2025 Phy Set 5

Answer **all** the questions.

1. Fig 1.1 shows a uniform beam which is supported by two light cables, AB and AC. They are attached to a vertical steel cable from a crane. The beam is at rest.

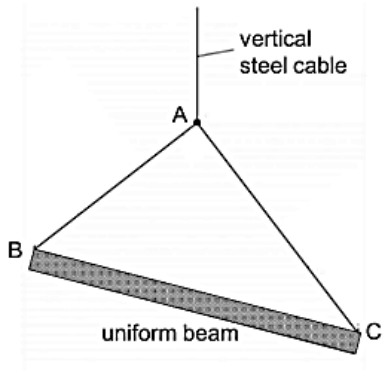

Fig 1.1

(a) Explain why the centre of gravity of the beam shown in Fig 1.1 must be vertically below A when the beam is at rest.

……

……[2]

(b) A student made this statement: "The tension in the vertical steel cable and the weight of the beam are an action and reaction pair of forces."

Explain with two reasons if you agree or disagree with the statement.

……

……

……[2]

(c) State the two conditions for a system in equilibrium.

……

……

……..……..[2]

2. A student with a weight of 500 N moves down a long slide as shown in Fig 2.1 on earth.

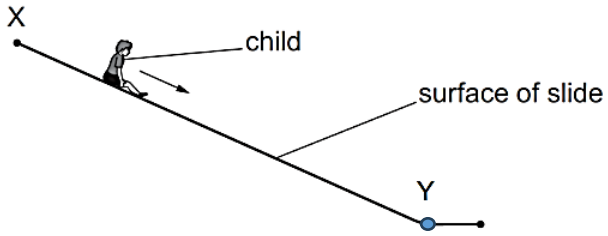

Fig 2.1

The student moves from rest from X which is located at the top end of the slide. The surface of the slide is rough. He experiences an average resistive force of 70 N as he slides from X to Y. The kinetic energy of the student at Y is 300 J. The decrease in the gravitational potential energy of the student as he moves from X to Y is 3000 J.

(a) State the law of conservation of energy.

……

……

……[2]

(b) Obtain the mass of the student.

mass=……..[1]

(c) Determine the speed of the student at Y.

speed=……..[2]

(d) Calculate the length of the slide. You may assume that the air resistance experienced by the student while sliding from X to Y is negligible.

length of the slide=……[2]

(e) At end Y of the slide, the student is brought to rest by a board as shown in Fig 2.2.

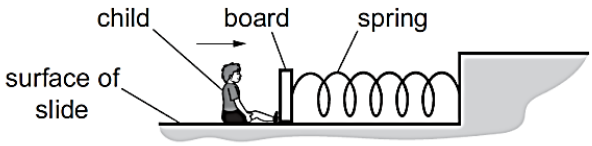

Fig 2.2

A spring connects the board to a fixed point. The student hits the board so that it moves to the right and compresses the spring. The speed of the student becomes zero when the elastic potential energy of the spring has increased to its maximum value of 140 J.

Calculate the percentage efficiency of the transfer of the kinetic energy of the child at Y to the elastic potential energy of the spring.

percentage efficiency=……..[1]

3. A uniform plank of length 4.00 m and weight 800 N is suspended by two strings at X and Y from the ceiling as shown in Fig 3.1. A box of 2.5 kg is placed on the plank.

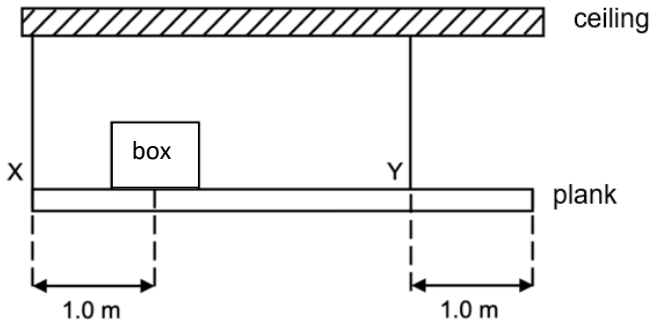

Fig 3.1

(a) Label clearly the following forces on Fig 3.1.

(i) Weight of plank (W_{plank})

(ii) Weight of the box (W_{box})

(iii) Tension in X(T_x)

(iv) Tension in Y(T_y) [2]

(b) Given that the plank is in equilibrium, calculate the tensions in X and in Y.

T_x=……

T_y=……..[3]

4. Fig 4.1 shows the interior of a spray can.

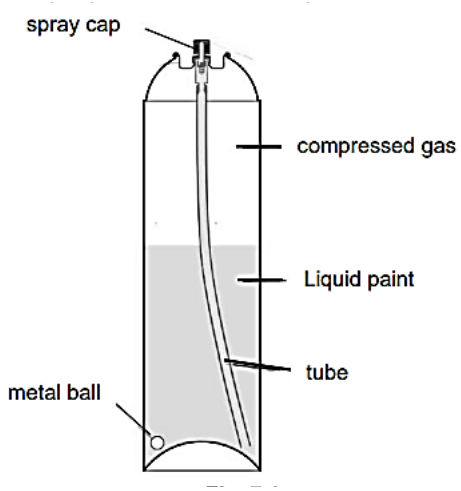

Fig 4.1

It is first filled with liquid paint and then injected with gas. The spray cap traps the highly compressed gas within the can. When used, some of the liquid paint leaves the can and the pressure inside the can decreases.

(a) Explain, using the motion of molecules, how the compressed gas exerted a pressure on the walls of the spray can.

……

……

……..…….[2]

(b) After using much of the liquid, the rate at which the liquid paint is sprayed out decreases. Using ideas about molecules, explain why this happens.

……

……

……....[2]

5. Fig 5.1 shows part of a hydraulic braking system of a car.

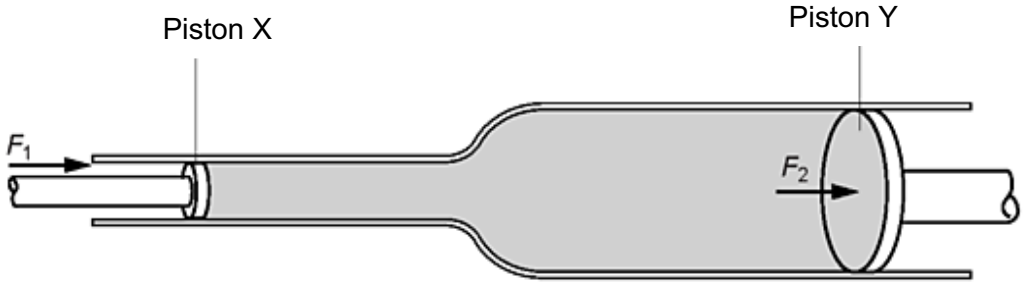

Fig 5.1

The force F_1 exerted by the driver's foot on the brake pedal moves piston X. The volume between piston X and piston Y is filled with oil which is incompressible. The force F_2 exerted by the oil moves piston Y. This force is applied to the brake mechanism in the wheels of the car. The cross-sectional area of piston X is 5.00 cm^2 and F_1 = 100 N

(a) Calculate the pressure, in Pa, exerted on the oil by piston X.

pressure=……[2]

(b) With reference to Fig 5.1, explain why force F_2 is greater than force F_1.

……

……

……..[2]

(c) Explain why piston Y moves a shorter distance than piston X.

……

……

……..[2]

(d) Suggest why the braking system will not work properly if the oil contains bubbles of air.

……

……[1]

6. Fig 6.1 shows a transverse wave travelling along a rope. The positions of the wave at the time intervals t = 0.0 s and t = 2.0 s as labelled.

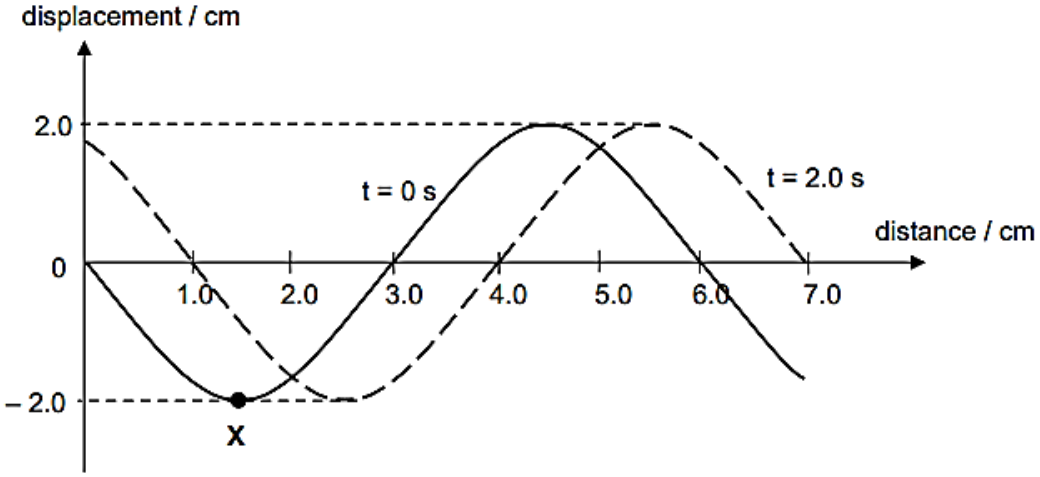

Fig 6.1

(a) Calculate the speed of the wave.

speed=……..[1]

(b) Determine the period of the wave.

period=…….[2]

(c) X is a particle on the wave at t= 0.0 s. On Fig 6.1, mark the new displacement of X at t= 6.0 s. Label the new vertical position as Y. [1]

7. Fig 7.1 shows an experiment set up (not drawn to scale) to investigate how light travels from water to air. A metre ruler with a small laser beam bulbs are fixed at 10.0 cm intervals is placed vertically into water. The refractive index of water is 1.33.

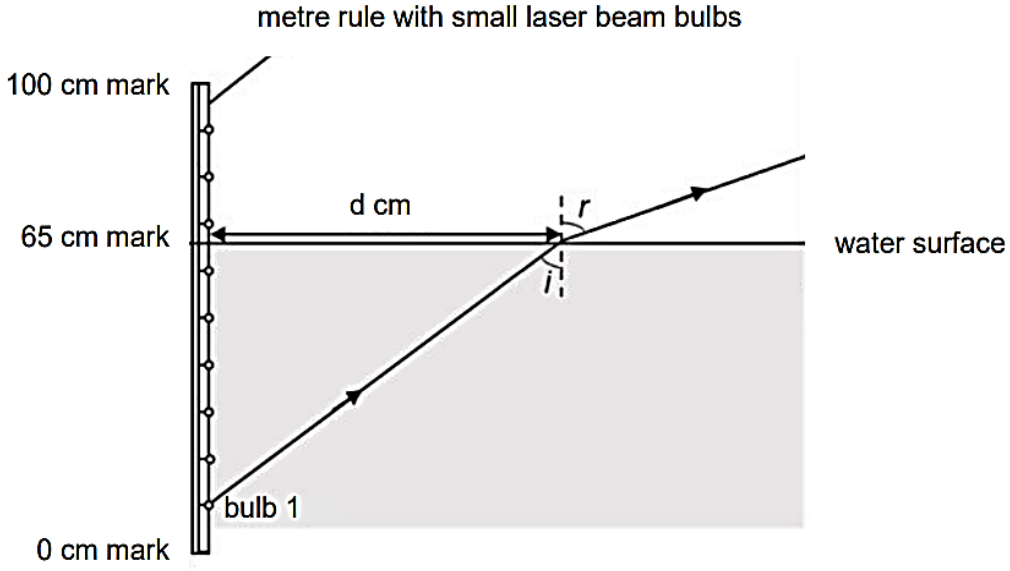

Fig 7.1

(a) Fig 7.1 shows a ray of light from bulb 1. The point of incidence on the water surface is *d* cm from the metre ruler and the water surface is at the 65.0 cm mark of the metre ruler. Given that the angle of incidence, *i* is 45°, calculate *d*.

d=……[1]

(b) Calculate the angle of refraction, *r*, in the air.

r=……[2]

(c) Calculate the critical angle of water.

critical angle=……..[2]

(d) With the metre ruler in the same position, each light bulb is switched on one at a time and each laser light aimed at the same point of incidence, with the same d value as calculated in (a).

Explain if total internal reflection will occur when bulb 2 is fixed at the 20 cm mark of the metre ruler. You may support your answer with relevant calculations.

calculations:

……

……

……....[2]

8. A student measures the speed of sound using an echo from a cliff. She stands facing the cliff and claps her hands as shown in Fig 8.1.

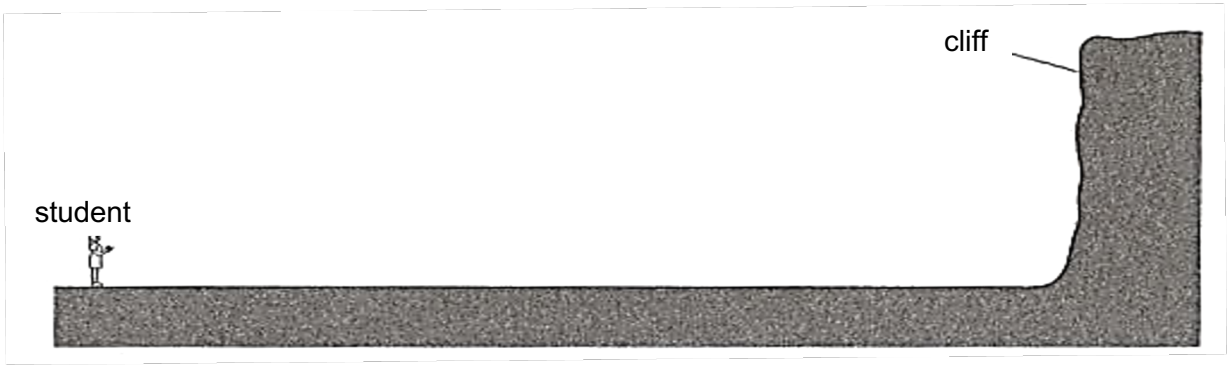

Fig 8.1

(a) The echo arrives 4.0 s after she claps her hands. She walks 220 m towards the cliff and then claps her hands again. The echo now arrives 2.6 s after she claps.

Calculate the speed of sound using these data. Give your answer to an appropriate number of significant figures.

speed=……[2]

(b) The student produces a musical sound. State how the sound changes when

(i) The amplitude of the sound increases.

……..……[1]

(ii) The wavelength of the sound increases.

……..……[1]

9. A student heats a metal block, M until it reaches a temperature of 100 °C. He transfers the metal block into a beaker containing 200 g of water at 25 °C as shown in Fig 9.1.

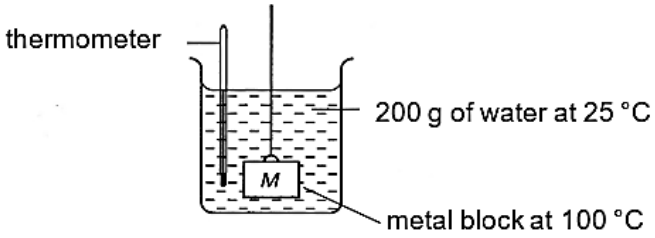

Fig 9.1

The temperature of water in the beaker is recorded at an interval of 30 seconds. A graph of temperature of water against time is shown in Fig 9.2.

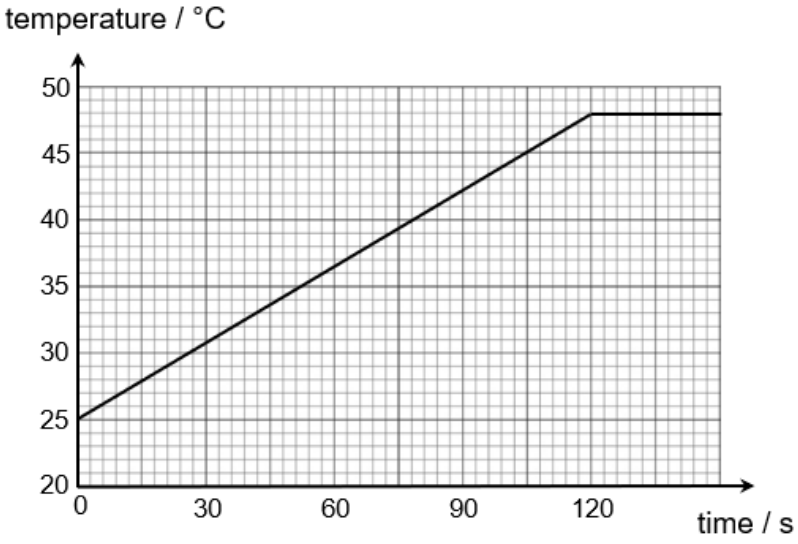

Fig 9.2

(a) Explain why the temperature of the water stops rising after 120 s.

……

……....[1]

(b) The specific heat capacity of water is 4200 J/(kg°C).

Calculate the amount of heat energy absorbed by the water during the first 120 s.

energy=…….[2]

(c) Using the answer from (b), calculate the power supplied to heat during the first 120 s.

power=…….[1]

(d) The student repeated the same experiment and made the following changes to the set up as shown in Fig 9.3.

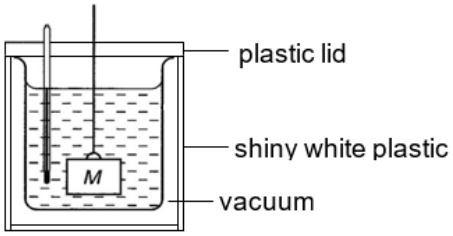

Fig 9.3

Explain how each of the changes helps to prevent heat loss from the water.

……

……

……

……

……

……

……..……[3]

10. Fig 10.1 shows a defibrillator which is a machine that sends an electrical charge through the heart of a patient whose heart is not beating correctly. Doctors and first responders learn to use a defibrillator by practicing on a medical dummy.

Fig 10.1

The contacts that touch the dummy are made from metal and when the defibrillator is being used, one contact becomes strongly negatively charged and the other contact becomes strongly positively charged. The handles of the contacts are made from plastic which is an electrical insulator.

(a) Explain the difference between an electrical insulator and a conductor in terms of how their particles behave.

……

..……..[1]

(b) Explain, in terms of the particles involved, how one contact becomes strongly negatively charged and the other contact becomes strongly positively charged.

……

..……

……

..……..[2]

(c) The defibrillator passes a charge of 0.50 C through the medical dummy in 20 ms.

(i) Calculate the average current in the dummy.

current=…….[2]

(ii) Given that the total amount of energy delivered by the defibrillator is 125 J, determine the applied voltage across the contacts.

applied voltage=…….[2]

11. A student is investigating the operation of a soap dispenser. A fixed volume of liquid soap is dispensed when a sensor in an electronic switch detects a hand underneath the nozzle as shown in Fig 11.1.

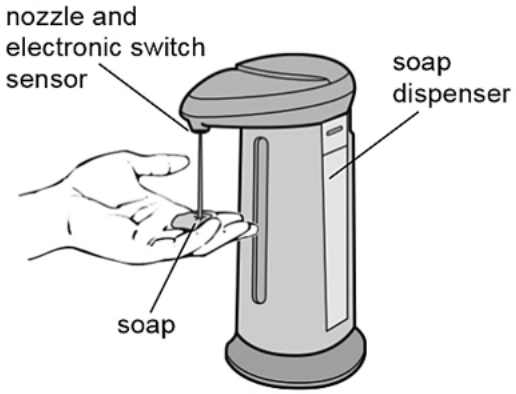

Fig 11.1

The student suggest that a light dependent resistor (LDR) could be used as a sensor in the electronic switch. The circuit is set-up with a 5000 Ω fixed resistor, a LDR and a 12 V supply as shown in Fig 11.2. When the user's hand is placed under the nozzle, it blocks the light falling on the LDR.

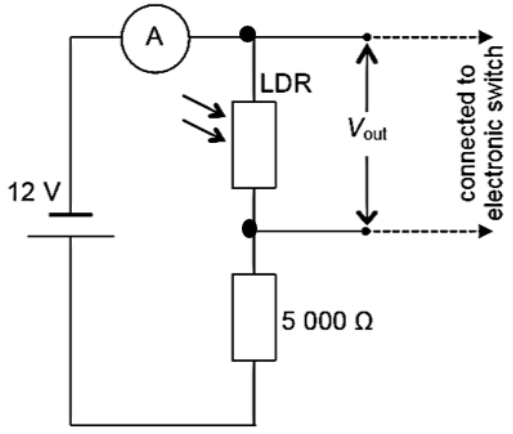

Fig 11.2

(a) When the LDR is not blocked the reading on the ammeter is 1.5 mA.

Calculate V_{out}, the potential difference across the LDR and the resistance of the LDR.

R_{LDR}=……

V_{out}=……..[3]

(b) The electronic switch of the nozzle is activated to dispense soap when V_{out} is larger than the value calculated in (a).

Explain how the soap dispenser is activated when a hand is placed under the nozzles

……

……

……..……[2]

12. A radioactive isotope, uranium, $^{238}_{92}U$ atom emits alpha (α) particles and gamma (γ) rays to form Thorium Th.

(a) Write a nuclide equation to represent this decay.

……[1]

(b) An experiment was conducted to find the range of α particles in air. Table 14.1 shows the results of the experiment.

distance from the source to the detector / cm	count rate / counts per minute
1.0	731
2.0	688
3.0	604
4.0	545
5.0	24
6.0	26
7.0	25
8.0	24
9.0	26

Table 14.1

(i) Estimate the background radiation count rate.

count rate=……..[1]

(ii) Based on your answer in (i) estimate the count rate of the radioactive source when the source is at 3.0 cm from the detector.

count rate=……[1]

(iii) State and explain the maximum distance that the α particles can travel from the source.

……

……..……..[2]

(iv) The background count rate is not a fixed constant value.
Explain why this is so.

……

……..……..[1]

Section B

Answer only one question in this section.

Either

13. Fig 13.1 shows a solenoid that is connected to a battery such that a north pole is induced at the right end of the solenoid.

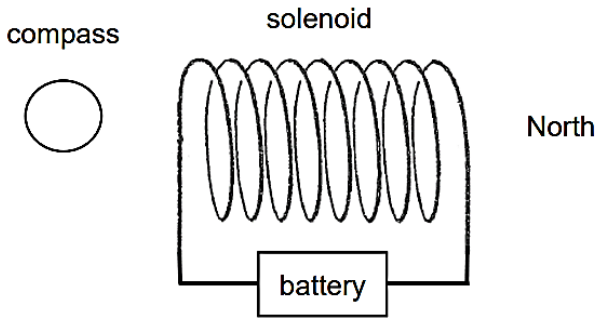

Fig 13.1

(a) Draw an arrow on the left end of the solenoid to indicate the direction of the current flowing through the solenoid. [1]

(b) A compass is placed at the left end of the solenoid.
Draw an arrow on Fig 13.1 to show how the compass needle will point. [1]

(c) Fig 13.2 shows a modified DC motor. The permanent magnet is replaced with the solenoid shown from Fig 13.1.

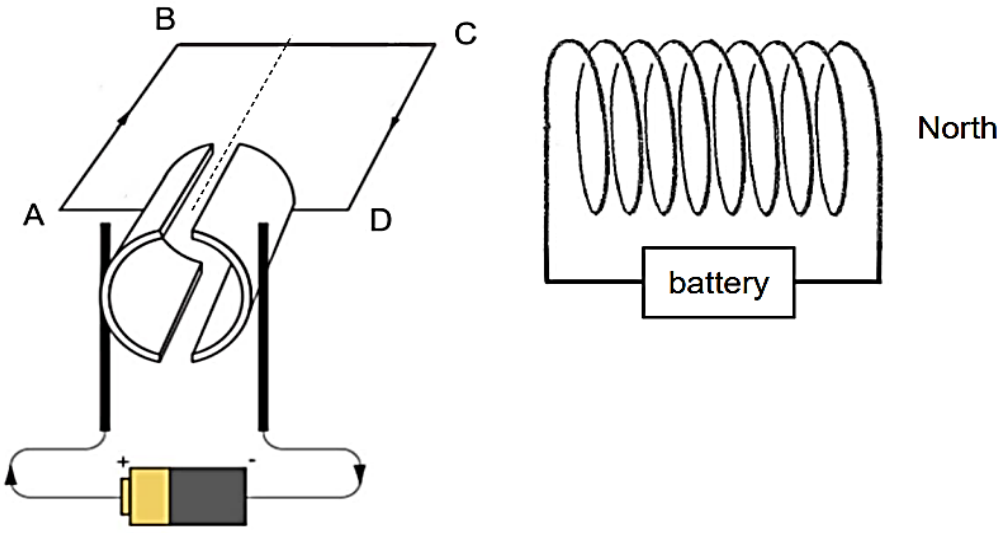

Fig 13.2

(i) On Fig 13.2, draw an arrow on wire AB to show the direction of the force induced on wire AB. [1]

(ii) Explain how the coil turns.

……

……

……...[2]

(iii) The slip rings shown in Fig 13.2 is replaced with a full ring (with no gaps). Explain how the change would affect the turning motion of the motor.

……

……

……...[2]

(d) Two solenoids are placed side by side as shown in Fig 13.3. S is a switch, and G is a centre-zero galvanometer.

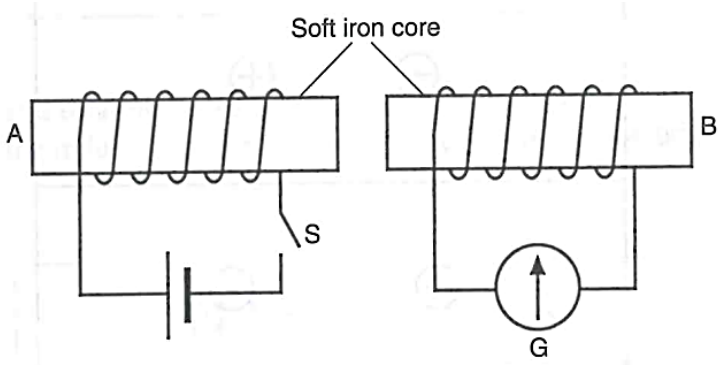

Fig 13.3

State and explain the polarity induced at end B when

(i) S is first closed.

……

……

……...…[2]

(ii) S remains closed.

……

……

……...…[1]

Or

13. In a power station, electrical energy is generated and then transmitted via transmission cables to all households and industries. Some countries use wind turbines to generate electrical energy. This form of generation is pollution free and renewable. Some other countries use a nuclear reaction to generate electrical energy. This alternative form of generation is also pollution free.

(a) State what is meant by a *renewable source* of energy.

……

……[1]

(b) Discuss briefly, how when compared to a fossil fuel power station, a nuclear power station is pollution free.

……

……[1]

(c) The current in the transmission line used to supply electrical power to a suburb is 65.0 A. The power is transmitted at a voltage of 23 kV. The transmission line has a resistance of 2.00 Ω.

Calculate

(i) The potential difference across the transmission line,

potential difference=…….[2]

(ii) The thermal energy produced in the transmission line in 4.00 s.

thermal energy=……..[2]

(d) Fig 13.4 shows a consumer unit where the individual circuit breakers are wired to different electrical appliances. A ring main (drawn from 30 A circuit breaker) is usually allocated to a room in a household.

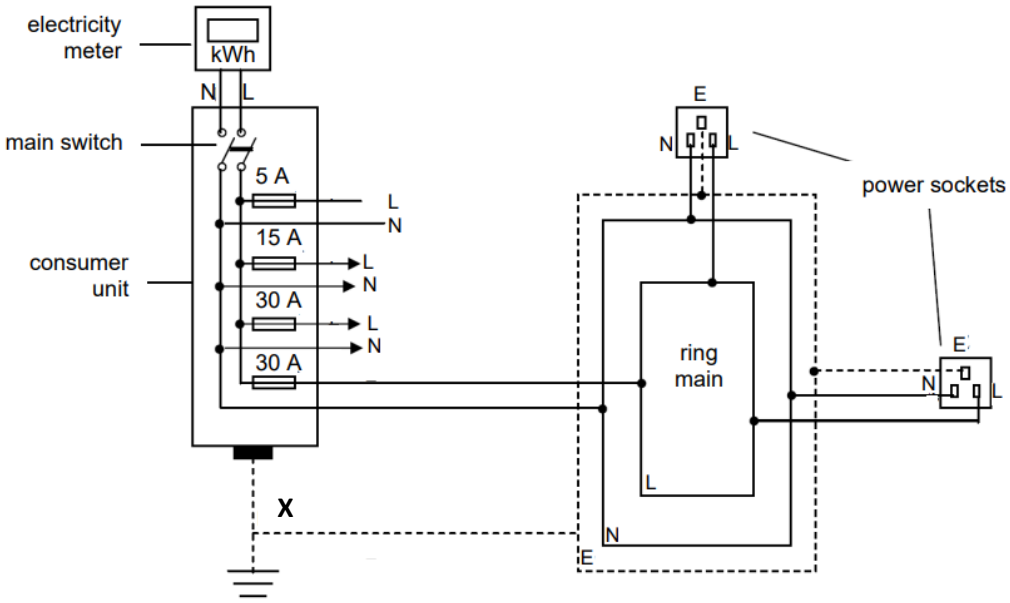

Fig 13.4

The owner wishes to convert the room to a study room where the family members can use their laptops at the same time. The laptops are rated 240 V, 4.00 A.

(i) State the function of component **X**.

……

……..[1]

(ii) Determine the maximum power that can be supplied to one main ring.

maximum power=……..[2]

(iii) Determine the maximum number of laptops he can set up in the room.

maximum number=……[1]

END OF PAPER

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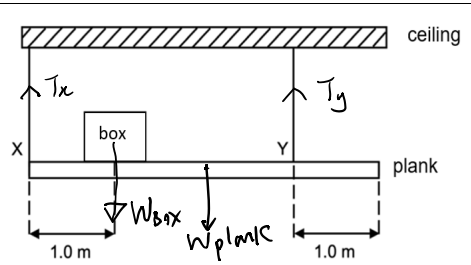
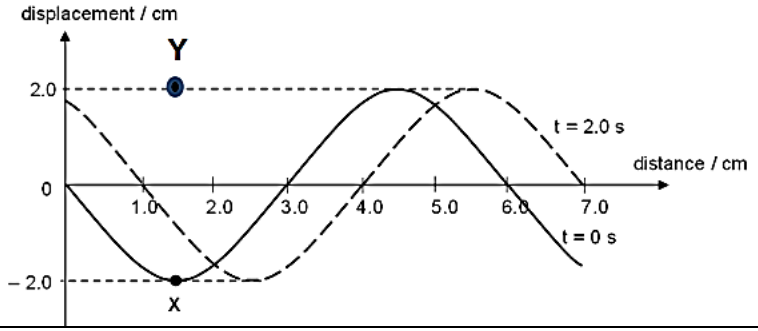
Question		
1(a)	Perpendicular distance between the line of action of weight of beam and pivot(A) is zero Moment of the line of action of weight about A is zero	[1] [1]
1(b)	Disagree Any two reasons: • They must act on 2 separate bodies/They must not act on the same body(beam)/Weight and tension act on the same object • Weight and tension are not of the same type/nature of force • Action and reaction pair for weight of beam should be force by beam on earth and force by earth on beam	[1] [1]
1(c)	• Net force acting on the system is zero • Sum of clockwise moments about a pivot is equal to the sum of anticlockwise moments about a pivot/Net moments of the system about a pivot is zero	[1] [1]
2(a)	Energy cannot be created nor destroyed. It can only be converted from one form to another form. The total energy in the system remains constant.	[1] [1]
2(b)	W= mg 500 = m(10) M = 50.0 kg	 [1]
2(c)	$E_k = 0.5mv^2$ $300 = 0.5 \times 50 \times v^2$ $300 = 25 \times v^2$ v= 3.46 m/s	 [1] [1]
2(d)	3000 = 300 + WD(friction) $2700 = 70(D_{xy})$	 [1]

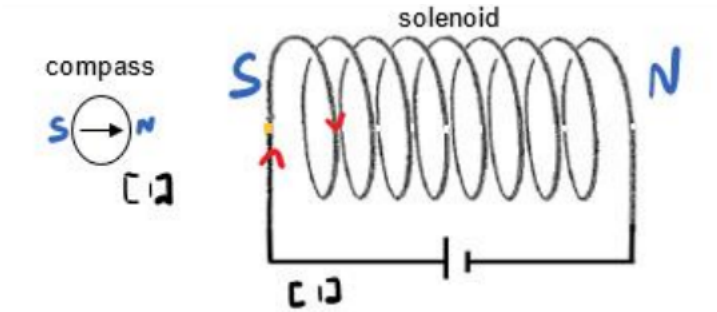
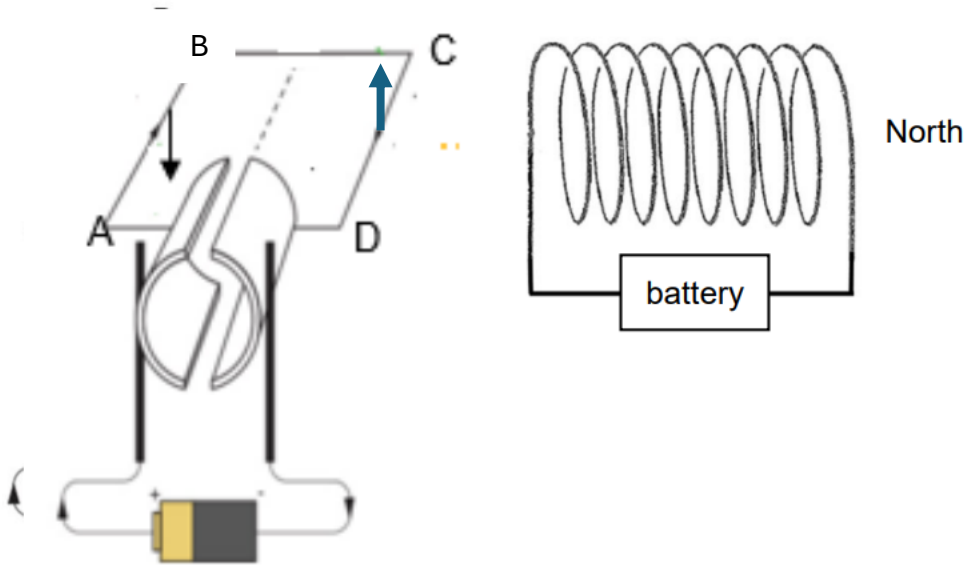
	D_{xy}= 2700/70 D_{xy}= 38.6 m	[1]
2(e)	Efficiency = 140/300 x 100% = 46.7%	[1]
3(a)	 1m: weight of box and plank 1m: T_x and T_y	[1],[1]
3(b)	W(box)= mg = 2.5 x 10 = 25 N Taking moments about X, Sum of CW moments = ACW moment (25 x 1) + (800 x 2) = T_y(3) Ty=541.7 = 542 N Net force of the system = 0 N T_x+T_y = 25+ 800 541.7 +Tx = 825 Tx = 283.3 =283 N	 [1] [1] [1]
4(a)	• The gas molecules which are moving randomly and freely in all directions collide with the walls of the container at high speeds. • The force exerted per unit area on the wall creates pressure	[1] [1]
4(b)	• The number of gas particles per unit volume decreases.	[1]

	• The pressure inside the spray can decreases/frequency of collision between the gas particles and the wall decreases.	[1]
5(a)	$5.00\ cm^2 = 5 \times (0.01)^2 = 5.00 \times 10^{-4}\ m^2$ $P=F/A = 100 /(5.00 \times 10^{-4}) = 200\ kPa$	[1] [1]
5(b)	Pressure is transmitted through the incompressible oil. Area of Y > Area of X Px =Py (F1/Ax) =(F2/Ay) Hence F2>F1	[1] [1]
5(c)	Either: Vol moved by X = Vol moved by X Since $A_y>A_x$; $D_y<D_x$ Or work done approach WD by X = WD by Y Since $F_2>F_1$; $D_y<D_x$	 [1] [1] OR [1] [1]
5(d)	When the air bubbles are compressed, this may cause either smaller force to be exerted on piston Y/Pressure on piston X will not be transmitted equally to all the other parts of the oil/shorter distance moved by piston Y	[1]
6(a)	Speed = distance/ time = 1.0 cm/2.0 s = 0.5 cm/s	[1]
6(b)	λ = 6.0 cm(From Fig) $V = f\lambda$ 0.5 = f(6.0)[Note: f=1/T] T=12.0 s	[1] [1]

6(c)		[1]
7(a)	tan θ =65/d tan 45° = 65/d d = 65 cm	[1]
7(b)	n = sin r/sin i 1.33 = sin r/ sin 45 r = 70.1°	[1] [1]
7(c)	n = 1/sin c 1.33 = 1/ sin c c= 48.8°	[1] [1]
7(d)	new i = 90-$\tan^{-1}$(45/65) new I = 55.3° >c Total internal reflection occurs as new i>c	[1] [1]
8(a)	After the student has walked 220 m towards the cliff, the echo reaches her in 2.6 s instead of 4.0 s. Time taken for the sound to travel 220 x 2 = 440 m	

	t= 4.0-2.6 = 1.4 s	[1]
	Speed of sound = 440 m/1.4 s	
	= 314 m/s	[1]
8(b)(i)	Loudness of sound increases	[1]
8(b)(ii)	Pitch of sound decreases	[1]
9(a)	Both the water and metal block reach thermal equilibrium/	[1]
	There is no net heat gained nor loss between the water and the metal block	
9(b)	$Q = mc\theta$	[1]
	=(200/1000)x 4200 x (48-25)	[1]
	=19320 J	
9(c)	Power = Q/t	
	=19320/120	[1]
	=161 W	
9(d)	<u>Vacuum:</u> Prevents heat loss by conduction and convection	[1]
	<u>Lid</u>: Prevents heat loss by convection from water to the air above.	[1]
	<u>Shiny white surface</u>: Reduces heat loss by infrared radiation	[1]
10(a)	Insulators do not have free/mobile/delocalized electrons whereas conductors have electrons which are	[1]
10(b)	mobile.	[1]
	Negative contact gains electrons and becomes negatively charged.	[1]
	Positive contact loses electrons and becomes positively charged	
10(c)(i)		
	Q= It	
	I =Q/t	[1]
	$I=0.5/(20x10^{-3})$	[1]
	I=25.0 A	

10(c)(ii)	V=E/It =125/(25x0.02) =250 V	 [1] [1]
11(a)	PD across fixed resistor V= IR = 1.5 x 10^{-3} x 5000 = 7.50 V Vout +Vr =12 V Vout = 12-7.5 Vout =4.5 V Resistance(LDR) =4.5/(1.5 x 10-3) =3000 Ω	[1] [1] [1]
11(b)	When the hand block lights on the LDR, the resistance of LDR increases PD across LDR increases hence switching on the soap dispenser	[1] [1]
12(a)	$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha + \gamma$	[1]
12(b)(i)	25 counts per minute (Accept 24-26)	[1]
12(b)(ii)	604-25=579 counts/minute	[1]
12(b)(iii)	Maximum distance = 4.0 cm since the <u>count rate dropped drastically</u> to 25 counts per minute after it has gone beyond 5.0 cm	[1] [1]
12(b)(iv)	Radioactive decay occurs spontaneously/randomly	[1]
Either 13(a)		[1] [1]

13(b)		
13(c)(i)		[1]
13(c)(ii)	The magnetic field caused by the current interacts with the magnetic field created by the electromagnet to create forces on the coil AB and CD The forces on AB(downwards) and CD (upwards) causes the coil to turn in anticlockwise manner.	[1]

		[1]
	The coil ABCD would not be able to turn beyond to the vertical position	
13(c)(iii)	At the vertical position, there is no net force produced/no net moment to create turning effect.	[1]
		[1]
	North pole	
13(d)(i)	According to lenz's law, the direction of the induced current is always to oppose the change causing it	[1]
	(There is an increase in the magnetic flux experienced; polarity induced on the solenoid placed on the right will repel the electromagnet placed on the left)	[1]
	No polarity; no change in magnetic flux, no induced current.	
13(d)(ii)		[1]
OR		
13(a)	Energy is replenished naturally/not depleted when used/will not run out	[1]
13(b)	Nuclear plants do not produce gases that pollutes the environment unlike fossil fuel stations	[1]
13(c)(i)	V =IR	
	V=65x2	[1]
	V=130 V	[1]
13(c)(ii)	$E= I^2Rt$	
	$E=65^2(2)(4)$	[1]
	E=33800J=33.8 kJ	[1]
13(d)(i)	To provide a conducting pathway of low resistance for the current to flow to earth when a fault develops in the circuit.	[1]
13(d)(ii)	Power = IV	
	=30 x 240	[1]
	=7200 W	[1]
13(d)(iii)	Number of laptops =30/4=7.5	
	Max number = 7	[1]