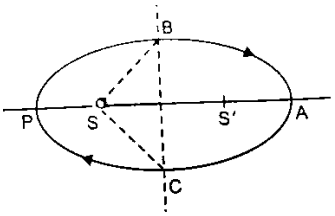
KEPLER'S LAWS

1. What is the direction of areal velocity of the earth around the sun?
2. Draw an areal velocity versus time graph for Mars.
3. Out of aphelion and perihelion, where is the speed of the earth more and why?
4. Is the Earth revolving around the Sun at a constant speed? Why?
5. The linear velocity of the planet around the sun is not constant in its orbit. Comment.
6. A geostationary satellite orbits around the earth in a circular orbit of radius 36000 km. Then, what will be the time period of a spy satellite orbiting a few hundred kilometers above the Earth's surface? (R_{earth} = 6400 Km)
7. If Earth be at one-half of its present distance from the Sun, how many days will there be in a year?
8. (a) According to Kepler's second law, the radius vector to a planet from the Sun sweeps out equal areas in equal intervals of time. The law is the consequence of which conservation law?
   (b) State Kepler's third law.
9. The distances of two planets from the sun are 10^{11} m and 10^{10} m respectively. What is the ratio of time periods of these two planets? *(Ans: 10√10)*
10. A geostationary satellite is orbiting the earth at a height of 6 R above the surface of the earth, R being the radius of the earth. What will be the time period of another satellite at a height of 2.5 R from the surface of the earth? *(Ans: 6√2 h)*
11. If the earth is 1/3rd its present distance from the sun. How many days will the present one year on the surface of the earth will change? *(Ans: 70.25 days)*
12. The largest and the shortest distances of the earth from the sun are r_1 and r_2 respectively. What is the distance from the sun when it is perpendicular to the major axis of the orbit from the sun? (Ans: $\frac{2r_1r_2}{r_1+r_2}$)
13. The distance of planet Jupiter from the sun is 5.2 times that of the Earth. Find the period of revolution of Jupiter around the sun. *(Ans: 11.86 years)*
14. Let the speed of the planet at the perihelion P(in the figure) be v_p and the sun-planet distance SP be r_p. Relate r_p, v_p to the corresponding quantities at the aphelion (r_A, v_A). will the planet take equal time to traverse BAC and CPB?



NEWTON'S LAW OF GRAVITATION AND SUPERPOSITION PRINCIPLE

15. Why is Newton's law of gravitation called as universal law of gravitation?
16. What are the main features of gravitational force?
17. Do the forces of friction and other contact forces arise due to gravitational attraction? If not, what is the origin of these forces?
18. The mass of the moon is nearly 1% of the mass of the earth. What will be the gravitational force of the earth on the moon in comparison to the gravitational force of the moon on the earth?
19. If the force of gravity acts on all bodies in proportion to their masses, why does a heavy body not fall faster than a light body?
20. A mass M is broken into two parts of masses m_1 and m_2. How are m_1 and m_2 related so that the gravitational attraction between the two parts is maximum? (Ans: m = M/2)
21. Our earth has value of G = 6.67 x 10^{-11} Nm^2/kg^2. What is its value on the moon, where g is nearly one-sixth than that of the Earth?
22. When a stone of mass m is falling on the Earth of mass M, find the acceleration of the Earth, if any.
23. When a body falls towards the Earth, the Earth moves towards the body. Why is the earth's motion

not noticed?

24. Does the gravitational force of attraction of the earth on a body become zero at some height above the earth's surface? Explain.

25. Is it possible to shield a body from the gravitational effects?

26. Gravitational force is a weak force but still it is considered the most important force. Why?

27. Under what conditions the weight of a person can become zero?

28. We can not move without disturbing all the stars. Comment?

29. Two particles of equal mass move in a circle of radius r under the action of their mutual gravitational attraction. Find the speed of each particle if its mass is m.

30. Two identical copper spheres of radius R are in contact with each other. If the gravitational attraction between them is F, find the relation between F and R.

31. A sphere of mass 40kg is attracted by a second sphere of mass 50kg with a force of 0.02gwt. Calculate the distance between them. *(Ans: 2.6 cm)*

32. The mass of the planet Jupiter is 1.9×10^{27} Kg and that of the sun is 1.99×10^{30} Kg. The mean distance of the Jupiter from the sun is 7.8×10^{11}m. Calculate the gravitational force that the sun exerts on Jupiter. Assuming that Jupiter moves in a circular orbit around the sun. calculate the speed of Jupiter. *(Ans: 4.15×10^{23} N)*

33. How far from the Earth must a body be, along a line joining the sun to the earth so that the resultant gravitational pull on the body due to the earth and the sun is 0? The distance between the sun and the earth is 1.5×10^{8} km. The mass of the sun = 3.25×10^{5} times the mass of the earth. *(Ans: 2.63×10^{5} km)*

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

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

(ii) What is the force if the mass at the vertex A is doubled? Take AG = BG = CG =1m. (Ans: 0, 2G m^2 along GA)

ACCELERATION DUE TO GRAVITY AND ITS VARIATION

35. Why the value of acceleration due to gravity is more at the poles than at the equator?

36. Why does a tennis ball bounce higher on a hill than on plains?

37. What are the two factors that determine: Why some bodies in the solar system have an atmosphere and others do not?

38. The value of g on the moon is $1/6^{th}$ of that of the earth. if a body is taken from the Earth to the moon then what will be the change in its (i) weight, (ii) inertial mass, and (iii) gravitational mass?

39. Moon travellers tie heavyweight at the back before landing on the moon. Why?

40. The mass of a body cannot be changed without changing weight but weight can be changed without changing mass. Explain

41. Where will the true weight of the body be zero?

42. Assuming that the earth is a sphere of radius R. At what altitude will the value of acceleration due to gravity be half its value at the surface of the earth? (Ans: (√2-1)R.

43. If the earth stops rotating about its polar axis, what will be the effect on the value of acceleration due to gravity 'g'? Will this effect be the same in all places?

44. What would happen if gravity suddenly disappear?

45. What will be the effect on the time period of a simple pendulum on taking it to a mountain?

46. When a clock controlled by a pendulum is taken from plains to a mountain, it becomes slow but a wristwatch controlled by a spring remains unaffected. Why?

47. Where will a body weigh more; 2 km above the surface of the earth or 2 km below the surface of the earth?

48. The mass and the diameter of a planet are twice those of Earth. What will be the time period of that

pendulum on this planet, which is the second pendulum on the Earth? (Ans: 2√2 second on the planet)

49. Draw graphs showing the variation of acceleration due to gravity with
(i) Height above the earth's surface,
(ii) Depth below the earth's surface.

50. What is the value of g on the surface of a planet whose mass as well as radius is half of the value of Earth? What is electrostatic shielding?

51. A body is taken from the centre of the earth to Moon. What will be the change in weight of the body?

52. A body weighs 54 kgf on the surface of the Earth. How much will it weigh on the surface of Mars whose mass is 1/9 and the radius is ½ of that of Earth? *(Ans: 24 kgf)*

53. If the radius of the Earth were increased by a factor 5, by what factor would its density have to be changed to keep the value of acceleration due to gravity the same? *(Ans: The density of Earth would change by a factor 1/5)*

54. A planet whose size is the same and mass 4 times that of the Earth, find the amount of energy needed to lift a 2 kg mass vertically upwards through 2m distance on the planet. The value of g on the surface of the Earth is $10 m/s^2$.*(Ans: 160 J)*

55. If the radius of the earth shrinks by 2%, and mass remains the same, then how would the value of acceleration due to gravity change? *(Ans: 4%)*

56. If radius of Earth is 6400 km, what will be the weight of 1 quintal body if taken to the height of 1600 km above sea level?

57. If a person goes to a height equal to the radius of the earth from its surface. What would be his weight relative to that on the earth? *(Ans: W' = W/4)*

58. 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, both x and h being much smaller than the radius of the earth, find the relation between x and h. *(Ans: x = 2h)*

59. At what height from the surface of the earth will the value of g become 40% of the value at the surface of the earth? Take the radius of the earth = 6.4×10^6m *(Ans: 3.72×10^6 m).*

60. At what height from the surface of the earth will the value of g be reduced by 36% from the value at the surface? The radius of the earth = 6400 Km *(Ans: 1600 km)*

61. Find the percentage decrease in the weight of the body when taken to a height of 16 km above the surface of the earth. The radius of the earth is 6400 km. *(Ans: 0.5%)*

62. An object weighs 10 N at the north pole of Earth. In a geostationary satellite distance 7R from the centre of Earth (of radius R), What will be its (i) true weight (ii) apparent weight? *(Ans: (i)0.2 N (ii) 0)*

63. How much below the surface of Earth does the acceleration due to gravity become 70 % of its value on the surface of Earth? Radius of earth = 6.4×10^6m *(Ans: 1.92×10^6m)*

64. At what depth from the surface of the earth, the value of acceleration due to gravity is reduced by 40% of its value on the surface of the earth. The radius of the earth = 6.4×10^6m. *(Ans: 2.56×10^6 m)*

65. Find the percentage decrease in the weight of the body when taken 64 km below the surface of the earth. Take the radius of the earth = 6400 km *(Ans: 1%)*

GRAVITATIONAL INTENSITY, GRAVITATIONAL POTENTIAL AND GRAVITATIONAL ENERGY

66. Under what condition the gravitational potential energy of a body will be 0?

67. Why is gravitational potential energy negative?

68. What is the maximum value of gravitational potential energy and where?

69. What is the relation between gravitational intensity and gravitational potential at a point?

70. Where is the gravitational field 0 and where is the gravitational potential zero, in the case of earth?

71. The gravitational potential energy of a body at a distance r from the centre of the earth is U. What is

the weight of the body at that point?

72. What is the work done in bringing the body of mass m from Infinity to the surface of the earth of radius R and mass M?

73. What are the S.I. units of gravitational intensity and gravitational potential?

74. What is the value of gravitational intensity at the surface of the earth and at the earth's centre?

75. If a point mass m is at a distance x from the centre of a spherical shell of mass M and radius R(>x), What is the force between them? *(Ans: 0)*

76. What is the binding energy of a satellite? *(Ans: GMm/2R)*

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

78. On a planet whose size is the same and mass 4 times that of the earth, find the energy needed to lift a 2 kg mass vertically upwards through a 2m distance in Joule. The value of g on the surface of the earth is 10m/s^2 *(Ans: 160 J)*

79. What is the change in gravitational potential energy when a body of mass m is raised to a height nR above the surface of the earth of radius R? *(Ans :* $\left(\frac{n}{n+1}\right) mgR$*)*

80. A particle is projected upwards from the surface of the earth of radius R with a kinetic energy equal to half the minimum value needed for it to escape. to what height does it rise above the surface of the earth? *(Ans : h = R)*

81. The gravitational potential energy of a body at a distance 3R from the centre of the earth is U where R is the radius of the earth. what is the weight of the body at that point? *(Ans: U/3R)*

82. Two bodies of masses m_1 and m_2 are initially at rest at an infinite distance apart. They are then allowed to move toward each other under a mutual gravitational attraction. Find the relative velocity of the approach at a separation distance r between them. *(Ans:* $\sqrt{\frac{2G(m_1+m_2)}{r}}$*)*

83. Three equal particles each of mass m are placed at the three corners of an equilateral triangle of side r. Find the force exerted by this system on another particle of mass m placed at (i) the midpoint of the side (ii) at the centre of the triangle. *(Ans:* $\frac{4Gm^2}{3r^2}$ $along\ DA$*, 0)*

84. What is the potential energy of a body of mass m relative to the surface of the earth of radius R, at a
(i) height h = R above its surface
(ii) depth, d =R below its surface. *(Ans: mgR/2, -mgR/2)*

85. In a certain region of space gravitational field is given by I = -(k/R). Taking the reference point to be at r = r_o, with gravitational potential V = V_o, find the gravitational potential at a distance r. (Ans: $V = V_0 + k\ ln\frac{r}{r_0}$)

86. A spherical cavity is made inside a sphere of density, d. If its centre lies at a distance l, from the center of the sphere, show that the gravitational strength, I of the field inside the cavity is
= (4/3) πGld.

87. The radius and mass of the earth are R and M. The acceleration due to gravity at its surface is g. Calculate the work required in raising a body of mass m to a height h from the surface of the earth. (Ans: $\frac{mgh}{1+{}^{h}/_{R}}$)

88. Two bodies of masses 100 kg and 10,000 kg are at a distance of 1m apart. At which point on the line joining them will the resultant gravitational field intensity is zero? What is the gravitational potential at that point? G = 6.67 x 10^{-11} Nm^2/kg^2(Ans: 1/11 m, -8 x 10^{-7} J/kg)

89. Two masses 800 kg and 600 kg are at a distance 25 cm apart. Compute the magnitude of the intensity of the gravitational field at a point distance 20 cm from the 800 kg mass and 15 cm from the 600 Kg mass. G = 6.67 x 10^{-11} Nm^2/kg^2 *(Ans: 2.22 x 10^{-6} N)*

90. Three particles each of mass m are placed at the vertices of an equilateral triangle of side, a. What

are the gravitational field and gravitational potential at the centroid of the triangle? (Ans: $-\frac{3\sqrt{3}Gm}{a}$)

91. A point mass body of mass 2 Kg is placed at a distance 20 cm from one end of a uniform rod of length 2m and mass 10 Kg. Calculate
(i) Gravitational intensity at the location of the point mass body due to the rod.
(ii) Gravitational force on the body due to the rod. Use G = 6.67 X 10^{-11} Nm^2/kg^2. *(Ans: 1.5 x 10^{-9} N/Kg, 3 x 10^{-9} N)*

92. Find the potential energy of a system of four particles each of mass, m placed at the vertices of a square of side, l. Also, obtain the potential at the center of the square. (Ans: $\frac{-5{\cdot}414Gm^2}{l}$ $-4\sqrt{2}\frac{Gm}{l}$)

93. A body is released at a distance r (r > R) from the centre of the Earth. What is the velocity of the body when it strikes the surface of the Earth? *(Ans:* $R\left[2g\left(\frac{1}{R}-\frac{1}{r}\right)\right]^{1/2}$*)*

94. What is the minimum energy required to launch a satellite of mass m kg from the Earth's surface of radius R in a circular orbit at an altitude of 2R? (Ans: 5/6 mgR)

95. Find the work done to bring 4 particles each of mass 200 g from a large distances to the vertices of a square of side 20 cm. G = 6.67 x 10^{-11} Nm^2/kg^2 *(Ans: - 7.223 x 10^{-11} J)*

SATELLITE, ESCAPE SPEED AND ORBITAL SPEED

96. The centripetal force on a satellite revolving around the earth is F. What is the gravitational force due to the earth on it? Net force? *(Ans: F, F)*

97. What is the source of motion for a satellite revolving around the Earth?

98. From where does a satellite revolving around a planet get the required centripetal force?

99. The Earth is acted upon by the gravitational force of attraction due to the sun. Then why does the earth not fall towards the sun?

100. An artificial satellite revolves in its orbit around the earth without using any fuel but an aeroplane requires fuel to fly at a certain height. Why?

101. An artificial satellite is revolving around the Earth at a height of 400 km from the Earth's surface. If a packet is released from the satellite what will happen to it? Will it reach the earth?

102. A satellite revolving around the earth loses height, how will its time period be changed?

103. Two artificial satellites one close to the surface and the other away are revolving around the Earth. Which has a larger speed?

104. What is the time period of the revolution of the polar satellite of Earth and the geostationary satellite of the Earth?

105. If a satellite is revolving around a planet of density ρ, show that the entity ρT^2 is a universal constant.

106. Two satellites A and B are orbiting around the Earth in circular orbits of the same radius. The mass of A is 16 times that of B. What is the ratio of the period of revolution of B to that of A? *(Ans: 1:1)*

107. For a satellite, the escape speed is 11 Km/s. If the satellite is launched at an angle of 60° with the vertical, what will be the escape speed?

108. Lighter gases like H_2, He etc are rare in the atmosphere of the earth. Why?

109. Two satellites A and B go around a planet P in circular orbits having radii 4R and R respectively. If the speed of the satellite A is 3v, Find the speed of the satellite B *(Ans: 6v)*

110. An artificial satellite is moving in a circular orbit around the Earth with a speed equal to half of the escape speed from the Earth of radius R. What is the height of the satellite above the surface of the Earth? *(Ans: R)*

111. Show that an artificial satellite circling around the Earth in an orbit of radius r obeys Kepler's third law.

112. A satellite is revolving around the earth, close to the surface of the earth with a kinetic energy E.

How much kinetic energy should be given to it so that it escapes from the surface of the earth? *(Ans: E)*

113. A particle is projected vertically upwards from the surface of Earth of radius R with a kinetic energy equal to half of the minimum value needed for it to escape. Find the height to which it rises above the surface of the Earth.

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

115. Calculate the escape speed for an atmospheric particle 1600 km above the Earth's surface, given that the radius of the Earth is 6400 km and acceleration due to gravity on the surface of the Earth is $9.8 m/s^2$. *(Ans: $10.02 \times 10^3 m/s$)*

116. A satellite is to be placed in equatorial geostationary orbit around Earth for communication:

(i) Calculate the height of such a satellite.

(ii) Find out the minimum number of satellites that are needed to cover the entire Earth so that at least one of the satellites is visible from any point on the equator. [$M = 6 \times 10^{24}$ kg, R = 6400 km, T = 24h, $G = 6.67 \times 10^{-11}$ SI units]

117. Show that the square of the escape speed is equal to the product of the diameter of the Earth and the acceleration due to gravity.

118. A black hole is a body from whose surface nothing may even escape. What is the condition for a uniform spherical body of mass M to be a black hole? What should be the radius of such a black hole if its mass is nine times the mass of the Earth? Mass of the earth = 6×10^{24} Kg, $G = 6.67 \times 10^{-11}$ Nm^2/kg^2. *(Ans: 8 cm)*