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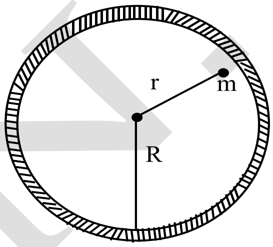
PHYSICS

2.GRAVITATION,GRAVITATION

Single Correct Answer Type

1. A satellite is orbiting at a certain height in a circular orbit. If the mass of the planet is reduced to half the initial value, the satellite would
   a) Fall on the planet
   b) Go to the orbit of smaller radius
   c) Go to the orbit of larger radius
   d) Escape from the planet
2. A body is projected vertically upwards from earth's surface. If its kinetic energy of projection is equal to half of its minimum value required to escape from earth's gravitational influence then the height upto which it rises is (R = radius of earth)
   a) 2R b) R
   c) 4R d) 3R
3. Imagine a light planet revolving around a very massive star in a circular orbit of radius r with a period of revolution T. If the gravitational force of attraction between the planet and the star is proportional to $R^{-3/2}$, then T^2 is proportional to
   a) R^3 b) $R^{5/2}$
   c) $R^{3/2}$ d) $R^{7/2}$
4. A mass m is placed inside a hollow sphere of mass M as shown in figure. The gravitational force on mass m is



   a) $\frac{GMm}{R^2}$ b) $\frac{GM\text{m}}{r^2}$
   c) $\frac{GMm}{(R-r)^2}$ d) zero
5. A body detached gently from the outer wall of a satellite orbiting around the earth will
   a) Fall of the earth
   b) Follow an irregular path
   c) Continue to move along with the satellite
   d) Escape from earth's field
6. If the earth suddenly contracts so that its radius reduces by 4% with mass remaining same, then what will happen to the escape velocity from earth's surface now?
   a) Increases by 4% b) Decreases by 4%
   c) Increases by 2% d) Decreases by 2%
7. An object is released from a height twice the radius of the earth on the surface of earth. Find the speed with which it will collide with group by neglecting effect of air. (Take, R radius of earth and mass of earth as M).
   a) $2\sqrt{\frac{GM}{3R}}$ b) $3\sqrt{\frac{GM}{2R}}$
   c) $2\sqrt{\frac{GM}{R}}$ d) $3\sqrt{\frac{GM}{R}}$
8. A body is projected vertically upwards from earth's surface. If its K. E. of projection is equal to half of its minimum value required to escape from the gravitational influence, then the height upto which it rises is (R = radius of the earth)
   a) 4R b) R
   c) 2R d) 3R
9. Two identical satellites are orbiting at distances R and $7R$ from the surface of the earth, R being the radius of the earth. The ratio of their
   a) kinetic energies is 4 b) potential energies is 4
   c) total energies is 4 d) All of these
10. A geostationary satellite has an orbital period of
    a) 2 hr b) 6 hr c) 12 hr d) 24 hr
11. A body of mass m is moved to a height equal to the radius of earth R. the increase in potential energy is:
    a) mgR b) 2mgR c) 1/2mgR d) 1/4 mgR
12. The gravitational potential energy of a body at a distance r from center of the earth is e, then

its weight at that point is:

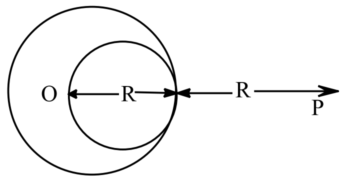
a) Er b) E/r c) E/r^2 d) Er^2

13. What are the reasons due to which the astronauts do not feel weight inside the satellite:
    a) There is no reaction of the floor on him
    b) The reaction of he floor balance the weight
    c) Gravitational pull due to earth provides the centripetal force
    d) Gravitational pull is balanced by centrifugal

    a) i and ii b) iii and iv
    c) i and iii d) iv and ii
14. The angular velocity of rotation of a star of mass M and radius R at which the matter will escape from its equator is

    a) $\sqrt{\frac{2GR}{M}}$ b) $\sqrt{\frac{2GM}{R^3}}$ c) $\sqrt{\frac{2GM}{R}}$ d) $\sqrt{\frac{2GM^2}{R}}$
15. A satellite of mass 'm' revolving around the earth of radius 'r' has kinetic energy 'E'. Its angular momentum is

    a) 2mEr b) $\sqrt{2mEr^2}$
    c) $\sqrt{2mEr}$ d) $4mEr^2$
16. A satellite moving along a circular orbit, a larger orbit corresponds to
    a) Longer period and slower velocity
    b) Larger velocity and longer periods
    c) Smaller periods and smaller velocity
    d) Smaller periods and larger velocity
17. The earth revolves about the sun in an elliptical orbit with mean radius 9.3×10^7m in a period of 1 year. Assuming that there are no outside influences, then
    a) The earth's kinetic energy remains constant
    b) The earth's angular momentum remains constant
    c) The earth's potential energy remains constant
    d) All the statements above are correct
18. 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 the figure. The sphere with cavity now applies a gravitational force F_2 on same particle placed at P. The ratio F_2/F_1 will be



    a) 1/2 b) 7/9
    c) 3 d) 7
19. Monitor or weather satellites are:
    a) Equatorial satellites
    b) Polar satellites
    c) Communication satellites
    d) Non polar satellites
20. Which of the following is conserved in the planetary motion around the sun?

    a) Linear momentum b) Kinetic energy
    c) Potential energy d) Angular momentum
21. If a body is taken from the surface of earth to moon, then its weight will
    a) First decrease then increase
    b) First increase then decrease
    c) Continuously increase
    d) Continuously decrease
22. There is body lying on earth and suppose earth suddenly looses its power of attraction then:
    a) The mass of body will reduce to zero
    b) The weight of body will reduce to zero
    c) Both will reduce to zero
    d) Become infinity
23. If the gravitational force were proportional to $\frac{1}{r}$, then a particle in a circular orbit under such a force would have its original speed

    a) Independent of r b) $\propto \frac{1}{r}$
    c) $\propto \frac{1}{r^2}$ d) $\propto r^2$
24. It is advantageous to launch space ship rockets
    a) From east to west in the equatorial plane
    b) From west to east in the equatorial plane
    c) From north to south in any direction
    d) From south to north in any direction
25. Infinite number of bodies, each of mass 2 kg are situated on x-axis at distance 1 m, 2 m, 4 m, 8 m, ... respectively, from the origin. The resulting gravitational potential due to this system at the origin will be

    a) $-G$ b) $-\frac{8}{3}G$ c) $-\frac{4}{3}G$ d) $-4G$
26. Which of the following has nothing to do (independent) with mass of the earth:
    a) Orbital velocity
    b) Escape velocity

c) Gravitational intensity (g)
d) Universal gravitational constant (E_G)

27. The ratio of radii of earth to another planet is 2/3 and the ratio of their mean densities is 4/5. If an astronaut can jump to a maximum height of 1.5 m on the earth, with the same effort, the maximum height he can jump on that planet is
a) 1 m b) 0.75 m
c) 0.5 m d) 1.25 m

28. A satellite is placed in a circular orbit around the earth at such a height that it always remains stationary with respect to the earth's surface. In such case, its height from the earth's surface is
a) 32000 km b) 36000 km
c) 6400 km d) 4800 km

29. Two satellites of masses m and 4m orbit the earth in circular orbits of radii 4r and r respectively. The ratio of their orbital speeds is
a) 1 b) $\frac{1}{2}$ c) $\frac{1}{\sqrt{2}}$ d) $\frac{1}{\sqrt{5}}$

30. Inertial mass of body can be measured by:
a) Hooks law
b) Newton's Ist law
c) Newton's IInd law
d) 2:1 Newton's law of gravitation

31. Let 'g_h' and 'g_d' be the acceleration due to gravity at height 'h' above the earth's surface and at depth 'd' below the earth's surface respectively. If $g_h = g_d$ then the relation between 'h' and 'd' is
a) $d = h$ b) $d = \frac{h}{2}$ c) $d = \frac{h}{4}$ d) $d = 2h$

32. The ratio between masses of two planets is 2 : 3 and ratio between their radii is 3 : 2. The ratio between accelerations due to gravity on these two planets is
a) 4 : 9 b) 8 : 27 c) 9 : 4 d) 27 : 8

33. Kepler's second law regarding constancy of aerial velocity of a planet is a consequence of the law of conservation of:
a) Energy b) Angular momentum
c) Linear momentum d) None of these

34. If a body is released from an artificial satellite then
a) It will fall on the earth
b) It will not fall on the earth but will be attracted towards the earth
c) It will escape in the universe
d) It will continue orbiting along with satellite

35. A body weighs 45 N on the surface of the earth. What is the gravitational force on it due to the earth at a height equal to half of the radius of the earth?
a) 20 N b) 45 N
c) 40 N d) 90 N

36. The gravitational potential per unit mass at a point gives _______ at that point
a) Gravitational field
b) Gravitational potential
c) Gravitational potential energy
d) None of these

37. The ratio of the acceleration due to gravity on two planets P_1 and P_2 is k_1. The ratio, of their respective radii is k_2. The ratio of their respective escape velocities is
a) $\sqrt{k_1 k_2}$ b) $\sqrt{2k_1 k_2}$ c) $\sqrt{\frac{k_1}{k_2}}$ d) $\sqrt{\frac{k_2}{k_1}}$

38. Newton's law of gravitation is universal because
a) It is always attractive
b) It acts on all the masses at all distances and not affected by the medium
c) It acts on all bodies and particles in the universe
d) No reason

39. Which of the following interaction is the weakest?
a) Gravitational b) Electrostatic
c) Nuclear d) Electromagnetic

40. A particle of mass m is subjected to an attractive central force of magnitude $\frac{k}{r^2}$, k being a constant. At the instant when the particle is at its extreme position in its closed orbit at a distance 'a' from the centre of force, its speed is $\frac{k}{2ma}$. If the distance of other extreme is b, find $\frac{a}{b}$
a) -1 b) 2 c) 3 d) 4

41. The earth (mass $= 6 \times 10^{24}$ kg) revolves round the sun with an angular velocity of 2×10^{-7} rad/s in a circular orbit of radius 1.5×10^8 km. The gravitational force exerted by the sun on the earth, in newton is
a) Zero b) 18×10^{25}
c) 36×10^{21} d) 27×10^{39}

42. A 400 kg satellite is in a circular orbit of radius $2R_E$ around the Earth, where R_E = radius of

the earth. With reference to the above situation, match the terms in Column I with items in Column II and choose the correct option from the codes given below.

Column I	Column II
A. Energy required to transfer it to a circular orbit of radius $4R_E$	1. $-6.26 \times 10^9\ J$
B. Change in $KE, \Delta K (KE \rightarrow K$ Kinetic energy)	2. $3.13 \times 10^9\ J$
C. Change in potential energy, ΔPE	3. $-3.13 \times 10^9\ J$

a) 2 3 1　　b) 1 2 3
c) 3 2 1　　d) 2 1 3

43. Which of the following is the S.I. unit of universal gravitational constant?
a) Nm/kg^2　b) Nm^2/kg　c) Nm/kg　d) Nm^2/kg^2

44. Two planets have radii r_1 and r_2 and densities d_1 and d_2, respectively. Then, the ratio of acceleration due to gravity on them will be
a) $r_1d_1 : r_2d_2$　　b) $r_1d_2 : r_2d_1$
c) $r_1^2d_1 : r_2^2d_2$　　d) $r_1 : r_2$

45. K.E. of revolving satellite at a height equal to radius of earth
a) 1/4 mgR　b) 1/2 mgR　c) 2 mgR　d) 3/4 mgR

46. If mean radius of earth is R, its angular velocity is ω and the acceleration due to gravity at the surface of the earth is g, then the cube of the radius of the orbit of geostationary satellite will be
a) $\frac{R^2g}{\omega^2}$　　b) $\frac{R^2\omega^2}{g}$
c) $\frac{R^2g}{\omega}$　　d) $\frac{R^2g}{\omega^2}$

47. A body is projected vertically upwards from earth's surface with velocity $2V_e$ where V_e is escape velocity from earth's surface. The velocity when body escapes the gravitational pull is
a) $3V_e$　　b) $\frac{V_e}{\sqrt{3}}$
c) $\sqrt{3}V_e$　　d) $\sqrt{2}V_e$

48. The maximum possible velocity of a satellite orbiting round the earth in a stable orbit is
a) $\sqrt{2R_eg}$　b) $\sqrt{R_eg}$　c) $\sqrt{\frac{R_eg}{2}}$　d) Infinite

49. Two bodies at a certain separation experience some gravitational force. If they are brought into contact, the gravitational force between them
a) Increases　　b) Decreases
c) Remains the same　　d) Becomes zero

50. The time period 'T' of a satellite is related to the density (ρ) of the planet which is orbiting close around the planet as
a) $T \propto \rho^{-1/2}$　　b) $T \propto \rho$
c) $T \propto \rho^{1/2}$　　d) $T \propto \rho^{-3/2}$

51. A body is thrown from the surface of the earth with velocity 'V' $\frac{m}{s}$. The maximum height above the earth's surface upto which is will reach is (R = radius of earth, g = acceleration due to gravity)
a) $\frac{V^2R}{2gR^2 - V^2}$　　b) $\frac{2gR}{V^2(R-1)}$
c) $\frac{VR}{2gR - V}$　　d) $\frac{VR^2}{gR - V}$

52. Gravitational intensity at a point on the surface of planet is:
a) $\frac{GM}{R^2}$　b) $-\frac{GM}{R}$　c) $\frac{GM}{R}$　d) $\frac{GM}{2R}$

53. When the earth revolves round the sun in an elliptical orbit, its kinetic energy is
a) Go on decreasing continuously
b) Greatest when it is closest to the sun
c) Greatest when it is farthest from the sun
d) Constant at all points on the orbit

54. A mass M is split into two parts m and (M − m), which are separated by a certain distance. The ratio m/M which maximises the gravitational force between the parts is
a) 1:4　　b) 1:2
c) 4:1　　d) 2:1

55. The binding energy of a body does not depend upon
a) Mass of the planet
b) Its distance from the centre of the planet
c) Mass of the body
d) Shape of the body

56. A body of mass ‘m’ is taken from the earth’s surface to the height equal to twice the radius (R) of the earth. The change in potential energy of body will be

a) mg2R b) $\frac{2}{3}$ mgR c) 3mgR d) $\frac{1}{3}$ mgR

57. If suppose moon is suddenly stopped and then released (given, radius of moon is (1/4) th of the radius of earth and the acceleration of moon with respect to earth is 0.0027 ms^{-2}), then the acceleration of the moon just before striking the earth's surface is (Given, g = 10 ms^{-2})

a) 0.0027 ms^{-2} b) 5.0 ms^{-2}
c) 6.4 ms^{-2} d) 10 ms^{-2}

58. A mass M is split into two parts, m and (M-m), which are then separated by a certain distance. What ratio of m/M maximizes the gravitational force between the two parts

a) $\frac{1}{3}$ b) $\frac{1}{2}$ c) $\frac{1}{4}$ d) $\frac{1}{5}$

59. The period of a planet around sun is 27 times that of earth. The ratio of radius of planet's orbit to the radius of earth's orbit is

a) 4 b) 9
c) 64 d) 27

60. If earth comes to standstill the weight of bodies lying on its equator shall:

a) Increase b) Decrease
c) Remains same d) Fly

61. If the horizontal velocity given to the satellite is less than critical velocity, then the satellite performs

a) Circular path
b) Elliptical path
c) Parabolic path
d) Tangent to the curve path

62. The ratio of acceleration due to gravity at a height 3R above earth’s surface to the acceleration due to gravity on the surface of earth is

a) $\frac{1}{9}$ b) $\frac{1}{16}$ c) $\frac{1}{4}$ d) $\frac{1}{64}$

63. The change in potential energy when a body of mass m is raised to a height nR from the earth’s surface is [R = Radius of earth]

a) $mgR\left(\frac{n}{n-1}\right)$ b) mmgR
c) $mgR\left(\frac{n^2}{n^2+1}\right)$ d) $mgR\left(\frac{n}{n+1}\right)$

64. If the radius of the earth was to shrink by 2%, its mass remaining same, the acceleration due to gravity on the earth's surface would be

a) decrease by 2% b) increase by 2%
c) increase by 4% d) decrease by 4%

65. The relay satellite transmits the TV programme continuously from one par of the world to another because its:

a) Period is greater than the period of rotation of the earth
b) Period is less than the period of the earth about its axis
c) Period has no relation with the period of the earth about its axis
d) Period is equal to the period of rotations of the earth about its axis

66. The acceleration due to gravity on the planet A is 9 times the acceleration due to gravity on planet B. A man jumps to a height of 2 m on the surface of A. What is the height of jump by the same person on the planet B?

a) 6 m b) 2/3 m
c) 2/9 m d) 18 m

67. If two identical satellites are at R and 7R away from earth surface, the wrong statement is (R = Radius of earth)

a) Ratio of their total energy will be 4
b) Ratio of their kinetic energies will be 4
c) Ratio of their potential energies will be 4
d) Ratio of their total energy will be 4 but ratio of potential and kinetic energies will be 2

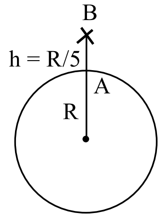
68. The orbital velocity of a body close to the earth's surface is

a) $8kms^{-1}$ b) $11.2kms^{-1}$
c) $3 \times 10^8\ ms^{-1}$ d) $2.2 \times 10^3 kms^{-1}$

69. The rotational period of a satellite close to the surface of the earth is 83 minutes. The time period of another earth satellite in an orbit at a distance four times the radius of earth from its surface will be

a) 83 minutes b) $83 \times \sqrt{8}$ minutes
c) 664 minutes d) 249 minutes

70. A body of mass m rises to a height h = R/5 from the surface of the Earth. If g is acceleration due to gravity on the Earth’s surface, then the increase in potential energy is (R = radius of Earth)



a) mgh b) $\frac{4}{5}$mgh c) $\frac{5}{6}$mgh d) $\frac{6}{7}$mgh

71. The time period of an earth satellite in circular orbit is independent of
a) Radius of the orbit
b) Neither he mass of the satellite nor the radius of the orbit
c) The mass of the satellite
d) Both the mass of satellite and radius of the orbit

72. A body weighs 500 N on the surface of earth. At what distance below the surface of earth it weighs 250 N? (Radius of earth, R = 6400 km)
a) 3200 km
b) 1600 km
c) 6400 km
d) 800 km

73. In a satellite, if the time of revolution is T, then KE is proportional to
a) $\frac{1}{T}$
b) $\frac{1}{T^2}$
c) $\frac{1}{T^3}$
d) $T^{-2/3}$

74. If the change in the value of 'g' at a height h above the surface of the earth is the same as at a depth x below it, then (both x and h being much smaller than the radius of the earth)
a) $x = h$ b) $x = 2h$ c) $x = \frac{h}{2}$ d) $x = h^2$

75. Consider a planet in some solar system which has 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

76. Two spheres, each of mass 625 kg, are placed with their centres 50 cm apart. The gravitational force between them is
a) 10.42 dyne
b) 15.42 dyne
c) 20.42 dyne
d) 5.42 dyne

77. The mass of the moon is $\frac{1}{81}$ of the earth but the gravitational pull is $\frac{1}{6}$ of the earth. It is due to the fact that
a) The radius of the moon is $\frac{81}{6}$ of the earth
b) The radius of the earth is $\frac{9}{\sqrt{6}}$ of the moon
c) Moon is the satellite of the earth
d) Moon rotates round the earth

78. If the horizontal velocity given to a satellite is greater than critical velocity but less than the escape velocity at the height, then the satellite will
a) Be lost in space
b) Falls on the earth along parabolic path
c) Revolve in circular orbit
d) Revolve in elliptical orbit

79. If the horizontal velocity given to the satellite is lies between critical velocity and escape velocity, then the satellite performs
a) Circular path
b) Elliptical path
c) Parabolic path
d) Tangent to the curve path

80. What is a period of revolution of the earth's satellite? I gnore the height of satellite above the surface of the earth.
Given, the value of gravitational acceleration, = 10 ms^{-2}, radius of the earth $R_e = 6400\ km$.
(take, $\pi = 3.14$)
a) 85 min
b) 156 min
c) 83.73 min
d) 90 min

81. Consider the earth to be homogeneous sphere scientist A goes deep down in a mine and scientist B goes high up in a balloon. The gravitational field measured by:
a) A goes on decreasing and that by B goes on increases
b) Each remains unchanged
c) B goes on decreasing and that A goes on increasing
d) Each goes on decreasing

82. The mass and diameter of a planet is twice that of earth. The period of oscillation of pendulum on this planet will be (It is a seconds pendulum on earth)
a) 4 s
b) $2\sqrt{2}$ s
c) 2 s
d) $\sqrt{2}$ s

83. The C.G.S. unit of universal gravitational constant is
a) dyne cm^2/g^2
b) dyne g^2/cm^2
c) $dyne^2$ cm/g
d) g^2/dyne cm^2

84. The radius of a planet is twice the radius of the earth. Both have almost equal average mass densities. If 'V_P' and 'V_E' are escape velocities of the planet and the earth respectively, then
a) $V_E = 1.5V_P$
b) $V_P = 1.5V_E$
c) $V_P = 2V_E$
d) $V_E = 3V_P$

85. A body weights 63 N on the surface of the Earth. At a height h above the surface of Earth, its weight is 28 N while at a depth h below the surface Earth, the weight is 31.5 N. The value of h is
a) 0.4 R b) 0.5 R c) 0. 8 R d) R

86. A body of mass 'm' is dropped from a height R/2, to the surface of earth where 'R' is radius of earth. It's speed when it will hit the earth's surface is (V_e = escape velocity from earth's surface)
a) $\sqrt{3}V_e$
b) $V_e/\sqrt{2}$
c) $V_e/\sqrt{3}$
d) $\sqrt{2}V_e$

87. A satellite of mass m is orbiting the earth at a height h from its surface. If M is the mass of the earth and R its radius, the kinetic energy of the satellite will be
a) $-\frac{GmM}{(R+h)}$ b) $\frac{GmM}{2(R+h)}$ c) $\frac{GmM}{(R+h)}$ d) $\frac{GmM}{2(R+h)}$

88. Two satellites of same mass are launched in circular orbits at heights 'R' and '2R' above the surface of the earth. The ratio of their kinetic energies is (R = radius of the earth)
a) 1:3
b) 3:2
c) 4:9
d) 9:4

89. The time period of a satellite in a circular orbit of radius R is T. The radius of the orbit in which time period is 8 T is
a) 2 R b) 3 R c) 4 R d) 5 R

90. If an object is thrown with a velocity less than the escape velocity, its total energy is
a) Equal to zero
b) Positive
c) Negative
d) Infinite

91. The force of gravitation between two bodies of mass 1 kg each separated by a distance of 1 m in vacuum is
a) 6.67×10^{-9}N
b) 6.67×10^{-10}N
c) 6.67×10^{-11}N
d) 6.67×10^{-12}N

92. Two satellites A and B go round a planet in circular orbits having radii 4R and R, respectively. If the speed of satellite A is 3v, then speed of satellite B is
a) $\frac{3v}{2}$ b) $\frac{4v}{2}$ c) 6v d) 12v

93. The period of geostationary artificial satellite is:
a) 24 hours
b) 12 hours or half day
c) 8 hours
d) 48 hours

94. The ration of inertial to gravitational mass is:
a) +1 b) -1 c) Zero d) Infinity

95. A body is projected vertically upwards from earth's surface. If velocity of projection is $(1/3)^{rd}$ of escape velocity, then the height upto which a body rises is (R = radius of earth)
a) $\frac{R}{4}$
b) 2R
c) R
d) $\frac{R}{8}$

96. The magnitude of force of attraction on a point mass m due to hollow spherical shell of mass M and radius R as a function of its distance r from the center is given as
$$F(r) = \begin{cases} A; & r < R \\ B; & r \geq R \end{cases}$$
Here, A and B refer to
a) $A \rightarrow \frac{GMm}{r^2}$; $B \rightarrow$ zero
b) $A \rightarrow$ zero; $B \rightarrow \frac{GMm}{r^2}$
c) $A \rightarrow \frac{GMm}{R^2}$; $B \rightarrow \frac{GMm}{r^2}$
d) None of these

97. A satellite orbits around the earth in a circular orbit with a speed v and orbital radius r. If it loses some energy, then v and r change as:
a) v decreases and r increases
b) v increases and r decreases
c) Both v and r decreases
d) Both v and r increases

98. Two masses m_1 and $m_2 (m_1 < m_2)$ are released from rest from a finite distance. They start under their mutual gravitational attraction. Then the wrong statement is,
a) Acceleration of m_1 is more than that of m_2
b) Acceleration of m_2 is more than that of m_1
c) Centre of mass remains at rest
d) Total energy of the system remains constant

99. If g is the acceleration due to gravity on earth's surface, the gain of the potential energy of an object of mass m raised from the surface of the earth to a height equal to the radius R of the earth is
a) $2mgR$
b) mgR
c) $\frac{1}{2}mgR$
d) $\frac{1}{4}mgR$

100. If somehow the distance between the sun and earth is doubled, the gravitational force between them will become:
a) Double
b) Half
c) Four times
d) One fourth

101. F is the gravitational force between two point masses m_1 and m_2, separated by a distance d. A point mass $2m_1$ is then brought near m_1. What is the force on m_2 due to m_1 ?
a) 2 F
b) 3 F
c) F
d) $\frac{F}{2}$

102. In the case of earth, mean radius is 'R', acceleration due to gravity on the surface is 'g', angular speed about its own axis is 'ω'. What will be the radius of the orbit of a geostationary satellite?

a) $\left[\frac{\omega^2}{gR^2}\right]^{1/2}$ b) $\left[\frac{\omega^2}{gR^2}\right]^{1/3}$

c) $\left[\frac{gR^2}{\omega^2}\right]^{1/2}$ d) $\left[\frac{gR^2}{\omega^2}\right]^{1/3}$

103. A triple star consists of two stars, each of mass m in the same circular orbit about a central star of mass $M = 10 \times 10^{30}$kg. The two opposite stars always lie at opposite ends of a diameter. The radius of circular orbit is $r = 2 \times 10^{11}$m and orbital period of each star is 0.6×10^7s. Find m. (in kg)

[Given $\pi^2 = 10$ and $G = \frac{20}{3} \times 10^{-11} Nm^2kg^{-2}$]

a) $\frac{11}{8} \times 10^{30}$ b) $\frac{15}{16} \times 10^{30}$

c) $\frac{40}{3} \times 10^{30}$ d) $\frac{20}{3} \times 10^{30}$

104. The period of revolution of planet A around the sun is 8 times that of B. The distance of A from the sun is how many times greater than that of B from the sun?

a) 2 b) 3

c) 4 d) 5

105. The gravitational potential of a body on the surface of the earth is proportional to (R=radius of earth, p =density of earth)

a) Radius of the earth

b) Square of density of earth

c) The product of radius and density

d) The product $R^2\rho$

106. Two satellites of same mass are launched in circular orbits at heights 'R' and '2R' above the surface of the earth. The ratio of their kinetic energies is (R = radius of the earth)

a) 1:3 b) 3:2

c) 4:9 d) 9:4

107. What is the percentage decrease in the weight of a body when it is taken to a height of 32 km from the surface of earth?

a) 0.5% b) 2%

c) 1.5% d) 1%

108. Suppose the gravitational force varies inversely as the nth power of distance. Then, the time period of a planet in circular orbit of radius r around the sun will be proportional to

a) $r^{\frac{1}{2}(n+1)}$ b) $r^{\frac{1}{2}(n-1)}$

c) r^n d) $r^{\frac{1}{2}(n-2)}$

109. The satellite is moving round the earth (radius of earth=R) at a distance r from the centre of the earth. If g is the acceleration due to gravity on the surface of the earth. The acceleration of the satellite will be

a) g b) $\sqrt{\frac{Rg}{r}}$ c) $\frac{R^2}{r^2}g$ d) $\sqrt{\frac{gr}{R}}$

110. A satellite of mass 'm' is revolving around the earth of mass 'M' in an orbit of radius 'r' with constant angular velocity 'ω'. The angular momentum of the satellite is (G = gravitational constant)

a) $\left(\frac{GMr}{m}\right)^2$ b) $m(GMr)^{1/2}$

c) $m(GMr)$ d) $(GMmr)^{1/2}$

111. If the earth of radius R, while rotating with angular velocity ω becomes stand still, what will be the effect on the weight of a body of mass m at a latitude of 45°?

a) Remains unchanged b) Decreases by $R\omega^2$

c) Increases $R\omega^2$ d) Increases by $R\omega^2/2$

112. The escape velocity of a particle of mass m varies as

a) m^2 b) m c) m^0 d) m^{-1}

113. Imagine a light planet revolving around a very massive star in a circular orbit of radius r with period T. If gravitational force of attraction between planet and star is proportional to $R^{-\frac{5}{2}}$, then T^2 is proportional to

a) $R^{\frac{7}{2}}$ b) $R^{-\frac{7}{2}}$ c) $R^{\frac{5}{2}}$ d) $R^{\frac{2}{5}}$

114. All planets move in elliptical orbits with the sun situated at one of the foci of the ellipse. The point at which the planet is closest to the sun is

a) Perihelion b) Aphelion

c) Hellion d) None of these

115. What is the escape velocity for a body on the surface of a planet on which the acceleration due to gravity is $(3.1)^2\ ms^{-2}$ and whose radius is 8100 km ?

a) $2790 kms^{-1}$ b) $27.9 kms^{-1}$

c) $27.9/\sqrt{5} kms^{-1}$ d) $2.79\sqrt{5} kms^{-1}$

116. Binding energy of a revolving satellite at height 'h' is 3.5×10^8 J. Its potential energy is

a) 3.5×10^8 J b) -35×10^8 J

c) -7×10^8 J d) 7×10^8 J

117. The value of 'g' at a certain height above the

surface of the earth is 16% of its value on the surface. The height is (R = 6300 km)

a) 10500 km b) 12500 km
c) 3000 km d) 9450 km

118. If density of the earth is doubled keeping radius constant, the new acceleration due to gravity is ($g = 9.8\ m/s^2$)

a) $9.8\ m/s^2$ b) $19.6\ m/s^2$
c) $4.9\ m/s^2$ d) $39.2\ m/s^2$

119. A body weighs w newton at the surface of the earth. Its weight at a height equals to half the radius of the earth, will be

a) $\frac{w}{2}$ b) $\frac{2w}{3}$
c) $\frac{4w}{9}$ d) $\frac{8w}{27}$

120. The binding energy of a satellite of mass m in an orbit of radius r is (where, R = radius of earth and g = acceleration due to gravity)

a) $\frac{mgR^2}{r}$ b) $\frac{mgR^2}{2r}$
c) $-\frac{mgR^2}{r}$ d) $-\frac{mgR^2}{2r}$

121. The ratio of the radii of the planets P_1 and P_2 is a. The ratio of their acceleration due to gravity is b. The ratio of the escape velocities from them will be

a) ab b) $\sqrt{ab}$
c) $\sqrt{a/b}$ d) $\sqrt{b/a}$

122. Mass of the Earth is 81 times mass of the Moon and distance between Earth and Moon is 60 times the radius of the Earth. If R is the radius of Earth, then the distance between the Moon and the point on the line joining the Moon and the Earth where gravitational force becomes zero is,

a) 30R b) 15R c) 6R d) 5R

123. A body is projected from earth's surface with thrice the escape velocity from the surface of the earth. What will be its velocity when it will escape the gravitational pull?

a) $2V_e$ b) $4V_e$
c) $2\sqrt{2}V_e$ d) $\frac{V_e}{2}$

124. The radius of the Earth is about 6400 km and that of Mars is about 3200 km. The mass of the Earth is about 20 times the mass of Mars. An object weighs 500 N on the surface of Earth. Its weight on the surface of Mars would be

a) 100 N b) 200 N c) 150 N d) 20 N

125. The acceleration due to gravity at a height $1/20^{th}$ of the radius of the earth above the earth surface is $9\ ms^{-2}$. Its value at a point at an equal distance below the surface of the earth in ms^{-2} is about

a) 8.5 b) 9.5 c) 9.8 d) 11.5

126. Gravitational force between two objects separated by 20 cm is 1.0×10^{-8}N. If total mass of the two objects is 5.0 kg, then the mass of objects in kg, are

a) 4, 1 b) 3, 2 c) 2.5, 2.5 d) 3.5, 1.5

127. The period of revolution of a satellite is

a) Independent of mass of a satellite b) Independent of radius of planet
c) Independent of height of the satellite from the planet d) Dependent on the mass of a satellite

128. A satellite of mass 'm', revolving round the earth of radius 'r' has kinetic energy (E). Its angular momentum is

a) (mEr^2) b) $(2mEr^2)^{1/2}$
c) $(mEr^2)^{1/2}$ d) $(2mEr^2)$

129. Three-point masses, each of mass 'm' are kept at the corners of an equilateral triangle of side 'L'. The system rotates about the centre of the triangle without any change in the separation of masses during rotation. The period of rotation is directly proportional to

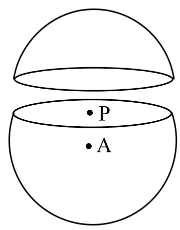
($\cos 30^0 = \sin 60^0 = \frac{\sqrt{3}}{2}, \cos 60^0 = \sin 30^0 = 1/2$)

a) $\sqrt{L}$ b) L
c) $L^{3/2}$ d) L^{-2}

130. The time period of a geostationary satellite at a height 36000 km is 24 h. A spy satellite orbits very close to earth's surface ($R = 6400\ km$). What will be its time period?

a) 4 h b) 1 h
c) 2 h d) 1.5 h

131. A spherical shell is cut into two pieces along a chord as shown in the figure. The point P is in the plane of the chord. The gravitational field at P due to the upper part is I_1 and that due to the lower part is I_2. Then relation between them is,



a) $I_1 > I_2$ b) $I_1 < I_2$

c) $I_1 = I_2$ d) No definite relation

132. A satellite constructs a circle around the earth in 90 *min*. The height of the satellite above the earth's surface is
a) 368 km b) 468 km
c) 500 km d) 268 km

133. A satellite is orbiting very close to a planet. Its periodic time depends only on
a) Density of the planet b) Mass of the planet
c) Radius of the planet d) Mass of the satellite

134. If the density of the earth is doubled keeping its radius constant, then acceleration due to gravity will be ($g = 9.8 m/s^2$)
a) $19.6\ m/s^2$ b) $9.8\ m/s^2$
c) $4.9\ m/s^2$ d) $2.45\ m/s^2$

135. A system of binary stars of masses m_A and m_B are moving in circular orbits of radii r_A and r_B respectively. If T_A and T_B are the times periods of masses m_A and m_B respectively then,
a) $\frac{T_A}{T_B} = \left(\frac{r_A}{r_B}\right)^{\frac{3}{2}}$ b) $T_A > T_B$ (if $r_A > r_B$)
c) $T_A > T_B$ (if $m_A > m_B$) d) $T_A = T_B$

136. If g is the acceleration due to gravity on earth's surface, the gain of the potential energy of an object of mass m raised from the surface of the earth's to a height equal to the radius R of the earth is
a) 2mgR b) mgR
c) $\frac{1}{2}$mgR d) $\frac{1}{4}$mgR

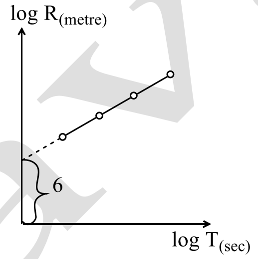
137. A mass 'm' suspended from a spring stretches it by 5 cm when on the surface of the earth. The mass is then taken on to a height of 1600 km above earth's surface and again suspended from the same spring. A this altitude the extension of the spring is (Radius of earth = 6400 km)
a) 3.2 cm b) 1.6 cm
c) 6.4 cm d) 0.8 cm

138. The potential energy of a circularly orbiting satellite around the earth at height 'h' from the earth's surface, is given by
P. E. = x(K. E.)
Where K. E. is the kinetic energy of this satellite. The value of 'x' is
a) −0.5 b) 2
c) −2 d) 0.5

139. A body is projected vertically from the surface of the earth of radius *R* with velocity equal to half of the escape velocity. The maximum height reached by the body is
a) $\frac{R}{5}$ b) $\frac{R}{3}$
c) $\frac{R}{2}$ d) $\frac{R}{4}$

140. The mean radius of the earth is R, its angular speed on its own axis is ω and the acceleration due to gravity at earth's surface is g. The cube of the radius of the orbit of a geostationary satellite will be
a) R^2g/ω b) $R^2\omega^2/g$ c) Rg/ω^2 d) R^2g/ω^2

141. For many planets revolving around the stationary sun in circular orbits of different radii (R), the time periods (T) were noted. Then log(R) v/s log(T) curve was plotted.
$\left[G = \frac{20}{3} \times 10^{-11} \text{ in M. K. S. system}, \pi^2 = 10\right]$
Estimate the mass of the sun



a) 6×10^{29}kg b) 5×10^{20}kg
c) 8×10^{25}kg d) 3×10^{25}kg

142. The radius of the Earth shrinks by 1%, its mass remaining the same. The percentage change in the value of g is
a) −2% b) +2% c) −3% d) +4%

143. If the horizontal velocity given to the satellite is equal to critical velocity, then the satellite performs
a) Circular path
b) Elliptical path
c) Parabolic path
d) Tangent to the curve path

144. A comet is moving around the earth in highly elliptical orbit. Identify the incorrect statement
a) Its K.E. and P.E. both change over the orbit
b) Its T.E. changes over the orbit
c) Its linear momentum changes in magnitude as well as in direction over the orbit
d) Its angular momentum remains constant over the orbit

145. Two point masses each equal to 1 kg attract one another with a force of 10^{-9} kg - wt. The distance between the two point masses is approximately (Given, $G = 6.67 \times 10^{-11} Nm^2\ kg^{-2}$]

a) 8.2 cm b) 0.8 cm
c) 82 cm d) 0.08 cm

146. A satellite S_1 of mass 'm' is moving in an orbit of radius 'r'. Another satellite S_2 of mass '2m' is moving in an orbit of radius '2r'. The ratio of time period of satellite S_2 to that of S_1 is
a) 1:4 b) 1:8
c) 2:1 d) $2\sqrt{2}:1$

147. Time period of second pendulum on a planet, whose mass and diameter are twice that of earth, is
a) $2\sqrt{2}$ s b) 2 s c) $\sqrt{2}$ s d) $\frac{1}{\sqrt{2}}$ s

148. Two artificial satellites are revolving in the same circular orbit. Then they must have the same
a) Mass b) Angular momentum
c) Kinetic energy d) Period of revolution

149. A body of mass m is placed on the earth's surface. It is taken from the earth's surface to a height h = 3R. The change in gravitational potential energy of the body is
a) $\frac{2}{3}$mgR b) $\frac{3}{4}$mgR c) $\frac{\text{mgR}}{2}$ d) $\frac{\text{mgR}}{4}$

150. Two small satellites move in circular orbits around the earth, at distances r and $r + \Delta r$ from the centre of the earth. Their time periods of rotation are T and $T + \Delta T (\Delta r \ll r, \Delta T \ll T)$, then ΔT is equal to
a) $\frac{3}{2}T\frac{\Delta r}{r}$ b) $\frac{2}{3}T\frac{\Delta r}{r}$
c) $\frac{-3}{2}T\frac{\Delta r}{r}$ d) $T\frac{\Delta r}{r}$

151. The value of the acceleration due to gravity g at a point 5.0 km above the earth's surface and 5.0 km below the earth's surface are respectively
a) $9.78\ \text{m/s}^2, 9.79\ \text{m/s}^2$ b) $9.78\ \text{m/s}^2, 0$
c) $9.79\ \text{m/s}^2, 0$ d) $9.78\ \text{m/s}^2, 9.78\ \text{m/s}^2$

152. The gravitational force exerted by the earth on a body is called
a) Weight of the body
b) Acceleration of that body
c) Mass of the body
d) Gravitational constant

153. Earth has mass M_1 and radius R_1. Moon has mass M_2 and radius R_2. Distance between their centre is r. A body of mass M is placed on the line joining them at a distance $\frac{r}{3}$ from centre of the earth. To project the mass M to escape to infinity, the minimum speed required is
a) $\left[\frac{3G}{r}\left(M_1 + \frac{M_2}{2}\right)\right]^{\frac{1}{2}}$ b) $\left[\frac{6G}{r}\left(M_1 + \frac{M_2}{2}\right)\right]^{\frac{1}{2}}$
c) $\left[\frac{6G}{r}\left(M_1 - \frac{M_2}{2}\right)\right]^{\frac{1}{2}}$ d) $\left[\frac{3G}{r}\left(M_1 - \frac{M_2}{2}\right)\right]^{\frac{1}{2}}$

154. Mass of an ant is found to be $1/10^2$ times smaller than that of elephant the escape velocity for elephant is
a) 10^7 times larger than ant
b) 10^{-7} times larger than ant
c) Same as that of ant
d) Zero for an ant

155. The escape velocity of a body contribute upon:
a) Gravitational constant
b) Mass of the body
c) Both mass and gravitational constant
d) Density of planet

156. If the distance between the sun and the earth is increased by three times, then attraction between two will
a) remain constant b) decrease by 63%
c) increase by 63% d) decrease by 89%

157. A satellite of mass m moving around the earth of mass m_E in a circular orbit of radius R has angular momentum L. The rate of the area swept by the line joining the centre of the earth and satellite is
a) L/2 m b) L/m c) 2L/m d) $2L/m_E$

158. The radius of the orbit of a satellite is r and its kinetic energy is K. If the radius of the orbit is 2 doubled, then the new kinetic energy K' is
a) 2K b) $\frac{K}{2}$
c) 4K d) Data insufficient

159. The mass and radius of the earth and 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 body of mass 'm' should be projected from a distance (2d/3) from the centre of M_1 so as to escape to ∞ is
a) $\left[\frac{3G(M_1 - M_2)}{2d}\right]^{1/2}$ b) $\left[\frac{6G(M_1 + 2M_2)}{2d}\right]^{1/2}$
c) $\left[\frac{3G(M_1 - M_2)}{d}\right]^{1/2}$ d) $\left[\frac{6G(M_1 - M_2)}{2d}\right]^{1/2}$

160. A satellite is moving in an orbit around the earth due to
a) Burning of fuel
b) Gravitational attraction between sun and earth
c) Ejection of gases from the exhaust of the

satellite
d) Gravitational attraction between earth and the satellite

161. The period of a satellite in a circular orbit around a planet is independent of
a) The mass of the planet
b) The radius of the planet
c) The mass of the satellite
d) All of these

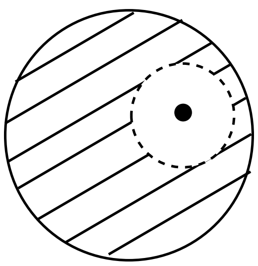
162. The total energy of an artificial satellite of mass m revolving in a circular orbit around the earth with a speed v is
a) $\frac{1}{2}mv^2$ b) $\frac{1}{4}mv^2$
c) $-\frac{1}{4}mv^2$ d) $-\frac{1}{2}mv^2$

163. A thin rod of length L is bent to form a semicircle. The mass of rod is M. What will be the gravitational potential at the centre of the circle?
a) $-\frac{GM}{L}$ b) $-\frac{GM}{2\pi L}$
c) $-\frac{\pi GM}{2L}$ d) $-\frac{\pi GM}{L}$

164. If R is the radius of earth and g is acceleration due to gravity on the surface of the earth, then binding energy of the satellite of mass m at the height h above earth's surface is
(r is orbital radius of satellite)
a) $\frac{\mathrm{mgR^2}}{\mathrm{r}}$ b) $-\frac{\mathrm{mgR^2}}{\mathrm{r}}$ c) $\frac{\mathrm{mgR^2}}{2\mathrm{r}}$ d) $-\frac{\mathrm{mgR^2}}{2\mathrm{r}}$

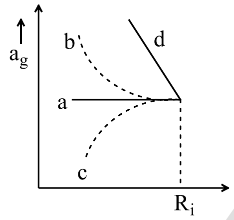
165. The period of oscillation of a second's pendulum on the planet whose mass and radius are twice that of earth will be
a) $\frac{1}{2}$s b) $\sqrt{2}$s
c) $\frac{1}{\sqrt{2}}$s d) $2\sqrt{2}$s

166. From a solid sphere of mass M and radius R, a spherical portion of radius $\left(\frac{R}{2}\right)$ is removed as shown in the figure. Taking gravitational potential $V = 0$ at $r = \infty$, the potential at the centre of the cavity thus formed is ($G =$ gravitational constant)



a) $\frac{-GM}{2R}$ b) $\frac{-GM}{R}$
c) $\frac{-2GM}{3R}$ d) $\frac{-2GM}{R}$

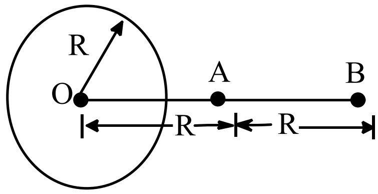
167. A (non-rotating) star collapses onto itself from on initial radius R_i, its mass remaining unchanged. Which curve in the figure best gives the gravitational acceleration a_g on the surface of the star as a function of radius of star during collapse?



a) A b) B c) C d) D

168. A body weights 'W' newton on the surface of the earth. Its weight at a height equal to half the radius of the earth, will be
a) $\frac{W}{2}$ b) $\frac{4W}{9}$
c) $\frac{2W}{3}$ d) $\frac{3}{8W}$

169. A ring having non-uniform distribution of mass having mass M and radius R is being considered. A point mass m_0 is taken slowly from A to B along the axis of the ring. In doing so, work done by the external force against the gravitational force exerted by ring is



a) $\frac{GMm_0}{\sqrt{2}R}$ b) $\frac{GMm_0}{R}\left[\frac{1}{\sqrt{2}}-\frac{1}{\sqrt{5}}\right]$
c) $\frac{GMm_0}{R}\left[\frac{1}{\sqrt{5}}-\frac{1}{\sqrt{2}}\right]$ d) It is not possible to find the required work as the nature of distribution of mass is not known

170. The depth 'd' below the surface of the earth where the value of acceleration due to gravity becomes (1/n) times the value at the surface of the earth is (R = radius of the earth)
a) $R\left(\frac{n-1}{n}\right)$ b) $R\left(\frac{n}{n+1}\right)$
c) $\frac{R}{n}$ d) $\frac{R}{n^2}$

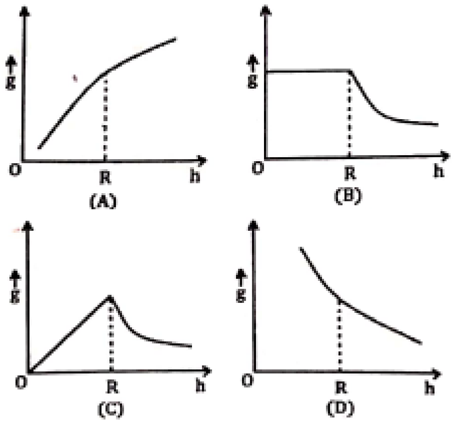
171. The value of 'g' at a depth of 80 km will be

(Radius of earth = 6400 km and value of ‘g’ on the surface of earth is $10\ m/s^2$)

a) $900\ cm/s^2$ b) $980\ cm/s^2$

c) $970\ cm/s^2$ d) $1000\ cm/s^2$

172. Earth is assumed to be a sphere of radius ‘R’ and uniform density. The variation of acceleration due to gravity (g) according to the depth and the height (h) from the earth’s surface is shown correctly by graph



a) (D) b) (B)

c) (A) d) (C)

173. Three particles each of mass ‘m_1’ are placed at the corners of an equilateral triangle of side ‘$\frac{L}{3}$’. A particle of mass ‘m_2’ is placed at the mid-point of any one side of triangle. Due to the system of particles the force acting on ‘m_2’ is (G = Universal constant of gravitation)

a) $\frac{4Gm_1m_2}{L^2}$ b) $\frac{12Gm_1m_2}{L^2}$

c) $\frac{2Gm_1m_2}{L^2}$ d) $\frac{8Gm_1m_2}{L^2}$

174. Earth revolves round the sun in a circular orbit of radius ‘R’. The angular momentum f the moving earth is directly proportional to

a) R^3 b) R^2

c) R d) $\sqrt{R}$

175. Three point masses, each of mass ‘m’ are kept at the corners of an equilateral triangle of side ‘L’. The system rotates about the centre of the triangle without any change in the separation of masses during rotation. The period of rotation is directly proportional to ($\cos 30^0 = \frac{\sqrt{3}}{2}$)

a) L b) $L^{1/2}$

c) $L^{3/2}$ d) L^{-2}

176. A rocket is launched vertically from the surface of the earth of radius R with an initial speed v. If atmospheric resistance is neglected, then the maximum height attained by the rocket is

a) $h = \frac{R}{\left(\frac{2gR}{v^2} - 1\right)}$ b) $h = \frac{R}{\left(\frac{2gR}{v^2} + 1\right)}$

c) $h = \frac{R^2}{\left(\frac{2gR}{v^2} - 1\right)}$ d) $h = \frac{R^2}{\left(\frac{2gR}{v^2} + 1\right)}$

177. v_e and v_p denote the escape velocities from the earth and another planet having twice the radius and the same mean density as the earth. Then

a) $v_e = v_p$ b) $v_e = \frac{v_p}{2}$

c) $v_e = 2v_p$ d) $v_e = \frac{v_p}{4}$

178. Calculate angular velocity of earth so that acceleration due to gravity at 60° latitude becomes zero. (Radius of earth = 6400 km, gravitational acceleration at poles = $10 m/s^2$, $\cos 60° = 0.5$)

a) 7.8×10^{-2}rad/s b) 0.5×10^{-3}rad/s

c) 1×10^{-3}rad/s d) 2.5×10^{-3}rad/s

179. If the diameter of mars is 6760 km and mass one-tenth that of the earth. The diameter of earth is 12742 km. If acceleration due to gravity on earth is $9.8\ ms^{-2}$, the acceleration due to gravity on mars is

a) $34.8\ ms^{-2}$ b) $2.48\ ms^{-2}$

c) $3.48\ ms^{-2}$ d) $28.4\ ms^{-2}$

180. A satellite launch station should be

a) Near the equatorial region

b) Near the polar region

c) On the polar axis

d) All the locations are equally good

181. If the speed of rotation of earth about its axis is increased

a) Weight of a body at the equator decreases

b) Weight of a body at the poles does not change

c) Both ‘a’ and ‘b’

d) Neither ‘a’ and ‘b’

182. Two satellites ‘A’ and ‘B’ of same mass are revolving round the earth at height ‘2R’ and ‘3R’ respectively above the surface of the earth. The ratio of kinetic energies of A to B will be

a) 3:2 b) 4:3

c) 3:4 d) 2:3

183. During a journey from earth to the moon and back the greatest energy required for the space ship rocket is to over come

a) The earth’s gravity at take off

b) The moon’s gravity at lunar landing

c) The moon’s gravity at lunar take off

d) The force at the point where the pull of the earth and moon are equal and opposite

184. The period of a satellite in a circular orbit around a planet is independent of
a) The mass of the planet
b) The radius of the planet
c) The mass of the satellite
d) All the three parameters 'a', 'b' and 'c'

185. Two stars of mass m_1 and m_2 are parts of a binary system. The radii of their orbits are r_1 and r_2 respectively, measured from the C.M. of the system. The magnitude of gravitational force m_1 exerts on m_2 is
a) $\frac{m_1 m_2 G}{(r_1+r_2)^2}$ b) $\frac{m_1 G}{(r_1+r_2)^2}$
c) $\frac{m_2 G}{(r_1+r_2)^2}$ d) $\frac{(m_1+m_2)}{(r_1+r_2)^2}$

186. For a particle projected in a transverse direction from a height h above earth's surface, find the minimum initial velocity so that it grazes the surface of earth such that path of this particle would be an ellipse with centre of earth as the farther focus, point of projection as the apogee and a diametrically opposite point on earth as perigee
a) $\sqrt{2GM_e \frac{R}{r(R+r)}}$ b) $\sqrt{2GM_e \frac{R}{R(R+r)}}$
c) $\sqrt{2GM_e \frac{r}{R(R+r)}}$ d) $\sqrt{2GM_e \left(\frac{R}{r^2}\right)}$

187. What should be the velocity of earth due to rotation about its own axis so that the weight at equator becomes 3/5 of initial value? Radius of earth on equator is 6400 km
a) 7.4×10^{-4}rad/s b) 6.7×10^{-4}rad/s
c) 7.9×10^{-4}rad/s d) 8.7×10^{-4}rad/s

188. A particle is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done per unit mass against the gravitational force between them, to take the particle far away from the sphere. (Take, $h = 6.67 \times 10^{-11} Nm^2\, kg^{-2}$)
a) $13.34 \times 10^{-10}\, J$ b) $3.33 \times 10^{-10}\, J$
c) $6.67 \times 10^{-9}\, J$ d) $6.67 \times 10^{-8}\, J$

189. The mass of a spherical planet is 4 times the mass of the earth, but its radius (R) is same as that of the earth. How much work is done is lifting a body of mass 5 kg through a distance of 2 m on the planet? ($g = 10\ ms^{-2}$)
a) 400 J b) 200 J
c) 800 J d) 300 J

190. Calculate angular velocity of the earth, so that acceleration due to gravity at 60° latitude becomes zero. (Take, radius of the earth = 6400 km, gravitational acceleration at poles = 10 ms^{-2} and $\cos 60° = 0.5$)
a) $7.8 \times 10^{-2} rads^{-1}$ b) $0.5 \times 10^{-3} rads^{-1}$
c) $1 \times 10^{-3} rads^{-1}$ d) $2.5 \times 10^{-3} rads^{-1}$

191. A body of mass 'm' is raised to a height '10 R' from the surface of earth, where 'R' is the radius of earth. The increase in potential energy is (G = universal constant of gravitation, M = mass of earth and g = acceleration due to gravity)
a) $\frac{GMm}{11R}$ b) $\frac{GMm}{10r}$ c) $\frac{mgR}{11G}$ d) $\frac{10GMm}{11R}$

192. If g_h is the acceleration due to gravity at a height h above the earth's surface and R is the radius of the earth then, the critical velocity of a satellite revolving round the earth in a circular orbit at a height h is equal to
a) $\sqrt{2g_h(R+h)}$ b) $\sqrt{g_h(R+h)}$
c) $\sqrt{\frac{2(R+h)}{g_h}}$ d) $\sqrt{\frac{(R+h)}{2g_h}}$

193. The life period of synchronous satellite is about:
a) Infinity b) 7 years
c) 10 years d) 1 day or 24 hrs

194. A man inside an artificial satellite feels weightlessness because the force of attraction due to earth is:
a) Zero at the place
b) Is balanced by the force of attraction due to moon
c) Equal to the centripetal force
d) Not effective due to particular design of the satellite

195. How much energy will be required if a mass of 100 kg escapes from the earth?
($R_e = 6.4 \times 10^6$m, $g = 10ms^{-2}$)
a) 3.2×10^9 joule b) 6.4×10^9 joule
c) 1.6×10^9 joule d) 8×10^9 joule

196. An iron ball and wooden ball of the same radius were released from height h in vacuum. Time taken by both of these to reach the ground will be:
a) Unequal, iron ball reach earlier
b) Unequal, wooden ball reach earlier
c) Exactly equal
d) Roughly equal

197. Two satellites A and B go round a planet P in circular orbits having radii 4R and R respectively. If the speed of the satellite A is 3v, the speed of the satellite B will be

a) 12 v b) 6 v c) $\frac{4}{3}$ v d) $\frac{3}{2}$ v

198. Consider a particle of mass 'm' suspended by a string at the equator. Let 'R' and 'M' denote radius and mass of the earth. If 'ω' is the angular velocity of rotation of the earth about its own axis, then the tension on the string will be ($\cos 0^0 = 1$)

a) $\frac{GMm}{R^2} - m\omega^2 R$ b) $\frac{GMm}{2R^2}$

c) $\frac{GMm}{2R^2} + m\omega^2 R$ d) $\frac{GMm}{R^2}$

199. The mass of a body on the surface of the earth is 10 kg. The mass of the same body on the surface on the moon is $g_m = \frac{1}{6} g_e$, where g_m, g_e acceleration due to gravity on the surface of the moon and the earth respectively

a) 10 kg b) 20 kg

c) 5 kg d) 15 kg

200. If the mean distance of Mars from the Sun is 1.525 times that of the earth from the sun, in how many years will Mars complete one revolution about the sun?

a) 1.883 b) 2 c) 3.766 d) 4

N.B.Navale

Date : 28.03.2025
Time : 06:00:00
Marks : 400

TEST ID: 46
PHYSICS

2.GRAVITATION,GRAVITATION

: ANSWER KEY :

1)	d	2)	b	3)	b	4)	d	105)	d	106)	b	107)	d	108)	a
5)	c	6)	c	7)	a	8)	b	109)	c	110)	b	111)	d	112)	c
9)	d	10)	d	11)	c	12)	b	113)	a	114)	a	115)	c	116)	c
13)	b	14)	b	15)	b	16)	a	117)	d	118)	b	119)	c	120)	b
17)	b	18)	b	19)	b	20)	d	121)	b	122)	c	123)	c	124)	a
21)	a	22)	b	23)	a	24)	b	125)	b	126)	b	127)	a	128)	b
25)	d	26)	d	27)	b	28)	b	129)	c	130)	d	131)	c	132)	d
29)	b	30)	c	31)	d	32)	b	133)	a	134)	a	135)	d	136)	c
33)	b	34)	d	35)	a	36)	b	137)	a	138)	c	139)	b	140)	d
37)	a	38)	b	39)	a	40)	c	141)	a	142)	b	143)	a	144)	b
41)	c	42)	a	43)	d	44)	a	145)	a	146)	d	147)	a	148)	d
45)	a	46)	d	47)	c	48)	b	149)	b	150)	a	151)	a	152)	a
49)	a	50)	a	51)	a	52)	a	153)	b	154)	c	155)	b	156)	d
53)	b	54)	b	55)	d	56)	b	157)	a	158)	b	159)	b	160)	d
57)	c	58)	b	59)	b	60)	a	161)	c	162)	d	163)	d	164)	c
61)	c	62)	b	63)	d	64)	c	165)	d	166)	b	167)	b	168)	b
65)	d	66)	d	67)	d	68)	a	169)	b	170)	a	171)	a	172)	d
69)	c	70)	c	71)	c	72)	a	173)	b	174)	d	175)	c	176)	a
73)	d	74)	b	75)	d	76)	a	177)	b	178)	d	179)	c	180)	a
77)	b	78)	d	79)	b	80)	c	181)	b	182)	b	183)	a	184)	c
81)	d	82)	b	83)	a	84)	c	185)	a	186)	a	187)	c	188)	d
85)	b	86)	c	87)	d	88)	b	189)	a	190)	d	191)	d	192)	b
89)	c	90)	c	91)	c	92)	c	193)	a	194)	c	195)	b	196)	c
93)	a	94)	a	95)	d	96)	b	197)	b	198)	a	199)	a	200)	a
97)	b	98)	b	99)	c	100)	d								
101)	b	102)	d	103)	c	104)	b								

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PHYSICS

2.GRAVITATION,GRAVITATION

: HINTS AND SOLUTIONS :

Single Correct Answer Type

2 **(b)**

Escape velocity $V_e = \sqrt{\frac{2Gm}{R}}$

$\therefore$ Energy required to escape from earth's gravitational influence

$= \frac{1}{2}mV_e^2 = \frac{1}{2}m \times \frac{2GM}{R} = \frac{GMm}{R}$

$\therefore$ K. E. of projection $= \frac{1}{2}\frac{GMm}{R}$

P. E. on earth's surface $= -\frac{GMm}{R}$

$\therefore$ Total energy on earth's surface

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

Total energy at the maximum height

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

$\therefore -\frac{GMm}{R+h} = \frac{1}{2}\frac{GMm}{R}$

$\therefore R + h = 2R$

$\therefore h = R$

3 **(b)**

Gravitational force $\left(= \frac{GMm}{R^{3/2}}\right)$ provides the necessary centripetal force, i.e. $mR\omega^2$.

So, $\frac{GMm}{R^{3/2}} = mR\omega^2 = mR\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 mR}{T^2}$ or $T^2 = \frac{4\pi^2 R^{5/2}}{GM}$, i.e. $T^2 \propto R^{5/2}$

4 **(d)**

Inside a shell, gravitational field strength is zero. Therefore, gravitational force on a particle is zero.

6 **(c)**

$v_e = \sqrt{\frac{2GM}{R}}$

$v_e = \frac{1}{\sqrt{R}}$

$\therefore v_e \propto R^{-1/2}$

$\therefore dv_e \propto -\frac{1}{2}dR\, R^{-3/2}$

$\therefore \frac{dv_e}{v_e} = -\frac{1}{2}\frac{dR}{R} = -\frac{1}{2} \times -4\% = 2\%$

$\therefore$ As radius decreases, escape velocity increases

7 **(a)**

The initial potential energy of object,

$U_i = -\frac{GMm}{3R}$

Final potential energy, $U_f = -\frac{GMm}{R}$

By law of conservation of energy,

$\Delta KE = -\Delta PE$

$\Rightarrow \frac{1}{2}mv^2 = -[U_f - U_i] = U_i - U_f$

$\Rightarrow \frac{1}{2}mv^2 = -\frac{GMm}{3R} + \frac{GMm}{R}$

$\Rightarrow \frac{1}{2}v^2 = \frac{2GM}{3R}$

$v = \sqrt{\frac{4GM}{3R}} = 2\sqrt{\frac{GM}{3R}}$

8 **(b)**

Minimum value of kinetic energy required to escape from the gravitational influence of the earth is given by

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

$\therefore$ The kinetic energy of projection is

$K = \frac{GMm}{2R}$

At the highest point the kinetic energy become zero.

Loss of kinetic energy = Gain in potential energy

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

$$\therefore \frac{1}{2R} = \frac{1}{R} - \frac{1}{R+h}$$

$$\therefore \frac{1}{R+h} = \frac{1}{R} - \frac{1}{2R} = \frac{1}{2R}$$

$$\therefore R + h = 2R$$

$$\therefore h = 2R - R = R$$

9 **(d)**

Let r_1 and r_2 be the respective distance of two satellites from the earth's surface.

$r_1 = R + R = 2R$ and $r_2 = 7R + R = 8R$

($\because R$ is the radius of the earth)

Kinetic energy of moving satellite,

Now, $K = \frac{GMm}{2r}$

$\Rightarrow \frac{K_1}{K_2} = \frac{r_2}{r_1} = 4$

Potential energy of moving satellite,

$$U = -\frac{GMm}{r} \Rightarrow \frac{U_1}{U_2} = \frac{r_2}{r_1} = 4$$

Total energy of moving satellite,

and $E = -\frac{GMm}{2r} \Rightarrow \frac{E_1}{E_2} = \frac{r_2}{r_1} = 4$

10 **(d)**

Geostationary satellite remains stationary with respect to the earth. Since the time period of earth is 24 hours, therefore time period of a geostationary satellite is also 24 hours

14 **(b)**

$\omega = \frac{v}{R}$. For a star, angular velocity at which matter will start escaping from its equator is

$$\omega = \frac{v_e}{R} = \frac{1}{R}\sqrt{\frac{2GM}{R}} = \sqrt{\frac{2GM}{R^3}}$$

15 **(b)**

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

$$\therefore v = \sqrt{\frac{2E}{m}}$$

Angular momentum $L = mvr = m \times \sqrt{\frac{2E}{m}} \times r$

$$= \sqrt{2mEr^2}$$

17 **(b)**

Kinetic and potential energies vary with position of earth w.r.t. sun. Angular momentum remains constant everywhere

18 **(b)**

Gravitational force due to solid sphere, $F_1 = \frac{GMm}{(2R)^2}$, where M and m are mass of the solid sphere and particle, respectively and R is the radius of the sphere.

The gravitational force on particle due to sphere with cavity is equal to the gravitational force due to solid sphere creating cavity, assumed to be present above at that position.

Density of sphere, $\rho = \frac{M}{\frac{4}{3}\pi R^3}$

Radius of sphere creating cavity, $R_1 = \frac{R}{2}$

Distance of P from centre of cavity, $R' = \frac{3R}{2}$

Mass of sphere creating cavity, $M' = \rho \cdot V_1$

$$= \frac{M}{4}\pi R^3 \cdot \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 = \frac{M}{8}$$

i.e. $F_2 = \frac{GM'm}{4R^2} - \frac{G(M/8)m}{(3R/2)^2} = \frac{7}{36} \cdot \frac{GMm}{R^2}$

So, $\frac{F_2}{F_1} = \frac{7GMm}{36R^2} / \left(\frac{GMm}{4R^2}\right) = \frac{7}{9}$

23 **(a)**

$$F \propto \frac{1}{r} \Rightarrow F = \frac{K}{r} = \frac{mv^2}{r} \Rightarrow v = \text{constant}$$

25 **(d)**

Gravitational potential is given as,

$$V = \frac{-GM}{R}$$

$$\therefore V = -GM\left[\frac{1}{1} + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \cdots + \infty\right]$$

$$= -G \times 2\left[1 + \frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3} + \cdots + \infty\right]$$

$$= -2G\frac{1}{\left[1 - \frac{1}{2}\right]}$$

$$\therefore V = -4G$$

27 **(b)**

Given, $\frac{R_e}{R_p} = \frac{2}{3}, \frac{d_\theta}{d_p} = \frac{4}{5}$

As, $MG = gR_\theta^2$

an d $M = d_e \times \frac{4}{3}\pi R_e^3$

or $d_e \times \frac{4}{3}\pi R_\theta \times G = g_\theta$ .... (i)

Similarly for planet, $d_p \times \frac{4}{3}\pi R_p G = g_p$ ....(ii)

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

$$\frac{g_e}{g_p} = \frac{R_e}{R_p} \times \frac{d_e}{d_p}$$

$$= \frac{2}{3} \times \frac{4}{5} = \frac{8}{15} = 0.5$$

$$g_p = \frac{g_e}{0.5} = 2g_e$$

But we know that, $U = mgh$

$$g_p h_p = g_\theta h_\theta$$

$$2g_\theta h_p = g_\theta \times 1.5$$

$$h_e = \frac{1.5}{2} = 0.75\,m$$

28 **(b)**

As, $h = \left(\frac{T^2R^2}{4\pi^2}\right)^{1/3} - R$

$$= \left[\frac{(24\times 60\times 60)^2 \times (6.4\times 10^6)^2 \times 9.8}{4\times (22/7)^2}\right]^{1/3} - 6.4 \times 10^6$$

$$= 3.6 \times 10^7\, m = 36000\, km$$

29 **(b)**

$r_1 = 4r, r_2 = r$

Orbital speed $v_e \propto \frac{1}{\sqrt{r}}$

$$\therefore \frac{v_1}{v_2} = \sqrt{\frac{r_2}{r_1}} = \sqrt{\frac{r}{4r}} = \frac{1}{\sqrt{4}} = \frac{1}{2}$$

31 **(d)**

Gravity at height h,

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

Gravity at depth d,

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

Given : $g_h = g_d$

$\Rightarrow d = 2h$

32 **(b)**

$$\frac{M_1}{M_2} = 2 : 3, \frac{R_1}{R_2} = 3 : 2$$

$$\frac{g_1}{g_2} = \frac{GM_1/R_1^2}{GM_2/R_2^2} = \frac{M_1}{M_2} \times \left(\frac{R_2}{R_1}\right)^2$$

$$= \frac{2}{3} \times \left(\frac{2}{3}\right)^2 = \frac{8}{27}$$

35 **(a)**

Weight of the body at the surface of the earth,

$w = mg = 45$ N

Using, $g' = \frac{g}{\left(1+\frac{h}{R}\right)^2} \Rightarrow mg' = \frac{mg}{\left(1+\frac{R}{2R}\right)^2}$ $\left[h = \frac{R}{2}\right]$

$$w' = \frac{45}{\left(1+\frac{1}{2}\right)^2} = \frac{4\times 45}{9} = 20\text{ N } (\because w' = mg')$$

37 **(a)**

$$\frac{v_1}{v_2} = \sqrt{\frac{2g_1R_1}{2g_2R_2}} = \sqrt{k_1k_2}$$

41 **(c)**

$r = 1.5 \times 10^8 \times 10^3$m

When orbiting, gravitational force

$F = m\omega^2 r$

$= 6 \times 10^{24} \times (2\times 10^{-7})^2 \times 1.5 \times 10^8 \times 10^3$

$= 36 \times 10^{21}$ N

42 **(a)**

Initially, $E_i = -\frac{GM_Em}{4R_E}$

and finally, $E_f = \frac{-GM_Em}{8R_E}$

Change in total energy,

$$\Delta E = E_f - E_i = \left(-\frac{GmM_E}{8R_E}\right) - \left(-\frac{GmM_E}{4R_E}\right)$$

$$= \frac{GmM_E}{8R_E} \text{ or } \frac{gmR_E}{8}$$

Thus, $\Delta E = \frac{gmR_E}{8} = \frac{9.81\times 400\times 6.37\times 10^6}{8}$

$= 3.13 \times 10^9\, J$..................... (i)

The kinetic energy is reduced and change in KE is just negative of ΔE.

$\Rightarrow \Delta K = K_f - K_i = -3.13 \times 10^9\, J$ .... (ii)

The change in potential energy is twice the change in the total energy,

$\therefore \Delta PE = PE_f - PE_i = -6.26 \times 10^9\, J$ ....(iii)

43 **(d)**

$$F = G\frac{m_1m_2}{r^2}$$

$$\therefore G = \frac{Fr^2}{m_1m_2}$$

$\therefore$ Units of G is $\frac{Nm^2}{kg^2}$

44 **(a)**

1. We know that, $g = \frac{GM_e}{R_e^2}$ and $d = \frac{M_\theta}{\frac{4}{3}\pi R_\theta^3}$

$$g = \frac{4\pi G d R_\theta}{g} \Rightarrow g \propto dR_\theta$$

$$\frac{g_1}{g_2} = \frac{d_1r_1}{d_2r_2}$$

46 **(d)**

1. Time period of satellite, $T = \frac{2\pi r^{3/2}}{\sqrt{GM}}$

$$\sqrt{GM} = \frac{2\pi}{T} \cdot r^{3/2}$$

As,

$$\frac{2\pi}{T} = \omega$$

As, $\Rightarrow \ \omega r^{3/2} = \sqrt{GM}$

$$r^3 = \frac{GM}{\omega^2} = \frac{gR^2}{\omega^2}$$

47 **(c)**

If V_e is the escape velocity, then the kinetic energy required to escape from the gravitational field of the earth is

$$K = \frac{1}{2}mv_e^2$$

If the body is given velocity $2V_e$ then kinetic energy given to it is

$$K_1 = \frac{1}{2}m(2V_e)^2 = \frac{1}{2}(4mv_e^2)$$

∴ Kinetic energy remaining after it escapes from the gravitational field is

$$K_2 = K_1 - K = \frac{1}{2}(4mv_e^2) - \frac{1}{2}mv_e^2 = \frac{1}{2}(3mv_e^2)$$

If V is the velocity of the body then

$$\frac{1}{2}mV^2 = \frac{1}{2}(3mv_e^2)$$

$$\therefore V = \sqrt{3}V_e$$

$$\therefore V^2 = 3v_e^2$$

48 **(b)**

If it is so, then the centrifugal force would exceed the force of attraction or we can say that gravitational force won't be able to keep the satellite in circular motion

50 **(a)**

For a satellite orbiting close to the surface of the planet

$$T = 2\pi\sqrt{\frac{R^3}{GM}} = \sqrt{\frac{R^3}{G \times \frac{4}{3}\pi R^3 \rho}} = \sqrt{\frac{3}{4\pi G\rho}}$$

$$\therefore T = \frac{1}{\rho} \text{ or } T = \rho^{1/2}$$

51 **(a)**

Initial velocity = V m/s

TE at surface = TE at height h

$$\frac{1}{2}mV^2 + \left(-\frac{GMm}{R}\right) = 0 + \left(-\frac{GMm}{R+h}\right)$$

$$\frac{1}{2}V^2 = \frac{GM}{R} - \frac{GM}{R+h} = GM\left[\frac{1}{R} - \frac{1}{R+h}\right]$$

$$= GM\left[\frac{R+h-R}{R(R+h)}\right] \left[g = \frac{GM}{R^2}\right] = \frac{gR^2h}{R(R+h)}$$

$$\frac{1}{2}V^2 = \frac{gR^2h}{R(R+h)}$$

$$\frac{R+h}{R} = \frac{2ghR}{V^2}$$

$$\frac{R+h}{Rh} = \frac{2gR}{V^2}$$

$$\frac{1}{h} + \frac{1}{R} = \frac{2gR}{V^2}$$

$$\frac{1}{h} = \frac{2gR}{V^2} - \frac{1}{R} = \frac{2gR^2 - V^2}{V^2R}$$

$$h = \frac{V^2R}{2gR^2 - V^2}$$

54 **(b)**

2. $\quad F = \frac{Gm(M-m)}{x^2}$

For maximum gravitational force, $\frac{dF}{dm} = 0$

$$\frac{dF}{dm} = \frac{G}{x^2}$$

$$\frac{m}{M} = \frac{1}{2}$$

56 **(b)**

The change in potential energy is given as, $\Delta U = U_f - U_i$

$$= \frac{-GMm}{R+2R} - \frac{-GMm}{R}$$

$$= \frac{GMm}{R}\left[1 - \frac{1}{3}\right] = \frac{2}{3}\frac{GMm}{R}$$

$$= \frac{2}{3}\frac{GMm \times R}{R^2} = \frac{2}{3}\left(\frac{GM}{R^2}\right)mR$$

$$\therefore \Delta u = \frac{2}{3}mgR$$

57 **(c)**

Just before striking, the distance between the centre of earth and moon is $r = R_e + \frac{R_e}{4} = \frac{5R_e}{4}$.

So, acceleration of moon at this moment is

$$g' = \frac{GM_e}{(5R_e/4)^2} = \frac{gR_e^2}{25R_e^2} \times 16$$

$$= \frac{16}{25} \times 10 = 6.4 \text{ ms}^{-2}$$

58 **(b)**

$F = \frac{Gm(M-m)}{r^2}$

For maximum force $\frac{dF}{dm} = 0$

$\Rightarrow \frac{d}{dm}\left(\frac{GmM}{r^2} - \frac{Gm^2}{r^2}\right) = 0$

$\Rightarrow M - 2m = 0 \Rightarrow \frac{m}{M} = \frac{1}{2}$

59 **(b)**

From Kepler's third law of planetary motion, $T^2 \propto R^3$ Given, $T_p = 27T_\theta, \frac{T_\theta^2}{T_p^2} = \frac{R_\theta^3}{R_p^3}$

$\Rightarrow \frac{T_\theta^2}{(27T_\theta)^2} = \frac{R_\theta^3}{R_p^3}$

$\frac{R_p}{R_\theta} = (27)^{2/3} \Rightarrow \frac{R_p}{R_\theta} = 3^2 \Rightarrow R_p = 9R_\theta$

62 **(b)**

$h = 3R \Rightarrow r = 4R$

$g = \frac{Gm}{R^2}, g_h = \frac{Gm}{(4R)^2} = \frac{Gm}{16R^2} = \frac{g}{16}$

$\therefore \frac{g_h}{g} = \frac{1}{16}$

63 **(d)**

$P.E. = -\frac{GMm}{(R+nR)}$

Change in potential energy

$P.E._2 = P.E._1 = \frac{-GMm}{R+nR} - \left(-\frac{GMm}{R}\right)$

$= \frac{GMm}{R} - \frac{GMm}{R(n+1)}$

$= \frac{GMm}{R}\left(1 - \frac{1}{n+1}\right)$

$= \frac{GMm}{R}\left(\frac{n+1-1}{n+1}\right)$

$= \frac{GMm}{R} \times \frac{n}{(n+1)} = \frac{gR^2m}{R}\left(\frac{n}{n+1}\right)$

$= mgR\left(\frac{n}{n+1}\right)$

64 **(c)**

As $g = \frac{GM}{R^2}$, if R decreases then g increases. Taking logarithm of both the sides, we get

$\log g = \log G + \log M - 2\log R$

Differentiating it, we get

$\frac{dg}{g} = 0 + 0 - \frac{2dR}{R} = -2\left(\frac{-2}{100}\right) = \frac{4}{100} \therefore$ % increase in $g = \frac{dg}{g} \times 100 = \frac{4}{100} \times 100 = 4\%$

66 **(d)**

It is given that, acceleration due to gravity on planet A is 9 times the acceleration due to gravity on planet B i.e.

$g_A = 9ga$ ... (i)

From third equation of motion,

$v^2 = 2gh$

At planet A,

$h_A = \frac{v^2}{2g_A}$ ... (ii)

At planet B,

$h_B = \frac{v^2}{2g_B}$ ... (iii)

Dividing Eq. (ii) by Eq. (iii), we have

$\frac{h_A}{h_B} = \frac{g_B}{g_A} \Longrightarrow \frac{h_A}{h_B} = \frac{1}{9}$ $(\because g_A = 9ga)$

$\Longrightarrow h_B = 9h_A = 9 \times 2 = 18$ m $(\because h_A = 2m)$

67 **(d)**

Orbital radius of satellites $r_1 = R + R = 2R$

$r_2 = R + 7R = 8R$

$P.E_1 = \frac{-GMm}{r_1}$ and $P.E_2 = \frac{-GMm}{r_2}$

$K.E_1 = \frac{GMm}{2r_1}$ and $K.E_2 = \frac{GMm}{2r_2}$

$T.E_1 = \frac{-GMm}{2r_1}$ and $T.E_2 = \frac{-GMm}{2r_2}$

$\therefore \frac{P.E_1}{P.E_2} = \frac{K.E_1}{K.E_2} = \frac{T.E_1}{T.E_2} = 4$

68 **(a)**

Since, orbital velocity of body close to earth can be given as

$v_o = \sqrt{rg} = \sqrt{6400 \times 10^3 \times 10}$

$= \sqrt{64 \times 10^6}$

$= 8 \times 10^3\ m\,s^{-1}$

$v_0 = 8kms^{-1}$

69 **(c)**

$T = 83$ min, $R' = 4R$

$\therefore \frac{T'}{T} = \left[\frac{R'}{R}\right]^{3/2} = \left[\frac{4R}{R}\right]^{3/2}$

T is increased by a factor of $[4]^{3/2}$ i.e. 8 times.

$T' = 8 \times 83$ minutes $= 664$ minutes

70 **(c)**

Increase in the P.E. is given by,

$\Delta U = U_B - U_A$

$U_B = -\frac{GMm}{R+h} = -\left(\frac{GMm}{R+R/5}\right) = \frac{5GMm}{6R}$

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

$\therefore \Delta U = -\frac{5GMm}{6R} + \frac{GMm}{R} = \frac{GMm}{R}\left(1 - \frac{5}{6}\right)$

$\Delta U = \frac{GMm}{6R}$

$\therefore \Delta U = \frac{mgR^2}{6R} \qquad (\because GM = gR^2)$

$\therefore \Delta U = \frac{mgR}{6}$

$\therefore \Delta U = \frac{5}{6}mgh \quad (\because R = 5h)$

Alternate method (I):

$\Delta U = \frac{mgh}{1 + h/R}$

Substituting $R = 5h$

We get $\Delta U = \frac{mgh}{1+1/5} = \frac{5}{6}mgh$

71 **(c)**

$$T = \frac{2\pi r}{V_0} = \frac{2\pi r}{\sqrt{\frac{GM}{r}}} = 2\pi\sqrt{\frac{r^3}{GM}}$$

$\therefore$ Time period is independent of mass of the satellite

72 **(a)**

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

$\therefore \frac{250}{500} = \frac{1}{2} = \left(1 - \frac{d}{R}\right)$

$\therefore \frac{d}{R} = \frac{1}{2}$

$\therefore d = \frac{R}{2} = \frac{6400\text{km}}{2} = 3200\text{ km}$

73 **(d)**

Velocity of satellite, $v = \sqrt{\frac{GM}{r}}$

$\therefore KE \propto v^2 \propto \frac{1}{r}$

and $T^2 \propto r^3$

$\Rightarrow KE \propto T^{-2/3}$

74 **(b)**

The value of g at the height h from the surface of earth

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

The value of g at depth x below the surface of earth

$g' = g\left(1 - \frac{x}{R}\right)$

These two are given equal, hence

$\left(1 - \frac{2h}{R}\right) = \left(1 - \frac{x}{R}\right)$

On solving, we get $x = 2h$

75 **(d)**

$M_p = 2M_e$

$\therefore \frac{4}{3}\pi R_p^1\rho = 2 \times \frac{4}{3}\pi R_e^3\rho$

$\therefore R_p^3 = 2R_e^3 \Rightarrow R_p = 2^{1/3}R_e$

$\therefore g_p = \frac{GM_p}{R_p^2} = \frac{G[2M_e]}{[2^{1/3}R_e]} = 2^{1-\frac{2}{3}}\frac{GM_e}{R_e^2}$

$\therefore g_p = 2^{1/3}g_e$

$\therefore mg_p = 2^{1/3}mg_e = 2^{1/3}W$

76 **(a)**

$r = 50\text{ cm} = 50 \times 10^{-2}\text{m}$

$F = G\frac{m_1m_2}{r^2} = \frac{6.67 \times 10^{-11} \times 625 \times 625}{50 \times 50 \times 10^{-4}}$

$= 1.042 \times 10^{-4}\text{N}$

$= 10.42$ dyne

77 **(b)**

Gravitational pull depends upon the acceleration due to gravity on that planet

$M_m = \frac{1}{81}M_e, g_m = \frac{1}{6}g_e$

$g = \frac{GM}{R^2} \Rightarrow R = \left(\frac{GM}{g}\right)^{1/2}$

$\therefore \frac{R_e}{R_m} = \left(\frac{M_e}{M_m} \times \frac{g_m}{g_e}\right)^{1/2} = \left(81 \times \frac{1}{6}\right)^{1/2}$

$\therefore R_e = \frac{9}{\sqrt{6}}R_m$

80 **(c)**

Given, $R_e = 6400\ km = 6.4 \times 10^6\ m$

$\pi = 3.14, g = 10\ m/s^2$

We know that, the period of revolution of the earth's satellite,

$T = 2\pi\sqrt{\frac{(R_e+h)^3}{gR_e^2}}$ [$if\ \ h \ll R_e$, then $(R_\theta + h = R_e)$]

So, $T = 2\pi\sqrt{\frac{R_e^3}{gR_e^2}} = 2\pi\sqrt{\frac{R_e}{g}} = 2 \times 3.14\sqrt{\frac{6.4\times10^6}{10}} =$

$2 \times 3.14 \times 0.8 \times 10^3 = 5.024 \times 10^3 = 5024\ s$

or $T = \frac{5024}{60} = 83.73\ min$

82 **(b)**

$g = \frac{GM}{R^2}$

$\therefore \frac{g'}{g} = \frac{M'}{M}.\left(\frac{R}{R'}\right)^2 = 2 \times \left(\frac{1}{2}\right)^2 = \frac{1}{2}$

$\therefore g' = \frac{g}{2}$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

84 **(c)**

Escape velocity $v = \sqrt{\frac{2GM}{R}}$

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

$$\therefore v = \sqrt{\frac{2G \times \frac{4}{3}R^3.\rho}{R}} = \sqrt{\frac{8G}{3}R^2\rho} = R\sqrt{\frac{8G}{3}\rho}$$

$$\therefore v \propto R\sqrt{\rho}$$

$\therefore$ IF ρ is constant, the $v \propto R$

$$\therefore \frac{v_p}{v_E} = \frac{R_p}{R_E} = 2$$

$$\therefore v_p = 2v_E$$

85 **(b)**

$$mg_d = mg\left[1 - \frac{d}{R}\right]$$

$$\therefore 31.5 = 63\left[1 - \frac{d}{R}\right]$$

$$\therefore 1 - \frac{d}{R} = \frac{31.5}{63} = \frac{1}{2}$$

$$\therefore \frac{d}{R} = 1 - \frac{1}{2} = \frac{1}{2}$$

$$\therefore 2d = R \text{ or } d = \frac{R}{2} = 0.5R$$

86 **(c)**

At a height

$$h = \frac{R}{2}$$

The potential energy is P. E.

$$= -\frac{GMm}{R + \frac{R}{2}} = -\frac{2GMm}{3R}$$

Initial K. E. is zero.

When it hits the surface, it has kinetic and potential energy

$\because$ total energy is conserved.

$$\therefore \frac{1}{2}mv^2 - \frac{GMm}{R} = -\frac{2GMm}{3R}$$

$$\therefore \frac{1}{2}mv^2 = \frac{GMm}{R} - \frac{2}{3}\frac{GMm}{R} = \frac{1}{3}\frac{GMm}{R}$$

$$\therefore V^2 = \frac{2}{3}\frac{Gm}{R}$$

$$\therefore V = \sqrt{\frac{2}{3}\frac{GM}{R}} = \frac{1}{\sqrt{3}}\sqrt{\frac{2Gm}{R}} = \frac{V_e}{\sqrt{3}}$$

88 **(b)**

Kinetic energy of a satellite is given by

$$K.E. = \frac{GMm}{2r}$$

The two satellites are of the same mass

$$\therefore K.E. \propto \frac{1}{r}$$

$$\frac{(K.E.)_1}{(K.E.)_2} = \frac{r_2}{r_1} = \frac{3R}{2R} = \frac{3}{2}$$

89 **(c)**

$T_1 = T, T_2 = 8T$

$$\therefore R_2 = R_1\left(\frac{T_2}{T_1}\right)^{2/3} = R\left(\frac{8T}{T}\right)^{2/3} = 4R$$

91 **(c)**

$$F = \frac{m_1 \times m_2}{r^2} = 6.67 \times 10^{-11} \times \frac{m^2}{r^2}$$

$$= 6.67 \times 10^{-11} \times \left(\frac{1}{1}\right)^2 = 6.67 \times 10^{-11}\ N$$

92 **(c)**

$$\frac{v_B}{v_A} = \sqrt{\frac{r_A}{r_B}} = \sqrt{\frac{4R}{R}} = 2$$

$$\Rightarrow v_B = 2 \times v_A = 2 \times 3v = 6v$$

95 **(d)**

$$V = \frac{1}{3}\sqrt{\frac{2GM}{R}}$$

$$TE_{\text{At surface}} = TE_{\text{at height h}}$$

$$-\frac{GMm}{R} + \frac{1}{2}mv^2 = -\frac{GMm}{R+h} + 0$$

$$-\frac{GMm}{R} + \frac{1}{2}m\frac{1}{9} \times \frac{2GM}{R} = -\frac{GMm}{R+h}$$

$$\left(\frac{1}{9} - 1\right)\frac{GMm}{R} = -\frac{GMm}{R+h}$$

$$-\frac{8}{9}\frac{GMm}{R} = -\frac{GMm}{R+h}$$

$$\frac{8}{9}\frac{1}{R}=\frac{1}{R+h}$$

$$\Longrightarrow 8R+8h=9R$$

$$8h=R$$

$$\therefore h=\frac{R}{8}$$

96 **(b)**

For a hollow spherical shell, $F(r)=$
$$\begin{cases} \text{zero}; & r<R \\ \frac{GMm}{r^2}; & r\geq R \end{cases}$$

99 **(c)**

1. The potential energy of an object at the surface of the earth,

$U_1=-\frac{GMm}{R}$ …… (i)

The potential energy of the object at a height, $h=R$ from the surface of the earth,

$U_2=-\frac{GMm}{R+h}=-\frac{GMm}{R+R}$ …. (ii)

Hence, the gain in potential energy of the object,
$$\Delta U=U_2-U_1$$
$$=-\frac{GMm}{R+R}+\frac{GMm}{R}$$
$$\Delta U=-\frac{GMm}{2R}+\frac{GMm}{R}$$
$$=\frac{1}{2}\cdot\frac{GMm}{R}$$
But we know that, $GM=gR^2$
Hence,
$$\Delta U=\frac{1}{2}\frac{gR^2m}{R}$$
$$=\frac{1}{2}gRm=\frac{1}{2}mgR$$

101 **(b)**

$$F=\frac{Gm_1m_2}{d^2}$$
If the point mass $2m_1$ is brought near m_1, then the force on m_2 due to m_1, will be still $F=\frac{Gm_1m_2}{d^2}$ because the gravitational force between two masses is independent of the presence of other masses. However, the total force on m_2 will be $F'=\frac{G\cdot m_2(m_1+2m_1)}{d^2}=3F$

102 **(d)**

$$mr\omega^2=\frac{GMm}{r^2}$$

$$r\omega^2=\frac{GM}{r^2}$$

$$r^3=\frac{GM}{\omega^2}=\frac{GM}{R^2}\times\frac{R^2}{\omega^2}=g\frac{R^2}{\omega^2}$$

$$\therefore r=\left[\frac{gR^2}{\omega^2}\right]^{1/3}$$

104 **(b)**

As, $T^2\propto r^3$

So, $\frac{T_A^2}{T_B^2}=\frac{r_A^3}{r_B^3}$ or $\frac{r_A}{r_B}=\left(\frac{T_A}{T_B}\right)^{2/3}=(8)^{2/3}=4\Rightarrow r_A=4r_B$

$\therefore\ r_A-r_B=4r_B-r_B=3r_B$

106 **(b)**

Kinetic energy of a satellite is given by

$$K.E.=\frac{GMm}{2r}$$

The two satellites are of the same mass

$$\therefore K.E.\propto\frac{1}{r}$$

$$\frac{(K.E.)_1}{(K.E.)_2}=\frac{r_2}{r_1}=\frac{3R}{2R}=\frac{3}{2}$$

107 **(d)**

At a height h (<<R), the acceleration due to gravity is given by

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

$$\therefore\frac{g-g'}{g}=\frac{2h}{R}$$

$$\therefore\frac{g-g'}{g}\times 100=\frac{2\times 32\times 100}{6400}=1\%$$

108 **(a)**

Given, $F\propto r^{-n}$,

so $\frac{mv^2}{r}\propto r^{-n}$ or $v\propto r^{(1-n)/2}$

As, time period, $T=\frac{2\pi r}{v}$

$\therefore T\propto rv^{-1}$ or $T\propto r\cdot r^{(n-1)/2}$

$\Rightarrow T\propto r^{(n+1)/2}$

110 **(b)**

$$\text{Angular momentum}=mvr=m\sqrt{\frac{GM}{r}}r=m\sqrt{GMr}$$
$$=m(GMr)^{1/2}$$

111 **(d)**

$g'=g-R\omega^2\cos^2\phi$; when $\phi=45°$,

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

When earth stops rotating, $g = 0$,

So $g' = \frac{R\omega^2}{2}$

Hence the weight of the body increases by $\frac{R\omega^2}{2}$

112 **(c)**

Because it does not depend on the mass of particle

113 **(a)**

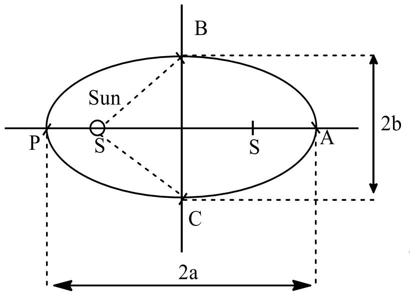
Since, $F = Mr\omega^2$

$$\therefore T \propto \sqrt{\frac{R}{F}} \Rightarrow T^2 \propto \frac{R}{F}$$

$$\therefore T^2 \propto \frac{R}{\left(R^{-\frac{5}{2}}\right)} \Rightarrow T^2 \propto R^{\frac{7}{2}}$$

114 **(a)**

The figure shown is an ellipse which is traced out by a planet around the sun. The closest point is *P* called Perihelion and the farthest point is *A* which is called Aphelion.



115 **(c)**

Escape velocity, $v_\theta = \sqrt{2gR}$

Given, $g = (3.1)^2\ ms^{-2}, R = 8100\ km = 8100 \times 10^3\ m$

$$\therefore\ v_\theta = \sqrt{2 \times (3.1)^2 \times 8100 \times 10^3}$$

$$= 12.5 \times 10^3\ ms^{-1}$$

$$\Rightarrow\ v_\theta = 12.5\ km\ s^{-1} \approx \frac{27.9}{\sqrt{5}} kms^{-1}$$

116 **(c)**

Potential energy $= -(2\text{B. E.})$

$$= -(2 \times 3.5 \times 10^8)\text{J} = -7 \times 10^8\ \text{J}$$

117 **(d)**

$$g' = 16\%\ g = \frac{16g}{100} \Rightarrow \frac{g'}{g} = \frac{16}{100}$$

$$\therefore \frac{R^2}{(R+h)^2} = \frac{16}{100} \Rightarrow \frac{R+h}{R} = \frac{5}{2}$$

$$\therefore \frac{h}{R} = \frac{3}{2} \Rightarrow h = \frac{3}{2} \times 6300 = 9450\ \text{km}$$

118 **(b)**

$\rho_2 = 2\rho_1, R_1 = R_2$

$g \propto \rho R \Rightarrow g_1 \propto \rho_1 R_1$ and $g_2 \propto \rho_2 R_2$

$$\therefore \frac{g_1}{g_2} = \frac{\rho_1}{\rho_2} \times \frac{R_1}{R_2} = \frac{1}{2} \times 1 = \frac{1}{2}$$

$\therefore g_2 = 2 \times 9.8 = 19.6 m/s^2$

119 **(c)**

The value of acceleration due to gravity at a height h above the earth's surface is given by

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

where, R is radius of earth.

When,

$$h = \frac{R}{2}, g' = \frac{g}{\left(1 + \frac{1}{2}\right)^2} = \frac{4g}{9}$$

Hence, weight, $w' = mg' = \frac{4}{9}mg = \frac{4}{9}w$.

120 **(b)**

Binding energy is equal to negative value of total mechanical energy of a satellite. The energy required to remove the satellite from its orbit around the earth to infinity is called binding energy of the satellite. It is equal to negative of total mechanical energy of satellite in its orbit.

Thus, binding energy $= -E = \frac{GMm}{2r}$

But $g = \frac{GM}{R^2}$

$\Rightarrow GM = gR^2$

or $BE = \frac{gmR^2}{2r}$

121 **(b)**

As, $\frac{(v_\theta)_{P_1}}{(v_\theta)_{P_2}} = \frac{\sqrt{2g_1R_1}}{\sqrt{2g_2R_2}} = \sqrt{\frac{g_1}{g_2} \times \frac{R_1}{R_2}} = \sqrt{ab}$

123 **(c)**

Energy required to escape the earth's gravitational field is

$$\frac{1}{2}mV_e^2$$

Energy given to the body is

$$= \frac{1}{2}m(3V_e)^2$$

$$= \frac{9}{2}mV_e^2$$

$\therefore$ If V is the velocity of the body when it has escaped from earth's gravitational field then

$\frac{1}{2}mV^2 = \frac{9}{2}mV_e^2 - \frac{1}{2}mV_e^2$

$\therefore \frac{1}{2}mV^2 = 4mV_e^2$

$\therefore V^2 = 8V_e^2$

$V = 2\sqrt{2}V_e$

124 **(a)**

$M_e = 20M_m$

$g_e = \frac{GM_e}{R_e^2}$ and $g_m = \frac{GM_m}{R_m^2}$

$\therefore \frac{g_m}{g_e} = \frac{M_m}{M_e} \times \left(\frac{R_e}{R_m}\right)^2 = \frac{M_m}{20M_m} \times \left(\frac{6400}{3200}\right)^2$

$\therefore \frac{mg_m}{mg_e} = \frac{4}{20}$

$\therefore$ Weight on Mars $= 500 \times \frac{4}{20} = 100$ N

125 **(b)**

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

$\therefore 9 - g\left[1 - \frac{2\left(\frac{R}{20}\right)}{R}\right]$

$= g\left(1 - \frac{1}{10}\right)$

$\therefore 9 = \frac{9g}{10} \Rightarrow g = 10ms^{-2}$

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

$= 10\left[1 - \frac{\left(\frac{R}{20}\right)}{R}\right]$

$= 10\left(\frac{19}{20}\right)$

$\therefore g_d = 9.5ms^{-2}$

126 **(b)**

$r = 20 \times 10^{-2}$m, total mass $= 5$kg

let m and $(5 - m)$ be the two masses

$F = \frac{Gm_1m_2}{r^2}$

$\therefore 1 \times 10^{-8} = \frac{6.67 \times 10^{-11} \times m \times (5 - m)}{(2 \times 10^{-1})^2}$

$\therefore 1 \times 10^{-8} = 6.67 \times \frac{m(5 - m)}{4} \times 10^{-9}$

$\therefore 10 = \frac{40}{6} \times \frac{m(5 - m)}{4}$

$\therefore m^2 - 5m + 6 = 0$

$\therefore (m - 2)(m - 3) = 0$

$\therefore m = 3$ or $m = 2$

127 **(a)**

T

$= 2\pi\sqrt{r^3/GM}$, It is independent of the mass of sate

128 **(b)**

$E = \frac{1}{2}mV^2$

$\therefore V = \sqrt{\frac{2E}{m}}$

Angular momentum $L = mvr$

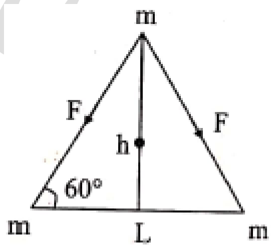
$= m.\sqrt{\frac{2E}{m}}.r = \sqrt{2mEr^2} = (2mEr^2)^{1/2}$

129 **(c)**

The force on any mass due to each of the other two masses will be of magnitude

$F = G\frac{m^2}{L^2}$

The two forces are acting at an angle of 60^0 and their resultant is given by



$F' = \sqrt{F^2 + F^2 + 2F^2\cos 60^0} = \sqrt{3}F$

The height of the triangle

$h = L\sin 60^0 = \frac{\sqrt{3}}{2}L$

the distance of the centroid from the vertices is

$\frac{2}{3}h = \frac{L}{\sqrt{3}}$

$\therefore$ Radius of the circular motion of the masses r

$= \frac{L}{\sqrt{3}}$

For circular motion the centripetal force in equal to the gravitational force due to the other masses.

$\therefore mr\omega^2 = \sqrt{3}F = \sqrt{3}\frac{Gm^2}{L^2}$

or $r\omega^2 = \sqrt{3}\frac{Gm}{L^2}$

$\frac{L}{\sqrt{3}}\omega^2 = \sqrt{3}\frac{Gm}{L^2}$

$\therefore \omega^2 = \frac{3Gm}{L^3}$

$\therefore \frac{4\pi^2}{T^2} = \frac{3GM}{L^3}$

$T^2 = \frac{4\pi^2 L^3}{3GM}$

$\therefore T^2 \propto L^1$

or $T \propto L^{3/2}$

130 **(d)**

As $T = \frac{2\pi r}{v} = \frac{2\pi r}{[GM/r]^{1/2}} = 2\pi\left[\frac{r^3}{GM}\right]^{1/2}$

As per question,

$24 = 2\pi\left[\frac{(6400+36000)^3}{GM}\right]^{1/2}$ .... (i)

And $T' = 2\pi\left[\frac{(6400)^3}{GM}\right]^{1/2}$ .... (ii)

From Eqs. (i) and (ii), we get

$\therefore \frac{T'}{24} = \left[\frac{(6400)^3}{(6400+36000)^3}\right]^{1/2} = (0.4)^3$

or $T' = (0.4)^3 \times 24 = 1.53\, h \simeq 1.5\, h$

132 **(d)**

Time period, $T = 2\pi\sqrt{\frac{(R+h)^3}{gR^2}}$

$R + h = \left[\frac{gR^2T^2}{4\pi^2}\right]^{1/3}$

$= \left[\frac{9.8 \times (6.4 \times 10^6)^2 \times (90 \times 60)^2}{4\pi^2}\right]^{1/3}$

$R + h = 6668\ km$

$h = 6668 - R = 6668 - 6400$

$h = 268\ km$

133 **(a)**

$T = \frac{2\pi r}{v_e} = \frac{2\pi r}{\sqrt{\frac{GM}{r}}} = \sqrt{\frac{4\pi^2 r^3}{GM}}$

Since $r \approx R_p$

Where R_p = Radius of planet, put

$M = \frac{4}{3}\pi R_p^3 \rho$

$\therefore \sqrt{\frac{4\pi^2 R_p^3}{G \times \frac{4}{3}\pi R_p^3 \rho}} = \sqrt{\frac{3\pi}{G\rho}}$

$\therefore T \propto \frac{1}{\sqrt{\rho}}$

134 **(a)**

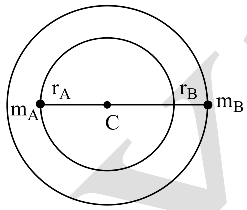
$g \propto \rho$

135 **(d)**

$\frac{Gm_A m_B}{(r_A + r_B)^2} = \frac{m_A r_A 4\pi^2}{T_A^2} = \frac{m_B r_B 4\pi^2}{T_B^2}$

$\Rightarrow m_A r_A = m_B r_B$

$\therefore T_A = T_B$



136 **(c)**

The potential energy of an object at the surface of the earth,

$U_1 = -\frac{GMm}{R}$ ... (i)

The potential energy of the object at a height h = R from the surface of the earth,

$U_2 = -\frac{GMm}{R+h} = -\frac{GMm}{R+R}$ ... (ii)

Hence, the gain in potential energy of the object

$\Delta U = U_2 - U_1 = -\frac{GMm}{R+R} + \frac{GMm}{R}$

$\Delta U = -\frac{GMm}{2R} + \frac{GMm}{R} = \frac{1}{2}.\frac{GMm}{R}$

But we know that $GM = gR^2$

Hence, $\Delta U = -\frac{1}{2}\frac{gR^2m}{R} = \frac{1}{2}\ gRm = \frac{1}{2}mgR$

137 **(a)**

$g = \frac{GM}{r^2}$

$\therefore \frac{g'}{g} = \frac{r^2}{r'^2}$

$R = 6400\ km, r' = 6400 + 1600 = 8000\ km$

$\therefore \frac{g'}{g} = \left(\frac{6400}{8000}\right)^2 = \left(\frac{4}{5}\right)^2 = \frac{16}{25}$

$\therefore \frac{W'}{W} = \frac{mg'}{mg} = \frac{16}{25}$

Extension e is proportional to weight

$$\frac{e'}{e} = \frac{16}{25}$$

$$\therefore e' = \frac{16}{25} \times e = \frac{16}{25} \times 5 = 3.2 \text{ cm}$$

138 **(c)**

$$\text{P.E.} = -\frac{GMm}{r}; \text{K.E.} = \frac{GMm}{2r}$$

$$\therefore \text{P.E.} = -2(\text{K.E.})$$

139 **(b)**

According to the law of conservation of energy,
(Total energy) surface =
(Total energy)$_{(\text{max height})}$

$$\Rightarrow (KE + PE)_{\text{surface}} = (KE + PE)_{max \text{ height}}$$

$$\Rightarrow \frac{1}{2}mv^2 + \left(-\frac{GMm}{R}\right) = 0 + \left(-\frac{GMm}{R+h}\right)$$

Given, $v = \frac{1}{2}v_\theta = \frac{1}{2}\sqrt{\frac{2GM}{R}}$

$$\Rightarrow \frac{1}{2}m\left[\frac{1}{4}\cdot\frac{2GM}{R}\right] - \frac{GMm}{R} = -\frac{GMm}{R+h}$$

$$\Rightarrow \frac{1}{4}\frac{GMm}{R} - \frac{GMm}{R} = -\frac{GMm}{R+h}$$

$$\Rightarrow \frac{-3}{4R} = -\frac{1}{R+h}$$

$$\Rightarrow R - 3h = 0 \Rightarrow h = \frac{R}{3}$$

140 **(d)**

$$v_e = \sqrt{\frac{GM}{r}} = \sqrt{\frac{gR^2}{r}} \text{ and } v_e = r\omega$$

This gives $r^3 = \frac{R^2 g}{\omega^2}$

142 **(b)**

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

$\therefore$ Percentage change in g = 2 × (Percentage change in R)

$= 2 \times 1\% = 2\%$

145 **(a)**

$$F = \frac{Gm_1m_2}{r^2}$$

$$\therefore r = \sqrt{\frac{Gm_1m_2}{F}} = \sqrt{\frac{6.67 \times 10^{-11} \times 1 \times 1}{9.8 \times 10^{-9}}}$$

$$= 0.082 \text{ m} = 8.2 \text{ cm}$$

146 **(d)**

Period of the satellite depends on the radius of the orbit and not on the mass of satellite

$T^2 \propto r^3$

$$\therefore \frac{T_2^2}{T_1^2} = \frac{r_2^3}{r_1^3} = (2)^3 = 8$$

$$\therefore \frac{T_2}{T_1} = \sqrt{8} = 2\sqrt{2}$$

147 **(a)**

$M_P = 2M_E, D_P = 2D_E \Rightarrow R_P = 2R_E$

$T_E = 2$ s

$$g_E = \frac{GM_E}{R_E}, g_P = \frac{GM_P}{R_P^2}$$

$$\therefore g_P = g_E \times \frac{M_P}{M_E} \times \left(\frac{R_E}{R_P}\right)^2$$

$$= g_E \times 2 \times \left(\frac{1}{2}\right)^2 = \frac{g_E}{2} \Rightarrow \frac{g_E}{g_P} = 2$$

Now, $T \propto \frac{1}{\sqrt{g}}$

$$\therefore T_P = T_E \times \sqrt{\frac{g_E}{g_P}} = T_E\sqrt{2} = 2\sqrt{2}$$

149 **(b)**

$$\Delta U = \frac{mgh}{\left(1 + \frac{h}{R}\right)} = \frac{mg \times 3R}{\left(1 + \frac{3R}{R}\right)} = \frac{3}{4}mgR$$

150 **(a)**

1. According to Kepler's law, $T^2 \propto r^3$

$T^2 = kr^3$

Differentiating it, we have $2T\Delta T = 3kr^2\Delta r$

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

$$\frac{2T\Delta T}{T^2} = \frac{3kr^2\Delta r}{kr^3}$$

$$\Rightarrow \Delta T = \frac{3}{2}T\frac{\Delta r}{r}$$

151 **(a)**

Acceleration due to gravity at h = 5km above

$$g_h = g\left(1 - \frac{2h}{R}\right) = 9.8\left(1 - \frac{2 \times 5}{6400}\right) = 9.78 \text{m/s}^2$$

$$\frac{GM}{(R+h)^2} = \frac{GM}{(R+5)^2} = \frac{GM}{R^2} \times \frac{R^2}{(R+5)^2}$$

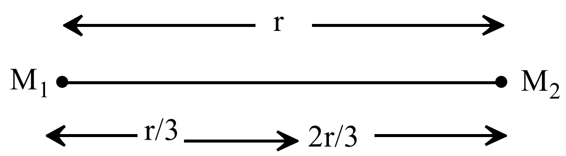
$$= \frac{gR^2}{(R+5)^2} = \frac{9.8 \times (6400)^2}{(6400+5)^2} = 9.78 \text{M/S}^2$$

Acceleration due to gravity at depth = 5 km,

$$g_d = g\left(1 - \frac{d}{R}\right) = 9.8\left(1 - \frac{5}{6400}\right) = 9.79 \text{ m/s}^2$$

153 **(b)**

The given situation can be drawn as



The gravitational potential at P is

$$V_P = -\left(\frac{GM_1}{\frac{r}{3}} + \frac{GM_2}{\frac{2r}{3}}\right)$$

$$= \frac{-3G(2M_1 + M_2)}{2r}$$

The work done to escape the mass M to infinity is

$$W = M(V_\infty - V_P)$$

$$= \frac{3GM(2M_1 + M_2)}{2r}$$

As, work done is equal to kinetic energy of mass M.

$$\Rightarrow \frac{1}{2}Mv_\theta^2 = \frac{3GM(2M_1 + M_2)}{2r}$$

$$v_\theta = \left[\frac{3G}{r}(2M_1 + M_2)\right]^{1/2} \text{ or } v_e$$

$$= \left[\frac{6G}{r}\left(M_1 + \frac{M_2}{2}\right)\right]^{1/2}$$

156 **(d)**

$F = \frac{Gm_1m_2}{r^2}$ and $F' = \frac{Gm_1m_2}{(3r)^2} = \frac{F}{9}$ ∴ % decrease in $F = \left(\frac{F-F'}{F}\right) \times 100 = \frac{8}{9} \times 100 = 88.8\% \simeq 89\%$

Thus, attraction force between sun and earth will decrease by 89%.

157 **(a)**

Angular momentum,

$$L = 2m\frac{\Delta A}{\Delta t} \Rightarrow \frac{\Delta A}{\Delta t} = \frac{L}{2m}$$

158 **(b)**

KE of a satellite $= \frac{GmM_E}{2(R_E+h)}$

Given, $KE = K$

Radius of orbit $= (R_E + h) = r \Rightarrow K = \frac{GmM_E}{2r}$

Since, $K \propto \frac{1}{r} \Rightarrow \frac{K_1}{K_2} = \frac{r_2}{r_1} \Rightarrow \frac{K}{K'} = \left(\frac{2r}{r}\right)$

(since, radius is doubled)

$$\therefore K' = \frac{K}{2}$$

159 **(b)**

If mass m is placed at $\frac{2}{3}$d from M_1, then potential energy of the mass is

$$U = -\frac{GM_1m}{\left(\frac{2}{3}d\right)} - \frac{GM_2m}{\left(\frac{d}{3}\right)} = -\frac{3GM_1m}{2d} - 3GM_2m/d$$

If it is given velocity V so that it escapes to infinity then

$$\frac{1}{2}mv^2 - \frac{3GM_1m}{2d} - \frac{3GM_2m}{d} = 0$$

$$\therefore \frac{1}{2}mV^2 = \frac{3GM_1m}{2d} - \frac{3GM_2m}{d}$$

$$\therefore V^2 = \frac{6GM_1}{2d} + \frac{6GM_2}{d} = \frac{6G}{d}\left(\frac{M_1}{2} + M_2\right)$$

$$V = \left[\frac{6G}{d}\left(\frac{M_1}{2} + M_2\right)\right]$$

162 **(d)**

∵ Total energy of the satellite is $E = -\frac{1}{2}\frac{GM_em}{R_e}$

and kinetic energy, $K = \frac{1}{2}\frac{GM_em}{R_e}$

∴ Total energy = − Kinetic energy

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

163 **(d)**

Since, length if rod is equal to the circumference of semicircle, $\pi R = L \Rightarrow R = \frac{L}{\pi}$

Therefore, the gravitational potential at the centre of circle will be $V = -\frac{GM}{R} = -\frac{\pi GM}{L}$

164 **(c)**

$$B.E. = \frac{GmM}{2r} = \frac{GM}{R^2} \times \frac{mR^2}{2r} = \frac{mgR^2}{2r}$$

165 **(d)**

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\frac{T'}{T} = \sqrt{\frac{g}{g'}}$$

$$g = \frac{GM}{R^2}$$

$$\therefore \frac{g}{g'} = \frac{M}{M'}\frac{R'^2}{R^2} = \frac{1}{2} \times (2)^2 = 2$$

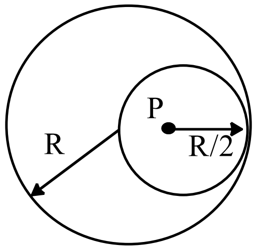
$$\therefore \frac{T'}{T} = \sqrt{2}$$

$$\therefore T' = \sqrt{2}T = 2\sqrt{2}s$$

166 **(b)**

Consider cavity as negative mass and apply superposition of gravitational potential.

Consider the cavity formed in a solid sphere as shown in figure.



According to the question, we can write potential at an internal point P due to complete solid sphere,

$$V_s = -\frac{GM}{2R^3}\left[3R^2 - \left(\frac{R}{2}\right)^2\right]$$

$$= \frac{-GM}{2R^3}\left[3R^2 - \frac{R^2}{4}\right]$$

$$= \frac{-GM}{2R^3}\left[\frac{11R^2}{4}\right] = \frac{-11GM}{8R}$$

Mass of removed part $= \frac{M}{\frac{4}{3}\times \pi R^3} \times \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 = \frac{M}{8}$

Potential at point P due to removed part,

$$V_C = \frac{-3}{2} \times \frac{GM/8}{\frac{R}{2}} = \frac{-3GM}{8R}$$

Thus, potential due to remaining part at point P,

$$V_P = V_s - V_c = \frac{-11GM}{8R} - \left(-\frac{3GM}{8R}\right)$$

$$\frac{(-11+3)GM}{8R} = \frac{-GM}{R}$$

168 **(b)**

$$W = \frac{Gm}{R^2}, W' = \frac{Gm}{\left(R+\frac{R}{2}\right)^3} = \frac{Gm}{\left(\frac{3R}{2}\right)^2} = \frac{4}{9}.\frac{Gm}{R^2} = \frac{4}{9}W$$

169 **(b)**

Even though the distribution of mass is unknown or non-uniform but we can find the potential due to ring on any axial point because from any axial point the entire mass is at the same distance (whatever would be the nature of distribution).

Potential at A due to ring is $V_A = -\frac{GM}{\sqrt{2}R}$

Potential at B due to ring is $V_B = -\frac{GM}{\sqrt{5}R}$

$$dU = U_f - U_i = U_B - U_{A'} = m_0(V_B - V_A)$$

$$= \frac{GMm_0}{R}\left[-\frac{1}{\sqrt{5}} + \frac{1}{\sqrt{2}}\right]$$

$$W_{gr} = -W_{ext} \Rightarrow W_{gr} = -dU = -W_{ext}$$

$$\therefore\ W_{ext} = dU = \frac{GMm_0}{R}\left[\frac{1}{\sqrt{2}} - \frac{1}{\sqrt{5}}\right]$$

170 **(a)**

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

If $g' = \frac{g}{n}$ then $\frac{g}{n} = g\left(1 - \frac{d}{R}\right)$

$$\therefore \frac{1}{n} = 1 - \frac{d}{R}$$

$$\therefore \frac{d}{R} = 1 - \frac{1}{n} = \frac{n-1}{n}$$

$$\therefore d = R\left(\frac{n-1}{n}\right)$$

171 **(a)**

$$g' = g\left(1 - \frac{d}{R}\right) = 10\left(1 - \frac{80}{6400}\right)$$

$$= 10\left(1 - \frac{1}{80}\right) = \frac{10 \times 79}{80}$$

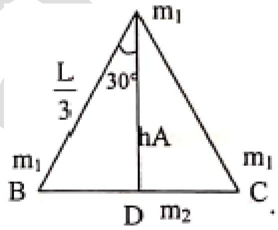
$$= 9.87\ m/s^2 \approx 990 cm/s^2$$

173 **(b)**

Forces on mass m_2 due to masses at B and C will be equal and opposite and cancel each other.

$$h = \frac{L}{3}\cos 30^0$$

$$= \frac{L}{3}\frac{\sqrt{3}}{2} = \frac{L}{2\sqrt{3}}$$



Force on m_2 due to mass m_1 at A is given by

$$F = G\frac{m_1 m_2}{\left(\frac{L}{2}\right)^2} = \frac{12Gm_1m_2}{L^2}$$

174 **(d)**

Angular momentum $L = mVR$

Where m is the mass of the earth and V its orbital velocity

$$V = \sqrt{\frac{GM}{R}}$$

Where M is mass of the sun

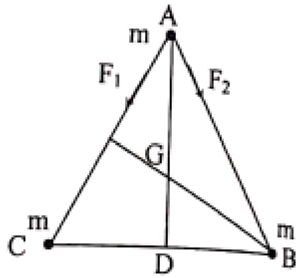
$$\therefore L = m \times \sqrt{\frac{GM}{R}} \times R = m\sqrt{GmR}$$

$$\therefore L \propto \sqrt{R}$$

175 **(c)**

Consider mass m at A.

The forces exerted on it by other two masses are given by



$F_1 = G\dfrac{m^2}{L^2} = F_2$

The angle between the two forces is 60^0. Hence the resultant force

$F = \sqrt{F_1^2 + F_1^2 + 2F_1^2 \cos 60^0} = \sqrt{3}F_1$

$\therefore F = \sqrt{3}.G\dfrac{m^2}{L^2}$

Mass m rotates around the centre G. The radius of the circular motion is AG.

$AG = \dfrac{2}{3}AD$

$AD = AC\sin 60^0 = L\sin 60^0 = \dfrac{\sqrt{3}}{2}L$

$\therefore AG = \dfrac{2}{3}.\dfrac{\sqrt{3}}{2}L = \dfrac{L}{\sqrt{3}}$

$\therefore \text{radius } r = \dfrac{L}{\sqrt{3}}$

For uniform circular motion, the gravitational force provides the centripetal force.

$\therefore mr\omega^2 = F$

$\therefore m\dfrac{L}{\sqrt{3}}.\omega^2 = \sqrt{3}G\dfrac{m^2}{L^2}$

$\therefore \omega^2 = 3G\dfrac{m}{L^3}$

$\therefore \omega = \left(3G\dfrac{m}{L^3}\right)^{\frac{1}{2}}$

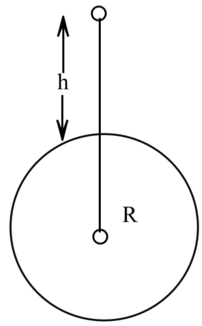
$\therefore \dfrac{2\pi}{T} = \left(\dfrac{3Gm}{L^3}\right)^{\frac{1}{2}}$

$\therefore T = 2\pi\left(\dfrac{L^3}{3Gm}\right)^{\frac{1}{2}}$

$T \propto L^{3/2}$

176 **(a)**

If h be the maximum height attained by the rocket then change in potential energy = kinetic energy of rocket



$U_2 - U_1 = \dfrac{1}{2}mv^2$

$\Rightarrow \left(-\dfrac{GMm}{R+h}\right) - \left(-\dfrac{GMm}{R}\right) = \dfrac{1}{2}mv^2$

$\Rightarrow GMm\left[\dfrac{1}{R} - \dfrac{1}{R+H}\right] = \dfrac{1}{2}mv^2$

$\Rightarrow GM\left(\dfrac{h}{R(R+h)}\right) = \dfrac{1}{2}v^2$

$\Rightarrow gR^2\left[\frac{h}{R(R+h)}\right] = \frac{1}{2}v^2 \quad (\because GM = gR^2)$

$\Rightarrow \dfrac{2gRh}{R+h} = v^2$

$\Rightarrow \dfrac{2gR}{\frac{R}{h}+1} = v^2 \Rightarrow \dfrac{v^2R}{h} = 2gR - v^2$

$\Rightarrow h = \dfrac{v^2R}{2gR - v^2}$

$\Rightarrow h = \dfrac{v^2R}{\frac{2gR}{v^2} - 1}$

177 **(b)**

$v = \sqrt{\dfrac{2GM}{R}}$

$\therefore v_e = R\sqrt{\dfrac{8}{3}\pi G\rho} \quad \ldots.(\because M = \dfrac{4}{3}\pi R^3\rho)$

Now, $v_e \propto R$ and $v_p \propto 2R$

$\therefore \dfrac{v_p}{v_e} = 2$ or $v_e = \dfrac{v_p}{2}$

178 **(d)**

$g' = g - \omega^2 R\cos^2\lambda, \lambda = 60°$

$\therefore 0 = 1 - \omega^2 \times 6400 \times 10^3 \times \dfrac{1}{4}$

$\therefore \omega^2 = \dfrac{10^{-4}}{16}$

$\Rightarrow \omega = \dfrac{10^{-2}}{4}$

$\therefore \omega = 2.5 \times 10^{-3}\text{rad/s}$

179 **(c)**

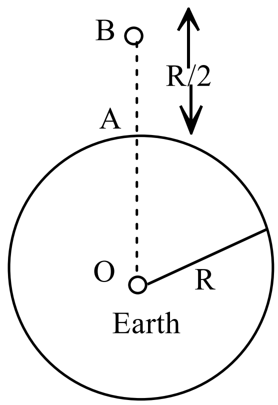
Acceleration due to gravity, $g = \frac{GM}{R^2}$

$$\frac{g_m}{g_e} = \left(\frac{M_m}{M_e}\right) \times \left(\frac{R_e}{R_m}\right)^2$$

$$= \frac{M_m}{M_e} \times \left(\frac{D_e/2}{D_m/2}\right)^2 = \frac{M_m}{m_e} \times \frac{D_e}{D_m}$$

$$= \frac{1}{10} \times \left(\frac{12742}{6760}\right)^2 = 0.35$$

$$g_m = 9.8 \times 0.35 = 3.48\ ms^{-2}$$



180 **(a)**

Earth has the maximum speed in the equatorial region. To take advantage of its, the launch station should be in the equatorial region.

182 **(b)**

$$K.E. = \frac{1}{2}\frac{GMm}{r}$$

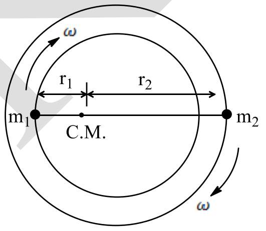
$$\therefore \frac{K_1}{K_2} = \frac{r_2}{r_1} = \frac{3R + R}{3R + R} = \frac{4}{3}$$

184 **(c)**

$$T = 2\pi\sqrt{\frac{(R + h)^3}{GM}}$$

185 **(a)**

Both the stars rotate with same angular velocity ω around the centre of mass (CM) in their respective orbits as shown in figure. The magnitude of gravitational force m_1 exerts on m_2 is $|F| = \frac{Gm_1m_2}{(r_1+r_2)^2}$



187 **(c)**

Weight of the body at equator

$= \frac{3}{5}$ of initial weight

$\therefore g' = \frac{3}{5}g$ (because mass remains constant)

$$g' = g - \omega^2 R\cos^2\phi$$

$$\frac{3}{5}g = g - \omega^2 R\cos^2(0°)$$

$$\therefore \omega^2 = \frac{2g}{5R}$$

$$\therefore \omega = \sqrt{\frac{2g}{5R}} = \sqrt{\frac{2 \times 10}{5 \times 6400 \times 10^3}}$$

$$= \sqrt{62.5 \times 10^{-8}} = 7.9 \times 10^{-4}\ rad/s$$

188 **(d)**

Gravitational potential $V_i = -\frac{GM}{r}$

$$V_i = -\frac{6.67 \times 10^{-11} \times 100}{0.1}$$

$$V_i = -\frac{6.67 \times 10^{-9}}{0.1} = -6.67 \times 10^{-8}\ J$$

$$V_t = 0$$

∴ Work done per unit mass,

$$W = \Delta V = (V_f - V_i) = 6.67 \times 10^{-8}\ J$$

189 **(a)**

$$g = \frac{GM}{R^2}, g' = \frac{GM'}{R^2} = \frac{G \times 4M}{R^2} = 4g$$

$$W = mg'h = 4mgh = 4 \times 5 \times 10 \times 2 = 400\ J$$

190 **(d)**

New acceleration due to gravity g' is given by

$$g' = g - R_\theta\omega^2 cos^2\lambda$$

$$0 = 10 - 6.4 \times 10^6\omega^2 cos^2 60°$$

$$\Rightarrow \omega^2 = \frac{10}{6.4 \times 10^6 (0.5)^2}$$

$$= 2.5 \times 10^{-3} rads^{-1}$$

191 **(d)**

$$P.E.(U) = -\frac{GMm}{R + h}$$

$$\therefore \text{Increase in P.E.} = U_2 - U_1$$

$$= \frac{-GMm}{R + 10R} + \frac{GMm}{R}$$

$$= \frac{GMm}{R}\left[1 - \frac{1}{11}\right] = \frac{10GMm}{11}$$

195 **(b)**

$$B.E. = \frac{GmM}{R} = mgR = 100 \times 10 \times 6.4 \times 10^6$$

$$= 6.4 \times 10^9 J$$

197 **(b)**

$$R_A = 4R, R_B = R$$

$$v = \sqrt{\frac{GM}{R}}$$

$$\therefore \frac{v_A}{v_B} = \sqrt{\frac{R_B}{R_A}} = \sqrt{\frac{R}{4R}} = \frac{1}{2}$$

$\therefore \frac{v_A}{v_B} = \frac{3v}{v_B} = \frac{1}{2} \Rightarrow v_B = 6v$

198 **(a)**

$g' = g - R\omega^2\cos^2\lambda$

here $\lambda = 0$

$\therefore mg' = m\frac{GM}{R^2} - mR\omega^2$

199 **(a)**

Mass does not depend on gravitation.

200 **(a)**

$r_M = 1.525\ r_E$

$\therefore \frac{r_M}{r_E} = 1.525$

$\therefore \left(\frac{T_M}{T_E}\right)^2 = \left(\frac{r_B}{r_E}\right)^3 = (1.525)^3$

$\therefore T_M^2 = T_E^2 \times (1.525)^3$

$= (1)^2(1.525)^3$

$\therefore T_M = (1.525)^{3/2}$

$= 1.883$ years