March 2023

APPLIED PHYSICS - I

Time Allowed: 2.5 Hours *Full Marks: 60*

Answer to Question No. 1 of Group A is compulsory and to be answered first. This answer is to be made in separate loose script(s) provided for the purpose. Maximum time allowed is 30 minutes, after which the loose answer scripts will be collected and fresh answer scripts for answering the remaining part of the question will be provided. On early submission of answer scripts of Question No. 1, a student will get the remaining script earlier.
Answer any Five (05) Questions from Group B.

Group A

1. Choose the correct answer from the given alternatives (any twenty): 1x20

(i) Which of the following pairs of physical quantities does not have same dimensional formula?
(a) work and torque, (b) impulse and linear momentum, (c) tension and surface tension, (d) angular momentum and Planck's constant.

(ii) The dimension of thermal conductivity is - (a) $MLT^{-2}K^{-1}$, (b) MLT^{-3}, (c) $MLT^{-3}K^{-1}$, (d) MLT^{-1}

(iii) The SI unit of stress is – (a) N (b) Nm^2 (c) Nm^{-2} (d) $N^{-1}m^2$.

(iv) If the percentage error in measurement of radius of a sphere is 2%, then the percentage error in measurement of its volume is - (a) 4%, (b) 6%, (c) 40%, (d) 60%.

(v) What is the shape of the graph between the speed and kinetic energy of a body?
(a) straight line (b) hyperbola (c) parabola (d) exponential

(vi) The rocket propulsion is based on the principle of conservation of – (a) mass, (b) linear momentum, (c) angular momentum, (d) kinetic energy.

(vii) A ball of mass 5 Kg strikes a wall with a speed of 10 m/sec and rebounds with the same speed. The change in momentum of the ball is – (a) Zero (b) 50 Kg-m/sec (c) 100 Kg-m/sec (d) none of these.

(viii) The angular velocity of the second hand of a clock is – (a) 2π rad/s, (b) $\frac{\pi}{3}$ rad/s,(c) $\frac{\pi}{5}$ rad/s, (d) $\frac{\pi}{30}$ rad/s.

(ix) When milk is churned, cream separates out because of - (a) cohesive force, (b) gravitational force, (c) viscous force, (d) centrifugal force.

(x) A mass of liquid is stirred and then allowed to settle. The liquid ultimately comes to rest because of - (a) inertia (b) viscosity (e) surface tension (d) none of these.

(xi) The ratio of kinetic energy of two body of mass m & 4m is 2:1, then the ratio of their linear momentum will be – (a) 1: $\sqrt{2}$, (b) 1:2, (c) 1:4, (d) 1:6.

(xii) Moment of inertia of the ring about an axis passing through the centre and perpendicular to the plane of the ring is mr^2. What will be the moment of inertia of the ring about its tangent - (a) $\frac{mr^2}{2}$, (b) $2mr^2$, (c) $\frac{3}{2}mr^2$, (d) None of these.

(xiii) If moment of inertia = I, angular velocity = ω, angular acceleration = α, torque = τ then which of the following relation is correct – (a) $\tau = I\omega$, (b) $\tau = I\alpha$, (c) $\alpha = I\omega$, (d) $\omega = I\alpha$.

(xiv) The longitudinal strain of a wire is 0.5×10^{-3} and its Poisson's ration is 0.2. The value of the lateral strain of the wire is - (a) 10^{-5}, (b) 10^{-4}, (c) 10^{-3}, (d) 10^{-2}.

(xv) Young's modulus of a perfectly rigid body is - (a) non-zero, (b) one, (c) zero, (d) infinity.

(xvi) A uniform rod of mass **m**, length **l**, area of cross-section **A** and Young's modulus **Y** hangs from ceiling. Its elongation under its own weight will be - (a) mgl/AY, (b) 4mgl/AY, (c) mgl/2AY, (d) zero.

(xvii) Hook's law is valid within - (a) length limit, (b) elastic limit, (c) temp. limit, (d) physical conditions limit.

(xviii) The specific gravity of a substance is 2.5. The density of the substance in kg/m^3 is – (a) 2.5, (b) 2.5x 62.5, (c) 2.5×10^3, (d) $2.5/10^3$.

(xix) Bernoulli's Theorem in fluid dynamics is another form of law of conservation of - (a) mass, (b) momentum, (c) energy, (d) none.

(xx) The height of liquid in a capillary tube of radius **r** is **h**. The height of the liquid in another capillary tube of same material but of radius **r/2** is - (a) h/2, (b) b, (c) 2h, (d) 4h.

(xxi) The rise of liquid in a capillary tube is directly proportional to - (a) radius of the tube, (b) density of the liquid, (c) surface tension of the liquid, (d) g.

(xxii) The internal energy of an ideal gas depends on – (a) pressure, (b) volume, (c) temperature, (d) size of the molecules.

(xxiii) Which process needs gravity?
(a) Conduction, (b) Convection, (c) Radiation, (d) All of these.

(xxiv) The difference of temperature of two bodies in Celsius scale is 25°. In Fahrenheit scale this difference will be – (a) 69°, (b) 27°, (c) 15°, (d) 45°.

(xxv) The SI unit of universal gas constant "R" is - (a) $N\ mole^{-1}\ K^{-1}$, (b) gm-mole K^{-1}, (c) $J\ mole^{-1}\ K^{-1}$, (d) none of these.

Group B

2. a) State the principle of dimensional homogeneity.
   b) The centripetal force depends on the mass 'm' of a body, the velocity 'v' and the radius 'r'. Find the expression of it with the help of dimensional analysis.
   c) In an experiment, the values of refractive index of glass were found to be 1.54, 1.53, 1.44, 1.54, 1.56, and 1.45 in successive measurements. Calculate (i) absolute error (ii) mean error and (iii) percentage error. 2+3+3

3. a) State the principle of conservation of mechanical energy.
   b) A man of mass 60 Kg carries a load of 20 Kg to the top of a building of height 15m in 2 min. Find the power of the man. Take $g = 10 m/sec^2$.
   c) "A body executing uniform circular motion in a circular path does no work" – Explain. 2+4+2

4. a) Which one is more fundamental - stress or strain? Explain. State the factors on which modulus of elasticity depend?
   b) Draw the stress-strain graph of an elastic body.
   c) Find the tension in a steel wire of length 3m and of diameter 1 mm when it is stretched by 1mm. Given Y of steel is $2 \times 10^{11}\ Nm^{-2}$. (2+2)+2+2

5. a) State the laws of limiting friction.
   b) An ice skater moving at 10 ms^{-1} comes to a halt in 100 m on an ice surface. Calculate the coefficient of friction between the ice and the skater.
   c) "Static friction is a self adjusting force" - Explain. 3+3+2

6. a) Define torque and angular momentum & establish the relation between them.
b) State & explain parallel axis theorem of moment of inertia.
c) The moment of inertia of uniform rod of mass m and length l through an axis passing through its centre of mass and perpendicular to the rod is $\frac{1}{12} ml^2$. Find the moment of inertia of this rod through an axis which passes through an end of the rod and perpendicular to the rod. (1+1+2)+2+2

7. a) A steel wire is subjected to longitudinal tensile force. Draw a stress-strain diagram and show the positions of proportional limit, elastic limit, ultimate tensile stress point and breaking point.
b) State with reason which is more elastic rubber band or steel wire?
c) Calculate the fall of mercury inside a capillary tube of radius 0.3 mm when it is dipped vertically into mercury. Surface tension of mercury is 0.46 N/m, angle of contact is 135° and density of mercury is 13.6 g/cc. 2+2+4

8. a) Define coefficient of viscosity. On which factors does the coefficient of viscosity of a fluid depend?
b) State Bernoulli's theorem mentioning the meaning of all terms in the required equation.
c) A garden hosepipe having internal diameter of 2cm is connected to a lawn sprinkler which contains 24 holes, each of 0.1cm in diameter. If the water in the hose has a speed of $1ms^{-1}$, at what speed does it leave the sprinkler holes? (1+2)+2+3

9. a) Write down differences among Conduction, Convection and Radiation.
b) An iron rod is rigidly attached to the opposite sides of a circular iron ring. If the system is equally heated, will the ring remain circular? Explain.
c) The walls of a refrigerator is 8cm thick having a surface area of $15m^2$. The temperature outside the refrigerator is 35°C. How much power in watt must the refrigerator supply in order to maintain 0°C inside the refrigerator. Thermal conductivity of the material of the refrigerator is K= 0.42 w/m/K. 3+2+3

10. a) What are the differences between isothermal and adiabatic processes?
b) Calculate the heat required to increase the temperature of a substance of mass 100g and specific heat capacity 2000 J/kg/K through 50°C.
c) Which one is greater - molar specific heat at constant pressure or molar specific heat at constant volume? Explain. What is their relation? 3+2+(2+1)