L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2023 SECOND SESSION

SUBJECT:	**Physics**
DATE:	5th September 2023
TIME:	4:00 p.m. to 7:05 p.m.

A list of useful formulae and equations is provided. Take the acceleration due to gravity $g=9.81\ ms^{-2}$ unless otherwise stated.

SECTION A

Attempt ALL 8 questions in this section. This section carries 50% of the total marks for this paper.

1. An aircraft is flying on a bearing of 050° as shown in Figure 1. The engine force pushing the aircraft forward is 12 kN whilst the opposing resistive forces add up to 4.5 kN.

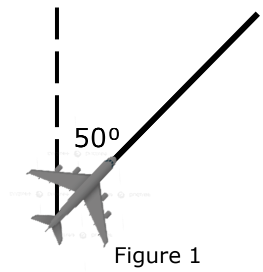

Figure 1

a) Define scalar and vector quantities, giving **ONE** example of each. (2)
b) Find the resultant force on a bearing of 050°. (1)
c) Resolve the resultant force vector into **TWO** perpendicular components. (2)

(Total: 5 marks)

2. Two students, Anna and Max, are on the same merry-go-round, as shown in Figure 2. Anna sits on the circumference while Max sits at a distance of 0.4 m from the centre. The diameter of the merry-go-round is 1 m.

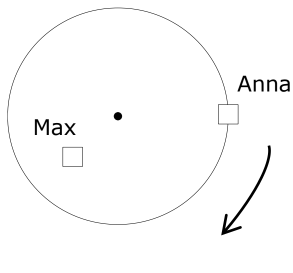

Figure 2

a) If Max takes 1.5 s to complete one revolution, how long does it take Anna to complete one revolution. (1)
b) Calculate Anna's linear speed. (2)
c) Determine who has the larger centripetal acceleration. (2)

(Total: 5 marks)

3. A sample of lead has a mass of 0.50 kg and a temperature of 27 °C. Energy is supplied to the lead at the rate of 1.5 kW. After 12 s of heating, it reaches its melting point of 327 °C. After heating for a further 3 minutes, all the lead became liquid. It should be assumed that all the energy supplied was transferred to the lead and there were no energy loses.

a) Calculate a value for the specific heat capacity of lead. (3)
b) Calculate a value for the latent heat of fusion of lead. (2)
c) Sketch a graph to show how the temperature of the lead varies with time from the moment energy started to be supplied to lead, until all lead became liquid. (2)

(Total: 7 marks)

4. An appliance is rated at 1200 W and 240 V. The cross-sectional area of the wire is 0.8 mm^2. The wire is a good conductor of electricity, and there are 1540 electrons per m^3. (Electron charge, $e = 1.6 \times 10^{-19}$ C)

   a) Calculate the drift velocity of the electrons in the wire. (3)
   b) For the same values of current and cross-sectional area, explain the change in the drift velocity if the wire is changed to a semiconductor. (2)

(Total: 5 marks)

5. A capacitor of 3400 μF is charged by a battery of 40 V.

   a) Draw a circuit setup for charging a capacitor. (1)
   b) Explain, by using a sketch graph, how the current in the circuit varies during charging of a capacitor. (3)
   c) Calculate the maximum charge stored on the capacitor. (2)
   d) Calculate the charge stored on the capacitor if a dielectric of relative permittivity 1.6 is inserted between the plates. (2)

(Total: 8 marks)

6. Figure 3 shows a positive ion P of charge +q moving with speed v, entering a region with a uniform electric field of strength E, and a uniform magnetic field of strength B.

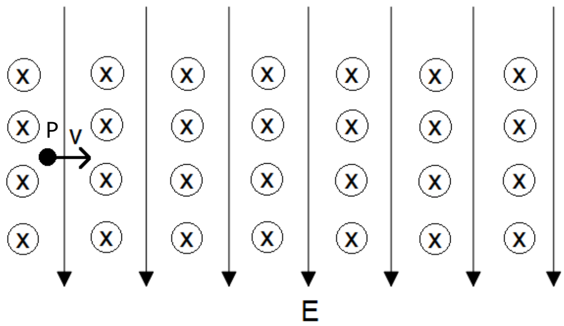

Figure 3

   a) Draw the positive ion P and **TWO** arrows, to represent the electric force and the magnetic force acting on the ion as shown in Figure 3. (2)
   b) Write an expression for the electric force acting on the ion. (1)
   c) Write an expression for the magnetic force acting on the ion. (1)
   d) Hence, or otherwise, show that $v = \frac{E}{B}$ if the ion travels without deflection. (1)
   e) If the electrical field is switched off, explain the path taken by the ion in the region of the magnetic field. (2)

(Total: 7 marks)

7. A helium production factory uses a small quantity of americium- 241 ($^{241}_{95}\mathrm{Am}$) which emits α-particles.

   a) Write down the equation representing the decay, by alpha-emission, of americium-241 into the element neptunium (Np). (2)
   b) Briefly explain why the amount of americium- 241 decreases with time. (1)
   c) Alpha-particles will not be emitted if the activity of the americium-241 falls below 1/32 of its initial value. If the half-life of americium-241 is 432 years, for how long will this sample emit alpha-particles? (3)

(Total: 6 marks)

8. Figure 4 shows wavefronts spreading out from two coherent sources in the ripple tank filled up with water. The dark circles indicate crests of waves. Small floaters are placed in the water at positions A, B and C.

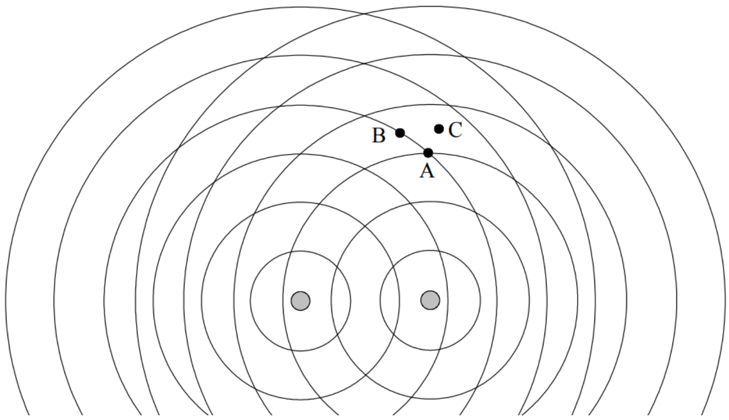

Figure 4

   a) Briefly explain the term coherent sources. (1)
   b) Describe the motion of **each** floater, A, B and C. (3)
   c) Describe how the interference pattern would change if the source separation and the wavelength are changed. (3)

(Total: 7 marks)

Please turn the page.

SECTION B
This question carries 14% of the total mark of this paper and must be attempted.

9. The following setup was used to determine the value of acceleration of free fall.

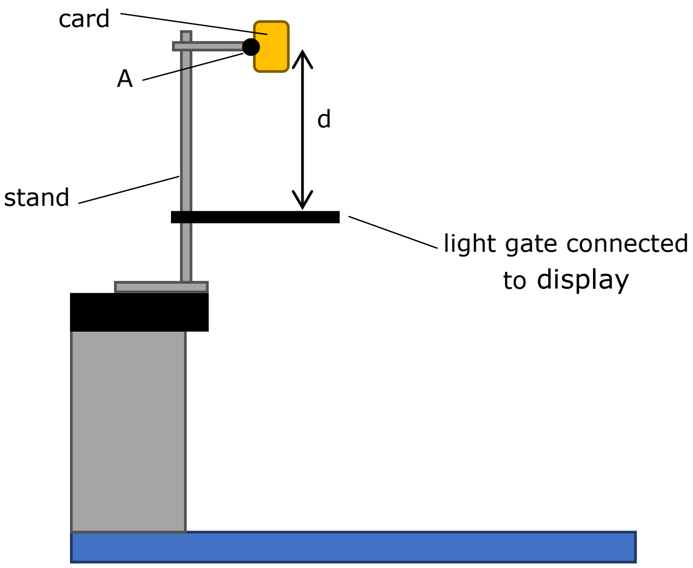

Figure 5

The card is dropped vertically from point A, which is at a distance, d, away from the light gate. The light gate gives a reading of the velocity of the card which is being assumed to be constant while falling through the light gate. Distance d is varied so that different values of the velocity were obtained which were recorded in the table below. The card was dropped twice for each value of d.

The following equation is used to find the value of g:

$$v^2 = 2gd$$

Table 1

d cm	d m	v_1 cms^{-1}	v_2 cms^{-1}	average velocity, v ms^{-1}	v^2 m^2s^{-2}
30		124	126		
32		139	137		
34		148	152		
36		165	163		
38		176	176		
40		189	187		

Question Continues on next page.

a) Copy and complete Table 1. (4)

b) Plot a graph of v^2/ m^2s^{-2} against d / m. (4)

c) Use the graph to determine the value of g in ms^{-2}. (3)

d) A card of greater mass was used. Would the value of g obtained be different than the one obtained in part c)? Explain. (2)

e) Explain why using a table tennis ball instead of the card is not suitable for this experiment. (1)

(Total: 14 marks)

Please turn the page.

SECTION C

Answer any TWO questions from this section. Each question carries 18 marks. This section carries 36% of the total mark for this paper.

10. A metal ball was released in a tall cylindrical tube filled with olive oil.

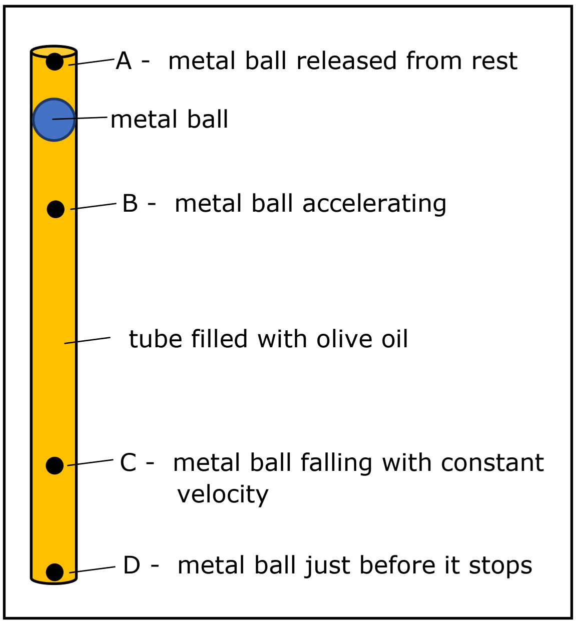

Figure 6

a) Define:
   i. drag force; (1)
   ii. viscosity. (1)

b) State how the drag force acting on the metal ball:
   i. changes when the metal ball goes from A to B; (1)
   ii. changes when the metal ball goes from C to D. (1)

c) Explain how the velocity of the metal ball is affected if olive oil is replaced with honey which is more viscous. (2)

d) Sketch the velocity-time graph of the metal ball while falling from A to D and indicate points A, B and C on the graph. (4)

e) A plane was travelling at a constant horizontal velocity of 62 ms^{-1} at a height of 1250 m. Accidentally, at the moment the parachutist jumped, a bag fell off. Ignoring air resistance, calculate:
   i. the time it took the bag to land on the ground. (3)
   ii. the horizontal distance travelled by the bag until it came to rest on the ground. (2)

f) When a parachutist jumps off a plane, terminal velocity can be reached twice before eventually landing. Explain. (3)

(Total: 18 marks)

11.

a) Give a definition and the SI units, where applicable, of the following:

i. stress; (1)

ii. strain; (1)

iii. Young's modulus. (1)

b) Irene was working in the Physics Laboratary. She was finding the Young modulus of a piece of fishing line.

i. Draw a labelled diagram of the setup of the apparatus she would use. (2)

ii. State the measurements she needs to take. (2)

iii. Explain how the measurements can be used to plot a graph to find the Young's modulus of the fishing line. (4)

iv. Explain **TWO** precautions she needs to take while doing this experiment. (2)

c) Irene went fishing. She used a fishing rod which had a fishing line of Young's modulus 2.45 GPa. The length of the fishing line is 3 m and diameter 0.8 mm. Calculate:

i. the extension of the fishing line when she catches a fish of mass 225 g; (2)

ii. the maximum mass of the fish which Irene can catch if the fishing line can withstand a maximum strain of 0.0061. (3)

(Total: 18 marks)

12.

A ray of green light travelling in air hits the boundary of a composite material made of diamond and glass as shown below. The angle of incidence is 43°. (η_{air} = 1; $\eta_{diamond}$ = 2.4; η_{glass} = 1.5;)

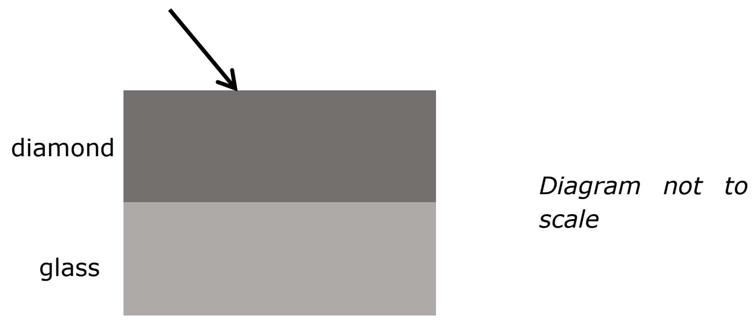

Figure 7

a) State the **TWO** laws of refraction. (2)

b) Copy the diagram and complete the motion of the light ray as it passes through the composite material until it emerges in air again. On your diagram, indicate the respective angles of incidence and refraction at each boundary. (Show your working and it is not necessary to draw the diagram to scale.) (5)

c) How does the direction of the incident ray into the block compare with the direction of the emergent ray out of the block? (1)

d) Explain what happens to the wavelength, the frequency and the velocity of the green light ray when it goes from air to diamond. (3)

Question Continues on next page.

Submarines make use of periscopes for observation of surroundings while travelling under the water level.

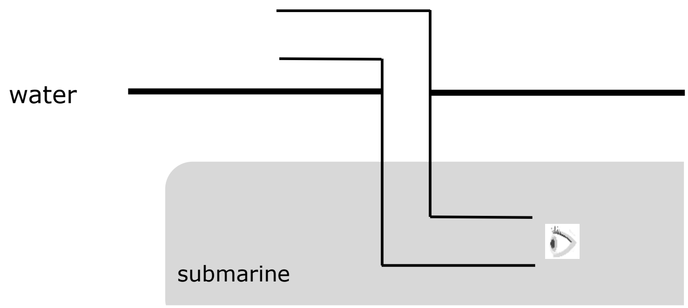

Figure 8

e) Explain, with the aid of a labelled diagram, how a periscope can function with the use of:
   i. mirrors; (2)
   ii. right angle prisms. (3)

f) On hot sunny days mirages are commonly visible on roads. Drivers may see what appears to be a layer of water which vanishes as they drive closer. Explain how mirages form. (2)

(Total: 18 marks)

13.

a) Define internal resistance. (1)

b) Explain **TWO** differences between e.m.f and terminal p.d. (2)

c) A cell of e.m.f., E, and internal resistance, r, supplies current I to an external resistance, R. Show that the terminal p.d., V, is:

$$V = \left(\frac{E}{R + r}\right) R$$

(2)

d) Describe an experiment which can be followed to find the internal resistance r, of a cell. In your answer:
   i. draw a diagram of the electric circuit required; (2)
   ii. list the measurements that should be taken; (1)
   iii. explain how the readings obtained can be used to plot a graph to find the internal resistance of the cell; (3)
   iv. explain **TWO** precautions that should be taken while doing this experiment. (2)

e) With reference to the graph, state what the y-intercept represents. (1)

f) Give **ONE** example where internal resistance is highly necessary and explain why. (2)

g) A current of 28 A is drawn from a cell which has an e.m.f. of 12.0 V and a terminal p.d. of 11.44 V. Find the internal resistance of the cell. (2)

(Total: 18 marks)