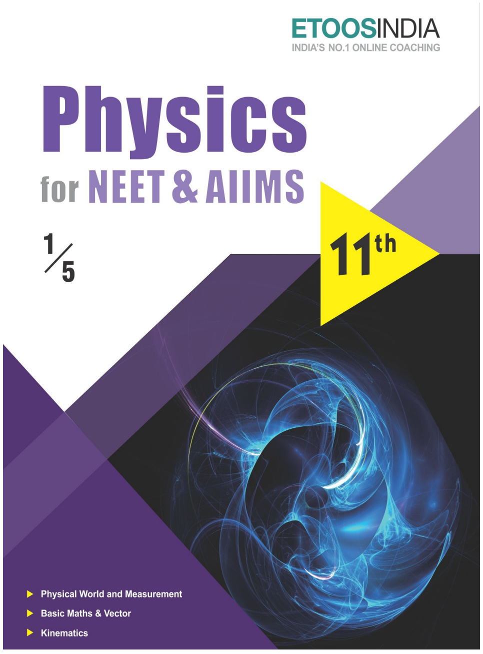
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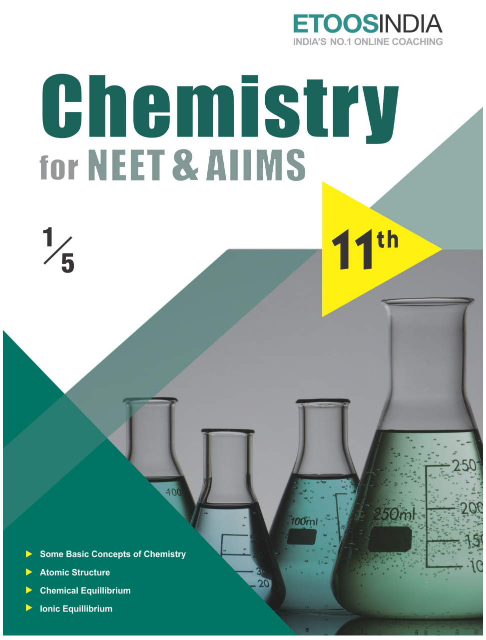
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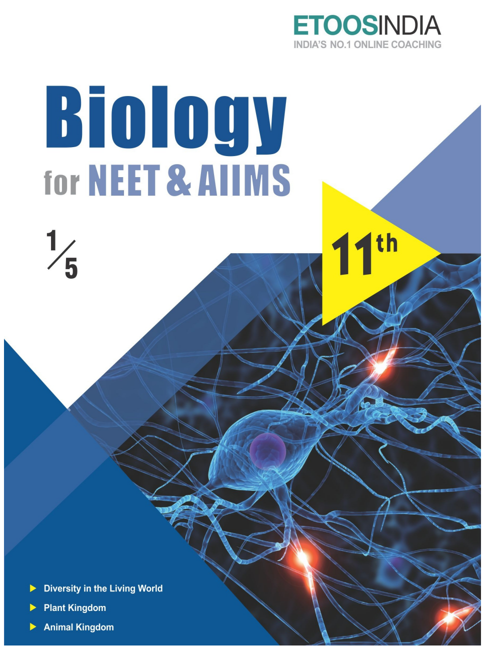
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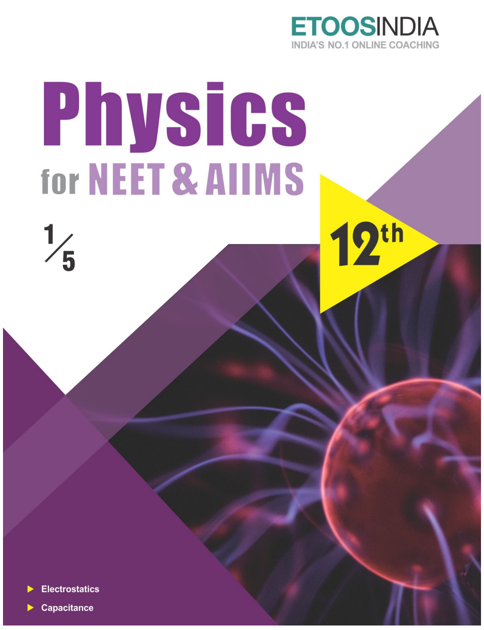
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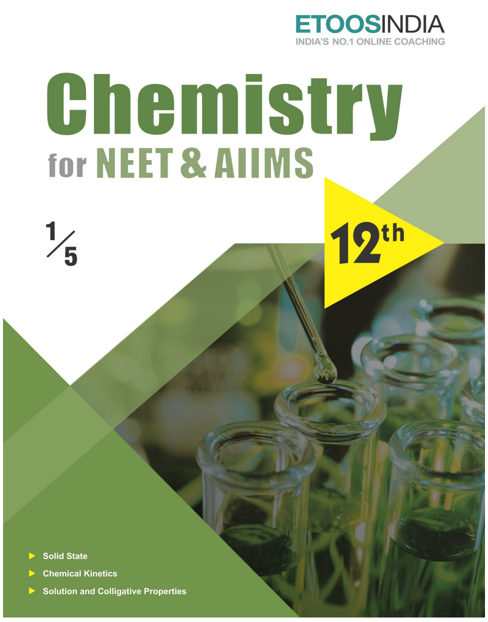
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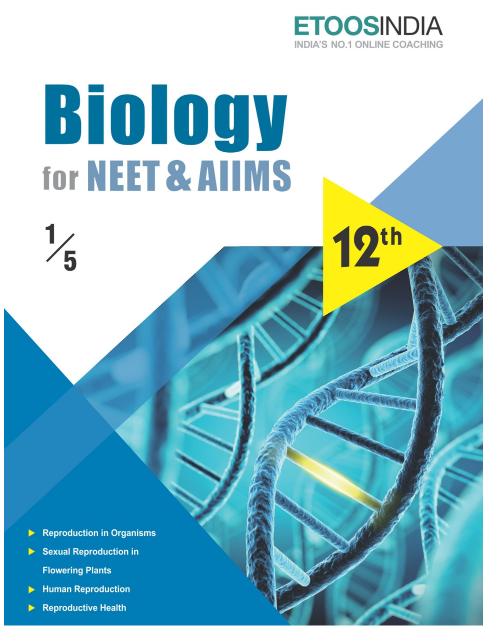
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Sexual Reproduction in
Flowering Plants
Human Reproduction
Reproductive Health

CHAPTER 06

MOTION OF SYSTEM OF PARTICLES & RIGID BODY

Just as the system of the sun,planets and comets is put in motin by the forces of gravity,and its parts persist in their motions,so the smaller system of bodies also seem to be set in motion by other forces and their particles to be variously moved in relation to each other and,especially,by the elecric force.

"ISAAC NEWTON"

INTRODUCTION

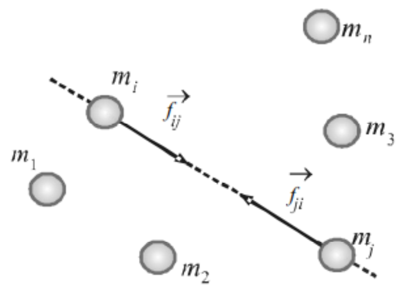
Study of kinematics enables us to explore nature of translation motion without any consideration to forces and energy responsible for the motion. Study of kinetics enables us to explore effects of forces and energy on motion. It includes Newton's laws of motion, methods of work and energy and methods of impulse and momentum. The methods of work and energy and methods of impulse and momentum are developed using equation $\vec{F} = m\vec{a}$ together with the *methods of kinematics*. The advantage of these methods lie in the fact that they make determination of acceleration unnecessary. Methods of work and energy directly relate force, mass, velocity and displacement and enable us to explore motion between two points of space i.e. in a space interval whereas methods of impulse and momentum enable us to explore motion in a time interval. Moreover methods of impulse and momentum provides only way to analyze impulsive motion.

The work energy theorem and impulse momentum principle are developed from Newton's second law, and we have seen how to apply them to analyze motion of single particle i.e. translation motion of rigid body. Now we will further inquire into possibilities of applying these principles to a system of large number of particles or rigid bodies in translation motion.

SYSTEM OF PARTICLES

By the term system of particles, we mean a well defined collection of several or large number of particles, which may or may not interact or be connected to each other.

As a schematic representation, consider a system of n particles of masses $m_1, m_2, ... m_i ... m_j ....$ and m_n respectively. They may be actual particles of rigid bodies in translation motion. Some of them may interact with each other and some of them may not. The particles, which interact with each other, apply forces on each other. The forces of interaction $\vec{f}_{ij}$ and $\vec{f}_{ji}$ between a pair of i^{th} and j^{th} particles are shown in the figure.



System of n interacting particles.

Similar to these other particles may also interact with each other. These forces of mutual interaction between the particles of the system are *internal forces* of the system.

These internal forces always exist in pairs of forces of equal magnitudes and opposite directions. It is not necessary that all the particles interact with each other; some of them, which do not interact with each other, do not apply mutual forces on each other. Other than internal forces, external forces may also act on all or some of the particles. Here by the term *external force* we mean a force that is applied on any one of the particle included in the system by some other body out-side the system.

In practice we usually deal with extended bodies, which may be deformable or rigid. An extended body is also a system of infinitely large number of particles having infinitely small separations between them. When a body undergoes deformation, separations between its particles and their relative locations change. A rigid body is an extended body in which separations and relative locations of all of its particles remain unchanged under all circumstances.

System of Particles and Mass Center

Until now we have deal with translation motion of rigid bodies, where a rigid body can be treated as a particle. When a rigid body undergoes rotation, all of its particles do not move in identical fashion, still we must treat it a system of particles in which all the particles are rigidly connected to each other. On the other hand we may have particles or bodies not connected rigidly to each other but may be interacting with each other through internal forces. Despite the complex motion of which a system of particles is capable, there is a single point, known as **center of mass** or **mass center** (CM), whose translation motion is characteristic of the system.

The existence of this special point can be demonstrated in the following examples dealing with a rigid body. Consider two disks A and B of unequal masses connected by a very light rigid rod. Place it on a very smooth table. Now pull it horizontally applying a force at different points. You will find a point nearer to the heavier disk, on

Etoos Tips & Formulas

1. Impulse-Momentum theorem

Impulse of a force is equal to the change of momentum

force time graph area gives change in momentum.

$$\int_{t_1}^{t_2} \vec{F}dt = \Delta\vec{p}$$

2. Collision of bodies

The event of the process, in which two bodies either coming in contact with each other or due to mutual interaction at distance apart, affect each others motion (velocity, momentum, energy or direction of motion) is defined as a collision.

3. In collision

The particles come closer before collision and after collision they either stick together or move away from each other.

The particles need not come in contact with each other for a collision.

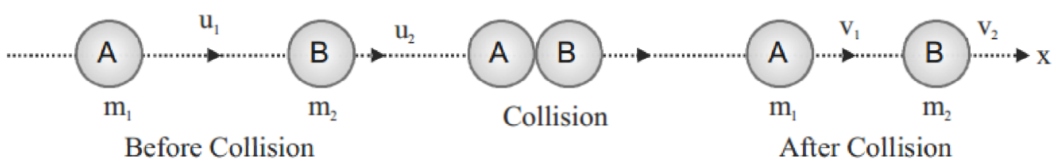
The law of conservation of linear momentum is necessarily applicable in a collision, whereas the law of conservation of mechanical energy is not.

4. Coefficient of restitution (Newton`s law)

$$e = \frac{\text{velocity of separation along line of impact}}{\text{velocity of approach along line of impact}} = \frac{v_2 - v_1}{u_1 - u_2}$$

Value of e is 1 for elastic collision, 0 for perfectly inelastic collision and $0 < e < 1$ for inelastic collision.

5. Head on collision



6. Head on inelastic collision of two particles

Let the coefficient of restitution for collision is e

(a) Momentum is conserved $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ ...(i)

(b) Kinetic energy is not conserved

(c) According to Newton`s law $e = \frac{v_2 - v_1}{u_1 - u_2}$ ....(ii)

By solving eq. (i) and (ii) :

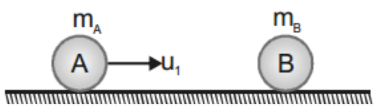
$$v_1 = \left(\frac{m_1 - em_2}{m_1 + m_2}\right)u_1 + \left(\frac{(1+e)m_2}{m_1 + m_2}\right)u_2 = \frac{m_1u_1 + m_2u_2 - m_2e(u_1 - u_2)}{m_1 + m_2}$$

$$v_2 = \left(\frac{m_2 - em_1}{m_1 + m_2}\right)u_2 + \left(\frac{(1+e)m_1}{m_1 + m_2}\right)u_1 = \frac{m_1u_1 + m_2u_2 - m_1e(u_2 - u_1)}{m_1 + m_2}$$

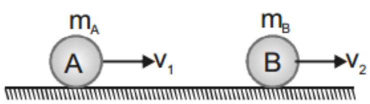
SOLVED EXAMPLE

Ex. 1 Consider an one dimensional elastic collision between a given incoming body A and body B, initially at rest. The mass of B in comparison to the mass of A in order that B should recoil with greatest kinetic energy is

Sol.



Before collision



After collision

Velocity of block B after collision

$$v_2 = \frac{2m_A u_1}{m_A + m_B}$$

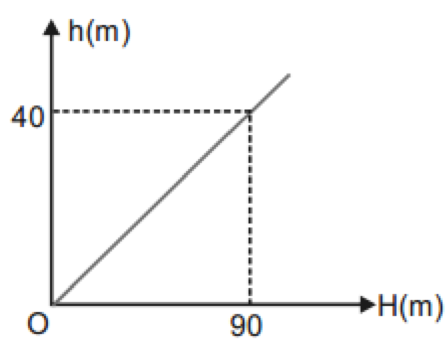
KE of block

$$B = \frac{1}{2}m_B v_2^2 = \frac{1}{2}m_B\left[\frac{4m_A^2u_1^2}{(m_A+m_B)^2}\right]$$

$$= \frac{2m_A^2 m_B}{(m_A+m_B)^2}u_1^2$$

which is maximum if $m_A = m_B$

Ex. 2 A ball of mass 2 kg dropped from a height H above a horizontal surface rebounds to a height h after one bounce. The graph that relates H to h is shown in figure. If the ball was dropped from an initial height of 81 m and made ten bounces, the kinetic energy of the ball immediately after the second impact with the surface was



Sol. From graph $e = \sqrt{\frac{h}{H}} = \sqrt{\frac{40}{90}} = \frac{2}{3}$

Kinetic energy of the ball just after second bounce

$$= \frac{1}{2}m(e^2u)^2 = \frac{1}{2}me^4u^2 = (e^4)(mgH)$$

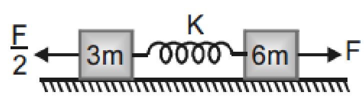
$$= \left(\frac{2}{3}\right)^4(2)(10)(81) = 320J$$

Ex. 3 An object is moving through air at a speed v. If the area of the object normal to the direction of velocity is A and assuming elastic collision with the air molecules, then the resistive force on the object is proportional to– (assume that molecules striking the object were initially at rest)

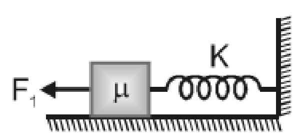
Sol. Velocity of air molecule after collision = 2v . The number of air– molecules accelerated to a velocity 2v in time Δt is proportional to $Av\Delta t$.

Therefore $F = \frac{\Delta p}{\Delta t} \propto (Av\Delta t)\left(\frac{2v}{\Delta t}\right) \Rightarrow F \propto 2Av^2$

Ex. 4 For shown situation find the maximum elongation in the spring. Neglect friction everywhere. Initially, the blocks are at rest and spring is unstretched.



Sol. By using reduced mass concept this system can be reduced to



Where $\mu = \frac{(3m)(6m)}{3m+6m} = 2$ m and F_1 = Force on either block w.r.t. centre of mass of the system

$$= \frac{F}{2} + (3m)a_{cm} = \frac{F}{2} + (3m)\left(\frac{F - F/2}{9m}\right)$$

$$= \frac{F}{2} + \frac{F}{6} = \frac{2}{3}F$$

Exercise # 1

SINGLE OBJECTIVE — NEET LEVEL

1. Two objects of masses 200g and 500g possess velocities $10\hat{i}$ m/s and $3\hat{i}+5\hat{j}$ m/s respectively. The velocity of their centre of mass in m/s is
(A) $5\hat{i}-25\hat{j}$ (B) $\frac{5}{7}\hat{i}-25\hat{j}$
(C) $5\hat{i}+\frac{25}{7}\hat{j}$ (D) $25\hat{i}-\frac{5}{7}\hat{j}$

2. Where will be the centre of mass on combining two masses m and M (M >m)
(A) Towards m (B) Towards M
(C) Between m and M (D) Anywhere

3. Two spherical bodies of mass M and 5M and radii R and 2R respectively are released in free space with initial separation between their centres equal to 12R. If they attract each other due to gravitational force only, then the distance covered by the maller body just before collision is
(A) 1.5 R (B) 2.5 R
(C) 4.5 R (D) 7.5 R

4. Distance of the centre of mass of a solid uniform cone from its vertex is z_0. If the radius of its base is R and its height is h the z_0 is equal to
(A) $\frac{h^2}{4R}$ (B) $\frac{3h}{4}$
(C) $\frac{5h}{8}$ (D) $\frac{3h^2}{8R}$

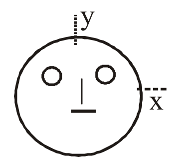
5. A large number of particles are placed around the origin, each at a distance R from the origin. The distance of the centre of mass of the system from the origin is
(A) = R (B) ≥ R
(C) > R (D) ≤ R

6. The distance between the carbon atom and the oxygen atom in a carbon monoxide molecule is 1.1Å. Given, mass of carbon atom is 12 a.m.u. and mass of oxygen atom is 16 a.m.u., calculate the position of the centre of mass of the carbon monoxide molecule
(A) 6.3 Å from the carbon atom
(B) 1 Å from the oxygen atom
(C) 0.63 Å from the carbon atom
(D) 0.12 Å from the oxygen atom

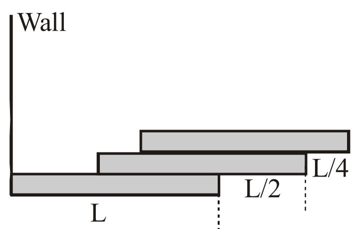
7. A rod of mass m and length l is made to stand at an angle of 60° with the vertical, potential energy of the rod in this position is
(A) mgl (B) $\frac{mgl}{2}$
(C) $\frac{mgl}{3}$ (D) $\frac{mgl}{4}$
(E) $\frac{mgl}{\sqrt{2}}$

8. The centre of mass of a body
(A) Lies always outside the body
(B) May lie within, outside on the surface of the body
(C) Lies always inside the body
(D) Lies always on the surface of the body

9. Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is 6 m. The coordinates of the centres of the different parts are : outer circle (0,0), left inner circle (–a, a), right inner circle (a, a), vertical line (0, 0) and horizontal line (0, -a). The y-coordinates of the centre of mass of the ink in this drawing is
(A) a/10
(B) a/8
(C) a/12
(D) a/3



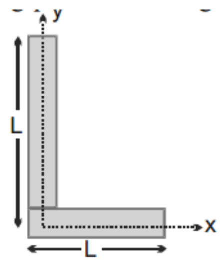
10. Three bricks each of length L and mass M are arranged as shown from the wall. The distance of the centre of mass of the system from the wall is



(A) L/4 (B) L/2
(C) (3/2)L (D) (11/12)L
(E) (5/6) L

Exercise # 2 SINGLE OBJECTIVE AIIMS LEVEL

1. Centre of mass of two uniform rods of same length but made up of different materials & kept as shown, if the meeting point is the origin of co–ordinates



(A) (L/2,L/2) **(B)** (2L/3,L/2)
(C) (L/3,L/3) **(D)** (L/3,L/6)

2. The centre of mass of a non uniform rod of length L whose mass per unit length varies as $\rho = kx^2/L$ (where k is a constant and x is the distance measured from one end) is at the following distance from the same end.

(A) 3L/4 **(B)** L/4
(C) 2L/3 **(D)** L/3

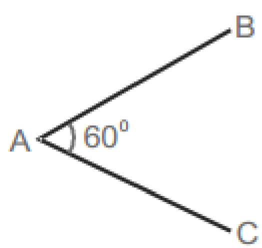
3. A uniform wire of length ℓ is bent into the shape of 'V' as shown. The distance of its centre of mass from the vertex A is

(A) $\ell / 2$

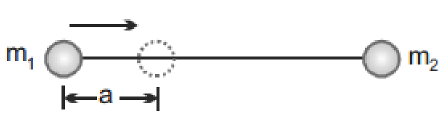
(B) $\dfrac{\ell\sqrt{3}}{4}$

(C) $\dfrac{\ell\sqrt{3}}{8}$

(D) None of these



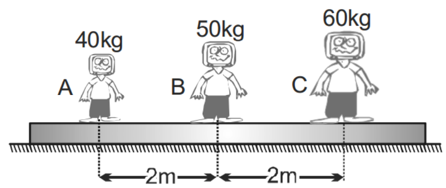
4. Considering a system having two masses m_1 and m_2 in which first mass is pushed towards centre of mass by a distance a, the distance required to be moved for second mass to keep centre of mass at same position is



(A) $\dfrac{m_1}{m_2}a$ **(B)** $\dfrac{m_1 m_2}{a}$

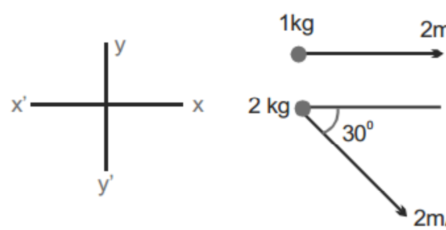
(C) $\dfrac{m_2}{m_1}a$ **(D)** $\left(\dfrac{m_2 m_1}{m_1 + m_2}\right) a$

5. Three man A, B & C of mass 40 kg, 50 kg & 60 kg are standing on a plank of mass 90 kg, which is kept on a smooth horizontal plane. If A & C exchange their positions then mass B will shift



(A) 1/3 m towards left
(B) 1/3m towards right
(C) will not move w.r.t. ground
(D) 5/3 m towards left

6. The velocity of centre of mass of the system as shown in the figure



(A) $\left(\dfrac{2-2\sqrt{3}}{3}\right)\hat{i} - \dfrac{1}{3}\hat{j}$ **(B)** $\left(\dfrac{2+2\sqrt{3}}{3}\right)\hat{i} - \dfrac{2}{3}\hat{j}$

(C) $4\hat{i}$ **(D)** None of these

7. Two particles A and B initially at rest, move towards each other under the mutual force of attraction. At the instant when the speed of A is v and the speed of B is 2v, the speed of the centre of mass of the system is:–

(A) 3v **(B)** v
(C) 1.5v **(D)** zero

8. An isolated particle of mass m is moving in horizontal plane (x–y), along the x–axis, at a certain height above the ground. It suddenly explodes into two fragment of masses $\dfrac{m}{4}$ and $\dfrac{3m}{4}$. An instant later, the smaller fragment is at y = +15 cm. The larger fragment at this instant is at :–

(A) y = –5 cm **(B)** y = +20 cm
(C) y = +5 cm **(D)** y = –20 cm

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. Two balls of mass m and 2m each have momentum 2p and p in the direction shown in figure. During collision they exert an impulse of magnitude p on each other.

Column I	Column II
(A) After collision momentum of m	(P) 2p
(B) After collision momentum of 2m	(Q) p
(C) Coefficient of restitution between them	(R) 1
	(S) None

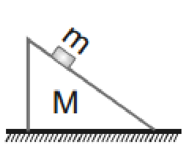
2. A particle of mass m, kinetic energy K and momentum p collides head on elastically with another particle of mass 2 m at rest. After collision :

Column I	Column II
(A) Momentum of first particle	(P) 3/4 p
(B) Momentum of second particle	(Q) – K/9
(C) Kinetic energy of first particle	(R) – p/3
(D) Kinetic energy of second particle	(S) $\frac{8K}{9}$
	(T) None

3. A particle of mass 1kg has velocity $\vec{v}_1 = (2t)\hat{i}$ and another particle of mass 2 kg has velocity $\vec{v}_2 = (t^2)\hat{j}$.

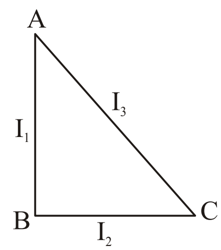
Column I	Column II
(A) Net force on centre of mass at 2 s	(P) $\frac{20}{9}$ unit
(B) Velocity of centre of mass at 2s	(Q) $\sqrt{68}$ unit
(C) Displacement of centre of mass in 2s	(R) $\frac{\sqrt{80}}{3}$ unit
	(S) None

4. In each situation of column–I, a system involving two bodies is given. All strings and pulleys are light and friction is absent everywhere. Initially each body of every system is at rest. Consider the system in all situation of column I from rest till any collision occurs. Then match the statements in column – I with the corresponding results in column–II

Column I	Column II
(A) The block plus wedge system is placed over smooth horizontal surface. After the system is released from rest, the centre of mass of system 	(P) Shifts towards right

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

1. ABC is a right angled triangular plate of uniform thickness. The sides are such that AB > BC as shown in figure. I_1, I_2, I_3 are moments of inertia about AB, BC and AC respectively. Then, which of the following relations is correct ? [CBSE AIPMT 2000]

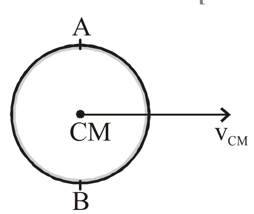


(A) $I_1 = I_2 = I_3$ (B) $I_2 > I_1 > I_3$
(C) $I_3 < I_2 < I_1$ (D) $I_3 > I_1 > I_2$

2. A particle of mass M is revolving along a circle of radius R and another particle of mass m is revolving in a circle of radius r. If time period of both particles are same, then the ratio of their angular velocities is [CBSE AIPMT 2001]

(A) 1 (B) $\frac{R}{r}$
(C) $\frac{r}{R}$ (D) $\sqrt{\frac{R}{r}}$

3. A wheel of bicycle is rolling without slipping on a level road. The velocity of the centre of mass is v_{CM}, then true statement is [CBSE AIPMT 2001]



(A) The velocity of point A is $2v_{CM}$ and velocity of point B is zero
(B) The velocity of point A is zero and velocity of point B is $2v_{CM}$
(C) The velocity of point A is $2v_{CM}$ and velocity of point B is $-v_{CM}$
(D) The velocities of both A and B are v_{CM}

4. A disc is rotating with angular velocity ω. If a child sits on it, what is conserved? [CBSE AIPMT 2002]
(A) Linear momenutm (B) Angular momentum
(C) Kinetic energy (D) Moment of inertia

5. A circular disc is to be made using iron and aluminium. To keep its moment of inertia maximum about a geometrical axis, it should be so prepared that [CBSE AIPMT 2002]
(A) aluminium is at the interior and iron surrounds it
(B) iron is at the interior and aluminium surrounds it
(C) aluminium and iron layers are in alternate order
(D) sheet of iron is used at both external surfaces and aluminium sheet as inner material

6. A solid sphere of radius R is placed on a smooth horizontal surface. A horizontal force F is applied at height h from the lowest point. For the maximum acceleration of the centre of mass [CBSE AIPMT 2002]
(A) h = R (B) h = 2R
(C) h = 0
(D) the acceleration will be same whatever h may be

7. A rod is of length 3 m and its mass acting per unit length is directly proportional to distance x from its one end. The centre of gravity of the rod from that end will be at [CBSE AIPMT 2002]
(A) 1.5 m (B) 2 m
(C) 2.5 m (D) 3 m

8. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω. Four objects each of mass m, are kept gently to the opposite ends of two perpendicular diameters of the ring. The angular velocity of the ring will be [CBSE AIPMT 2003]

(A) $\frac{(M+4m)\omega}{M}$ (B) $\frac{(M-4m)\omega}{M+4m}$
(C) $\frac{M\omega}{4m}$ (D) $\frac{M\omega}{M+4m}$

9. A ball rolls withou slipping. The radius of gyration of the ball about an axis passing through its centre of mass is k. If radius of the ball be R, then the fraction of total energy associated with its rotational energy will be [CBSE AIPMT 2003]

(A) $\frac{k^2}{k^2+R^2}$ (B) $\frac{R^2}{k^2+R^2}$
(C) $\frac{k^2+R^2}{R^2}$ (D) $\frac{k^2}{R^2}$

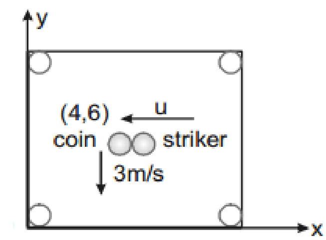
MOCK TEST

STRAIGHT OBJECTIVE TYPE

1. Two particles A and B start moving due to their mutual interaction only. If at any time 't', $\vec{a}_A$ & $\vec{a}_B$ are their respective accelerations, $\vec{v}_A$ and $\vec{v}_B$ are their respective velocities and upto that time W_A and W_B are the work done on A & B respectively by the mutual force, m_A and m_B are their masses respectively, then which of the following is always correct.

(A) $\vec{v}_A + \vec{v}_B = 0$ (B) $m_A\vec{v}_A + m_B\vec{v}_B = 0$ (C) $W_A + W_B = 0$ (D) $\vec{a}_A + \vec{a}_B = 0$

2. On a smooth carom board, a coin moving in negative y–direction with a speed of 3 m/s is being hit at the point (4, 6) by a striker moving along negative x-axis. The line joining centres of the coin and the striker just before the collision is parallel to x-axis. After collision the coin goes into the hole located at the origin. Masses of the striker and the coin are equal. Considering the collision to be elastic, the initial and final speeds of the striker in m/s will be :



(A) (1.2, 0) (B) (2, 0) (C) (3, 0) (D) none of these

3. A train of mass M is moving on a circular track of radius ' R ' with constant speed V. The length of the train is half of the perimeter of the track. The linear momentum of the train will be

(A) 0 (B) $\frac{2MV}{\pi}$ (C) MVR (D) MV

4. A canon shell moving along a straight line bursts into two parts. Just after the burst one part moves with momentum 20 Ns making an angle 30º with the original line of motion. The minimum momentum of the other part of shell just after the burst is :

(A) 0 Ns (B) 5 Ns (C) 10 Ns (D) 17.32 Ns

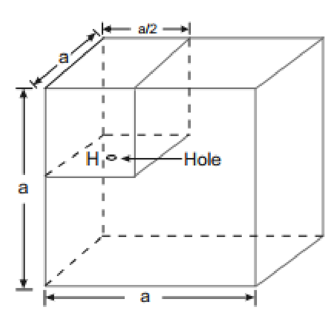
5. The figure shows a hollow cube of side 'a' of volume V. There is a small chamber of volume $\frac{V}{4}$ in the cube as shown. This chamber is completely filled by m kg of water. Water leaks through a hole H. Then the work done by gravity in this process assuming that the complete water finally lies at the bottom of the cube is :

(A) $\frac{1}{2}$ mg a

(B) $\frac{3}{8}$ mg a

(C) $\frac{5}{8}$ mga

(D) $\frac{1}{8}$ mga



11^{th} 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

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

CHEMISTRY

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

BIOLOGY

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