous question calculate orbital speed of satellite.

A. $6.335km/\sec$

B. $7.335km/\sec$

C. $8.335km/\sec$

D. $9.335km/\sec$

Answer: A

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36. Find the work done in bringing three particles each having a mass of 100 g, from large distances to the vertices of an equilateral triangle of side 20 cm.

A. $5.0 \times 10^{-12} J$

B. $2.25 \times 10^{-10} J$

C. $4.0 \times 10^{-11} J$

D. $6.0 \times 10^{-15} J$

Answer: A

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37. In a satellite if the time of revolution is T, then kinetic energy is proportional to

A. $1/T$

B. $1/T^2$

C. $1/T^3$

D. $T^{-2/3}$.

Answer: B

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38. A saturn year is 29.5 times the earth year. How far is the saturn from the sun if the earth is 1.5×10^8 away from the sun?

A. $1.43 \times 10^9 km$

B. $2.43 \times 10^9 km$

C. $3.43 \times 10^9 km$

D. $4.43 \times 10^9 km$

Answer: A

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39. A spherical planet far out in space has a mass M_0 and diameter D_0. A particle of mass m falling freely near the surface of this planet will experience an accelertion due to gravity which is equal to

A. $\frac{GM_0}{D_0^2}$

B. $\frac{4GmM_0}{D_0^2}$

C. $\frac{4GM_0}{D_0^2}$

D. $\frac{GmM}{D_0^2}$

Answer: C

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40. A body which is initially at rest at a height R above the surface of the earth of radius R, falls freely towards the earth. Find out its velocity on reaching the surface of earth. Take $g =$ acceleration due to gravity on the surface of the Earth.

A. $\sqrt{\frac{4}{3}gR}$

B. $\sqrt{\frac{2}{3}gR}$

C. $\frac{4}{3}gR$

D. $2gR$

Answer: A

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41. Two satellite A and B are moving round a planet in circular orbit having radii R and 3R respectively, if the speed of satellite A is v the speed f satellite B will be :

A. $v/3$

B. $v/\sqrt{3}$

C. $3v$

D. Data insufficient

Answer: C

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42. The radius of a planet is R. A satellite revolves around it in a circle of radius r with angular velocity ω_0. The acceleration due to the gravity on planet's surface is

A. $\frac{r^3\omega}{R}$

B. $\frac{r^2\omega^3}{R}$

C. $\frac{r^3\omega^2}{R^2}$

D. $\frac{r^2\omega^2}{R}$

Answer: C

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43. The gravitational field in a in region is given by $\overrightarrow{g} = \left(4\hat{i} + \overrightarrow{j}\right) N/kg$. What done by this field is zero when the particle is moved along the line :

A. $y + 4x = 2$

B. $4y + x = 6$

C. $x + y = 5$

D. all of the above

Answer: A

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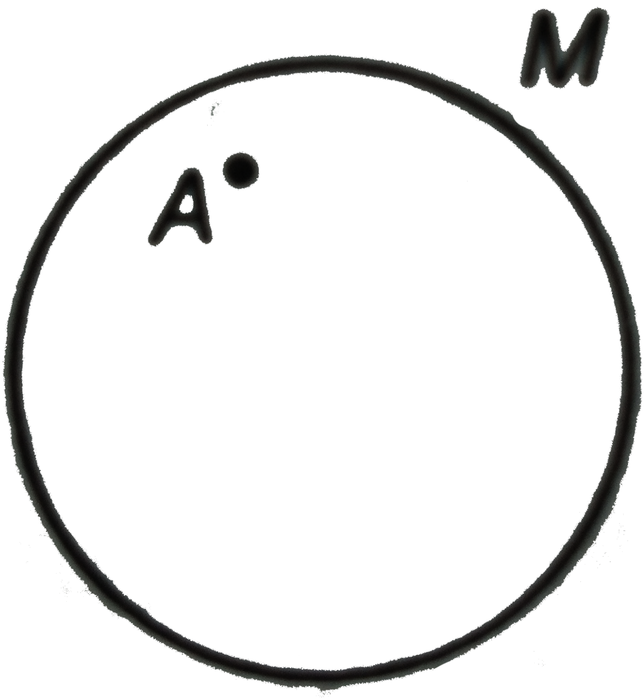
44. The figure shows a spherical shell of mass M. The point A is not at the centre but away from the centre of the shell. If a particle of mass m is placed at A, then



A. The particle will move towards the centre.

B. The particle will move away from the centre, towards the nearest wall.

C. The particle will move towards the centre if $m < M$ and away from the centre if $m < M$

D. The particle will remain stationary

Answer: D

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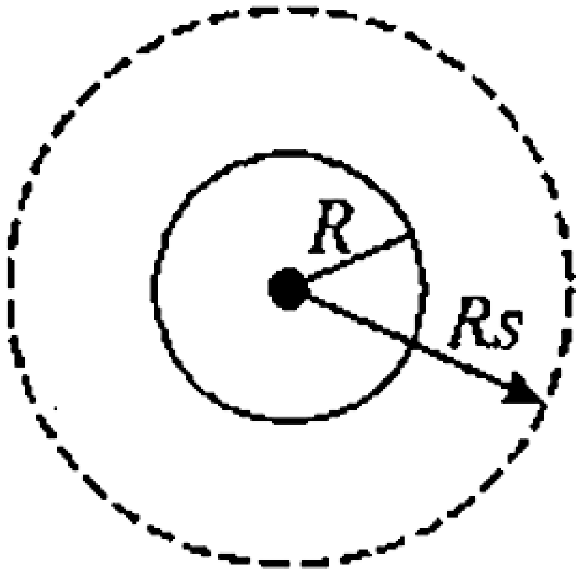
45. Supernova refer to the explosion of a massive star. The material in the central case of such a star continues to collapse under its own gravitational pull. If mass of the core is less is than 1.4 times the mass of sun, its collapse finally results in a white dwarf star. However, if the core has a mass greater than this, it could end up soon as a neutron. star and if its mass is more than about three solar masses, the collapse may still continue till the star becomes a very small object with an extremely high value of density called a 'Black hole'. Escape speed for a black hole is very large. The figure shows a block hole of radius R and another concentric sphere of radius R_S, called the 'Schwarzschild Radius'. It is the critical radius at which escape speed equals the speed of light c. Nothing even the light, can escape from within the sphere of Radius R_S. So light from a black hole can not escape and hence the terminology 'black hole'. There has been astronomical evidence of a small and massive object at the centre of our galaxy the 'Milky way'. Suppose that there is a particle at a distance about 6 light years. that orbits this massive object with an orbital speed of about $2 \times 10^5 m/s$. Use the given data whereever necessary and answer the questions that hollow. $G = 6.67 \times 10^{-11} N - m^2/kg^2$, Solar mass $M = 2 \times 10^{30} kg$, $C = 3 \times 10^8 m/s$, 1 light year $= 9.5 \times 10^{15} m$.



Mass (in kg) of the massive object at the centre of the milky galaxy is of the order :

A. 10^{32}

B. 10^{37}

C. 10^{43}

D. 10^{29}

Answer: B

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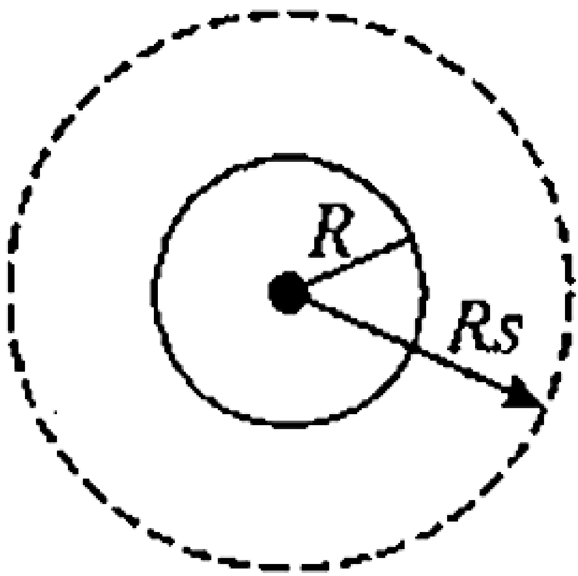
46. Supernova refer to the explosion of a massive star. The material in the central case of such a star continues to collapse under its own gravitational pull. If mass of the core is less is than 1.4 times the mass of sun, its collapse finally results in a white dwarf star. However, if the core has a mass greater than this, it could end up soon as a neutron. star and if its mass is more than about three solar masses, the collapse may still continue till the star becomes a very small object with an extremely high value of density called a 'Black hole'. Escape speed for a black hole is very large. The figure shows a block hole of radius R and another concentric sphere of radius R_S, called the 'Schwarzschild Radius'. It is the critical radius at which escape speed equals the speed of light c. Nothing even the light, can escape from within the sphere of Radius R_S. So light from a black hole can not escape and hence the terminology 'black hole'. There has been astronomical evidence of a small and massive object at the centre of our galaxy the 'Milky way'. Suppose that there is a particle at a distance about 6 light years. that orbits this massive object with an orbital speed of about $2 \times 10^5 m/s$. Use the given data whereever necessary and answer the questions that hollow. $G = 6.67 \times 10^{-11} N - m^2/kg^2$, Solar mass $M = 2 \times 10^{30} kg, C = 3 \times 10^8 m/s, 1$ light year $= 9.5 \times 10^{15} m.$



Theories suggest that it is not possible for a single star to have a mass of more than 50 masses. The massive object at the centre of milky way galaxy is most likely to be a :

A. white dwarf

B. neutron star

C. black hole

D. single ordinary star

Answer: C

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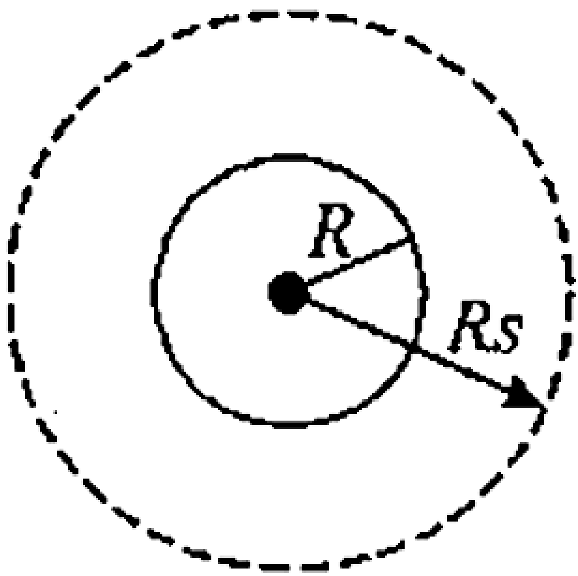
47. Supernova refer to the explosion of a massive star. The material in the central case of such a star continues to collapse under its own gravitational pull. If mass of the core is less is than 1.4 times the mass of sun, its collapse finally results in a white dwarf star. However, if the core has a mass greater than this, it could end up soon as a neutron. star and if its mass is more than about three solar masses, the collapse may still continue till the star becomes a very small object with an extremely high value of density called a 'Black hole'. Escape speed for a black hole is very large. The figure shows a block hole of radius R and another concentric sphere of radius R_S, called the 'Schwarzschild Radius'. It is the critical radius at which escape speed equals the speed of light c. Nothing even the light, can escape from within the sphere of Radius R_S. So light from a black hole can not escape and hence the terminology 'black hole'. There has been astronomical evidence of a small and massive object at the centre of our galaxy the 'Milky way'. Suppose that there is a particle at a distance about 6 light years. that orbits this massive object with an orbital speed of about $2 \times 10^5 m/s$. Use the given data whereever necessary and answer the questions that hollow. $G = 6.67 \times 10^{-11} N - m^2/kg^2$, Solar mass $M = 2 \times 10^{30} kg, C = 3 \times 10^8 m/s, 1$ light year $= 9.5 \times 10^{15} m$.



If mass of earth $M_E \approx 6 \times 10^{24} kg$ and its radius $R_E = 6400km$, to what fraction of its presents radius does the earth need to be compressed in order to become a black hole ?

(Give only the order of your answer)

A. 10^{-4}

B. 10^{-9}

C. 10^{-7}

D. 10^{-14}

Answer: B

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48. A hole is drilled from the surface of earth to its centre. A particle is dropped from rest in the surface of earth in terms of its escape velocity on the surface of earth v_e is :

A. $\frac{v_e}{2}$

B. v_e

C. $\sqrt{2}v_e$

D. $\frac{v_e}{\sqrt{2}}$

Answer: D

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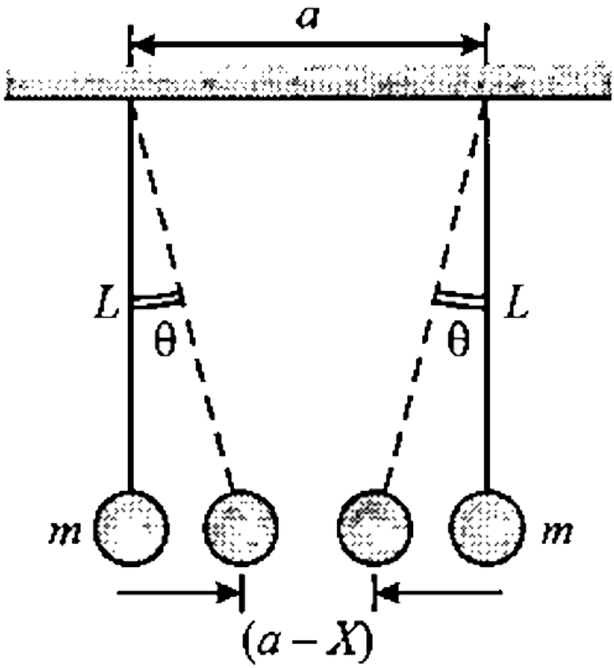
49. Two small balls of mass m each are suspended side by side by two equal threds to length L. If the distance between the upper ends of the threads be a, the angle θ that the threads will make with the vertical due to attraction between the balls is :



A. $\tan^{-1}\dfrac{(a-X)g}{mG}$

B. $\tan^{-1}\dfrac{mG}{(a-X)^2 g}$

C. $\tan^{-1}\dfrac{(a-X)^2 g}{mG}$

D. $\tan^{-1}\dfrac{(a^2-X^2)g}{mG}$

Answer: B

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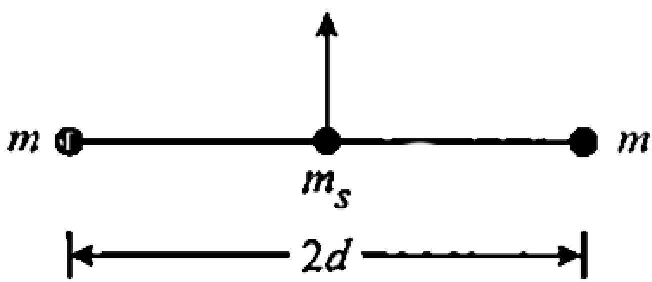
50. Two masses of mass m each are fixed at a separation distance of $2d$. A small mass m_s placed midway, when displaced slightly, starts oscillating. Then :



A. Frequency of simple harmonic motion is given by $\frac{1}{2\pi}\sqrt{\frac{4Gm}{d^3}}$

B. Frequency of simple harmonic motion is given by $\frac{1}{2\pi}\sqrt{\frac{2Gm}{d^3}}$

C. Accleration of the mass m_s, is given by $\frac{Gm}{d^2}$

D. Time period of vibration is $2\pi\sqrt{\frac{GM}{(2d)^3}}$

Answer: B

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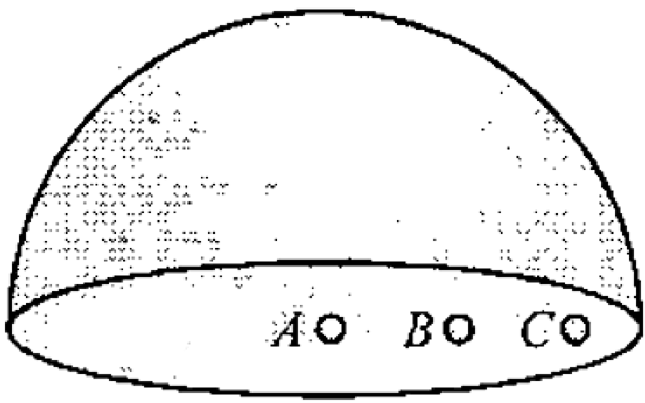
51. Mass M is uniformly distributed only on curved surface of a thin hemispherical shell. A, B and C are three points on the circular base of hemisphere, such that A is the centre. Let the gravitational potential at poins A, B and C be V_A, V_B, V_C respectively. Then :



A. $V_C > V_B > V_C$

B. $V_C > V_B > V_A$

C. $V_B > V_A$ and $V_B > V_A$

D. $V_A = V_B = V_C$

Answer: D

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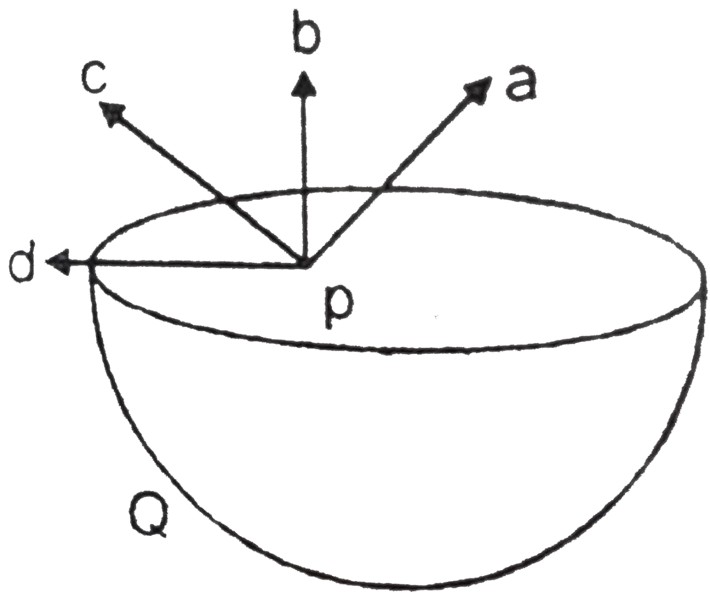
52. Figure shows a uniformly charges hemispherical shell. The direction of electric field at point p that is off centre (but in the plane of the largest circle of the hemisphere), will be along



(C) pc

A. a

B. b

C. c

D. d

Answer: C

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53. A straight rod of length L extends from $x = a$ to $x = L + a$. Find the gravitational force exerts on a point mass m at $x = 0$ is (if the linear density of rod$\mu = A + Bx^2$)

A. $Gm\left(a\left(\frac{1}{\alpha} - \frac{1}{\alpha + 1}\right) + bl\right)$

B. $\frac{Gm(a + bx^2)}{l^2}$

C. $Gm\left(a\left(\frac{1}{\alpha} - \frac{1}{\alpha + 1}\right) + bl\right)$

D. $Gm\left(a\left(\frac{1}{\alpha+1}-\frac{1}{\alpha}\right)+bl\right)$

Answer: A

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54. The planets with radii R_1 and R_2 have densities p_1, p_2 respectively. Their atmospheric pressures are p_1 and p_2 respectively.Therefore, the ratio of masses of their atmospheres, neglecting variation of g within the limits of atmoshpere is

A. $p_1 R_2 \rho_1 / p_2 R_1 \rho_2$

B. $p_1 R_2 \rho_2 / p_2 R_1 \rho_1$

C. $p_1 R_1 \rho_1 / p_2 R_2 \rho_2$

D. $p_1 R_1 \rho_2 / p_2 R_2 \rho_1$

Answer: D

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55. A satellite of mass m orbits the earth in an elliptical orbit having aphelion distance r_a and perihelion distance r_p. The period of the orbit is T. The semi-major and semi-minor axes of the ellipse are $\frac{r_a + r_p}{2}$ and $\sqrt{\rho_p r_a}$ respectively. The angular momentum of the satellite is :

A. $\frac{m\pi(r_a + r_p)\sqrt{r_a r_p}}{T}$

B. $\frac{2m\pi(r_a + r_p)\sqrt{r_a r_p}}{T}$

C. $\frac{m\pi(r_a + r_p)\sqrt{r_a r_p}}{2T}$

D. $\frac{m\pi(r_a + r_p)\sqrt{r_a r_p}}{4T}$

Answer: A

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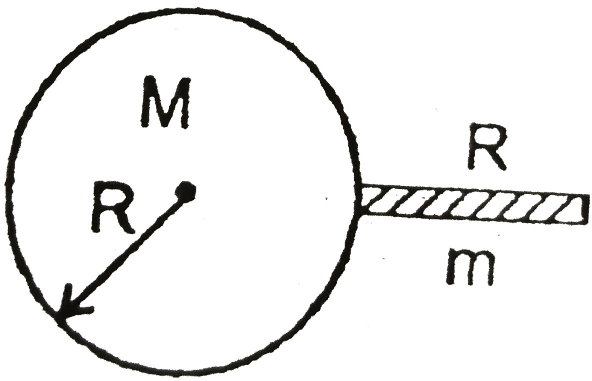
56. A uniform thin rod of mass m and length R is placed normally on surface of earth as shown. The mass of earth is M and its radius R. Then the magnitude of gravitational force exerted by earth on the rod is



A. $\dfrac{GMm}{4R^2}$

B. $\dfrac{GMm}{2R^2}$

C. $\frac{4GMm}{9R^2}$

D. $\frac{GMm}{8R^2}$

Answer: B

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57. A small body of superdense material, whose mass is twice the mass of the earth but whose size is very small compared to the size of the earth, starts form rest at a height $H < < R$ above the earth's surface, and reaches the earth's surface in time t. then t is equal to

A. $t = \sqrt{\frac{h}{g}}$

B. $t = \sqrt{\frac{2h}{g}}$

C. $t = \sqrt{\frac{2h}{3g}}$

D. $t = \sqrt{\frac{4h}{3g}}$

Answer: C

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58. Consider a mass m_0 enclosed by a closed imaginary surface S. Let $\vec{g}$ be the gravitational field intensity due to m_0 at the surface element $d\vec{S}$ directed as outward normal to it. The surface integral of the gravitational field over S is :

A. $-m_0 G$

B. $-4\pi m_0 G$

C. $-\frac{m_0 G}{4\pi}$

D. None of these

Answer: B

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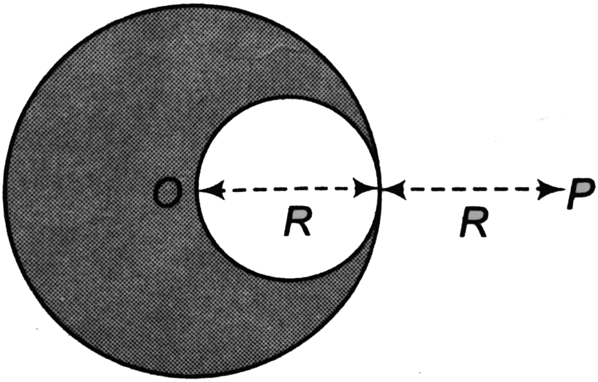
59. A solid sphere of uniform density and radius R applies a gravitational force of attraction equal to F_1 on a particle placed at P, distance $2R$ from the centre O of the sphere. A spherical cavity of radius $R/2$ is now made in the sphere as shown in figure. The particle with cavity now applies a gravitational force F_2 on same particle placed at P. The radio F_2 / F_1 will be



A. $\frac{9}{7}$

B. $\frac{7}{9}$

C. $\frac{1}{2}$

D. $\frac{4}{3}$

Answer: A

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Advance Mcqs

1. Two objects of masses m and $4m$ are at rest at an infinite separation. They move towards each other under mutual gravitational attraction. If G is the universal gravitaitonal constant, then at separation r

A. The tatal energy of the two object is zero

B. Their relative velocity of approach is $\left(\frac{10Gm}{r}\right)^{1/2}$ amplitude

C. The total kinetic energy of the object is $\frac{4Gm^2}{r}$

D. Net angular momentum of both the particles is zero about any point

Answer: A::B::C::D

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2. A planet of mass m is revolving round the sun (of mass M_s) in an elliptical orbit. If $\overrightarrow{v}$ is the velocity of the planet when its position vector from the sun is $\overrightarrow{r}$, then areal velocity of the positon vector of the planet is :

A. $\overrightarrow{v} + \overrightarrow{r}$

B. $\overrightarrow{r} \times \overrightarrow{v}$

C. $\frac{1}{2}\left(\overrightarrow{v} \times \overrightarrow{r}\right)$

D. $\frac{1}{2}\left(\overrightarrow{r} \times \overrightarrow{v}\right)$

Answer: D

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3. In Q.No 6.2, if the planet rotates in counter clockwise direction, then areal velocity has a direaction :

A. Given by "Right Hand Thumb Rule"

B. Given by "Left Hand Thumb Rule"

C. Normal to the plane of orbit upwards

D. Normal to the plane of orbit downwards

Answer: A::C

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4. A particle of mass m lies at a distance r from the centre of earth. The force of attraction between the particle and earth as a function of distance is F(r),

A. $F(r) \propto \frac{1}{r^2}$ for $r < R$

B. $F(r) \propto \frac{1}{r^2}$ for $r \geq R$

C. $F(r) \propto r$ for $r < R$

D. $F(r) \propto \frac{1}{r}$ for $r < R$

Answer: B::C

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5. Consider a planet moving in an elliptical orbit round the sun. The work done on the planet by the gravitational force of the sun

A. In some parts of the orbit

B. In any part of the orbit

C. In no part of the orbit

D. In one complete revolution

Answer: A::D

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6. if a satellite orbits as close to the earth's surface as possible.

A. The time period of revolution of satellite is independent of its mass and is maximum.

B. The orbital speed of satellite is maximum

C. The kinetic energy of the satellite is minimum.

D. The total energy of the "earth plus satellite" system is maximum.

Answer: A::B::C

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7. Suppose universal gravitational constant starts to decrease, then

A. Length of the year will increase

B. Earth will follow a spiral path of decreasing radius

C. Kinetic energy of earth will decrease

D. All of the above

Answer: A::C

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8. A body is imparted a velocity v from the surface of the earth. If v_0 is orbital velocity and v_e be the escape velocity then for :

A. $v = v_0$ the body follows a circular track around the earth.

B. $v > v_0$, but $< v_e$, the body follows elliptical path around the earth

C. $v < v_0$, the body follows elliptical path and returns to surface of earth

D. $v > v_e$, the body follows hyperbolic path and escapes the gravitational pull of the earth

Answer: A::B::C::D

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9. Let V and E be the gravitational potential field. Then select the correct alternative(s) :

A. The plot of E against r (distance from centre) is discontinuous for a spherical shell

B. The plot of V against r is continuous for a spherical shell

C. The plot of E against r is discontinuous for a solid sphere

D. The plot of V against r is continuous for a solid sphere

Answer: A::B::D

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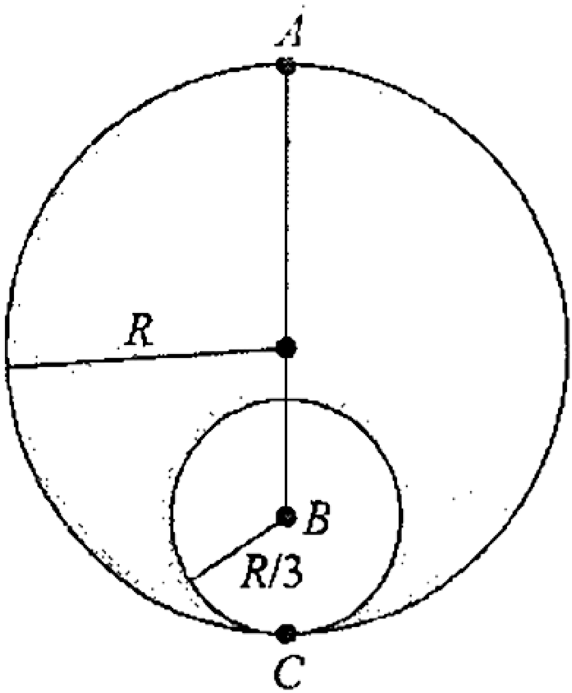
10. Inside a uniform sphere of mass M and radius R, a cavity of radius $R/3$, is made in the sphere as shown :



A. Gravitational field inside the cavity is uniform

B. Gravitational field inside the cavity is non-uniform

C. The escape velocity of a particle projected from point A is $\sqrt{\frac{88GM}{15R}}$

D. Escape velocity is defined for earth and particle system only

Answer: A

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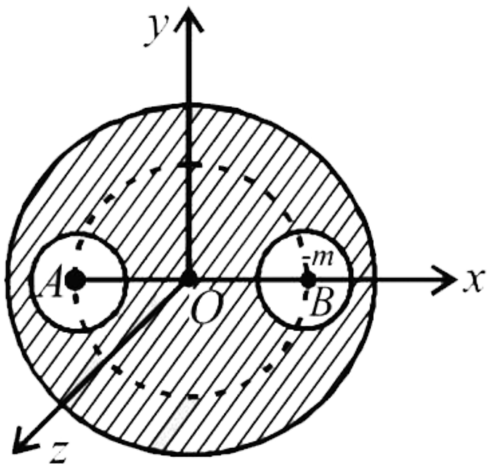
11. A solid sphere of uniform density and radius 4 units is located with its centre at the origin O of coordinates. Two sphere of equal radii 1 unit, with their centres at A(-2,0 ,0) and B(2,0,0) respectively, are taken out of the solid leaving behind spherical cavities as shown if fig Then:



A. The gravitational field due to this object at origin is zero

B. The gravitational field at the point $B(2, 0, 0)$ is zero

C. The gravitational potential is the same at all points on the circle $y^2 + z^2 = 36$

D. The gravitational potential is the same at all points on the circle $y^2 + z^2 = 4$

Answer: A::C::D

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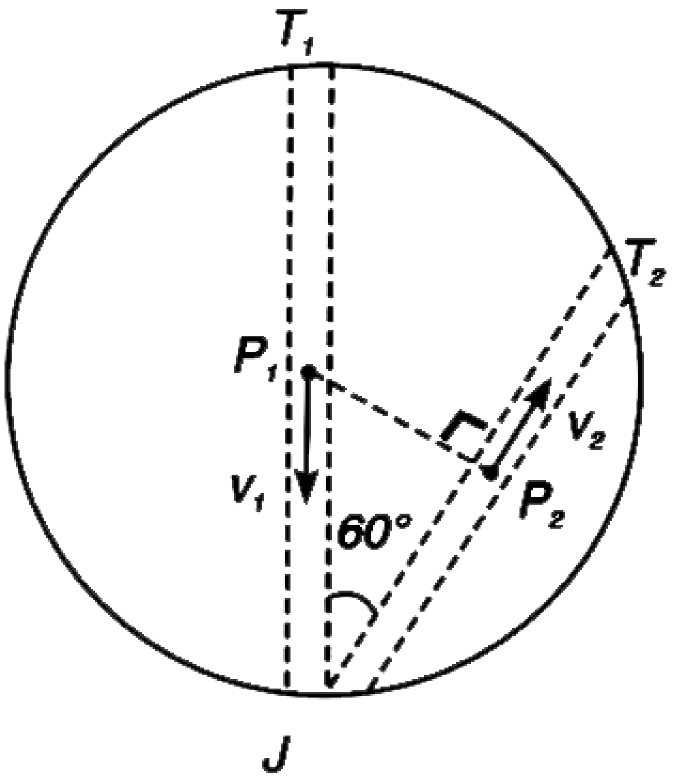
12. Two tunnels - T_1 and T_2 are dug across the earth as shown in figure. One end of the two tunnels have a common meeting point on the surface of the earth. Two particles P_1 and P_2 are oscillating from one end to the other end of the tunnels. At some instant particles are at mid point of their tunnels as shown in figure. Then -



(a) Write phase difference between the particle P_1 and P_2. Can the two particles ever meet?

(b) Write the ratio of maximum velocity of particle P_1 and P_2.

A. $T_1 = T_2$

B. $T_1 > T_2$

C. $v_1 = v_2$

D. $v_1 > v_2$

Answer: A::D

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13. A satellite is revolving round the earth in an elliptical orbit :

A. Gravitational force exerted by earth to centripetal force at every point of trajectory.

B. Power associted with gravitational force is zero at every point

C. Work done by gravitational force is zero in some shell parts of the orbit

D. At some point, magnitude of gravitational force is greater than that of centripetal force

Answer: C::D

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14. The spherical planets have the same mass but densities in the ratio $1:8$. For these planets the :

A. Acceleration due to gravity will be in the ratio $4:1$

B. Acceleration due to gravity will be in the ratio $1:4$

C. Escape velocites from the their surfaces will be in the ratio $\sqrt{2}:1$

D. Escape velocites from the their surfaces will be in the ratio $1 : \sqrt{2}$

Answer: B::D

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15. An artificial satellite is in a circular orbit around the earth. The universal gravitational constant starts decreasing at time $t = 0$, at a constant rate with respect to time t. Then the satellite has its:

A. Path gradually spiralling out, away from the centre of the earth

B. Path gradually spiralling in, towards the centre of the earth

C. Angular momentum about the centre of the earth remains constant

D. Potential energy increases

Answer: A::C::D

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16. Suppose an earth satellite, revolving in a circular orbit experiences a resistance due to cosmic dust. Then

A. Its kinetic energy will increase

B. Its kinetic energy will decrease

C. It will spiral towards the earth and in the process its angular momentum will remain conserved

D. It will get heated and burn off ultimately or fall somewhere on the surface of earth

Answer: A::B::D

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17. P is a point at a distance r from the centre of a spherical shell of mass M and radius a, where $r < a$. The gravitational potential at P is

A. $g = 0$

B. $g = -\frac{GM}{r^2}$

C. $V = 0$

D. $V = -\frac{GM}{a}$

Answer: A::D

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Unsolved Numerical

1. At what distance from the center of the earth will a 1 kg object have a weight of $1N$? If released from rest at this distance, What will its initial acceleration be ?

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2. The radius of Mars is $3.4 \times 10^6 m$ and the accelerationof a freely falling object on its surface is $3.7 m / s^2$. Determine the mass of Mars.

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3. Suppose we invent a unit of mass which we shall call the caendish (C). One cavendish of mass is defined such that $G = 1.0000(AU)^3 / \left(yr^2 C\right)$. Our unit of length is the astronomical unit (AU), the earth-sun distance$-1AU = 1.496 \times 10^{11} m$-and our unit of time is the year (yr). (a) Datermine the conversion factor between C and kg. (b) Find the mass of the sun in C.

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4. Determine the fractional reduction of the acceleration of gravity due to an increase in elevation of $10km$ neart the earth's surface.

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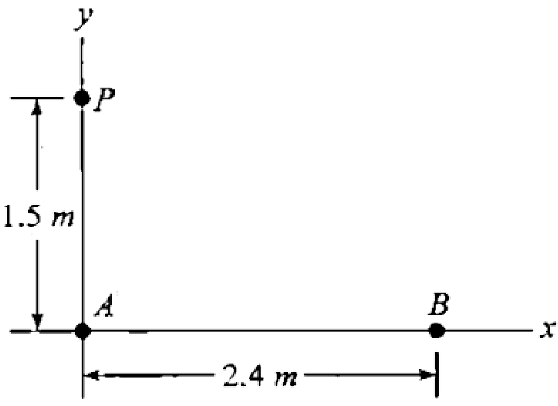
5. In figure-6.105, particle A has a mass of 1.4 and particle B has a mass of $3.1kg$. What is the gravitational field at point P ?



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6. While investigating the planet Norc in another solar system, we find that the radius of Norc is $9.54 \times 10^6 m$ and that the period of a satellite put in circular orbit of radius

$1.476 \times 10^7 m$ is $8.09 \times 10^3 s$. Determine (a) the mass of Norc, (b) The average, mass density of Norc, (c) the value of the gravitational field on the surface of Norc. (d) If the period of Norc's rotation about its axis is $1.04 \times 10^4 s$, what will be the reading on a spring scale (calibrated on earth) supporting a $1.0 kg$ object at Norc's equator ?

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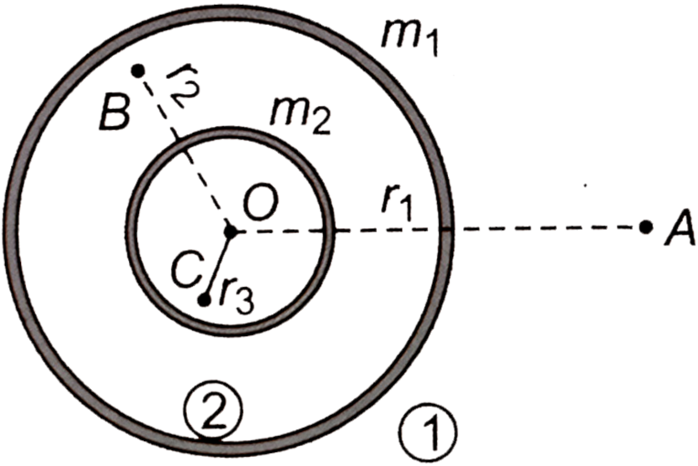
7. Two concentric shells of mass m_1 and m_2 are situated as shown. Find the force on a particle of mass m when the particles is located at $(a) r = r_1$, $(b) r = r_2$, $(c) r = r_3$. The distance r is measured from the centre of the shell.



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8. Two point masses, each equal to M, are placed a distance $2a$ apart. Show that a small mass m placed midway between them on the line joining them will be in equilibrium and if it is slightly displaced from this position along the line perpendicular to the line joining the masses, it will execute simple harmonic oscillations. Calculate the frequnency of these oscillations.

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9. Computer the mass and density of the moon if acceleration due to gravity on its surfac is $1.62m/s^2$ and its radius is $1.74 \times 10^6 m [G = 6.67 \times 10^{-11} MKS$ units].

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10. Two masses m_1 and m_2 at an infinite distance from each other are initially at rest, start interacting gravitationally. Find their velocity of approach when they are at a distance r apart.

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11. Imagine a planet whose diameter and mass are both one half of those of earth. The day's temperature of this planet surface reaches upto $800K$. ? Make calculation and tell whether oxygen molecules are possible in the atmosohere of the planet.

[Escape velocity from earth's surface

$= 11.2km/s, k = 1.38 \times 10^{-23} J/K,$ mass of oxygen molecule $= 5.3 \times 10^{-26} kg$].

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12. A thin rod of mass M and length L is bent in a semicircle as shown in figure (a). What is its gravitational force (both magnitude and direction) on a particle with mass m at O the centre of curvature ? (b) what would be the force on m if the rod is in the form of complete circle?

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13. Three identical particles each of mass "m" are arranged at the corners of an equiliteral triangle of side "L". If they are to be in equilibrium, the speed with which they must revolve under the influence of one another's gravity in a circular orbit circumscribing the triangle is

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14. A smooth tunnel is dug along the radius of earth that ends at centre. A ball is released from the surface of earth along tunnel. Coefficient of restitution for collision between soil at centre and ball is 0.5. Calculate the distance travelled by ball just before second collision at centre. Given mass of the earth is M and radius of the earth is R.

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15. A particle of mass m is subjected to an attractive central force of magnitude k/r^2, k being a constant. If at the instant when the particle is at an extreme position in its closed orbit, at a distance a from the centre of force, its speed is $\sqrt{k/2ma}$, if the distance of other extreme position is b. Find a/b.

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16. If the radius of the earth were to shrink by one percent its mass remaining the same, the acceleration due to greavity on the earth's surface would

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17. In a certain region of space gravitational field is given by $I = -(k/r)$. Taking the reference point to be at $r = r_0$, with gravitational potential $V = V_0$, find the gravitational potential at distance r.

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18. A short , straight and frictinless tunnel is bored through the centre of the earth and a body is realesed from the surface into the tunnel . Show that the motion of the body in the tunnell will be simple harmoic and hence calculate the taken by the body to travel from one end of the tunnel to the other (Radius of the earth = $6.38 \times 10^6 m$ and acceleration due to gravity at the surface = $9.81 ms^2$

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19. An iron ball o fradius 1 m and density $8000 kgm^{-3}$ is placed in water . A bubble of radius 1 cm at a distance 1.5 m from the centre of the ball . Will there be a force of attraction or repulsion between them and what will be the magnitude of this force ? (Neglect the mass of air and take $G = 6.67 \times 10^{-11}$.)

20. Two satellites A and B of equal mass move in the equatorial plane of the earth, close to earth's surface. Satellite A moves in the same direction as the of the rotation of the earth while satellite B moves in the opposite direction. Calclate the ratio of the kinetic energy of B of that of A in the reference frame fixed to the earth $\left(g = 9.8 ms^{-2}\right.$ and radius of the earth $= 6.37 \times 10^{6} km\left.\right)$

21. Three masses, $100kg$, $200kg$ and $500kg$ are placed at the vertices of an equilibrium triangle with sides $10m$. They are rerranged by an agent on the vertices of a bigger triangle of sides $15m$ and with the same in-centre. Calculate the work done by the agent.

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22. A satellite of Sun is in a circular orbit around the Sun, midway between the Suna and earth. Find the period of this satellite.

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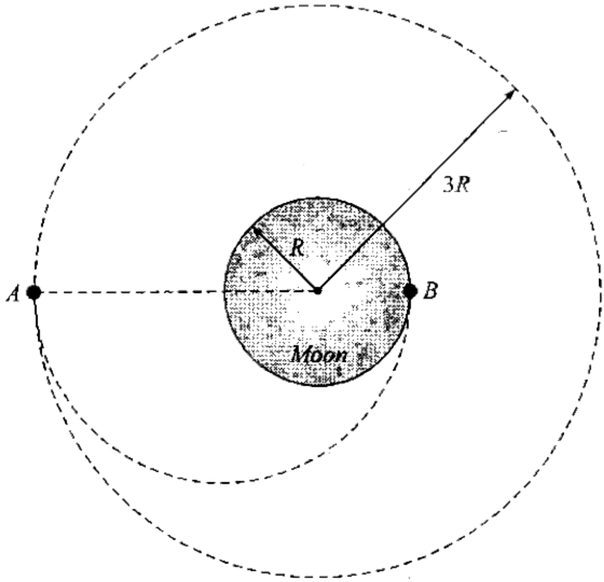
23. A spacecraft is in a circular orbitof radius $3R$ around the moon as shown in figure-6.109. At point A, the spacraft fires a probe which is supposed to arrive at the surface of the moon at point B. Datermine the necessary velocity v_r of the probe relative to the spacecraft just fter ejection. Also calculate the angular displacement θ of the spacecraft when the probe arrives at point B. Assume velocity of spacecraft remains unchanged due to ejection of probe.



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24. An object weighs $10N$ at north pole of Earth. In a geostationary satellite distance $7R$ from centre of Earth (of radius R), what will be its (a) true weight (b) apparent weight?

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25. What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of 2R?

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26. What will be acceleration due to gravity on the surface of the moon if its radius were $(1/4)^{th}$ the radius of earth and its mass $(1/80)^{th}$ the mass of earth? What will be the escape velocity on the surface of moon if it is $11.2km/s$ on the surface of the earth? (given that $g = 9.8m/s^2$)

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27. In a gravitational field $\overrightarrow{\overrightarrow{}} rg = \left(2\hat{i} + 3\hat{j}\right)N/kg$. What is the work done in moving particle from $(1, 1)$ to $(2, 1/3)$ along the line $2x + 3y = 5$.

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28. A satellite is revolving in the circular equatorial orbit of radius $R = 2 \times 10^4 km$ from east to west. Calculate the interval after which it will appear at the same equatorial town. Given that the radius of the earth $= 6400km$ and g (acceleration due to gravity) $= 10ms^{-2}$

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29. A system consists of a thin ring of radius R and a very long uniform wire oriented along axis of the ring with one of its ends coinciding with the centre of the ring. If mass of ring be M and mass of wire be λ per unit length, calculate interaction force between the ring and the wire.

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30. A pendulum beats seconds on the surface of the Earth. Calculate as to how much it loses or gains per day if it is taken to,

(a) a mass 8 km below,

(b) a point 8 km above, the surface. (Radius of the Earth $= 6.4 \times 10^6 m$)

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31. The ratio of the K.E. required to the given to the satellite to escape earth's gravitational field to the K.E. required to be given so that the satellite moves in a circular orbit just above earth atmosphere is

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32. If the time period of a satellite T_S is different from that of earth's rotation T_E and the satellite is moving in the direction of earth's rotation, show that the time interval between two successive appearances of the satellite overhead is given by ltbRgt

$$\frac{1}{T} = \frac{1}{T_S} \tilde{} \frac{1}{T_E}$$

What will happen to this interval if $T_S = T_E$

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33. Two identical solid copper spheres of radius R placed in contact with each other. The gravitational attracton between them is proportional to

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34. The masses and radii of the Earth and the Moon are M_1, R_1 and M_2, R_2 respectively. Their centres are at a distance d apart. The minimum speed with which a particel of mass m should be projected from a point midway between the two centres so as to escape to infinity is ....

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35. A 50 kg astronaut is floating at rest in space $35m$ from her stationary $150,000$ kg spaceship. About how long will it take her to float to the ship under the action of the force of gravity?

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36. The eccentricity of the earth's orbit is 0.0167, the ratio of its maximum speed in its orbit to its minimum speed is

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37. Find the proper potential energy of gravitational interaction of matter forming

(a) a thin uniform spherical layer of mass m and radius R,

(b) a uniform sphere of mass m and radius R(make use of the answer to Problem)

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38. A man of mass m starts falling towards a planet of mass M and radius R. As he reaches near to the surface realizes that he will pass through a small hole in the planet. As he enters the hole he seen that the planet really made of two places a spherical shell of negligible thickness of mass $\frac{2M}{3}$ and a point mass $\frac{M}{3}$ of centre. Change in the force of gravity experienced by the man is

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39. A pair of stars rotates about a common centre of mass. One of the stars has a mass M and the other m. Their centres are a distance d apart, d being large compared to the size of either star. Derive an expression for the period of revolution of the stars about their common centre of mass. Compare their angular momenta and kinetic energies.

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40. A planet of mass M moves around the Sun along an ellipse so that its minimum distance from the Sun is equal to r and the maximum distance to R. Making use of Kepler's laws, find its period of revolution around the Sun.

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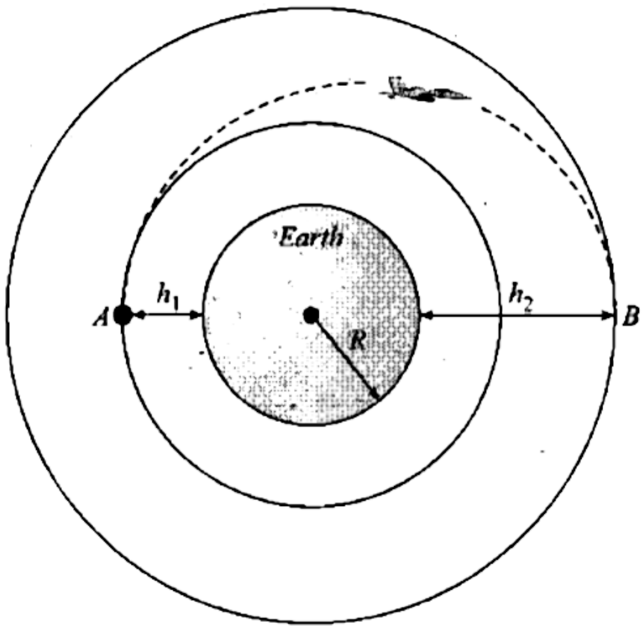
41. The optimal way of transferring a space vehicle from an inner circular orbit to an outer coplanar circular orbit is to fire its engines as it passes through A to increase its speed and place it in an elliptic transfer orbit. Another increase in speed as it passes through B will place it in the desired circular orbit. For a vehicle in a circular orbit about the earth at an altitude $h_1 = 320km$, which is to be transferred to a circular orbit at an altitude $h_2 = 800km$, determine :

(a) The required increases in speed at A and B.

(b) The total energy per unit mass required to execute the



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42. A lunar probe is rocketed from earth directly toward the moon in such a way that it always between the earth and the moon. The probe narrowly misses the moon and continues to travel beyond it on an extension of the line segement described above. At what distance from the center of the earth will the force due to the earth be equal to the force due to the moon?

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43. A particle is projected from earth surface with a velocity $\sqrt{\frac{4gR}{3}}$ in upward direction where R is the radius of earth. Find the velocity of particle when it is at half its maximum height.

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44. A rocket starts vertically upward with speed v_0. Show that its speed v at height h is given by $v_0^2 - v^2 = \frac{2hg}{1 + \frac{h}{R}}$

where R is the radius of the earth and g is acceleration due to gravity at earth's suface. Deduce an expression for maximum height reachhed by a rocket fired with speed 0.9 times the escape velocity.

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45. A satellite is in a circular orbit very close to the surface of a planet. At some point it is given an impulse along its direction of motion, causing its velocity to increase n times . It now goes into an elliptical orbit. The maximum possible value of n for this to occur is

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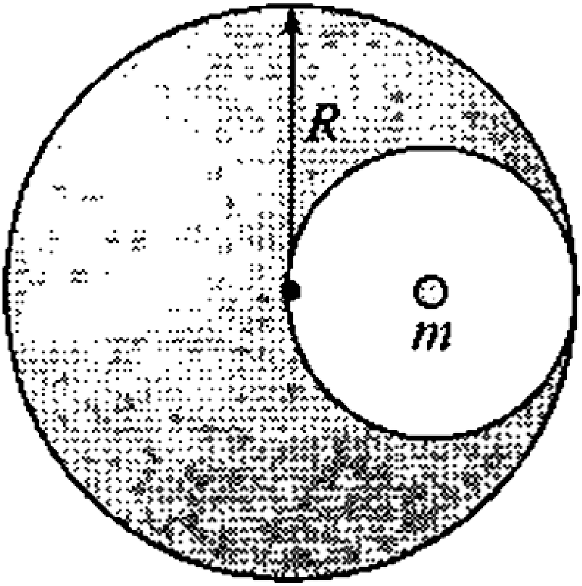
46. A spherical hollow is made in lead sphere of radius R, such that its surface touche the outside surface of the lead sphere and passes though its centre. The mass of the sphere before hollowing sphere exert on a point mass m placed at the centre of the hollow?



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47. If a satellites is revolving close to a planet of density ρ with period T, show that the quantity ρT^2 is a universal constant.

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48. Find the angular speed of earth so that a body lying at 30° latitude may become weightless.

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49. A projectile is fired vertically upwards from the surface of the earth with a velocity Kv_e, where v_e is the escape velocity and $K < 1$.If R is the radius of the earth, the maximum height to which it will rise measured from the centre of the earth will be (neglect air resistance)

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50. A satellite is in a circular polar orbit of altitude $300km$. Determine the sparation d at the equator between the ground tracks associated with two successive overhead passes of the satellite.

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51. A satellite of mass $5M$ orbits the earth in a circular orbit. At one point in its orbit, the satellite explodes into two pieces, one of mass M and the other of masses $4M$. After the explosion the mass M ends up travelling in the same circular orbit, but in the opposite direction. After explosion the mass $4M$ is

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52. A body is projected vertically upward from the surface of earth with a velocity sufficient to carry it to initially. Calculate the time taken by it to reach height h.

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53. What is the radius of a planet of density ρ if at its surface escape velocity of a body is v.

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54. Consider two satellites A and B of equal mass, moving in the same circular orbit of radius r around the earth but in the opposite sense and therefore a collision occurs.

(a) Find the total mechanical energy $E_A + E_B$ of the two satellite-plus-earth system before collision.

(b) If the collision is completely inelastic, find the total mechanical energy immediately after collision. Describe the subsequent motion of the combined satellite.

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55. A satellite is moving around the earth's with speed v in a circular orbit of radius r. If the orbit radius is decreases by 1%, its speed will

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56. A body on the equaotr of a planet weighs half of its weight at the pole. The density of matter of the planet is $3g/cm^3$. Determine the peiod of rotation of the planet about its axis.

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57. Two satellites move in circular orbits around the earth at distances $9000km$ and $9010km$ from earth's centre. If the satellite which is moving faster has a period of revolution 90 minutes. Find the difference in their revolution periods.

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58. A body Is projected horizontally near the surface of the earth with $\sqrt{1.5}$ times the orbital velocity. Calculate the maximum height up to which it will rise above the surface of the earth.

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59. A satellite is orbiting around earth with its orbit radius 16 times as great as that of parking satellite. What is the period of this satellite.

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60. What should be the radius of a planet with mass equal to that of earth and escape velocity on its surface is equal to the velocity of light. Given that mass of earth is $M = 6 \times 10^{24} kg$.

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61. Treating the earth as a symmetrical sphere of radius $R = 6400km$ with field $9.8N/kg$ at its surface, calcualate the vertical speed with which a rocket should be fired so as to reach a height $4R$ from the surface.

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62. A diametrical tunnel is dug across the earth. A ball dropped into the tunnel from one side. The velocity of the ball when it reaches the centre of the earth is [Given: gravitational potential at the centre of earth

$= -3/2(GM/R)]$

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63. Two satellite S_1 and S_2 revolve around a planet in coplanar circular orbits in the opposite sense. The periods of revolutions are T and ηT respectively. Find the angular speed of S_2 as observed by an astronouts in S_1, are observed by an astronaut in S_1, when they are closest to each other.

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64. A small body starts falling onto the Sun from a distance equal to the radius of the Earth's orbit. The initial velocity of the body is equal to zero in the heliocentric reference frame. Making use of Kepler's laws, find how long the body will be falling.

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65. Gravitational potential difference between surface of a planet and a point situated at a height of 20 m above its surface is 2joule/kg. if gravitational field is uniform, then the work done in taking a 5kg body of height 4 meter above surface will be-:

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66. What woluld be the length of a day. If angular speed of earth is increased such that bodies typing on the equator by off?

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67. A communication satellite is put in parking orbit. What is the time taken by a wave to go to satellite and come back to earth in its checking mode.

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68. A cord of length $64m$ is used to connected a $100kg$ astronaut to spaceship whose mass is much larger than that of the astronuat. Estimate the value of the tension in the cord. Assume that the spaceship is orbiting near earth surface. Assume that the spaceship and the astronaut fall on a straight line from the earth centre. the radius of the earth is $6400km$.

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69. The escape velocity for a planet is $20km / s$. Find the potential energy of a particle of mss $1kg$on the surface of this planet.

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70. A particle of mass $1kg$ is placed at a distance of $4m$ from the centre and on the axis of a uniform ring mass $5kg$ and radius $3m$. The work done to increase the distance of the particle from $4m$ to $3\sqrt{3}$m is

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71. A body of mass m rises to a height $h = R/5$ from the earth's surface where R is earth's radius. If g is acceleration due to gravity at the earth's surface, the increase in potential energy is

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72. A missile which missed its target went into an orbit around the earth at a mean radius 4

times great as the parking orbit. Find the period of missile

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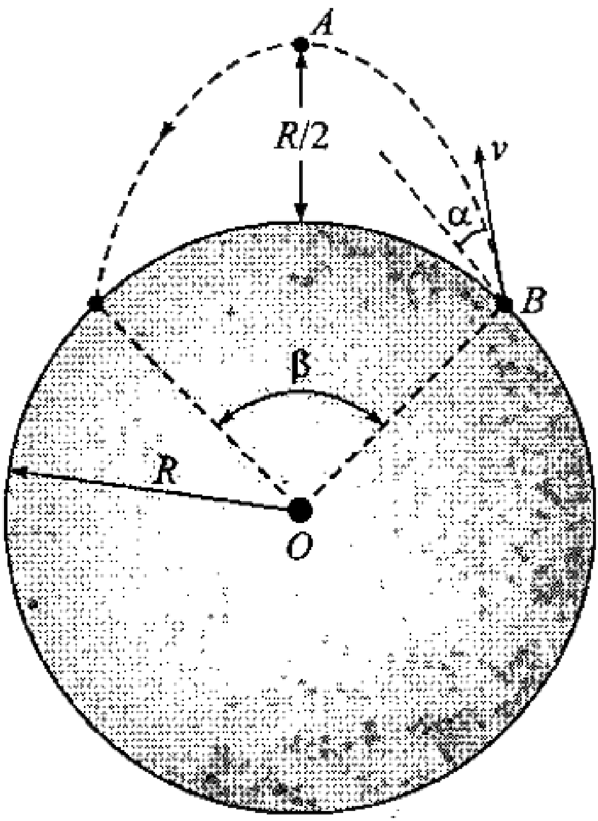
73. Compute the magnitude of the necessary launch velocity at B and angle α. If the projectile trajectory is to intersect the earth's surface so that the angle β equals 90°. The altitude at the highest point of the trajectory is $0.5R$.



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74. Suppose Moon's orbital motion around the earth is suddenly stopped. Making use of Kepler's third law find the time the moon shell take to fall on to the earth?

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75. Distance between the centres of two stars is 10α. The masses of these stars are M and 16M and their radii a and 2a, respectively. A body of mass m is fired straight form the surface of the larger star towards the smaller star. What should be its minimum inital speed to reach the surface of the smaller star? Obtain the expression in terms of G,M and a.

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76. If a body is to be projected vertically upwards from earth's surface to reach a height of $10R$ where R is the radius of earth. The velocity required to be is

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77. A satellite of mass , os revolving round the eartj at height of $10R$, where R is the radius of earth. What is the kinetic energy of satellite.

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78. A sapceship nears the Moon along a parabolic trajectory that almost toches the Moon's surface. In order to transfer closest approach. The engine ejects gas ata speed of $u = 4km/s$ realtive to the spaceship In its direction of motion. If $v_1 =$ velocity of spaceship in parabolic trajectory, when it almost touches the earth and $v_2 =$ velocity of spaceship in circular orbit when it almost to'uches the earth. Then what friction of total mass should the fuel burn to transfer space ship to circular orbit?

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79. If Earth be at one half its present distance from the sun, how many days will there be in a year?

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80. At what height from the ground will the value of ' g ' be the same as that in 10 km deep mine below the surface of earth

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81. A Body moving radially away from a planet of mas M, when at distance r from planet, explodes in such a way that two of its many fragments move in mutually prependicular circular orbits around the planet what will be

(i). Then velocity in circular orbits?

(ii). Maximum distance between the two fragments before collision and

(iii). Magnitude of their relative velocity just before they collide?

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82. Two equal masses each in are hung from a balance whose scale pans differ in vertical height by h. The error in weighing in terms of density of the earth ρ is

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83. The acceleration due to gravity about the earth's surface would be half of its value on the surface of the earth at an altitude of (R = 4000 mile)

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84. A ring of radius $R = 4m$ is made of a highly dense material. Mass of the ring is $m_1 = 5.4 \times 10^9 kg$ distributed uniformly over its circumference. A highly dense particle of mass $m_2 = 6 \times 10^8 kg$ is placed on the axis of the ring at a distance $x_0 = 3m$ from the centre. Neglecting all other forces, except mutual gravitational interacting of the two. Caculate

(i) displacemental of the ring when particle is at the centre of ring, and

(ii) speed of the particle at that instant.

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85. For particles of equal masses M that move along a circle of radius R under the action of their mutual gravitational attraction. Find the speed of each particle.

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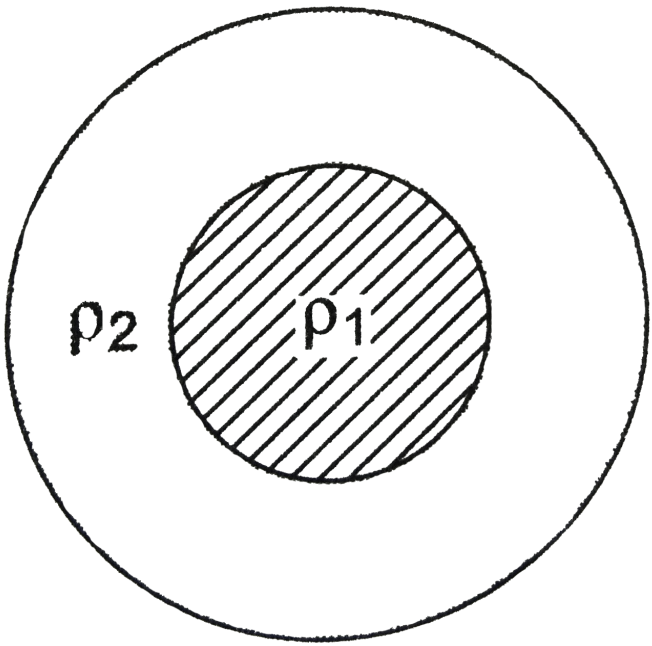
86. The density of the core a planet is ρ_1 and that of the outer shell is ρ_2. The radii of the core and that of the planet are R and $2R$ respectively. The acceleration due to gravity at the surface of the planet is same as at a depth R. Find the ratio of $\frac{\rho_1}{\rho_2}$



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87. A planet A moves along an elliptical orbit around the Sun. At the moment when it was at the distance r_0 from the Sun its velocity was equal to v_0 and the angle between the radius vector r_0 and the velocity vector v_0 was equal to α. Find the maximum and minimum distances that will separate this planet from the Sun during its orbital motion.

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88. If gravitational forces between a planet and a satellite is proportional to $R^{-5/2}$. If R is the orbit radius. Then the period of revolution of satellites is proportional to R^n. Find n.

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89. A uniform sphere of radius a and density ρ is divided in two parts by a plane at a distance b from its centre. Calculate the mutual attraction between two parts.

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90. A uniform sphere has a mass M and radius R. Find the pressure p inside the sphere, caused by gravitational compression, as a function of the distance r from its centre. Evaluate p at the centre of the Earth, assuming it to be a uniform sphere.

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91. A meteorite approaching a planet of mass M (in the straight line passing through the centre of the planet) collides with an automatic space station orbiting the planet in a circular trajectory of radius R. The mass of the station is ten times as large as the mass of the meteorite. As a result of the collision, the meteorite sticks in the station which goes over to a new orbit with the minimum distance R/2 from the planet. Speed of the meteorite just before it collides with the planet is : .

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92. Two satellites of the earth move in the sme plane with radii a and b,b being slghtly gerater than a. what is the minimum intants when they are on the same line thourth the centre of the earth (i) when they move in the same direction ,(ii) in oppsite direction?

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93. Two lead spheres of $20cm$ and $2cm$ diametre respectively are planet with centres $100cm$ apart. Calculate the attraction between them, given the radius of the Earth as $6.37 \times 10^8 cm$ and its mean density as $5.53 \times 10^3 kgm^{-3}$. Speciffic gravity of lead $= 11.5$. If the lead spheres are replaced by bress sphere of the same radii, would the force of attraction be the same?

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94. What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of 2R?

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