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PHYSICS

2012

Trial Examination 2

Electric power
Interactions of light and matter
Sound

(Note: Use information in the formula data sheet supplied by VCAA)

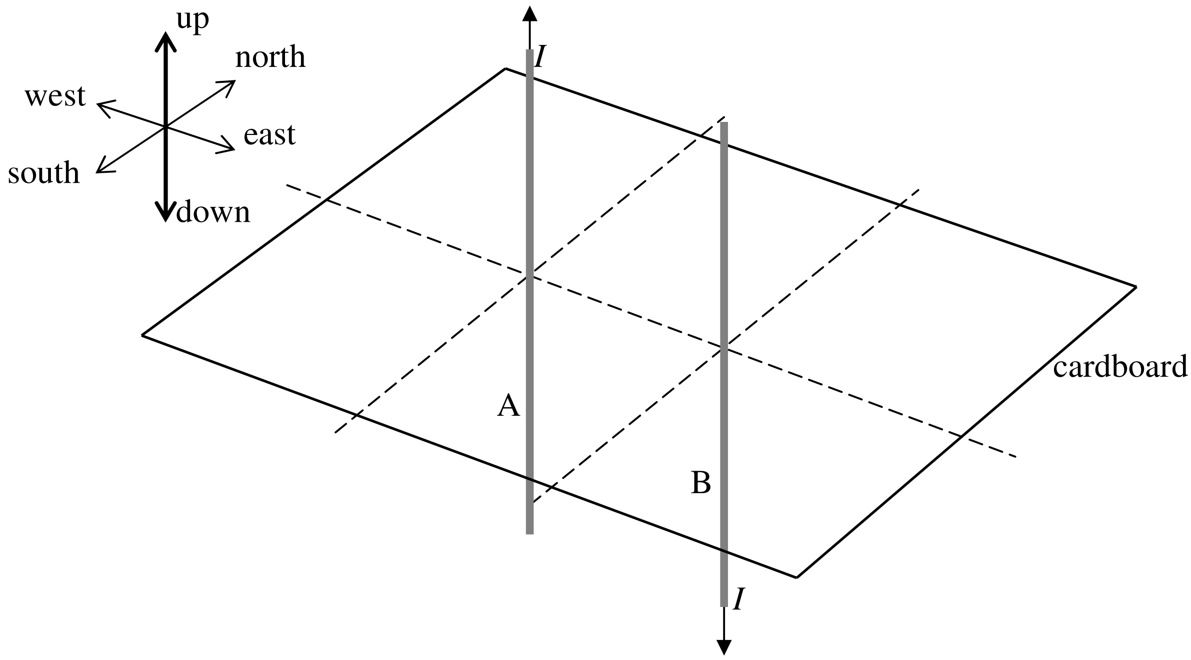
SECTION A – Core

Instructions for Section A: Answer **all** questions for **both** Areas of study.

Area of study 1 – Electric power (38 marks)

Question 1

Two parallel conducting rods A and B pass through a cardboard and are perpendicular to it. They carry electric currents of the same magnitude *I* in opposite directions. Ignore Earth's magnetic field.



a Draw on the cardboard 3 directed magnetic field lines *between* conductors A and B to show the indicative net magnetic field of the currents in the conductors.

2 marks

b The magnetic force on conductor A is directed

A. upwards B. downwards C. to the east D. to the west E. to the north F. to the south

2 marks

c Name 2 changes (in terms of magnetic field, force and/or direction) that occur when both currents are in the same direction.

2 marks

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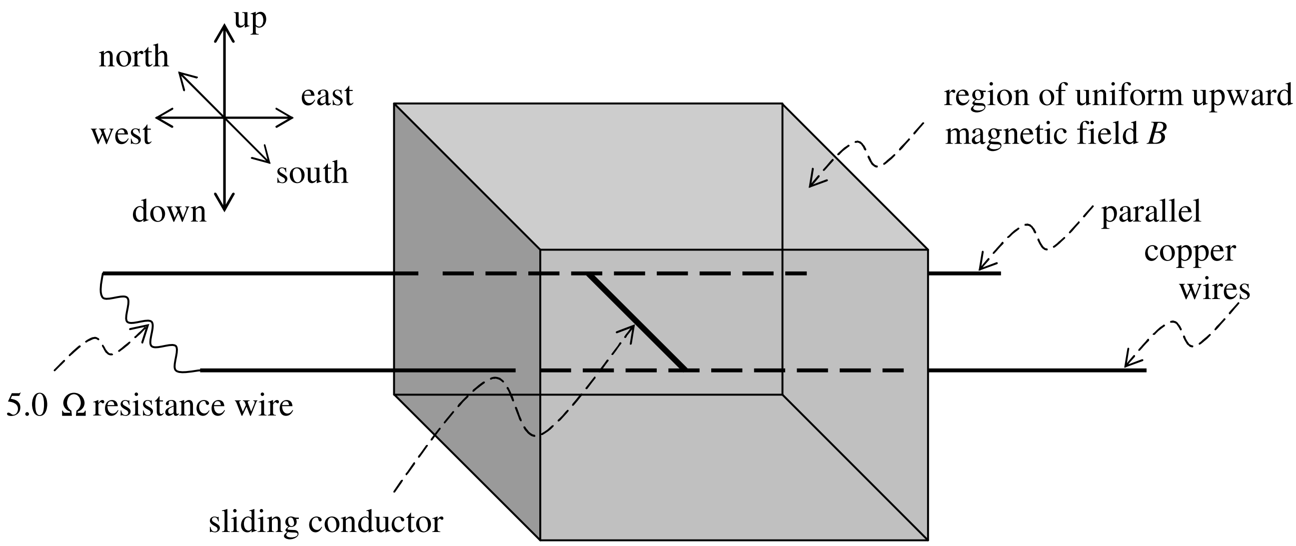
Question 2 The following diagram shows a simple dc generator. It consists of a region of uniform ***upward*** magnetic field $B = 0.80\,\text{T}$. A 5.0 Ω resistance wire is connected to two parallel copper wires. A 0.25 m long sliding conductor is forced to move to the *east* at a constant speed of 0.50 m s^{-1}. The sliding conductor is always in contact with the two parallel copper wires.



a Calculate the change in magnetic flux through the rectangular loop formed by the two copper wires, the sliding conductor and the resistance wire in 1.0 second.

wb

2 marks

b Calculate the magnitude of the emf induced in the rectangular loop.

V

1 mark

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c Determine the magnitude and direction of the induced current in the sliding conductor. Explain.

mA

3 marks

d Calculate the horizontal force required to keep the sliding conductor moving at constant velocity.

N

2 marks

e Determine the power output of the simple dc generator.

W

2 marks

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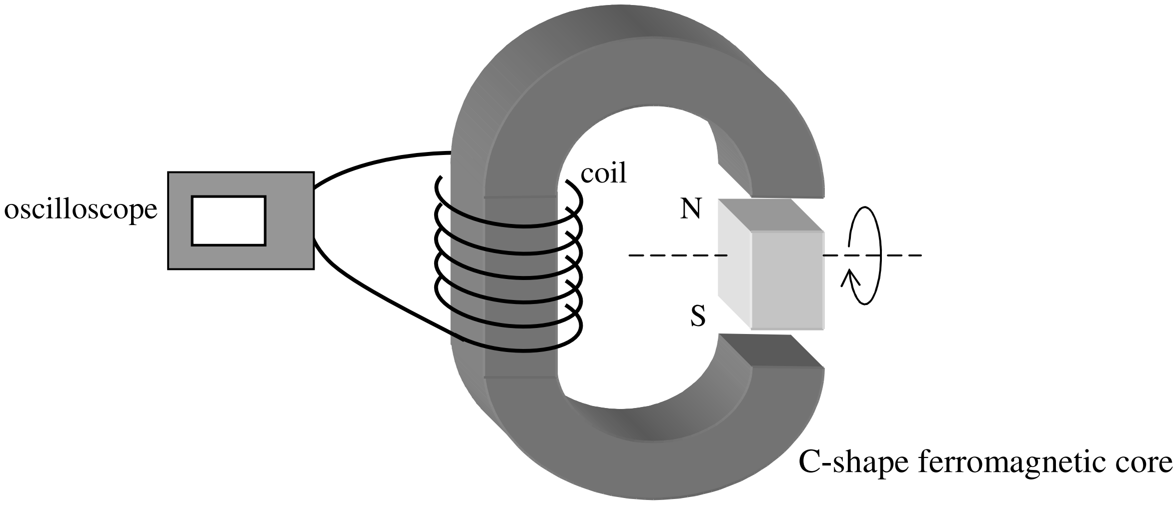
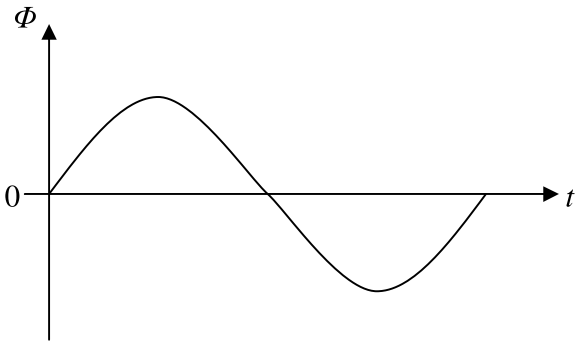
Question 3 A bar magnet is made to rotate at constant speed in the gap of a C-shape ferromagnetic core. An oscilloscope is connected to the coil. The following diagram shows the bar magnet at $t = 0$.

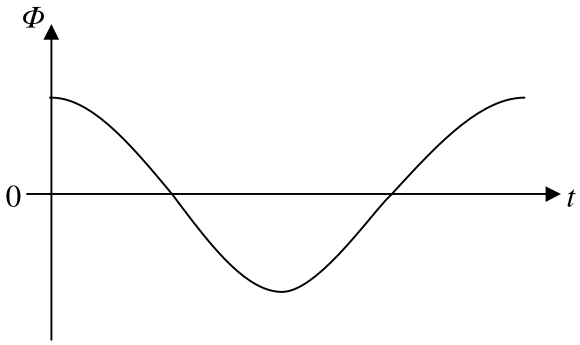


a Which one of the following graphs gives the *best* description of the magnetic flux through the coil?

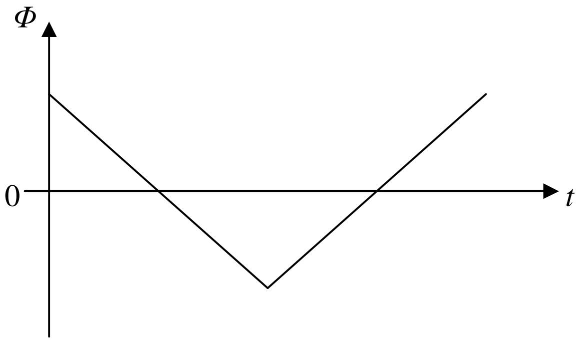
A.



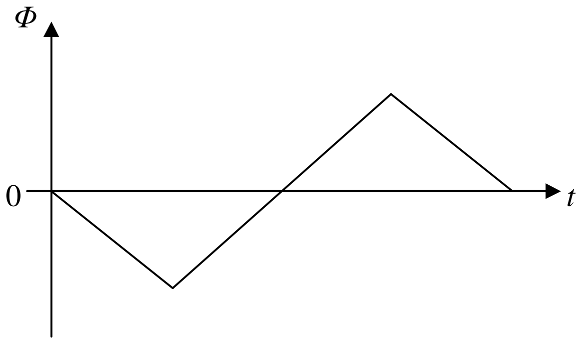
B.



C.



D.



2 marks

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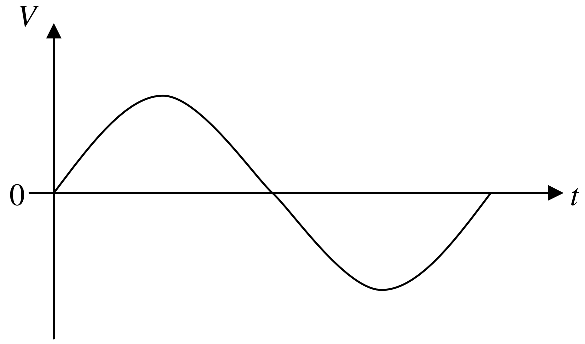
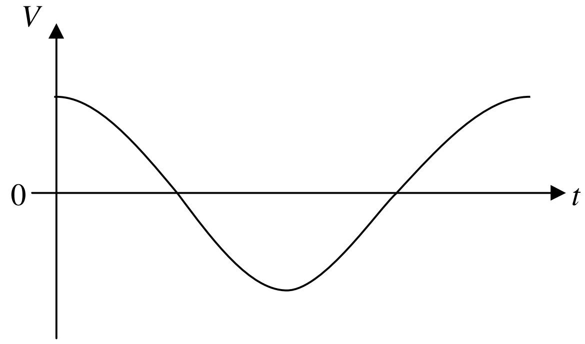
b Which one of the following graphs gives the *best* description of the voltage measured by the oscilloscope?

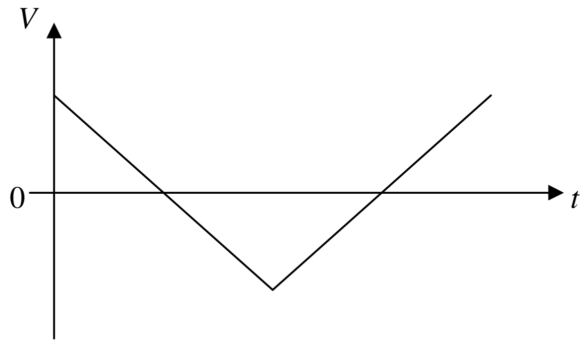
A.



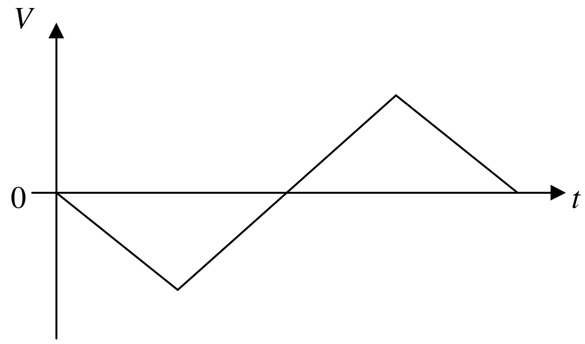
B.



C.



D.



2 marks

c Describe the voltage display on the oscilloscope when the bar magnet is made to rotate with increasing speed.

2 marks

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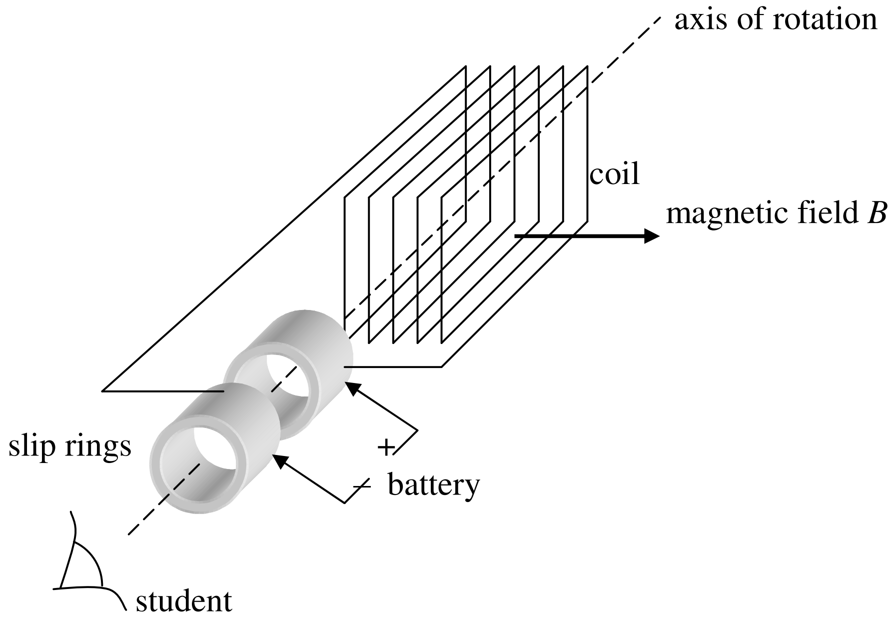
Question 4 A student makes an 'electric motor' as shown in the sketch below. Two large magnets, one on each side of the coil, provide the uniform magnetic field *B*.

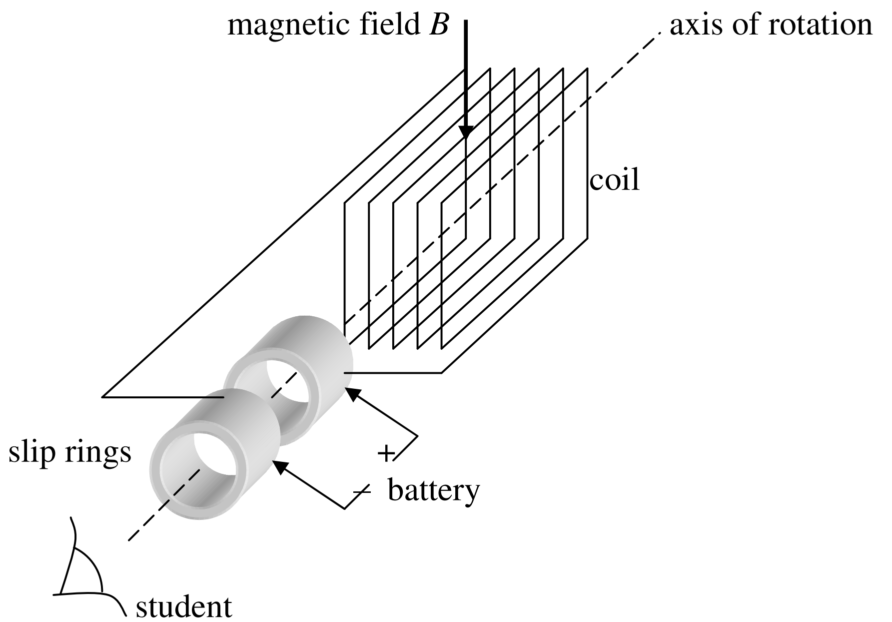


Ignore friction and air resistance in the following two questions.

a Describe and explain the motion of the 'motor' as seen by the student when it is connected to the battery.

2 marks

The student rotates the magnetic field by $90°$ as shown in the following diagram.



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b Describe and explain the motion of the 'motor' as seen by the student when it is connected to the battery.

3 marks

Question 5 A student uses a pair of insulated copper wires (50 metres each in length) as transmission cables in her model transmission system. The copper wires have a resistance of 0.0060 Ω per metre.

A school power pack is used to supply power for transmission. It is set at 12 V dc. A light globe rated 60 W 12 V is connected at the other end of the cables. The resistance of the light globe is constant.

a Calculate the voltage across the light globe when its current is 4.0 A.

V

2 marks

b Determine the power loss in the cables.

W

2 marks

c The student wants to increase the brightness of the light globe by means of a step-up transformer near the power pack and a step-down transformer next to the light globe. The student has correctly connected the transformers. Describe and explain what will happen to the light globe when the power pack is switched on. What does the student need to do to achieve an increase in brightness?

3 marks

d Calculate the peak output voltage of the power pack when it is set at 12 V ac.

V

1 mark

e The step-up transformer has 100 turns in the primary coil and 200 turns in the secondary coil, and the step-down transformer has 200 turns in the primary coil and 100 turns in the secondary coil. When the transformers are in place and the whole transmission system is working correctly, the current in the transmission cables is 2.35 A. Calculate the power dissipated in the light globe, assume the transformers are 100% efficient.

W

3 marks

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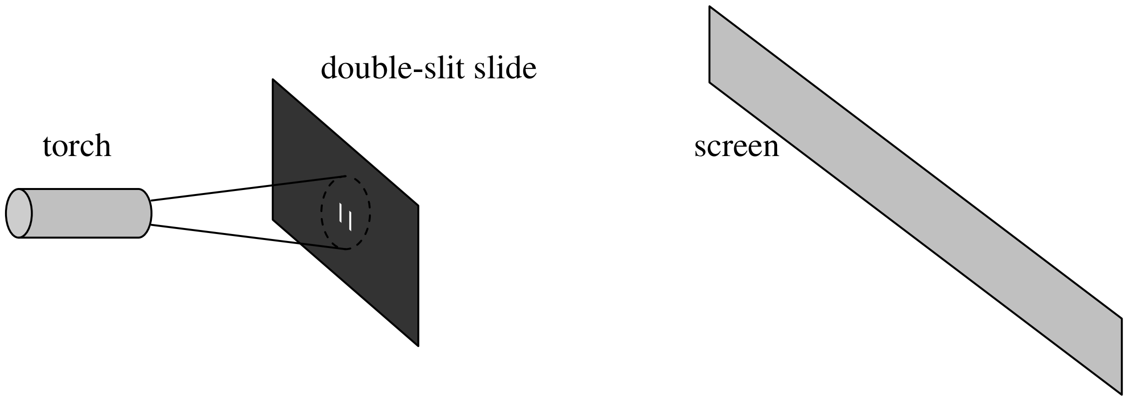
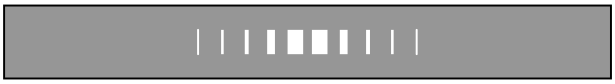
Area of study 2 – Interactions of light and matter (28 marks)

Question 1 A torch shines light through a double-slit slide produces a light pattern on the screen.

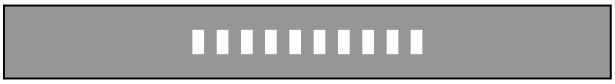


a Which one of the following diagrams best illustrates the light pattern on the screen?

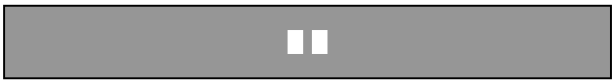
A



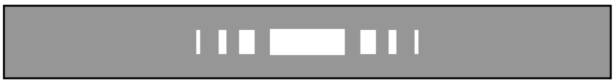
B



C



D



1 mark

b Name a change to the light pattern on the screen when the distance between the two slits is reduced.

1 mark

c Which one of the diagrams above (A, B, C or D) best illustrates the light pattern on the screen when the torch light beam is replaced with a laser beam?

1 mark

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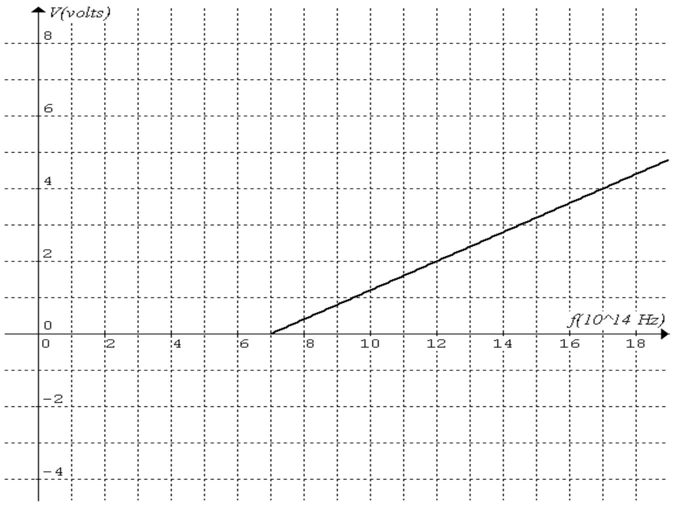
d Which one of the diagrams above (A, B, C or D) best illustrates the light pattern on the screen when the torch light beam is replaced with a laser beam and the double-slit slide is replaced with a *single-slit* slide?

1 mark

Question 2 In a photoelectric effect experiment, a photocell is used to investigate the relationship between the frequency of light used and the minimum retarding voltage required to stop the photoelectric current completely. A set of data is plotted and a line of best fit is shown in the graph below.



a Estimate Planck's constant from the set of data.

eV s

2 marks

b Estimate the work function of the photoelectron emitter in the photocell.

eV

2 marks

c Estimate the maximum kinetic energy of the photoelectrons when light of frequency 1.2×10^{15} Hz is directed at the emitter.

J

2 marks

d Explain the term 'threshold frequency' in photoelectric effect experiments. 2 marks

e The experiment is repeated with a different photocell. The threshold frequency is found to be 9.0×10^{14} Hz. Estimate the minimum retarding voltage required to stop the photocurrent completely when light of frequency 1.2×10^{15} Hz is used. Use your answer in part **a** to make the estimation.

V

2 marks

f How did Einstein explain the observation that the intensity of light used in a photoelectric effect experiment does not affect the minimum retarding voltage required to stop the photocurrent completely?

2 marks

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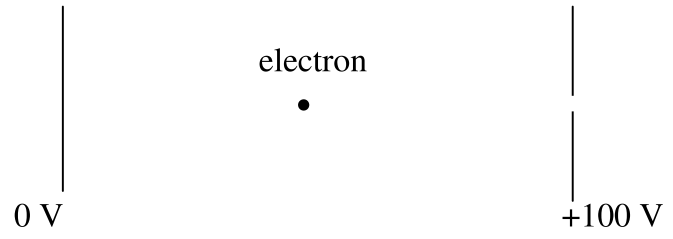
Question 3 An electron is accelerated from rest through a potential difference of 100 volts between two parallel metal plates.



a Calculate the de Broglie wavelength of the electron when it passes through the +100 V mark.

m

2 marks

b Calculate the energy of a *photon* having the same wavelength as the electron in part **a**.

J

2 marks

c Which one of the following equations does ***NOT*** link the particle and wave properties of a light beam (or electron beam)?

A $\lambda = \frac{h}{p}$

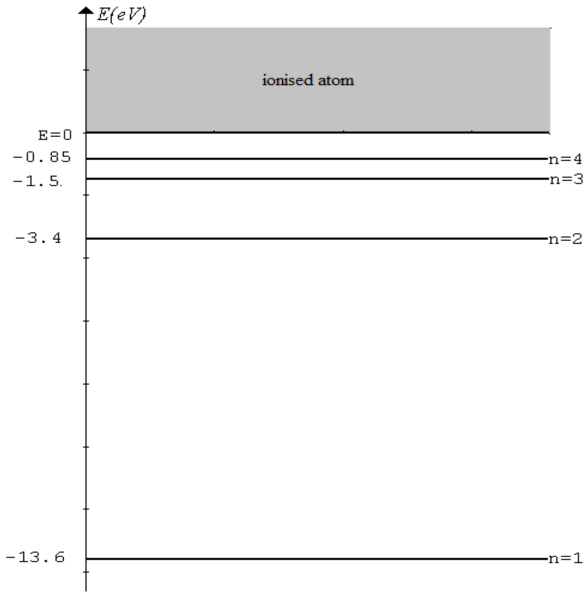
B $E = hf$

C $f\lambda = c$

D $p = \frac{hf}{c}$

2 marks

Question 4 An energy-level diagram for the hydrogen atom is shown below.



a An electron in orbit around a nucleus can be considered as a matter wave. Draw a standing wave to represent the electron in a hydrogen atom in the second excited state.

2 marks

b Determine the wavelength of a photon emitted by a hydrogen atom making a transition from the second excited state to the ground state.

nm

2 marks

c At low temperatures, assuming all the atoms in hydrogen gas to be in the ground state, calculate the minimum frequency of the photon through the gas for the photoelectric effect to be observed.

Hz

2 marks

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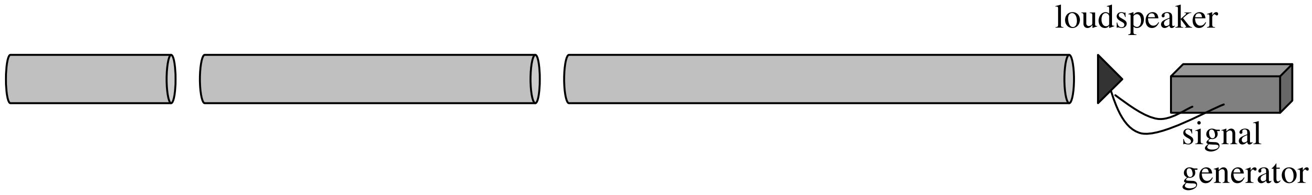
SECTION B – Detailed studies

Detailed study 3 – Sound (24 marks) Answer **all** the questions. Always choose the ***best*** answer.

Use the following information to answer Questions 1, 2 and 3

Three open pipes of lengths 0.50 m, 1.0 m and 1.5 m are placed end to end as shown below. They resonate together when the sound from a loudspeaker is set at frequency *f* Hz. The speed of sound in air is 336 m s^{-1}. Ignore the end corrections of the pipes.



Question 1 The lowest value of *f* is

A. 168
B. 336
C. 672
D. 1008

Question 2 Which one of the following statements is true?

A. The resonance wavelength in the pipes is longer than the wavelength of the sound in the air.
B. The resonance wavelength in the pipes is shorter than the wavelength of the sound in the air.
C. The resonance wavelength in the pipes equals the wavelength of the sound in the air.
D. The resonance wavelengths of the pipes are different.

Question 3 When the left end of the 0.50 m pipe is closed, which one of the following statements is ***NOT*** true?

A. The three pipes cannot be made to resonate together at the same frequency.
B. The three pipes can be made to resonate together at the same frequency, but the resonance is too weak to be noticeable.
C. The two longer pipes can be made to resonate together at the same frequency.
D. The three pipes can be made to resonate when they are joined together to form a longer closed pipe.

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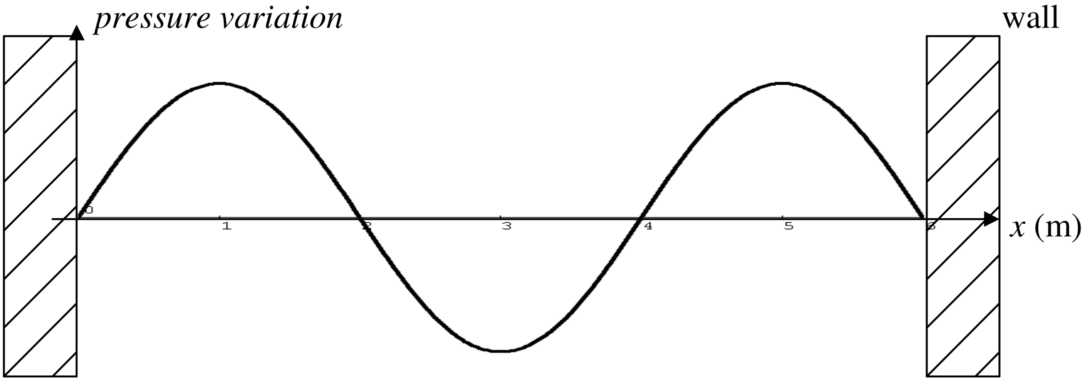
Use the following information to answer Questions 4, 5 and 6

The graph shows the pressure variation of a standing sound wave set up between two parallel walls 6.0 metres apart as a function of displacement x from one wall. The speed of sound is 336 ms^{-1}.



Question 4 The frequency (Hz) of the sound wave is closest to

A. 0.25
B. 56
C. 84
D. 168

Question 5 The period (seconds) of the standing wave is closest to

A. 0.006
B. 0.012
C. 0.018
D. 4

Question 6 Which one of the following statements is ***NOT*** true?

A. The standing sound wave is a longitudinal wave.
B. The standing sound wave has odd number of pressure antinodes between the two walls.
C. The standing sound wave has even number of pressure nodes between the two walls.
D. Another standing sound wave can be set up between the walls at one half of the original frequency.

Use the following information to answer Questions 7, 8 and 9

The siren (taken as a point source) of a stationary ambulance sends out sound waves in all directions. At 8.0 m from the siren the intensity level is measured with a sound meter and the reading is 85 dB.

Question 7 The sound intensity (W m^{-2}) at 8.0 m from the siren is closest to

A. 44
B. 19
C. 3×10^{-2}
D. 3×10^{-4}

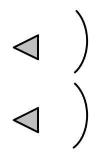
Question 8 At 30 m from the siren the sound intensity level (dB) is closest to

A. 82
B. 74
C. 21
D. 5

Question 9 Another ambulance with an identical sounding siren arrives at the crash site next to the first ambulance. At 8.0 m from the sirens the sound meter reading (dB) is closest to

A. 88
B. 91
C. 97
D. 176

Question 10 Two loudspeakers 1.1 m apart are in phase. They send out sound waves of the same frequency 800 Hz in the same direction producing an interference pattern. Sound speed = 336 m s^{-1}.

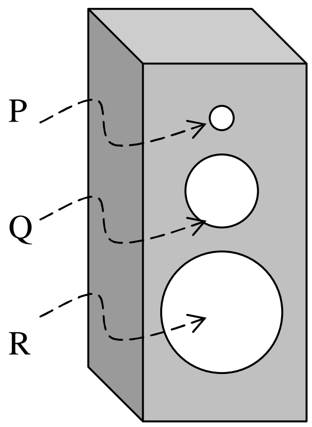


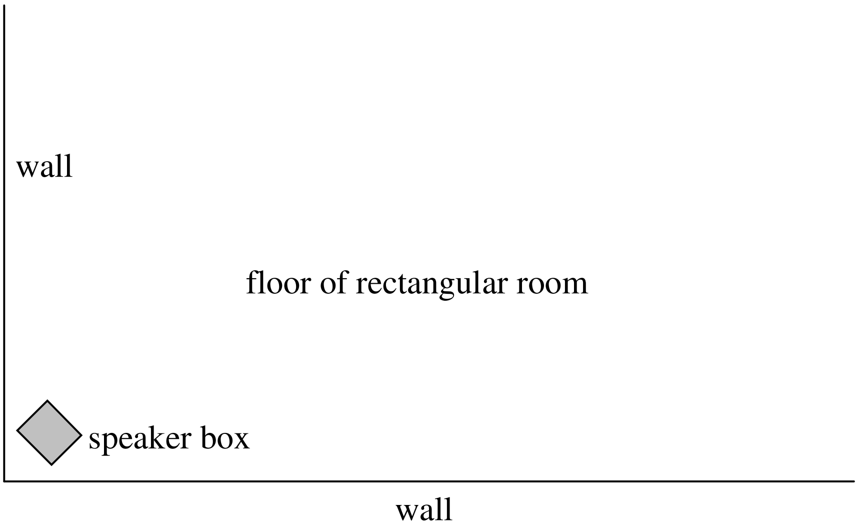
The number of pressure nodal lines between the loudspeakers is

A. 4
B. 6
C. 8
D. 10

Use the following information to answer Questions 11 and 12

A speaker box consisting of three loudspeakers labeled as P, Q and R is shown in the following diagram. Loudspeaker P sends out high frequency sound, Q midrange frequency sound, and R low frequency sound. It is placed on the floor and positioned at a corner in a large rectangular room.





Question 11 The three loudspeakers are designed to have different diameters

A. to prevent interference of the sound waves
B. to ensure the sound waves from them are diffracted to the same extent
C. to ensure the same sound intensity from each one
D. to prevent resonance from happening

Question 12 The positioning of the speaker box at a corner will

A. cause distortion of the sound waves from the loudspeakers
B. make the sound intensity significantly louder in the region directly in front of it
C. make the sound intensity significantly softer in the region directly in front of it
D. produce a stable pattern of pressure nodal and antinodal lines

End of Exam 2

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