Index Number: _____ SEC24/1.24s

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

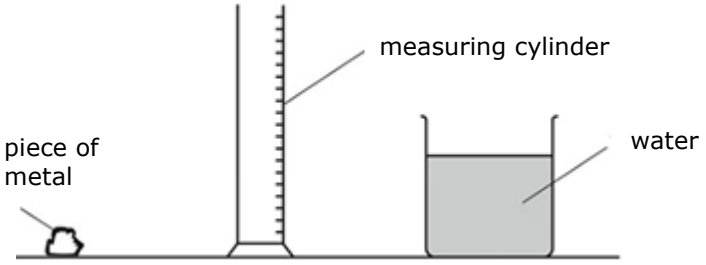
SECONDARY EDUCATION CERTIFICATE LEVEL
2024 SUPPLEMENTARY SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	I
DATE:	28th August 2024
TIME:	9:00 a.m. to 11:05 a.m.

Answer all questions.
You are requested to show your working and to write the units where necessary.
When necessary, take g, acceleration due to gravity, as 10 m/s^2.

Density	$m = \rho V$		
Pressure	$F = p A$	$p = \rho g h$	
Moments	Moment = F × perpendicular distance		
Energy and Work	$PE = m g h$	$KE = \frac{1}{2} m v^2$	$W = F s$
	Work Done = energy converted		$E = p t$
Force and Motion	m a = unbalanced force	$W = m g$	$v = u + a t$
	average speed = $\frac{\text{total distance}}{\text{total time}}$		$s = (u + v)\frac{t}{2}$
	$v^2 = u^2 + 2 a s$	$s = u t + \frac{1}{2} a t^2$	momentum = m v
Waves	$\eta = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$		$v = f\lambda$
	$\eta = \frac{\text{real depth}}{\text{apparent depth}}$	Magnification = $\frac{\text{image distance}}{\text{object distance}}$	
	Magnification = $\frac{\text{image height}}{\text{object height}}$		$T = \frac{1}{f}$
Electricity	$Q = I t$	$V = I R$	$E = Q V$
	$P = I V$	$R \propto \frac{L}{A}$	$E = I V t$
	$R_{total} = R_1 + R_2 + R_3$	$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$	
Electromagnetism	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	$V_p I_p = V_s I_s$	
Heat	$Q = m c \Delta\theta$		
Radioactivity	$A = Z + N$		
Other equations	Area of a triangle = $\frac{1}{2}$ b h	Area of a trapezium = $\frac{1}{2}$ (a + b) h	
	Area of a circle = πr^2		

1. A student has an irregularly shaped piece of metal, a beaker with water and a measuring cylinder, as shown below.



a. Use numbers 2 to 5 to indicate the order of the steps needed to find the volume of the irregularly shaped piece of metal. The first step is indicated with the number 1. (4)

	Slightly tilt the measuring cylinder and allow the piece of metal to slide down slowly.
	Once submerged, take the reading of the volume of water from the measuring cylinder.
1	Pour water from the beaker to the measuring cylinder.
	Subtract the initial volume reading from the final volume reading. Repeat the procedure.
	Take the reading of the volume of water from the measuring cylinder.

b. Name the instrument used to measure the mass of the irregularly shaped piece of metal.

_____ (1)

c. If the volume of the piece of metal is 20 cm^3 and the mass is 0.2 kg, calculate the density of the metal in g/cm^3.

_____

_____

_____ (3)

d. Apart from preventing damage to the measuring cylinder, explain why the procedure outlines that the student should:

- allow the piece of metal to slide down slowly: _____

_____ (1)

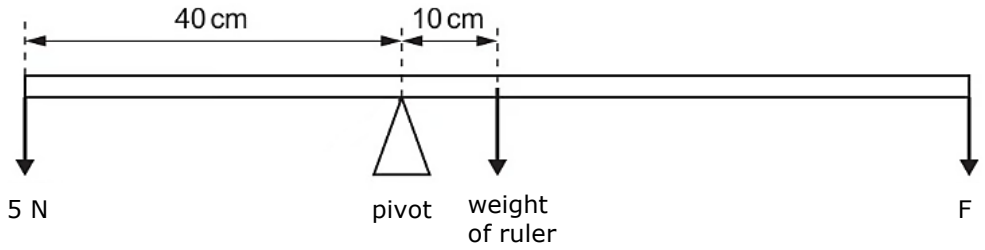
- repeat the procedure: _____

_____ (1)

(Total: 10 marks)

10

2. A wooden rod of length 1 m rests on a pivot, 40 cm away from one end. Three forces act downward on the rod, as shown in the figure below. The rod is in equilibrium.



a. Fill in the blanks:

The rod is in equilibirum, as the total _____ moments is equal to the total _____ moments. (2)

b. Given that the mass of the rod is 1 kg, calculate its weight.

_____

_____

_____ (2)

c. Show that the moment of the 5 N force about the pivot is 2 Nm.

_____

_____

_____(2)

d. Hence, calculate force F.

_____

_____

_____(2)

e. A reaction force acts on the rod to keep it in equilibrium. On the figure above, draw an arrow to indicate where this force is acting and label it as R. (1)

f. Calculate the value of the reaction R.

_____

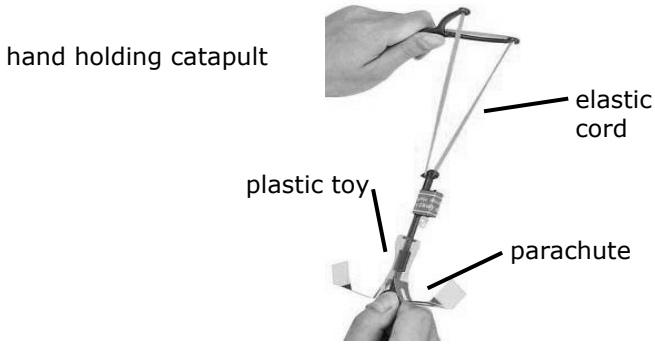
_____

_____(1)

(Total: 10 marks)

10

3. The figure below shows a catapult that uses an elastic cord to throw a plastic toy upwards. The toy is handheld and pulled downwards, stretching the elastic cord. When the toy is released, it shoots upwards.



(https://www.ebay.com)

a. As the toy is pulled back, it applies a force on the elastic cord. At the same time, the cord applies an equal but opposite force on the toy. Underline the correct word in brackets to complete the sentence below.

This is an application of Newton's (first, second, third) law. (1)

b. Fill in the blanks with the relevant energy forms:

The work done to stretch the elastic is transferred to elastic potential energy stored in it. When the plastic toy is released, this energy is transformed into _____ energy as the toy is launched. This in turn changes into_____ energy as the toy travels upwards. (2)

c. Name the **TWO** forces acting on the toy as it leaves the elastic cord and is moving upwards.

_____ (2)

d. The work done in stretching the elastic is 1.8 J and the mass of the toy is 0.30 kg. Ignore air resistance and calculate the maximum height reached by the toy. Explain your reasoning.

_____

_____

_____ (3)

e. The toy reaches a maximum height and then starts falling back downwards. State the value of the resultant force acting on the plastic toy as it falls at constant speed. Explain.

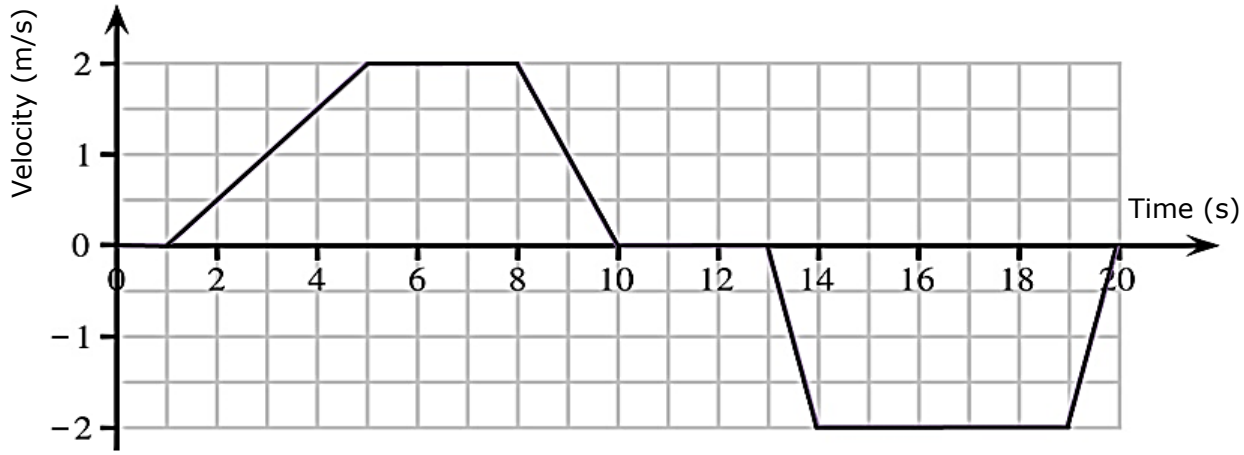
_____

_____ (2)

(Total: 10 marks)

10

4. The graph shows the motion of an object being lifted vertically upwards by a crane on a building site, stopping briefly at the top, and then being lowered back to the ground.



a. Underline the correct word in brackets. Velocity is a (vector, scalar) quantity. (1)

b. Complete the following statement by using the correct word.
The graph above shows that while the velocity is taken to be positive in one direction, in the opposite direction it is _____ . (1)

c. Without making any calculations, state how the graph indicates that:
i. the object was at rest during the first second and between the 10th and 13th second?

_____ (1)

ii. the values of both acceleration and deceleration as the object moves downwards, are greater than those on its way upwards?

_____ (1)

d. Calculate:
i. the acceleration of the object as it moves upwards;

_____

_____ (2)

ii. the height through which the object is raised.

_____

_____ (2)

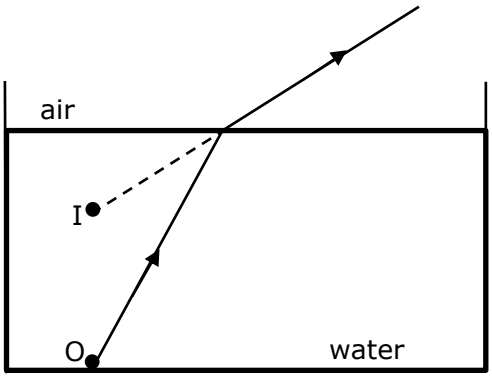
e. Ignoring the weight of the cable, is the tension in the cable holding the object **smaller than**, **equal to** or **larger than** the weight of the object when:
i. the object is hanging at rest from crane. _____ (1)

ii. the object is rising at constant speed. _____ (1)

(Total: 10 marks)

10

5. An experiment is carried out to determine the refractive index of water using the real and apparent depth method. A small object O is placed at the bottom of the water as shown in the figure. As light from the object exits the water, it changes direction. An image appears at the point marked as I.



a. On the figure above, draw an arrow to represent the apparent depth. (1)

b. Underline the correct word in the bracket.

As it moves from water into air, light changes direction because its (speed, frequency) decreases.

(1)

The object depth is varied and each time the corresponding depth of the image is measured. The results were then tabulated as shown in the table below.

real depth (cm)	3.5	5.3	6.8	8.5	10.0
apparent depth (cm)	2.6	4.0	5.1	6.4	7.5

c. Plot a graph of real depth (cm) on the y-axis against apparent depth (cm) on the x-axis. (4)

d. From your graph, read the value of the apparent depth when the real depth of the object is 6.0 cm.

_____ (1)

e. The gradient of the graph is equal to the refractive index. Hence calculate the refractive index of water from the graph.

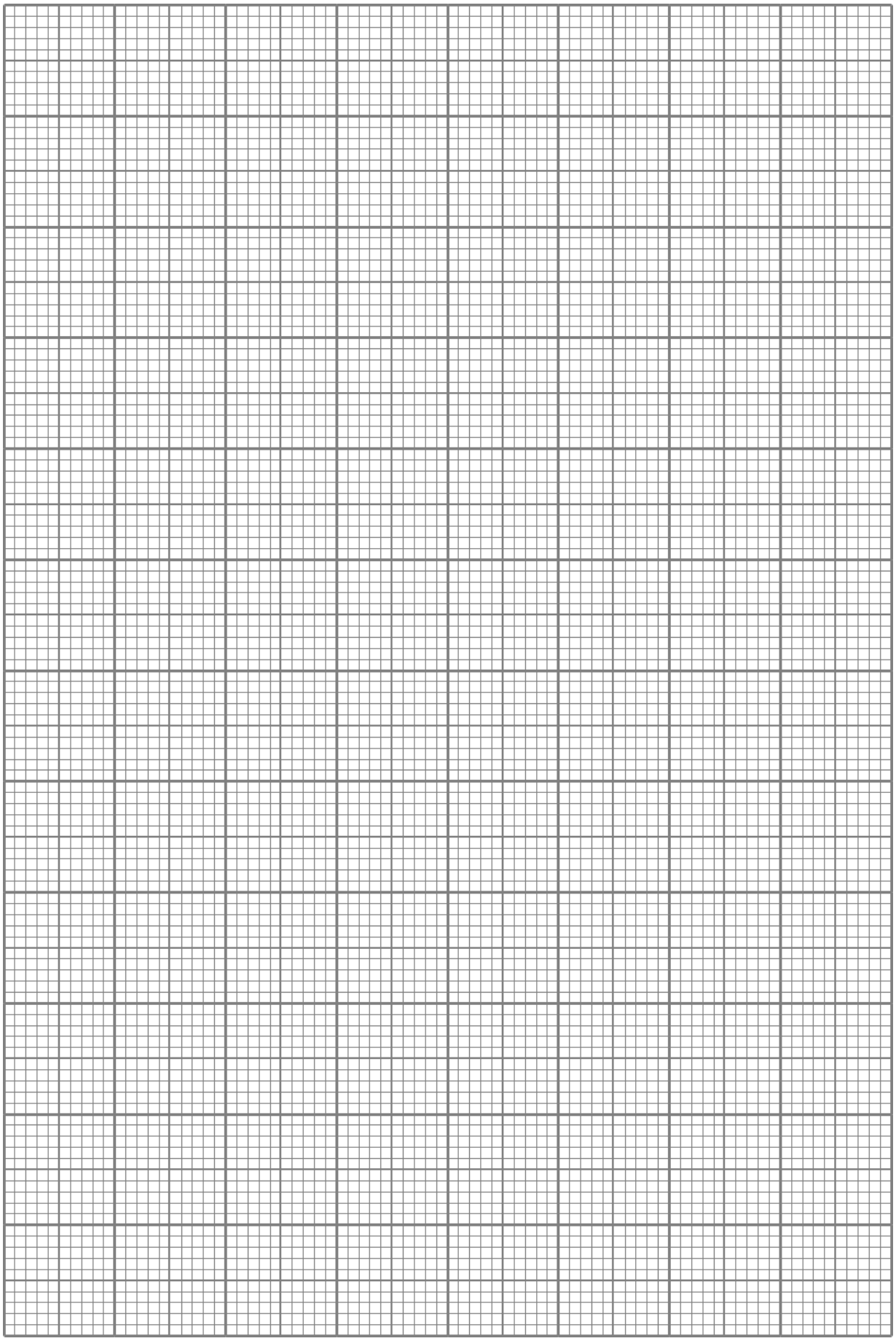
_____

_____

_____ (2)

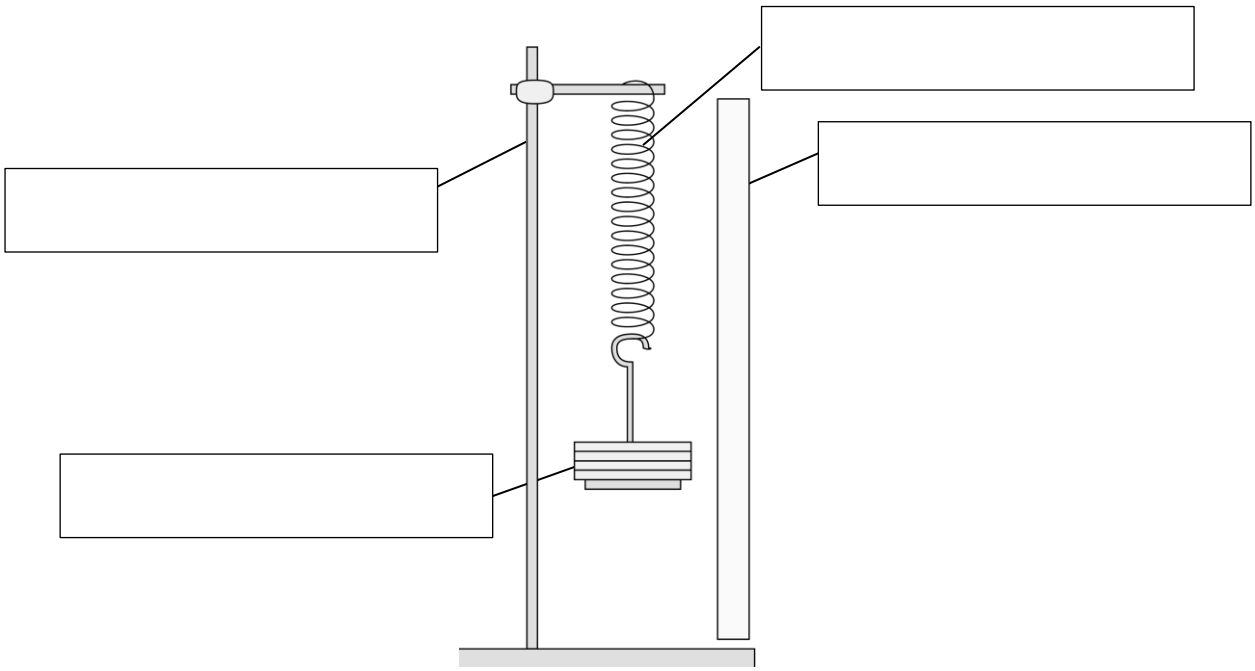
f. Draw a second line on the same axes, to show the expected graph had the experiment been repeated using vegetable oil, of refractive index 1.47, instead of water. Label this graph as L. No calculations are expected. (1)

(Total: 10 marks)



6. A helical spring is loaded with a 200 g mass. It stretches by 12 mm. The spring is perfectly elastic and obeys Hooke's Law.

a. Label the diagram. (4)



b. Briefly describe the behaviour of the helical spring when subjected to an increasing force.

_____

_____ (1)

c. State Hooke's Law.

_____

_____ (2)

d. Calculate the extension of the spring in metres, if **another** mass of 300 g is added on the spring.

_____

_____

_____ (2)

e. Briefly explain the change in extension (if any), if the spring is replaced with a stiffer spring.

_____

_____

_____ (1)

(Total: 10 marks)

7. Microwaves form part of the electromagnetic spectrum and are in fact radio waves having a short wavelength.

a. State **TWO** properties common to all electromagnetic waves.

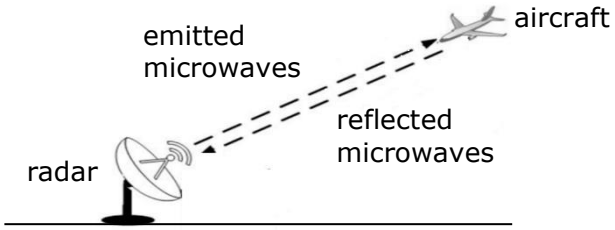
_____

_____ (2)

b. Identify the electromagnetic wave with the shortest wavelength.

_____ (1)

c. A radar installation in an airport is used to determine the distance of an aircraft. It sends microwaves which are then reflected by the aircraft.



(https://www.researchgate.net/)

The time taken for the waves to reach an aircraft and return is 0.0001 s. If the speed of electromagnetic waves is $3x10^8$ m/s, calculate the distance of the aircraft from the radar.

_____

_____

_____ (3)

d. In 1945, an American engineer was working in a radar installation and noticed that a bar of chocolate he had nearby melted in a short time. He investigated this effect and went on to invent the microwave oven.

i. Underline the correct word in the brackets.
The energy carried by the microwaves changes into (chemical, heat) energy for the chocolate to melt. (1)

ii. The frequency of microwaves used in these ovens is 2.45 x 10^9 Hz. Calculate the wavelength of the microwaves, taking the speed of the waves to be that as in part (c) above.

_____

_____

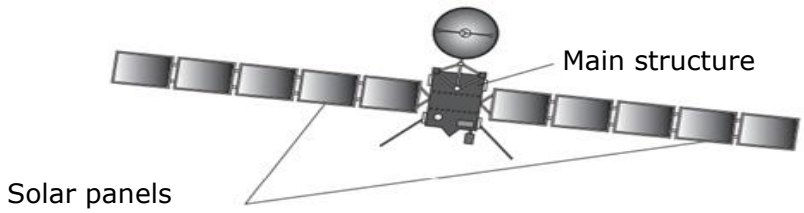
_____(2)

iii. Microwaves can also be used in outer space. Explain.

_____(1)

(Total: 10 marks)

8. On the 12th of November 2014, the European Space Agency successfully landed the spacecraft Rosetta on the surface of a comet. The main structure of the Rosetta spacecraft consists of an orbiter, a lander and propellant.



a. The solar panels contain photovoltaic cells.
   i. Identify the forms of energy change occurring in a photovoltaic cell.

_____ energy is transferred into _____ energy. (2)

   ii. Explain why the solar panels were designed so that they can rotate.

_____(1)

b. While on its journey, **four** thrusters producing a force of 10 N each, were switched on to accelerate the spacecraft forward. Thrusters are devices used to launch spacecrafts forward.
   i. Calculate the total force produced by these thrusters.

_____(1)

   ii. At this point, the spacecraft has a mass of 3000 kg. Calculate its acceleration, given that the total force produced by the thrusters remains constant.

_____

_____(2)

c. The spacecraft landed on a comet orbiting the Sun.
   i. Name the force that keeps the comet orbiting the Sun.

_____(1)

   ii. How would the distance between the Sun and the comet change if the force named in part c (i) decreased?

_____(1)

d. Several man-made satellites are orbiting the Earth. Name the **TWO** main uses of these satellites.

_____(2)

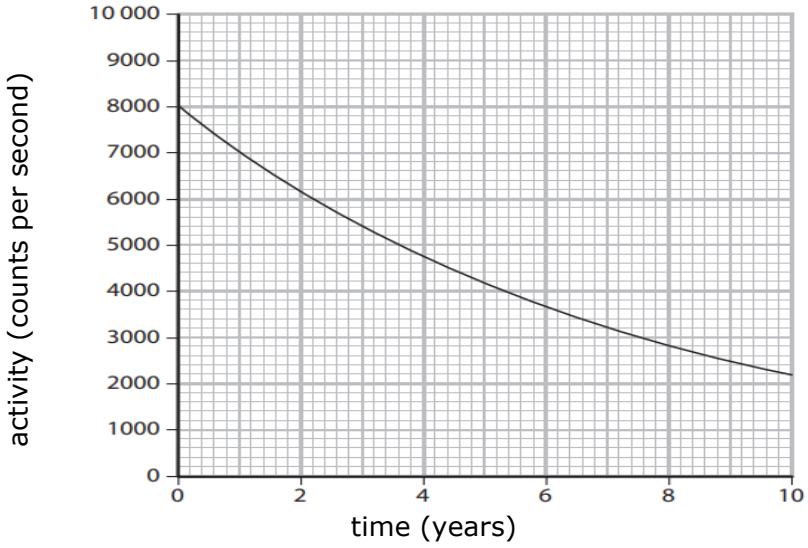
(Total: 10 marks)

9. In some countries, food is sold displaying the label shown in the figure.

a. The label indicates that the food has been deliberately exposed to gamma radiation. Explain why food is processed with this treatment.

_____ (1)

b. Cobalt-60 is one source of gamma radiation used for food irradiation. This graph shows how the activity of a sample of Cobalt-60 changes over 10 years.



i. Use the graph to find the half-life of Cobalt-60 in years. Show your reasoning.

_____

_____(2)

ii. The source of Cobalt-60 must be replaced when its activity falls below 1000 counts per second. Calculate how long it takes for the activity to fall from 8000 counts per second to 1000 counts per second.

_____

_____

_____(3)

c. There are many isotopes of Cobalt.

i. Define the term isotopes.

_____

_____(2)

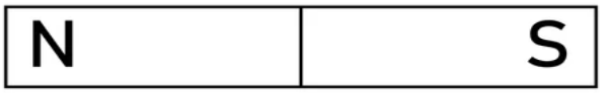
ii. Two isotopes of Cobalt can be expressed as $^{60}_{27}\mathrm{Co}$ and $^{59}_{27}\mathrm{Co}$. Complete the following:

- Number of electrons in a neutral Cobalt atom. _____ (1)
- Number of neutrons in $^{59}_{27}\mathrm{Co}$. _____ (1)

(Total: 10 marks)

10. a. The diagram below shows a bar magnet.

i. Draw the magnetic field pattern around the bar magnet. (2)



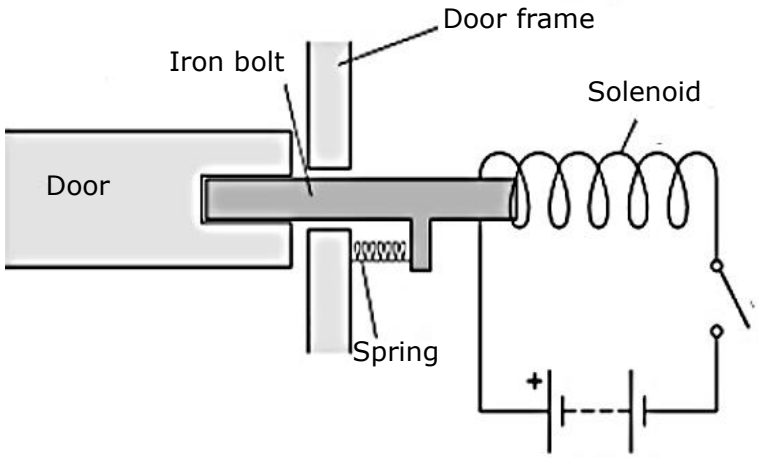
ii. A South pole placed next to another South pole would experience a magnetic force. Would this be a force of attraction or repulsion?

_____ (1)

iii. Underline the correct term from the brackets:
A bar magnet is an example of (an electromagnet, an induced magnet, a permanent magnet). (1)

b. The diagram below shows an electromagnetic lock used to open and close a door as needed.

i. Use numbers 2 to 5 in the table below, to explain the order of how an electromagnetic lock works. The first one has been done for you. (4)



The switch is closed.	1
The iron bolt moves.	
A magnetic field is created around the solenoid.	
The door unlocks.	
Current flows through the solenoid.	

ii. Explain the function of the spring when the circuit is just switched off.

_____

_____ (2)

(Total: 10 marks)

Index Number:_____ SEC24/2B.24s

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2024 SUPPLEMENTARY SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	IIB
DATE:	28th August 2024
TIME:	4:00 p.m. to 6:05 p.m.

Answer all questions.
You are requested to show your working and to write the units where necessary.
When necessary, take g, acceleration due to gravity, as $10 m/s^2$.

Density	$m = \rho V$		
Pressure	$F = p A$	$p = \rho g h$	
Moments	Moment = F × perpendicular distance		
Energy and Work	$PE = m g h$	$KE = \frac{1}{2} m v^2$	$W = F s$
	Work Done=energy converted		$E=Pt$
Force and Motion	m a = unbalanced force	$W = m g$	$v = u + a t$
	average speed $= \frac{\text{total distance}}{\text{total time}}$		$s = (u + v)\frac{t}{2}$
	$v^2 = u^2 + 2 a s$	$s = u t + \frac{1}{2} a t^2$	momentum = m v
Waves	$\eta = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$		$v = f\lambda$
	$\eta = \frac{\text{real depth}}{\text{apparent depth}}$	Magnification $= \frac{\text{image distance}}{\text{object distance}}$	
	Magnification $= \frac{\text{image height}}{\text{object height}}$		$T = \frac{1}{f}$
Electricity	$Q = I t$	$V = I R$	$E = Q V$
	$P = I V$	$R \propto \frac{L}{A}$	$E = I V t$
	$R_{total} = R_1 + R_2 + R_3$	$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$	
Electromagnetism	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	$V_p I_p = V_s I_s$	
Heat	$Q = m c \Delta\theta$		
Radioactivity	$A = Z + N$		
Other equations	Area of a triangle $= \frac{1}{2}$ b h	Area of a trapezium $= \frac{1}{2}$ (a + b) h	
	Area of a circle $= \pi r^2$		

1. This question is about momentum.

A car of mass 1000 kg is being driven at a speed of 16 m/s. The driver notices someone crossing the road ahead so he applies the brakes. The driver's reaction time is 0.6 s and the car takes a further 2.5 s to come to a complete stop.

a. Calculate the:

i. thinking distance, namely the distance the car travels during the driver's reaction time;

_____

_____

_____ (2)

ii. deceleration of the car during braking;

_____

_____

_____ (2)

iii. braking distance;

_____

_____

_____ (2)

iv. total stopping distance;

_____ (1)

v. the resultant force on the car during deceleration.

_____

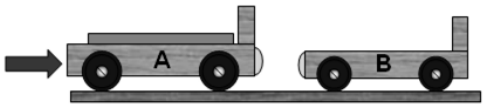
_____ (2)

b. Underline the correct word in each of the situations listed below.

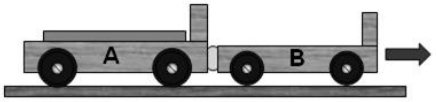
i. When the road is wet and slippery the (thinking / braking) distance will (increase / decrease). (2)

ii. If the driver is distracted while driving, the (thinking / braking) distance will (increase/ decrease). (2)

c. The figure below shows the apparatus used to investigate momentum and its conservation. A and B are two trolleys. The figure on the left shows trolley A after being given a push and moving towards trolley B, which is initially at rest. The figure on the right shows both trolleys moving together after collision.



Before collision



After collision

(https://www.schoolphysics.co.uk/)

i. State the principle of conservation of momentum.

_____

_____

_____(2)

ii. When trolley A, of mass 0.6 kg, is given a push it moves with a velocity of 0.5 m/s. Calculate the momentum of trolley A.

_____

_____(2)

iii. Trolley B has a mass of 0.4 kg. Assuming the law of conservation of momentum is obeyed, calculate the velocity with which the two trolleys move together after collision.

_____

_____

_____(2)

iv. What effect, if any, would there have been on the answer in part c(iii), if friction was present between the wheels of the trolleys and the ground?

_____(1)

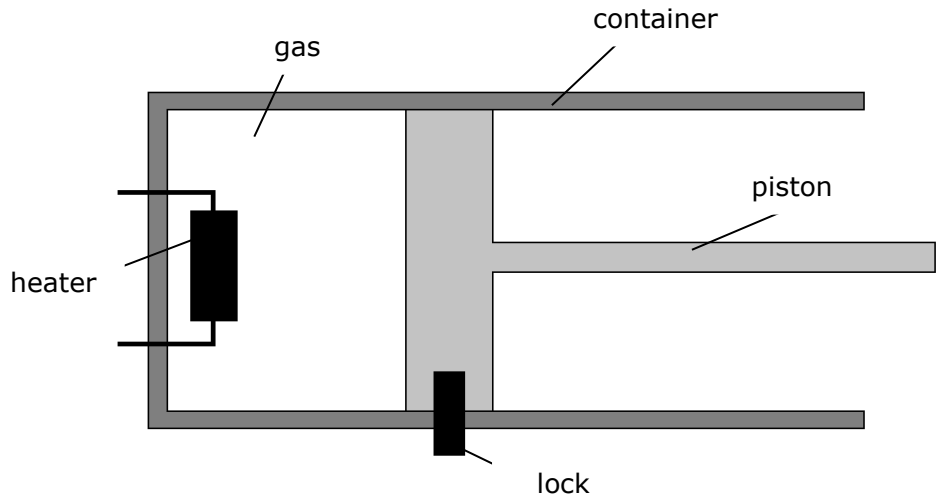
(Total: 20 marks)

Please turn the page.

20

2. This question is about particle energy.

A gas of mass 0.19 g, is trapped in a rectangular container by a piston. The gas is at atmospheric pressure, 100000 Pa, and at a temperature of 20 °C. When the lock pin is in place, the gas is trapped in a space of width 0.15 m, length 0.15 m, and a height of 0.10 m.



a. Describe the motion of the particles of the trapped gas.

_____

_____

_____ (2)

b. Calculate the volume, in m^3, of the trapped gas when the lock pin is in place. Assume that the heater occupies a negligible volume.

_____

_____

_____ (2)

c. Calculate the density of the trapped gas in kg/m^3.

_____

_____

_____ (2)

d. If the specific heat capacity of the gas is 0.65 J/kg°C, calculate the energy required by the heater to raise the temperature of the gas to 68 °C.

_____

_____

_____ (3)

e. Describe the change, if any, in the motion of the particles of the trapped gas, at higher temperature.

_____

_____(2)

f. State **TWO** assumptions made in your calculation to part (d).

_____

_____

_____(2)

g. If the power of the heater is 0.002 W, calculate the time needed for the heater to supply the energy for the gas to reach 68 °C.

_____

_____

_____

_____(2)

h. Briefly explain why the time calculated in part (g) may be inaccurate in real life scenario.

_____

_____

_____ (2)

i. The lock pin is removed, and the temperature of the trapped gas is kept constant. State the change, if any, in the following quantities:

- Volume of gas _____ (1)
- Frequency of collisions of the particle with the container _____ (1)
- Pressure of the trapped gas. _____ (1)

(Total: 20 marks)

Please turn the page.

3. This question is about heat transfer.

A mug manufacturing company is designing a new mug for the market. The aim is to create a mug which keeps the hot beverage warm as long as possible.

a. Explain the following choices, using scientific terms.

i. The material for manufacturing is plastic, rather than metal.

_____

_____

_____ (2)

ii. Mugs are painted white, rather than black.

_____

_____

_____ (2)

iii. Mug design is narrow and tall, rather than wide and short.

_____

_____

_____ (2)

iv. Some mugs have double-wall design, with vacuum in between the walls.

_____

_____

_____ (2)

b. During the testing phase, it was suggested that the mugs are each completed with a lid, to avoid evaporation. Explain evaporation in terms of particles.

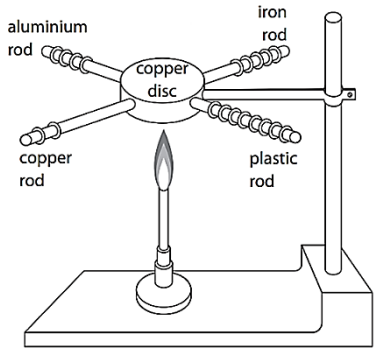
_____

_____

_____

_____ (2)

c. Prior to choosing the material, the company conducted several tests to find the best thermal insulator for the mugs. The following setup was used, in which rods of different materials were inserted in a copper disc. An identical number of wax rings where initially hung with each rod. After some time, the number of wax rings decreased as shown in the figure.



Fill in the blanks with the correct word:

Heat travels from regions at _____ temperature, to regions of _____ temperature, until the _____ temperature is reached. (3)

d. Identify **TWO** heat energy transfers from the bunsen burner to the wax rings.

_____

_____ (2)

e. Outline **ONE** design in the setup which ensures fair testing.

_____

_____ (1)

f. When the investigation was over, and the copper disc was removed, and warm air was observed rising above the bunsen burner. Explain in terms of particles.

_____

_____

_____ (2)

g. The rods seemed to be stuck in the copper disc. However, onced cooled, they were pulled out very easily. Explain why.

_____

_____

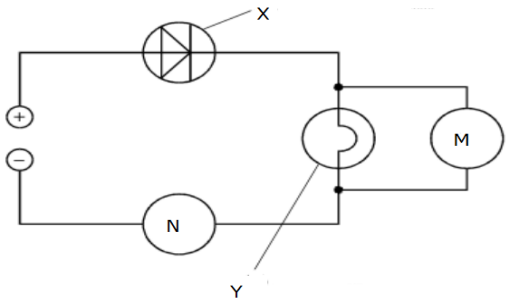
_____ (2)

(Total: 20 marks)

Please turn the page.

20

4. This question is about electric current.
The electrical circuit below shows components X and Y connected in series with a power supply. M and N are two meters.



a. i. Name components X and Y.

X _____ Y _____ (2)

ii. State the physical quantities that meters M and N measure.

M _____ N _____ (2)

b. Component X is replaced by a fixed resistor.
i. Use the space below to draw the symbol of a fixed resistor. (1)

ii. Does a fixed resistor obey Ohm's law? Explain.

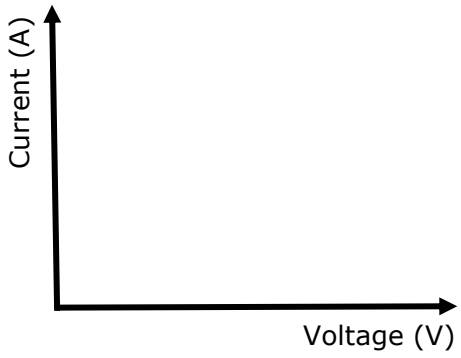
_____

_____ (2)

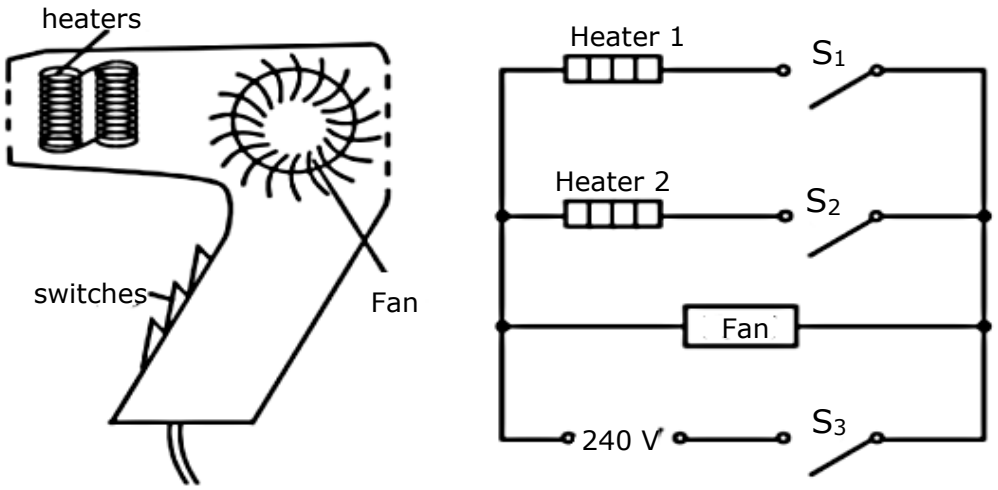
iii. What other quantity should be kept constant to maintain a constant resistance in the resistor?

_____(1)

iv. Use the axes provided to sketch a graph showing how current varies through a fixed resistor as the voltage changes. (2)



c. The figure below shows a hairdryer and the circuit inside it. Switches S_1, S_2 and S_3 are all open.



Which switch or switches must be closed to allow:

i. only the fan to work? _____ (1)

ii. both heaters to work? _____ (2)

d. All three switches are now closed.

i. State the voltage across each heater. _____ (1)

ii. The heaters have a resistance of 18 Ω each at a given temperature. Calculate the current through each heater.

_____

_____

_____ (2)

e. The information on the hairdryer states a power rating of 1300 W.

i. Explain the meaning of a power rating of 1300 W.

_____ (1)

ii. Hence calculate the total energy consumption of the hairdryer in 5 minutes. Give your answer in joules.

_____

_____

_____ (3)

(Total: 20 marks)

20

5. This question is about magnetic fields.

a. An electromagnet is constructed by coiling a length of insulated wire around an iron nail.

i. In the space below, draw a diagram showing the electromagnet connected in series with a battery and a switch. (4)

ii. The strength of the electromagnet is to be investigated by using several paper clips. The method used is listed below. Use numbers 1 to 3, to put the statements in order. (3)

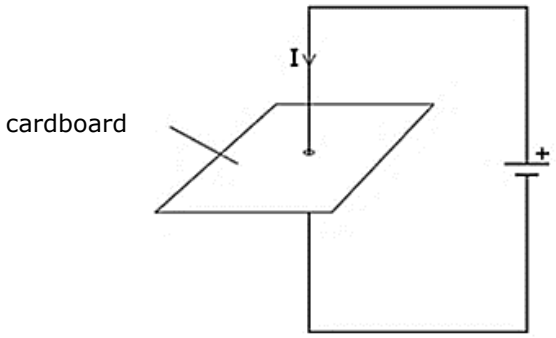
The number of attracted paper clips is counted and the switch is opened.	
The tip of the nail is placed near the paperclips and the switch is closed.	
Some paper clips are attracted to the nail.	

iii. State **TWO** ways in which the strength of the electromagnet can be increased.

_____

_____ (2)

b. In another experiment a straight wire is passed vertically through a piece of cardboard as shown in the figure below. The circuit is closed and current flows through the wire in the direction shown.



i. Describe how iron filings can be used to show that a magnetic field has been produced around the wire.

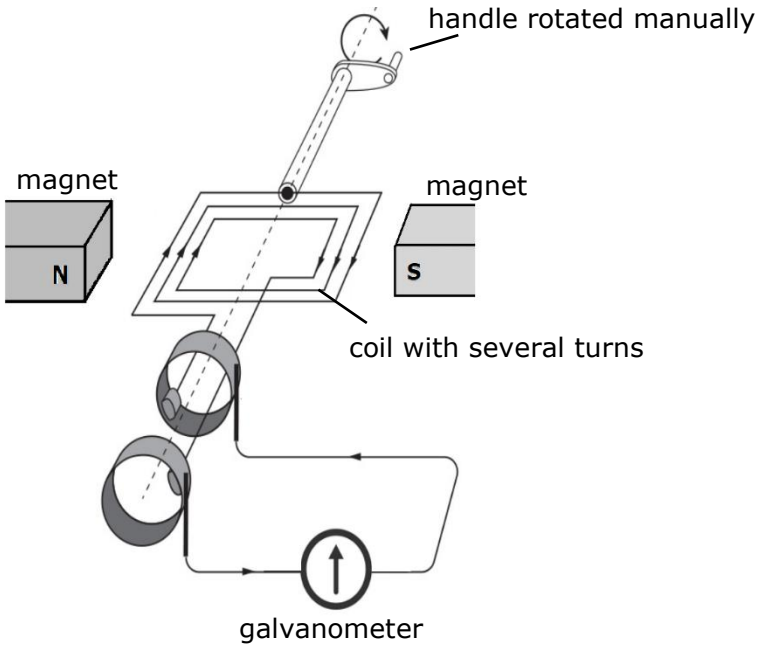
_____

_____

_____(3)

ii. On the cardboard shown in the figure above, draw the magnetic field pattern that is obtained. Use arrows to include its direction. (2)

c. The figure below shows a simple experiment used to prove that a changing magnetic field can induce an e.m.f. in a circuit. This device is used to indicate how fast the handle is being rotated by observing the reading on the galvanometer.



(https://courses.lumenlearning.com)

i. Use numbers 1 to 4 to rearrange the statements below in order, to explain how the current is induced in the coil. (4)

An e.m.f. is induced in the coil as per Faraday's law.	
The induced current in the coil is then observed from the galvanometer.	
The handle is rotated manually and this causes the coil to rotate.	
The rotating coil cuts the magnetic field lines of the magnets.	

ii. State the effect on the current induced if the coil is rotated faster.

_____ (1)

iii. How would the current induced change if the number of turns in the coil were decreased?

_____ (1)

(Total: 20 marks)

Blank Page