Index Number:_____ SEC24/1.24m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

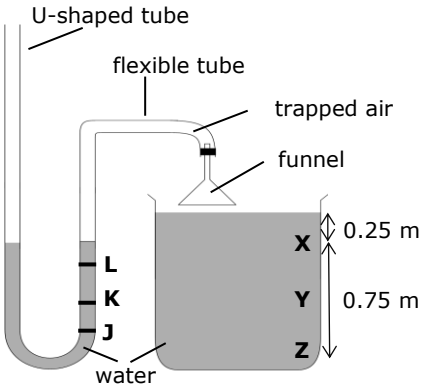
SECONDARY EDUCATION CERTIFICATE LEVEL
2024 MAIN SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	I
DATE:	18th May 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/s².

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. The setup shown is used to investigate pressure in fluids. The U-shaped tube is connected to a flexible tube and an inverted funnel. The U-shaped tube and the large container contain water. The connection between the flexible pipe and the funnel is sealed. The inverted funnel is sealed with a plastic bag, so that no water can enter the funnel.



a. Define pressure.

_____

_____ (1)

b. Describe the molecular structure and the motion of the particles of the trapped air in the flexible tube.

_____

_____ (2)

c. When the inverted funnel is lowered under water, the water level in the U-shaped tube is changed.

i. Complete the table below, using J, K and L, to indicate these changes: (1)

Funnel at:	X	Y	Z
Water level in U-tube at:			

ii. Briefly explain the changes, if any, in the mass of the trapped air in the flexible tube and funnel.

_____

_____ (2)

d. The density of water is 1000 kg/m^3. Calculate the difference in pressure between point X and Z, ignoring the effects of atmospheric pressure.

_____

_____ (2)

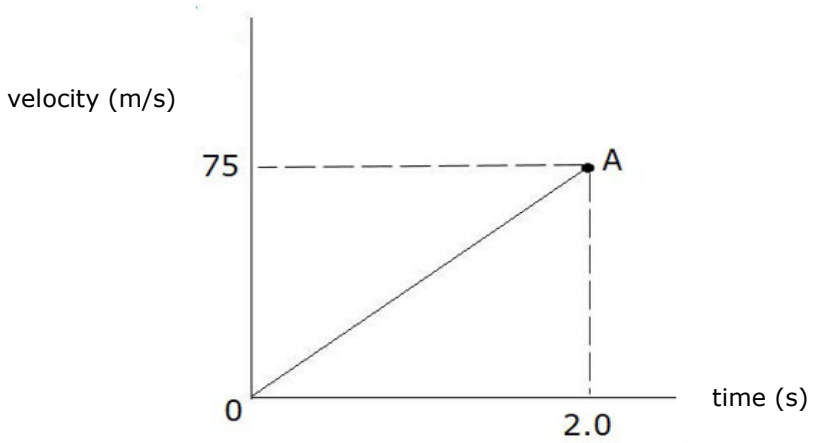
e. The inverted funnel is now kept at position Y. The container with water is heated such that the temperature of water increased from 22°C to 60°C. In terms of particles, describe the changes, if any, of the pressure of the trapped air in the flexible tube and funnel.

_____

_____ (2)

(Total: 10 marks)

2. Aircraft on board aircraft carriers have a much shorter runway than normal at their disposal for take-off. In fact such aircraft are assisted by a catapult, a device on the deck of the aircraft carrier. This catapult pulls the aircraft and together with the aircraft's engines provides a sufficient force to reach take-off velocity over a short distance.



The above represents the velocity-time graph of an aircraft of mass 1 x 10^4 kg reaching a take-off velocity at A of 75 m/s from rest in just 2.0 s.

a. Use the graph to calculate the acceleration in the first 2.0 s.

_____

_____ (2)

b. Calculate the distance travelled by the aircraft in 2.0 s.

_____

_____ (2)

c. Calculate the change of momentum of the aircraft between the rest position and position A.

_____

_____ (2)

d. Hence calculate the unbalanced force causing this acceleration.

_____

_____ (2)

e. During take-off, the pilot feels pushed back against his seat. Explain.

_____

_____ (2)

(Total: 10 marks)

Please turn the page.

3. A uniform wooden plank has a length of 2 m and a mass of 5 kg. The plank rests on a pivot, 40 cm away from its left end, as shown in the diagram. An object is placed at the plank's left end so as to keep the plank perfectly horizontal.

a. Mark and label on the diagram **THREE** forces acting on the wooden plank. (3)

b. If the wooden plank is in equilibrium, the total clockwise moment is _____ to the total anti-clockwise moment. (1)

c. Calculate the total clockwise moment acting on the wooden plank.

_____

_____

_____

_____ (2)

d. Calculate the mass of the object needed at the plank's end, to keep the plank in equilibrium.

_____

_____

_____

_____ (3)

e. Describe the changes, if any, if a second object is placed on the wooden plank, at the pivot.

_____

_____

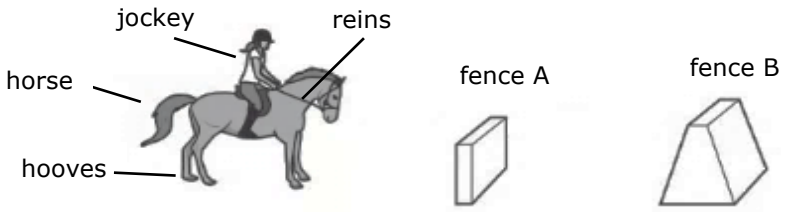
_____

_____ (1)

(Total: 10 marks)

10

4. A horse and its jockey are moving towards two fences at a constant speed, as shown in diagram.



a. Name the force acting in the reins when they are being pulled by the jockey to control the horse's movement.

_____ (1)

b. On the diagram above draw and name **ONE** arrow to represent the resistive force acting between the horse's hooves and the ground. (2)

c. A forward force of 2500 N is provided by the horse.

i. What is the total value of the resistive forces acting against the movement of the horse and its jockey?

_____ (1)

ii. Hence state the resultant force acting on the horse and its jockey.

_____ (1)

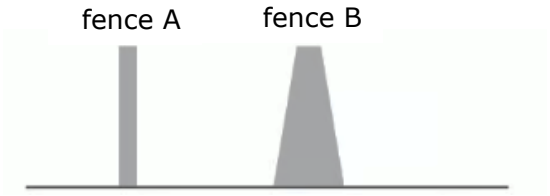
iii. Name and state the law that justifies your answers in part c(i) and c(ii).

_____

_____ (2)

d. A side view of the fences is shown in the diagram below.

i. Mark the centre of gravity of fence B with an X on the diagram below. (1)



ii. The fences are made up from the same material, and have identical height, yet one is less likely to topple over if hit by the horse. State and explain which fence is more stable.

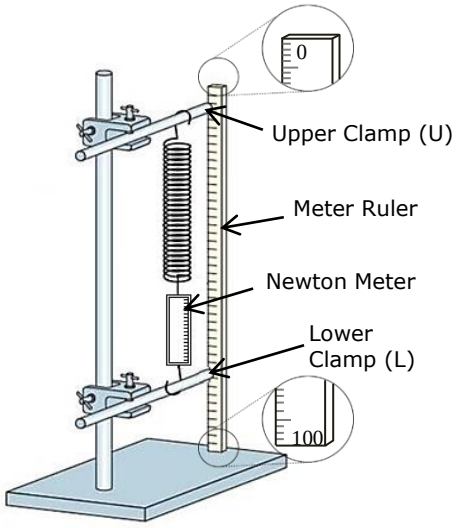
_____

_____ (2)

(Total: 10 marks)

Please turn the page.

5. A Newton meter is held vertically between a helical spring and a lower clamp. The helical spring is then hung from the upper clamp, as shown in the diagram. The upper clamp is kept stationary at position U. The lower clamp is lowered gradually, each time recording the value from the Newton meter and the position of the lower clamp, L. The length of the Newton meter is 18 cm and remains constant throughout the experiment. The diagram is not to scale.



a. Complete the following table. (3)

Position of upper clamp U (cm)	10	10	10	10	10	10	10
Position of lower clamp L (cm)	40	42	43	44	46	48	49
Helical Spring Length (cm)							
Extension (cm)							
Newton Meter Reading (N)	0	5.0	7.5	10.0	15.0	20.0	22.5

b. Plot a graph of Newton Meter Reading (N) on the y-axis against Extension (cm) on the x-axis. (4)

c. Describe the behaviour of a helical spring when subjected to an increasing force.

_____

_____

_____

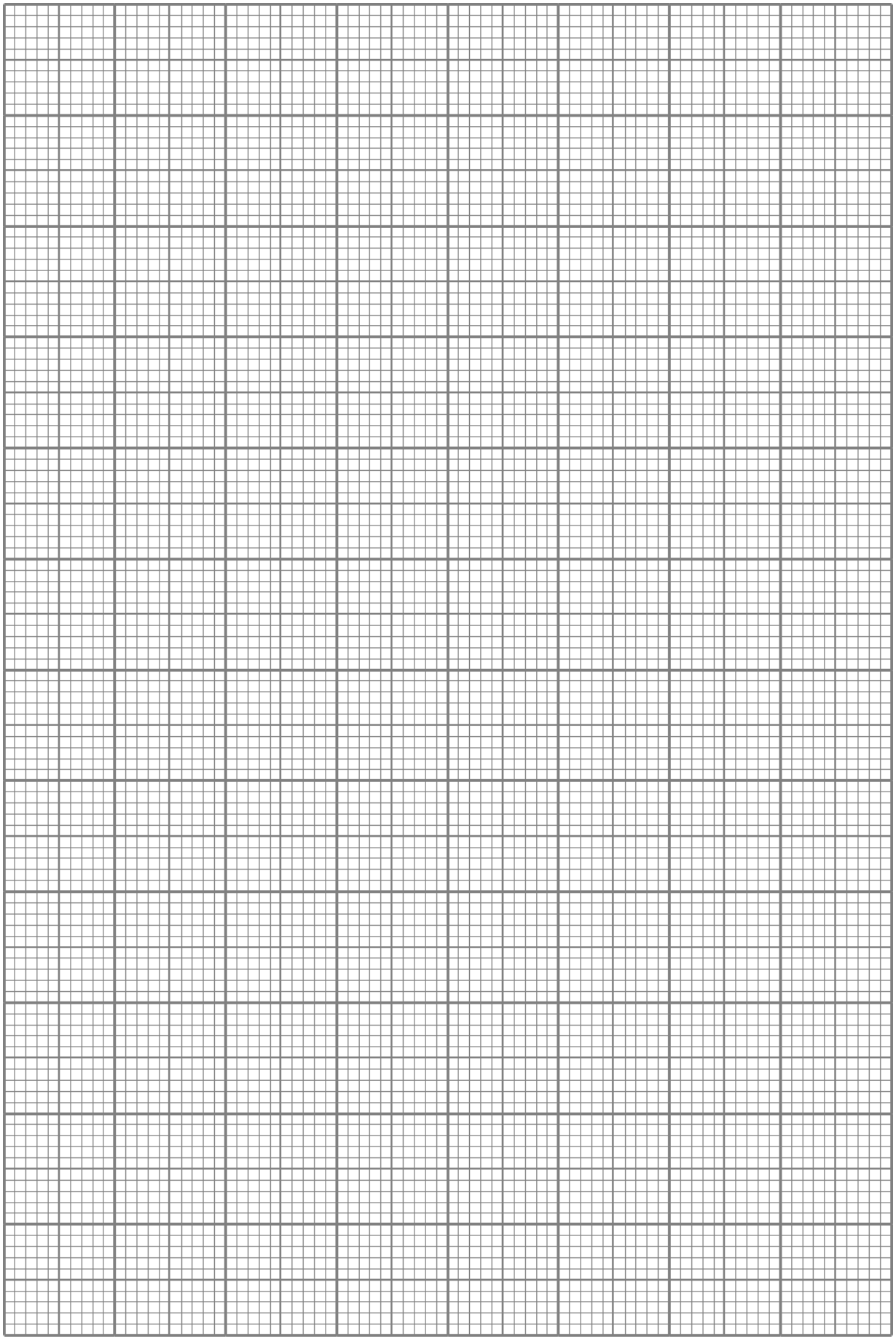
_____ (2)

d. Outline the changes, if any, when the helical spring is substituted with a stiffer spring.

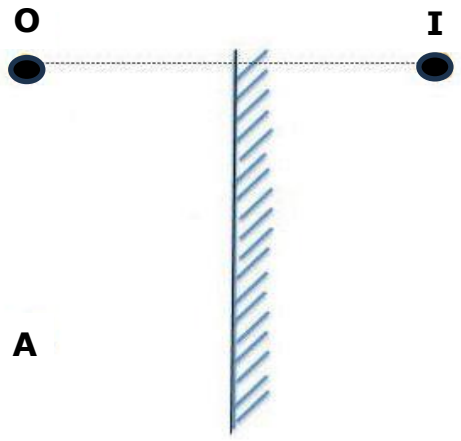
_____

_____ (1)

(Total: 10 marks)



6. a. A student is standing at position A, looking at the image I of an object O placed in front of a plane mirror as shown.



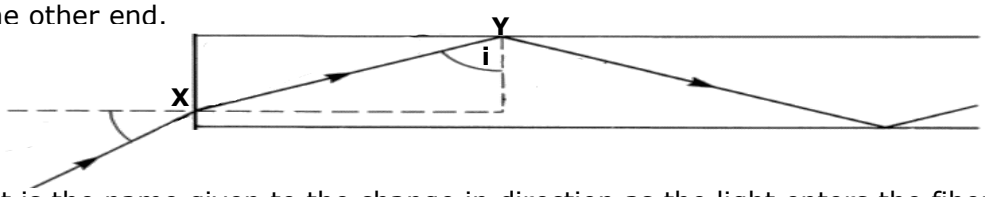
i. On the above diagram, draw **TWO** rays leaving the object and reaching the student's eyes, at point A, after reflection at the mirror. Mark the direction of these rays. (2)

ii. For any **ONE** of these rays, draw also the normal and label with an 'i' and 'r' the angles of incidence and reflection at the mirror. (2)

iii. State **TWO** properties of the image formed at I.

_____ (2)

b. The diagram shows a ray of light entering a straight portion of a fiber optic cable at X. It undergoes several reflections inside the fiber, such as at point Y, until it finally emerges out from the other end.



i. What is the name given to the change in direction as the light enters the fiber optic cable at X?

_____ (1)

ii. Explain why the light ray does not emerge from the fiber at point Y, stating the name given to this type of reflection.

_____

_____

_____ (2)

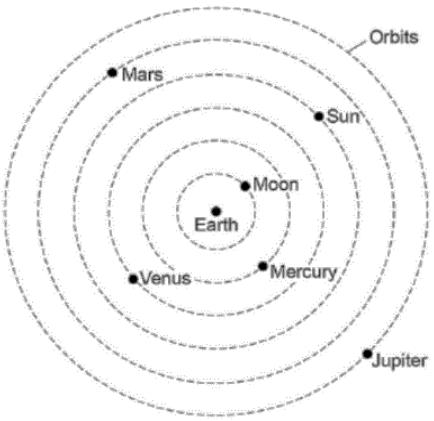
iii. State **ONE** use of a fiber optic cable.

_____ (1)

(Total: 10 marks)

7. The diagram represents a historical model of our solar system.

a. State **ONE** way in which the model of the solar system shown in the diagram differs from the present model of the solar system.



_____ (1)

b. Name **ONE** instrument that can be used to observe planets and stars.

_____ (1)

c. Name the force keeping the planets in orbit.

_____(1)

d. Name **TWO** planets in our solar system which are not represented in this historical model.

_____(2)

e. In space large distances are measured in light years.

i. What is the meaning of one light year?

_____

_____(1)

ii. One light year is equivalent to 9.46 x10^{15} m. The Sun is 1.5 × 10^{11} m away from Earth. How far is it in light years?

_____

_____(2)

iii. Calculate the time taken by light from the Sun to reach the Earth. Light travels at a speed of 3.0 × 10^{8} m/s.

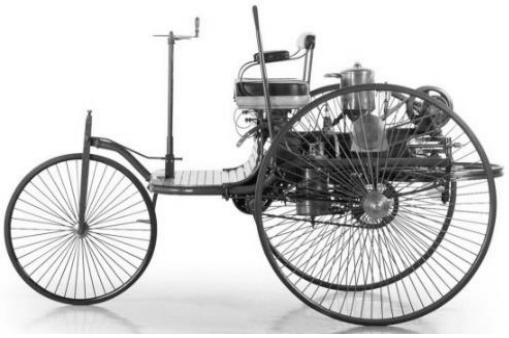
_____

_____(2)

(Total: 10 marks)

Please turn the page.

8. The Benz Motorwagen, built by the German Karl Benz in 1885 and powered by a fossil fuel, is regarded as the first car to be put in production.



(Source: https://wikipedia.org)

a. Why are fossil fuels so called?

_____

_____

_____ (1)

b. Name **TWO** types of fuel which may be used in a fossil fuelled car.

_____ (2)

c. Fossil fuels are said to be non-renewable. Explain why.

_____ (1)

d. Name the respective forms of energy in a fossil-fuelled car.

- Input energy _____ (1)
- Useful output energy _____ (1)
- Wasted output energy _____ (1)

e. Several initiatives are being promoted to reduce the use of fossil fuels as the energy source in cars, and replace these by alternative forms of energy. Give **ONE** reason for this.

_____

_____ (1)

f. One of the alternative designs, the all-electric car, has an efficiency of about 75%. Explain what is meant by saying that a car has an efficiency of 75%.

_____

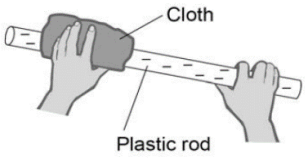
_____ (1)

g. During braking, some hybrid and electric cars convert the kinetic energy into electrical energy, instead of wasting it. State **ONE** main use for the electrical energy produced.

_____ (1)

(Total: 10 marks)

9. The diagram shows a plastic rod being rubbed by a cloth. The plastic rod acquires a negative charge.



a. Suggest a type of plastic material that could be used for the rod.

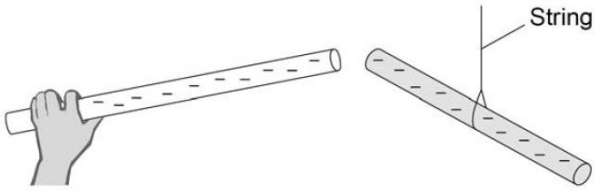
_____(1)

b. Complete the sentences below.

The plastic rod becomes charged because it gains _____. The cloth acquires a

_____ charge as it loses _____. (3)

c. The negatively charged plastic rod is placed near another negatively charged plastic rod that is hanging from a string as shown in the diagram below.

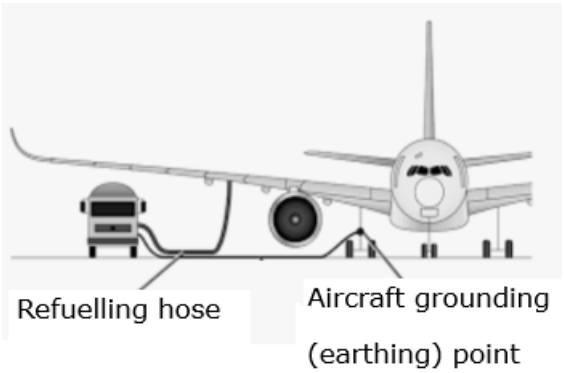


State what happens to the hanging rod. Give a reason for your answer.

_____

_____(2)

d. The diagram shows an aeroplane being refuelled after a flight. Sparks from electrostatic discharge can sometimes be very dangerous during refuelling. They can cause a fire or an explosion.



i. Explain why sparks might occur during refuelling.

_____

_____(2)

ii. Hence, describe the function of the aircraft grounding (earthing) point.

_____

_____(2)

(Total: 10 marks)

Please turn the page.

10. Hospitals use ionising radiation for various applications.

a. Alpha and beta are two main types of radiation. State the other main type of radiation.

_____(1)

b. State **ONE** use of ionising radiation in hospitals.

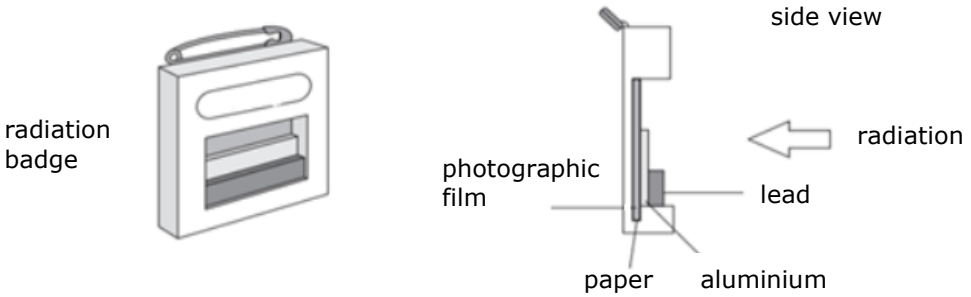
_____(1)

c. Hospital radiographers working with radioactive isotopes wear a radiation badge.

i. The badge is used to monitor the amount of radiation the radiographer is exposed to. Explain the importance of monitoring the amount of radiation exposure.

_____(1)

ii. The radiation badge contains a photographic film which detects radiation as shown in the diagram below. The film is sent to the laboratory every month to be analysed.



Describe how the badge records the different types of radiation that the radiographer has been exposed to.

_____

_____

_____(3)

iii. Another detector of radiation is the GM tube. A count rate is observed even without a specific radioactive source present in the room. Explain.

_____(1)

d. The isotope technetium-99 has a half-life of 6 hours. A hospital has a sample which contains 40 mg of technetium-99.

i. Define half-life.

_____(1)

ii. Calculate how much technetium-99 will be left in this sample after 12 hours.

_____(2)

(Total: 10 marks)

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L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2024 MAIN SESSION

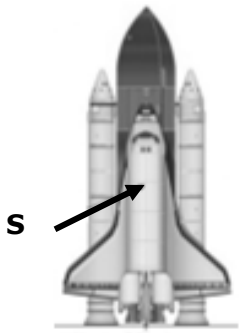
SUBJECT:	**Physics**
PAPER NUMBER:	IIA
DATE:	18th May 2024
TIME:	4:00 p.m. to 6:05 p.m.

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		$E = p t$
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. This question is on Newton's laws of motion.

The Space Shuttle program was used by NASA between 1981 and 2011 to send astronauts and cargo in Earth orbit. The diagram shows the space shuttle at launch. The shuttle S is attached to two booster rockets and to the main fuel tank.



(Source:www.britannica.com)

a. The force for lift-off is provided by the shuttle engines producing 5.2×10^6 N, together with 2 booster rockets **each** producing 1.3×10^7 N. Calculate the total force available.

_____ (1)

b. The total mass at lift-off is 2.0×10^6 kg. Calculate the initial acceleration of the shuttle.

_____

_____ (2)

c. The mass of the fuel at lift-off is 1.7×10^6 kg. Calculate this as a percentage of the total mass at lift-off.

_____ (1)

d. In terms of fuel mass, explain why the acceleration increases as fuel is burned.

_____

_____ (2)

e. What happens to the value of air resistance as the shuttle moves away from the Earth's surface?

_____ (1)

f. Hence explain in terms of forces how this change in air resistance affects the acceleration.

_____

_____ (2)

After each space mission is completed, the shuttle prepares to return to Earth. At this point, the shuttle having a total mass of 1.0 x 10^5 kg will be travelling without the booster rockets, at 7700 m/s at a height of 300 km above earth.

g. Calculate the kinetic energy of the shuttle at this speed.

_____

_____ (2)

h. Calculate the gravitational potential energy of the shuttle at this height.

_____

_____

_____ (3)

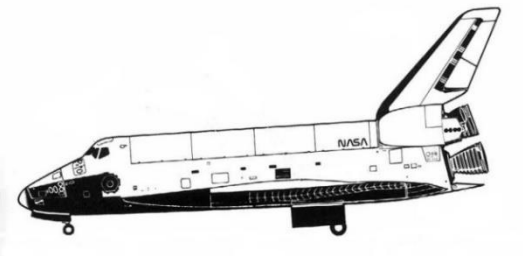
i. Use parts (g) and (h) above to calculate the total mechanical energy possessed by the shuttle.

_____ (1)

j. As the shuttle enters the earth's atmosphere, work done against friction with the atmosphere slows the shuttle down considerably. Explain why the shuttle is covered by heat resistant tiles to protect the shuttle and the astronauts inside.

_____ (1)

k. Having used all its fuel, the shuttle glides down to land. The diagram here shows the shuttle just before it touches down on the runway. Draw and name on the diagram the **TWO** forces acting on the shuttle at this instant. (2)



(Source: https://history.nasa.gov)

l. A parachute is used for braking after the shuttle landing. Explain how this affects the braking effect.

_____

_____ (2)

(Total: 20 marks)

Please turn the page.

20

2. This question is on waves.

a. i. When playing a guitar, transverse waves in the vibrating strings produce a longitudinal sound wave in air. Define the terms:

Transverse _____ (1)

Longitudinal _____ (1)

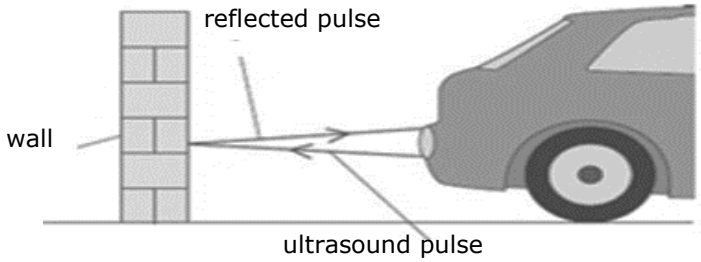
ii. What happens to the amplitude of the vibrations when the strings are plucked with a stronger force?

_____ (1)

iii. Underline the correct word from each bracket in the following statement:

A guitar can produce sounds of different frequencies. These different frequency sounds have the (same / different) wavelength and travel at the (same / different) speed in air. (2)

b. Some cars have parking sensors to help the driver avoid nearby obstacles when parking. Each sensor works by emitting an ultrasound pulse which hits nearby obstacles, is reflected, and picked up by the sensor. The time required for this echo is measured by an electronic timer.



(Source: cyberphysics.co.uk)

i. Define ultrasound _____ (1)

ii. In the diagram above, the reflected pulse was received 0.006 s after being emitted. Calculate the distance between the car and the wall. The speed of sound in air is 340 m/s.

_____

_____

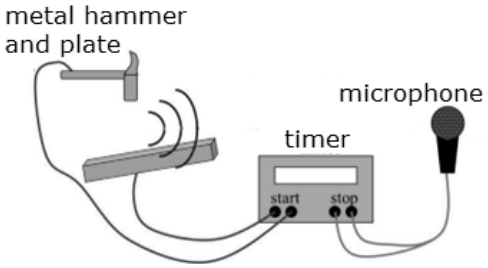
_____ (3)

iii. A car designer suggested using radio waves to be used instead of ultrasound in such sensors. Briefly explain, in terms of wave speed, why this would require more sensitive electronic timers.

_____

_____ (1)

c. The apparatus shown is used to measure the speed of sound in air. As the metal hammer hits the metal plate, it makes a sharp sound, and closes a circuit which starts the timer.



(Source: https://blogs.glowscotland.org.uk/)

i. What other piece of apparatus is necessary for this experiment?

_____ (1)

ii. State clearly what measurement needs to be taken using this apparatus.

_____ (1)

iii. Describe in detail how this experiment is to be carried out. Include the calculation needed to obtain the speed of sound.

_____

_____

_____

_____ (4)

iv. State **ONE** main precaution which needs to be taken during this experiment.

_____ (1)

d. In the past in Malta, rock was sometimes excavated from a quarry using explosives. After each explosion people living nearby used to feel the vibrations in the ground first, followed by hearing the explosion in air shortly after. Briefly explain the cause of this delay.

_____ (1)

e. A popular science fiction film about space had this quote on its poster as promotional material. The quote read: "*In space no one can hear you scream".* Explain the scientific truth of this statement using your knowledge of Physics.

_____

_____ (2)

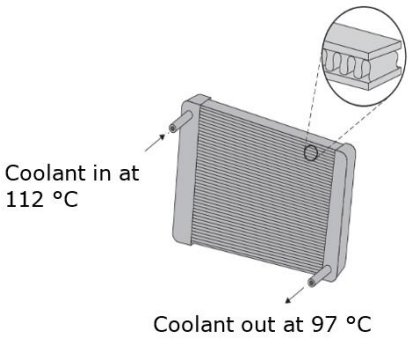
(Total: 20 marks)

Please turn the page.

20

3. This question is about heat energy.

The diagram shows a car radiator. The liquid coolant enters the radiator at high temperature, circulates around the radiator pipes, and exits the radiator at a lower temperature, prior to returning to the car engine.



a. Outline why the radiator is painted black.

_____ (1)

b. Name and explain briefly, the process by which heat is transferred from the liquid coolant to the radiator.

_____

_____ (2)

c. Name and explain briefly, the process by which heat is transferred from the radiator to the surroundings.

_____

_____ (2)

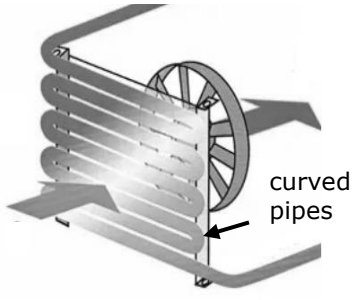
d. When the car engine is working normally, 2 kg of coolant passes through the radiator each second. The temperature of the coolant falls from 112 °C to 97 °C. Calculate the energy transferred each second from the coolant. The specific heat capacity of the coolant is 3800 J/kg°C.

_____

_____

_____ (3)

e. The pipes carrying the coolant inside the radiator are designed to be long and curved, rather than straight lines. This was done to increase the efficiency of the radiator. Explain.

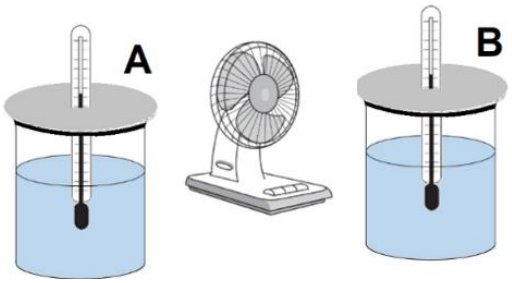


_____

_____

_____ (2)

A student wants to investigate whether placing a beaker with water at the side of fan (position A) or directly in front of a fan (position B), would affect their rate of heat loss to the surrounding.
The apparatus provided includes two identical beakers with lids, hot water at 80°C, two thermometers, a stopwatch and a metre ruler. Assume room temperature is 20°C.



f. Describe the procedure that the student should follow to carry out the investigation.

_____

_____

_____

_____

_____ (4)

g. Sketch a graph to show the expected results achieved through this investigation. Label the graphs for thermometers A and B. (3)

h. Parallax errors can occur whilst reading the thermometers. Identify **ONE** other source of error.

_____

_____ (1)

i. After some time, both thermometers reached 20°C and remained at this temperature, even though the electric fan remained switched on. Explain.

_____

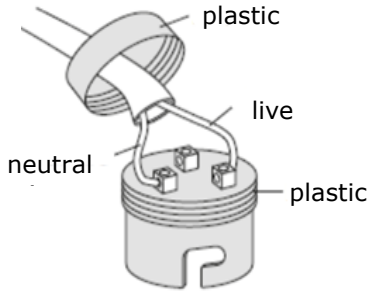
_____ (2)

(Total: 20 marks)

Please turn the page.

20

4. This question is about electricity.



The diagram shows the fitting used to connect a filament bulb to the mains electricity supply. The light fitting does not have an earth wire connected.

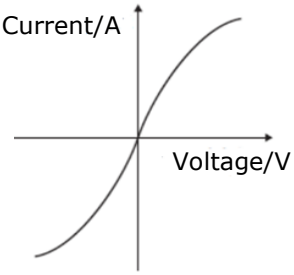
a. Explain why the light fitting is still safe to use.

_____

_____ (2)

b. The graph shows the relationship between current and voltage for an electrical component.

i. Explain the shape of the graph in terms of temperature, resistance and change in current as the voltage is varied.



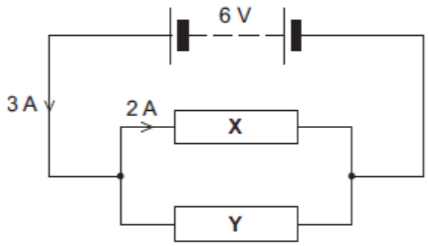
_____

_____

_____ (2)

ii. Name the component. _____ (1)

c. The circuit below shows a 6 V battery connected to two parallel resistors, X and Y.



i. State the potential difference across X and Y. _____ (1)

ii. Calculate the value of resistance X.

_____

_____ (2)

iii. Determine the current in Y.

_____ (1)

iv. Calculate the resistance of Y.

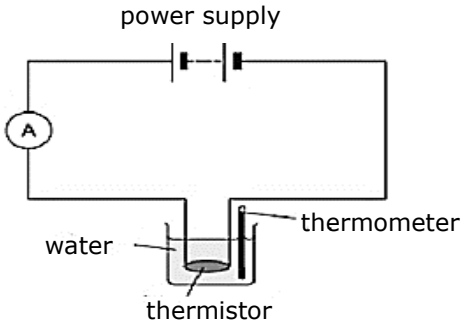
_____

_____ (2)

v. When the temperature of resistor X increases, its resistance increases. Tick **THREE** boxes from the table below to show what happens to the quantities listed. (3)

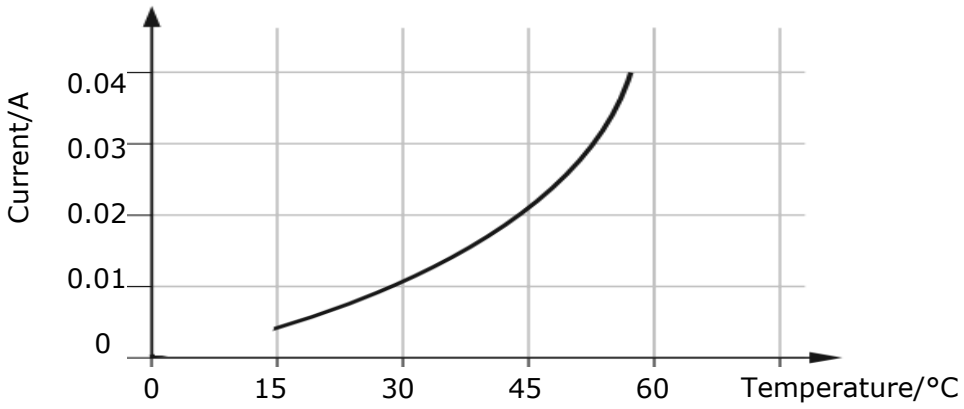
	Decreases	Stays the same	Increases
Voltage across X			
Current in X			
Total current in circuit			

d. The setup shown is used to investigate how the current through a thermistor depends on the temperature of the thermistor.



i. Draw the correct symbol for a thermistor in the space provided below. (1)

Water at 57 °C was poured into the beaker. The temperature of the water and current through the thermistor were then recorded as the water cooled. The graph shows the results obtained.



ii. Suggest **TWO** ways the investigation could have been changed to give a wider range of temperatures.

_____ (2)

iii. Describe how the resistance and current through the thermistor are changing as its temperature changes.

_____ (2)

iv. Use the graph to determine the current through the thermistor at 30 °C.

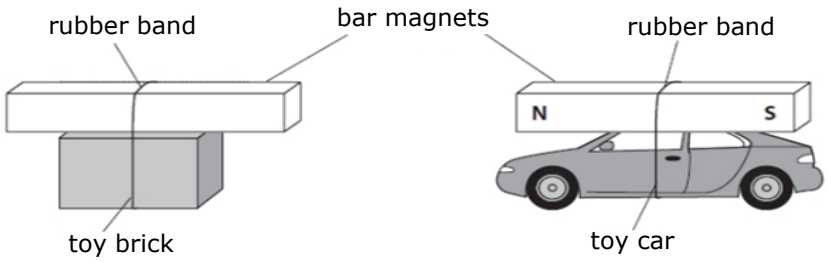
_____ (1)

(Total: 20 marks)

Please turn the page.

5. This question is about magnetic fields.

A student investigates magnetism using two toys as shown in the diagram.



a. There is a magnet attached to the top of each toy. The student moves the toy brick towards the toy car. The toy car moves backwards.

i. On the diagram above, label the north pole and the south pole on the magnet attached to the toy brick. (1)

ii. Explain why the toy car starts to move only when the toy brick gets near to the toy car.

_____

_____ (2)

iii. The student wants to investigate if two magnets on top of each other, on both the car and on the brick, would produce a stronger magnetic field. She has a metre ruler and more magnets available. Describe how the idea can be tested.

_____

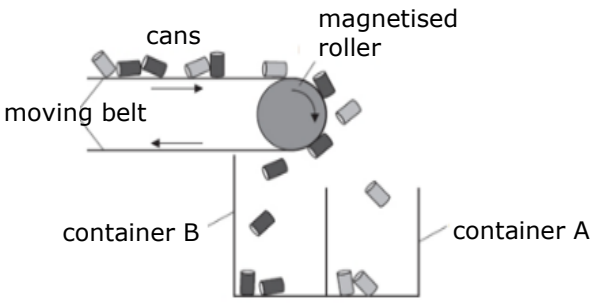
_____

_____

_____ (4)

b. The diagram shows part of a machine used to separate steel cans from aluminium cans. The cans are carried along a moving belt. The belt goes around a magnetised roller. Each can drops into one of the containers below it.

Explain how this machine separates the steel cans from the aluminium cans.

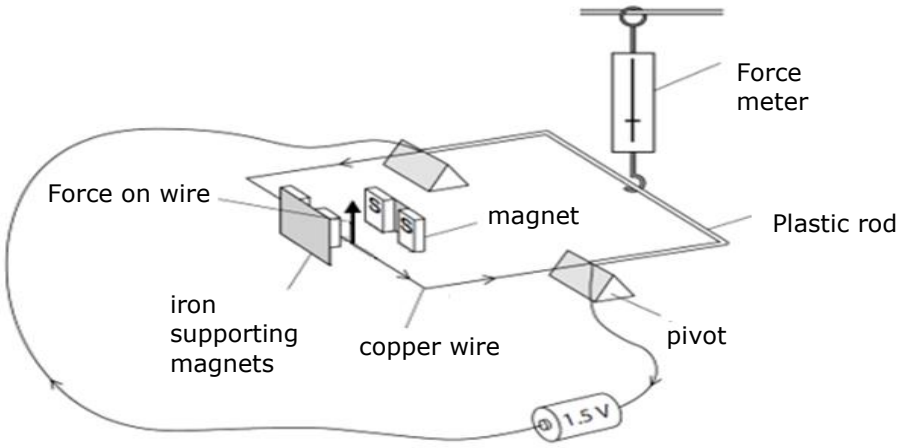


_____

_____

_____ (3)

c. The student now investigates the relationship between the magnetic flux and the electromagnetic force on a current-carrying wire. She uses the apparatus shown below.



i. The copper wire in between the magnets is seen to move upwards as shown by the arrow in the diagram. Name and state the rule used to justify the direction of this force.

_____

_____

_____ (3)

ii. Explain how the upward movement of the copper wire affects the plastic rod and the reading on the force meter.

_____

_____ (2)

iii. Observations showed that the equipment was not producing a large enough reading on the force meter. Give **THREE** changes that could be made to increase the force reading on the meter.

_____

_____

_____

_____ (3)

iv. If the polarity of the magnets is changed, what effects, if any, would this have on the reading on the force meter. Explain your reasoning.

_____

_____ (2)

(Total: 20 marks)

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Index Number:_____ SEC24/2B.24m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2024 MAIN SESSION

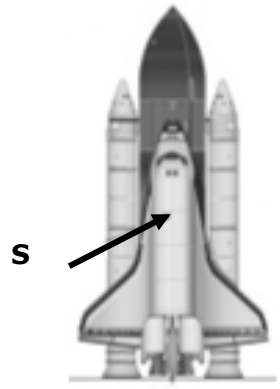
SUBJECT:	**Physics**
PAPER NUMBER:	IIB
DATE:	18th May 2024
TIME:	4:00 p.m. to 6:05 p.m.

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		$E = p t$
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. This question is about Newton's laws of motion.

   The Space Shuttle program was used by NASA between 1981 and 2011 to send astronauts and cargo in earth orbit. The diagram shows the space shuttle at launch. The shuttle orbiter S is attached to two booster rockets and to the main fuel tank.



(Source: https://britannica.com)

a. The force for lift-off is provided by the shuttle engines producing 5.2×10^6 N, together with 2 booster rockets **each** producing 1.3×10^7 N. Calculate the total force available.

_____ (2)

b. The total mass at lift-off is 2.0×10^6 kg. Calculate the initial acceleration of the shuttle.

_____

_____ (2)

c. i. As fuel is burned, what happens to the mass of the whole space shuttle?

_____ (1)

ii. Hence explain why the acceleration increases as fuel is burned.

_____ (1)

d. Underline the correct word in each bracket:

As the shuttle moves away from the earth's surface, the atmospheric pressure (increases / decreases / remains constant). The air resistance acting on the shuttle therefore (increases / decreases / remains constant). This causes the acceleration of the shuttle to (increase / decrease / remain constant). (3)

After each space mission is completed, the shuttle prepares to return to earth. At this point, the shuttle having a total mass of 1.0×10^5 kg will be travelling without the booster rockets, at 7700 m/s at a height of 300 km above earth.

e. Calculate the kinetic energy of the shuttle at this speed.

_____

_____

_____ (3)

f. Calculate the gravitational potential energy of the shuttle at this height.

_____

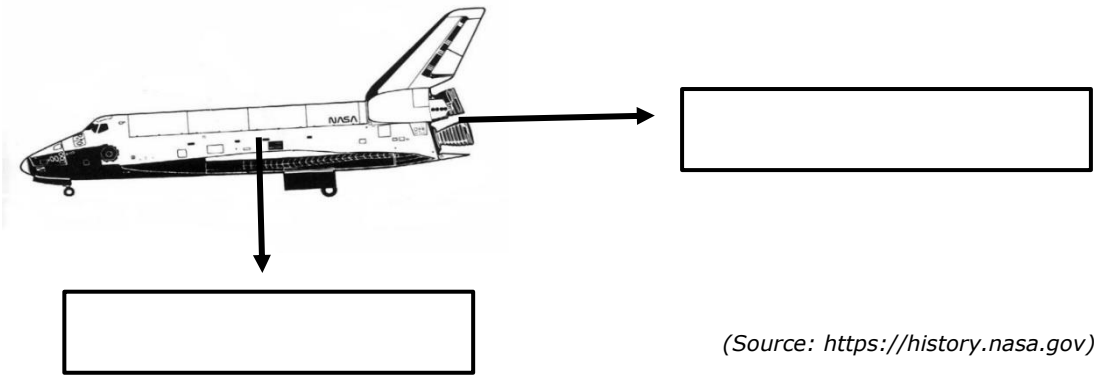
_____

_____ (3)

g. As the shuttle enters the earth's atmosphere, the work done against friction with the atmosphere will slow down the shuttle. Explain why the shuttle is covered by heat resistant tiles to protect the shuttle and the astronauts inside.

_____ (1)

h. When the shuttle uses all its fuel, it glides down to land. The diagram shows the shuttle just before it touches down on the runway. Name the **TWO** forces on the shuttle at this point, using the spaces provided. (2)



(Source: https://history.nasa.gov)

i. A parachute is opened at the back end of the shuttle to increase the braking effect. What effects does this have on the:

- surface area of the back end of the shuttle; _____ (1)
- resultant backward force. _____ (1)

(Total: 20 marks)

Please turn the page.

2. This question is on waves.

a. When playing a guitar, transverse waves in the vibrating strings produce a longitudinal sound wave in air.

i. Underline the correct word from each bracket in the sentence below.

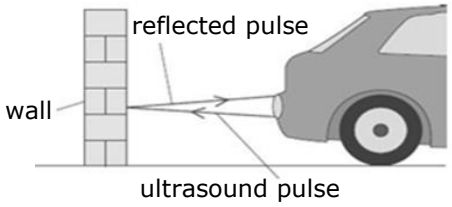
In a transverse wave the vibrations are (perpendicular / parallel) to the direction of wave travel while in a longitudinal wave the vibrations are (perpendicular / parallel) to the direction of wave travel. (2)

ii. What happens to the amplitude of the vibrations when the strings are plucked with a stronger force? _____(1)

iii. Underline the correct word from each bracket in the following statement:

A guitar can produce sounds of different frequencies. These different frequency sounds have the (same / different) wavelength and travel at the (same / different) speed in air. (2)

b. Some cars have parking sensors to help the driver avoid nearby obstacles when parking. The diagram shows one arrangement. Each sensor works by emitting an ultrasound pulse which hits nearby obstacles and is then reflected to be picked up by the sensor. The time required for this echo is measured by an electronic timer.



(Source: cyberphysics.co.uk)

i. Underline **ONE** correct frequency of ultrasound.

(30 Hz, 3000 Hz, 30 000 Hz) (1)

ii. Can ultrasound normally be heard by humans? _____ (1)

iii. In the diagram above, the ultrasound pulse took 0.006 s to travel the distance shown by the 2 arrowed lines in the diagram. Given that the speed of sound is 340 m/s, what distance did the pulse travel in 0.006 s?

_____

_____ (2)

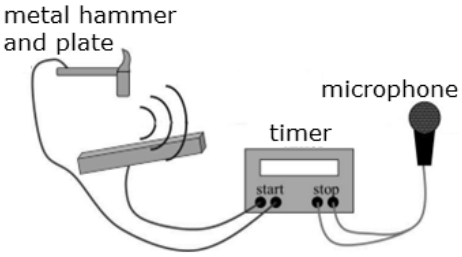
iv. Use your answer to part b(iii) above to calculate the distance between the car and the wall.

_____

_____ (1)

c. The apparatus shown here is used to measure the speed of sound in air. As the metal hammer hits the metal plate, it makes a sharp sound, and closes a circuit which starts the timer. The timer stops when the sound reaches the microphone.

(Source: https://blogs.glowscotland.org.uk/)



i. What other piece of apparatus is necessary for this experiment?

_____ (1)

ii. State clearly what measurement needs to be taken using this apparatus.

_____ (1)

iii. Use numbers 1 to 5, to put the following steps in order, to show how this experiment is carried out. (5)

Note down the reading of the timer.	
Set up the apparatus as shown in the diagram.	
Hit the hammer against the plate to make the sound and start the timer.	
Repeat this several times.	
Make sure the timer reads zero at the start.	

iv. State the equation used to calculate the speed using the results from this experiment.

_____(1)

d. During a firework display in the sky, the sound of each firework is heard briefly after the light from the firework is seen. Explain why.

_____(1)

e. Why is sound not heard in space?

_____(1)

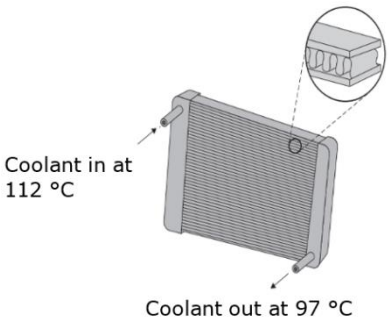
(Total: 20 marks)

Please turn the page.

20

3. This question is about energy.

The diagram shows a car radiator. The liquid coolant enters the radiator at high temperature, circulates around the radiator pipes, and exits the radiator at a lower temperature, prior to returning to the car engine.



a. Fill in the blank:

The radiator is painted black, since the colour black is a _____ absorber and emitter of heat. (1)

b. Heat is transferred from the liquid coolant to the radiator by a process called conduction. Tick with an **X** the **TWO** correct statements describing the process of conduction of heat. (2)

The particles do not travel through the material but vibrate about a fixed point.	
Conduction occurs between two objects that have the same temperature.	
The particles travel from one point to the other of the material.	
Heat energy travels through the material or from one material to another one in contact.	

c. Heat is transferred from the radiator to the surroundings by a process called radiation. Tick with an **X** the **TWO** correct statements describing the process of radiation of heat. (2)

During this process the object with the higher temperature emits particles.	
During this process the object with the higher temperature emits infrared waves.	
Radiation of heat can occur in a vacuum.	
Radiation of heat requires a medium in which to occur.	

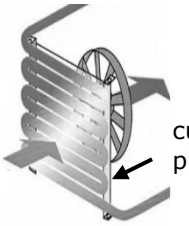
d. In a car engine, 2 kg of coolant passes through the radiator each second. The temperature of the coolant falls from 112 °C to 97 °C. Calculate the energy transferred each second from the coolant. The specific heat capacity of the coolant is 3800 J/kg°C.

_____

_____

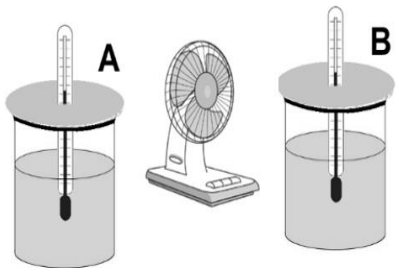
_____ (3)

e. The pipes carrying the coolant inside the radiator are designed to be long and curved, rather than straight lines. This increases their surface area. State the effect this would have on the:



- heat energy radiated per second _____ (1)
- the efficiency of the radiator _____ (1)

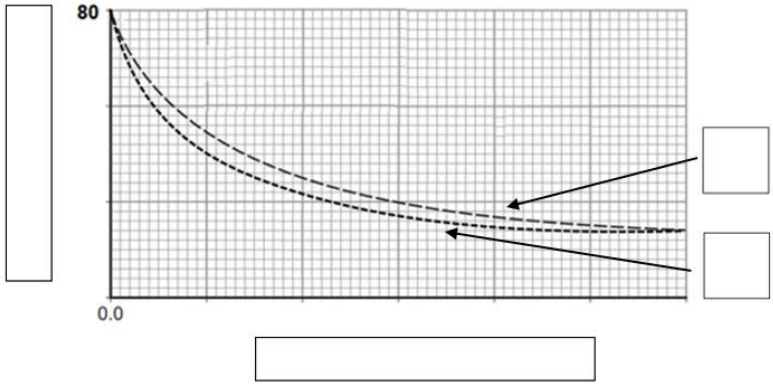
A student wants to investigate whether placing a beaker with water at the side of a fan (position A) or in front of a fan (position B) would affect how much the temperature decreases per second. The apparatus provided includes two identical beakers with lids, hot water at 80°C, two thermometers, a stopwatch and a metre ruler. Assume room temperature is 20°C.



f. Use numbers 1 to 4, to put the following experimental steps in order. (4)

A reading of time and temperature is taken at regular intervals for both thermometers, until both thermometers reach 20°C.	
The stopwatch and the electric fan are switched on simultaneously.	
The 2 beakers are filled in with the same amount of water at 80 °C and covered with the lid, allowing thermometer to be placed in the centre of each.	
The 2 beakers are placed at equal distance from the fan one in front and one at the back.	

g. The following graph shows the results achieved through this investigation. Label the axes of the graph, and which represents the reading from thermometers A and B. (3)



h. Parallax errors can occur whilst reading the thermometers. Identify **ONE** other source of error.

_____ (1)

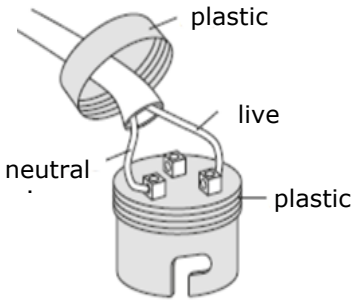
i. Fill in the blanks with the correct word to complete the sentence:

After some time, both thermometers reach a steady temperature and remain at this temperature, even though the electric fan is still switched on. Radiation of heat _____ because both beakers have reached the same _____ as the room. (2)

(Total: 20 marks)

Please turn the page.

4. This question is about electricity.



The diagram shows a light fitting used to connect a filament bulb to the mains electricity supply.

a. The light fitting does not have an earth wire connected.

i. State the colours for the live and neutral wire.

Live _____

Neutral _____ (2)

ii. Is this light fitting safe to use? Explain your reasoning.

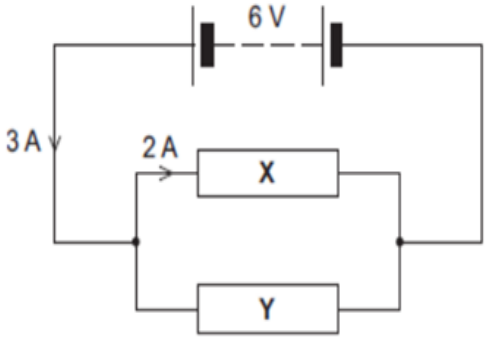
_____

_____(2)

iii. A circuit breaker can be used to protect an electrical circuit in case of excess current. Name another device that can be used for the same purpose.

_____(1)

b. The circuit below shows a 6 V battery connected to two parallel resistors, X and Y.



i. State the potential difference across X and Y. _____(1)

ii. Calculate the value of resistance X.

_____

_____(2)

iii. Determine the current in Y.

_____ (1)

iv. Calculate the resistance of Y.

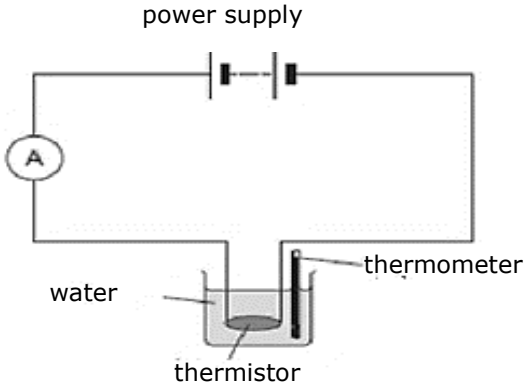
_____

_____(2)

v. When the temperature of resistor X increases, its resistance increases. Tick **THREE** boxes from the table below to show what happens to the listed quantities. (3)

	Decreases	Stays the same	Increases
Voltage across X			
Current in X			
Total current in circuit			

c. The setup shown is used to investigate how the current through a thermistor depends on the temperature of the thermistor.



i. Use numbers 2 to 5, to put the following experimental steps in order. The first one has been done for you. (4)

Set up the circuit as shown in the diagram.	1
Take readings of the current through the thermistor as the temperature falls.	
Plot a graph of Current/A on y axis against Temperature/ °C on x axis.	
Pour boiling water into the beaker.	
Record how the current varies with temperature.	

ii. The current through the thermistor was found to increase with increasing temperature. State how the resistance of the thermistor varies with temperature and how this is related to the current.

_____

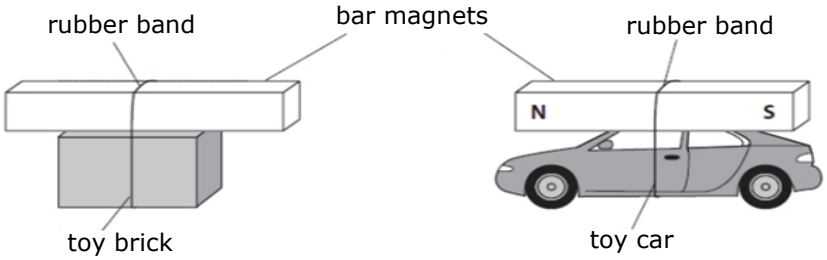
_____ (2)

(Total: 20 marks)

Please turn the page.

5. This question is about magnetic fields.

A student investigates magnetism using two toys as shown in the diagram.



a. There is a magnet attached to the top of each toy. The student moves the toy brick towards the toy car. The toy car moves backwards.

i. On the diagram above, label the north pole and the south pole on the magnet attached to the toy brick. (1)

ii. Explain why the toy car starts to move only when the toy brick gets near to the toy car.

_____

_____ (2)

iii. Sketch the magnetic field around the bar magnet attached to the toy car on the diagram above. (2)

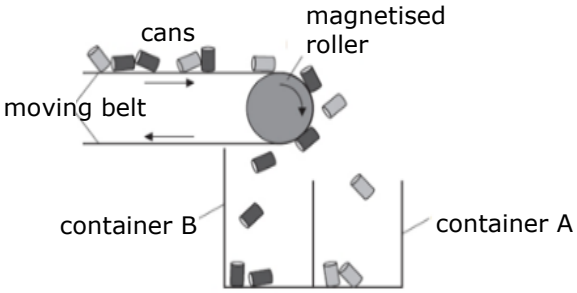
iv. The student wants to investigate if two magnets on top of each other, on both the car and the brick, will produce a magnetic field that is stronger than the original magnetic field. She has a metre rule and more magnets available. Use numbers 1 to 3 in the table below to put the following steps in order. (3)

She then places two magnets on each toy and again measures the distance at which the car starts to move backwards	
The experiment is repeated, each time adding an additional magnet to each toy.	
With one magnet on the toy brick and toy car, she measures, using a metre ruler, the distance at which the toy car experiences a force.	

v. As more magnets are placed on each other, does the car start experiencing a push when it is closer to the brick or further away from it?

_____ (1)

b. The diagram shows part of a machine used to separate steel cans from aluminium cans. The cans are carried along a moving belt that goes around magnetic roller at its end. Each can drops into one of the containers below it.



i. In terms of magnetism, state a difference between steel and aluminium.

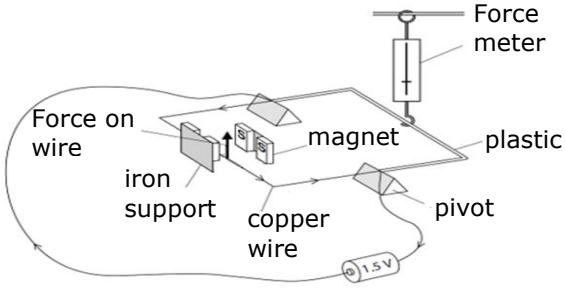
_____ (1)

ii. Explain how this difference allows for the separation of steel and aluminium cans.

_____

_____ (2)

c. The diagram shows a rectangular coil pivoted on two wedges. One side, made from a copper wire is placed in between two magnets, perpendicular to their magnetic field. The other side, which is made of plastic, is attached to a force meter.



i. When current flows in the copper wire, it is seen to move upwards as shown by the arrow in the diagram. Name the rule which verifies the direction of the force acting on the wire.

_____ (1)

ii. Indicate with TRUE or FALSE whether the following changes would increase the upward force acting on the wire.

- Increasing the current in the circuit. _____ (1)
- Using a weaker magnetic field strength. _____ (1)
- Adding more turns in the wire. _____ (1)

iii. The polarity of the magnets is reversed. State what effect, if any, this would have on:

- the direction of the force _____ (1)
- the reading on the force meter _____ (1)

iv. The effect demonstrated above is called the motor effect. Name **TWO** devices which function using this effect.

_____ (2)

(Total: 20 marks)

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