PHYSICS

BOOKS - MODERN PUBLICATION

Gravitational potential and potential energy

Example

1. The distance between the moon and the earth is 3.8×10^8m. Find the intensity of the

gravitational potential at the midpoint of the line joining them. given that the mass of the earth is 6×10^{24}kg, mass of the moon = 7.4×10^{22}kg and G =$6.67 \times 10^{-11} Nm^2 kg^{-2}$

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2. The distance between the moon and the earth is 3.8×10^{8}m. Find the intensity of the gravitational potential at the midpoint of the line joining them. given that the mass of the

earth is 6×10^{24}kg, mass of the moon = 7.4×10^{22}kg and G =$6.67 \times 10^{-11} Nm^2 kg^{-2}$

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3. Find the velocity of escape at the moon. Given that its radius is $1.7 \times 10^6 m$ and the value of 'g' is $1.63 ms^{-2}$.

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4. Determine the escape speed of Moon. Given, the radius of Moon is $1.74 \times 10^6 m$, its mass is 7.36×10^{22}kg. G = $6.67 \times 10^{-11} nm^2 kg^{-2}$.

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5. A particle of mass 10g is kept on the surface of a uniform sphere of mass 100kg and radius 10cm. Find the work to be done against the gravitational force between them to take the

partice far away from the sphere (you may take G = $6.67 \times 10^{-11} N \frac{m^2}{k} g^2$)

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6. If g is the acceleration due to gravity on the earth's surface, what will be the gain in the potential energy of an object of mass m raised from the surface of the earth to a height equal to twice the radius of the earth?

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7. In Greek methology, Atlas carried the entire earth on his shoulders. How much work did Atlas do in supporting the earth on his shoulders?

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8. 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.

Given, mass of the earth- $6.0 \times 10^{24} kg$ and radius of the earth = 6,400 km.

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9. Three mass points each of mass mare placed at the vertices of an equilateral triangle of side 1. What is the gravitational field and potential due to three masses at the centroid of the triangle?

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10. The potential energy between two atoms in a molecule is given by $U(x) = \left(\frac{a}{x^{12}}\right) - \left(\frac{b}{x^6}\right)$, where a and b are positive constants and x is the distance between the atoms. find the distance between the atoms so that the molecule is in stable equilibrium

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11. Jupiter has a mass 318 times that of the earth and its radius is 11.2 times the earth's

radius. Estimate the escape velocity of a body from jupiter's surface. Given, the escape velocity from the earth's surface = $11.2 kms - {}^{1}$.

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12. With what velocity should an object be projected from the surface of the earth so that its height above the surface becomes equal to the radius of the earth?

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13. the earth is assumed to be a sphere of radius R. A platform is arranged at a height R from the surface of the earth. the escape velocity of a body from its platform is kv_e where v_e is its escape velocity from the surface of the earth. find the value of k.

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14. The escape speed of a projectile on the earth's surface is $11.2kms^{-1}$. 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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15. Distance between the centres of two stars is 10a. the masses of these charges are M and 16M whereas the radii are a and 2a respectively. a body of mass m is fired straight from the surface of the largest star towards

the smallest star. what would be its minimum initial speed to reach the surface of the smaller star? obtain an expression in terms of G,M and a.

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16. There is a crater of depth $\frac{R}{100}$ on the surface of the moon (radius R). A projectile is fired vertically upwards from the crater with velocity, which is equal to theescape velocity v from the surface of the moon. Find the

maximum height attained attained by the projectile.

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17. What will be the corresponding expression for the energy needed to completely diassemble the planet earth against the gravitational pull amongst its constituent particles? Assume the earth to be a sphere of uniform mass density. calculate the energy,

given that the product of the mass and the radius of the earth to be $2.5 \times 10^{31} kg - m$

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18. What is meant by gravitational field strength?

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19. What is the value of gravitational field on the surface of earth?

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20. What is the gravitational field strength of a planet, where the weight of a 60 kg astronaut is 300 N?

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21. What is the gravitational potential energy of two point masses infinite distance away from each other?

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22. where is a value for gravitational potential energy maximum?

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23. Is the gravitational potential energy of bodies is positive or negative? Give reason in support of your answer.

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24. Can gravitational potential be positive?

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25. Does the escape velocity depend upon the mass of the object to be projected?

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26. An elephant and an ant are to be projected far away into space. Do we need different

velocities for their projection?

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27. Why do different planets have different escape velocities?

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28. Name two factors which determine whether a planet has an atmosphere or not

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29. What is gravitational force?

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30. Define the terms ,gravitational field inensity and gravitaional potential.

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31. The acceleration due to gravity at a place gives a measure of the gravitational field at that point, Explain.

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32. Four equal masses are placed at the four comers of a square. What is the intensity of gravitational field at the point of intersection of the diagonals of the square?

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33. The earth's gravitational force causes an acceleration of 5m//s^(2) in 1 kg mass somewhere in space. How much will the acceleration of a 3 kg mass be at the same place? Give your answer with reason.

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34. Why do stars appear displaced away from the sun?

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35. Does the change in gravitational potential energy of a body between two points depend upon the nature of path followed? Explain.

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36. What is the gravitational potential energy of two point masses infinite distance away from each other?

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37. A comet orbits the sun in a highly elliptical orbit. Does the comet have a constant:- linear speed,

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38. A comet orbits the sun in a highly elliptical orbit. Does the comet have a constant:- angular momentum,

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39. A comet orbits the sun in a highly elliptical orbit. Does the comet have a constant:- total energy throughout its orbit? Neglect any mass loss of the comet when it comes very close to the Sun.

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40. A comet orbits the sun in a highly elliptical orbit. Does the comet have a constant:- potential energy,

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41. A comet orbits the sun in a highly elliptical orbit. Does the comet have a constant:- total energy throughout its orbit? Neglect any mass loss of the comet when it comes very close to the Sun.

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42. What is gravitational potential? What are its units and dimensions?

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43. Explain why moon has no atmosphere.

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44. Why there is practically no atmosphere near the surface of the moon?

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45. Why does hydrogen escape faster from earth's atmosphere than oxygen?

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46. Why does the atmosphere of jupiter contain light gases (mostly hydrogen), whereas the earth's atmosphere has little of hydrogen gas?

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47. Two spheres of masses 64 kg and 298 kg are placed a distance 10 m apart. Find the position of a point on the line joining the centres of the two spheres, where the gravitational field is zero.

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48. The distance between earth and moon is 3.8×10^5 km and the mass of earth is 81 times the mase of the moon. Find the position of a point on the line joining the centres of earth

and moon, where the gravitational field is zero. Given, radius of the earth-6.04×10^6 m.

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49. Three mass, each of 1 kg, are placed on the vertices of an equilateral triangle of side length 0.4m. What is the total gravitational potential energy of the configuration?

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50. It R is radius of the earth, then find the energy required to move a body of map in from an orbit of radius 2R to 3R

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51. How much energy must be given to a 100 kg rocket missile to carry it from the surface of eartly into five space? Given, the gravitational constant, C- $6.67 \times 10^{-11} Nm^2 kg^{-2}$ mass of

the earth 6×10^{24} kg and radius of the earth 6.4×10^{6} m

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52. Find the change in gravitational potential energy of a body of mass 50 kg, when it is moved from the surface of earth to a point at height twice the radius of the earth. Givent radius of the earth, R-6.4×10^{6} m and acceleraation due to gravity, g=$9.8 ms^{-2}$

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53. A body is projected vertically upwards from the surface of the Earth so as to reach a height equal to the radius of the Earth. Neglecting resistance due to it, calculate the initial speed which should be imparted to the body. Mass of Earth = $5.98 \times 10^{24} kg$, Radius of Earth = 6400 km, G = $6.67 \times 10^{-11} Nm^2 kg^{-2}$

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54. A body is released at a distance far away from the surface of the earth. Calculate its speed when it is near the surface of earth. Given g=$9.8ms^{-2}$ radius of earth R=6.37×10^6 m

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55. The radius of the earth is 6.37×10^6 m, its mean density is $5.5 \times 10^3 kgm^{-3}$ and G=

$6.67x10^{-11}Nm^2kg^{-2}$ Calculate the earth's surface potential.

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56. Calculate the gravitational field strength and the gravitational potential at the surface of the moon. The mass of the moon is 7.34×10^{22}kg and its radius is 1.74×10^{6}m. (G=$6.67 \times 10^{-11}Nm^2kg^{-2}$)

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57. At a point above the surface of the earth, the gravitational potential is- $5.12 \times 10^7 Jkg^{-1}$ and acceleration due to gravity is $6.4ms^{-2}$ Find the height of the point above the surface of earth. Given, radius of the earth, R-6.4×10^6 m.

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58. If the potential at a point due to the earth's gravitation is taken to approach zero as the distance of the point from the earth's

centre becomes larger and larger (e approaches infinity), what is the gravitational potential and potential energy of a body of mass 0.1 kg at the earth's surface.

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59. If the potential at a point due to the earth's gravitation is taken to approach zero as the distance of the point from the earth's centre becomes larger and larger (e approaches infinity), what is the gravitational

potential and potential energy of a body of mass 0.1 kg at a height above the surface of the earth equal to its mean radios R. Given that G=$6.67x10^{-11}Nm^2kg^{-2}$, mans of the earth =5.98×10^{24}kg and R-6.37×10^6 m. Assume the earth to be a perfect sphere of uniform mass density

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60. Calculate the speed of projection necessary to send a body right out of the filed

of the earth's grvivtational attraction. G= $6.63 \times 10^{-11} Nm^2 Kg^{-2}$ Mass of the earth = $6.05 \times 10^{27} g$ Radius of the earth = 6.37×10^6 m.

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61. If Earth has mass nine times and radius twice that of the planet Mars, calculate the velocity required by a rocket to pull out of the gravitational force of Mars. Take escape speed on surface of Earth to be $11.2 km / s$

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62. What will be acceleration due to gravity on the surface of moon if its radius is $\frac{1}{4}$th the radius of the earth and its mass is $\frac{1}{81}$th the mass of the earth? What will be the escape velocity on the surface of moon, if it is $11.2 kms^{-1}$ on the surface of the earth?

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63. A body of mass 100 kg falls on the earth from infinity. Given radius of earth = 6400 km and $g = 9.8m/s^2$. Air friction may be neglected. Its velocity and energy on reaching the earth are:

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64. The escape speed of a projectile on the earth's surface is $11.2kms^{-1}$. 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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65. Two bodies of masses m_1 and m_2 are placed at a distance r apart. Show that at the position, where the gravitational field due to them is zero, the potential is given by $V_{grav} = -\frac{G}{r}(m_1 + m_2 + 2\sqrt{m_1 m_2})$

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66. 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. Find 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 their gravitation pull

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67. Two masses M_1 and M_2 are initially at rest at infinite distance apart. They approach each other due to gravitational interaction. Find their speed of approach at the instant, when they are distance rapart.

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68. 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 = $2 \times 10^{30} kg$, mass of mars = $6.4 \times l0^{23} kg$, radius of mars = 3395 km, radius of the orbit of mars = 2.28x10^8 km, $G = 6.67$xx10^-11 N m^2 kg^-2`.

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69. A rocket is launched vertically from the surface of earth with a velocity u. Find the height up to which the rocket can go from the

surface of the earth before falling back to earth

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Exercise

1. What do you understand by gravitational field?

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2. Define gravitational field. Give its SI unit.

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3. Show that the gravitational field and potential at any point on the surface of the earth are g and g R respectively. The earth may be assumed to be a sphere of uniform density.

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4. Define the terms ,gravitational field inensity and gravitaional potential.

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5. Define gravitational potential and find an expression for it.

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6. What is escape velocity ?

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7. Define escape velocty. Obtain an expression for the escape velocity of a body from the surface of earth.

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8. Define escape velocty. Obtain an expression for the escape velocity of a body from the surface of earth.

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9. Show that the escape velocity of a planet is $\sqrt{2gR}$ where g is the acceleration due to gravity of the planet and R is the radius.

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10. Value of escape velocity from the earth's surface is

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11. Show that the square of the escape velocity is equal to the product of the diameter of the earth and the acceleration due to gravity.

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12. Show that the velocity, with which an object is to be projected from the surface of the earth, so that it may overcome the gravitational pull of the earth, must have a maximum value of `sqrt(2GM/R).

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13. It is said that Bhima was so powerful a person that held throw big elephants so that they would never return to the surface to the earth. How much work had he to do in throwing up an elephant of mass m?

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14. Derive an expression for gravitational potential energy of body of mass M at

distance r from centre of earth.

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15. Derive an expression for the increase in potential energy of a body, when moved from a point at distance r_1, to a point at distance r_2 (`r_1

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16. Prove that the velocity of escape of a body from the earth's surface is $\sqrt{2}$ times the velocity for a circular orbit just above the earth's surface

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17. Find the expression for escape velocity of earth.

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