L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 MAIN SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	I
DATE:	26th June 2021
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. Table 1 shows three different construction materials and their corresponding density, given in S.I. units.

Table 1

Material	**Density (S.I. unit)**
Concrete	2400
Porous clay brick	2000
Foam concrete	1000

a. Define the term density.

____ (1)

b. State the S.I. unit of density. ______________________________ (1)

c. It can be noted that foam concrete has a lower density than concrete. By referring to Figure 1 explain why foam concrete has a lower density.


Concrete

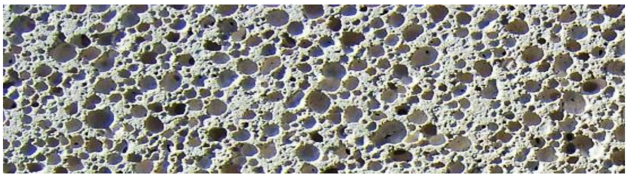
Foam Concrete

Figure 1
Source: https://foamconcreteworld.com

____

____ (2)

d. The density of foam concrete can be reduced further by increasing the percentage of foam used, forming a new material X. A block of height of 1.5 m, length of 1.2 m and width of 98 cm is produced with material X.

i. Calculate the volume of the block in m^3.

____

____ (2)

ii. Calculate the density of the block if it has a mass of 1040 kg.

____

____ (2)

iii. The density of water is the same as that of foam concrete listed in Table 1. Use the result for the density of mixture X and the density of porous clay brick provided in the table to state if **each** of the two materials will sink or float when placed in water.

____

____ (2)

(Total: 10 marks)

10

2. One of the world's fastest cars can accelerate from 26.67 m/s to 53.61 m/s in just 2.5 s.

a. Calculate the car's acceleration.

____

____ (2)

b. Apart from their speed, cars are also tested in special laboratories for safety during accidents. A dummy is used instead of the driver as shown in Figure 2.

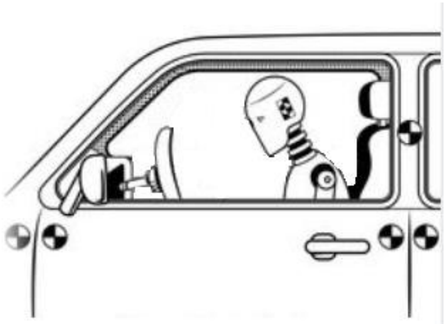

Figure 2
Source: https://www.canstockphoto.com

i. When the car crashes into the barrier, it can be noted that the dummy continues moving forward. Name and state the law that explains why this happens.

____

____ (2)

ii. A seatbelt is used to prevent the driver from continuing to move forward after a collision or sudden braking. Seatbelts are made from a material that stretches by a small amount when pulled. Explain why this helps to prevent further injuries on the driver.

____

____ (2)

iii. Mention another **TWO** features in a car that help prevent injuries during a collision.

____

____ (2)

iv. The seatbelt manages to bring the dummy to rest from an initial velocity of 53.61 m/s in 0.18 s. Calculate the forward distance travelled by the dummy in this time.

____

____ (2)

(Total: 10 marks)

10

3. A footballer kicks a ball towards a wall with a velocity of 14 m/s. On impact, it rebounds back in the opposite direction with a velocity of 8 m/s.

a. State the SI units of momentum.

____ (1)

b. The ball has a mass of 450 g. Calculate the initial momentum of the ball as it is travelling towards the wall.

____

____ (2)

c. Calculate the momentum of the ball as it rebounds from the wall.

____

____ (2)

d. Hence calculate the change in momentum experienced by the ball.

____ (1)

e. Calculate the force exerted by the wall on the ball if this change in momentum occurs in 0.12 s.

____

____ (2)

f. The ball is replaced by a heavier one. If this ball had to undergo the same change in velocity as it rebounds against the wall in the same time, would the force exerted by the wall on the ball remain the same, increase or decrease? Explain your answer.

____

____

____

____ (2)

(Total: 10 marks)

10

4. a. A small metal block is placed on a table as shown in Figure 3.

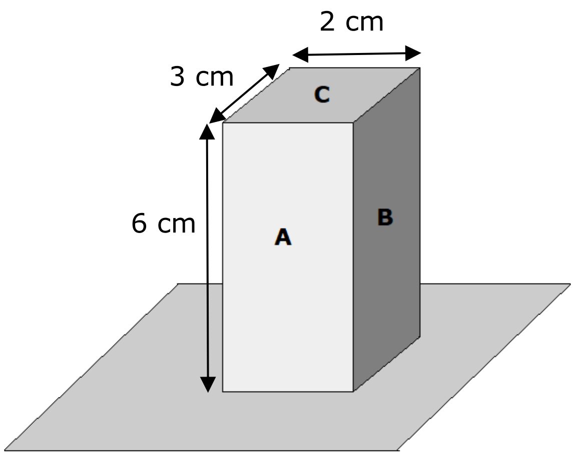

Figure 3

i. Calculate the pressure exerted on the table if the metal block has a mass of 0.24 kg.

____

____

______________________________ (3)

ii. Would you expect the pressure exerted on the table to change if the metal block is turned to rest on side B? Explain the change, if any.

____

____

______________________________ (2)

b. Figure 4 shows a metal block tied to a string and lowered into a beaker full of water. Tick with an **X** the correct box in Table 2 to state how the pressure on the block will change in each of the given different instances. (3)

Table 2

	Pressure increases	**Pressure decreases**	**No change in pressure**
Lowering the block further down into the water.			
Lowering a block of the same material, but larger mass at the same depth.			
Using a liquid of lower density than that of water but keeping the block at the same depth.			

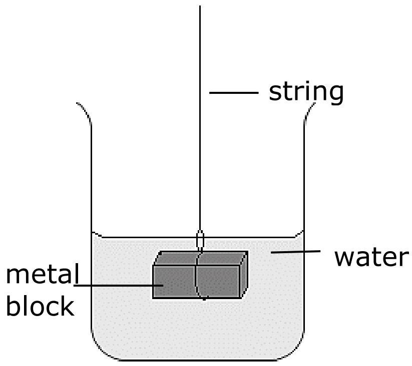

Figure 4

c. The block is removed from the water. Will there still be any pressure acting on it? Explain.

____(2)

(Total: 10 marks)

10

5. A professional diver walks along a uniform diving board AB as shown in Figure 5.

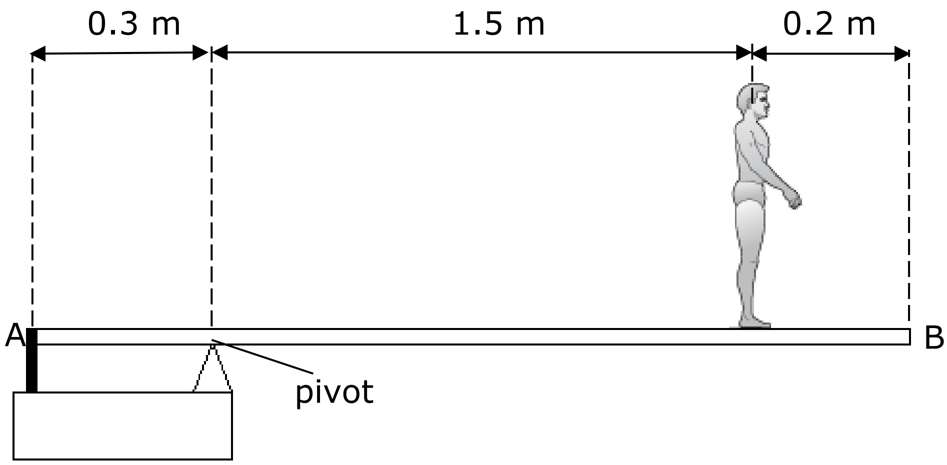

Figure 5

a. On Figure 5 above, draw and label with an F, the force created by the diver on the diving board. (1)

b. Table 3 shows how the moment created by the diver changes as he walks away from the pivot. Plot a graph for the moment of diver/Nm on the y-axis against distance from pivot/m on the x-axis. (4)

Table 3

Distance from pivot/m	0	0.25	0.50	0.75	1.00	1.25	1.50
Moment of diver / Nm	0	155	310	465	620	775	930

c. Using your graph or otherwise, calculate the mass of the diver.

____

____ (2)

d. The weight of the diving board AB is 65 N.

i. Calculate the distance between the pivot and the point where the weight of the diving board acts.

____(1)

ii. Calculate the total clockwise moment created by the diving board and diver, when he walks further away from the pivot and stops at edge B of the diving board.

____

____ (2)

(Total: 10 marks)

10

6. A teacher is showing her students how a slinky spring can be used to produce two different types of waves A and B as shown in Figure 6. Both waves travel to the right as shown by the arrow indicating the wave movement.

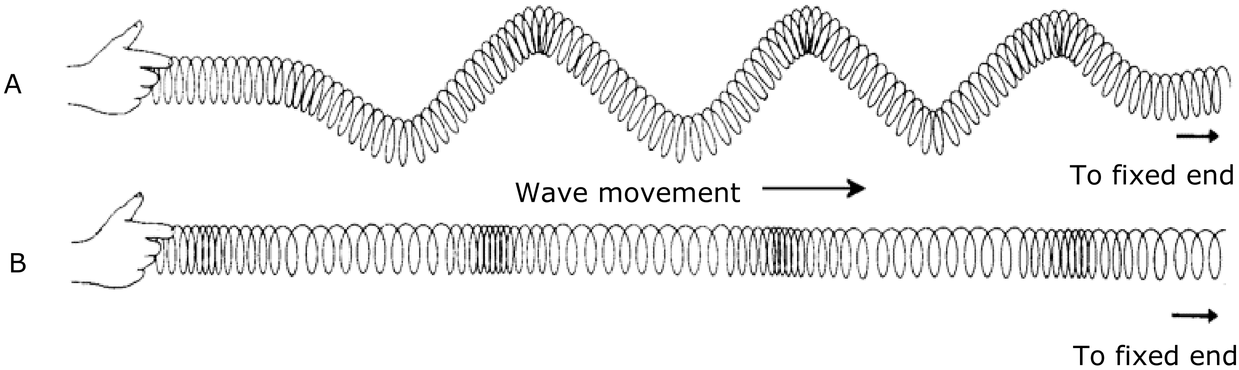

Figure 6

a. Draw horizontal or vertical arrows (⟷ or ↕) next to each hand (A and B in Figure 6), to show the direction in which **each** hand has to move to produce the waves shown. (2)

b. State the type of wave produced in each case:

Wave A: ____________________________ Wave B: ______________________________ (2)

c. Define frequency of a wave.

____

____ (1)

d. Draw necessary lines in the figure above to show the amplitude of wave A and label it **'a'**. (1)

e. The distance between two successive crests in wave A is found to be 0.25 m and the speed of the wave is measured to be 0.50 m/s. Calculate the frequency of this wave.

____

____ (2)

f. Fill in the blanks.

The time taken for one complete oscillation is known as the __________________________. When calculated, its value for the wave in part (e) is found to be _________________________________

____. (2)

(Total: 10 marks)

10

7. Table 4 below shows a list of stars and galaxies and their respective distances away from Earth.

Table 4

Stars and Galaxies	Distance from Earth
Sun	8.3 light-minutes
Our closest neighbouring star, Proxima Centauri	4.3 light-years
North Star, Polaris	320 light-years
Our closest neighbouring galaxy, Andromeda	2.5 million light-years
One of the oldest galaxies, GN-z11	13.4 billion light-years

Source: https://spaceplace.nasa.gov

a. Explain what is a light year.

______________________________ (1)

b. Why are distances in astronomy measured in light years?

______________________________ (1)

c. Use the information displayed in Table 4 to answer the following questions.

i. If the speed of light is 3×10^8 m/s, calculate the distance between Earth and the North Star, Polaris.

____

____

______________________________ (3)

ii. Mention **TWO** features that makes the Sun and Proxima Centauri different from Earth.

____

______________________________ (2)

iii. GN-z11 and Andromeda are both galaxies in our Universe. What is a galaxy?

______________________________ (1)

d. For centuries, scientists had been looking at the prospects of travelling into outer space.

i. Name **ONE** instrument used by astronomers to observe outer space.

______________________________ (1)

ii. Mention **ONE** social and economic benefit of space exploration.

____

______________________________ (1)

(Total: 10 marks)

10

8. a. A rubber balloon was given a negative charge as shown in Figure 7.

i. State **ONE** way how the balloon might have obtained a negative charge.

____ (1)

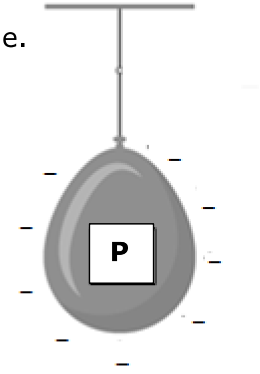

Figure 7

ii. Underline the correct answer.
The balloon became negatively charged because it:

- Gained protons
- Gained electrons
- Lost electrons
- Lost protons (1)

iii. Explain why the supporting thread needs to be made of an insulating material.

____(1)

b. Two more balloons are hung one on each side of balloon P as shown in Figure 8. Balloon R moves close to balloon P, whilst balloon Q moves away from balloon P.

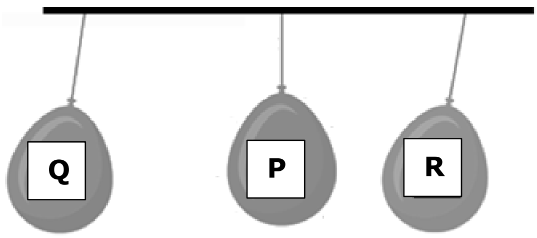

Figure 8

i. What can you deduce about the charge, if any, of balloon Q and R?

Balloon Q: __________________________ (1)

Balloon R: __________________________(1)

ii. Give a reason for your answer referring to balloon Q above.

____(1)

c. An aluminium needle is connected to a centre zero galvanometer and is brought close to a negatively charged copper plate held by an insulating material, as shown in Figure 9.

i. Explain why a brief, small reading is registered by the galvanometer. Mention the particles responsible for this reading.

____

____________________________________ (2)

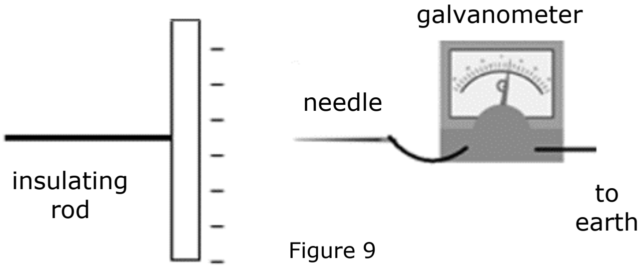

Figure 9

ii. The galvanometer registers a current of 0.3 mA for 0.2 s. Calculate the charge that flows through the needle during this time.

____

____(2)

(Total: 10 marks)

10

9. a. A Physics teacher explains to her students that magnetic materials may be soft or hard.

i. Give **ONE** example of each of the following:

Soft magnetic material: ________________________________ (1)

Hard magnetic material: ________________________________ (1)

ii. This teacher gives her students a metal bar and asks them to change it into a permanent magnet. Should she give them a bar made of a soft magnetic material or a hard magnetic material? ____ (1)

iii. Briefly describe a method involving electricity that can be used to change this metal bar into a magnet.

____

____ (2)

b. Figure 10 shows a simplified version of the magnetic field around the earth. This field is mainly generated by convection currents of molten iron in the earth's core. It behaves as if there is an imaginary bar magnet, shown by the rectangle inside the earth. The geographic North pole of the earth lies at the top.

i. Using the direction of the field lines as a guide, mark the magnetic North pole, with an N and the South pole, with an S of this imaginary bar magnet inside the earth in Figure 10. (1)

ii. Explain briefly how you reached this conclusion.

____

____ (1)

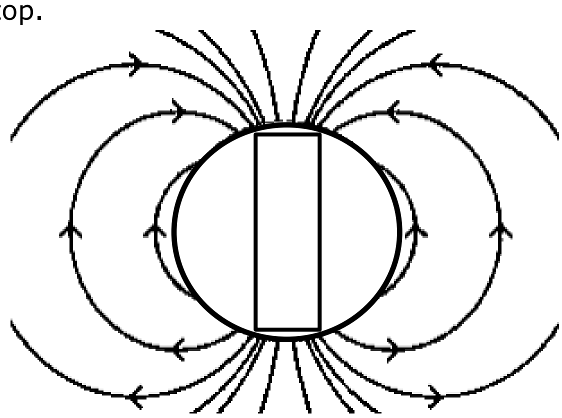

Figure 10
Source: http://www.compassadjustment.com

iii. Explain why objects like metal railings are sometimes found to be weakly magnetised.

____ (1)

iv. The magnetic compass is very useful in navigation. Explain why these compasses on board a ship are not installed close to objects made of a magnetic material.

____

____ (2)

(Total: 10 marks)

10

10. a. Figure 11 shows how the count rate of a radioactive isotope X varies with time.

i. What is meant by half-life?

____

____

__________________________________ (1)

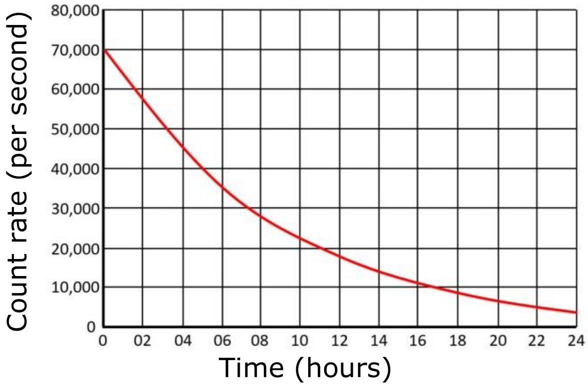

Figure 11

ii. Work out the half-life of isotope X and briefly explain how you arrived at your answer.

____

____ (2)

iii. Sketch on this graph, starting from 70 000 counts/second, the decay of an isotope with a longer half-life and label it, **Y**. (1)

b. Carbon is found in all living things and in things which were once living, like fossil bones and natural wood. Naturally occurring carbon consists of three isotopes, ${}^{12}_{6}\mathrm{C}$ ${}^{13}_{6}\mathrm{C}$ and ${}^{14}_{6}\mathrm{C}$. Isotope ${}^{14}_{6}\mathrm{C}$, unlike the first two, is radioactive and decays with a half-life of 5700 years.

i. Define isotope.

____ (1)

ii. The ${}^{14}_{6}\mathrm{C}$ nucleus contains __________ protons and ___________ neutrons. (1)

c. When a living thing dies, ${}^{14}_{6}\mathrm{C}$ in it starts to decay. By measuring the amount of ${}^{14}_{6}\mathrm{C}$ left, scientists can work out the age of for example, a fossil bone. This technique is known as carbon dating.
The bone remains of a fox are discovered and sent for carbon dating. It was found that the amount of ${}^{14}_{6}\mathrm{C}$ atoms present was one fourth of that present when the animal was alive.

i. Calculate the age of these fox remains. ____

____(2)

ii. Explain why carbon dating cannot be used to date a 100-million-year-old dinosaur fossil.

____ (1)

iii. Dinosaur fossils can in fact be dated using isotopes other than ${}^{14}_{6}\mathrm{C}$. What important property should these other radioactive isotopes have?

____(1)

(Total: 10 marks)

10

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

L-Università ta' Malta

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 MAIN SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	IIA
DATE:	26^{th} June 2021
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 $= \pi r^2$		

1. Malcolm wants to investigate the relationship between the height of the ramp, (h) and the horizontal distance, (d) travelled by the toy car on the ground before it comes to rest. Figure 1 shows the setup used.

Figure 1

a. What apparatus should Malcolm use to measure the quantities d and h?

____ (1)

b. Write down the method that he should use to carry out this investigation.

____

____

____

____ (4)

c. Mention **TWO** precautions which should be taken.

____

____ (2)

d. A table is required to record the measurements taken. Draw the table header with the quantities that need to be measured. Include their respective units. (2)

e. Malcolm wants to determine if the horizontal distance, d is directly proportional the vertical height, h. Which graph can he plot to verify this? Explain how the shape of the graph plotted can confirm whether d and h are directly proportional or not.

____

____ (2)

f. The toy car has a mass of 400 g and the height was set at 0.12 m.

i. Calculate the gravitational potential energy of the toy car at the top of the slope.

____

____ (2)

ii. Assuming that no resistive forces act against the motion of the car, calculate the kinetic energy of the toy car at the bottom of the slope.

____ (1)

iii. State the law that you used to arrive to your answer in part (ii).

____

____ (2)

iv. Hence calculate the velocity of the toy car at the bottom of the slope.

____

____

____ (2)

v. In reality, the velocity of the toy car at the bottom of the slope would be less than the value obtained. Explain why.

____

____ (2)

(Total: 20 marks)

20

2. Oliver and Kate designed a new kettle as shown in Figure 2. It is made up of two layers of plastic separated by a layer of polystyrene (jablo). It is designed to keep the water inside the kettle warm for a longer time.

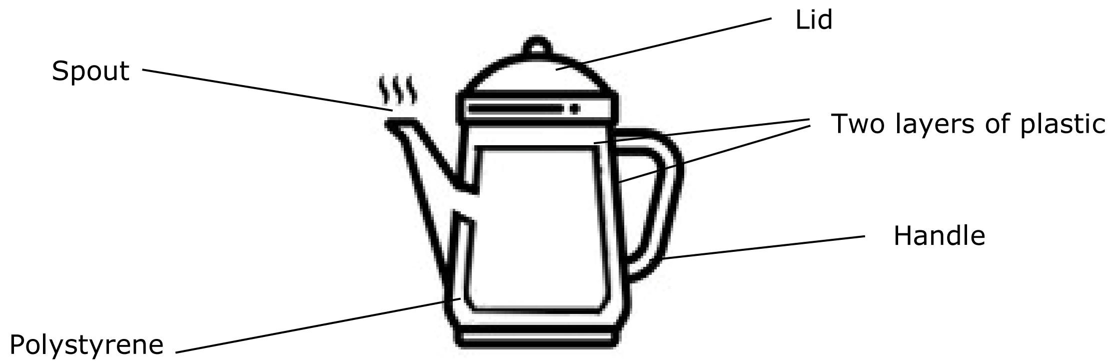


Figure 2

a. Explain why the polystyrene reduces energy transfer to the surroundings.

____

____ (2)

b. Which mode of heat transfer does the polystyrene reduce?

____ (1)

c. Kate suggests that instead of polystyrene they should introduce a vacuumed layer. Oliver still thinks that polystyrene is the better option. Who is correct? Explain your answer.

____

____ (2)

d. Suggest a suitable colour for the interior of the kettle. Explain.

____

____ (2)

e. After the water was heated and the kettle was switched off, they noticed a main source of heat loss from the kettle. Identify this source of heat loss and state what can be done in this case to keep the water warmer for a longer time.

____

____ (2)

f. Kate and Oliver want to test the kettle. They filled it up with 0.75 kg of water at 18 °C.

i. They switched on the heating source found at the bottom of the kettle and the water's temperature started to increase. Briefly explain how water is heated inside the kettle.

____ (2)

ii. The water is boiled using 265300 J of energy. Calculate the specific heat capacity of water.

____ (2)

iii. The actual value for the specific heat capacity (SHC) of water is 4200 J/kg°C. Give a reason for the difference in value obtained.

____ (1)

iv. As soon as the water starts boiling, they switched off the heater and start off the timer. After 2 hours the water inside the kettle loses 46200 J to the surroundings. Calculate the final temperature of water. Use 4200 J/kg°C as the SHC of water.

____ (3)

v. Calculate the average power loss from the water in the kettle to the surroundings in 2 hours.

____ (3)

(Total: 20 marks)

20

3.a. Figure 3 shows wavefronts in a ripple tank entering a region of shallower water during a Physics demonstration.

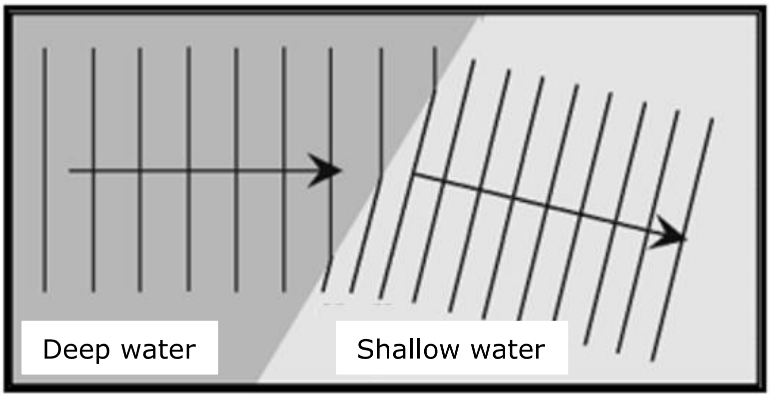


Figure 3
Source: http://ipl.physics.harvard.edu

i. How are these plane waves produced?

____ (1)

ii. How can this change in water depth be carried out in practice?

____ (1)

iii. Name the phenomenon taking place as the waves travel from deep to shallow water. Explain clearly why this happens.

____

____ (2)

iv. What changes, if any, occur to the following as the water enters the shallow water?

Wave speed: ________________________ (1)

Frequency: ________________________ (1)

Wavelength: ________________________ (1)

v. Figure 3 shows that there is a change in direction of the waves as they cross the boundary between the two depths. What change in the set-up of the apparatus would ensure that there would be no change in direction on entering shallower water?

____ (1)

b. Give **ONE** similarity and **ONE** difference between water waves and electromagnetic waves.

Similarity: ____ (1)

Difference: ____ (1)

c. Figure 4 shows an electric bell suspended by its own wires passing through a rubber stopper inside a sealed bell jar. The electric bell is connected to a battery. At the bottom of the bell jar there is a pipe leading to a vacuum pump.

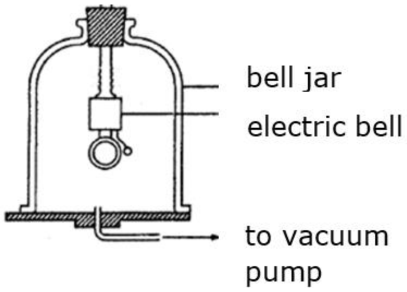


Figure 4
Source: https://toppr.com

i. Are sound waves in air transverse or longitudinal?

____ (1)

ii. The bell is switched on. What happens to the sound heard as the air inside the bell jar is removed? Explain.

____

____ (2)

iii. How would the observation in part (ii) be different if the electric bell was to be placed on the base at the bottom of the bell jar, instead of being suspended? Explain this difference.

____

____ (2)

d. Roberta and Valerie carry out an experiment to measure the speed of sound in air. They find a suitable place in the open and stand next to each other, 200 m away from a large wall. Valerie makes a sharp loud sound by banging together two blocks of wood. Roberta holds a microphone connected to an electronic timer. The latter starts when the sharp loud sound is made and stops when the microphone receives the echo from the wall. They repeat this several times and obtain an average value of 1.2 s.

i. Calculate the value obtained for the speed of sound in air.

____

____ (2)

ii. Give **ONE** reason why they carried out this experiment in an open space and not in built-up areas.

____ (1)

iii. Explain why using a hand operated stopwatch instead of an electronic timer is **not** desirable in this experiment.

____

____ (2)

(Total: 20 marks)

20

4. Jane and Paul found several small filament bulbs used in car headlamps, brakes and indicator lamps.

a. Each small filament bulb is rated at 12 V, 21 W. This implies that each bulb requires 12 V to operate at normal brightness.

   i. State the energy conversions that takes place in a small filament bulb.

____

____(3)

   ii. What do you understand by the term power rating of 21 W?

____(1)

b. Jane connects three of these bulbs in parallel with a power supply and a switch, as shown in Figure 5. The circuit is switched on.

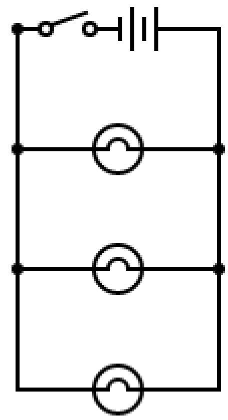


Figure 5

   i. What is the total power generated by the circuit when the bulbs are operating at normal brightness?

____ (1)

   ii. Calculate the total current supplied by the battery.

____

____

____ (2)

   iii. Calculate the resistance of **ONE** of these filament bulbs.

____

____ (2)

   iv. Jane now connects the **THREE** light bulbs in series such that they can still operate at normal brightness. What change, if any, occurs to each of the following quantities. Tick with an **X** the correct box in Table 1 below. (3)

Table 1

	Decreases	**Increases**	**Stays the same**
Total voltage required to operate the bulbs at normal brightness.			
Total power generated by the circuit.			
Total current that flows in the circuit.			

c. Jane thinks that the resistance of a filament bulb remains fixed, even when subjected to different voltages. Paul disagrees and thinks that the value of resistance of a bulb changes with different voltages. They set up the circuit shown in Figure 6 to check who is correct.

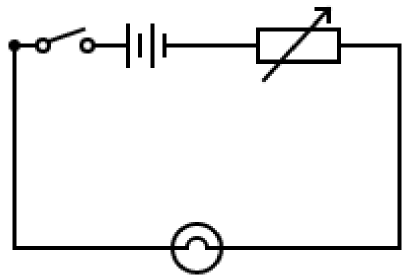


Figure 6

i. On the circuit in Figure 6, include **TWO** more components that Jane and Paul need to carry out their investigation. (2)

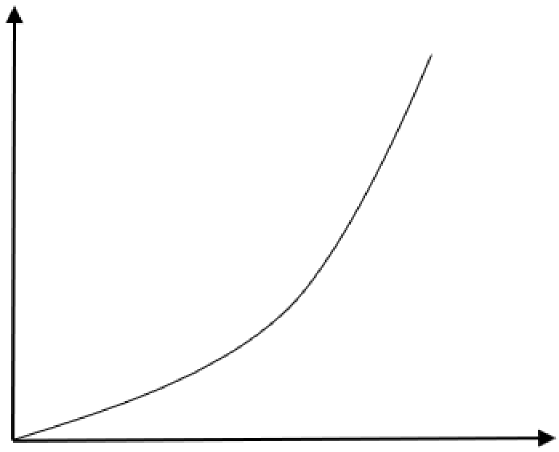
ii. Briefly explain how the circuit is used to check Jane and Paul's theory.

____

____

____ (2)

iii. Jane and Paul use the values obtained from their experiment to plot a graph. They obtain the graph below. Label the axis of the graph and give the relevant units. (2)



iv. Who was right? Jane or Paul? Give a reason for your answer.

____

____ (2)

(Total: 20 marks)

20

5 a. A bar magnet rests near a solenoid AB, the ends of which are connected to an instrument as shown in Figure 7.

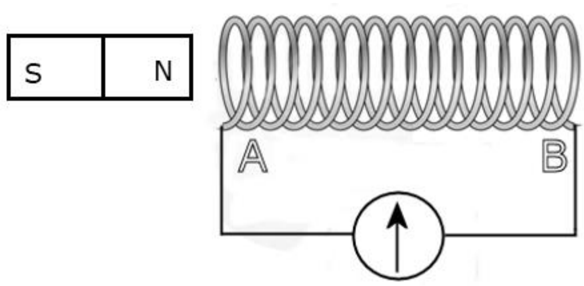


Figure 7

i. Name the instrument connected to the solenoid.

____ (1)

ii. The magnet is then moved slowly towards the solenoid. State what is observed on the instrument and explain fully your observations.

____

____

____ (3)

iii. What magnetic pole is induced at end A as the N pole of the magnet moves towards the solenoid? Explain why this is so and name the law used to explain your answer.

____

____

____ (3)

iv. What would be observed in part (ii), if:

- the solenoid is moved towards a stationary magnet;

____ (1)

- the solenoid and magnet are both moved at the same speed in the same direction.

____ (1)

v. Fill in the blanks to complete the paragraph.

The phenomenon taking place as the magnet moves towards the solenoid is an example of a change of energy from ______________________ to ______________________.

One practical application of this phenomenon is ______________________. (3)

b. Jan has a small pond in his garden and would like to install an underwater lamp to light it up. He uses a transformer to operate a 12 V 100 W lamp connected to its secondary coil. The primary coil of the transformer is connected to a 230 V mains supply.

i. Is he using a step-up or step-down transformer? ______________________________ (1)

ii. This transformer has 100 turns in its secondary coil. How many turns should it have in the primary coil?

____

____ (2)

iii. Assuming this transformer to be 90% efficient, calculate the current in the primary coil.

____

____

____

____

____ (3)

iv. Various types of transformers are used in the national grid to supply electricity from the power station to consumers, as shown in a simplified version in Figure 8. A and B are two such transformers.

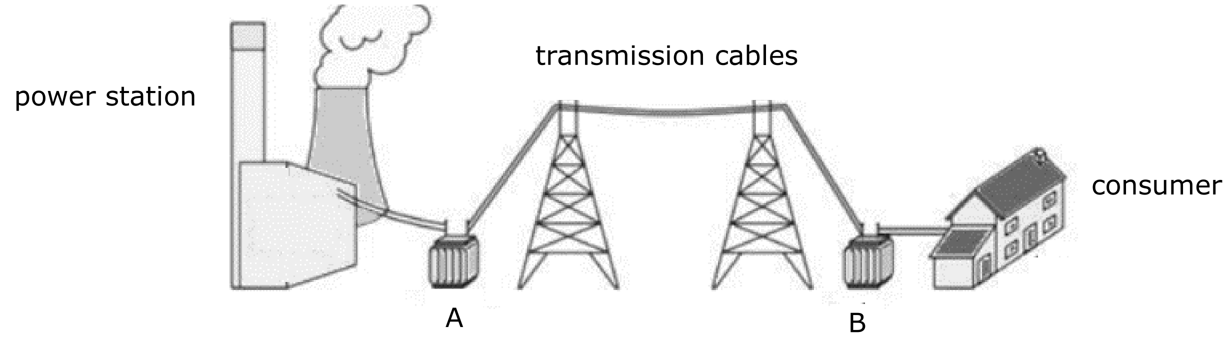


Figure 8
Source: https://www.cyberphysics.co.uk

State whether transformers A and B are step-down or step-up.

A: ______________________________ B: ______________________________ (2)

(Total: 20 marks)

20

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Index Number:________________ SEC24/2B.21m

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

L-Università ta' Malta

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 MAIN SESSION

SUBJECT:	**Physics**
PAPER NUMBER:	IIB
DATE:	26th June 2021
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 10m/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 $= \pi r^2$		

1. Malcolm wants to investigate the relationship between the height of the ramp, (h) and the horizontal distance, (d) travelled by the toy car on the ground before coming to rest. Figure 1 shows the setup used.

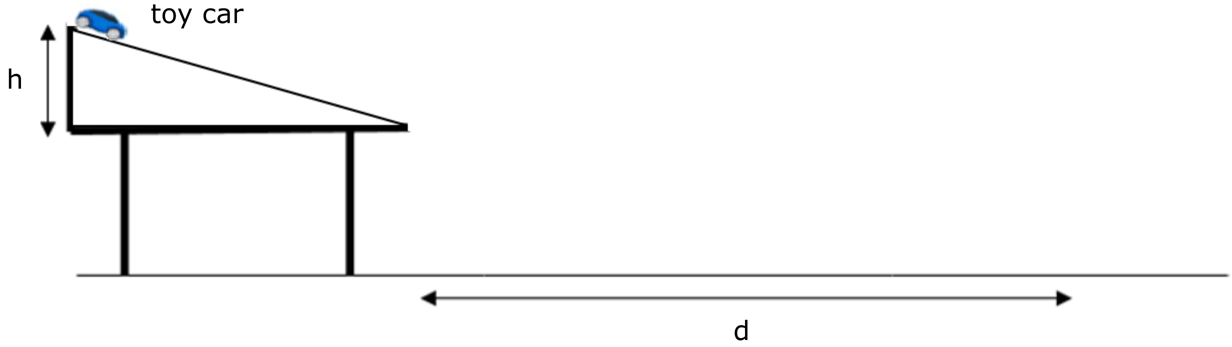


Figure 1

a. What apparatus should Malcolm use to measure the quantities d and h?

____ (1)

b. Fill in the blanks to complete the method used for this investigation. The same word/s can be used more than once.

Set the initial vertical ____________ of the ramp. Measure its value and release the toy car. Let the toy car come to ____________ and measure the horizontal _____________. Repeat this procedure by varying the _______________. (4)

c. Mention **TWO** precautions which should be taken.

____

____ (2)

d. Fill in the headings of Table 1 to show what measurements need to be taken and their respective SI units. (2)

Table 1

e. Malcolm predicts that the horizontal distance, d and vertical height, h are directly proportional. Which graph can he plot to check his theory?

____ (1)

f. What should the graph suggested in part (e) look like if d and h were directly proportional?

____ (1)

g. The toy car has a mass of 0.40 kg and the height was set at 0.12 m.

i. Calculate the gravitational potential energy of the toy car at the top of the slope.

____

____ (2)

ii. Assuming that there are no resistive forces acting against the motion of the toy car, calculate the kinetic energy of the toy car at the bottom of the slope.

____ (1)

iii. State the law of conservation of energy.

____

____ (2)

iv. The following equation relates the velocity, v of the car to its mass, m and kinetic energy, KE at that point during its motion.

$$v = \sqrt{\frac{KE}{0.5\ m}}$$

Use the equation to calculate the velocity of the car at the bottom of the slope.

____

____

____ (2)

v. The velocity of the toy car at the bottom of the slope will be smaller in reality than the value calculated in part (iv). Explain why this happens.

____

____ (2)

(Total: 20 marks)

20

2. Oliver and Kate designed a new kettle as shown in Figure 2. It is made up of two layers of plastic separated by a layer of polystyrene (jablo). It is designed to keep the water inside the kettle warm for a longer time.

Figure 2

a. Explain why the polystyrene reduces energy transfer to the surroundings.

___

___ (2)

b. Which mode of heat transfer does the polystyrene reduce?

___ (1)

c. Kate suggests that instead of polystyrene, they should introduce a vacuumed layer. Oliver still thinks that polystyrene is the better option. Explain why vacuum is a better option than polystyrene.

___ (1)

d. Oliver suggested that the interior layer of the kettle should be made from a silver, shiny surface. State **TWO** reasons why this could improve the ability of the kettle to keep the water warmer for a longer time.

___

___ (2)

e. After the water is heated and the kettle switched off, they notice that heat will still be lost from the kettle's spout. Explain what type of heat transfer is present in this case.

___ (1)

f. What can they do to minimise heat losses from the kettle's spout?

___ (1)

g. Kate and Oliver want to test the kettle. They filled it up with 0.75 kg of water at 18 ^oC.

i. They switched on the heating source found at the bottom of the kettle and the water's temperature started to increase. Fill in the blanks to explain how water is heated inside the kettle.

The water molecules close to the heating source start to ______________ more rapidly. This increases the distance between the molecules which increases the ______________ of water at that point. This will cause a decrease in _______________so that the hot water will rise to the top while the cold water will sink to the bottom. (3)

ii. The water is boiled using 265300 J of energy. Calculate the specific heat capacity of water.

____

____ (2)

iii. The actual value for the specific heat capacity (SHC) of water is 4200 J/kg^{o}C. Give **ONE** reason for the difference from the value obtained in part (ii).

____

____ (1)

iv. As soon as the water starts boiling, they switched off the heater and start off the timer. After 2 hours the water inside the kettle loses 46200 J to the surroundings. Calculate the change in temperature of water. Use 4200 J/kg^{o}C as the SHC of water.

____

____

____ (2)

v. Hence calculate the final temperature of water.

____ (1)

vi. Convert the time taken to heat the water into seconds.

____

____ (1)

vii. Calculate the average power loss from the water in the kettle to the surroundings in 2 hours.

____

____ (2)

(Total: 20 marks)

20

3. a. Figure 3 shows wavefronts in a ripple tank entering a region of shallower water during a Physics demonstration.

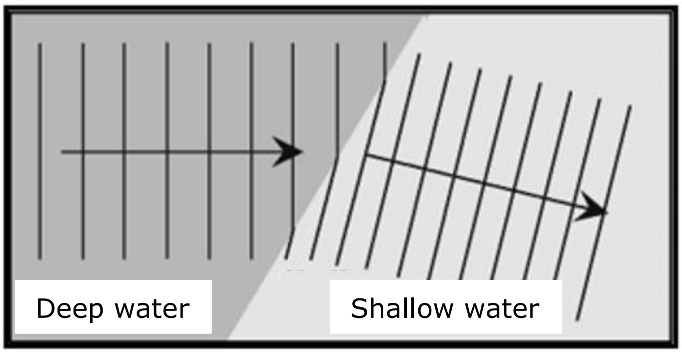


Figure 3
Source: http://ipl.physics.harvard.edu

i. How are these plane waves produced?

____ (1)

ii. A glass block is placed at the bottom of the tank. What is it for?

____ (1)

iii. Fill in the blanks to complete the following paragraph.

As the waves travel from deep to shallow water there is a change in wave direction as shown in Figure 3. This phenomenon is known as __________________________ and is caused by the change in ________________________ as the waves cross the boundary into shallow water. The distance between two wavefronts, known as _____________________________, changes also. There is however no change in _________________________ as this depends only on the source producing the vibrations. (4)

iv. The teacher adjusts the apparatus so that the incident wavefronts are now parallel to the boundary and not at an angle as shown above. In what ways are the observed waves in the shallow water the same as and different than before?

Same as before: ____ (1)

Different than before: ____ (1)

b. Give **ONE** similarity and **ONE** difference between water waves and electromagnetic waves.

Similarity: ____ (1)

Difference: ____ (1)

c. Figure 4 shows an electric bell suspended by its own wires passing through a rubber stopper inside a sealed bell jar. The electric bell is connected to a battery. At the bottom of the bell jar there is a pipe leading to a vacuum pump.

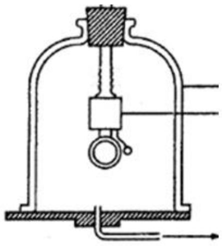


Figure 4
Source: https://toppr.com

i. Are sound waves in air transverse or longitudinal?

____ (1)

ii. The bell is switched on. What happens to the sound heard as the air inside the bell jar is removed? Explain.

____

____ (2)

iii. How would the observation in part (ii) be different if the electric bell was to be placed on the base at the bottom of the bell jar, instead of being suspended? Explain this difference.

____

____ (2)

d. Roberta and Valerie carry out an experiment to measure the speed of sound in air. They find a suitable quiet place in the open and stand next to each other, 200 m away from a large wall. Valerie makes a sharp loud sound by banging together two blocks of wood. Roberta uses a microphone connected to an electronic timer. This timer starts when the sharp loud sound is made and stops when the microphone receives the echo from the wall. The timer gives a value of 1.2 s.

i. What is an echo? ____ (1)

ii. What distance does the sound travel in these 1.2 s?

____ (1)

iii. Calculate the value obtained for the speed of sound in air.

____

____ (2)

iv. Give **ONE** reason why they carried out this experiment in the open and not in built-up areas.

____ (1)

(Total: 20 marks)

20

4. Jane and Paul found several small filament bulbs used in car headlamps, brakes and indicator lamps.

a. Fill in the energy flow chart in Figure 5 below to show the energy conversions that occur in a light bulb. (3)

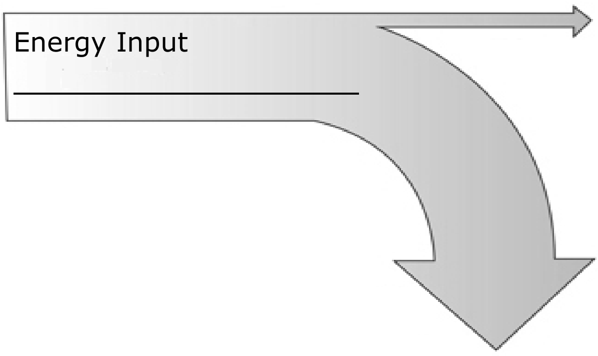


Figure 5
Source: http://www.sankey-diagrams.com/

b. Each small filament bulb is marked as having a power rating of 21 W and requires 12 V to operate at normal brightness.

i. What do you understand by the term a power rating of 21 W?

______________________________ (1)

ii. Calculate the total power generated by the circuit to operate all three bulbs at normal brightness.

______________________________ (1)

iii. The three light bulbs are connected in parallel with a power supply and a switch, as shown in Figure 6. Calculate the current flowing through each lamp when the circuit is switched on.

____

______________________________ (2)

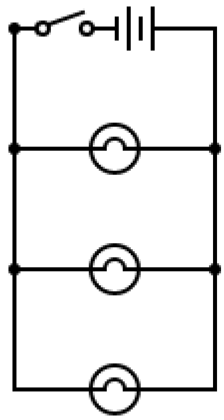


Figure 6

iv. Hence calculate the total current flowing through the circuit.

______________________________ (1)

v. What is the voltage across the bulbs in the circuit?

______________________________ (1)

vi. Calculate the total resistance of these filament bulbs.

____

______________________________ (2)

c. Jane thinks that the resistance of a filament bulb remains fixed, even when subjected to different voltages. Paul disagrees and thinks that the value of resistance of the bulb changes with different voltages. They set up the circuit shown in Figure 7 to check who is correct.

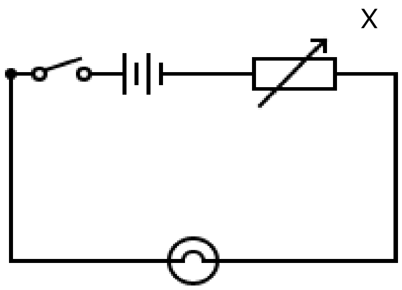


Figure 7

i. What is the component marked with an X in Figure 7? ____________________________ (1)

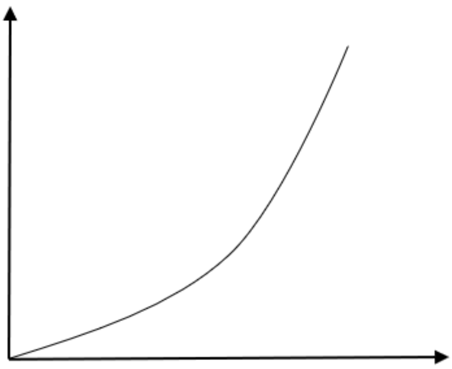
ii. Include an ammeter and a voltmeter to the circuit in Figure 7 so that they can be used to carry out the investigation. (2)

iii. Put the following statements in order, using numbers 1 to 4, to explain how the circuit is used to check Jane and Paul's theory. The first one has been done for you. (3)

	The value of component X is changed and a new reading of current and voltage is recorded.
1	The circuit is switched on and the current and voltage across the filament lamp are recorded.
	The value of resistance is worked for each set of readings.
	The previous step is repeated for another 4 times.

iv. Jane and Paul use the values obtained from their experiment to plot a graph. They obtain the graph below. Label the axis of the graph and give the relevant units. (2)

Quantity: _____________
Unit: _____________



Quantity: ______________
Unit: ______________

v. Who was right? Jane or Paul? ____(1)

(Total: 20 marks)

20

5. a. A bar magnet rests near a solenoid AB, the ends of which are connected to an instrument as shown in Figure 8.

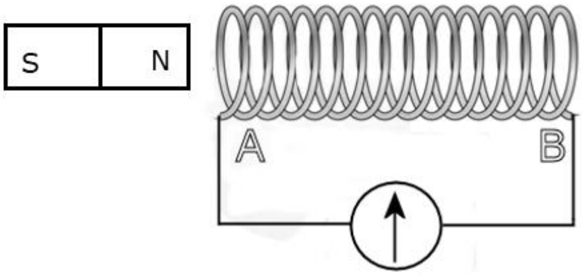


Figure 8

i. Name this instrument and state what it is used for.

____ (2)

ii. The magnet is then moved slowly towards the solenoid. State what is observed on the instrument and explain fully your observations.

____

____

____ (3)

iii. Fill in the blanks with the appropriate words.

As the magnet moves towards the solenoid, a north pole is induced at end A. This is because the induced pole always ________________________ the change causing it. This is known as ___________________ law. (2)

iv. What would be observed in part (ii), if:

- the solenoid is moved towards a stationary magnet.

____ (1)

- the solenoid and magnet are both moved at the same speed in the same direction.

____ (1)

v. Fill in the blanks to complete the paragraph.

The phenomenon taking place as the magnet moves towards the solenoid is an example of a change of energy from kinetic to ______________________________. One practical application of this phenomenon is ___________________________________. (2)

b. Jan has a small pond in his garden and would like to install an underwater lamp to light it up. He uses a transformer to operate a 12 V 100 W lamp connected to its secondary coil. The primary coil of the transformer is connected to a 230 V mains supply.

i. Is he using a step-up or step-down transformer? ___________________________ (1)

ii. This transformer has 100 turns in its secondary coil. How many turns should it have in the primary coil?

____

____ (2)

iii. Calculate the power in the primary coil if the efficiency of the transformer is 90%.

____

____ (2)

iv. Calculate the current in the primary coil.

____

____ (2)

c. Various types of transformers are used in the national grid to supply electricity from the power station to consumers, as shown in a simplified version in Figure 9. A and B are two such transformers.

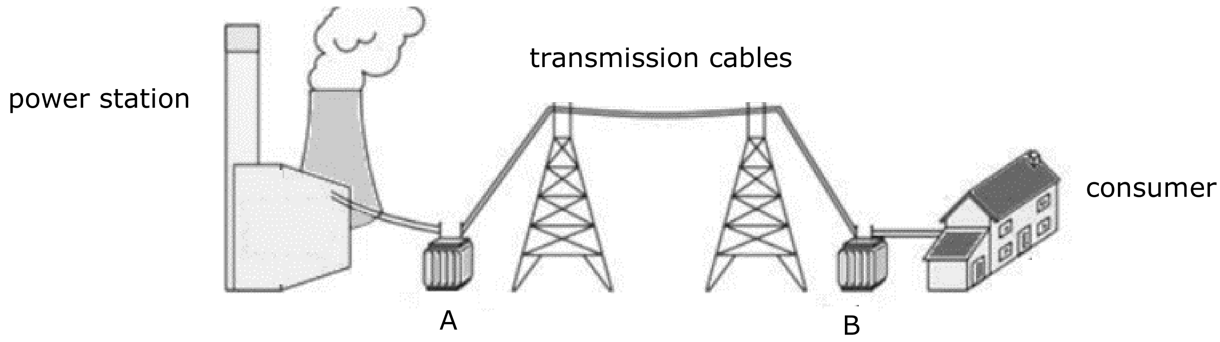


Figure 9
Source: https://www.cyberphysics.co.uk

State whether transformers A and B are step-down or step-up.

A: ________________________________ B: __________________________________ (2)

(Total: 20 marks)

20

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