PHYSICS

NCERT - NCERT PHYSICS(GUJRATI)

GRAVITATION

Example

1. Let the speed of the planet at the perihelion pin be vP and the Sun-planet distance SP be r_P. Relate $\{r_P, v_P\}$ to the corresponding

quantities at the aphelion $\{r_A, v_A\}$. Will the planet take equal times to traverse BAC and CPB ?

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2. Three equal masses of m kg each are fixed at the vertices of an equilateral triangle ABC.

(a) What is the force acting on a mass 2m placed at the centroid G of the triangle?

(b) What is the force if the mass at the vertex

A is doubled ?

Take AG = BG = CG = 1 m

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3. Find the potential energy of a system of four particles placed at the vertices of a square of side l. Also obtain the potential at the centre of the square.

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4. Two uniform solid spheres of equal radii R, but mass M and 4 M have a centre to centre separation 6 R, as shown . The two spheres are held fixed. A projectile of mass m is projected from the surface of the sphere of mass M directly towards the centre of the second sphere. Obtain an expression for the minimum speed v of the projectile so that it reaches the surface of the second sphere.

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5. The planet Mars has two moons, phobos and delmos. (i) phobos has a period 7 hours, 39 minutes and an orbital radius of 9.4 $\times$ 103 km. Calculate the mass of mars. (ii) Assume that earth and mars move in circular orbits around the sun, with the martian orbit being 1.52 times the orbital radius of the earth. What is the length of the martian year in days ?

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6. Weighing the Earth : You are given the following data: g = 9.81 ms^{-2}, $R_E = 6.37 \times x10^6$ m, the distance to the moon R = $3.84 \times x10^8$ m and the time period of the moon's revolution is 27.3 days. Obtain the mass of the Earth M_E in two different ways.

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7. Express the constant k of Eq. (8.38) in days and kilometres. Given k = $10^{-13} s^2 m^{-3}$. The moon is at a distance of $3.84x \times 105$ km from the earth. Obtain its time-period of revolution in days.

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8. A 400 kg satellite is in a circular orbit of radius $2R_E$ about the Earth. How much energy is required to transfer it to a circular orbit of

radius $4R_E$? What are the changes in the kinetic and potential energies ?

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Exercises

1. You can shled a charge from electrical forces by putting it inside a hollow conductor. Can you shield a body from the gravitational influence of nearby matter by putting it inside a hollow sphere or by some other means ?

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

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3. If you compare the gravitational force on the earth due to the sun to that due to the

moon, you would find that the Sun's pull is greater than the moon's pull. (you can check this yourself using the data available in the succeeding exercises). However, the tidal effect of the moon's pull is greater than the tidal effect of sun. Why ?

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4. Acceleration due to gravity increases/decreases with increasing altitude.

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5. Acceleration due to gravity increases/decreases with increasing depth (assume the earth to be a sphere of uniform density).

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6. Acceleration due to gravity is independent of mass of the earth/mass of the body.

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7. The formula $-G\ Mm(1/r_2 - 1/r_1)$ is more/less accurate than the formula $mg(r_2 - r_1)$ for the difference of potential energy between two points r_2 and r_1 distance away from the centre of the earth.

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8. Suppose there existed a planet that went around the Sun twice as fast as the earth.

What would be its orbital size as compared to that of the earth ?

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9. Let us assume that our galaxy consists of 2.5 $x \times 10^{11}$ stars each of one solar mass. How long will a star at a distance of 50,000 ly from the galactic centre take to complete one revolution? Take the diameter of the Milky Way to be 10^5 ly.

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10. If the zero of potential energy is at infinity, the total energy of an orbiting satellite is negative of its kinetic/potential energy.

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11. The energy required to launch an orbiting satellite out of earth's gravitational influence is more/less than the energy required to project a stationary object at the same height (as the satellite) out of earth's influence.

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12. Does the escape speed of a body from the earth depend on (a) the mass of the body, (b) the location from where it is projected, (c) the direction of projection, (d) the height of the location from where the body is launched?

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13. A comet orbits the sun in a highly elliptical orbit. Does the comet have a constant (a) linear speed, (b) angular speed, (c) angular momentum, (d) kinetic energy, (e) potential energy, (f) total energy throughout its orbit? Neglect any mass loss of the comet when it comes very close to the Sun.

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14. Which of the following symptoms is likely to afflict an astronaut in space (a) swollen feet, (b) swollen face, (c) headache, (d) orientational problem.

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

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16. A rocket is fired from the earth towards the sun. At what distance from the earth's centre is the gravitational force on the rocket zero ? Mass of the sun = 2×10^{30}kg. Mass of the earth = 6×10^{24}kg. Neglect the effect of other planets etc. (orbittal radtus = 1.5×10^{11} m).

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17. How will you 'weigh the sun', that is estimate its mass? The mean orbital radius of

the earth around the sun is 1.5×10^8 km.

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

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19. A body weighs 63 N on the surface of the earth. What is the gravitational force on it due

to the earth at a height equal to half the radius of the earth ?

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

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21. A rocket is fired vertically with a speed of 5 km s^{-1} from the earth's surface. How far from the earth does the rocket go before returning to the earth ? Mass of the earth = 6.0×10^{24} kg, mean radius of the earth = $6.4 \times 10^{6} m, G = 6.67 \times 10^{-11}$ N $m^{2} kg^{-2}$.

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22. The escape speed of a projectile on the earth's surface is 11.2 km s^{-1} . A body is

projected out with thrice this speed. What is the speed of the body far away from the earth? Ignore the presence of the sun and other planets.

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23. A satellite orbits the earth at a height of 400 km above the surface. How much energy must be expended to rocket the satellite out of the earth's gravitational influence? Mass of the satellite = 200 kg, mass of the earth

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

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24. Two stars each of one solar mass $\left(= 2 \times 10^{30} kg \right)$ are approaching each other for a head on collision. When they are a distance 10^{9} km, their speeds are negligible. What is the speed with which they collide ? The radius of each star is 10^4 km. Assume the

stars to remain undistorted until they collide. (Use the known value of G).

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

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Additional Exercises

1. As you have learnt in the text a geostationary satellite orbits the earth at a height of nearly 36,000 km from the surface of the earth. What is the potential due to earth's gravity at the site of this satellite ? (Take the potential energy at infinity to be zero).

Mass of the earth $6.0 \times 10^{24\,(kg)}$,

Radius = 6400 km .

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2. A star 2.5 times the mass of the sun and collapsed to a size of 12 km rotates with a speed of 1.2 rev. per second. (Extremely compact stars of this kind are known as neutron stars. Certain stellar objects called pulsars belong to this category). Will an object placed on its equator remain stuck to its surface due to gravity ?

(Mass of the sun $= 2 \times 10^{30} kg$).

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

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4. A rocket is fired 'vertically' from the surface of mars with a speed of 2 km s^{-1}. If 20% of its initial energy is lost due to martian atmospheric resistance, how far will the rocket go from the surface of mars before returning to it ? Mass of mars = 6.4×10^{23} kg, radius of mars = 3395 km, G = $6.67 \times 10^{-11} Nm^2 Kg^{-2}$.

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