2020-2021
MOCK
PHY (DSE)

PAPER 1B

B

F.6 MOCK EXAMINATION 2020-2021

4th February 2021
8:25 – 10:55 am (2 hours 30 minutes)

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 Candidate Number in the space provided on Page 1.

(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 Candidate Number and question number on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

Candidate Number				

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

Section B: Answer **ALL** questions. Parts marked with * involve knowledge of the extension component. Write your answers in the spaces provided.

1. Humans generate internal energy when running, while their core temperature remains approximately constant.

(a) Distinguish between the concepts of internal energy and temperature in molecular terms. (3 marks)

(b) An athlete loses 5.4 kg of water from his body through sweating during a marathon that lasts 3.2 hours. Estimate the rate of energy loss by the athlete due to sweating. The specific latent heat of vaporization of water is 2.3×10^{6} J kg^{-1}. (2 marks)

(c) After finishing the marathon, the athlete is given a shiny foil sheet to wear as shown. This stops him cooling down too quickly. Explain how the foil sheet reduces heat loss. (2 marks)

Answers written in the margins will not be marked.

*2. The air in a kitchen has pressure 1.0×10^5 Pa and temperature 22 °C. A refrigerator of internal volume 0.36 m^3 is installed in the kitchen. Assume air behaves as an ideal gas.

(a) Before the refrigerator is switched on, the air in the refrigerator is initially at the same temperature and pressure as the air in the kitchen. Calculate the number of molecules of air in the refrigerator. (2 marks)

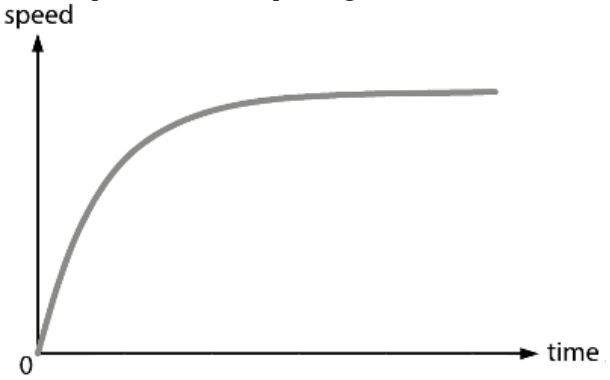
(b) (i) After the refrigerator has been switched on for several hours, the air inside the refrigerator is cooled to 5.0 °C. Determine the pressure of the air inside the refrigerator. (2 marks)

(ii) With reference to the kinetic model, explain the change in pressure of the air inside the refrigerator. (2 marks)

(iii) The door of the refrigerator has an area of 0.72 m^2. Calculate the net force acting on the door due to air pressure. (2 marks)

Answers written in the margins will not be marked.

3. The graph below shows how the speed of a raindrop changes with time after it falls from a cloud.

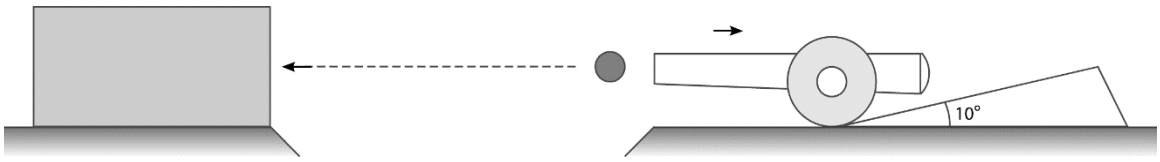


(a) Describe and explain the variation of the speed of the raindrop during its fall. (3 marks)

(b) When the raindrop falls at a constant speed, what is its gravitational potential energy converted into? (1 mark)

Answers written in the margins will not be marked.

4. A movable cannon is fired at a fixed target. The mass of the cannon ball and the mass of the cannon are 10 kg and 200 kg respectively.



(a) Assume the cannon ball leaves the cannon horizontally at a speed of 110 m s^{-1} toward the target.

(i) Find the recoil speed of the cannon. (2 marks)

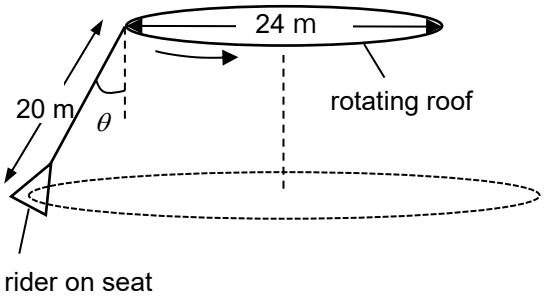
(ii) A fixed ramp inclined at 10° to the horizontal is built behind the cannon to stop the cannon from recoiling. How far will the cannon move up along the ramp at most? (2 marks)

(b) The cannon ball travels 1 m inside the fixed target before coming to a stop. Estimate the distance travelled by the ball in the target if its speed when hitting the target is doubled. (2 marks)

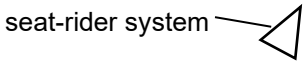
(c) The ball hits the target and becomes embedded in the target. Explain why the total momentum of **this system** (the cannon, the cannon ball and the fixed target) is not conserved in this process. (1 mark)

Answers written in the margins will not be marked.

*5. The Texas SkyScreamer is the world's tallest tower swing ride in which riders sit on the seats hung from the rim of a rotating roof. Initially, the chains hanging the seats are vertical. When the roof starts to rotate, the seats and the riders swing outwards and rise. The diameter of the roof is 24 m and the distance between each rider and the rim of the roof is 20 m. Neglect air resistance.



(a) Draw and label all the force(s) acting on the seat-rider system (i.e. taking the rider and the seat as one object) when it is rotating. (1 mark)



(b) The ride starts at time $t = 0$. After 1 minute, the roof rotates steadily and a seat-rider system of mass 70 kg moves along a horizontal circular path with a constant speed. The angle θ between the chain hanging the seat and the vertical is 30°.

(i) Find the net force acting on the seat-rider system. (2 marks)

(ii) Find the linear speed of the seat-rider system. (2 marks)

Answers written in the margins will not be marked.

(iii) Find the energy gained by the seat-rider system from $t = 0$ to $t = 60$ s. (3 marks)

(iv) Find the average power of the swing ride in the first minute, if all 24 seats are seated and each seat-rider system is of mass 70 kg. (2 marks)

Answers written in the margins will not be marked.

6. Figure a is a mobile phone screen magnifier which consists of a lens and Figure b shows the image formed by the magnifier.

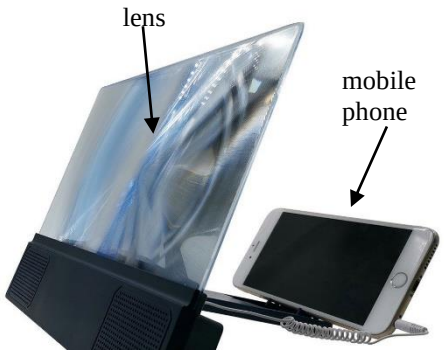


Figure a

Figure b

(a) What kind of lens is used? (1 mark)

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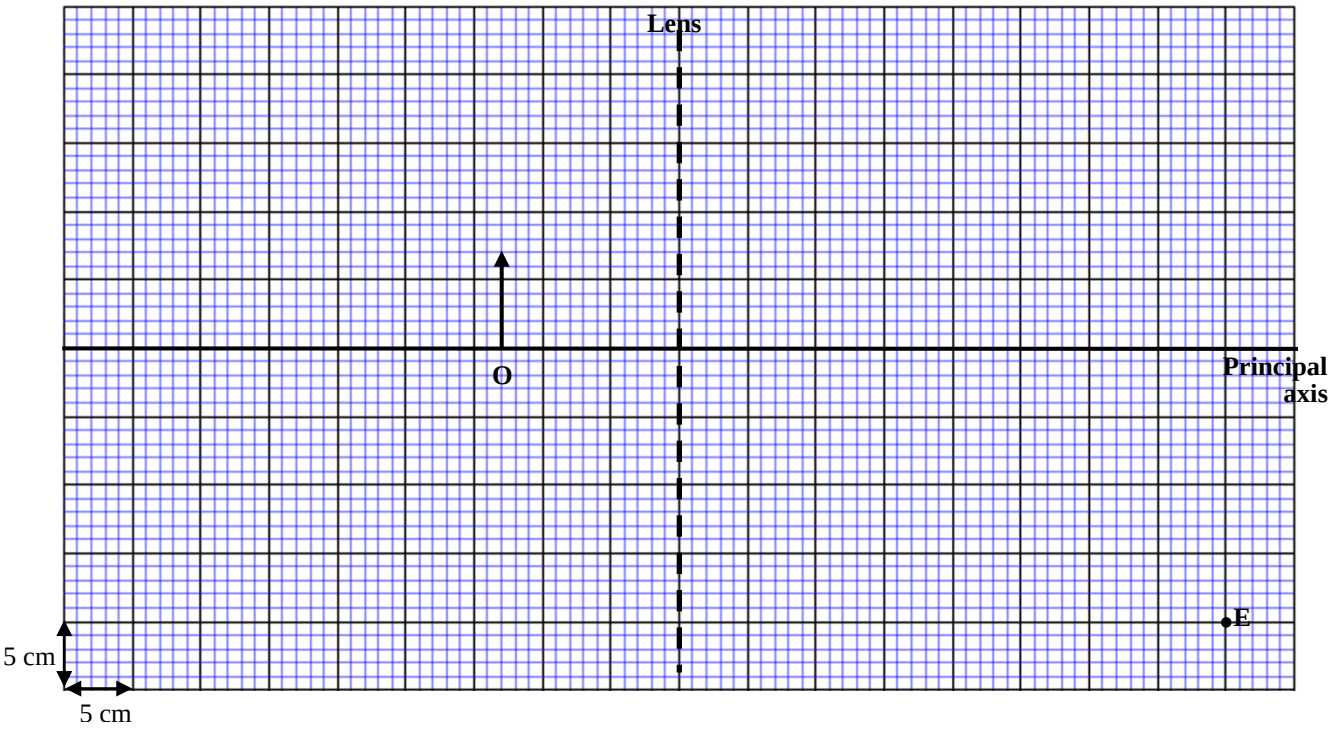
The height of the image produced is 3 times the height of the object.

(b) Locate the image formed and denote it as *I* in the following diagram. Hence, determine the focal length of the lens graphically. (3 marks)



Focal length of the lens = _____

(c) A person looks at the image at the position E. Determine, graphically, the minimum size of the lens for the person to see the whole image. (2 marks)

Minimum size of the lens = _____

(d) The actual size of the lens is less than the answer calculated in (c). Suggest a method for the person to see the whole image. (1 mark)

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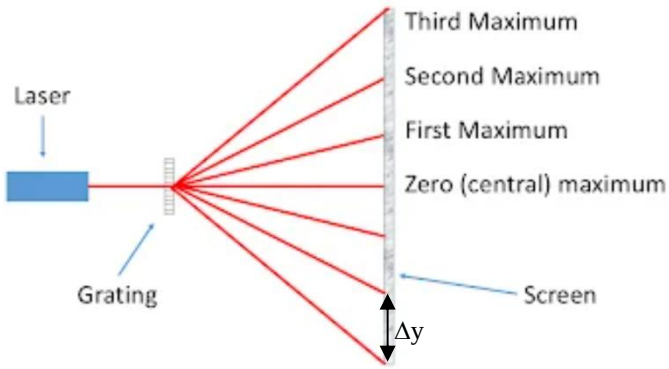
Answers written in the margins will not be marked.

*7. A laser beam is incident normally on a grating and a screen is placed behind the grating to display the interference pattern of light. When the screen is 1 m from the grating, the third-order bright fringes can just be captured by the screen as shown. The width of the screen is 1.8 m and the wavelength of the laser beam is 650 nm.

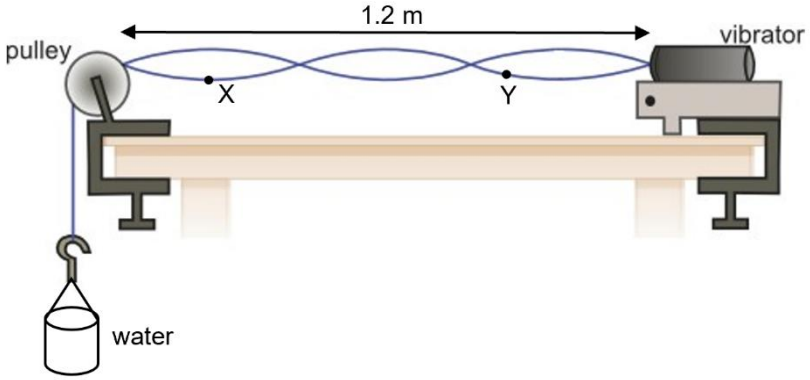


(a) Calculate the slit separation of the grating. Express your answer in no. of slits per cm. (3 marks)

(b) Find the separation between the third-order bright fringe and the second-order bright fringe (Δy) on the screen. (2 marks)

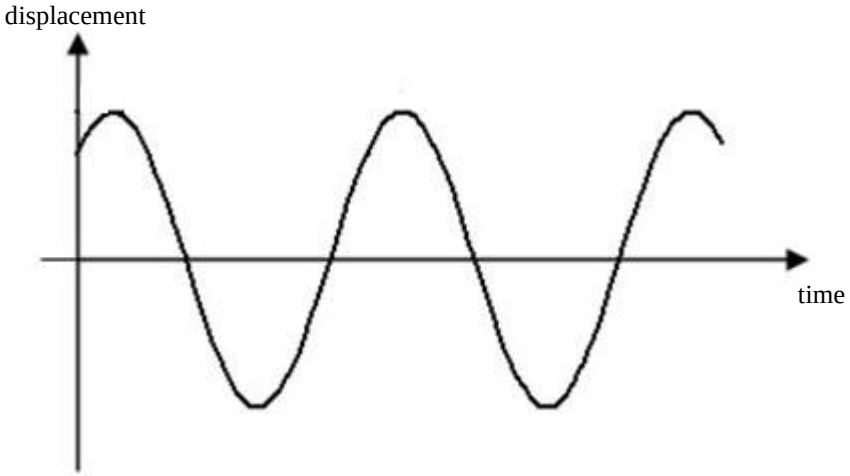
Answers written in the margins will not be marked.

8. One end of a string is connected to a vibrator while a small bucket of water is hung at the other end of the string over a smooth pulley. When the vibrator is vibrating at a frequency of 80 Hz, a stationary wave is formed as shown. The total mass of the bucket of water is 0.8 kg.



(a) Determine the speed of the wave along the string. (2 marks)

(b) The following figure shows the displacement-time graph of particle X. Sketch, on the same axes, how the displacement of particle Y from its equilibrium position varies with time. (2 marks)



The wave speed along a string is proportional to the square root of tension in the string (i.e. $v \propto \sqrt{T}$). Some water is added to the bucket gradually until another stationary wave pattern is formed on the string.

(c) Sketch the stationary wave pattern in the following diagram. (1 mark)

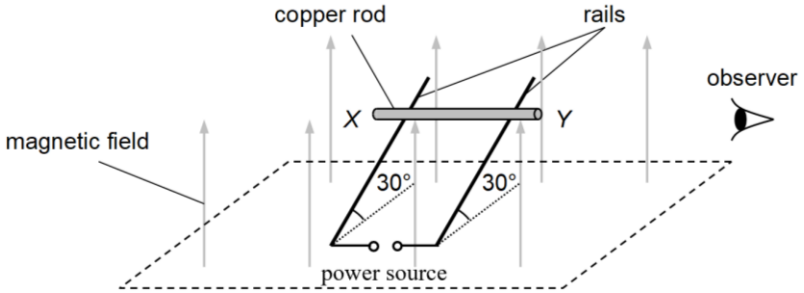
Answers written in the margins will not be marked.

(d) Comparing with the pervious stationary wave pattern, state the changes (if any) in period and amplitude of particle Y. (2 marks)

(e) Find the mass of water added. (2 marks)

Answers written in the margins will not be marked.

9. In the following figure, a copper rod XY of mass 40 g is placed on a pair of smooth parallel metal rails making an angle of 30° to the horizontal plane. The rod is perpendicular to the rails, which are 10 cm apart and connected to a power source. An upward magnetic field of magnitude 200 mT is applied to the set-up. A current flows through the copper rod and the rails and the rod remains stationary on the rails. The copper rod has a non-zero resistance while the rails have none.



(a) State the directions of (i) the magnetic force on the copper rod and (ii) the current passing through the rod as seen from the observer shown in the diagram. (2 marks)

(b) Show that the current in the rod is 11.3 A. (2 marks)

(c) If the separation of the rail is halved, explain why the e.m.f. of the power source need not be changed to keep the copper rod stationary. (2 marks)

Answers written in the margins will not be marked.

(d) Another identical copper rod is placed on the rails, parallel to and below the first one. The e.m.f. of the power source remains unchanged.

(i) Neglecting the mutual magnetic force between the copper rods, explain if they can both be stationary on the rails. (2 marks)

(ii) If the original power output of the power source is P_0, express the new power output P in terms of P_0. (2 marks)

Answers written in the margins will not be marked.

10. Read the following description about a Faraday flashlight and answer the questions that follow.

Faraday flashlight, or 'shake flashlight', as shown in Figure a is a type of mechanically powered flashlight.

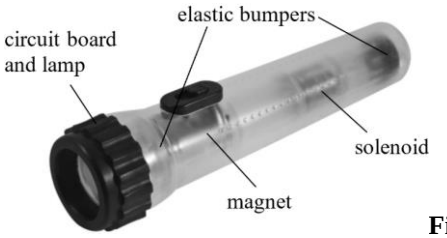


Figure a

The flashlight has a generator which charges a rechargeable battery when the flashlight is shaken lengthwise. The battery is then used to power a lamp. The generator consists of a permanent magnet which can slide back and forth through a solenoid when the flashlight is shaken. A current is induced in the solenoid due to the movement of the magnet. As a result, the battery is charged. Shaking the flashlight vigorously for about 30 seconds can provide up to 5 minutes of light.

Figure b shows the circuit of the flashlight. A rectifier (whose detailed structure is not shown) is installed so that the induced current always flows from R to S through the battery.

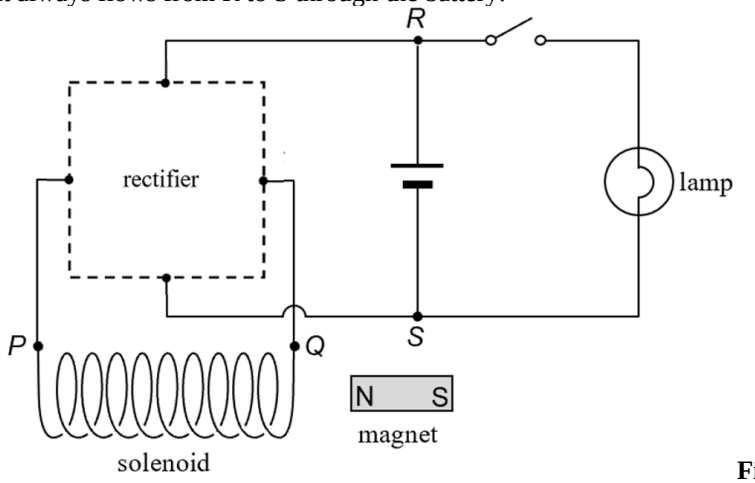
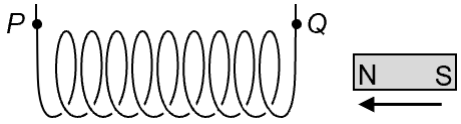
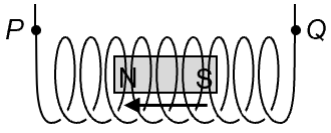


Figure b

(a) The magnet in Figure b is passing through the solenoid with a constant speed. It approaches the solenoid from the right, moves inside the solenoid and leaves the solenoid completely from the left. In the table below, put ticks (✓) in the appropriate boxes to indicate whether there is any induced current following through the solenoid at various instants. (2 marks)

Motion of the magnet	Is there any induced current?
 approaching the solenoid	☐ Yes, from Q to P ☐ Yes, from P to Q ☐ No.
 passing through the midpoint inside the solenoid	☐ Yes, from Q to P ☐ Yes, from P to Q ☐ No.

Answers written in the margins will not be marked.

(b) The specifications of the shake flashlight are shown below:

Average power of generator (when shaken vigorously) = 1 W
Number of turns of solenoid = 330
Maximum rate of change in magnetic flux through a turn of the solenoid in vigorous shaking = 0.0133 Wb s^{-1}

(i) Estimate the average power of the lamp. Assume that there is no energy loss in charging the battery. (1 mark)

*(ii) Assume that the induced e.m.f. across the solenoid is a sinusoidal voltage. Estimate the peak value and hence the r.m.s. value of the induced e.m.f. (3 marks)

(iii) Suggest TWO modifications for the flashlight which can increase its induced e.m.f.. (2 marks)

(c) Explain why elastic bumpers are installed at the two ends of the tube in which the magnet slides. (2 marks)

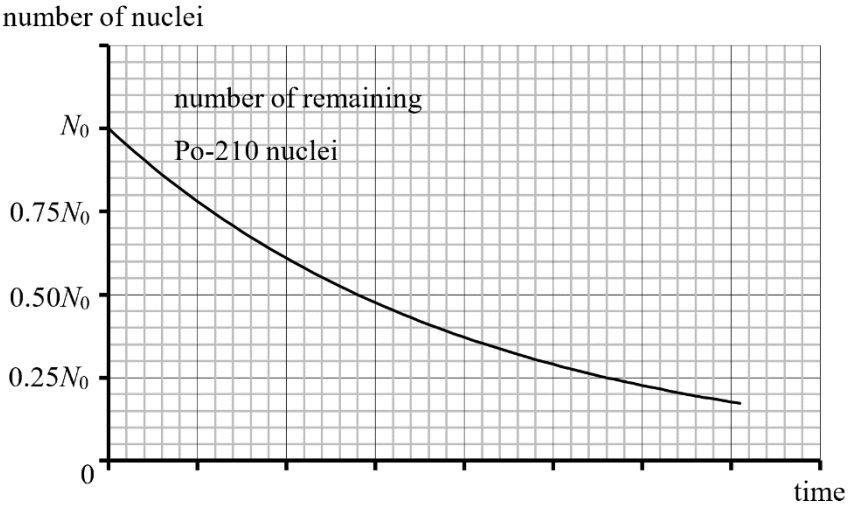
Answers written in the margins will not be marked.

11. The radioactive nuclide polonium-210 (Po-210) undergoes alpha (α) decay to form a stable lead (Pb) nuclide.

(a) Why is the radioactive decay said to be "random"? (1 mark)

(b) Given that the atomic number of lead is 82, write down the nuclear equation that represents the alpha (α) decay of polonium-210 (Po-210). (1 mark)

(c) The initial number of nuclei in a pure sample of polonium-210 is N_0. The graph shows how the number of remaining polonium nuclei in the sample varies with time.



(i) On the graph, sketch how the number of lead nuclei in the sample varies with time. (2 marks)

*(ii) After 415.2 days,

$$\frac{\text{number of produced lead nuclei}}{\text{number of remaining polonium nuclei}} = 7$$

What is the decay constant for this alpha (α) decay? (3 marks)

End of Paper

Answers written in the margins will not be marked.