CHAPTER: 03

DYNAMICS I

Short Response Questions:

1. When a motorcyclist hits a stationary car, he may fly off the motorcycle and driver in the car may get neck injury. Explain.

When the motorcyclist suddenly hits the stationary car, the motorcycle stops abruptly but the rider continues moving forward due to **inertia of motion**. This causes the rider to fly off the motorcycle. The driver inside the car experiences a sudden jerk, and due to **inertia of rest**, his neck may get injured.

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2. In autumn, when you shake a branch, the leaves are detached. Why?

When the branch is shaken suddenly, the branch comes into motion but the leaves tend to remain at rest due to **inertia of rest**. This difference in motion causes the leaves to get detached from the branch. Hence, leaves fall off easily in autumn.

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3. Why is it not safe to apply brakes only on the front wheel of a bicycle?

If brakes are applied only on the front wheel, the front wheel stops suddenly while the rider's body continues moving forward due to **inertia of motion**. This can cause the bicycle to overturn forward. Therefore, it is not safe to apply brakes only on the front wheel.

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4. Deduce Newton's first law of motion from Newton's second law of motion.

According to Newton's second law, acceleration is produced only when a **net external force** acts on a body. If the net force is zero, acceleration becomes zero. Hence, the body remains at rest or continues moving with uniform velocity, which is Newton's first law of motion.

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5. Action and reaction are equal but opposite in direction. These forces always act in pair. Do they balance each other? Can bodies move under action–reaction pair?

Action and reaction forces do not balance each other because they act on **different bodies**. Since they act on separate objects, their effects do not cancel. Bodies can move under action–reaction pairs, as seen in walking, jumping and recoil of a gun.

6. A man slips on the oily floor; he wants to move out of this area. He is alone. He throws his bag to move out of this slippery area. Why is it so?

When the man throws his bag backward, the bag gains momentum in one direction. By the **law of conservation of momentum**, the man gains an equal momentum in the opposite direction. As a result, he moves forward and escapes the slippery area.

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7. How would you use Newton's third law of motion and law of conservation of momentum to explain motion of rocket?

In a rocket, hot gases are expelled downward with large momentum. According to Newton's third law, an equal and opposite reaction force pushes the rocket upward. By conservation of momentum, the backward momentum of gases equals the forward momentum of the rocket, causing it to accelerate.

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8. Why are cricket batter gloves padded with foam?

When a fast-moving ball strikes the bat, its momentum changes suddenly. Padding increases the **time of impact**, which reduces the force acting on the hands. Therefore, foam padding protects the batter from injury.

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9. Where will your weight be greater, near Earth or near Moon? What about mass?

Your weight will be greater near the Earth because the value of gravitational acceleration is higher. On the Moon, gravity is weaker, so weight is less. However, mass remains the same at both places because it does not depend on gravity.

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10. When Ronaldo kicks the ball, at the highest point both Earth and ball attract each other with same force. Why then does the ball move towards Earth and not the Earth?

According to Newton's third law, Earth and ball attract each other with equal force. However, due to the **very large mass of the Earth**, its acceleration is negligible. The ball, having very small mass, accelerates more and moves toward the Earth.

Long Response Questions:

1. State first law of motion. Explain with the help of examples. Why is it called law of inertia?

Newton’s first law of motion states that *a body continues in its state of rest or uniform motion in a straight line unless acted upon by an external unbalanced force*. This law explains the basic behavior of objects when no net force acts on them.

For example, a book lying on a table remains at rest unless someone applies a force to move it. Similarly, a ball rolling on a smooth surface continues its motion for a long time unless friction or another force stops it. When a bus starts suddenly, passengers tend to fall backward, and when it stops suddenly, they tend to fall forward.

This behavior occurs due to **inertia**, which is the resistance of a body to any change in its state of motion. Since Newton’s first law describes this resistance to change, it is called the **law of inertia**. Objects with larger mass have greater inertia and require more force to change their motion.

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2. Define inertia. Why is it important to have knowledge of inertia in our daily life? Elaborate your answer with examples.

Inertia is the property of matter by which a body resists any change in its state of rest or uniform motion. It depends upon the mass of the body; greater the mass, greater is the inertia.

Knowledge of inertia is very important in daily life. When a moving bus stops suddenly, passengers are thrown forward due to inertia of motion. Seat belts are used in vehicles to prevent injury caused by this sudden motion. Similarly, when a carpet is beaten with a stick, dust particles fall off due to inertia of rest.

Inertia also explains why it is difficult to push or stop heavy objects. Understanding inertia helps in designing safety devices such as airbags, seat belts and shock absorbers, which reduce injuries by controlling sudden changes in motion.

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3. State and prove Newton’s second law of motion. Deduce Newton’s second law of motion from its first law.

Newton’s second law of motion states that *the acceleration of a body produced by a net force is directly proportional to the magnitude of the force, is in the direction of the force, and inversely proportional to the mass of the body*.

Consider a body of mass **m** moving with initial velocity **u**. When a force **F** acts on it, its velocity becomes **v** in time **t**. The acceleration produced is
a=v−uta = \frac{v-u}{t}a=tv−u

According to Newton’s second law,
F∝aF \propto aF∝a and a∝1ma \propto \frac{1}{m}a∝m1

Combining both relations:
$$F \propto \frac{m(v-u)}{t}$$

Using SI units, this becomes:
$$F = m \frac{(v-u)}{t} = ma$$

Thus, force is equal to the rate of change of momentum.

This law can also be deduced from the first law. According to the first law, if no net force acts, velocity remains constant. Therefore, a net force is required to change velocity, which produces acceleration. This change is explained quantitatively by Newton's second law.

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4. State Newton's third law of motion. Explain with examples from daily life.

Newton's third law of motion states that *for every action, there is an equal and opposite reaction*. These forces act on different bodies and occur simultaneously.

When a person walks, he pushes the ground backward with his foot. In response, the ground pushes him forward with an equal and opposite force, allowing him to move. Similarly, when a gun fires a bullet, the bullet moves forward while the gun recoils backward.

Another example is jumping from a boat. When a person jumps forward, the boat moves backward. Action and reaction forces do not cancel each other because they act on different objects. This law explains many motions observed in daily life.

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5. State the limitations of Newton's laws of motion.

Although Newton's laws of motion are very successful in explaining everyday motion, they have certain limitations. These laws are not applicable at very high speeds close to the speed of light, where relativistic effects become significant.

Newton's laws also fail at atomic and subatomic scales, where quantum mechanics is required. At such small scales, concepts like precise position and acceleration are not well defined.

However, for ordinary objects moving at low speeds and large scales, Newton's laws provide very accurate results and are widely used in science and engineering.

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6. Differentiate with examples between contact and non-contact forces. Also explain fundamental forces and the role of Dr. Abdus Salam in unifying two fundamental forces.

Contact forces are those forces that act only when two objects are in physical contact. Examples include friction, normal force, tension and thrust. For example, friction acts between a book and a table.

Non-contact forces act at a distance without physical contact. Examples include gravitational, magnetic and electrostatic forces. The attraction between Earth and Moon is due to gravitational force.

There are four fundamental forces in nature: gravitational, electromagnetic, strong nuclear and weak nuclear forces. Dr. Abdus Salam, a Pakistani physicist, played a major role in unifying electromagnetic and weak nuclear forces into a single theory known as the **electroweak theory**. This work earned him the Nobel Prize in Physics.

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7. Represent the forces acting on a body using free body diagrams.

A free body diagram is a diagram that shows all the forces acting on a body. In this diagram, the body is represented by a point and forces are shown by arrows.

Each arrow represents a force acting on the body, and its direction shows the direction of the force. The length of the arrow represents the magnitude of the force. Common forces shown include weight, normal force, friction and applied force.

Free body diagrams help in analyzing motion and calculating net force acting on an object.

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8. Define momentum. What is its formula and unit? Is it a scalar or vector quantity? Show that units of momentum, Ns and kg m/s are equal.

Momentum is defined as the product of mass and velocity of a body. It is represented by the symbol **p**.

Mathematically,
p=mvp = mvp=mv

The SI unit of momentum is kilogram meter per second (kg m/s). Momentum is a **vector quantity** because it has both magnitude and direction.

Since force equals rate of change of momentum,
F=ΔptF = \frac{Δp}{t}F=tΔp

Thus,
p=Ftp = Ftp=Ft

The unit of force is newton (N) and time is second (s), so momentum can also be written as Ns. Hence,
1 Ns = 1 kg m/s.

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9. Differentiate between mass and weight of a body.

Mass is the amount of matter contained in a body and is a measure of inertia. It remains constant everywhere and does not depend on gravity. Its SI unit is kilogram.

Weight is the gravitational force acting on a body. It depends on the value of gravitational acceleration and changes from place to place. Its SI unit is newton.

Mass is measured using a beam balance, while weight is measured using a spring balance.

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10. What are gravitational field and gravitational field strength? Explain.

A gravitational field is the region around a massive body in which another body experiences gravitational force. The Earth creates a gravitational field around it.

Gravitational field strength is defined as the gravitational force acting per unit mass at a point in the field. It is given by
g=Fmg = \frac{F}{m}g=mF

Its unit is N/kg and it is directed toward the center of the Earth. Gravitational field strength varies from place to place.

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11. Justify and illustrate the use of electronic balances to measure mass.

Electronic balances measure the force acting on a body due to gravity. Using Newton's second law, this force is converted into mass.

These balances are calibrated to divide the measured weight by gravitational acceleration. As a result, they display mass directly in kilograms.

Electronic balances are accurate, easy to use and widely used in laboratories and shops.

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12. State and prove Newton's second law of motion in terms of momentum.

Newton's second law states that the rate of change of momentum of a body is directly proportional to the net force acting on it and occurs in the direction of the force.

If a body of mass m changes velocity from u to v in time t, then

$$p = mv$$

Change in momentum

$$\Delta p = m(v - u)$$

Rate of change of momentum

$$\frac{\Delta p}{t} = m\frac{(v-u)}{t} = ma$$

Hence,

$$F = ma$$

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13. Define isolated system. State law of conservation of linear momentum. Explain with example.

An isolated system is a system on which no external force acts. Only internal forces act between bodies in the system.

The law of conservation of linear momentum states that *the total momentum of an isolated system remains constant*.

For example, when a gun fires a bullet, the forward momentum of the bullet is equal to the backward momentum of the gun. The total momentum before and after firing remains the same.

