GRADE: XI Date: 02/12/24	TERM 2 EXAMINATION 2024-25 PHYSICS MS	Marks: 70 Time: 3h

SECTION A:

1. Bernoulli's principle is based on the principle of conservation of
   - (a) mass
   - (b) momentum
   - (c) energy
   - (d) linear momentum

   Answer: (c) energy

2. A particle is falling through a viscous liquid and reaches its terminal velocity. The acceleration then is
   - (a) g
   - (b) 0
   - (c) > g
   - (d) < g

   Answer: (b) 0

3. According to Stefan's law, the total energy emitted per second per unit area of the surface (E) is proportional to
   - (a) T
   - (b) T^2
   - (c) T^3
   - (d) T^4

   Answer: (d) T^4

4. An ideal fluid flows through a pipe of circular cross-section made of two sections with diameters 2.5 cm and 3.75 cm. The ratio of velocities in the pipe is
   - (a) 9:4
   - (b) 3:2
   - (c) $\sqrt{3}:\sqrt{2}$
   - (d) $\sqrt{2}:\sqrt{3}$

   Answer: (a) 9:4

5. Which of the following is not a derived quantity in the SI system?
   - (a) force
   - (b) work
   - (c) plane angle
   - (d) electric current

Answer: (d) electric current

6. The fastest mode of transmission of heat is
    - (a) induction
    - (b) conduction
    - (c) convection
    - (d) radiation

   Answer: (d) radiation

7. The number of significant figures in 0.002470 g cm^{-3} is:
    - (a) 3
    - (b) 4
    - (c) 5
    - (d) 6

   Answer: (c) 5

8. An object is weighed in the following places using a spring balance. In which place will it weigh the heaviest?
    - (a) on the moon
    - (b) equator
    - (c) pole
    - (d) outer space

   Answer: (c) pole

9. The escape velocity for a body projected vertically upwards from the surface of the Earth is 11 km per second. If the body is projected at an angle of 45° with the vertical, the escape velocity will be
    - (a) $11\sqrt{2}$ km/s
    - (b) 22 km/s
    - (c) 11 km/s
    - (d) $11/\sqrt{2}$ km/s

   Answer: (a) $11\sqrt{2}$ km/s

10. Which of the following is an example of uniformly accelerated motion?

- (a) Uniform circular motion
- (b) Free fall
- (c) Both a and b
- (d) Neither a nor b

Answer: (b) Free fall

11. A and B are two wires, the radius of A is twice that of B. They are stretched by the same load. Then the stress on B is

- (a) Equal to A
- (b) Four times that on A

- (c) 2 times that on A
- (d) Half that on A

Answer: (b) Four times that on A

12. Two bodies are projected with the same velocities such that they have the same horizontal range. At what angle might they have been projected?

- (a) 20° and 60°
- (b) 25° and 65°
- (c) 30° and 55°
- (d) 40° and 60°

Answer: (c) 30° and 55°

13. Assertion (A): Mass is a measure of inertia of the body in linear motion. Reason (R): Greater the mass, greater is the force required to change its state of rest or uniform motion.
    - (a) Both A and R are true and R is the correct explanation of A
    - (b) Both A and R are true and R is NOT the correct explanation of A
    - (c) A is true but R is false
    - (d) A is false and R is also false

    Answer: (a) Both A and R are true and R is the correct explanation of A

14. Assertion (A): If two objects of different masses have the same momentum, the lighter body possesses greater velocity. Reason (R): For all bodies, momentum always remains the same.
    - (a) Both A and R are true and R is the correct explanation of A
    - (b) Both A and R are true and R is NOT the correct explanation of A
    - (c) A is true but R is false
    - (d) A is false and R is also false

    Answer: (c) A is true but R is false

15. Assertion (A): Work done by or against gravitational force in moving a body from one point to another is independent of the actual path followed between the two points. Reason (R): Gravitational forces are conservative forces.
    - (a) Both A and R are true and R is the correct explanation of A
    - (b) Both A and R are true and R is NOT the correct explanation of A
    - (c) A is true but R is false
    - (d) A is false and R is also false

    Answer: (a) Both A and R are true and R is the correct explanation of A

16. Assertion (A): Adhesive force > cohesive, angle of contact is acute. Reason (R): Angle of contact is acute; liquids do not wet the glass.
    - (a) Both A and R are true and R is the correct explanation of A
    - (b) Both A and R are true and R is NOT the correct explanation of A
    - (c) A is true but R is false

- (d) A is false and R is also false

Answer: (c) A is true but R is false

SECTION B:

17. Find the orbital velocity of an artificial satellite of the earth given g = 10 m/s^2, R = 6400 km
    - Formula: $v = \sqrt{g \cdot R}$
    - Given: g = 10 m/s^2, R = 6400 km = 6.4×10^6 m
    - $v = \sqrt{10 \cdot 6.4 \times 10^6}$
    - $v = \sqrt{6.4 \times 10^7}$
    - $v \approx 8000$ m/s
18. Draw pressure vs Volume graphs for isobaric and isochoric process
    - In the isobaric process (constant pressure), the graph will be a straight horizontal line.
    - In the isochoric process (constant volume), the graph will be a vertical line.
19. One point of difference between streamline flow and turbulent flow:
    - Streamline flow has smooth, parallel layers with no mixing, while turbulent flow is chaotic and characterized by eddies and vortices.
    - Reynolds number helps distinguish between the two. If the Reynolds number (Re) is below 2000, the flow is generally laminar (streamline). If Re is above 4000, it is turbulent.
20. Cooking is easier in a pressure cooker but difficult on hills. Why?
    - In a pressure cooker, the pressure is higher, which increases the boiling point of water, allowing food to cook at higher temperatures.
    - On hills, the atmospheric pressure is lower, and water boils at a lower temperature, making cooking slower.

    OR

    The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but narrows down when held vertically down. Explain why?

    - The stream spreads upward due to the conversion of velocity into height against gravity. When held downward, the water accelerates due to gravity, and the stream narrows due to increased kinetic energy focused in a smaller cross-section.
21. Check the dimensional consistency of the equation: $\frac{1}{2} mv^2 = mgh$
    - Left side: $\frac{1}{2} mv^2$
        - Dimension of mass (m) is [M], velocity (v) is $[LT^{-1}]$.
        - Dimensional formula of $\frac{1}{2} mv^2 = M \times (LT^{-1})^2 = ML^2T^{-2}$
    - Right side: mgh

- Dimension of acceleration due to gravity (g) is $[LT^{-2}]$ and height (h) is [L].
- (\text{Dimensional formula of } mgh = M \times LT^{-2

22. Find out the load to be suspended at the end of a wire of length 8 meters to stretch it through 1 cm, diameter of the wire is 0.4 mm and Young's modulus of wire is 90×10^9 Pascal.

Solution: The formula for elongation of a wire under load is:

$$\Delta L = \frac{FL}{AY}$$

Where:

- ΔL is the elongation (1 cm = 0.01 m),
- F is the force (load),
- L is the length of the wire (8 m),
- A is the cross-sectional area of the wire,
- Y is Young's modulus of the wire.

The cross-sectional area A of the wire is:

$$A = \pi \left(\frac{d}{2}\right)^2 = \pi \left(\frac{0.4 \times 10^{-3}}{2}\right)^2 = 1.25664 \times 10^{-7}\,\mathrm{m}^2$$

Now substitute the known values into the elongation formula:

$$0.01 = \frac{F \times 8}{1.25664 \times 10^{-7} \times 90 \times 10^9}$$

Solving for F:

$$F = \frac{0.01 \times 1.25664 \times 10^{-7} \times 90 \times 10^9}{8} \approx 1.13\,\text{N}$$

Thus, the load to be suspended is approximately **1.13 N**.

---

23. State Stoke's formula and derive the expression for maximum constant velocity acquired by the body (Terminal velocity) by falling freely through a viscous medium.

Solution: Stoke's law for the motion of a small spherical object falling through a viscous medium states:

$$F = 6\pi\eta r v$$

Where:

- F is the resistive force (viscous drag),
- η is the dynamic viscosity of the fluid,
- r is the radius of the object,
- v is the velocity of the object.

At terminal velocity, the force due to gravity is balanced by the resistive force:

$$mg = 6\pi\eta r v_t$$

Where:

- m is the mass of the object,
- g is acceleration due to gravity,
- v_t is the terminal velocity.

Substituting $m = \frac{4}{3}\pi r^3 \rho$ (volume of the sphere times density of the object) into the equation:

Simplifying:

$$v_t = \frac{2r^2(\rho - \eta)}{9\eta}$$

Thus, the expression for terminal velocity v_t is:

$$v_t = \frac{2r^2(\rho - \eta)}{9\eta}$$

---

24. Why is $C_p > C_v$? Show that $C_p - C_v = R$.

Solution: C_p is the specific heat at constant pressure, and C_v is the specific heat at constant volume. $C_p > C_v$ because, when heating at constant pressure, the gas does work on its surroundings as it expands, so more heat is required to raise its temperature compared to heating at constant volume, where no work is done.

The relationship between C_p and C_v can be derived from the first law of thermodynamics and the ideal gas law:

$$dQ = C_v dT + PdV$$

At constant pressure, we use the ideal gas law $P = \frac{RT}{V}$ to get:

$$C_p - C_v = R$$

Thus, $C_p - C_v = R$, where R is the universal gas constant.

---

25. State Pascal's law and explain the working of a hydraulic lift. Obtain a relation connecting the mass of the object to be lifted and the force applied.

Solution: Pascal's Law states that a change in pressure applied to an enclosed fluid is transmitted

A **hydraulic lift** works based on Pascal's Law. The system consists of a large piston and a small piston connected by a hydraulic fluid. When a force is applied to the smaller piston, the pressure is transmitted through the fluid to the larger piston, lifting the heavy object.

Let F_1 be the force applied on the small piston, A_1 the area of the small piston, and F_2 the force on the large piston with area A_2.

According to Pascal's Law:

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Thus, the mass of the object $m = \frac{F_2}{g}$, so the relation becomes:

$$m = \frac{F_1 A_2}{A_1 g}$$

26. Distinguish between elastic and inelastic collision. Show that in one-dimensional elastic collision of two objects, the velocity of separation after collision is equal to the relative velocity of approach before collision.

Solution: Elastic Collision: Both momentum and kinetic energy are conserved. **Inelastic Collision:** Momentum is conserved, but kinetic energy is not conserved.

In one-dimensional elastic collision, for two objects with masses m_1 and m_2 and velocities u_1, u_2 before the collision, and v_1, v_2 after the collision, the following equations hold:

- Conservation of momentum:

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

- Conservation of kinetic energy:

$$\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$$

From these, the relative velocities before and after the collision are related as:

$$v_1 - v_2 = -(u_1 - u_2)$$

This shows that the velocity of separation after the collision is equal in magnitude and opposite in direction to the relative velocity of approach before the collision.

---

27. The reading of a pressure meter attached with a closed pipe is $4 \times 10^5 \, \mathrm{Nm}^{-2}$. On opening the valve of the pipe, the reading of the meter is reduced to $3.2 \times 10^5 \, \mathrm{Nm}^{-2}$. Calculate the velocity of water flowing in the pipe.

Solution: Using Bernoulli's equation, the pressure difference is related to the velocity of the fluid. Bernoulli's equation is:

$$P_1 + \frac{1}{2} \rho v_1^2 = P_2 + \frac{1}{2} \rho v_2^2$$

Assuming v_1 (velocity before opening the valve) is very small, and simplifying the equation:

$$P_1 - P_2 = \frac{1}{2}\rho v_2^2$$

Substitute the given values:

$$4 \times 10^5 - 3.2 \times 10^5 = \frac{1}{2} \times 1000 \times v_2^2$$

$$8 \times 10^4 = 500 \times v_2^2$$

Solving for v_2:

$$v_2^2 = \frac{8 \times 10^4}{500} = 160$$

$$v_2 = \sqrt{160} \approx 12.65\,\mathrm{m/s}$$

Thus, the velocity of the water is approximately **12.65 m/s**.

28. A liquid is flowing through a horizontal pipeline of varying area of cross-section. At a certain cross-section, the diameter of the pipe is 5×10^{-2} m and the velocity of flow is 25×10^{-2} m/s. Calculate the velocity of flow at another cross-section where the diameter is 1×10^{-2} m.

Solution: Using the **continuity equation** for flow of a liquid:

$$A_1 v_1 = A_2 v_2$$

Where:

- $A_1 = \pi \left(\frac{d_1}{2}\right)^2$,
- $A_2 = \pi \left(\frac{d_2}{2}\right)^2$,
- v_1 is the velocity at cross-section 1,
- v_2 is the velocity at cross-section 2.

Substitute the values:

$$\pi \left(\frac{5 \times 10^{-2}}{2}\right)^2 \times 25 \times 10^{-2} = \pi \left(\frac{1 \times 10^{-2}}{2}\right)^2 \times v_2$$

Substitute the values:

$$\pi \left(\frac{5 \times 10^{-2}}{2}\right)^2 \times 25 \times 10^{-2} = \pi \left(\frac{1 \times 10^{-2}}{2}\right)^2 \times v_2$$

Solving for v_2:

$$v_2 = \frac{(5 \times 10^{-2})^2 \times 25 \times 10^{-2}}{(1 \times 10^{-2})^2}$$

$$v_2 = \frac{25 \times 10^{-4} \times 25 \times 10^{-2}}{1 \times 10^{-4}} = 625\,\mathrm{m/s}$$

Thus, the velocity of the flow at the second cross-section is approximately **625 m/s**.

Question 29: Expression for acceleration due to gravity at the surface of the Earth, and its variation with distance

The acceleration due to gravity g at the surface of the Earth can be derived using Newton's law of gravitation.

The gravitational force F between two masses M (Earth's mass) and m (object's mass) separated by a distance r (Earth's radius) is given by:

$$F = \frac{GMm}{r^2}$$

According to Newton's second law of motion, the force acting on the object is also equal to its mass times its acceleration:

$$F = ma$$

Equating both expressions for force:

$$ma = \frac{GMm}{r^2}$$

Canceling m from both sides:

$$a = \frac{GM}{r^2}$$

This acceleration is the acceleration due to gravity g at the Earth's surface, where r is the Earth's radius, and G is the gravitational constant. Thus, the expression for g is:

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

Effect of moving away or towards the center of the Earth:

1. **Moving away from the Earth's surface:**
   As the distance r increases, the value of g decreases because $g \propto \frac{1}{r^2}$. So, if an object moves away from the Earth's surface, g becomes weaker as r increases.
2. **Moving towards the center of the Earth:**
   As an object moves toward the center of the Earth, the gravitational force decreases, because only the mass of the Earth enclosed within a sphere of radius r contributes to the gravitational force. The formula for g inside the Earth is:

   $$g = \frac{GM_{\text{enc}}}{r^2}$$

   where M_{enc} is the mass enclosed within a sphere of radius r. As the object gets closer to the center, M_{enc} decreases, and so does g. At the center of the Earth, $g = 0$.

Question 30: Streamline flow, turbulent flow, Bernoulli's theorem

1. **Streamline Flow vs. Turbulent Flow:**
   - **Streamline Flow:** In streamline flow, the fluid flows along well-defined paths called streamlines, with no crossing or mixing between adjacent streamlines. The velocity of the fluid remains constant along a streamline, and this type of flow is typically observed at low velocities and in small diameter pipes.

- **Turbulent Flow:** In turbulent flow, the fluid particles move in irregular and chaotic paths, causing mixing between adjacent layers. This flow occurs at higher velocities, leading to vortices and eddies.

2. **Bernoulli's Theorem:** Bernoulli's theorem states that for an incompressible, non-viscous fluid, the total mechanical energy (sum of pressure energy, kinetic energy, and potential energy) per unit volume remains constant along a streamline. It can be expressed as:

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

where:

- P is the pressure,
- ρ is the density,
- v is the velocity,
- g is the acceleration due to gravity,
- h is the height.

Proof for varying cross-section pipe:

Consider a fluid flowing through a pipe of varying cross-sectional area. Let the velocity of the fluid at two points, 1 and 2, be v_1 and v_2, and the cross-sectional areas be A_1 and A_2. From the continuity equation:

$$A_1 v_1 = A_2 v_2$$

By Bernoulli's equation at points 1 and 2:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

This shows that the total energy per unit volume (pressure energy, kinetic energy, and potential energy) remains constant along a streamline, even when the area of the pipe changes.

Question 31: Liquid drops and excess pressure

1. **Spherical Shape of Liquid Drops:** Liquid drops tend to take a spherical shape due to surface tension. The molecules at the surface experience an inward force, which causes the drop to minimize its surface area. A sphere has the smallest surface area for a given volume, which is why liquid drops adopt this shape.
2. **Excess Pressure:** The excess pressure inside a liquid drop or bubble is the pressure difference between the inside and the outside of the drop or bubble.
   - **For a liquid drop:** The excess pressure inside the drop is given by:

$$\Delta P = \frac{4\sigma}{r}$$

   where σ is the surface tension of the liquid, and r is the radius of the drop.

   - **For a liquid bubble:** The excess pressure inside a bubble is:

$$\Delta P = \frac{8\sigma}{r}$$

The difference arises because a bubble has two surfaces (inside and outside), while a drop has only one.

Question 32: Football Trajectory Analysis

i) **Type of motion and trajectory:** The motion of the football is projectile motion. The trajectory of the football is parabolic.

ii) **Acceleration during motion:** The acceleration of the football is due to gravity and is constant, g, directed downward throughout the motion. It is unaffected by the horizontal velocity of the football.

iii) **Expression for total time of flight:** The total time of flight for projectile motion is given by:

$$T = \frac{2v_0 \sin\theta_0}{g}$$

where v_0 is the initial velocity, and θ_0 is the angle of projection.

iv) **Angle for maximum range:** The angle for maximum horizontal distance (range) is $\theta_0 = 45^\circ$.

OR

For a projectile launched with a speed of $10\,\mathrm{m/s}$ at 60°:

- **Maximum height:**

  The maximum height is given by:

$$H_{\max} = \frac{v_0^2 \sin^2\theta_0}{2g}$$

  Substituting values:

$$H_{\max} = \frac{(10)^2 \sin^2 60^\circ}{2 \times 9.8}$$

$$H_{\max} = \frac{100 \times (\frac{\sqrt{3}}{2})^2}{2 \times 9.8} = \frac{100 \times 0.75}{19.6} = \frac{75}{19.6} \approx 3.83\,\mathrm{m}$$

Question 33: Surface Tension and Related Concepts

1. **Statement not true about surface tension:** (b) **Surface tension is a vector quantity** is false. Surface tension is a scalar quantity as it acts in the plane of the surface.
2. **Statement not true about angle of contact:** (b) **Angle of contact increases with increase in temperature of liquid** is false. Usually, the angle of contact decreases as temperature increases.
3. **Correct statement:** (c) **Reynolds number is a dimensionless quantity** is true.
4. **Angle of contact greater than 90°:** A liquid does not wet a solid surface if the angle of contact is greater than 90°. Thus, the correct answer is (d) greater than 90°.
