CLASS 9TH PHYSICS • UNIT 3

Dynamics

Complete Notes, Numericals & MCQs

Colorful Study Booklet

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1 Q.1. Define and explain concept of force.

Ans. Concept of Force: A force is commonly defined as a push or pull that starts, stops, or changes the magnitude and direction of an object's velocity.

Explanation: (i) Opening a door involves pushing/pulling. (ii) Sitting in a turning car, we push against the seat. (iii) Force transfers energy - a man moving a wheelbarrow applies force to lift and push it. (iv) Other examples: gravity, friction while walking.

2 Q.2. Differentiate between contact and non-contact forces with detailed examples of daily life.

Ans. (i) Contact Forces: exerted by one object on another at the point of contact.

(a) Friction - resists motion, e.g. helps us walk.

(b) Drag - resistive force from motion through a fluid.

(c) Thrust - upward force from a liquid, e.g. ships float.

(d) Normal Force - reaction force perpendicular to a surface.

(e) Air Resistance - opposition offered by air.

(f) Tension Force - force in a pulled rope.

(g) Elastic Force - restoring force, e.g. springs, rubber bands.

(ii) Non-Contact Forces: act between objects not in physical contact (field forces).

(a) Gravitational Force - attractive force between masses, F = G(m1 m2 / r^2), G = 6.67x10^-11 N.m2/kg2.

(b) Electrostatic Force - between charged objects, opposite charges attract, like charges repel.

(c) Magnetic Force - between magnets/magnetic materials, like poles repel, unlike attract.

(d) Strong and Weak Nuclear Forces - act between subatomic particles.

3 Q.3. Explain four fundamental forces in nature. Explain contribution of Dr. Abdus Salam in unification of weak nuclear and electromagnetic forces.

Ans. (i) Gravitational Force: weakest, long-range, extends to infinite distances, keeps planets in orbit.

(ii) Electromagnetic Force: causes interactions between charged particles, long-range, stronger than gravity/ weak force, responsible for chemical reactions and friction.

(iii) Strong Nuclear Force: binds protons and neutrons, short-range (~10^-14 m).

(iv) Weak Nuclear Force: responsible for beta decay, stronger than gravity but weaker than EM force, short-range (~10^-17 m).

Unification: Dr. Abdus Salam, with Sheldon Glashow and Steven Weinberg, unified weak nuclear and electromagnetic forces into the electroweak force, earning the Nobel Prize in Physics in 1979. This unification becomes apparent at very high energies.

4 Q.4. What is meant by free-body diagram? Explain by means of a suitable example.

Ans. Free-Body Diagram: shows relative magnitudes and directions of all forces acting on an object - a special vector diagram.

Drawing: object shown as a box; force arrows drawn outward from the center, length reflecting magnitude, arrowhead showing direction; each force labeled (friction, gravity, normal force, drag, tension).

5 Q.5. State and explain Newton's First Law of motion.

Ans. Newton's First Law: "A body continues its state of rest or of uniform motion in a straight line unless acted upon by some external force."

Example: A book on a table stays still unless pushed; a rolling ball eventually stops due to friction.

Explanation: When a bus stops suddenly, passengers move forward (tendency to continue motion); when it starts, passengers feel pushed back (tendency to remain at rest).

Force Definition (from First Law): "Force is an agency which changes or tends to change the state of rest or of uniform motion of a body."

Inertia: The property of a body to maintain its state of rest or uniform motion. Net force = resultant of all forces; required to change velocity.

Dependence: Inertia is directly related to mass - greater mass means greater inertia. This is why the First Law is called the law of inertia.

6 Q.6. State and explain Newton's Second Law of Motion in detail.

Ans. Newton's Second Law: "If a net external force acts upon a body, it accelerates the body in the direction of force. The magnitude of acceleration is directly proportional to the force and inversely proportional to the mass."

Mathematical Expression: a proportional to F, a proportional to 1/m, so a = F/m, or F = ma.

Newton (unit of force): The force required to produce 1 m/s2 acceleration in a 1 kg mass. 1 N = 1 kg.m/s2.

Effect on Velocity: Force can change magnitude, direction, or both of a body's velocity.

7 Q.7. State and explain Newton's Third Law of Motion giving examples from daily life.

Ans. Newton's Third Law: "For every action, there is always an equal but opposite reaction."

Action and Reaction: forces are simultaneous, act on two different bodies, equal in magnitude, opposite in direction - they never balance each other since they act on different objects.

Examples: (i) Block on a table - weight (action) and normal reaction force. (ii) Bullet fired from a gun - bullet moves forward (action), gun recoils backward (reaction).

8 Q.8. State the limitations of Newton's Laws of Motion.

Ans. Newton's laws apply with high accuracy to everyday motion but fail for particles moving near the speed of light, where relativistic mechanics (Einstein) is needed. Newton's laws provide a good approximation unless objects are extremely small or moving near light speed.

9 Q.9. Differentiate between mass and weight.

Ans. Mass: characteristic determining acceleration produced by force; scalar; same everywhere; SI unit kg; measured by ordinary balance; m = F/a.

Weight: force with which Earth attracts a body toward its center; vector, directed downward; varies with location (depends on g); SI unit newton (N); measured by spring balance; w = mg.

10 Q.10. Write a brief note on mechanical balances.

Ans. Balance Scales compare masses using standard masses. Mechanical Balance: rigid horizontal beam with a central knife-edge fulcrum, two pans; pointer indicates deflection; weights adjusted to bring beam to equilibrium. Mechanical Platform Balances: used for heavy items (flour bags, cement bags); fulcrum kept near one end so smaller calibrated weights balance heavier loads.

11 Q.11. Explain very briefly electronic balance.

Ans. No standard weights required; connects to power supply or uses dry cell batteries; more precise than mechanical balance; displays mass on screen; some can display total price based on rate per kg.

12 Q.12. Write a note on 'force meter' for measuring force.

Ans. Force Meter (newton meter/spring balance): has a spring; upper end attached to a handle, lower end has a hook; pointer indicates weight on a newton scale. Object hung on hook causes spring to stretch/compress; pointer shows the weight. Digital force meters measure weight directly in newtons.

13 Q.13. Define friction. Explain dissipative effect of friction.

Ans. Friction: "The force that opposes the motion of moving objects."

Dissipative Effect: Friction wastes energy as heat while overcoming resistance. Example: rubbing hands produces heat; machine parts heat up due to friction; tyres wear out; shooting stars burn up due to air friction.

14 Q.14. Write different types of friction with examples.

Ans. Sliding Friction (between two solid surfaces): (i) Static Friction - opposes an object starting to move; (ii) Kinetic Friction - exists once the object is sliding.

Rolling Friction: friction between a rolling body and surface - about 100 times smaller than sliding friction, since the wheel touches the surface at only a point without sliding. Used in ball bearings.

15 Q.15. Define and explain the concept of terminal velocity.

Ans. Terminal Velocity: the constant velocity reached when upward air resistance balances downward gravity, so the object stops accelerating.

Applications: Meteorites reach terminal velocity before hitting the ground; parachutes increase air resistance for paratroopers, giving a safe controlled descent.

16 Q.16. Write down few methods of reducing friction.

Ans. (i) Polishing Sliding Parts - reduces surface roughness. (ii) Using Oil or Grease - liquid friction is less than solid friction. (iii) Using Ball Bearings - converts sliding friction to rolling friction. (iv) Streamlining Vehicles - minimizes air/water resistance via streamline flow.

17 Q.17. Define momentum and impulse, and demonstrate how the rate of change of momentum relates to the applied force.

Ans. Momentum: quantity of motion of a body, p = m x v - a vector, SI unit kg.m/s or N.s.

Impulse: total change in momentum when a large force acts for a short time: F x delta t = m(v_f - v_i) = impulse of the force.

Rearranged: F = delta p / delta t. "The rate of change of momentum of a body is equal to the force acting on it" (Newton's second law restated). Direction of momentum change is same as direction of force.

18 **Q.18. State and explain Principle of Conservation of momentum.**

Ans. A system is a collection of objects; isolated system - no external force acts.

Principle: "If no external force acts on an isolated system, the total momentum of the system remains constant before and after the collision."

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

Example: Two identical balls - moving ball collides with stationary ball; first ball stops, second moves with the first ball's original velocity, momentum conserved. Applies to micro-objects (atoms, molecules) too.

19 **EXAMPLES (Unit 3)**

20 **Example 3.1: A 10 kg block on frictionless surface accelerates at 2 m/s2. Find force.**

Solution: F = ma = 10 x 2 = 20 N.

21 **Example 3.2: 7500 N applied to a 3000 kg truck. Find acceleration and time to go from 36 km/h to 72 km/h.**

Solution: a = F/m = 7500/3000 = 2.5 m/s2. v_i=10 m/s, v_f=20 m/s. t=(20-10)/2.5=4 s.

22 **Example 3.3: A 15 g bullet fired at 150 m/s. Find momentum.**

Solution: p = mv = 0.015 x 150 = 2.25 kg.m/s.

23 **Example 3.4: A 160 g cricket ball hit, leaves bat at 52 m/s, struck bat at -28 m/s, contact time 4x10^-3 s. Find average force.**

Solution: F = m(v_f - v_i)/t = 0.16[52-(-28)]/(4x10^-3) = 3200 N.

24 **Example 3.5: Bullet of mass m1 fired by gun of mass m2. Find velocity of gun in terms of bullet velocity v1.**

Solution: 0 = m1v1 + m2v2 => v2 = -(m1v1)/m2 (negative sign shows gun recoils backward).

25 **Example 3.6: A 3 kg ball at 5 m/s collides with stationary 2 kg ball, they move together. Find velocity after collision.**

Solution: m1v1 = (m1+m2)v => 15 = 5v => v = 3 m/s.

MULTIPLE CHOICE QUESTIONS (Exercise)

1 When we kick a stone, we get hurt. This is due to: (a) inertia (b) velocity (c) momentum (d) reaction

Ans: (d)

2 An object will continue its motion with constant acceleration until: (a) resultant force decreases (b) resultant force is zero (c) resultant force increases (d) resultant force is at right angle to tangential velocity

Ans: (b)

3 Which of the following is a non-contact force? (a) Friction (b) Air resistance (c) Electrostatic force (d) Tension in the string

Ans: (c)

4 A ball with momentum p bounces back with the same velocity. Its momentum p' is: (a) p'=p (b) p'=-p (c) p'=2p (d) p'=-2p

Ans: (b)

5 A particle of mass m with velocity v collides with an identical particle at rest. Velocity of first particle after collision: (a) v (b) -v (c) 0 (d) -1/2

Ans: (c)

6 Conservation of linear momentum is equivalent to: (a) Newton's 1st law (b) Newton's 2nd law (c) Newton's 3rd law (d) None

Ans: (c)

7 A 5 kg object at 10 m/s is acted on by a constant force for 5 s giving 2 m/s in opposite direction. Force is: (a) 5 N (b) -10 N (c) -12 N (d) -15 N

Ans: (c)

8 A large force acts for a very short time - easy to determine: (a) magnitude of force (b) time interval (c) product of force and time (d) none

Ans: (c)

9 A lubricant decreases friction because it: (a) decreases temperature (b) acts as ball bearings (c) prevents direct contact of surfaces (d) provides rolling friction

Ans: (c)

ADDITIONAL MCQs

1 Inertia of a body is related to: (a) mass (b) force (c) weight (d) friction

Ans: (a)

2 When a hanging carpet is beaten, dust flies off mainly due to: (a) action force on carpet (b) reaction force by carpet (c) inertia of dust (d) rate of change of momentum of carpet

Ans: (c)

3 A force of 5 N applied to a body weighing 10 N. Acceleration in m/s2: (a) 0.5 (b) 2 (c) 5 (d) 50

Ans: (a)

4 SI unit of linear momentum: (a) kg.m-1.s-1 (b) kg.m2.s-1 (c) N.m (d) kg.m.s-1

Ans: (d)

5 N/kg is equivalent to: (a) m/s (b) m/s2 (c) kg.m/s (d) kg.m/s2

Ans: (b)

6 Rate of change of momentum of free falling body equals its: (a) momentum (b) velocity (c) weight (d) size

Ans: (c)

7 Change in momentum of a body equals: (a) (force)(velocity) (b) (force)(time) (c) (mass)(time) (d) force

Ans: (b)

8 A 5 kg book placed on table, net force acting: (a) 0 N (b) 5 N (c) 25 N (d) 10 N

Ans: (a)

9 Thrust force is a consequence of which law: (a) first (b) second (c) third (d) fourth

Ans: (c)

10 Force acts for 2 s producing 50 kg.m/s change in momentum. Force is: (a) 100 N (b) 50 N (c) 25 N (d) 2 N

Ans: (c)

11 The force which moves the car is: (a) force developed by engine (b) force of friction between road and tyre (c) uniform velocity (d) water split on the road
Ans: (a)

12 Object of mass 1 kg on Earth's surface experiences a force of: (a) 1 N (b) 9.8 N (c) 100 N (d) any value
Ans: (b)

13 Net force on body falling in air with uniform velocity equals: (a) weight (b) air resistance (c) difference of weight and air resistance (d) zero
Ans: (d)

14 At the fairground, force balancing your weight is: (a) gravitational force (b) centripetal force (c) electrostatic force (d) frictional force
Ans: (b)

15 Water does not spill from a bucket revolved upside down in a vertical circle due to: (a) weight of water (b) centrifugal force on water (c) inertia of water (d) action-reaction balance
Ans: (b)

SHORT QUESTIONS

26 3.1 What kind of changes in motion may be produced by a force?

Answer: (i) Change in Speed - acceleration or deceleration. (ii) Change in Direction - e.g. circular motion. (iii) Change in Shape - deformation. (iv) Starting or Stopping Motion.

27 3.2 Give 5 examples of contact forces.

Answer: Frictional Force, Tension Force, Normal Force, Applied Force, Air Resistance.

28 3.3 An object moves with constant velocity in free space. How long will it continue?

Answer: Forever, unless an external force acts on it (Newton's First Law - no friction/air resistance in free space).

29 3.4 Define impulse of force.

Answer: Impulse = F x delta t = delta p (change in momentum). Unit: N.s or kg.m/s.

30 3.5 Why has Newton's first law not been proved on the Earth?

Answer: Because external forces like friction and air resistance are always present on Earth, constantly affecting motion.

31 3.6 When sitting in a car which suddenly accelerates from rest, you are pushed back into the seat, why?

Answer: Due to inertia - your body tends to resist the change in its state of rest (Newton's First Law).

32 **3.7 The force expressed in Newton's second law is a net force. Why?**

Answer: Because it is the total (resultant) force after summing all individual forces acting on the object, which causes acceleration.

33 **3.8 How can you show that rolling friction is lesser than sliding friction?**

Answer: In rolling, only a small area of contact touches the surface, reducing resistance; sliding involves direct surface contact creating more resistance.

34 **3.9 Define terminal velocity of an object.**

Answer: The constant velocity reached when upward air resistance balances downward gravity, so acceleration stops.

35 **3.10 An astronaut walking in space wants to return to his spaceship by firing a hand rocket. In what direction does he fire the rocket?**

Answer: Opposite to the spaceship direction - expelling gas one way pushes the astronaut back (Newton's Third Law).

ADDITIONAL SHORT QUESTIONS

36 **3.1 When and where was Sir Isaac Newton born, and what is the name of his famous book?**

Answer: Born in Lincolnshire on January 4, 1643. Famous book: "Principia Mathematica."

37 **3.2 When an astronaut throws a wrench in space, he moves in the opposite direction. Why?**

Answer: Newton's Third Law - equal and opposite reaction.

38 **3.3 What is the weight of a 100 g mass?**

Answer: m=0.1 kg, g=10 m/s2. w=mg=1 N.

39 **3.4 Why does water not form a wet layer between tyre and road on a wet road, reducing skidding?**

Answer: Tread pattern spaces allow water to be displaced, improving grip.

40 **3.5 Why does the surface temperature of a shuttle rise to over 950 C when re-entering the atmosphere?**

Answer: Friction with the atmosphere generates intense heat.

41 **3.6 Why don't human bones normally wear out, even after many years of use?**

Answer: The body has a natural lubricating system reducing friction in joints.

42 **3.7 How does a wheel produce a frictional force when it contacts the surface?**

Answer: The contact point flattens slightly under pressure, and this flat portion slides against the surface, producing friction.

43 **3.8 How does a hovercraft move over both water and ground?**

Answer: It ejects air underneath through powerful fans, creating a cushion of air with very small resistance.

44 **3.9 How does a cricketer reduce the impact of the ball when catching it?**

Answer: Draws hands back to increase the time of contact, reducing the force (impulse-momentum theorem).

45 **3.10 How does the momentum of the apple and arrow change when an arrow penetrates an apple?**

Answer: The apple's momentum changes due to the arrow's force; the apple applies an equal and opposite force on the arrow, changing its momentum too.

46 **3.11 How do soft packing materials protect fragile objects during transportation?**

Answer: They increase the time over which momentum changes, reducing the force on the object (Styrofoam, cardboard, bubble wrap).

47 **3.12 How do crumple zones in automobiles help protect passengers during an accident?**

Answer: They compress during a crash, absorbing energy in the outer (weaker) parts of the vehicle rather than transmitting it to occupants in the stronger passenger cabin.

48 **3.13 What is a seatbelt, and how does it help protect passengers in a car?**

Answer: A safety feature that prevents passengers from moving forward suddenly when the car stops, reducing chances of hitting the windshield/steering wheel.

49 **3.14 A person falling on a cemented floor gets badly hurt. Explain why?**

Answer: Newton's second law - large acceleration (short stopping time) means greater force, causing more injury on a hard floor.

50 **3.15 A person falling on sand is not hurt much. Explain why?**

Answer: Sand is soft and increases stopping time, decreasing the force (a proportional to F, and time increases means force decreases).

51 **3.16 A cricket player draws or pulls his hands while catching a ball. Explain why?**

Answer: Increases stopping time, decreasing the force on the hands (F proportional to 1/t).

52 **3.17 Why on shaking the branch of a tree fruits fall down?**

Answer: Due to inertia - fruits tend to remain at rest while the branch moves, so they detach and fall.

53 **3.18 When a bus suddenly starts, passengers fall in the backward direction. Explain why?**

Answer: The lower body moves with the bus while the upper body tends to remain at rest due to inertia, causing a backward fall.

54 **3.19 Why does dust fly off, when a hanging carpet is beaten with a stick?**

Answer: The carpet suddenly moves while dust particles tend to remain at rest due to inertia, so they separate from the carpet.

DESCRIPTIVE/APPLICATION QUESTIONS

55 **3.1 Two ice skaters (60 kg and 80 kg) push off on frictionless ice. The 60 kg skater gains 4 m/s. Explain using Newton's third law.**

Answer: Momentum of skater 1 = 60x4 = 240 kg.m/s. Total momentum stays zero (isolated system): 240 + 80v2 = 0 => v2 = -3 m/s. Skater 2 moves opposite direction at 3 m/s - forces equal and opposite.

56 **3.2 Inflatable air bags - advantage over seatbelts in terms of momentum?**

Answer: Airbags increase the time over which the passenger's momentum reaches zero, reducing force per impulse-momentum theorem (delta p = F x delta t).

57 **3.3 A horse refuses to pull a cart, arguing action-reaction cancels net force. What is wrong?**

Answer: The horse pushes against the ground (friction), and the ground's reaction force propels the horse and cart forward - net force on horse is not zero because of ground friction.

58 **3.4 When a cricket ball is hit high, a fielder draws hands back while catching. Why?**

Answer: Increases time to stop the ball, reducing force on hands (impulse-momentum theorem).

59 **3.5 When someone jumps from a small boat onto the river bank, why does the jumper often fall into the water?**

Answer: Newton's Third Law - jumping forward pushes the boat backward; the unbalanced backward motion of the boat can cause loss of balance, leading to a fall into the water.

60 **3.6 If friction vanishes suddenly, what could be the scenario of daily life activity?**

Answer: Walking would be impossible (no push-off grip); vehicles would slide uncontrollably; writing would leave no marks; holding objects would be impossible.

61 **3.7 Why does a balloon filled with air move forward when its air is released?**

Answer: (i) Newton's Third Law - air pushed backward (action), balloon pushed forward (reaction). (ii) Conservation of momentum - isolated system's total momentum is zero; escaping air's backward momentum is balanced by the balloon's forward momentum.

COMPREHENSIVE QUESTIONS

62 **3.1 Explain the concept of force by practical examples. -- See Q.1.**

63 **3.2 Describe Newton's laws of motion. -- See Q.5, 6, 7.**

64 **3.3 Define momentum and express Newton's 2nd law in terms of change in momentum. -- See Q.17.**

65 **3.4 State and explain the principle of conservation of momentum. -- See Q.18.**

66 **3.5 Describe the motion of a block on a table taking into account friction. What is static and kinetic friction? -- See Q.14.**

67 **3.6 Explain the effect of friction on vehicle motion in context of tyre surface and braking force.**

Answer: (i) Tire Surface Friction provides traction for acceleration, deceleration, cornering, but causes rolling resistance. (ii) Braking Force and Friction between brake pads and rotor slows the vehicle; road surface, tire condition, brake pad material, and temperature affect friction.

NUMERICAL PROBLEMS (Unit 3)

68 **3.1 A 10 kg block on smooth surface, horizontal force 5 N applied. Find (a) acceleration (b) velocity after 5 s.**

Solution: a=F/m=5/10=0.5 m/s2. v_f=v_i+at=0+0.5x5=2.5 m/s.

Result: (a) 0.5 m/s2 (b) 2.5 m/s.

69 **3.2 Mass of person = 80 kg. Find weight on Earth and on Moon (g_moon=1.6 m/s2).**

Solution: W_earth=80x10=800 N. W_moon=80x1.6=128 N.

Result: 800 N on Earth, 128 N on Moon.

70 **3.3 Force required to increase velocity of 800 kg car from 10 m/s to 30 m/s in 10 s?**

Solution: a=(30-10)/10=2 m/s2. F=ma=800x2=1600 N.

Result: 1600 N.

71 **3.4 A 5 g bullet fired at 300 m/s from a 10 kg gun. Find recoil speed of gun.**

Solution: 0=m_bullet v_bullet + m_gun v_gun => v_gun = -(0.005x300)/10 = -0.15 m/s.

Result: -0.15 m/s (opposite direction to bullet).

72 **3.5 An astronaut (70 kg) throws a 300 g wrench at 3.5 m/s. Find (a) recoil speed (b) distance covered in 30 min.**

Solution: v_ast = -(0.3x3.5)/70 = -0.015 m/s. Distance = 0.015x1800 = 27 m.

Result: (a) -1.5x10^-2 m/s (b) 27 m.

73 **3.6 A 6.5x10^3 kg bogie at 0.8 m/s couples with a 9.2x10^3 kg bogie at 1.2 m/s. Find common velocity.**

Solution: m1v1+m2v2=(m1+m2)v_f => 16240=15.7x10^3 v_f => v_f=1.03 m/s.

Result: 1.03 m/s.

74 **3.7 A 55 kg cyclist on a 5 kg bicycle applies 90 N for 8 s then constant speed for 8 more s. Find total distance.**

Solution: a=90/60=1.5 m/s2. v_f=1.5x8=12 m/s. S1=1/2x1.5x64=48 m. S2=12x8=96 m. Total=144 m.

Result: 144 m.

75 **3.8 A 0.4 kg ball dropped from 1.8 m rebounds to 0.8 m. Find magnitude and direction of impulse.**

Solution: v1=6 m/s (down), v2=4 m/s (up). Δp=m(v2-(-v1))=0.4x10=4 N.s, direction upward.

Result: 4 N.s, upward.

76 **3.9 Two balls (0.2 kg at 20 m/s, 0.4 kg at -5 m/s) collide; 0.2 kg ball becomes 6 m/s after. Find velocity of 0.4 kg ball.**

Solution: m1u1+m2u2=m1v1+m2v2 => 4-2=1.2+0.4v2 => v2=2 m/s.

Result: 2 m/s.