CHAPTER: 04

DYNAMICS II

Short Response Questions:

1. Why is a long spanner used to open or tighten nuts of a vehicle's tyre? Why is an extra-long wrench not suitable for tightening a small nut?

A long spanner provides a larger moment arm, which produces a greater turning effect for the same applied force. This makes it easier to loosen tight nuts. However, using an extra-long wrench for a small nut produces excessive torque, which may damage or break the nut or threads.

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2. Why are door knobs fixed at the edge of the door? What will happen if the door knob is at the middle of the door?

Door knobs are fixed at the edge to increase the moment arm, which produces greater torque with less force. If the knob is fixed at the middle, the moment arm becomes smaller, and more force will be required to open the door.

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3. If you drop a feather and a bowling ball from the same height, which will reach terminal velocity first? Which one will hit the ground first?

The feather reaches terminal velocity first because it experiences a large air resistance compared to its weight. The bowling ball experiences negligible air resistance and continues accelerating longer, therefore it hits the ground first.

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4. Why do ice skates effortlessly slide on ice, while your shoes cause skidding?

Ice skates have a very small contact area, producing high pressure that slightly melts the ice, reducing friction. Shoes have a larger contact area, producing more friction, which causes skidding instead of smooth sliding.

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5. Explain why it is easier to push a car on flat tyres than inflated ones. What happens to the frictional force?

Flat tyres increase the area of contact with the road, which increases rolling resistance but reduces slipping friction. This makes pushing easier compared to inflated tyres, where rolling friction is less effective for pushing.

6. When standing on a crowded school bus, which stance provides better stability: legs joined or legs spread apart?

Standing with legs spread apart provides better stability because it increases the base of support. A wider base reduces the chances of toppling when an external force acts on the body.

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7. Why is a moving bicycle easier to balance? Relate this to rotational motion.

A moving bicycle is easier to balance due to rotational motion of the wheels, which provides stability through angular momentum. The rotating wheels resist changes in direction, helping the bicycle remain upright.

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8. Why is a pencil standing on its tip unstable? What factors affect the stability of an object balanced on a point?

A pencil standing on its tip is unstable because its center of gravity is very high and the base of support is very small. Stability depends on the height of the center of gravity and the area of the base of support.

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9. While driving, what happens if the driver takes a curve too fast? How does centripetal force help prevent skidding?

If a car takes a curve too fast, insufficient centripetal force is available, causing the car to skid outward. Friction between the tyres and the road provides the required centripetal force to keep the car on the curved path.

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10. When swinging a ball attached to a string in a circle, how does tension vary and what forces are involved?

The tension in the string provides the centripetal force required for circular motion. Tension remains directed toward the center and may vary with speed, mass of the ball, and radius of the circular path.

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11. Why must communication satellites in geostationary orbit maintain a specific speed?

A specific speed is required so that the gravitational force exactly provides the necessary centripetal force. This allows the satellite to remain in a fixed position relative to Earth, enabling continuous communication.

Long Response Questions:

1. Differentiate between like and unlike parallel forces.

Parallel forces are forces that act in the same plane and whose lines of action are parallel to each other. When two or more parallel forces act in the **same direction**, they are called **like parallel forces**. These forces combine to produce a resultant force equal to the sum of their magnitudes and act in the same direction.

When parallel forces act in **opposite directions**, they are called **unlike parallel forces**. In this case, the resultant force is equal to the difference of their magnitudes and acts in the direction of the larger force. Like parallel forces tend to move or rotate a body in the same direction, while unlike parallel forces may balance each other or cause rotation depending on their points of application.

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2. What is moment of force or torque? On what factors does it depend? Write its mathematical formula.

The **moment of force**, also called **torque**, is the turning effect of a force about a fixed point or axis. It determines the ability of a force to rotate a body around a pivot.

The moment of force depends on two factors: the **magnitude of the applied force** and the **perpendicular distance** between the line of action of the force and the pivot point. A larger force or a greater distance produces a larger turning effect.

Mathematically, moment of force is given by

$\tau = F \times d$

where **F** is the applied force and **d** is the perpendicular distance from the pivot. Its SI unit is **newton meter (Nm)**.

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3. Define center of mass. What is the effect of mass distribution in a body on its center of mass?

The **center of mass** of a body is the point at which the whole mass of the body can be considered to be concentrated for translational motion. It represents the average position of all the mass elements of the body.

If the mass of a body is **uniformly distributed**, the center of mass lies at the geometrical center of the body. However, if the mass distribution is **non-uniform**, the center of mass shifts toward the region containing more mass. Changing the shape or distribution of mass within a body changes the position of its center of mass. The motion of the body can be described as the motion of its center of mass.

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4. What is center of gravity? Where will be the center of gravity of regular shaped bodies? Differentiate between center of mass and center of gravity.

The **center of gravity** of a body is the point through which the entire weight of the body acts vertically downward. For regular shaped bodies made of uniform material, the center of gravity coincides with the geometrical center.

For a **circular plate**, rectangular plate and square plate, the center of gravity lies at the center. For a **triangular plate**, it lies at the point where the medians intersect. For a **cylinder and sphere**, it lies at their geometric centers. (Figures are drawn in examination to support the answer.)

The center of mass depends only on mass distribution, while the center of gravity depends on the gravitational field. In a uniform gravitational field, both points coincide.

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5. How can you find the center of gravity of an irregular shaped thin sheet of plastic?

The center of gravity of an irregular shaped thin sheet can be found by the **suspension method**. First, a small hole is made near the edge of the sheet, and the sheet is suspended freely from this hole using a pin or nail. A plumb line is hung from the same point and a vertical line is drawn along the direction of the plumb line.

The sheet is then suspended from another point and the process is repeated to draw a second vertical line. The point where the two vertical lines intersect gives the position of the center of gravity of the sheet. This method works because the entire weight of the sheet always acts vertically downward through its center of gravity.

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6. What is equilibrium? Describe the conditions of equilibrium. State and explain the principle of moments.

A body is said to be in **equilibrium** if it is either at rest or moving with constant velocity and no net force or turning effect acts on it. In equilibrium, the body does not accelerate or rotate.

For a body to be in equilibrium, two conditions must be satisfied. First, the **resultant force** acting on the body must be zero. Second, the **resultant moment (torque)** about any point must also be zero.

The **principle of moments** states that *for a body in equilibrium, the sum of clockwise moments about a point is equal to the sum of anticlockwise moments about the same point*. This principle is widely used in balancing beams, levers and weighing scales.

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7. Propose how the stability of an object can be improved. Illustrate the applications of stability physics in real life.

The stability of an object can be improved by **lowering its center of gravity** and **increasing the area of its base**. A low center of gravity makes it difficult for the object to topple, while a wide base provides greater support.

Real-life applications of stability include racing cars, which are designed with a low center of gravity to prevent overturning. Buildings are constructed with wide foundations to improve stability. Athletes spread their legs while standing to increase base area and avoid falling. These examples show how stability principles are applied in daily life.

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8. Define force of friction. What causes friction? What are the advantages and disadvantages of friction? How can friction be reduced?

The **force of friction** is the force that opposes the relative motion or the tendency of motion between two surfaces in contact. It always acts in a direction opposite to the motion of the body. Friction plays an important role in our daily life.

Friction is caused due to the **interlocking of microscopic irregularities** present on the surfaces in contact. Even surfaces that appear smooth have tiny roughness which resists motion. Greater the roughness and normal force, greater is the frictional force.

Friction has many advantages. It enables us to walk without slipping, allows vehicles to move on roads, and helps in writing and holding objects. Without friction, brakes would not work and motion control would be impossible.

However, friction also has disadvantages. It causes **wear and tear** of machine parts, produces heat, and results in loss of useful energy. To reduce friction, lubricants are used, surfaces are polished, ball bearings are introduced, and objects are streamlined.

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9. Compare rolling friction and sliding friction. How are they different in terms of contact surfaces, motion, and forces involved? Explain with examples.

Sliding friction occurs when one surface slides over another surface, such as a book sliding on a table. In this case, a large number of surface irregularities interlock with each other, producing greater resistance to motion.

Rolling friction occurs when a body rolls over a surface, such as a wheel moving on a road. In rolling motion, the contact between surfaces continuously changes, reducing the interlocking of irregularities.

Rolling friction is much smaller than sliding friction and requires less force to maintain motion. Sliding friction produces more heat and energy loss. This is why wheels and ball bearings are used in vehicles and machines instead of dragging objects directly on surfaces.

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10. Analyse the dynamics of an object reaching terminal velocity.

When an object falls freely through air, it accelerates due to the gravitational force acting downward. At the same time, air resistance acts upward and increases as the speed of the object increases.

Initially, the gravitational force is greater than air resistance, so the object accelerates. As the speed increases, air resistance also increases until it becomes equal to the weight of the object.

When air resistance equals gravitational force, the net force acting on the object becomes zero. As a result, acceleration becomes zero and the object continues to fall with a constant maximum speed called **terminal velocity**.

Terminal velocity depends on the mass, shape, surface area of the object and the density of the medium through which it moves.

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11. Define centripetal force. Describe the motion of a body in a circular path under the action of centripetal force.

Centripetal force is the force that acts toward the center of a circular path and keeps a body moving along that path. Without centripetal force, a body cannot move in a circular path.

In circular motion, the speed of the body may remain constant, but its velocity continuously changes due to change in direction. This change in velocity requires a force acting toward the center of the circle.

The centripetal force does not do work on the body but continuously changes the direction of motion. Examples include tension in a string, gravitational force in planetary motion, and friction between tyres and road when a car turns.

12. Identify different sources of centripetal force in real-life examples.

Centripetal force can be provided by different physical forces depending on the situation. When a stone is tied to a string and whirled in a circle, the **tension in the string** provides the centripetal force.

In the motion of planets and satellites, **gravitational force** acts as the centripetal force that keeps them in orbit. When a car moves along a curved road, **friction between the tyres and the road** provides the required centripetal force.

In circular motion of charged particles, **magnetic force** acts as centripetal force. Thus, centripetal force is not a new force but can be provided by various forces in different situations.

