THE OPEN UNIVERSITY OF SRI LANKA
ADVANCED CERTIFICATE IN SCIENCE
PHF 2523-PHYSICS – 1
FINAL EXAMINATION 2023/2024
DURATION – THREE HOURS

Date: 2nd September 2023 **Time: 1.30 pm to 4.30 pm**

Part I – MCQ

- **The Question paper (Part I) consist of 25 multiple choice questions.**
- **Answer all the questions.**
- **Answer for all Multiple-Choice Questions, by underline the correct answer.**
- **At the end of the examination, you should submit the question paper.**
- **Maximum marks for this part is 50%.**

($g = 10\ ms^{-2}$)

1. Dimensions of power are,

   1) ML^2T^{-3} 2) M^2LT^{-2} 3) ML^2T^{-1} 4) MLT^{-2} 5) $M^2\ L^2T^{-3}$

2. The equation of state of some gases can be expressed as $\left(P + \frac{a}{V^2}\right)(V - b) = RT$, where the symbols have their usual meanings. The dimensions of "a" are,

   1) $ML^{-1}T^{-2}$ 2) ML^5T^{-2} 3) $M^{-1}L^2T^{-1}$ 4) L^6 5) ML^6T^{-2}

3. Which one of the following groups do not have the same dimension?

   1) Pressure, Stress 2) Velocity, Speed 3) Force, Impulse
   4) Work, Energy 5) None of these

4. Two forces, one of 10 N and another of 6 N, act upon a body. The directions of the forces are unknown. The resultant force on the body is,

   1) Between 6 and 10 N 2) Between 4 and 16 N 3) More than 6 N
   4) More than 10 N 5) None of the above

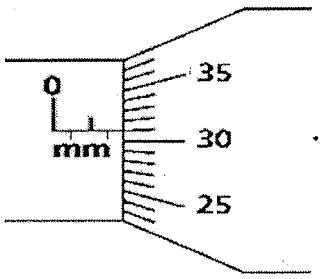
5. Rain is falling vertically with a speed of 30 ms^{-1}. A person is running with a speed of 10 ms^{-1} in the east to west direction. In which direction should he hold his umbrella?

   1) At $\tan^{-1}(3)$ with the vertical towards east
   2) At $\tan^{-1}(3)$ with the vertical towards west
   3) At $\tan^{-1}(1/3)$ with the vertical towards east
   4) At $\tan^{-1}(1/3)$ with the vertical towards west
   5) None of the above

6. The least count of vernier calipers is defined as:

1) Ratio of main scale division and a vernier scale division.
2) Difference between a main scale division and a vernier scale division
3) Product of a main scale division and vernier scale division
4) Sum of a main scale division and a vernier scale division
5) None of the above.

7. Pitch of the following micrometer screw gauge is 0.5 mm and the circular scale is divided into 50 equal divisions. What will be the reading of the scale?

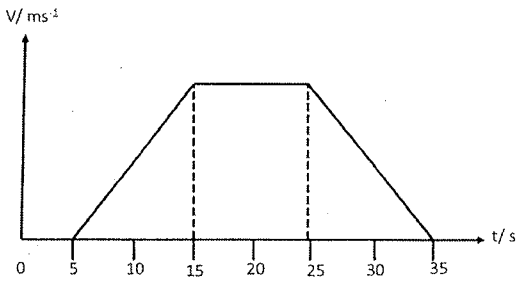


1) 0.23 mm 2) 0.38 mm 3) 31 mm 4) 1.81 mm 5) 0.31 mm

8. A cyclist completes half of a journey with speed V_1 and the other with speed V_2. The average speed of the cyclist is,

1) $\frac{1}{2}(V_1 + V_2)$ 2) $\sqrt{V_1 V_2}$ 3) $\frac{V_1 V_2}{V_1 + V_2}$ 4) $\frac{2V_1 V_2}{V_1 + V_2}$ 5) $\frac{V_1}{V_2}(V_1 + V_2)$

9. A velocity-time graph of the motion of a body in straight line is shown in the figure. The distance covered by it during the last 10 s is what fraction of the total distance covered by it in 35 s,

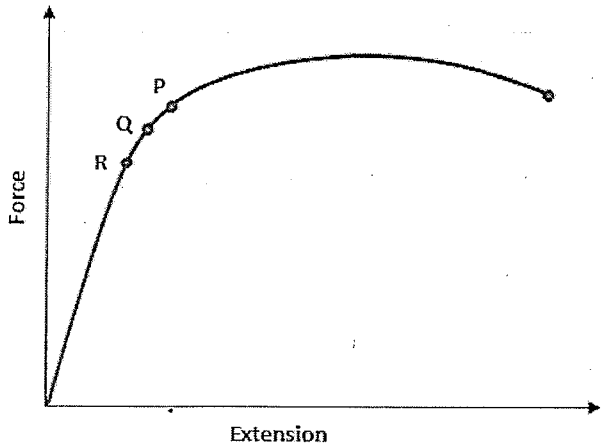


1) $\frac{1}{4}$ 2) $\frac{1}{6}$ 3) $\frac{1}{2}$ 4) $\frac{1}{3}$ 5) Impossible to calculate

10. One stone is dropped from a height of H and another thrown vertically up from the ground simultaneously which rises to a maximum height of 4 H. The two stone cross each other after time,

1) $\sqrt{2Hg}$ 2) $\sqrt{4Hg}$ 3) $\sqrt{8Hg}$ 4) $\sqrt{\frac{8H}{g}}$ 5) $\sqrt{\frac{H}{8g}}$

11. A length of steel wire is fixed at one end. An increasing force is applied to the other end of the wire. The force extension graph for the wire is shown.

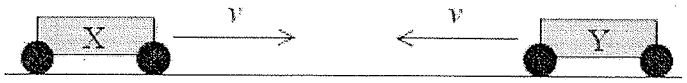


	P	Q	R
(i)	Elastic limit	Limit of proportionality	Yield point
(ii)	Elastic limit	Yield point	Limit of proportionality
(iii)	Yield point	Limit of proportionality	Elastic limit
(iv)	Yield point	Elastic limit	Limit of proportionality
(v)	Yield point	Breaking point	Limit of proportionality

12. The speed of a projectile at the maximum height is half of its initial speed v. Its horizontal range is,

1) $\frac{V^2}{\sqrt{3}g}$ 2) $\frac{\sqrt{3}V^2}{2g}$ 3) $\frac{V^2}{\sqrt{3}g}$ 4) $\frac{\sqrt{3}V^2}{2g}$ 5) $2V$

13. Trolleys X and Y of masses m and $3m$ respectively are travelling at the same speed towards each other. The trolleys collide and move off together.



Which of the following statements is correct?

(i) The force of X on Y during the collision is greater than the force of Y on X.
(ii) The force of X on Y during the collision is less than the force of Y on X.
(iii)The speed of X after the collision is greater than v.
(iv) The speed of X after the collision is less than v.
(v) The speed of X after the collision is v.

14. A 0.5 kg hammer is used to drive a nail. The speed of the hammer just before it hits the nail is 40 ms^{-1} and it stops in 0.05 s after the strike. The average force exerted on the hammer by the nail is,

1) 100 N 2) 200 N 3) 240 N 4) 400 N 5) 2000 N

15. When a spring is stretched by 2 cm its elastic potential energy is E. If it is stretched by 12 cm its new elastic potential energy is,

1) 6E 2) 10E 3)12E 4) 24 E 5) 36E

16. Two objects P and Q have the same kinetic energy and the speed of Q is twice the speed of P. The ratio of $\frac{momentum\ of\ P}{Momentum\ of\ Q}$ is equal to,

1) 0.5 2) 1 3) 2 4) 4 5) 8

17. A bock of mass m is at rest on an inclined plane making an angle θ with the horizontal. If the coefficient of friction is μ, then the frictional force between the block and the inclined plane is,

1) 0 2) $mg\sin^2\theta$ 3) $mg\cos^2\theta$ 4. $\mu mg\sin\theta$ 5. $\mu mg\cos\theta$

18. An ice skater spine with arms outstretched 2.0 rev s^{-1}. Her moment of inertia at this time is 1.5 kg m^2. If she pulls her arms her moment of inertia becomes 0.5 kg m^2. Her new rate of rotation in rev s^{-1} is,

1) 0.7 2) 1.0 3) 2.3 4) 4.5 5) 6.0

19. The bob of a pendulum has mass m and it is released from the horizontal position. The tension in the string at the lowest position is,

1) mg 2) 2 mg 3) 3 mg 4) $3\sqrt{2}mg$ 5) 6 mg

20. A vassal contains oil of density 600 kg m^{-3} over mercury (Density 13600 kg m^{-3}). A solid sphere floats with half its volume immersed in mercury and the other half in oil. The density of the material of the sphere is,

1. 3600 $kg\ m^{-3}$ 2. 6500 $kg\ m^{-3}$ 3. 7100 $kg\ m^{-3}$ 4. 12400 $kg\ m^{-3}$
5. 13000 $kg\ m^{-3}$

21. Two spheres P and Q of same material fall at their terminal velocities in a given liquid. If the radius of Qis twice that of P the ratio of terminal velocity Q to that of P is,

1) 4:1 2) 2:1 3) 1:1 4) 1:2 5) 1:4

22. Two capillary tubes of the same radius and length l_1 and l_2 are attached horizontally to side of a vessel containing water at the bottom. What is the length of the single tube with same radius that can replace the two tubes such that its volume flow rate equals the total volume flow rate of the two tubes?

1) $\frac{l_1+l_2}{2}$ 2) $\frac{l_1 l_2}{l_1+l_2}$ 3) $\frac{l_1+l_2}{l_1 l_2}$ 4) l_1+l_2 5) $\sqrt{l_1+l_2}$

23. When a capillary tube of radius r is held vertically with one end immersed in a liquid of unknown density, the liquid rises h up the capillary tube to a height h above the liquid, If the surface tension of the liquid is T and the angle of contact is zero the density of the liquid is given by,

1) $\frac{2Tr}{\pi gh}$ 2)) $\frac{Tr}{2gh}$ 3) $\frac{2Tr}{rgh}$ 4) $\frac{\pi T}{2rgh}$ 5) $\frac{2T}{rgh}$

24. Two wires made of the same material have lengths in the ratio 1:2 and diameters in the ratio 2:1. If they are stretched by the same force their ratio of extension will be

1) 2:1 2) 1:4 3) 4:1 4) 1:8 5) 8:1

25. The thigh bone of a man is 45 cm long and has area of cross section 6.0×10^{-7} m^2. If the maximum compressive strain is 0.002. Find the maximum load it can hold safely. Assume the Young modulus of bone is 10^{10} N m^{-2}.

1) 1.2×10^{3} N 2) 1.2×10^{4} N 3) 3×10^{6} N 4) 2.4×10^{8} N

5) 3.6×10^{11} N

(4× 25 = 100 Marks)

Part II

- **Answer any four (04) questions only.**
- **If more than (04) questions are answered only the first four will be marked.**
- **Each question earns twenty-five (25) marks, amounting to total of 50% marks.**

1.A. State Newton's second law of motion (4 Marks)

A car of mass 1200 kg has a frontal area of 2.3 m^2. It travels at 36 ms^{-1} of velocity when the engine exerts tractive force of 1050 N.

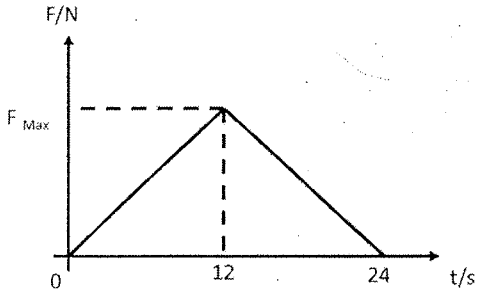
(i) Drag force F acting on the car is given by the formula $F = \frac{1}{2}AC_DV^2$ where C_D is the drag coefficient. If the drag coefficient is 0.34 calculate the drag force acting on the car. (2 Marks)

(ii) If a rolling frictional force of 100 N acts on the non-diving wheels. Find the total force opposing the motion of car (Rolling drag force is defined as the resistive force in the motion of the vehicle). (2 Marks)

(iii) What is the acceleration of the car? (2 Marks)

B. State the law of conservation of liner momentum and show how the principle of conservation of momentum may be derived by Newton's second law of motion. (5 Marks)

A car of mass 1800 kg is travelling at a speed of 30 ms^{-1}. In order to stop it, the driver applies brakes, by uniformly increasing the force, F to a maximum (At that moment velocity of the car is 15 ms^{-1}) and then decreasing it uniformly to zero as shown in the following figure. Total braking time is 24 s.



(i) Calculate the momentum of the car just before the application of the braking force. (2 Marks)

(ii) Calculate the change of the momentum during the first 12 s of the braking time. (2 Marks)

(iii)Calculate the maximum braking force (F_{max}) (2 Marks)

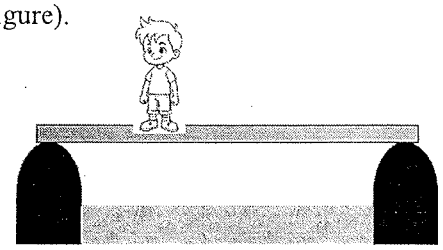
(iv)Draw the sketches of followings,

I. Velocity-time graph (2 Marks)

II. Distance-time graph for the motion of the car. (2 Marks)

2. A. State the principle of Moments. (4 Marks)

A simple beam bridge across a canal is supported by two pillars 4.8 m apart. The beam is uniform and weight 1060 N. A boy of mass 68 kg stands on the beam 1.5 m from the left-hand support (See figure).

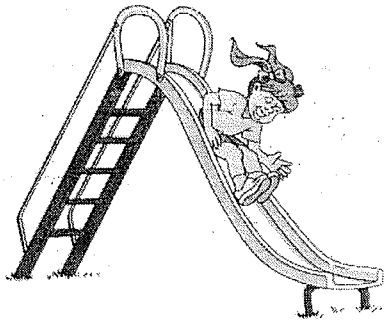


(i) What is the reaction at the left-hand pillar? (4 Marks)

(ii) What is the reaction at the Right-hand pillar? (4 Marks)

B (i) State the principle of conservation of mechanical energy. (4 Marks)

(ii) Which conditions should be satisfied to apply the above concept ? (2 Marks)



(iii)A girl slides down as shown in the figure. She begins 2 m above the ground from rest and experiences no friction. Use the principle of conservation of mechanical energy to calculate her speed when she is 50 cm above the ground. (5 Marks)

3. A. State Archimede's principle. (4 Marks)

(i) An iceberg floats in the sea with 10% of its volume above the surface of sea water. If the density of ice is 920 kg m^{-3}. Find the density of the sea water. (3 Marks)

(ii) Determine the amount of minimum weight that should be placed on an iceberg to totally immerse it in sea water. (3 Marks)

B. State Bernoulli's equation and identify each term in it and write down the two practical applications of Bernoulli's principle. (7 Marks)

The wings of an airplane of 200kg have an effective area of 5.2 m^2. At one instant in take-off, the speed of air flowing over the wing is 80 ms^{-1} and below the wing 68 ms^{-1}. Assuming the density of air is constant at 1.2 kg m^{-3}.

Calculate,

(i)The aerodynamic lift on the wings. (5 Marks)

(ii) The resultant force exerted by the wings on the aircraft. (3 Marks)

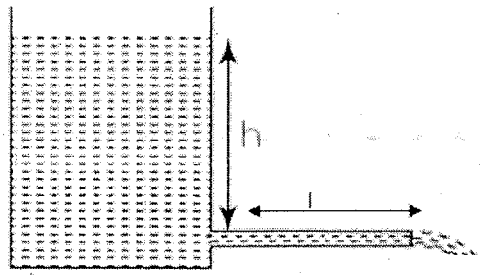
4. A. Define coefficient of viscosity. (3 Marks)

Poiseuille's formula for the volume of liquid V flowing per second through a uniform capillary tube of radius a under laminar flow is given by,

$$V = \frac{\pi a^4}{8\eta}\frac{\Delta P}{\Delta l}$$, where $\Delta P/\Delta l$ is the pressure gradient along the tube.

(i) Show that this equation is dimensionally correct. (2 Marks)

(ii) A horizontal capillary tube of length (l) 20 cm and internal diameter 0.2 cm is attached to a point just above the base of an empty vessel. Water flows into the vessel at a constant rate of 2.0 $cm^3\ s^{-1}$. Find the height (h) of the water level as shown in the diagram.
Coefficient of viscosity of water = 1.0×10^{-3} N s m^{-2}, The density of the water = 1000 kg m^{-3}. (4 Marks)



B. Explain what is meant by terminal velocity. (3 Marks)

A small metal sphere is released from rest in a viscous liquid contained in a wide tall cylinder.

(i) Draw the force acting on the sphere.
   a. at the releasing moment (2 Marks)
   b. after the terminal velocity has been attained (2 Marks)
   c.

(ii) Sketch the graphs to illustrate the variation of velocity (v), acceleration (a) and displacement of falling sphere against time t. (3 Marks)

(iii) An aluminum sphere of diameter 2.0 mm is released at the surface of water in a tank. Find the terminal velocity achieved by the sphere. (4 Marks)

Density of the aluminum = 2700 kg m^{-3}, water = 1000 kg m^{-3}, coefficient of viscosity of water = 0.8×10^{-3} N s m^{-2}.

5. A. Define the term of coefficient of surface tension and write down the factors effect on the coefficient of surface tension of liquids (7 marks)

A tree 40 m tall, has xylem tubes which carry sap from roots. Thery can be considered as tubes with radius 0.25 μm. The surface tension of the sap is 6.0×10^{-2} N m^{-1} and the angle of contact is 45^0. (Assume density of the sap = 1000 kg m^{-3})
The rice of the sap due to the surface tension can be written as,

$$h = \frac{2T\cos\theta}{r\rho g}$$

(i) Using a diagram, identify each term in the above equation. (5 Marks)

(ii) Calculate the rising height of sap due to the surface tension. (5 Marks)

(iii) Calculate the remaining height to be raised. (3 Marks)

(iv)Find the minimum pressure the roots must develop for the sap to reach the top of the tree. (5 Marks)

6. A. (a) Define the following terms in elasticity.
(i) Stress
(ii) Strain (4 Marks)

(b) State Hook's law of elasticity and define the Yong's modulus of material. (5 Marks)

(c) The Hookean material deforms according to the equation F = –kx.
Show that the elastic strain energy stored when it is stretched is $\frac{1}{2} kx^2$.
(4 Marks)

Cylindrical, Hookean wire has a diameter of 3 mm, a length of 1 m and a mass of 64 g (when it is not being loaded). An applied force of 10 N is required to induce an extension of 2 cm.

(i) What is the density of the wire? (4 Marks)

(ii) Determine the young's modulus of the material of wire. 4 Marks)

(ii) When extended by 10 cm what is the elastic strain energy stored in the wire?
(4 Marks)

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