CBSE

GRAVITATION WS 2

Class 11 - Physics

Section A

1. A point mass m is placed inside a spherical shell of radius R and mass M at a distance $\frac{R}{2}$ from the centre of the shell. The gravitational force exerted by the shell on the point mass is: **[1]**

   a) $4\frac{GMm}{R^2}$ b) $\frac{GMm}{R^2}$

   c) Zero d) $-\frac{GMm}{R^2}$

2. The acceleration due to gravity at the North Pole of Neptune is approximately 10.7 m/s^2. Neptune has a mass 1.0 $\times$ 10^{26} kg and radius 2.5 $\times$ 10^4 km and rotates once around its axis in about 16 h. What is the gravitational force on a 5.0-kg object at the north pole of Neptune? **[1]**

   a) 53.5 N b) 55.8 N

   c) 54.5 N d) 56 N

3. As observed from earth, the sun appears to move in an approximate circular orbit. For the motion of another planet like mercury as observed from earth, this would **[1]**

   a) not be true because the major gravitational force on mercury is due to sun

   b) not be true because mercury is influenced by forces other than gravitational forces

   c) be similarly true

   d) not be true because the force between earth and mercury is not inverse square law

4. If the position of the spheres approximates two uniformly dense rings, which of the following is the concerning a mass placed at position D? **[1]**

   i. The net gravitational force due to the spheres of the larger ring would be zero.
   ii. The net gravitational force due to the spheres of the smaller ring would be zero.
   iii. The net gravitational force due to the spheres of the both rings would be zero.
   iv. If the smaller ring were removed, the mass would move towards the centre of the larger ring.

   a) Option iv b) Option iii

   c) Option ii d) Option i

5. A uniform, solid, 1000.0-kg sphere has a radius of 5.00 m. Find the gravitational force this sphere exerts on a 2.00-kg point mass placed at a distance of 5.01 m from the center of the sphere? **[1]**

   a) 5.31×10^{-9} N b) 5.41×10^{-9} N

   c) 5.63×10^{-9} N d) 5.52×10^{-9} N

6. Different points in the earth are at slightly different distances from the sun and hence experience different forces due to gravitation. For a rigid body, we know that if various forces act at various points in it, the resultant motion **[1]**

is as if a net force acts on the c.m. (centre of mass) causing translation and net torque at the c.m. causing rotation around an axis through the c.m. For the earth-sun system (approximating the earth as a uniform density sphere)

a) the torque is zero

b) the torque causes the earth to spin

c) the rigid body result is not applicable since the earth is not even approximately a rigid body

d) the torque causes the earth to move around the sun

7. Find the period of oscillation of a simple pendulum of length L suspended from the roof of a vehicle which moves without friction down an inclined plane of inclination α. **[1]**
8. Explain why tidal waves (high tide and low tide) are formed on seas. **[1]**
9. If you compare the gravitational force on the earth due to the sun to that due to the moon, you would find that the sun's pull is greater than the moon's pull. However, the tidal effect of the moon's pull is greater than the tidal effect of the sun. Why? **[1]**
10. Is it possible to shield a body from gravitational effects? **[1]**
11. What is the basis of Newton's law of gravitation? **[1]**
12. If the force of gravity acts on all bodies in proportion to their masses, then why doesn't a heavy body fall faster than a light body? **[1]**
13. A thief with a box in his hand jumps from the top of a building. What will be the load experienced by him during the state of free fall? **[1]**
14. Find the intensity of gravitational field when a force of 100 N acts on a body of mass 10 kg in the gravitational field. **[1]**
15. Calculate the force of attraction between two balls each of mass 1 kg each, when their centres are 10 cm apart. Given $G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$. **[1]**
16. Distance between two bodies is increased to three times its original value. What is the effect on the gravitational force between them? **[1]**
17. What is the ratio of the force of attraction between two bodies kept in air and the same distance apart in the water? **[1]**
18. The distance between two bodies A and B is r. Taking the gravitational force according to the law of inverse square of r, the acceleration of the body is a. If the gravitational force follows an inverse fourth power law, then what would be the acceleration of the body A? **[1]**
19. How is the gravitational force between two point masses affected when they are dipped in water keeping the separation between them the same? **[1]**
20. If suddenly the gravitational force of attraction between earth and satellite become zero, what would happen to the satellite? **[1]**
21. The gravitational force between two blocks is F. What would happen if a mass of both the blocks as well as distance between them is doubled? **[1]**
22. If spheres of same material and same radius r are touching each other, then show that the gravitational force between them is directly proportional to r^4. **[1]**
23. Name the scientist who first determined the value of G experimentally. **[1]**
24. What is the source of centripetal force that a planet requires to revolve around the Sun? On what factors does that force depend? **[1]**
25. We cannot move a finger without disturbing all-stars. Why? **[1]**
26. Does the force of attraction between two bodies depend upon the presence of other bodies and properties of the **[1]**

intervening medium?

Section B

27. A spaceship is launched into a circular orbit close the Earth's surface. What additional velocity has now to be imparted to the spaceship in the orbit to overcome the gravitational pull of Earth. Take radius of Earth as 6400 km and g = 9.8 m s^{-2} **[2]**

28. A mass **M** is broken into two parts of masses m_1 and m_2. How are m_2 and m related so that force of gravitational attraction between the two parts is maximum. **[2]**

29. The mass of planet Jupiter is 1.9×10^{27} kg and that of the sun is 1.99×10^{30}kg. The mean distance of Jupiter from the Sun is 7.8×10^{11}m. Calculate gravitational force which sun exerts on Jupiter, and the speed of Jupiter. **[2]**

30. Two particles of equal mass go round a circle of radius R under the action of their mutual gravitational attraction. Find the speed of each particle. **[2]**

31. Calculate the force of gravitation between two bodies, each of mass 100 kg and 1 m apart on the surface of the earth. Will the force of attraction be different if the same bodies are taken on the moon, their separation remaining constant? **[2]**

32. A sphere of mass 40 kg is being attracted by another sphere of mass 80 kg with a force equal to $\frac{1}{4}$ of a milligram weight when their centres are 30 cm apart. Calculate the value of G. **[2]**

33. Show that for a two-particle system $\overrightarrow{F_{12}} = \overrightarrow{F_{21}}$. **[2]**

34. 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? **[2]**

35. The distance between the earth and the moon is 3.85×10^8 metre. At what point in between the two will the gravitational field intensity be zero? Mass of the earth = 6.0×10^{24} kg, mass of the moon = 7.26×10^{22} kg. **[2]**

36. A sphere of mass 40 kg is attracted by the second sphere of mass 60 kg with a force equal to 4 mgf. If G is 6×10^{-11} Nm^2/kg^2, then calculate the distance between them. Consider acceleration due to gravity is $10m/s^2$. **[2]**

37. A mass of 1 g is separated from another mass of 1 g by a distance of 1 cm. How many g^{-1}wt of force exists between them? **[2]**

38. A body weighs 63 N on the surface of the earth. What is the gravitational force on it due to the earth at a height equal to half the radius of the earth? **[2]**

39. Write four characteristics of gravitational force. **[2]**

40. The gravitational force between a hollow spherical shell (of radius R and uniform density) and a point mass is F. Show the nature of F versus r graph where r is the distance of the point from the centre of the hollow spherical shell of uniform density. **[2]**

41. The sun attracts all bodies on the earth. At midnight, when the sun is directly below, it pulls on a body in the same direction as the pull of the earth on that body; at noon, when the sun is directly above, it pulls on a body in a direction opposite to the pull of the earth. Then will the weight of the body be greater at mid-night than at noon? **[2]**

42. The gravitational force between two spheres is x when the distance between their centres is y. What will be a new force, if the separation is made 3y? **[2]**

43. The centres of two identical spheres are 1.0 m apart. If the gravitational force between the spheres be 1.0 N, then what is the mass of each sphere? (G = 6.67×10^{-11} Nm^2kg^{-2}). **[2]**

44. A spherical mass of 20 kg lying on the surface of the earth is attracted by another spherical mass of 150 kg with **[2]**

a force equal to the weight of 0.25 mg. The centres of the two masses are 30 cm apart. Calculate the mass of the earth. Radius of the earth = 6×10^6 m.

45. Which of the following observations point to the equivalence of inertial and gravitational mass: **[2]**
    i. Two spheres of different masses dropped from the top of a long evacuated tube reach the bottom of the tube at the same time.
    ii. The time period of a simple pendulum is independent of its mass.
    iii. The gravitational force on a particle inside a hollow isolated sphere is zero.
    iv. For a man in closed cabin that is falling freely under gravity, gravity disappears.
    v. An astronaut inside a spaceship orbiting around the Earth feels weightless.
    vi. Planets orbiting around the sun obey Kepler's Third Law (approximately).
    vii. The gravitational force on a body due to the Earth is equal and opposite to the gravitational force on the Earth due to the body.

46. Find the gravitational attraction between two H-atoms of a hydrogen molecule. Given G = 6.67×10^{-11} Nm^2 kg^{-2}, mass of the atom = 1.67×10^{-27} kg and distance between two H-atoms = 1 $\mathring{A}$. **[2]**

47. State Newton's law of gravitation. Hence define universal gravitational constant. Give the value and dimensions of G. **[2]**

48. A uniform ring of mass m and radius a is placed directly above a uniform sphere of mass M and of equal radius. The centre of the ring is at a distance 33 a from the centre of the sphere. Find the gravitational force exerted by the sphere on the ring. **[2]**

49. Two heavy spheres each of mass 100 kg and radius 0.10 m are placed 1.0 m apart on a horizontal table. What is the gravitational force and potential at the midpoint of the line joining the centres of the spheres? Is an object placed at that point in equilibrium? If so, is the equilibrium stable or unstable? **[2]**

50. Three particles A, B and C, each of mass m, are placed in a line with AB = BC = d. Find the gravitational force on a fourth particle P of same mass, placed at a distance d from the particle B on the perpendicular bisector of the line AC. **[2]**

51. What would happen if the force of gravity were to disappear suddenly? **[2]**

52. What is the difference between inertial mass and gravitational mass of a body? **[2]**

53. How far from earth must a body be along a line towards the sun so that the sun's gravitational pull on it balances that of the earth. Distance between sun and earth's centre is 1.5×10^{10} km. Mass of sun is 3.24×10^5 times mass of earth. **[2]**

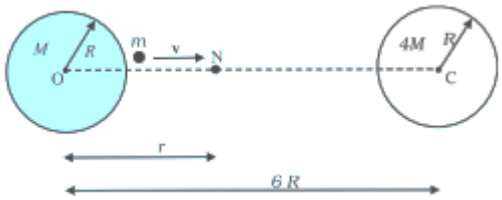
54. i. Among the known types of forces in nature, the gravitational force is the weakest. Why then does it play a dominant role for motion of bodies on the terrestrial, astronomical and cosmological scale? **[2]**
    ii. Do the forces of friction and other contact forces arise due to gravitational attraction? If not, what is the origin of these forces?

Section C

55. Six point masses of mass m each are at the vertices of a regular hexagon of side l. Calculate the force on any of the masses. **[3]**

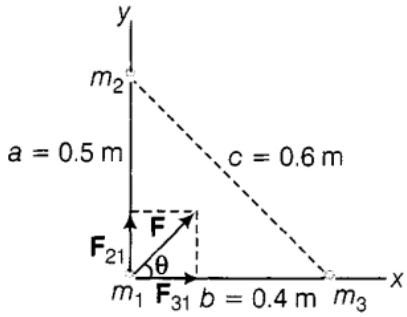
56. Two uniform solid spheres of equal radii R, but mass M and 4M have a centre to centre separation 6R, as shown in Fig. The two spheres are held fixed. A projectile of mass m is projected from the surface of the sphere of mass M directly towards the centre of the second sphere. Obtain an expression for the minimum speed v of the **[3]**

projectile so that it reaches the surface of the second sphere.



57. Two particles of masses 1.0 kg and 2.0 kg are placed at a separation of 50 cm. Assuming that the only forces acting on the particles are their mutual gravitation, find the initial accelerations of the two particles. **[3]**

58. Consider the three billiard balls of masses 400 g are placed on a table at the corners of a right angle as shown in figure. Calculate the gravitational force vector on the ball of the mass ml resulting from the other two balls. Also, find the magnitude and direction of this force. **[3]**



59. How many times faster than its present speed the earth should rotate so that the apparent weight of an object at equator becomes zero? Given radius of the earth = 6.37×10^6 m. What would be the duration of the day in that case? **[3]**

60. State the universal law of gravitation. Establish the relationship $M_e = \frac{gR_e^2}{G}$, where M_e and R_e are the mass and radius of the earth respectively. **[3]**

61. Two uniform solid spheres of radii R and 2R are at rest with their surfaces just touching. Find the force of gravitational attraction between them if density of spheres be P? **[3]**

62. Two stationary particles of masses M_1 and M_2 are a distance d part. A third particle lying on the line joining the particles experiences no resultant gravitational force. What is the distance of this particle from M_1? **[3]**

63. Three equal masses of M kg each are fixed at the vertices of an equilateral triangle ABC. **[3]**

    i. What is the force acting on a mass 2M placed at the centroid of the triangle?

    ii. What is the force if the mass at the centroid is doubled?

    [Take AO = BO = CO = 1 m]

64. Distinguish between inertial and gravitational masses, giving an illustration for each. Show that the two types of masses are equivalent. **[3]**

Section D

Question No. 65 to 69 are based on the given text. Read the text carefully and answer the questions: **[5]**

A black hole is a place in space where gravity pulls so much that even light can not get out. The gravity is so strong because matter has been squeezed into a tiny space.

From Newton's universal law of gravitation, $F = G\frac{Mm}{r^2}$

The photons have no mass. From Einstein's mass energy equivalence relation $E = mc^2$

According to quantum theory of radiation,

$E = hv$

$\therefore m = \frac{h}{c\lambda}$

Putting in the expression of Newton's law of gravitation,

Force acting on the light particles = $G\frac{Mh}{v\lambda R^2}$

Because no light can get out, people can't see black holes. They are invisible. Space telescopes with special tools can help find black holes.

A beam of light just grazing the edge of the sun also bend a little. This may be observed during total solar eclipse. The position of a star will appears closer to the sun.

Black holes can be big or small. Scientists think the smallest black holes are as small as just one atom.

These black holes are very tiny but have the extremely high density. Another kind of black hole is called stellar. Its mass can be up to 20 times more than the mass of the sun. There may be many, many stellar-mass black holes in milky Way. The largest black holes are called super massive. These black holes have masses those are more than 1 million suns together. Scientists have found proof that every large galaxy contains a super massive black hole at its centre. The super massive black hole at the centre of the Milky Way galaxy is called Sagittarius A. It has a mass equal to about 4 million suns and would fit inside a very large ball that could hold a few million Earths. A black hole cannot be seen because strong gravity pulls all of the light into the middle of the black hole. But scientists can see how the strong gravity affects the stars and gas around the black hole. If a black hole of the same mass as the sun replaces the sun, Earth and the other planets will orbit the black hole as they orbit the sun now.

65. The gravity of black hole is so strong because:

a) Its density is too low
b) All of these
c) Its volume is too small
d) Its density is too high

66. The super massive black hole at the center of the Milky Way galaxy is:

a) Cygnus X-3
b) Sagittarius A
c) Sagittarius B2
d) Cygnus X-15

67. What will happen to the earth and other planets if a black hole of same mass as the sun replaces the sun?

a) The orbits of earth and other planets will be much shorter.
b) Earth and other planets will fall into the black hole.
c) Earth and other planet will stop orbiting.
d) Earth and other planets will orbit the black hole as they orbit the Sun now.

68. The attractive force acting on a light particle by a black hole is:

a) $G\frac{M\lambda}{dR^2}$
b) $G\frac{Md_1}{hR^2}$
c) $G\frac{Mh}{c\lambda R^2}$
d) $G\frac{Mc}{h\lambda R^2}$

69. A beam of light just grazing the edge of the sun also bend a little. It is observable during:

a) Total solar eclipse
b) Partial lunar eclipse
c) Full lunar eclipse
d) Partial solar eclipse

70. Two stars each of 1 solar mass (=2×10^{30} kg) are approaching each other for a head-on collision. When they are at a distance of 10^9 km, their speeds are negligible. What is the speed with which they will collide? The radius of each star is 10^4 km. Assume the stars to remain undistored until they collide (use the known value of G). **[5]**

71. Two heavy spheres each of mass 100 kg and radius 0.10 m are placed 1.0 m apart on a horizontal table. What is **[5]**

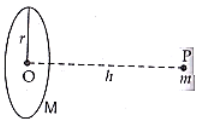
the gravitational force on a sphere of mass m placed at midpoint of the line joining spheres? What is the potential at the mid-point of the line joining the centers of the spheres? Is an object placed at that point in equilibrium? If so, is the equilibrium stable or unstable?

72. Io, one of the satellites of Jupiter, has an orbital period of 1.769 days and the radius of the orbit is $4.22 \times 10^8 \mathrm{m}$. Show that the mass of Jupiter is about one-thousandth that of the sun. **[5]**

73. Two lead spheres of 20 cm and 2 cm diameter respectively are placed with centres 100 cm apart. Calculate the attraction between them, given the radius of the earth as 6.37×10^8 cm and its mean density as 5.53×10^{-3} kg m^{-3}. Specific gravity of lead = 11.5. If the lead spheres are replaced by brass spheres of same radii, would the force of attraction be same? **[5]**

74. A rocket is fired from the earth towards the sun. At what distance from the earth's centre is the gravitational force on the rocket zero? Mass of the sun = 2×10^{30} kg, mass of the earth = 6×10^{24} kg. Neglect the effect of other planets etc. (orbital radius = 1.5×10^{11} m). **[5]**

75. A mass m is placed at P, a distance h along the normal through the centre O of a thin circular ring of mass M and radius r (Figure). **[5]**



If the mass m is removed further away such that OP becomes 2h, by what factor the force of gravitation will decrease, if h = r?