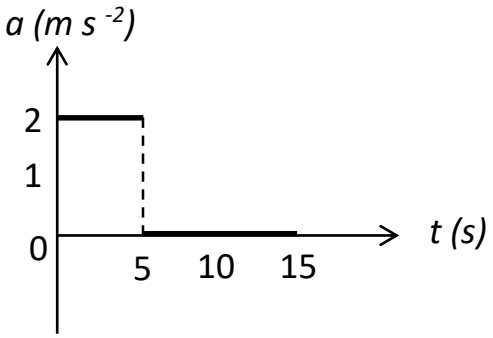
Answer **ALL** questions.

1. A derived quantity X is given as $\frac{1}{2}\rho v^2$, where ρ is the density of a fluid and v is its speed. What is the dimension of the derived quantity?

[2 marks]

2. (a)



The acceleration-time graph above is drawn for an object which starts from rest and moves in a straight line.

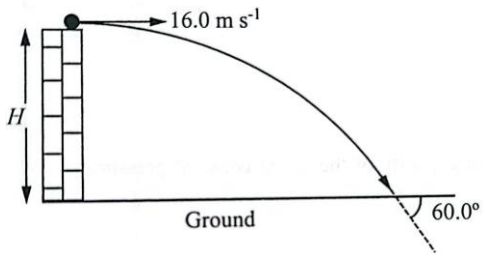
(i) Determine the speed of the object at t = 5 s.
(ii) Calculate the average acceleration for the whole journey.

[3 marks]

(b) A car travelling at 16 m s^{-1} is at a distance of 36 m from a stationary lorry when the brakes of the car are applied. If the car decelerates at 3.5 m s^{-2}, does the car manage to avoid from crashing into the lorry before it stops?

[4 marks]

(c) A ball is thrown horizontally from the roof of a building of height H as shown in the diagram below.



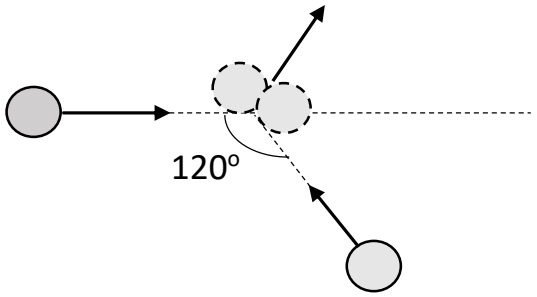
The initial speed of the ball is 16.0 m s^{-1}. It hits the ground at an angle of 60.0° with the horizontal. Assuming that air resistance is negligible, calculate the height H of the building.

[3 marks]

3. (a) A ball bearing of mass 10.0 g is dropped vertically downward onto a hard metal surface. If the speed of the ball bearing is 4.43 m s^{-1} just before it hits the ground and the duration of impact is 0.02 s, calculate the average force the ball bearing will exert on the surface.

[3 marks]

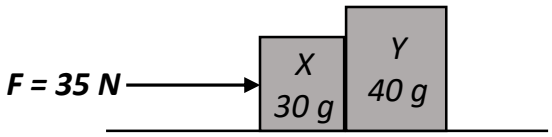
(b) Two 75.0 kg objects moving at 5.50 m s^{-1} collide and stick together as shown in the diagram below.



If the angle between their initial directions was 120°, what is their magnitude of velocity after the collision?

[4 marks]

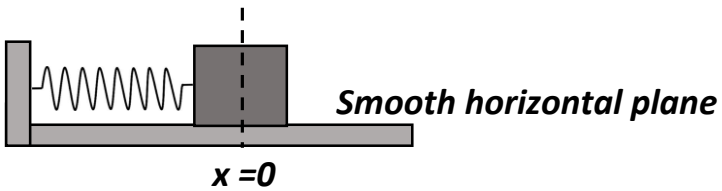
(c) Two blocks of wood, *X* and *Y*, weigh 30 g and 40 g respectively. They are placed so that they touch each other above a smooth horizontal surface. A horizontal force of 35 N is applied on the block *X* so that both blocks accelerate together.



(i) Sketch free-body diagrams for both blocks *X* and *Y*.
(ii) Determine the acceleration of both blocks.
(iii) Find the horizontal force acting on *Y.*

[6 marks]

4. (a)



An object of mass 2.0 kg is connected to one end of a light spring with spring constant 2.0 kN m^{-1}, as shown in the diagram above. The object is pulled to the right through 10.0 cm from its equilibrium position. When the object is released from rest, determine its speed when the extension of the spring is 5.0 cm.

[3 marks]

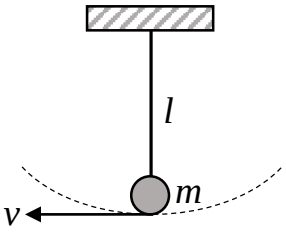
(b) A skier of mass 70 kg is pulled up a slope by a motor-driven cable.

(i) How much work is required to pull him 60 m up a 30° slope (assumed frictionless) at a constant speed of 2.0 m s^{-1}?

(ii) What power must a motor have to perform this task?

[5 marks]

5. (a) The length of a simple pendulum is l and the mass of the bob is m. The speed of the bob is v as it passes the lowest point as shown in the diagram.



What is the tension T in the string when the string is vertical? Give your answer in terms of m, g, v and l.

[2 marks]

(b) A particle of mass 0.020 kg is attached to an elastic string which is fixed at one end on a smooth horizontal table. The length of the string is 0.50 m with force constant 40 N m^{-1}. When the particle is moving in a horizontal circle of radius 0.65 m, what is the angular velocity of the particle?

[3 marks]

6. (a) A mass of 0.50 kg hangs from the end of a vertical string as shown in the diagram below. When the mass is raised 0.20 m from its equilibrium position and then released, it performs simple harmonic motion with period 1.6 s.

(i) Calculate the spring constant.

(ii) Determine the speed of the mass when it passes the equilibrium position.

(iii) What is the magnitude and direction of the acceleration of the mass when it is at the lowest point?

(iv) Sketch the displacement-time graph of the simple harmonic motion. Mark suitable values on both axes.

(v) If the mass at the end of the spring is reduced but the amplitude of oscillation remains the same, what will happen to the period of oscillation? Explain.

[11 marks]

(b) A stretched wire of length 60.0 cm and mass 10.0 g vibrates transversely. Waves travel along the wire at speed 210 m s^{-1}. Three antinodes can be found in the stationary waves formed in between the two ends of the wire.

(i) Determine the wavelength of the progressive waves which move along the wire.
(ii) Sketch the stationary waves that formed in the wire. Label the positions of node (N) and antinode (A).
(iii) Find the frequency of vibration of the wire.
(iv) Calculate the tension in the wire.

[8 marks]

(c) A stationary wave is described by the equation

$$y = 5 sin2t\, cos3x$$

where *y* and *x* are in meter, *t* is in seconds.
Find

(i) the displacement of the particle at *x* = 1.0 m when *t* = 3 seconds.
(ii) the amplitude of vibration when *x* = $\frac{\pi}{3} m$.
(iii) distance between two adjacent nodes.

[4 marks]

7. (a) When a wire of length 2.0 m and cross-sectional area 1.0 x 10^{-6} m^2 is stretched by a force of 100 N, the elongation produced is 2.0 mm.
Calculate the

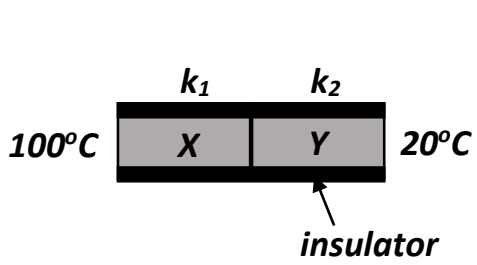
(i) Young's Modulus of the material of the wire.
(ii) strain energy in the stretched wire.

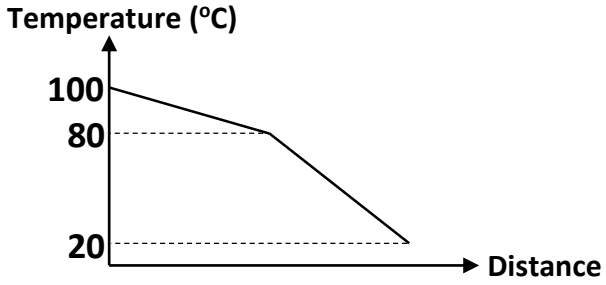
[3 marks]

(b) A circular hole of area 1.0 cm^2 was drilled in a steel plate. During the drilling, the friction caused the temperature of the plate to rise to 150°C. What will the area of this hole be when the plate cools down to 30°C?
[Given the coefficient of linear expansion for the steel at 30°C = 1.1 x 10^{-5} K^{-1}]

[2 marks]

(c) Two identical uniform rods *X* and *Y* of different material are joined in series and perfectly insulated. The thermal conductivities of the materials are k_1 and k_2 respectively. The ends of the combined rod are 100°C and 20°C. The variation of temperature along the combined rod is shown in the diagram below. What is the value of $\frac{k_1}{k_2}$?





[3 marks]

8. (a) A cylinder contains 0.25 mol of oxygen gas at a temperature of 27°C. Assume oxygen gas as an ideal gas.

(i) Determine the mean translational kinetic energy of the gas molecules.
(ii) Calculate the internal energy of the gas.

[3 marks]

(b) The volume of an ideal gas is 0.12 m^3 when its temperature is 300 K and pressure 1.0 x 10^5 Pa. The gas undergoes the following changes.

I. Isothermal expansion to twice its initial volume.
II. Its pressure is increased at constant volume until its pressure returns to its initial value.
III. The gas then undergoes isobaric compression back to its initial volume of 0.12 m^3.

(i) What is the pressure of the gas when its volume is doubled?
(ii) Determine temperature of the gas at the end of process II.
(iii) Calculate the work done in process I.
(iv) Sketch a *p*-*V* graph to show the three processes I, II and III.

[8 marks]