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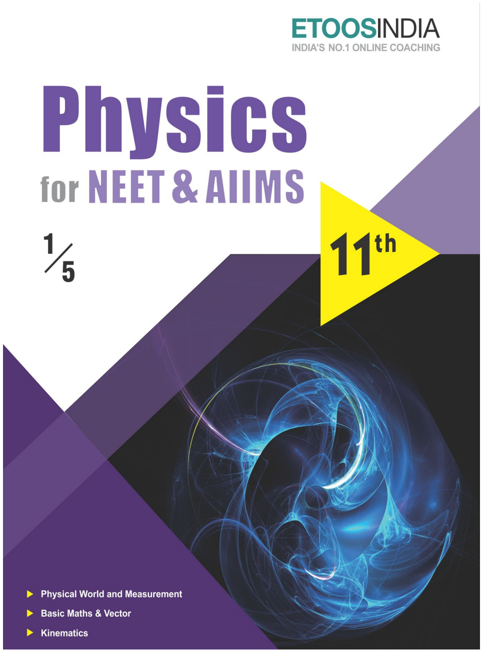
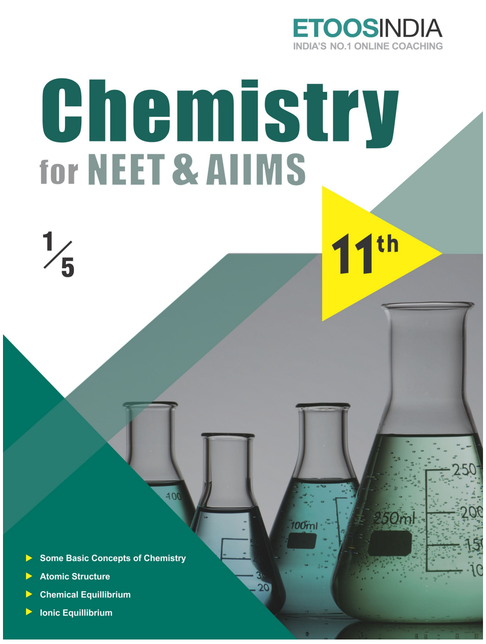
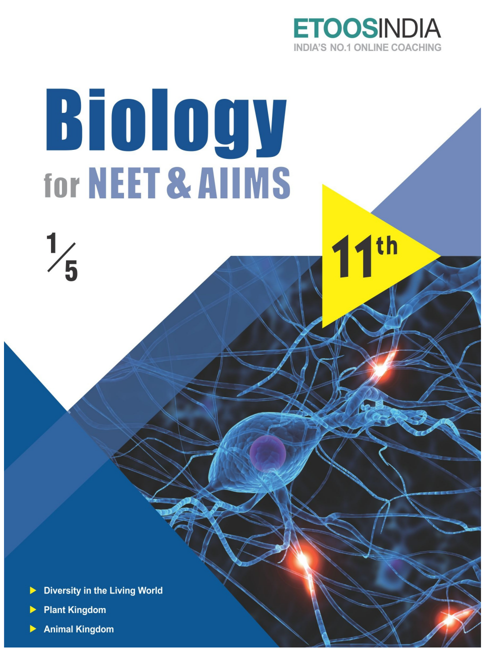
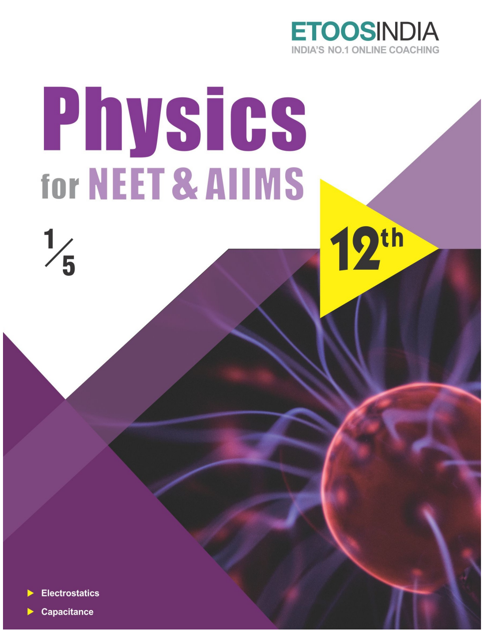
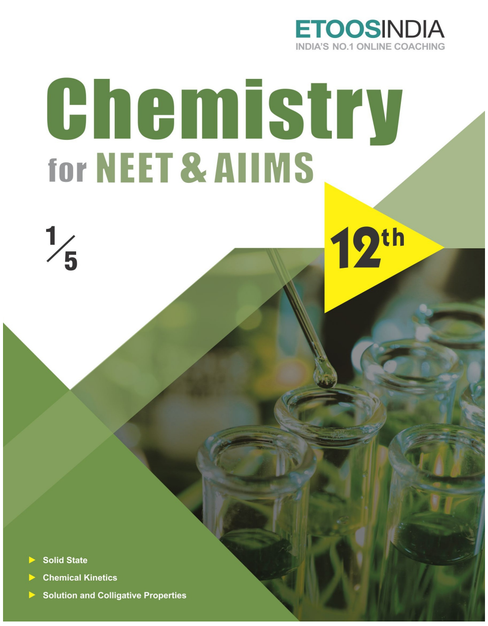
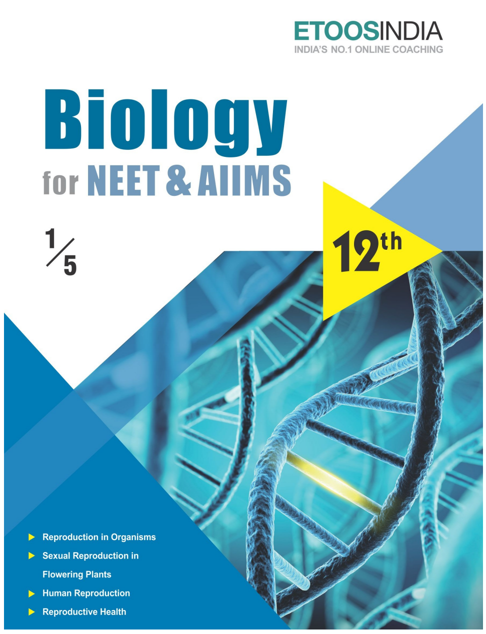












ETOOS Comprehensive Study Material For NEET & AIIMS

CHAPTER 07

GRAVITATION

Gravity may put the planets into motion, but without the divine Power, it could never put them into such a circulating motion as they have about the Sun; and therefore, for this as well as other reasons, I am compelled to ascribe the frame of this System to an intelligent Agent.

" ISAAC NEWTON"

INTRODUCTION

From at least the time of the ancient Greeks, two problems were puzzling : (1) the falling of objects released near the Earth's surface, and (2) the motions of the planets. Although there was no reason at that time to connect these two problems, today we recognize that they result from the effect of the same force-gravitation. In fact, this force also determines the motion of the Sun in our Milky Way galaxy, as well as the motion of the galaxy in our Local Cluster of galaxies, the motion of the Local Cluster in the Local Supercluster, and so on through the universe. In short, the gravitational force, and the law that describes that force, controls the structure, the development, and the eventual fate of the universe.

Famous Indian astronomer and mathematician, Aryabhat, studied motion of earth in great detail, most likely in the 5th century A.D., and wrote his conclusions in his book Aryabhat. He established that the earth revolves about its own axis and moves in a circular orbit about the sun, and that the moon moves in a circular orbit about the earth. But these ideas could not be communicated to the world.

We have discussed various forces : pushes and pulls, elastic force, friction and other forces that act when one body is in contact with another. In this chapter we study the properties of one particularly important non contact force, gravitation, which is one of the fundamental and universal forces of nature.

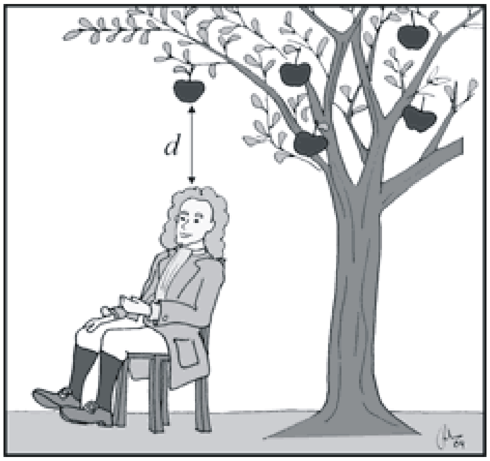
Isaac Newton Observation

The year 1665 was very fruitful for Isaac Newton aged 23. He was forced to take rest in his home in Lincolnshire after his college at Cambridge was closed for an indefinite period due to plague. In this year, he performed brilliant theoretical and experimental takes mainly in the field of mechanics and optics. In this same year he focussed his attention of the motion of the moon about the earth.

The moon makes a revolution about the earth in T = 27.3 days. The distance of the moon from the earth T = 27.3 days. The distance of the moon from the earth is R = 3.85 × 10^5 km. The acceleration of the moon is, therefore,

$$a = \omega^2 R = \frac{4\pi^2 \times (3.85\times10^5\,\text{km})}{(27.3\,\text{days})^2} = 0.0027\ \text{ms}^{-2}.$$

The first question before Newton was that what is the force that produces this acceleration. The acceleration is towards the center of the orbit, that is towards the center of the earth. Hence, the force must act towards the centre of the earth. A natural guess was that the earth is attracting the moon. The saying goes that Newton was sitting under an apple tree when an apple fell down from the tree on the earth. This sparked the idea that the earth attracts all bodies towards its centre. The next question was what is the law governing this force.



Newton had to make several daring assumptions which proved to be turning points in science and philosophy. He declared that the law of nature are the same for earthly and celestial bodies. The force operating between the earth and an apple and that operating between the earth and the moon, must be governed by the same laws. This statement may look vary obvious today but in the era before Newton, there was a general belief in the western countries that the earthly bodies are governed by certain rules and the heavenly bodies are governed by different rules. In particular, this heavenly structures was supposed to be so perfect that there could not be any change in the sky. This distinction was so sharp that when Tycho Brahe saw a new star in the sky, he did not believe his eyes as there could be no change in the sky.

So the Newton's declaration was indeed revolutionary.

The acceleration of a body falling near the earth's surface is about 9.8 ms^{-2}.

Thus, $$\frac{a_{apple}}{a_{moon}} = \frac{9.8\ \text{ms}^{-2}}{0.0027\ \text{ms}^{-2}} = 3600$$

Also, $$\frac{\text{distance of the moon from the earth}}{\text{distance of the apple from the earth}} = \frac{d_{moom}}{d_{apple}} = \frac{3.85\times10^5\ \text{km}}{6400\,\text{km}} = 60$$

Thus, $$\frac{a_{apple}}{a_{moon}} = \left(\frac{d_{moon}}{d_{apple}}\right)^2.$$

Newton guessed that the acceleration of a body towards the earth is inversely proportional to the square of the distance of the body from the same of the earth.

Thus, $$a \propto \frac{1}{r^2}$$

Also, the force is mass times acceleration and so it is proportional to the mass of the body.

$$F \propto \frac{m}{r^2}$$

By the third law of motion, the force on a body due to the earth must be equal to the force on the earth due to the body. Therefore, this force should also be proportional to the mass of the earth. Thus, the force between the earth and a body is

$$F \propto \frac{Mm}{r^2} \text{ or } F = \frac{GMm}{r^2}$$

Newton further generalized the law by saying that not only the earth but all material bodies in the universe attract each other.

Here, G called the gravitational constant, has the experimentally determined value

$$G = 6.67 \times 10^{-11} \text{ N.m}^2/\text{kg}^2$$

G is a universal constant with the same value for any pair of particles at any location in the universe.

ETOOS KEY POINTS

(i) Gravitational, the force that acts between bodies due only to their masses, is one of four basic forces of physics. It acts throughout the universe : between bodies on Earth, where it is weak and difficult to measure ; between the Earth and bodies in its vicinity, where it is the controlling feature of our lives ; and among the stars and galaxies, where it controls their evolution and structure.

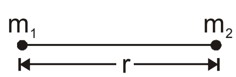
(ii) Normally, however, it is only when the mass of at least one of the interacting bodies is large (planet-sized) that the effects of the gravitational force become significant.

(iii) In this argument, the distance of the apple from the earth is taken to be equal to the radius of the earth. This means we have assumed that earth can be treated as a single particle placed at its centre. This is of course not obvious. Newton had spent several years to prove that indeed this can be done. A spherically symmetric body can be replaced by a point particle of equal mass placed at its centre for the purpose of calculating gravitational force.

UNIVERSAL LAW OF GRAVITATION : NEWTON'S LAW

According to this law "Each particle attracts every other particle. The force of attraction between them is directly proportional to the product of their masses and inversely proportional to square of the distance between them".

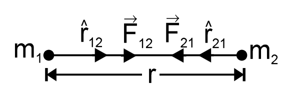
$$F \propto \frac{m_1 m_2}{r^2} \quad \text{or} \quad F = G\frac{m_1 m_2}{r^2}$$



where $G = 6.67 \times 10^{-11}$ Nm^2 kg^{-2} is the universal gravitational constant. This law holds good irrespective of the nature of two objects (size, shape, mass etc.) at all places and all times. That is why it is known as universal law of gravitation.

Newton's Law of gravitation in vector form :

$$\vec{F}_{12} = \frac{Gm_1m_2}{r^2}\hat{r}_{12} \quad \& \quad \vec{F}_{21} = \frac{Gm_1m_2}{r^2}\hat{r}_{21}$$

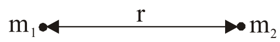


Where $\vec{F}_{12}$ is the force on mass m_1 exerted by mass m_2 and vice-versa.

Now $\hat{r}_{12} = -\hat{r}_{21}$, Thus $\vec{F}_{21} = \frac{-G\, m_1\, m_2}{r^2}\hat{r}_{12}$. Comparing above, we get $\vec{F}_{12} = -\vec{F}_{21}$

Etoos Tips & Formulas

1. Newton`s law of gravitation



Force of attraction between two points masses $F = \frac{Gm_1m_2}{r^2}$

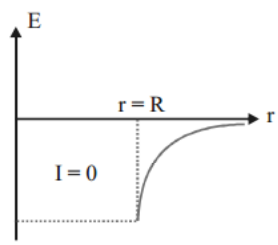
Directed along the line joining of point masses.

- It is a conservation force field $\Rightarrow$ mechanical energy is conserved.
- It is a central force field $\Rightarrow$ angular momentum is conserved.

2. Gravitation field due to spherical shell

- Outside the shell $E_g = \frac{GM}{r^2}$, where r > R
- On the surface $E_g = \frac{GM}{R^2}$, where r = R
- Inside the shell $E_g = 0$, where r < R

[Note : Direction always towards the centre of the sphere]

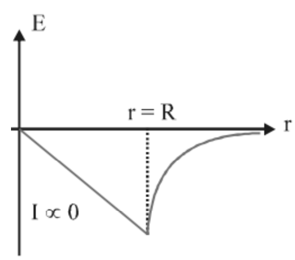


3. Gravitation field due to solid sphere

(a) Outside the sphere $E_g = \frac{GM}{r^2}$, where r > R

(b) On the surface $E_g = \frac{GM}{R^2}$, where r = R

(c) Inside the sphere $E_g = \frac{GMr}{R^3}$, where r < R



4. Acceleration due to gravity

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

At height h $g_h = \frac{GM}{(R+h)^2}$, If h << R ; $g_h \approx g_s \left(1 - \frac{2h}{R}\right)$

At depth d $g_d = \frac{GM(R-d)}{R^3} = g_s = \left(1 - \frac{d}{R}\right)$

Effect of rotation on g : $g' = g - \omega^2 R\cos^2\lambda$ where λ is angle of latitude

5. Gravitational potential

Due to a point mass at a distance $V = -\frac{Gm}{r}$

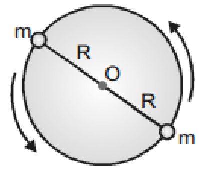
SOLVED EXAMPLE

Ex. 1 Two particles of equal mass m go round a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is

(A) $\frac{1}{2R}\sqrt{\frac{1}{Gm}}$ (B) $\sqrt{\frac{Gm}{2R}}$

(C) $\frac{1}{2}\sqrt{\frac{Gm}{R}}$ (D) $\sqrt{\frac{4Gm}{R}}$

Sol. Centripetal force provided by the gravitational force of attraction between two particles i.e.



$$\frac{mv^2}{R} = \frac{Gm \times m}{(2R)^2}$$

$$\Rightarrow v = \frac{1}{2}\sqrt{\frac{Gm}{R}}$$

Ex. 2 The escape velocity for a planet is v_e. A particle starts from rest at a large distance from the planet, reaches the planet only under gravitational attraction, and passes through a smooth tunnel through its centre. Its speed at the centre of the planet will be-

(A) $\sqrt{1.5}\,v_e$ (B) $\frac{v_e}{\sqrt{2}}$

(C) v_e (D) zero

Sol. From mechanical energy conservation 0 + 0

$$= \frac{1}{2}mv^2 - \frac{3GMm}{2R} \Rightarrow v = \sqrt{\frac{3GM}{R}} = \sqrt{1.5}\ v_e$$

Ex. 3 A particle is projected vertically upwards the surface of the earth (radius R_e) with a speed equal to one fourth of escape velocity. What is the maximum height attained by it from the surface of the earth ?

(A) $\frac{16}{15}R_e$ (B) $\frac{R_e}{15}$

(C) $\frac{4}{15}R_e$ (D) None of these

Sol. From conservation of mechanical energy $\frac{1}{2}mv^2$

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

Where R = maximum distance from centre of the earth Also $v = \frac{1}{4}v_e = \frac{1}{4}\sqrt{\frac{2GM}{R_e}}$

$$\Rightarrow \frac{1}{2}m \times \frac{1}{16} \times \frac{2GM}{R_e} = \frac{GMm}{R_e} - \frac{GMm}{R}$$

$$\Rightarrow R = \frac{16}{15}R_e \Rightarrow h = R - R_e = \frac{R_e}{15}$$

Ex. 4 A mass 6×10^{24} kg (= mass of earth) is to be compressed in a sphere in such a way that the escape velocity from its surface is 3×10^8 m/s (equal to that of light). What should be the radius of the sphere?

(A) 9 mm (B) 8 mm

(C) 7 mm (D) 6 mm

Sol. As, $v_e = \sqrt{\left(\frac{2GM}{R}\right)}$, $R = \left(\frac{2GM}{v_e^2}\right)$,

$$\therefore\ R = \frac{2 \times 6.67 \times 10^{-11} \times 6 \times 10^{24}}{(3 \times 10^8)^2} = 9 \times 10^{-3}\,m = 9\ mm$$

Ex. 5 Calculate the mass of the sun if the mean radius of the earth's orbit is 1.5×10^8 km and $G = 6.67 \times 10^{-11}$ N × m²/kg².

(A) $M \simeq 2 \times 10^{30}$ kg

(B) $M \simeq 3 \times 10^{30}$ kg

(C) $M \simeq 2 \times 10^{15}$ kg

(D) $M \simeq 3 \times 10^{15}$ kg

Sol. In case of orbital motion as $v = \sqrt{\left(\frac{GM}{r}\right)}$

So $T = \frac{2\pi r}{v} = 2\pi r\sqrt{\frac{r}{GM}}$, i.e., $M = \frac{4\pi^2 r^3}{GT^2}$

$$M = \frac{4 \times \pi^2 \times (1.5 \times 10^{11})^3}{6.67 \times 10^{-11} \times (3.15 \times 10^7)^2}$$

[as T = 1 year = 3.15×10^7s] i.e., $M \simeq 2 \times 10^{30}$ kg

Exercise # 1

SINGLE OBJECTIVE | NEET LEVEL

1. The tidal waves in the sea are primary due to
(A) The gravitational effect of the moon on the earth
(B) The gravitational effect of the sun on the earth
(C) The gravitational effect of venus on the earth
(D) The atmospheric effect of the earth itself

2. A point mass m is placed inside a spherical shell of radius R and mass M at a distance R/2 from the centre of the shell. The gravitational force exerted by the shell on the point mass is
(A) $\frac{GMm}{R^2}$ (B) $-\frac{GMm}{R^2}$
(C) 0 (D) $4\frac{GMm}{R^2}$

3. A satellite of the earth is revolving in a circular orbit with a uniform speed v. If the gravitational force suddenly disappears, the satellite will
(A) Continue to move with velocity v along the original orbit
(B) Move with a velocity v, tangentially to the original orbit
(C) Fall down with increasing velocity
(D) Ultimately come to rest somewhere on the original orbit

4. The atmosphere is held to the earth by
(A) Winds (B) Gravity
(C) Clouds (D) None of the above

5. Two identical solid copper spheres of radius R are placed in contact with each other. The gravitational attraction between them is proportional to
(A) R^2 (B) R^{-2}
(C) R^4 (D) R^{-4}

6. If the distance between two masses is doubled, the gravitational attraction between them
(A) Is doubled
(B) Becomes four times
(C) Is reduced to half
(D) Is reduced to a quarter

7. Two sphere of mass m and M are situated in air and the gravitational force between them is F. The space around the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be
(A) F (B) $\frac{F}{3}$
(C) $\frac{F}{9}$ (D) 3 F

8. The gravitational force F_g between two objects does not depend on
(A) Sum of the masses
(B) Product of the masses
(C) Gravitational constant
(D) Distance between the masses

9. Two particles of equal mass go round a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is
(A) $v = \frac{1}{2R}\sqrt{\frac{1}{Gm}}$ (B) $v = \sqrt{\frac{Gm}{2R}}$
(C) $v = \frac{1}{2}\sqrt{\frac{Gm}{R}}$ (D) $v = \sqrt{\frac{4Gm}{R}}$

10. Force between two objects of equal masses is F. If 25& mass of one object is transferred to the other object, then the new force will be
(A) $\frac{F}{4}$ (B) $3\ \frac{F}{4}$
(C) $\frac{15}{16}F$ (D) F

11. A body of mass 500 g thrown upward with a velocity 20 m/s and reaches back to the surface of a planet after 20 sec. Then the weight of the body on that planet is
(A) 2 N (B) 4 N
(C) 5 N (D) 1 N

12. 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) $x = h^2$

Exercise # 2 SINGLE OBJECTIVE AIIMS LEVEL

1. If the gravitational force were to vary inversely as m^{th} power of the distance, then the time period of a planet in circular orbit of radius r around the Sun will be proportional to

(A) $r^{-3m/2}$ (B) $r^{3m/2}$
(C) $r^{m+1/2}$ (D) $r^{(m+1)/2}$

2. Three identical point masses, each of mass 1 kg lie in the x–y plane at points (0, 0) (0, 0.2m) and (0.2m,0). The gravitational force on the mass at the origin is :–

(A) $1.67 \times 10^{-11} (\hat{i}+\hat{j})N$ (B) $3.34 \times 10^{-10} (\hat{i}+\hat{j})N$
(C) $1.67 \times 10^{-9} (\hat{i}+\hat{j})N$ (D) $3.34 \times 10^{-10} (\hat{i}-\hat{j})N$

3. If the distance between the centres of Earth and Moon is D and mass of Earth is 81 times that of Moon. At what distance from the centre of Earth gravitational field will be zero ?

(A) $\frac{D}{2}$ (B) $\frac{2D}{3}$
(C) $\frac{4D}{5}$ (D) $\frac{9D}{10}$

4. Weight of a body of mass m decreases by 1% when it is raised to height h above the Earth's surface. If the body is taken to a depth h in a mine, then its weight will :–

(A) decrease by 0.5% (B) decrease by 2%
(C) increase by 0.5% (D) increase by 1%

5. The radius of Earth is about 6400 km and that of mars is 3200 km. The mass of the Earth is 10 times the mass of mars. An object weight 200 N on the surface of Earth. Its weight on the surface of mars will be :–

(A) 80 N (B) 40 N
(C) 20 N (D) 8 N

6. A stone drop from height 'h' reaches to Earth surface in1 sec. If the same stone taken to Moon and drop freely then it will reaches from the surface of the Moon in the time (The 'g' of Moon is 1/6 times of Earth):–

(A) $\sqrt{6}$ second (B) 9 second
(C) $\sqrt{3}$ second (D) 6 second

7. An object weighs 10 N at the north pole of the Earth. In a geostationary satellite distance 7R from the centre of the Earth (of radius R), the true weight and the apparent weight are–

(A) 0 N, 0 N (B) 0.2 N, 0
(C) 0.2 N, 9.8 N (D) 0.2 N, 0.2 N

8. Imagine a new planet having the same density as that of Earth but it is 3 times bigger than the Earth in size. If the acceleration due to gravity on the surface of Earth is g and that on the surface of the new planet is g', then

(A) g' = 3g (B) $g' = \frac{g}{9}$
(C) g' = 9g (D) g' = 27 g

9. The rotation of the Earth having radius R about its axis speeds upto a value such that a man at latitude angle 60^0 feels weightless. The duration of the day in such case will be

(A) $8\pi\sqrt{\frac{R}{g}}$ (B) $8\pi\sqrt{\frac{g}{R}}$
(C) $\pi\sqrt{\frac{R}{g}}$ (D) $4\pi\sqrt{\frac{g}{R}}$

10. A body attains a height equal to the radius of the Earth when projected from Earth' surface. The velocity of the body with which it was projected is :–

(A) $\sqrt{\frac{GM_e}{R}}$ (B) $\sqrt{\frac{2GM_e}{R}}$
(C) $\sqrt{\frac{5}{4}\frac{GM_e}{R}}$ (D) $\sqrt{\frac{3GM_e}{R}}$

11. A small body of superdense material, whose mass is twice the mass of the Earth but whose size is very small compared to the size of the Earth, starts from rest at a height H < < R above the Earth's surface, and reach the Earth's surface in time t. Then t is equal to

(A) $\sqrt{2H/g}$ (B) $\sqrt{H/g}$
(C) $\sqrt{2H/3g}$ (D) $\sqrt{4H/3g}$

Exercise # 3 — PART - 1 — MATRIX MATCH COLUMN

Following question contains statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as p, q, r and s. Any given statement in **Column-I** can have correct matching with **one or more** statement(s) in **Column-II**.

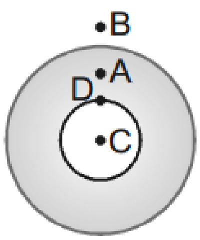
1. In elliptical orbit of a planet, as the planet moves from apogee position to perigee position,

	Column–I		Column–II
(A)	Speed of planet	(P)	Remains same
(B)	Distance of planet from centre of Sun	(Q)	Decreases
(C)	Potential energy	(R)	Increases
(D)	Angular momentum about centre of Sun	(S)	Can not say

2. A satellite is in a circular equatorial orbit of radius 7000 km around the Earth. If it is transferred to a circular orbit of double the radius

	Column I		Column II
(A)	Angular momentum	(P)	Increases
(B)	Area of Earth covered by satellite signal	(Q)	Decreases
(C)	Potential energy	(R)	Becomes double
(D)	Kinetic energy	(S)	Becomes half

3. Two concentric spherical shells are as shown in figure. :



	Column–I		Column–II
(A)	Potential at A	(P)	greater than B
(B)	Gravitational field at A	(Q)	less than B
(C)	As one moves from C to D	(R)	potential remains constant
(D)	As one moves from D to A	(S)	gravitational field decreases
		(T)	None

4.

	Column–I		Column–II
(A)	Kinetic energy of a particle in gravitational field is increasing	(P)	work done by gravitational force should be positive
(B)	Potential energy of a particle in gravitational field is increasing	(Q)	work done by external force should be non zero
(C)	Mechanical energy of a particle in gravitational field is increasing	(R)	work done by gravitational force should be negative
		(S)	can not say anything

Exercise # 4 PART - 1 PREVIOUS YEAR (NEET/AIPMT)

1. Escape velocity from the earth is 11.2 km/s. Another planet of same mass has radius 1/4 times that of the earth. What is the escape velocity from another planet? **[CBSE AIPMT 2000]**

(A) 11.2 km/s (B) 44.8 km/s
(C) 22.4 km/s (D) 5.6 km/s

2. A body attains a height equal to the radius of the earth. The velocity of the body with which it was projected is **[CBSE AIPMT 2001]**

(A) $\sqrt{\frac{GM}{R}}$ (B) $\sqrt{\frac{2GM}{R}}$
(C) $\sqrt{\frac{5}{4}\frac{GM}{R}}$ (D) $\sqrt{\frac{3GM}{R}}$

3. A body of mass m is placed on the earth's surface. It is then taken form the earth's surface to a height h = 3R, then the change in gravitational potential energy is **[CBSE AIPMT 2002]**

(A) $\frac{mgh}{R}$ (B) $\frac{2}{3}mgR$
(C) $\frac{3}{4}mgR$ (D) $\frac{mgR}{2}$

4. The acceleration due to gravity on the planet A is 9 times the acceleration due to gravity on the planet B. A man jumps to a height of 2m on the surface of A. What is the height of jump by the same person on the planet B? **[CBSE AIPMT 2003]**

(A) 6 m (B) $\frac{2}{3}$m
(C) $\frac{2}{9}$m (D) 18 m

5. Two spheres of masses m and M are situated in air and the gravitational force between them is F. The space around the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be **[CBSE AIPMT 2003]**

(A) $\frac{F}{3}$ (B) $\frac{F}{9}$
(C) 3 F (D) F

6. The density of newly discovered planet is twice that of the earth. The acceleration due to gravity at the surface of the planet is equal to that at the surface of the earth. If the radius of the earth is R, the radius of the planet would be **[CBSE AIPMT 2004]**

(A) 2 R (B) 4 R
(C) $\frac{1}{4}$R (D) $\frac{1}{2}$R

7. Imagine a new planet having the same density as that of the earth but it is 3 ti me bigger than the earth in size. If the acceleration due to gravity on the surface of the new planet is g′, then **[CBSE AIPMT 2005]**

(A) $g' = 3g$ (B) $g' = \frac{g}{3}$
(C) $g' = 9\,g$ (D) $g' = 27\,g$

8. For a satllite moving in an orbit around the earth, the ratio of kinetic energy to potential energy is **[CBSE AIPMT 2005]**

(A) 2 (B) 1/2
(C) $\frac{1}{\sqrt{2}}$ (D) $\sqrt{2}$

9. The earth is assumed to be a sphere of radius R. A platform is arranged at a height R from the surface of the earth. The escape velocity of a body from this platform is fv_e, where v_e is its escape velocity from the surface of the earth. The value of f is **[CBSE AIPMT 2006]**

(A) $\sqrt{2}$ (B) $\frac{1}{\sqrt{2}}$
(C) $\frac{1}{3}$ (D) $\frac{1}{2}$

10. Two satellites of the earth, S_1 and S_2 are moving in the same orbit. The mass of S_1 is four times the mass of S_2. Whic one of the following statements is true? **[CBSE AIPMT 2007]**

(A) The time period of S_1 is four times that of S_2
(B) The potential energies of the earth and satellite in the two cases are equal
(C) S_1 and S_2 are moving with the same speed
(D) The kinetic energies of the two satellites are equal

MOCK TEST

STRAIGHT OBJECTIVE TYPE

1. A tunnel is dug along the diameter of the earth (Radius R & mass M). There is a particle of mass 'm' at the centre of the tunnel. The minimum velocity given to the particle so that it just reaches to the surface of the earth is :

(A) $\sqrt{\frac{GM}{R}}$ (B) $\sqrt{\frac{GM}{2R}}$ (C) $\sqrt{\frac{2GM}{R}}$

(D) it will reach with the help of negligible velocity.

2. A cavity of radius R/2 is made inside a solid sphere of radius R. The centre of the cavity is located at a distance R/2 from the centre of the sphere. The gravitational force on a particle of mass ' m ' at a distance R/2 from the centre of the sphere on the line joining both the centres of sphere and cavity is (opposite to the centre of cavity). [Here $g = GM/R^2$, where M is the mass of the sphere]

(A) $\frac{mg}{2}$ (B) $\frac{3\,mg}{8}$ (C) $\frac{mg}{16}$ (D) none of these

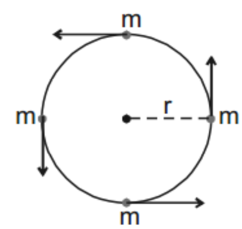
3. A satellite is launched in the equatorial plane in such a way that it can transmit signals upto 60° latitude on the earth. The angular velocity of the satellite is :

(A) $\sqrt{\frac{GM}{8R^3}}$ (B) $\sqrt{\frac{GM}{2R^3}}$ (C) $\sqrt{\frac{GM}{4R^3}}$ (D) $\sqrt{\frac{3\sqrt{3}GM}{8R^3}}$

4. A satellite is seen after each 8 hours over equator at a place on the earth when its sense of rotation is opposite to the earth. The time interval after which it can be seen at the same place when the sense of rotation of earth & satellite is same will be :

(A) 8 hours (B) 12 hours (C) 24 hours (D) 6 hours

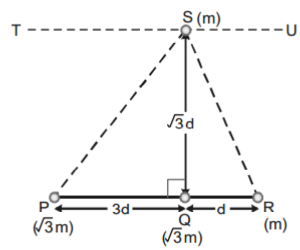
5. Four similar particles of mass m are orbiting in a circle of radius r in the same angular direction because of their mutual gravitational attractive force. Velocity of a particle is given by



(A) $\left[\frac{Gm}{r}\left(\frac{1+2\sqrt{2}}{4}\right)\right]^{\frac{1}{2}}$ (B) $\sqrt[3]{\frac{Gm}{r}}$

(C) $\sqrt{\frac{Gm}{r}\left(1+2\sqrt{2}\right)}$ (D) $\left[\frac{1}{2}\frac{Gm}{r}\left(\frac{1+\sqrt{2}}{2}\right)\right]^{\frac{1}{2}}$

6. Three particles P, Q and R are placed as per given figure. Masses of P, Q and R are $\sqrt{3}$ m, $\sqrt{3}$ m and m respectively. The gravitational force on a fourth particle 'S' of mass m is equal to



(A) $\frac{\sqrt{3}\,GM^2}{2d^2}$ in ST direction only

(B) $\frac{\sqrt{3}\,Gm^2}{2d^2}$ in SQ direction and $\frac{\sqrt{3}\,Gm^2}{2d^2}$ in SU direction

(C) $\frac{\sqrt{3}\,Gm^2}{2d^2}$ in SQ direction only

(D) $\frac{\sqrt{3}\,Gm^2}{2d^2}$ in SQ direction and $\frac{\sqrt{3}\,Gm^2}{2d^2}$ in ST direction

11th Class Modules Chapter Details

Physics
5
Modules

Chemistry
5
Modules

Mathematics
5
Modules

PHYSICS

Module-1

1. Physical World & Measurements
2. Basic Maths & Vector
3. Kinematics

Module-2

1. Law of Motion & Friction
2. Work, Energy & Power

Module-3

1. Motion of system of particles & Rigid Body
2. Gravitation

Module-4

1. Mechanical Properties of Matter
2. Thermal Properties of Matter

Module-5

1. Oscillations
2. Waves

CHEMISTRY

Module-1(PC)

1. Some Basic Conceps of Chemistry
2. Atomic Structure
3. Chemical Equilibrium
4. Ionic Equilibrium

Module-2(PC)

1. Thermodynamics & Thermochemistry
2. Redox Reaction
3. States Of Matter (Gaseous & Liquid)

Module-3(IC)

1. Periodic Table
2. Chemical Bonding
3. Hydrogen & Its Compounds
4. S-Block

Module-4(OC)

1. Nomenclature of Organic Compounds
2. Isomerism
3. General Organic Chemistry

Module-5(OC)

1. Reaction Mechanism
2. Hydrocarbon
3. Aromatic Hydrocarbon
4. Environmental Chemistry & Analysis Of Organic Compounds

BIOLOGY

Module-1

1. Diversity in the Living World
2. Plant Kingdom
3. Animal Kingdom

Module-2

1. Morphology in Flowering Plants
2. Anatomy of Flowering Plants
3. Structural Organization in Animals

Module-3

1. Cell: The Unit of Life
2. Biomolecules
3. Cell Cycle & Cell Division
4. Transport in Plants
5. Mineral Nutrition

Module-4

1. Photosynthesis in Higher Plants
2. Respiration in Plants
3. Plant Growth and Development
4. Digestion & Absorption
5. Breathing & Exchange of Gases

Module-5

1. Body Fluids & Its Circulation
2. Excretory Products & Their Elimination
3. Locomotion & Its Movement
4. Neural Control & Coordination
5. Chemical Coordination and Integration

12th Class Modules Chapter Details

Physics
5
Modules

Chemistry
5
Modules

Mathematics
5
Modules

PHYSICS	CHEMISTRY	BIOLOGY
Module-1 1. Electrostatics 2. Capacitance **Module-2** 1. Current Electricity 2. Magnetic Effect of Current and Magnetism **Module-3** 1. Electromagnetic Induction 2. Alternating Current **Module-4** 1. Geometrical Optics 2. Wave Optics **Module-5** 1. Modern Physics 2. Nuclear Physics 3. Solids & Semiconductor Devices 4. Electromagnetic Waves	**Module-1(PC)** 1. Solid State 2. Chemical Kinetics 3. Solutions and Colligative Properties **Module-2(PC)** 1. Electrochemistry 2. Surface Chemistry **Module-3(IC)** 1. P-Block Elements 2. Transition Elements (d & f block) 3. Co-ordination Compound 4. Metallurgy **Module-4(OC)** 1. HaloAlkanes & HaloArenes 2. Alcohol, Phenol & Ether 3. Aldehyde, Ketone & Carboxylic Acid **Module-5(OC)** 1. Nitrogen & Its Derivatives 2. Biomolecules & Polymers 3. Chemistry in Everyday Life	**Module-1** 1. Reproduction in Organisms 2. Sexual Reproduction in Flowering Plants 3. Human Reproduction 4. Reproductive Health **Module-2** 1. Principles of Inheritance and Variation 2. Molecular Basis of Inheritance 3. Evolution **Module-3** 1. Human Health and Disease 2. Strategies for Enhancement in Food Production 3. Microbes in Human Welfare **Module-4** 1. Biotechnology: Principles and Processes 2. Biotechnology and Its Applications 3. Organisms and Populations **Module-5** 1. Ecosystem 2. Biodiversity and Conservation 3. Environmental Issues