Applied Physics - 1, 2024 Question Paper and Solution

By Poly Notes Hub | Author: Arun Paul

Question

JANUARY 2024 102(N)

APPLIED PHYSICS-I

Time Allowed: 2.5 Hours *Full Marks: 60*

Answer to Question No. 1 of Group A must be written in the main answer script. In Question No. 1, out of 2 marks for each MCQ, 1 marks is allotted for right answer and 1 marks is allotted for correct explanation of the answer.
Answer any Five (05) Questions from Group-B.

GROUP-A

1. Choose the correct answer from the given alternatives and explain your answer (any ten): 2x10=20

i. The dimensional formula of torque is-
a) $[M^1 L^2 T^{-2}]$ b) $[M^1 L^2 T^2]$ c) $[M^2 L^2 T^{-2}]$ d) $[M^1 L^1 T^{-2}]$

ii. Which of the following pairs does not have the same dimensional formula?
a) Force and Thrust, b) Work and Heat, c) Velocity and Angular velocity, d) Acceleration and Acceleration due to gravity.

iii. The correct number of significant figures in 0.6230 is
a) 4 b) 3 c) 5 d) 2

iv. If the kinetic energy of a body increase by 100%, then momentum of the body increase by –
a) 112 % b) 100 % c) 41 % d) 50%

v. Angle of banking is independent of–
a) velocity of the vehicle b) radius of curvature c) acceleration due to gravity d) mass of vehicle

vi. Newton-second stands for the unit of
a) Energy b) Momentum c) torque d) energy

vii. On which of the following factor does the moment of inertia of an object not depend upon
a) Axis of rotation b) Angular velocity c) Distribution of mass d) Mass of an object.

viii. In an inclined plane, the relationship between angle of friction, θ and angle of repose, Φ is –
a) $\Phi > \theta$ b) $\Phi < \theta$ c) $\Phi = \theta$ d) $\Phi >> \theta$

ix. What energy transformation takes place when you turn on an electric light?
a) Chemical → light + heat b) Chemical → electrical + heat c) Mechanical → light + heat d) Electrical → light + heat

x. Angular momentum(L) of a rigid body is equal to (I=Moment of Inertia, ω = angular speed, α = angular acceleration) a) $L = I\omega$ b) $L = \frac{1}{2} I\omega$ c) $L = \frac{1}{2} I^2\omega$ d) $L = I\alpha$

xi. A load of 98 N is suspended by a wire of length 1 m and cross-sectional area is 0.10 cm^2. The longitudinal stress will be _____. a) 98×10^4 N/m^2 b) 9.8×10^6 N/m^2 c) 980 N/m^2 d) 9.8×10^3 N/m^2.

xii. When the detergent is added to Water, its surface tension will
a) decreases b) increases c) remains unchanged d) none of these.

xiii. What is the relation between the viscosity of Blood and Water ?
a) Both are equal. b) Blood is more viscous than water. c) Water is more viscous than blood.
d) They cannot be compared.

xiv. While deducing the relation $C_P - C_V = R$, the amount of gas taken should be –
a) Any amount b) n mole c) 1 mole d) 1 gm

xv. At what temperature, do the Celsius and Fahrenheit scale gives the same reading?
a) 40^0 b) 0^0 c) -40^0 d) 72^0

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Question

GROUP-B
Answer any Five (05) questions.

2. a) Give the name of fundamental physical quantities and their units in S.I. system.
   b) The viscous force (F) acting on a steel ball falling through a viscous liquid may depend on i) radius (r) of the ball, ii) coefficient of viscosity(η) of the liquid and iii) terminal velocity (v) of the steel ball. Find an expression for the viscous force (F) by the method of dimensional analysis.
   c) What do you mean by absolute error and percentage in the measurement? (3+3+2).

3. a) State the principle of conservation of linear momentum.
   b) A 10 kg gun fires a bullet of mass 50g with a velocity of 400 m/s. Find the recoil velocity of the gun.
   c) Give one example of centrifugal force.
   d) Why does a cyclist bend inwards while riding along a curved path? (2+3+1+2)

4. a) What is meant by coefficient of friction and angle of friction?
   b) Prove that the total mechanical energy of a freely falling body under gravity is conserved.
   c) A body of mass 5 kg is dropped from a tower of height 100 m. Calculate the kinetic energy of the body when it hits the ground. (2 + 3 + 3)

5. a) Define the terms angular momentum and the torque. Write down the relation between them.
   b) State perpendicular axes theorem.
   c) An uniform circular disc having diameter 2 m and mass 2 kg undergoes rotational motion. Evaluate the moment of inertia about an axis passing through the centre and perpendicular to its plane. (1+1+1)+2+3

6. a) Define stress, strain and elastic limit.
   b) What do you understand by the statement that Young's modulus of structural steel is 2.0×10^{11} N/m^2 ?
   c) Draw and explain a typical stress-strain curve for a metal (mild steel). (1+2) +2+ (1+2)

7. a) What is Reynold number ? State the difference between streamline flow and turbulent flow.
   b) A drop of liquid is always tends to acquire spherical shape—Give reason.
   c) Write Bernoulli's Principle and give one example of application where the Bernoulli principle is applied in daily life. (1+2)+2+(2+1)

8. a) Define molar specific heat of a gas at constant volume and at constant pressure. Write the S.I. unit of molar specific heat.
   b) Find the dimension of the coefficient of thermal conductivity.
   c) The walls of a refrigerator are 8cm thick having a surface area 15m^2. The temperature outside the refrigerator is 35^{0}C. How much power in watt must the refrigerator supply in order to maintain 0^{0}C inside the refrigerator. Thermal conductivity of the material of the refrigerator is K= 0.42 S.I. unit. (1+1+1) +2+3

9. a) Define coefficient of volume expansion of a solid substance and write its relation with the coefficient of linear expansion.
   b) State the equation of continuity of a fluid flow. Which conservation law is expressed by the equation of continuity?
   c) What do you mean by the statement "The coefficient of linear expansion of brass is 19 x 10^{-6} K^{-1}" ? (2+1)+(2+1)+2

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Answers

Group A

i. The dimensional formula of torque is:

Torque (T) = Force × Distance = $[M^1L^1T^{-2}] \times [L]$

= $[M^1L^2T^{-2}]$

Answer: (b) $[M^1L^2T^{-2}]$

ii. Which of the following pairs does not have the same dimensional formula?

- **Force and Thrust:** Same dimensional formula $[M^1L^1T^{-2}]$
- **Work and Heat:** Same dimensional formula $[M^1L^2T^{-2}]$
- **Velocity and Angular Velocity:** Different (Velocity is $[M^0L^1T^{-1}]$, Angular Velocity is $[T^{-1}]$)
- **Acceleration and Acceleration due to gravity:** Same dimensional formula $[M^0L^1T^{-2}]$

  Answer: (c) Velocity and Angular Velocity

iii. The correct number of significant figures in 0.6230 is:

- The trailing zero after the decimal point counts as significant.

  Answer: (a) 4

iv. If the kinetic energy of a body increases by 100%, then momentum of the body increases by:

- Kinetic energy (KE) = $\frac{1}{2}mv^2$, and momentum (p) = mv.
- If KE increases by 100%, the velocity increases by $\sqrt{2}$.
- Momentum increases by $\sqrt{2}$, which is approximately **41%**.

  Answer: (c) 41%

v. Angle of banking is independent of:

- Banking angle depends on velocity, radius of curvature, and acceleration due to gravity. It does not depend on the **mass of the vehicle**.

  Answer: (d) Mass of the vehicle

vi. Newton-second stands for the unit of:

- Impulse or momentum = Force × Time = $[M^1L^1T^{-1}]$.

  Answer: (b) Momentum

vii. On which of the following factors does the moment of inertia of an object not depend upon:

- Moment of inertia depends on axis of rotation, mass distribution, and total mass, but not on angular velocity.

  Answer: (b) Angular velocity

viii. In an inclined plane, the relationship between angle of friction (θ) and angle of repose (Φ) is:

- Angle of friction = Angle of repose, i.e., $\Phi = \theta$.

  Answer: (c) Φ = θ

ix. What energy transformation takes place when you turn on an electric light?

- Electrical energy is converted to light and heat energy.

  Answer: (d) Electrical → Light + Heat

x. Angular momentum (L) of a rigid body is equal to:

- Angular momentum = $I\omega$, where I is the moment of inertia and ω is angular velocity.

  Answer: (a) $L = I\omega$

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Answers

Group A

xi. A load of 98 N is suspended by a wire of length 1 m and cross-sectional area is 0.10 cm². The longitudinal stress will be:

- Stress = Force / Area = $98\,N/(0.10\times10^{-4})\,m^2 = 9.8\times10^6\,N/m^2$.
  Answer: (b) $9.8\times10^6\,N/m^2$

xii. When the detergent is added to water, its surface tension will:

- Detergents reduce surface tension.
  Answer: (a) Decrease

xiii. What is the relation between the viscosity of blood and water?

- Blood is more viscous than water due to its plasma and cellular components.
  Answer: (b) Blood is more viscous than water.

xiv. While deducing the relation $C_p - C_v = R$, the amount of gas taken should be:

- The relation is derived for 1 mole of gas.
  Answer: (b) 1 mole

xv. At what temperature do the Celsius and Fahrenheit scales give the same reading?

- Using the relation $C = \frac{5}{9}(F-32)$, solve $C = F$:
  $C = \frac{5}{9}(C-32) \implies C = -40.$
  Answer: (c) -40°

Group B

2.

a) Fundamental physical quantities and their S.I. units:

- Length: **Meter (m)**
- Mass: **Kilogram (kg)**
- Time: **Second (s)**
- Electric Current: **Ampere (A)**
- Temperature: **Kelvin (K)**
- Luminous Intensity: **Candela (cd)**
- Amount of Substance: **Mole (mol)**

b) Viscous force acting on a steel ball falling through a viscous liquid depends on:

- Radius (r): Larger radius → greater force.
- Coefficient of viscosity (η): Higher viscosity → more resistance.
- Terminal velocity (v): Faster motion → greater force.

Using dimensional analysis, viscous force is given as:
$F = 6\pi\eta r v$

c) Definitions:

- Absolute Error: The difference between the measured value and the true value.
- Percentage Error: The absolute error divided by the true value, expressed as a percentage.

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Answers

Group B

3.

a) Principle of conservation of linear momentum:

- Total momentum before collision = Total momentum after collision.

b) Recoil velocity of gun:

Using momentum conservation:

$m_1v_1 = m_2v_2$

Given: $m_1 = 10\,\text{kg}, v_1 = ?, m_2 = 0.05\,\text{kg}, v_2 = 400\,\text{m/s}$:

$v_1 = \frac{m_2v_2}{m_1} = \frac{0.05\times400}{10} = 2\,\text{m/s}$

c) Example of centrifugal force:

Water moving outward in a spinning bucket.

d) Cyclist bending:

A cyclist bends inward to balance centripetal force and reduce the chance of toppling.

4.

a) Coefficient of friction and angle of friction:

- Coefficient of friction (μ): Ratio of frictional force to normal force.
- Angle of friction (θ): $\tan\theta = \mu$.

b) Mechanical energy conservation:

- Total energy ($K.E + P.E$) remains constant for a freely falling body.

c) Kinetic energy of a body:

Given: $m = 5\,\text{kg}, h = 100\,\text{m}, g = 9.8\,\text{m/s}^2$:

$K.E = mgh = 5 \times 9.8 \times 100 = 4900\,\text{J}$

5.

a) Angular momentum and torque:

- Angular momentum ($L = I\omega$).
- Torque ($\tau = I\alpha$).

b) Perpendicular axes theorem:

- The moment of inertia about an axis perpendicular to a plane is the sum of moments of inertia about two perpendicular axes in the plane.

c) Moment of inertia of a circular disc:

Given: $r = 1\,\text{m}, m = 2\,\text{kg}$.

Moment of inertia about perpendicular axis:

$I = \frac{1}{2}mr^2 = \frac{1}{2} \times 2 \times 1^2 = 1\,\text{kg.m}^2$

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Answers

Group B

6.

a) Definitions:

- Stress: Force per unit area (N/m^2).
- Strain: Ratio of deformation to original dimensions (no unit).
- Elastic limit: Maximum stress a material can withstand without permanent deformation.

b) Young's modulus of steel:

Stress-strain relation for structural steel = $2.0 \times 10^{11}\,\mathrm{N/m^2}$.

c) Stress-strain curve:

Draw the typical curve showing:

- Proportionality limit.
- Elastic limit.
- Yield point.
- Ultimate tensile strength.

7.

a) Reynold number:

- Ratio of inertial forces to viscous forces.
- Streamline flow: Smooth motion.
- Turbulent flow: Chaotic motion.

b) Spherical shape of a drop:

Due to surface tension minimizing the surface area.

c) Bernoulli's principle:

- Total energy (pressure, kinetic, potential) is constant in streamline flow.
  Example: Lift on airplane wings.

8.

a) Molar specific heat:

- Heat capacity per mole at constant volume or pressure.
- S.I. unit: $J/(mol.K)$.

b) Thermal conductivity dimension:

$[M^1L^1T^{-3}\Theta^{-1}]$.

c) Power for refrigerator:

Given: Thickness = $0.08\,\mathrm{m}$, Area = $15\,\mathrm{m^2}$, $K = 0.42$, $T = 35\,^\circ\mathrm{C}$.

$P = \frac{KA(T_2-T_1)}{d} = \frac{0.42\times15\times35}{0.08} = 2756.25\,\mathrm{W}$

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Answers

Group B

9.

a) Coefficient of volume expansion:

- Fractional change in volume per unit temperature change.
- Relation: $\beta = 3\alpha$.

b) Equation of continuity:

$A_1 v_1 = A_2 v_2$ (Conservation of mass).

c) Linear expansion of brass:

- Coefficient $\alpha = 19 \times 10^{-6} K^{-1}$:
  A small expansion per degree temperature rise.