2023-DSE
PHY

PAPER 1B

Name	
Class	
Class No.	

Methodist College

F.6 First Examination 2022-23

PHYSICS PAPER 1

SECTION B : Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first write your name, class and number on the cover page.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

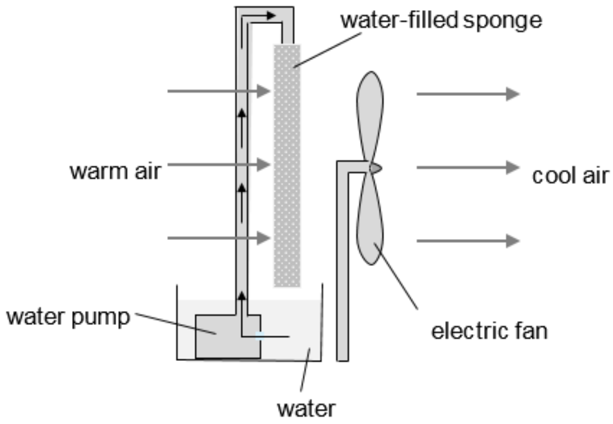
(5) Graph paper and supplementary answer sheets will be provided on request. Write your name, class and number on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(6) No extra time will be given to candidates for writing this information after the 'Time is up' announcement.

Question No.	Marks
1	/ 8
2	/ 7
3	/ 9
4	/ 10
5	/ 7
6	/ 11
7	/ 7
8	/ 7
9	/ 10
10	/ 8
Total	/ 84

Answer ALL questions. Parts marked with "*" involve knowledge of the extension component.

1. A student builds an air cooler by putting a water-filled sponge behind an electric fan as shown in Fig.1.1. A small water pump keeps adding water (at room temperature) to the sponge. The fan draws warm air through the sponge. As air passes through the sponge, some of the water in the sponge evaporates and the air is cooled. Then the fan blows the cool air out.



Majority of students were unable to identify that the working principle is based on the enhanced evaporation of water. It is not related to forced convection.

Fig.1.1

Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1} not useful in this Qn.

specific heat capacity of air = 1000 J kg^{-1} K^{-1}

specific latent heat of vaporization of water = 2.26×10^{6} J kg^{-1}

mass of 1 m^3 of air = 1.3 kg

(a) The student estimates that 8 m^3 of air is drawn through the cooler per minute. This causes 10 g of water in the cooler to evaporate.

(i) How much energy is needed for 10 g of water to evaporate? (2 marks)

Performance: Generally good.
Some students thought that energy is needed to heat up the water to 100°C before the absorption of the latent heat for vaporization. In fact, the energy absorbed from air is only used for evaporating the water in the sponge. Since evaporation can occur at temperature below the b.p., the water needs not be heated up to 100 °C in the process.

(ii) Assume that all the energy needed for the water to evaporate comes from the air. By how many degrees Celsius is the air cooled? $\Rightarrow \Delta T = ?$ (not the final temp) (2 marks)

Performance: Generally good.
Energy lost by air = $m_{air}c_{air}\Delta T$
Some students have made careless mistakes e.g. m_{air} was wrongly taken as 1.3 kg, c_{air} was wrongly taken as 4200 J kg^{-1} °C^{-1}

(b) The student claims that in order to have the cooler working properly, all the windows and the doors should be closed during operation. Comment on his claim. (3 marks)

Performance: Poor

Only 1 student knew that closing all the windows will affect the humidity which will then lower the evaporation of water as well as the cooling efficiency.

The cooling effect is nothing related to convection.

(c) Suggest one way to enhance the cooling effect of the cooler. (1 mark)

Performance: Satisfactory

Any means which can enhance the evaporation of water are acceptable answers.

Another possible answer is “adding ice into the water / using ice water”.

*2. Fig.2.1 shows a vacuum storage system. It consists of a container, a lid with a valve, and a hand pump. Food is put into the container, the lid is covered on it and the pump is used to manually remove air from the sealed container through the valve at the center of the lid. The container and the lid are rigid so that their shapes do not change under pressure.

Fig.2.1

(a) Explain why the lid is tightly attached to the container after some air is pumped out. (1 mark)

Performance: Good

Almost all students were able to point out that the pressure inside was being reduced.

However, 1 or 2 students said that there was a vacuum produced inside the container!

(b) Suppose that before pumping, the gas pressure inside the container is 1.01×10^{5} Pa, the volume of the container is 0.002 m^3 and the temperature is at 30°C.

(i) What is the number of moles of air initially? (2 marks)

Performance: Good

Majority of the students knew that absolute temp should be used in the general gas law PV = nRT. However, 1 student used “275” instead of “273” in the conversion.

(ii) If each stroke removes 0.001 mol of air and the temperature is kept constant, what is the final gas pressure inside the container after 10 strokes? (2 marks)

Performance: Good

Majority of the students were able to use the general gas law PV = nRT and reduce the amount of gas by 0.1×10 mol in solving the question.

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(c) Given that the radius of the lid is 10 cm, find the net force acting on the lid after 10 strokes.

(2 marks)

Performance: Poor

Common mistake 1:

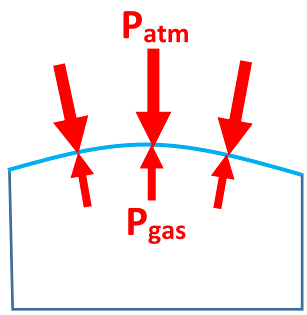
$F = P/A$ ✗ In fact, $P = F/A$ or $\Delta P = F_{net}/A$

Common mistake 2:

$F_{net} = PA$ ✗

In fact, the net force pressing the lid is caused by the pressure difference.

$\therefore F_{net} = P_{atm}A - P_{gas}A = (\Delta P)A$



3. Read the following passage about rescue cushion and answer the questions that follow.

A rescue cushion is a rescue equipment used by firefighters. It gives people on the upper floors of a burning building an opportunity to jump to safety, usually to ground level (Fig.3.1).
Rescue cushions are manufactured using fire retardant, vinyl reinforced fabric. It is connected to 2 powerful fans which can inflate the cushion within minutes. It consists of the upper cell and the lower cell (fig.3.2). There are 2 breathers on the opposite sides of the upper cell. It allows air to "breathe out" from the upper cell quickly when being hit by the falling person. While the lower compartment is more or less a firm air compartment. A rescue cushion is also made with a white top surface with a red center target area.

Fig.3.1

Fig.3.2

The practical height limit of the rescue cushion shown in fig.3.2 is about ten storeys. For higher height limit, the cushion has to be thicker and larger in area.

not above the ground

(a) A person falls from a height of 20 m above the rescue cushion with negligible initial speed. Neglect air resistance and the size of the person. ($g = 9.81\ ms^{-2}$)

(i) Estimate (1) the vertical speed v and (2) the time of fall t of the person just before hitting the cushion. (2 marks)

Performance: Good

Some students made the following careless mistake!

$v^2 = u^2 + 2as = 0 + 2(9.81)(20) = 19.8\ ms^{-1}$

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(ii) If the person of mass 70 kg is stopped in 0.7 s by the cushion, estimate the average force acting on the person by the cushion within this time interval. (3 marks)

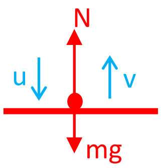
Performance: partly correct for the majority

For impact in the vertical direction, the force of impact = $\left|\frac{\Delta p}{\Delta t}\right|$+mg

For impact in the horizontal direction, the force of impact = $\left|\frac{\Delta p}{\Delta t}\right|$

$\left|\frac{\Delta p}{\Delta t}\right|$= F_{net} causing the change in momentum

<u>Vertical impact</u>



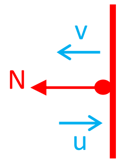
F_{net} = N – mg

∴ force of impact, N

= F_{net} + mg

= $\left|\frac{\Delta p}{\Delta t}\right|$ + mg

<u>Horizontal impact</u>



force of impact, N

= F_{net}

= $\left|\frac{\Delta p}{\Delta t}\right|$

(iii) Before hitting the cushion, the person possesses a lot of kinetic energy. Where does his kinetic energy go after his stop? (1 mark)

Performance: Poor

A lot of students mentioned that the KE was converted to elastic PE. In fact, the material of the cushion is not elastic. No elastic PE involved.

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(b) (i) Why are 2 breathers needed in the upper cell but not in the lower cell of the cushion? (1 mark)

Performance: Poor

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(ii) It has been reported that a falling person died because of landing near the side of the cushion. Explain why it is not easy for a person jumping from a height to reach the central part of the cushion. (2 marks)

Performance: Satisfactory

Majority of students mentioned “not moving along straight line”, “effect of wind or air current”. Only 1 to 2 students explained in terms of projectile motion.

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4. The photo (fig.4.1) was taken in the Dancing Water Show (水舞間). By using a special photographic function, the positions of the dancer were recorded at regular time intervals.

Fig.4.1

Fig.4.2 shows a simplified drawing of the above situation (the performers are not shown).

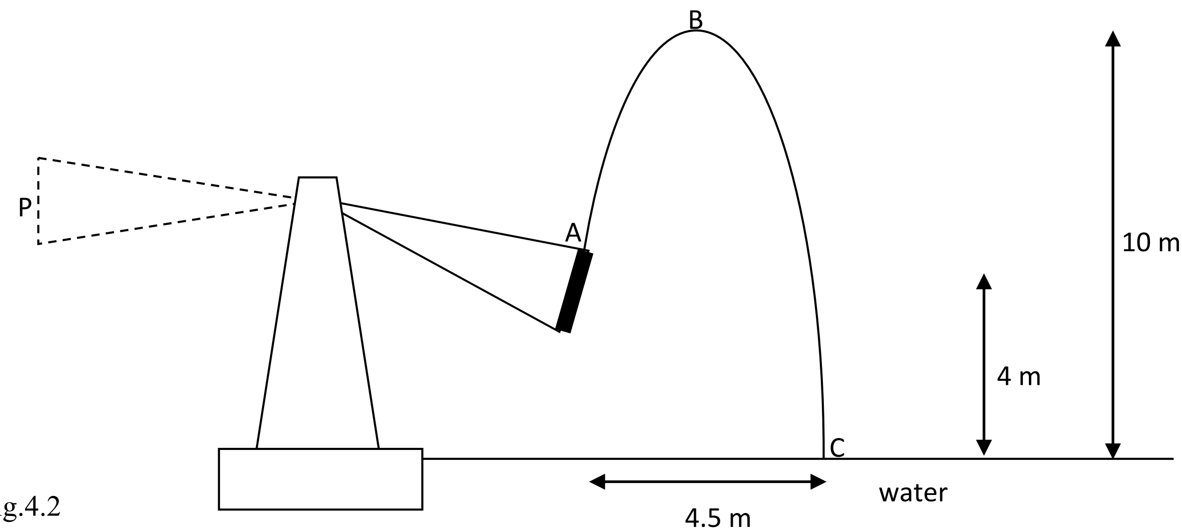

Fig.4.2

(a) Consider the dancer is a point mass, find his vertical speed just before entering the water. (1 mark)

Performance: Generally good.

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(b) Assuming the force of buoyancy (浮力) is 90% of his body weight and the average water resistance is 2000 N, find the minimum depth of the pool so that the 80 kg dancer will not hit the base. (2 marks)

Performance: poor

Method 1: KE & PE at C = WD against water resistance & buoyancy

Method 2: find the deceleration and then apply $v^2 = u^2 + 2as$

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(c) Find the initial vertical speed of the dancer when he is just leaving the swing at A. (2 marks)

Performance: Generally good.

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(d) Find the time of flight from A to C. (2 marks)

Performance: satisfactory

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(e) Find the initial horizontal speed of the dancer when he is just leaving the swing at A. (1 mark)

Performance: satisfactory

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(f) Before the "fly", the swing and the performers start from rest at the horizontal position P (fig.4.2). Explain why the dancer is able to fly up to a position higher than P. (2 marks)

Performance: satisfactory

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5. Fig.5.1 shows the structure of a simple camera. It consists of a lens and an image sensor. The distance between the lens and the sensor is adjustable. The opening in front of the lens allows light to enter the camera. Its size is adjustable.

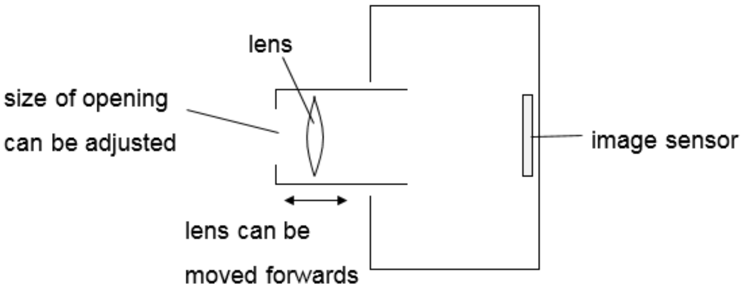

Fig.5.1

The focal length of the lens is 20 cm. A point object *P* is 60 cm in front of the lens.

(a) In Fig.5.2 below, complete the light ray and locate the image of *P* graphically. Hence find the lens-to-sensor distance in order to take a sharp picture of *P*. (3 marks)

Poor performance. Unable to add construction lines to solve the problem.

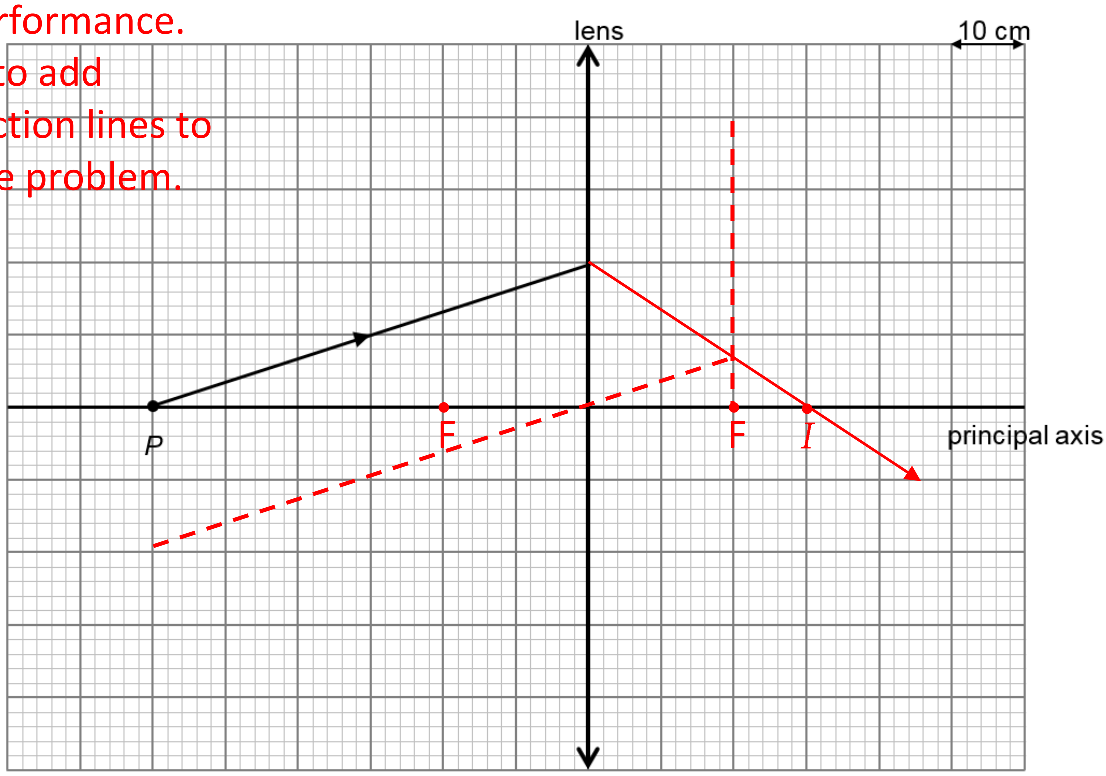

Fig.5.2

Lens-to-sensor distance = ______________________________

(b) The camera with the lens-to-sensor distance found in **(a)** is used to take a picture of another point object *Q*, which is at another distance from the camera. Fig.5.3 shows *Q* and its image. The image is not on the image sensor, so the picture of *Q* appears blurred.

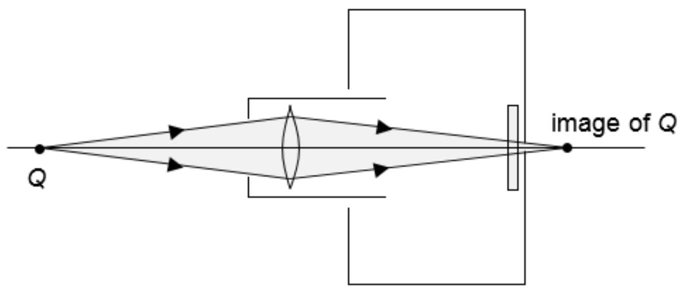

Fig.5.3

(i) Is Q closer to or farther away from the camera than P? (1 mark)

Performance: generally good

(ii) The opening of the lens is then made smaller so that the cone of rays entering the camera becomes smaller (Fig.5.4). What happens to the sharpness of the picture of Q taken by the camera? Hence suggest a setting of the camera to take a reasonably sharp picture of both P and Q. (2 marks)

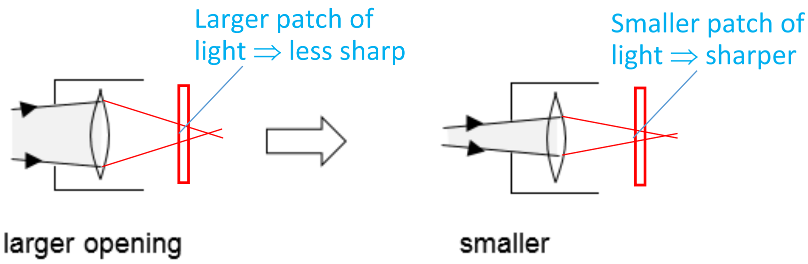

Fig.5.4

Performance: poor

Some students argued that smaller opening leads to more significant diffraction and worsen the sharpness of the image. In fact, the opening is not so small, diffraction of light is negligible and will not affect the image quality.

(iii) Describe another effect on the picture taken when the opening of the lens is made smaller. (1 mark)

Performance: generally good

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6. Fig.6.1 shows 2 identical loudspeakers L_1 and L_2 connected to a signal generator. At the beginning, only L_1 has turned on. A microphone M, which is connected to a CRO (not shown in fig.6.1), records the sound from L_1 and the signal is displayed on fig.6.2. (Speed of sound in air = 330 ms^{-1})

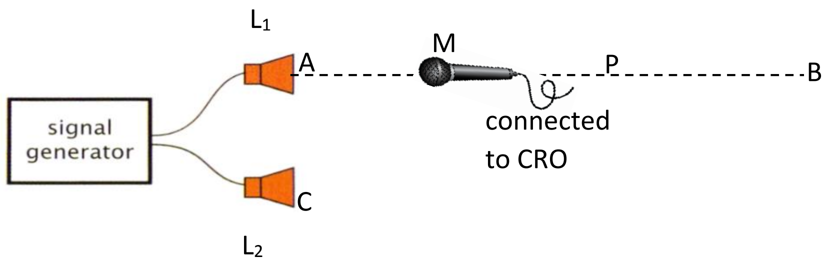
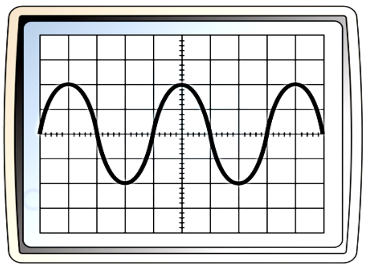


Fig.6.1



time-base: 0.1 ms/div.

Fig.6.2

(a) Find the frequency and wavelength of the sound wave. (2 marks)

Performance: generally good

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(b) What will happen to the waveform in fig.6.2 if the mic M is being moved slowly away from L_1 along AB? (1 mark)

Performance: generally good

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(c) Now, both L_1 and L_2 are turned on and produce identical sound waves. When the mic M is being moved slowly away from L_1 along AB, the amplitude of the waveform in fig.6.2 is found to rise and fall alternately. With the help of a suitable diagram, explain the phenomenon. (3 marks)

Performance: not good

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(d) When the mic M is moved to P (fig.6.1), a large amplitude is observed on the waveform.

Given AP = 0.55 m, AC = 0.6 m, show that the observation agrees with the prediction from wave theory. (2 marks)

Performance: satisfactory

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(e) If M is being moved further away from P, how many "large amplitude" position(s) can it record?

Performance: poor

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(f) M is then placed at a "small amplitude" position, describe and explain what will happen to the waveform if L_1 is switched off. (2 marks)

Performance: satisfactory

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7. In fig.7.1, two identical bulbs X and Y of rating '3 V, 0.15 W' are connected in parallel to a 3-V battery. Switch S can turn on or off the lamps. When switch S is open, the measured voltage across the battery is 3.00 V. When switch S is closed, the measured voltage across the battery drops to 2.95 V.

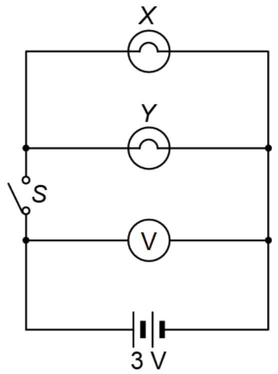

Fig.7.1

(a) Explain why the voltage across the battery drops when switch S is closed. (1 mark)

Performance: satisfactory

Majority knows that the voltage drop across the terminals of a battery is due to its internal resistance.

However, do not just state "there is internal resistance". No mark for it.

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(b) (i) Find the equivalent resistance of the two bulbs. (2 marks)

Performance: Good

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(ii) Find the total power output of the two bulbs when switch S is closed. (2 marks)

Performance: satisfactory

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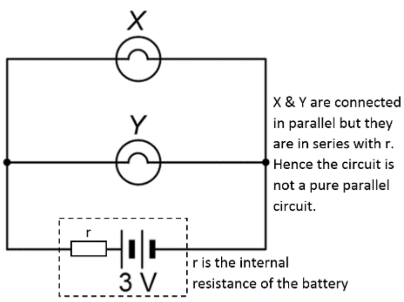
(iii) How will the brightness of bulb Y change if bulb X blows out suddenly? Explain. (2 marks)

Performance: poor

A lot of students thought that X & Y are connected in parallel, they work independently & the brightness of Y won't be affected by the blow of X. However, if the battery has internal resistance, the circuit is not a pure parallel circuit. Y will be affected by X.



8. Fig.8.1 shows the main components of an eddy current brake. A metal disc is fixed to the rotating axle of a wheel of a vehicle. An electromagnet is mounted with its poles placed on either side of the metal disc without touching it. When the vehicle moves, the axle, the metal disc and the wheel rotate together. When the brake is applied, a direct current passes through the coil of the electromagnet and a magnetic field is produced through the metal disc. The disc together with the wheel will then be slowed down.

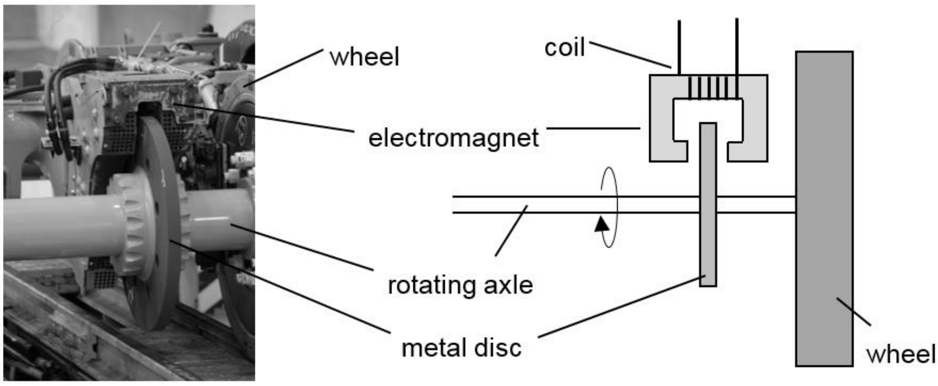


Fig.8.1

(a) The brake is applied when the metal disc is rotating. Fig.8.2 shows the region where the electromagnet produces a magnetic field through the metal disc. The disc is rotating clockwise and the magnetic field points into the page.

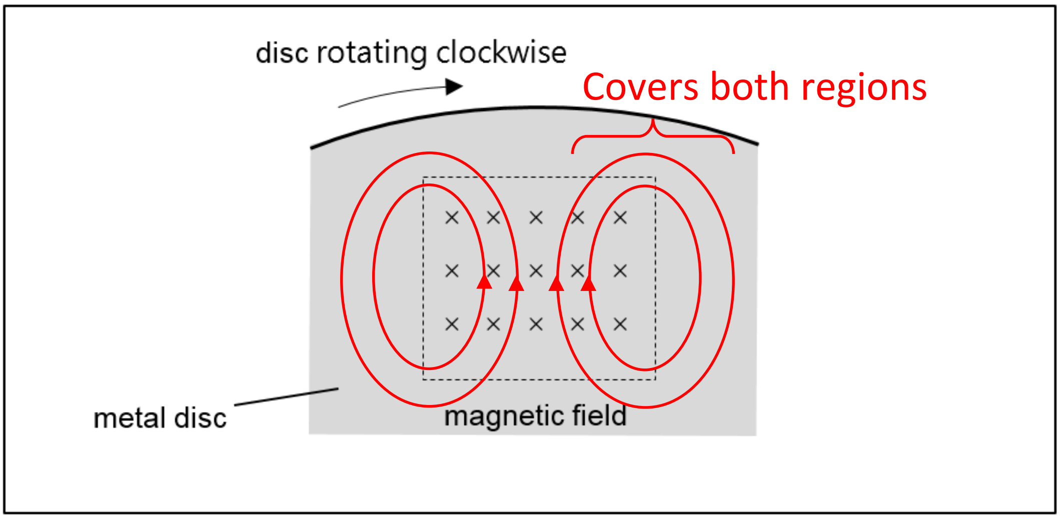


Fig.8.2

(i) In fig.8.2, draw loops to represent eddy currents induced in the metal disc. Use arrows to indicate the direction of current. Poor performance (2 marks)

(ii) In terms of the magnetic force acting on the metal disc, explain why the disc is slowed down when the brake is applied. (2 marks)

not in terms of energy

Performance: poor

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(iii) State one way to increase the strength of the electromagnet. (1 mark)

Performance: good
However, has to be specific and clear.

(b) A conventional brake slows down the vehicle by bringing friction pads into contact with the moving wheels. State one advantage and one disadvantage of an eddy current brake compared to a conventional brake. (2 marks)

Didn't know the word "wearing". Eddy current brake won't have the problem of wearing. Friction pads will wear off after being used for long time.
No one can point out that eddy current brake cannot be used to prevent sliding to start while conventional brake can. OR eddy current brake can only work on moving object and cannot work on stationary object.

9. A square coil of side length 2 cm is moved between a pair of slab-shaped magnets with unlike poles facing each other. Fig.9.1 shows the position of the coil at time $t = 0$.

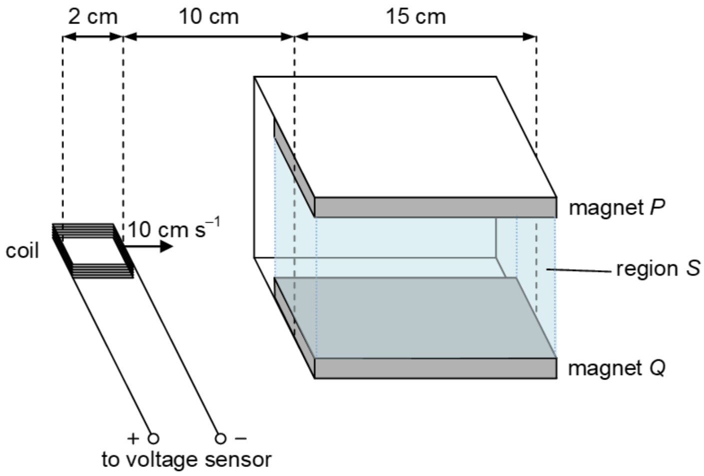
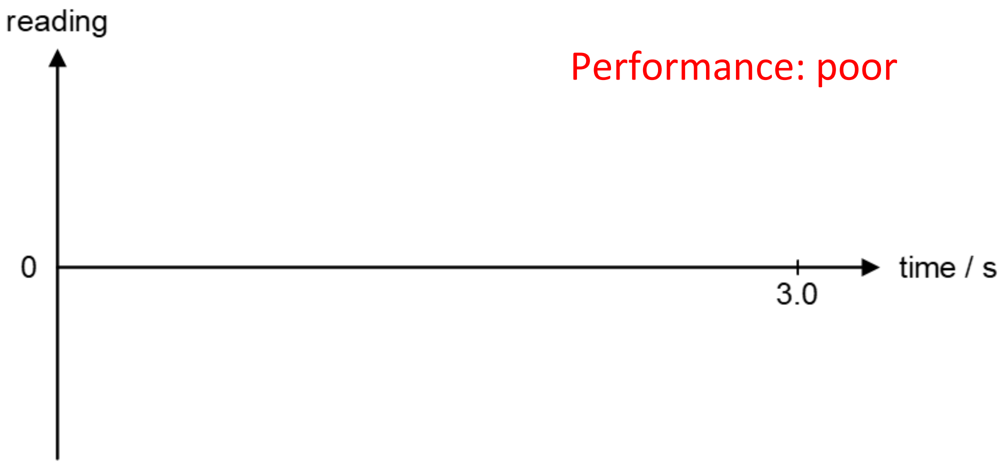


Fig.9.1

S is the region between the two magnets and is shaded in fig.9.1. The coil moves horizontally through region *S* at a constant speed of 10 cm s^{-1}. Assume that a uniform magnetic field points from magnet *Q* to magnet *P* in region *S*, and there is no magnetic field outside region *S*.

⇒ constant rate of cutting of B-field

*(a) (i) Sketch a graph to show how the voltage sensor reading varies with time from $t = 0$ to 3 s. (3 marks)



Performance: poor

(ii) The coil has 50 turns. The magnetic flux density in region *S* is 5×10^{-4} T. Calculate the maximum magnitude of the e.m.f. induced in the coil when it travels through the magnetic field. (2 marks)

Performance: poor

$\varepsilon = N\frac{\Delta\phi}{\Delta t} = N\frac{BA}{t}$ unit of A: m^2 (not cm^2)

Unit of ε: V (avoid using Tm^{2}s^{-1} or Wbs^{-1})

For straight conducting wire of length L: ε = LvB N turns ⇒ ε = NLvB

(b) Suggest **TWO** methods that can increase the induced e.m.f. in the coil. (2 marks)

Performance: good

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(c) In which of the following situations will it be harder to keep the coil moving at a constant speed through the magnetic field? Explain briefly. (3 marks)

- when its two ends are connected to a light bulb, or
- when they are not connected to anything.

Poor explanation

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10. You are given three radioactive sources. One is a pure α source, one is a pure γ source and the remaining one emits both α and γ radiations. However, the labels of the sources were worn away and they cannot be identified from their outlook.

With the help of the following items, describe how the sources can be identified experimentally. Suitable labelled diagram is expected in your description.

For taking the radioactive source

A pair of forceps, a set of different absorbers including paper sheet, aluminium plates and lead plates of different thickness, 3 suitable holders for holding the sources, a GM tube connected to the counter

(8 marks)

Poor presentation, lack of organization

Wrong idea: using lead absorber can reduce the count of γ by half.

Please write γ properly.

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End of Paper