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PHYSICS

2011

Trial Examination 2

Electric power
Interactions of light and matter
Sound

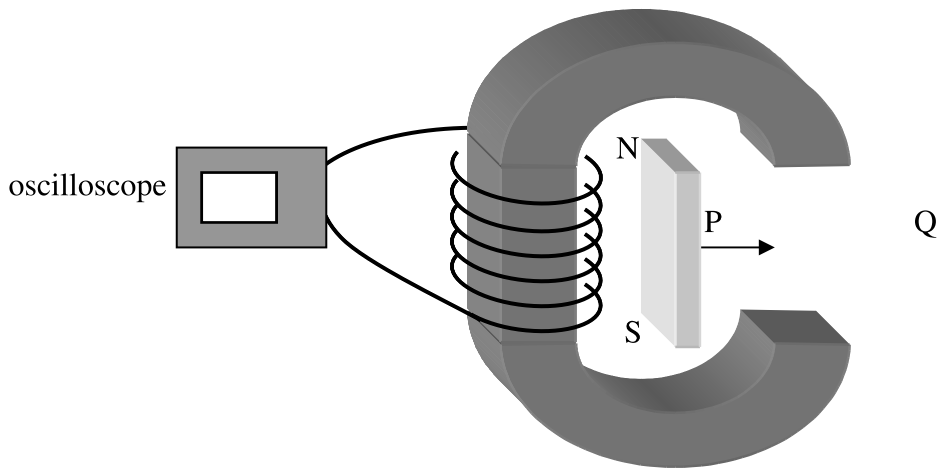
(Note: Use information in the formula data sheet supplied by VCAA)

SECTION A – Core

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

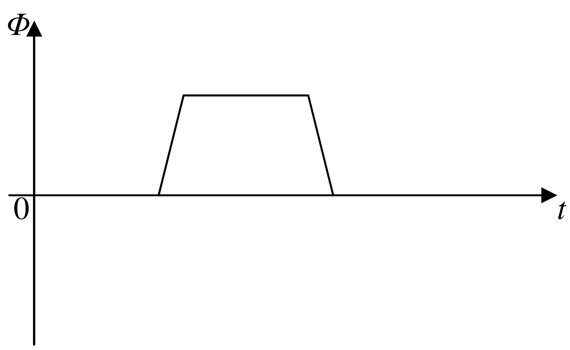
Area of study 1 – Electric power (38 marks)

A bar magnet is moved from position P to position Q at constant velocity through the gap of a C-shape ferromagnetic core.

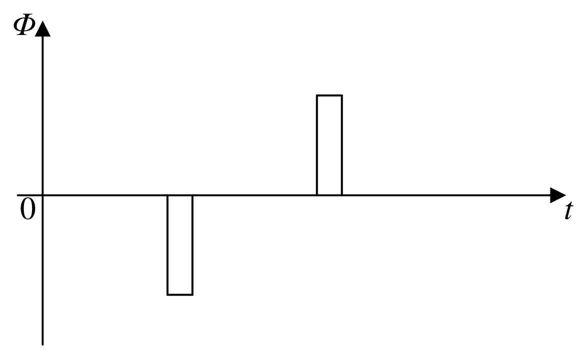


Question 1 Which one of the following graphs gives the *best* description of the magnetic flux through the coil?

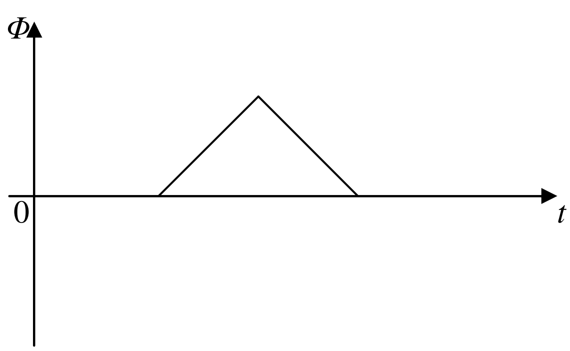
A.



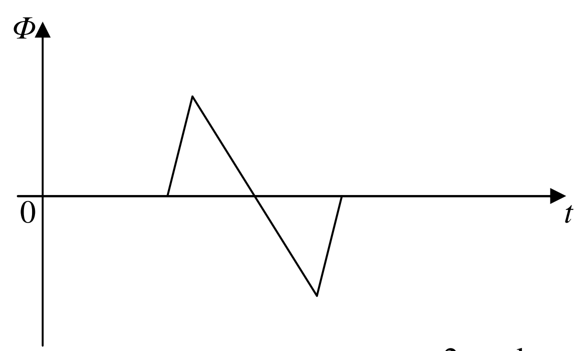
B.



C.



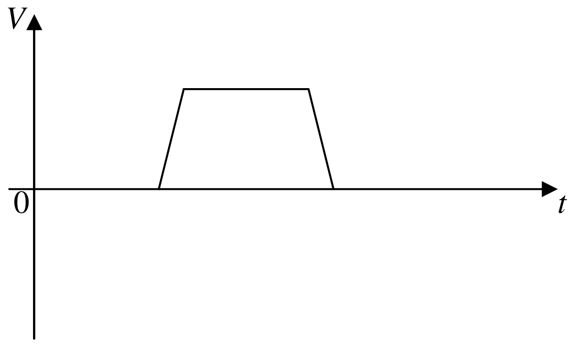
D.



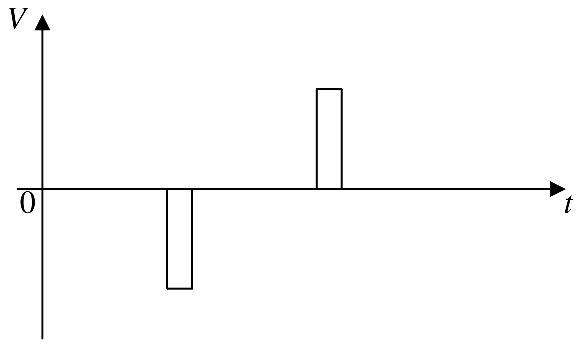
2 marks

Question 2 Which one of the following graphs gives the *best* description of the voltage measured by the oscilloscope?

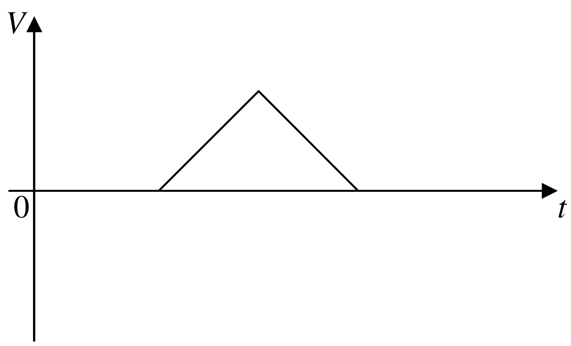
A.



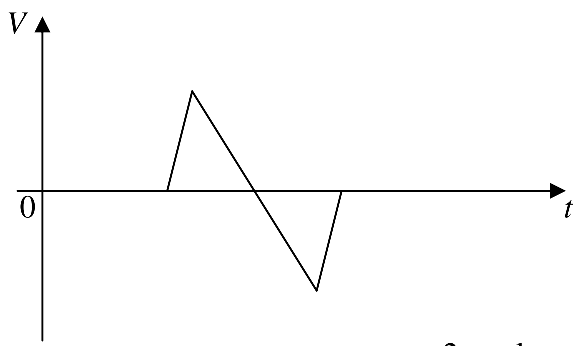
B.



C.



D.



2 marks

Question 3 Name *two* changes to the *V*-*t* graph if the bar magnet is moved from P to Q at **twice** the original speed.

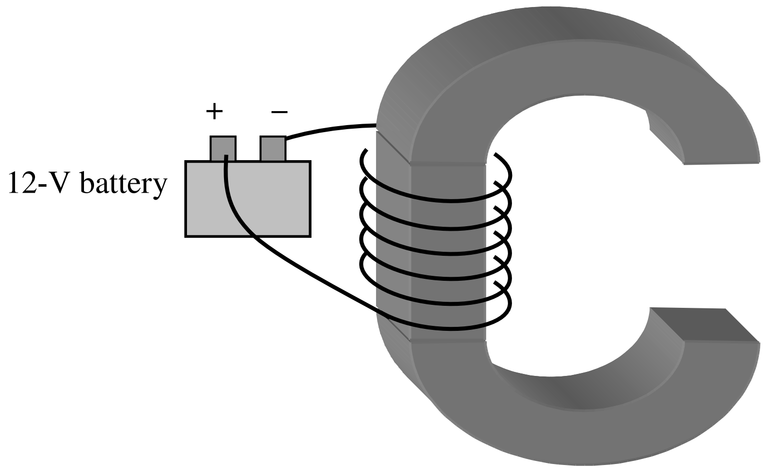
2 marks

Question 4 Now the number of turns in the coil connected to the oscilloscope is doubled, and the bar magnet is moved from position P to position Q at the *original* constant velocity through the gap of the C-shape ferromagnetic core. Which one of the following statements is closer to reality?

A. A constant force is required to move the bar magnet from P to Q.
B. A force is required to move the bar magnet while it is entering or leaving the gap.
C. The force required to move the bar magnet is strongest in the middle of the gap.
D. The force required to move the bar magnet is halved.

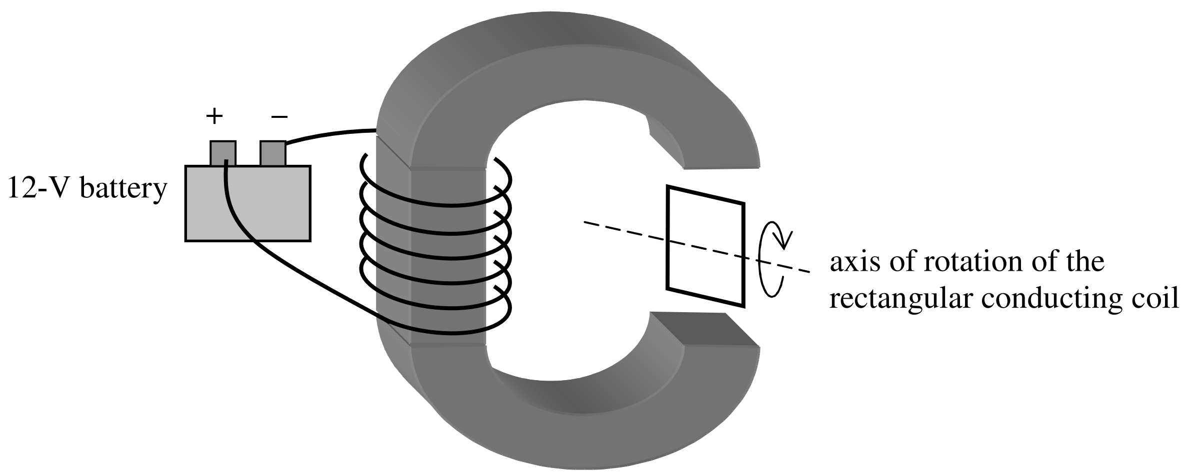
2 marks

The oscilloscope is removed and a 12-V battery is now connected to the coil.



Question 5 On the diagram above draw 3 appropriate magnetic field lines at/near the gap region to indicate the magnetic field pattern.

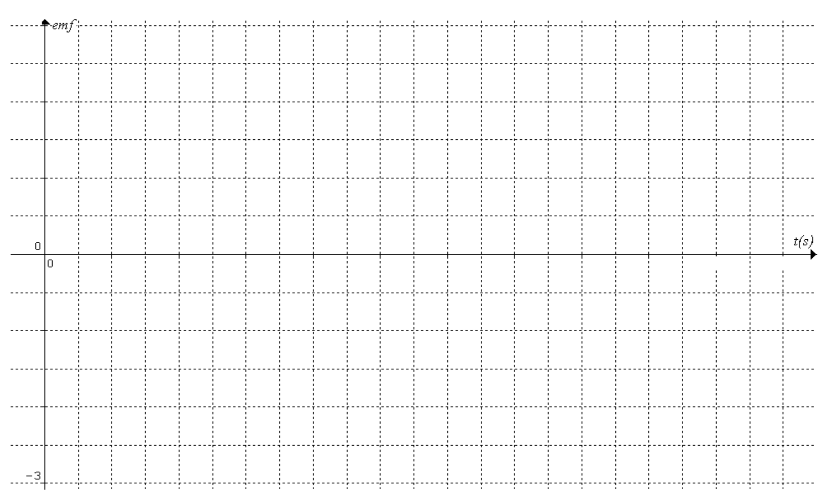
2 marks



The diagram above shows a rectangular conducting coil (at $t = 0$) which is made to rotate at a constant speed of 2 revolutions per second. Assume that the magnetic field is uniform in the gap region.

Question 6 Sketch on the grid below the magnitude of the induced *emf* (arbitrary unit) as a function of time in seconds.

3 marks

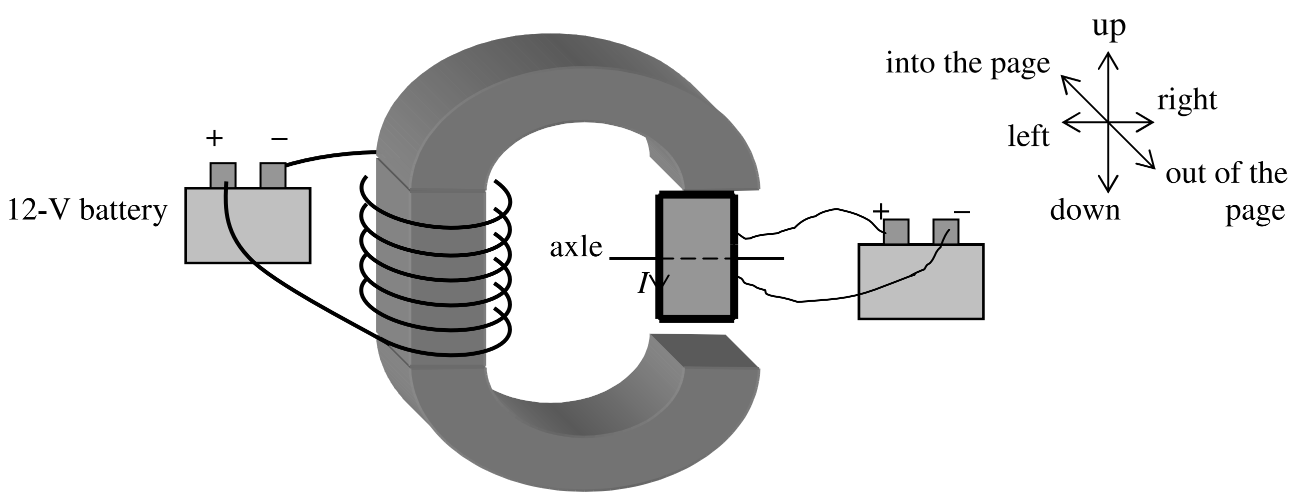


Question 7 The average rate of change of magnetic flux is 0.15 wb per second between $t = \frac{1}{16} = 0.0625\,\text{s}$ and $t = \frac{2}{16} = 0.125\,\text{s}$. During this time interval what is the magnitude of the average *emf* induced in the rectangular coil which consists of 5 turns of a continuous insulated copper wire?

2 marks

V

Now another rectangular coil (2.0 cm × 1.0 cm) of 20 turns is placed in the gap and it is free to rotate about the axle. The ends of the coil are connected to a second battery. The current in the rectangular coil is 0.25 A and its direction is indicated by an arrow as shown in the diagram below. The initial orientation of the rectangular coil is also shown below. Assume that the magnetic field is uniform in the gap region.



Question 8 Describe (i) the direction of the force exerted by the electromagnet on each side of the rectangular coil, and (ii) the initial direction of motion of the rectangular coil.

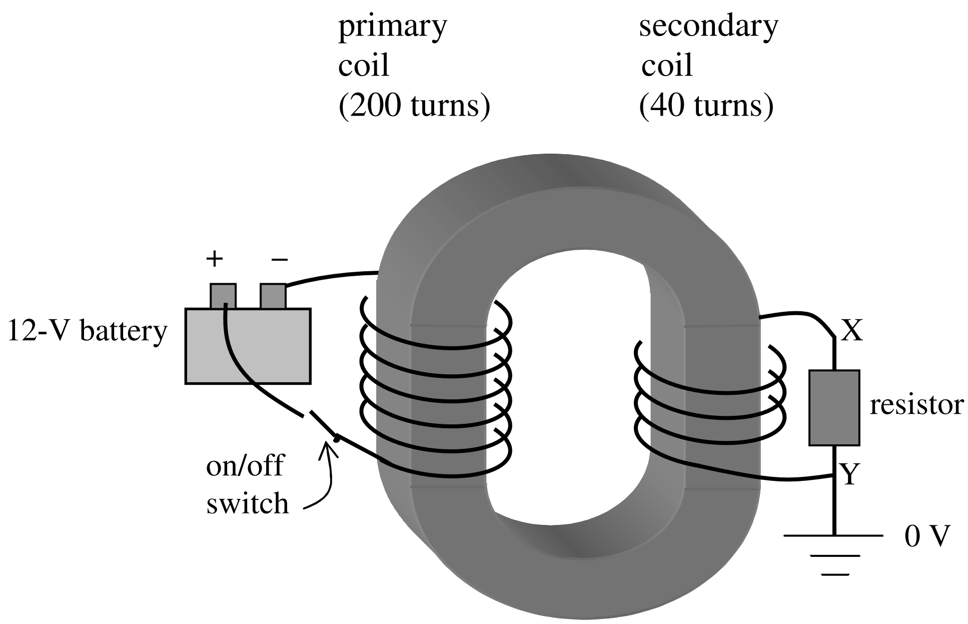
3 marks

Question 9 The force on the top section of the rectangular coil is 0.0025 N. Determine the magnetic field in the gap.

2 marks

tesla

The gap is closed to form an O-shape ferromagnetic core of a simple ideal transformer.



Question 10 The on/off switch in the primary coil is initially at the off position. When it is switched **on** and then **off**, the potential at point X in the secondary coil

A. changes from negative to positive
B. changes from positive to negative
C. remains negative
D. remains positive.

2marks

Question 11 Use the phenomenon of electromagnetic induction and Lenz's law to explain your choice in Question 10.

3 marks

A new farm shed is a long distance from the farm house. The power supply to the farm shed is provided directly by the mains power supply of 240 V rms at the farm house through transmission cables. The total resistance of the transmission cables is 1.5 ohms.

Question 12 Do you expect anything to happen when you connect only a florescent light (20 W, 240 V) to the power supply in the farm shed? Justify your answer with calculations.

3 marks

Now the florescent light is replaced with an electrical heater (2500 W, 240 V).

Question 13 What is the rms voltage across the electrical heater? 2 marks

	V

Question 14 What percentage of the power from the farm house is lost during transmission to the farm shed when the heater is connected?

2 marks

%

The farmer wants to reduce the power loss in the transmission cables by 99%. An ideal step-up transformer is installed next to the farm house to increase the voltage for transmission.

Question 15 Determine the value of the ratio $\frac{N_s}{N_p}$ for the step-up transformer. 3 marks

Note: N_s and N_p are the numbers of turns in the secondary and primary coils respectively.

Question 16 Determine the rms voltage at the output of the step-up transformer. 1 mark

V rms

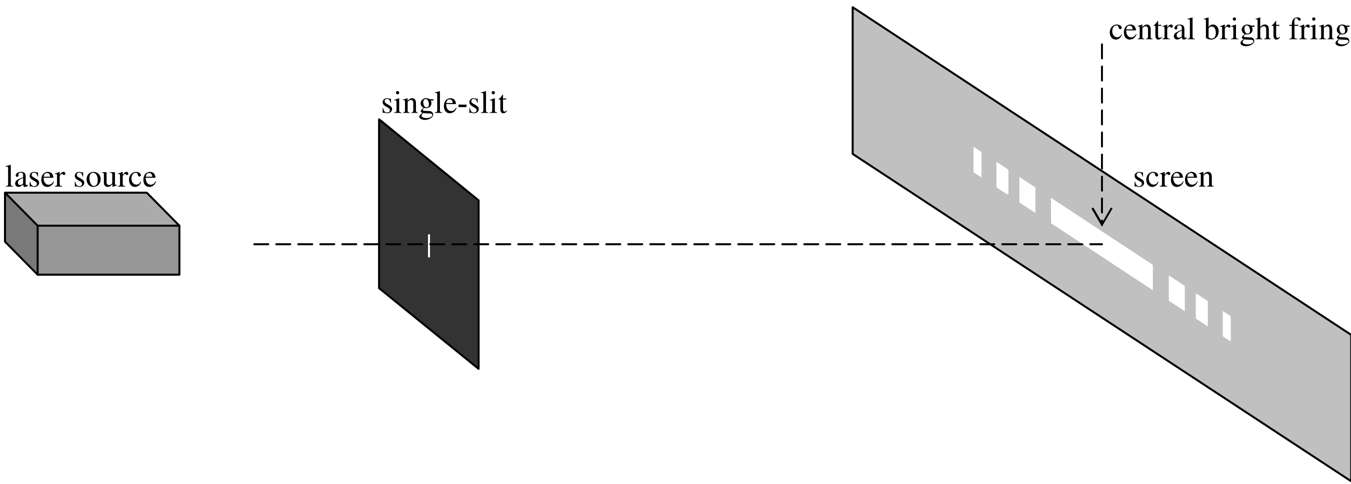
Question 17 Calculate the peak-to-peak voltage at the output of the step-up transformer. 2 marks

V

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

Use the following information to answer Questions 1 and 2

A laser beam passing through a single-slit produces a light pattern on the screen.



Question 1 Which one of the following statements best describes and explains the pattern on the screen?

A. The interference pattern can be explained by the wave-particle dual nature of light.
B. The diffraction pattern can be explained by the wave-particle dual nature of light.
C. The interference pattern can be explained by the wave nature of light.
D. The dark fringes in the diffraction pattern can be explained by the interference of light waves.

2 marks

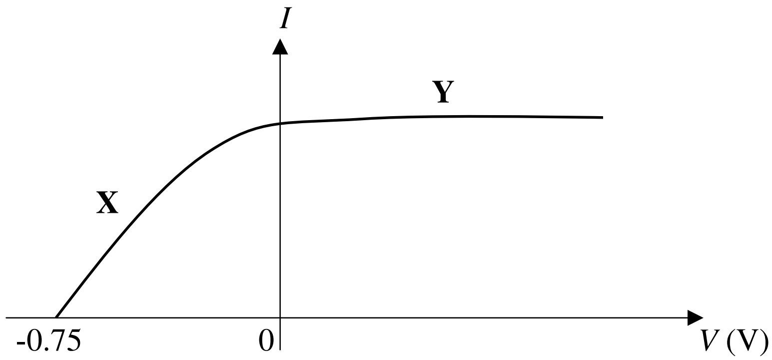
Question 2 Which **one or more** of the following changes will increase the width of the central bright fringe on the screen?

A. Increase the distance between the laser source and the single-slit.
B. Increase the distance between the single-slit and the screen.
C. Increase the width of the slit.
D. Increase the wavelength of the laser light.

2 marks

Use the following information to answer Questions 3, 4, 5 and 6

A photocell is used to investigate the photoelectric effect. A set of data (photoelectric current *I* versus applied voltage *V*) is shown below for a particular light intensity. The sloping section of the set of data is labeled as **X** and the horizontal section as **Y**.



Question 3 Explain the horizontal feature of section **Y** in terms of light intensity and emission of photoelectrons.

2 marks

Question 4 Explain the sloping feature of section **X** in terms of the Compton effect and the kinetic energy of the photoelectrons.

2 marks

Question 5 Determine the highest kinetic energy of the photoelectrons. 2 marks

J

Question 6 The photoelectron emitter in the photocell has a work function of 2.28 eV. Determine the frequency of the light used for the investigation.

3 marks

Question 7 The development of the first electron microscope in 1931 was based on the idea that

A. electrons are real particles
B. electrons interact with the electrons in the atoms/molecules of the specimen
C. electrons have wave properties
D. electrons are small enough to pass through the specimen

2 marks

Question 8 An electron microscope gives a better image resolution than a light microscope because

A. light is a beam of particles called photons
B. light has wave properties and diffracts less than an electron beam
C. the electron beam in the electron microscope has a much shorter wavelength than light has
D. the speed of the electrons is less than the speed of light

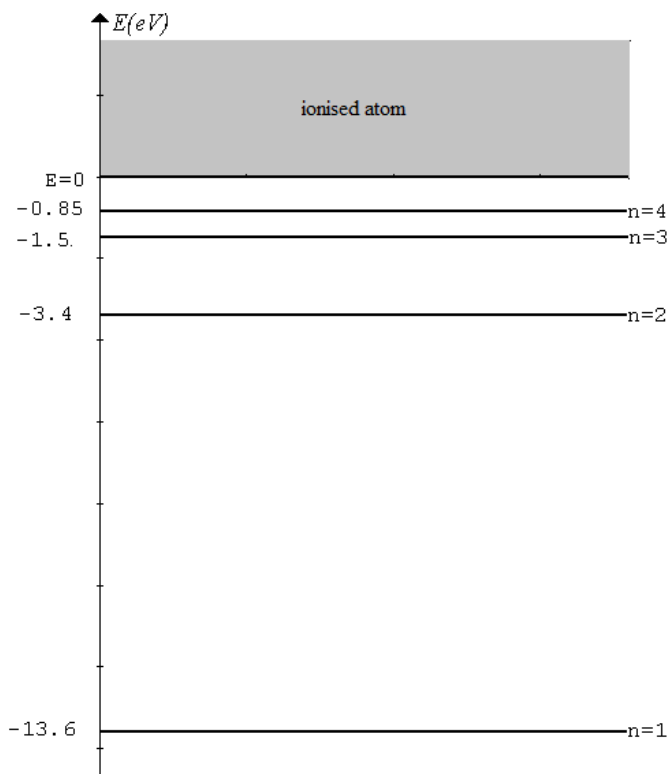
2 marks

Question 9 Name and describe a type of light and matter interactions besides the photoelectric effect and the Compton effect.

3 marks

Use the following information to answer Questions 10, 11, 12 and 13

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



Question 10 What is the ionisation energy for hydrogen?

1 mark

eV

Question 11 Determine the wavelength of light emitted when a hydrogen atom makes a transition from the $n = 4$ energy level to the ground state.

2 marks

nm

Question 12 Determine the momentum of light emitted when a hydrogen atom makes a transition from the $n = 4$ energy level to the ground state.

2 marks

kg m s^{-1}

Question 13 Give a brief outline of de Broglie's explanation for the discrete energy levels of the hydrogen atom theorised by Bohr. Provide an example for $n = 3$.

3 marks

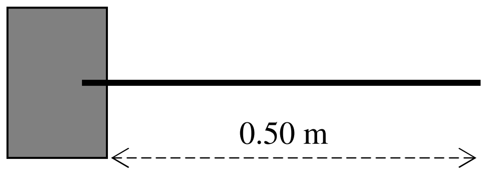
SECTION B – Detailed studies

Detailed study 3 – Sound (24 marks)

Answer **all** the questions. Always choose the best answer.

Use the following information to answer Questions 1 and 2

A 0.50-m long rod is fixed at one end as shown below. It is made to resonate transversely at its fundamental frequency of 168 Hz. The speed of sound in air is 336 ms^{-1}.



Question 1 Which one of the following statements is true?

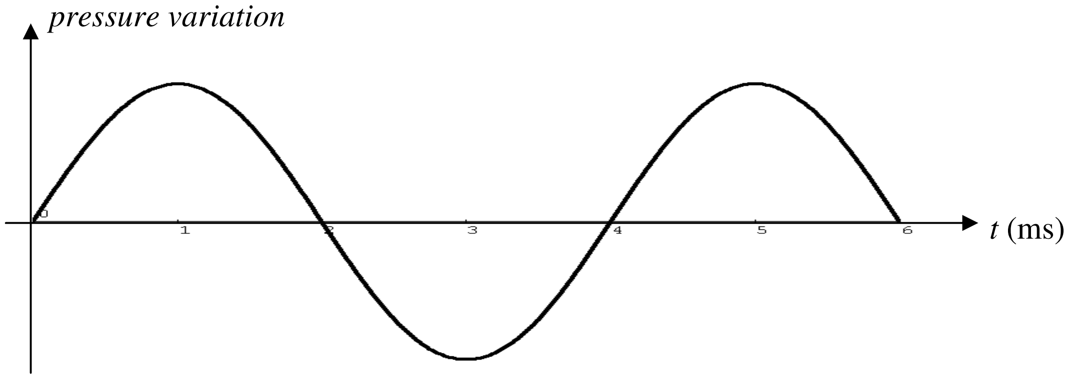
A. The wavelength of the resonance in the rod is longer than the wavelength of the sound in the air.
B. The wavelength of the resonance in the rod is shorter than the wavelength of the sound in the air.
C. The wavelength of the resonance in the rod equals the wavelength of the sound in the air.
D. The wavelength of the resonance in the rod is longer than the wavelength of the sound in the air if the rod has a lower fundamental frequency than 168 Hz.

Question 2 The rod will also resonate at a frequency (Hz) of

A. 84 B. 252 C. 336 D. 504

Use the following information to answer Questions 3, 4 and 5

The graph shows the pressure variation as a function of time *t* of a standing sound wave set up between two parallel walls 6.72 m apart. The pressure variation is recorded at the midpoint of the perpendicular distance between the walls. The speed of sound is 336 ms^{-1}.



Question 3 The frequency (Hz) of the sound wave is closest to

A. 1.35 B. 170 C. 250 D. 400

Question 4 The wavelength (metres) of the standing wave is closest to

A. 1.35 B. 1.70 C. 2.50 D. 4.00

Question 5 Which one of the following statements is true?

A. The standing sound wave is a transverse wave.
B. The standing sound wave has even number of pressure antinodes between the two walls.
C. The standing sound wave has ten pressure nodes between the two walls.
D. The standing sound wave will not be affected if there is a change in the air temperature between the walls.

Use the following information to answer Questions 6, 7 and 8

An alarm, a point source, radiates sound energy in all directions. At 12 m from the alarm the intensity is measured to be 0.050 W m^{-2}. The speed of sound in air is 336 ms^{-1}.

Question 6 There is an opened window (area = 1.5 m^{2}) facing the alarm at 12 m from it. The amount of sound energy (J) passing through the window in 15 s is closest to

A. 1.0 B. 1.1 C. 1.2 D. 1.7

Question 7 At 8.0 m from the alarm the intensity (W m^{-2}) is closest to

A. 0.10 B. 0.11 C. 0.12 D. 0.17

Question 8 At 6.0 m from the alarm the approximate sound intensity level (dB) is

A. 6 B. 110 C. 113 D. 430

Use the following information to answer Questions 9 and 10

Two loudspeakers send out sound waves of the same frequency (1000 Hz) but *out of phase by half a cycle* (i.e. when one loudspeaker sends out a compression, the other loudspeaker sends out a rarefaction). At point *P* the first loud sound on one side of the central line is detected. The speed of sound in air is 336 ms^{-1}.

Question 9 In cm the path difference $PS_2 - PS_1$ is closest to

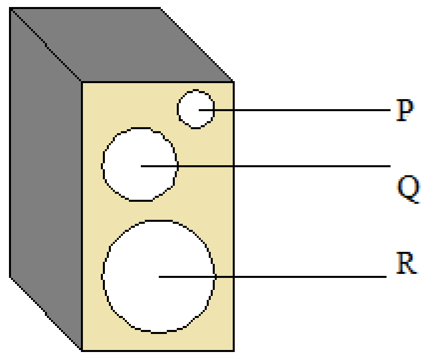
A. 50 B. 34 C. 17 D. 9

Question 10 When the distance between the two loudspeakers decreases, the number of nodal/antinodal lines between the two loudspeakers

A. increases B. decreases C. remains the same D. is doubled

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.
It is placed on the floor close to a wall in a large room.
Loudspeaker P sends out high frequency sound, Q midrange frequency sound, and R low frequency sound.



Question 11 The *best* reason for mounting the loudspeakers on a box is

A. to improve the blending of the wide range of frequencies, thus enhancing the fidelity of the speaker system.

B. to reduce the interference of sound waves generated from the front and back of each loudspeaker.

C. to increase the effect of resonance for certain frequencies.

D. to increase the sound power from the loudspeakers.

Question 12 One of the important reasons why loudspeakers P, Q and R have different diameters is

A. to make the full range of frequencies produced by the loudspeakers reaching everywhere in the room.

B. to make high frequency sound softer and low frequency sound louder.

C. to make low frequency sound diffracting to a greater extent than high frequency sound.

D. to ensure resonance of P at high frequency, Q at midrange frequency and R at low frequency.

End of Exam 2