L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2025 SECOND SESSION

SUBJECT:	**Physics**
DATE:	4th September 2025
TIME:	4:00 p.m. to 7:05 p.m.

A list of useful formula 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. a) Distinguish between base and derived quantities. Give **ONE** example of each. (2)
   b) Consider the following equation for work done, $F \times s = mv^2$, where F is the applied force, s is the distance, m is the mass and v is the speed. By using base units, determine if this equation is homogeneous: (2)
   c) Outline why the equation in part b) is physically incorrect. (1)

(Total: 5 marks)

2. Consider the following velocity-time graph (Figure 1) for an athlete's journey.

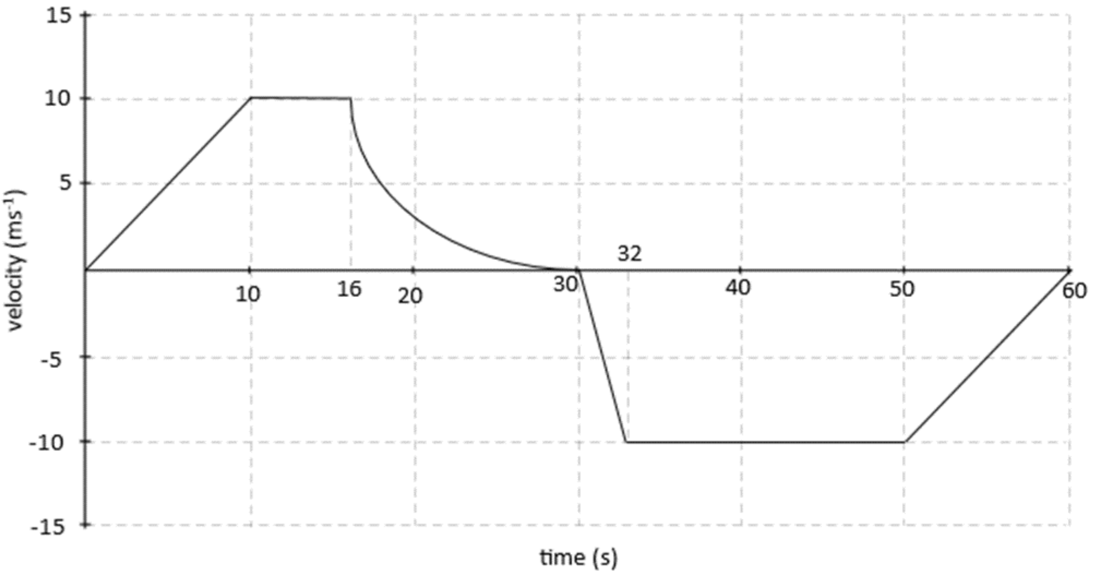

Figure 1

   a) By referring to the time intervals, identify **ONE** section that indicates:
      i. constant velocity; (1)
      ii. constant acceleration; (1)
      iii. variable acceleration. (1)
   b) Determine the distance travelled in the last 30 s of the journey. (1)
   c) Compare the acceleration of the athlete between the first and the last 10 s of the journey. (2)

(Total: 6 marks)

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3. Consider the pendulum shown in Figure 2. The pendulum is suspended by a string, attached with a fixed support on top.

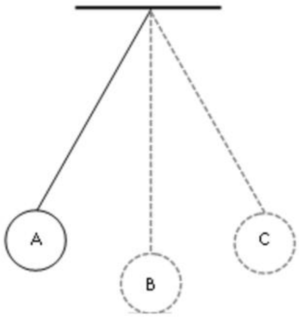

Figure 2

a) Outline the energy transformations during half an oscillation (A to C), assuming no external forces acting on the pendulum. (2)
b) Distinguish between gravitational potential energy, electrical potential energy and elastic potential energy. (3)
c) Identify **TWO** energy losses from the above pendulum. (2)

(Total: 7 marks)

4. A car's brakes are applied to help the car come to a stop. During the braking time, frictional forces (work done on the system) amount to 0.45 MJ. Friction leads to unuseful heat energy emitted by the system to the surroundings, amounting to 0.16 MJ.
a) State the first law of thermodynamics. (2)
b) Define a sign convention to distinguish between an increase and decrease in energy in this case. (2)
c) Using the equation representing the first law of thermodynamics, find the net change in internal energy of the system. (3)

(Total: 7 marks)

5. a) Derive, for a current-carrying conductor, the expression $I = nAvq$, where n is the number of charge carriers per unit volume, A is the uniform cross-sectional area, v is the drift speed and q is the charge of the charge carrier. (3)
b) With reference to the expression in part a), explain the difference between conductors, semiconductors and insulators. (2)

(Total: 5 marks)

6. a) State Newton's law of universal gravitation qualitatively. (1)
b) Two spheres, one of mass 4 kg and the other 6 kg, are placed 2 m apart in space (far from any other large masses). Calculate the gravitational force of attraction between the two spheres. $G = 6.67\times10^{-11}$ N m^2/kg^2. (2)
c) Relate the gravitational force to the weight. (2)
d) Sketch a graph of how the gravitational field strength varies with distance from the Earth's surface. (2)

(Total: 7 marks)

7. a) State the law of radioactive decay. (1)

Consider the following radioactive decay scenarios:

b) Radium-226 ($^{226}_{88}Ra$) is a radioactive element used in some medical treatments. It undergoes alpha decay to produce Radon (Rn). Write the nuclear equation for the alpha decay of Radium-226. (2)

c) Phosphorus-32 ($^{32}_{15}P$) undergoes beta decay to become sulfur-32 (S). Write the nuclear equation for the beta decay of Phosphorus-32. (2)

d) Caesium-137 has a half-life of 30 years.

i. Calculate its decay constant. (1)

ii. Calculate the number of nuclei needed to give an activity of 2.0×10^5 Bq. (2)

(Total: 8 marks)

8. A drone releases a ball that hits a point on a ramp that makes an angle of 12 ° with the horizontal. The ball is ejected as a horizontal projectile at a speed of 8.66 m/s from a height of 1.27 m measured from the ground and travels a horizontal distance of 1.16 m before hitting the ramp. The projectile path is shown in Figure 3.

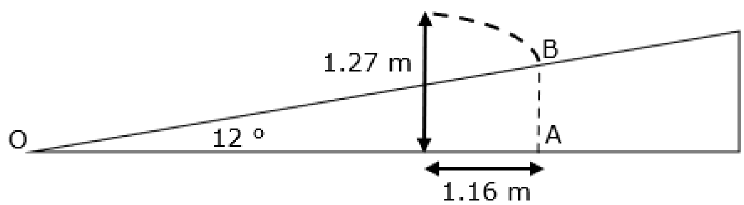

Figure 3

a) Find the time it takes for the ball to hit the ramp. (2)

b) Find the distance AB. (3)

(Total: 5 marks)

Please turn the page.

SECTION B

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

9. The apparatus in Figure 4 is used to find the specific heat capacity of a metal M, $c_{metal\ M}$. Six blocks of metal M of different mass are used. The mass (m_{metal}) of each block is recorded. The blocks are heated. Before placing the first block in a calorimeter, the mass (m_{water}) and the initial temperature (T_{water}) of cold water in the calorimeter are recorded. Then the hot metal block is gently placed in the water and when thermal equilibrium is reached, the temperature (T_{final}) of the system is recorded. The procedure is repeated for all the blocks. It is assumed that the initial temperature (T_{metal}) of all the blocks will be of 60 °C and the initial temperature of the water (T_{water}) in the calorimeter will be of 20 °C.

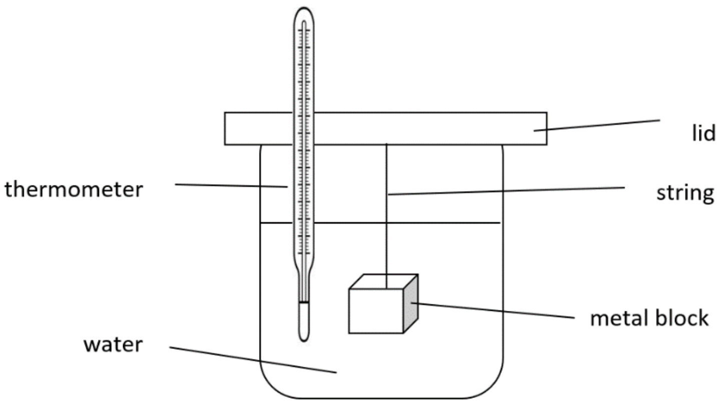

Figure 4

The following readings were obtained.

Table of Results

Metal block	Mass of block (m_{metal}/kg)	Initial temp. of block (T_{metal}/°C)	Mass of water (m_{water}/kg)	Initial temp. of water (T_{water} /°C)	Final Temp of system (T_{final}/°C)	P m_{water} (T_{final} −T_{water}) / kg°C	Q m_{metal} (T_{metal} −T_{final})/kg°C
1	0.1	60	0.3	20	22.9		
2	0.2	60	0.3	20	24.8		
3	0.3	60	0.3	20	26.5		
4	0.4	60	0.3	20	28.1		
5	0.5	60	0.3	20	29.7		
6	0.6	60	0.3	20	31.6		

The equation for this experiment is given as:

$$P = \frac{c_{metal}}{c_{water}} Q$$

Where $P = m_{water}\,(T_{final} - T_{water})$
$Q = m_{metal}\,(T_{metal} - T_{final})$
$c_{water} = 4200\ \text{J kg}^{-1}\,{}^{o}\text{C}^{-1}$

a) Define specific heat capacity and thermal equilibrium. (2)
b) Copy and complete the last two columns of the table above. (2)
c) Plot a graph of P (kg°C) on the y-axis against Q (kg°C) on the x-axis. (4)
d) Using the graph, find the value of the specific heat capacity of metal M, $c_{metal\ M}$. (4)
e) List **TWO** sources of error. (2)

(Total: 14 marks)

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. Paula and Jake were investigating linear momentum in the physics lab. They were provided with a linear air track, photogates, and various gliders.
    a) State the principle of conservation of linear momentum. (2)
    b) Describe an experiment that these students can perform to confirm the principle mentioned in part a) for a completely elastic collision. Your answer should include:
    - a labelled diagram of the setup; (2)
    - an outline of the steps to be followed and measurements taken; (4)
    - the equations and calculations which should be used to confirm the principle; (2)
    - **TWO** precautions that are required during the experiment. (2)

    c) The students went to a fun fair and hired two bumping cars. At one time, Paula's car of mass 80 kg which was moving at 4.20 ms^{-1} bumped into Jake's car of mass 70 kg which was moving at a speed of 2.40 ms^{-1} in the same direction. After collision both cars kept moving in the same direction and Paula's car had a speed of 2.52 ms^{-1}. Assume that the surface was frictionless.
    i. Calculate the speed of Jake's car after collision. (3)
    ii. Determine whether the collision was perfectly elastic or not. Show your working. (3)

(Total: 18 marks)

Please turn the page.

11. Capacitors are very useful in cameras when the use of a flash is required. The capacitor stores energy from the battery and discharges it quickly to produce a bright flash.
    a) Draw a labelled diagram of the circuit used to discharge a capacitor, including the necessary components to take readings of current through and voltage across the capacitor. (4)

    A capacitor of capacitance, C, was discharged through a 120 kΩ resistor. The following is the Voltage – Time graph (Figure 5) obtained while the capacitor was discharging.

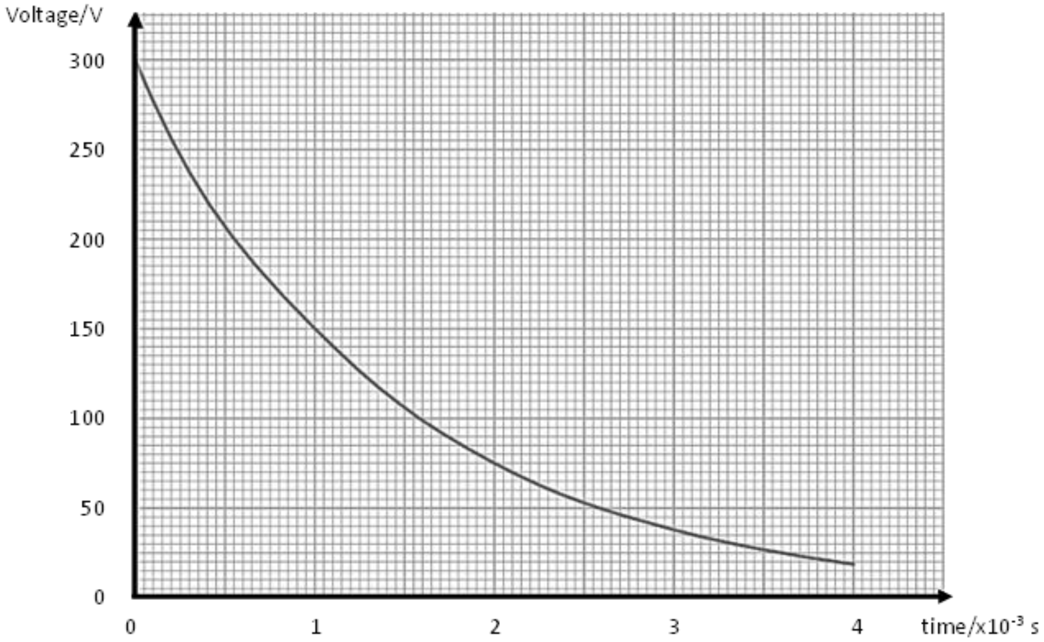

Figure 5

    b) Calculate:
        i. the initial current in the circuit; (2)
        ii. the time constant of the circuit; (2)
        iii. the capacitance C of the capacitor. (2)
    c) Sketch the corresponding graph of the Current against Time of the capacitor when it was being discharged. The graph should include the maximum value of current. (2)
    d) Sketch the corresponding graph of the Stored Charge against Time of the capacitor when it was being discharged. The graph should include the maximum value of the stored charge. (4)
    e) Describe the change in the voltage across, the current through and the charge stored in a capacitor when it is discharging through a resistor, and explain how it is similar to radioactive decay. (2)

(Total: 18 marks)

12. a) i. Explain what is meant by a progressive wave. (1)

ii. Sketch a labelled displacement-position graph for a progressive wave Q, of amplitude 0.5 m, and wavelength 2 m. In your sketch, include **TWO** full wavelengths. (3)

iii. On your graph, label a crest and a trough. (1)

iv. If wave Q is travelling at a speed of 2.5 ms^{-1}, calculate its frequency. (2)

b) Figure 6 is a displacement-time graph for a progressive wave, R.

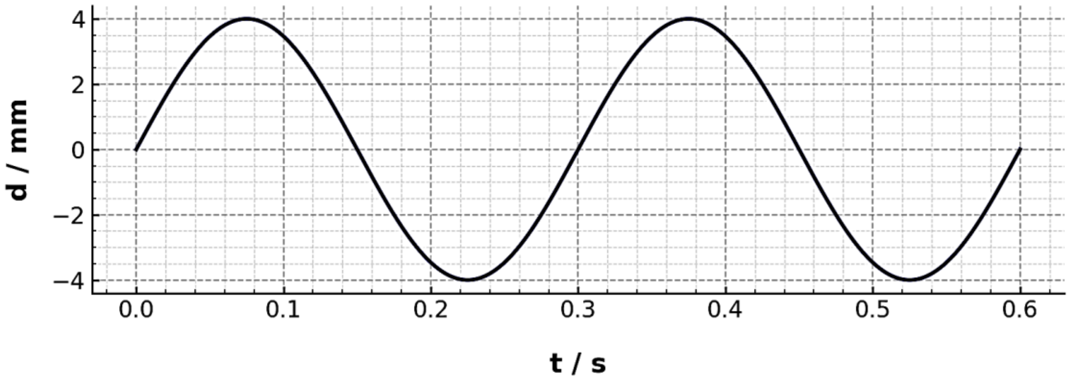

Figure 6

i. State the amplitude of wave R. (1)

ii. Find the frequency of wave R. (2)

c) When a new harbour is being designed, engineers consult the theory behind diffraction of water waves to reduce wave energy and protect sea vessels and shorelines. Describe an experiment to investigate the diffraction of water waves at a gap when the width of the gap is changed. Your answer should include:

i. a labelled diagram of the setup; (2)

ii. sketches of the observations made with a small and a large gap. (2)

d) The same setup can be used to investigate constructive and destructive interference of waves originating from two coherent point sources. Describe what is a:

i. constructive interference; (2)

ii. destructive interference. (2)

(Total: 18 marks)

Please turn the page.

13. a) State Coulomb's Law of Electrostatics. (2)

b) Two small spheres G and H exert an electrostatic force, F = X N on each other. The distance between the spheres is 80 cm.

i. Show that when the distance between the spheres is changed to 3.2 m, the electrostatic force between the spheres is $\frac{X}{16}\,N$; (4)

ii. Determine the value of the electrostatic force in terms of X, if the charge of sphere G is doubled and that of sphere H is halved if the distance between them is still 3.2 m. (2)

c) Define:

i. Electric Field Strength; (1)

ii. Electrostatic Potential Difference. (1)

d) Draw a labelled diagram of the uniform electric field between two oppositely charged plates. (2)

e) Calculate:

i. the electrostatic force acting on a proton placed in a uniform electric field between two plates of 1.65×10^{6} NC^{-1}. (Charge of a proton = 1.6×10^{-19} C); (2)

ii. the work required to move the proton between the plates if there is a potential difference of 120 V between them. (2)

f) A driver noted that every time she goes out of her car and accidentally touches the metal of the car body she feels a minor sensation of an electric shock. This happens because her body would be discharging some charge which built on her body. Calculate the voltage discharged through a spark across a uniform electric field of 9.25×10^{5} Vm^{-1}, when her hand is 6 mm away from the metallic body of the car. (2)

(Total: 18 marks)