PHYSICS

2009

Trial Examination 2

Electric power
Interactions of light and matter
Sound

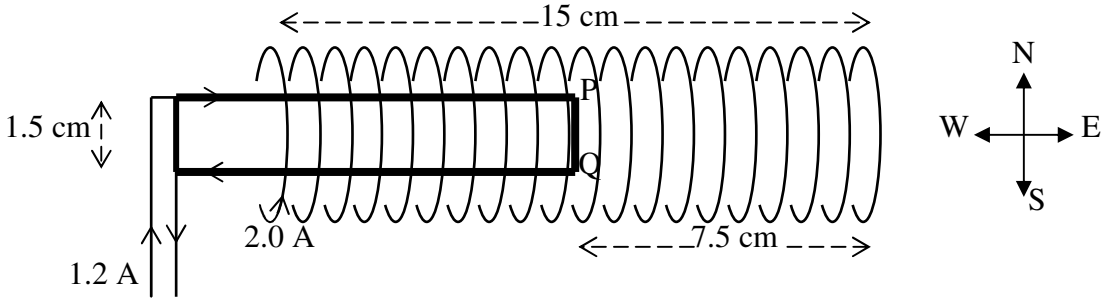
SECTION A – Core

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

Area of study 1 – Electric power (38 marks)

The solenoid shown below has a current of 2.0 A. The magnetic field inside the solenoid is 1.0×10^{-2} T. A rectangular coil of **5 loops** is placed at the centre inside the solenoid. The current in the rectangular coil is 1.2 A.

Aerial view



Question 1 Describe shape and direction of the magnetic field inside and near the middle of the solenoid.

2 marks

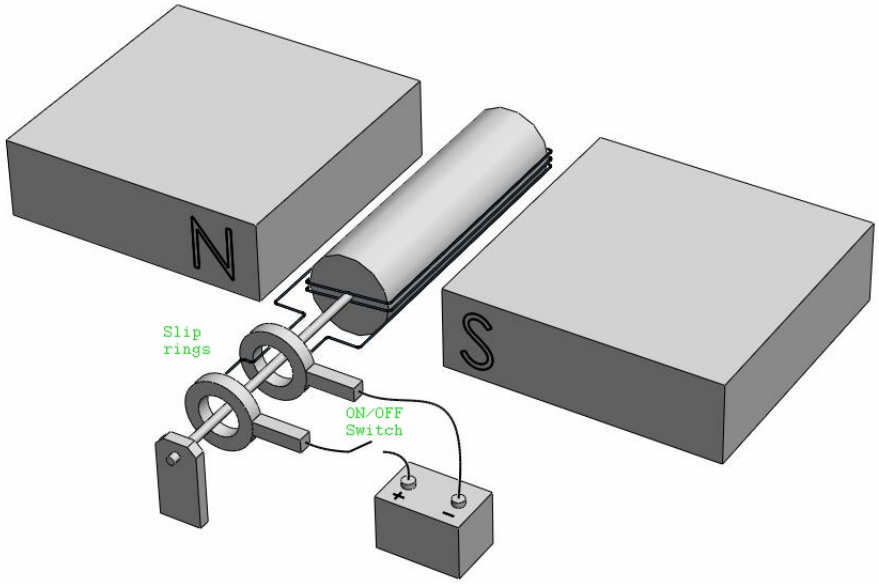
Question 2 Calculate the magnetic force on side PQ of the rectangular coil. 2 marks

N

Question 3 The direction of the net magnetic force on the coil is closest to

A. North B. East C. South D. West E. Upward F. Downward

2 marks



The position (orientation) of the cylindrical armature before the switch is turned on is as shown in the above diagram.

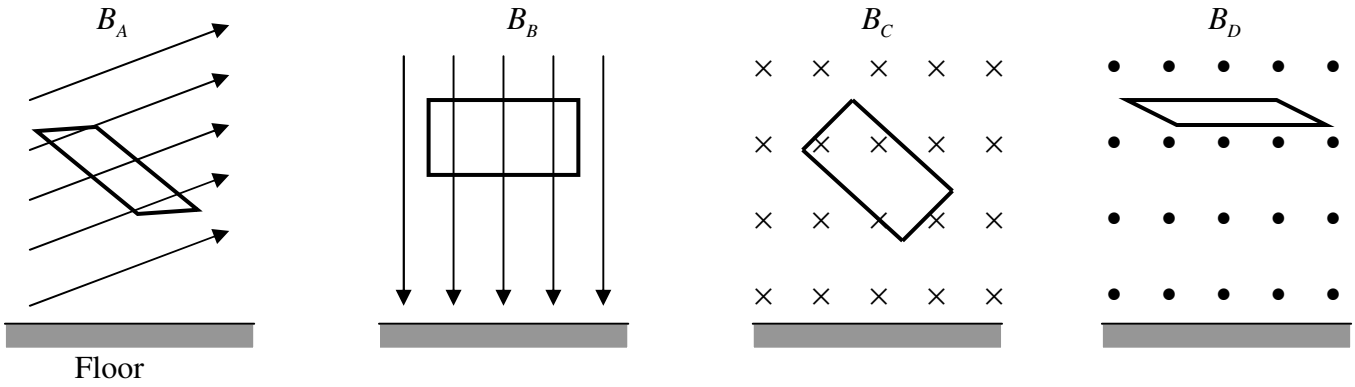
Question 4 Describe the subsequent motion of the cylindrical armature when the switch is turned on. Ignore air resistance and friction.

3 marks

Question 5 How do you modify the above setup to make it a simple DC motor? Explain the working of the modification.

3 marks

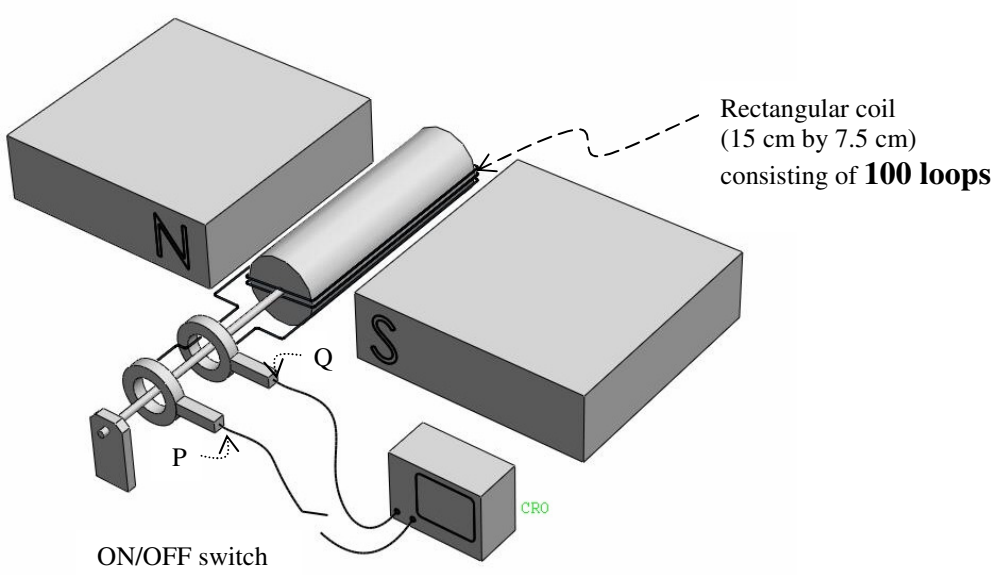
A closed rectangular loop falls vertically through four uniform magnetic fields, B_A, B_B, B_C and B_D. Ignore air resistance.



Question 6 While the closed rectangular loop falls (completely) inside the magnetic field, in which magnetic field (B_A, B_B, B_C or B_D) is its acceleration constant? One or more answers.

2 marks

The battery in **question 4** is replaced with a CRO. The armature is made to rotate mechanically at a uniform rate of 5 Hz. The diagram shows the initial position of the rectangular coil.



Question 7 During a particular interval of rotation (between zero and 90°), the magnitude of the average induced emf is 0.80 volts. Determine the magnitude of the average rate of change of magnetic flux during the interval.

2 marks

Wbs^{-1}

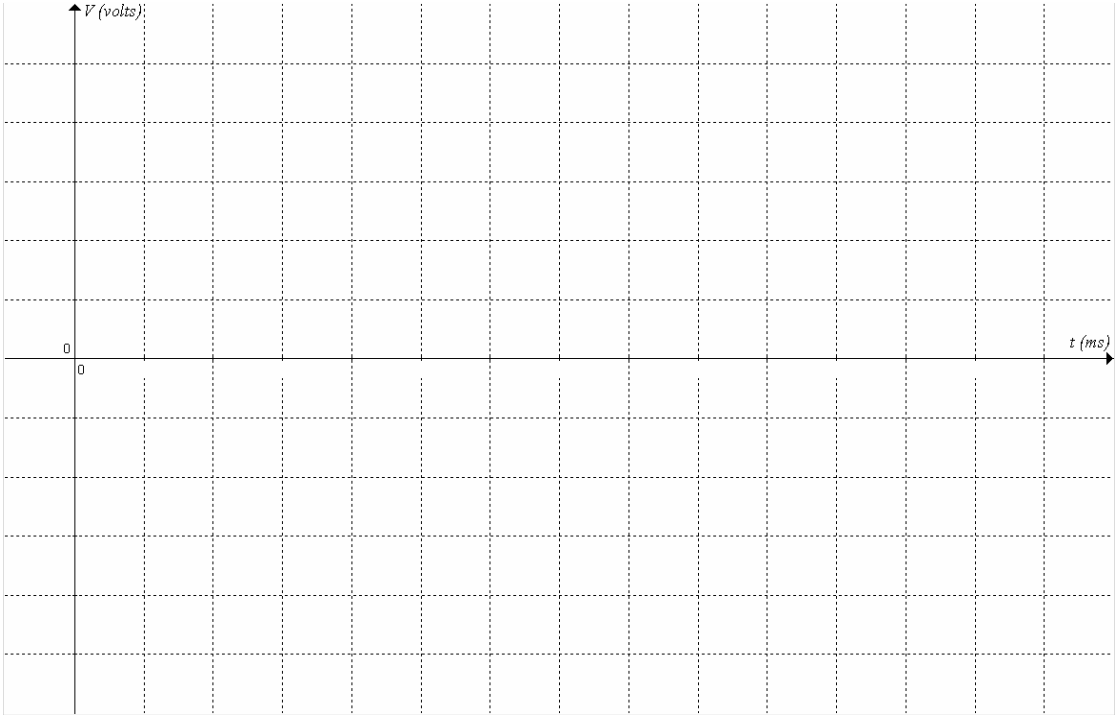
Question 8 At the moment when the coil is rotated 90° from its initial position, what is the direction of the induced current in the coil, P to Q or Q to P? Use Lenz' law to explain your answer.

3 marks

When a light globe ($R = 4.5\ \Omega$) is connected to this generator, its brightness is the same as when it is connected to a 1.5 V dry cell. Ignore internal resistance of the dry cell.

Question 9 When the switch is turned on, the CRO displays the output voltage V (volts) of the generator as a function of time t (ms). Draw the CRO display in the following grid. Show scales on the axes.

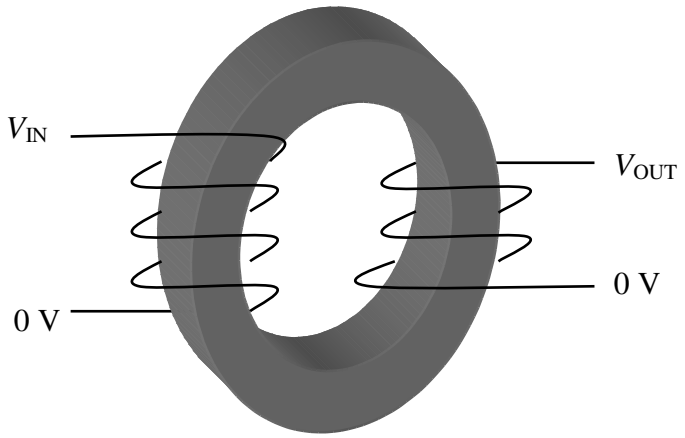
4 marks



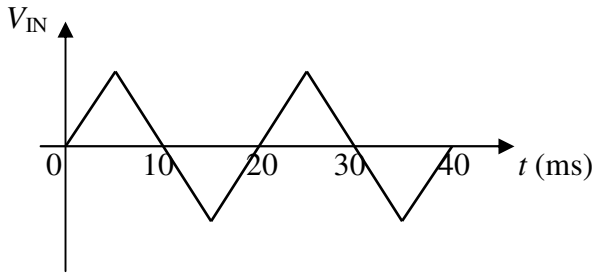
Question 10 Determine the power output of the generator. 2 marks

W

The following diagram shows a simple transformer. The primary coil has 200 turns, and the secondary has 50 turns.

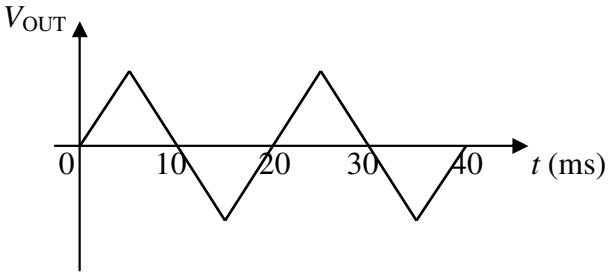


Question 11 The voltage at V_{IN} is shown below.

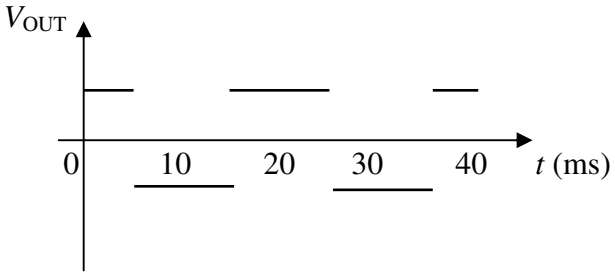


The shape of the voltage at V_{OUT} is best represented by

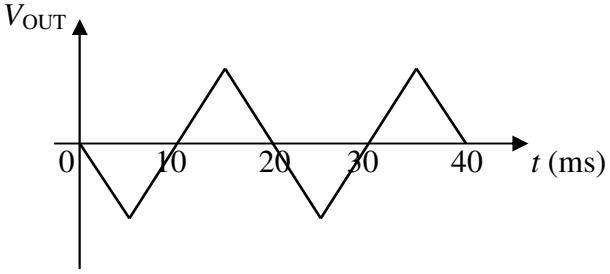
A.



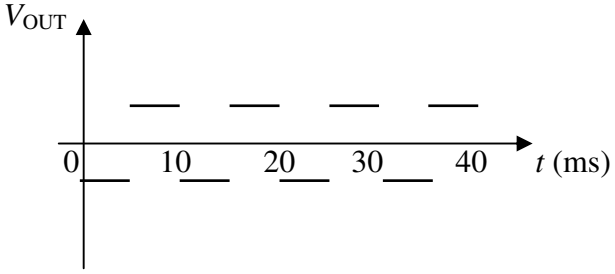
B.



C.



D.



2 marks

Question 12 If V_{IN} is sinusoidal and $V_{peak-peak} = 1.8$ V, calculate the RMS V_{OUT}. 3 marks

V

The supply of electricity to a small town is from a power station 10 km away. The transmission cables have a total resistance of 0.40 Ω. For the small town, the power output of the generator at the station is 120 kW. Suppose the voltage output of the power station is 300 V (RMS) for transmission.

Question 13 Determine the power loss in the transmission cables. 3 marks

W

Question 14 Determine the supply voltage (RMS) at the small town. 2 marks

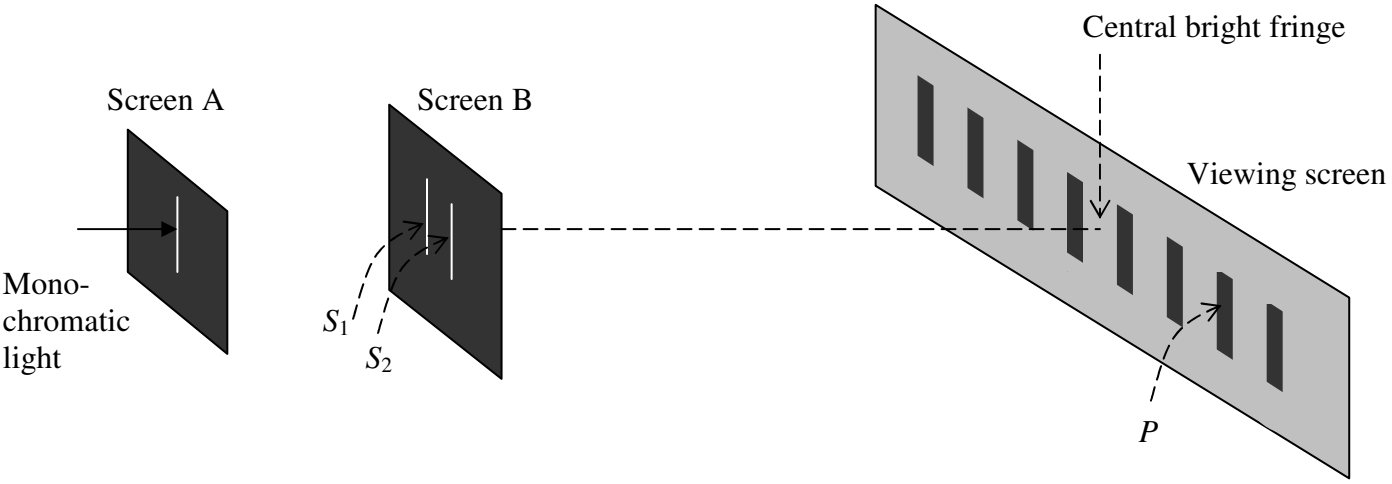
V

Question 15 How would you reduce the power loss and ensure a supply voltage close to 240 V (RMS) at the small town? (No calculations required)

3 marks

Area of study 2 – Interactions of light and matter (26 marks)

Setup of Young's double-slit experiment is shown below.



Question 1 Why is it necessary to have the single-slit screen A in the setup? 2 marks

Question 2 The frequency of the monochromatic light is 6.0×10^{14} Hz. Calculate the distance $PS_1 - PS_2$.

2 marks

m

Question 3 Which one or more of the following will increase the separation between any two adjacent fringes?

A. Decrease the width of the slits on screen B.

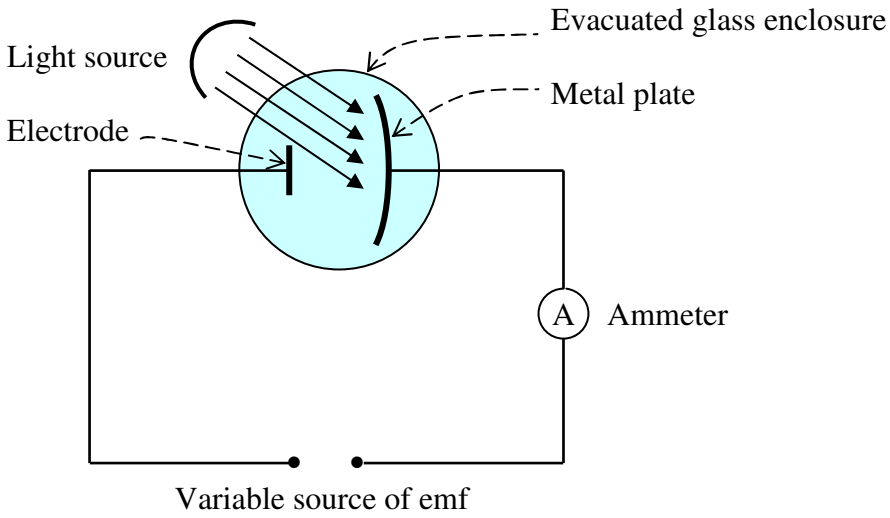
B. Increase the distance between screen A and screen B.

C. Increase the distance between screen B and the viewing screen.

D. Decrease the separation between the two slits on screen B.

E. Increase the frequency of the monochromatic light used.

2 marks



The above setup is used to study the photoelectric effect when the **intensity** of the light source is varied.

Question 4 Describe the predictions made by the **wave theory** about the number of photoelectrons and their maximum kinetic energy.

2 marks

Now the setup is used to study the photoelectric effect when the **frequency** of the light source is varied.

Question 5 Describe the predictions made by the **photon theory** about the number of photoelectrons and their maximum kinetic energy.

2 marks

Question 6 The metal plate is made of lithium that has a work function of 2.28 eV, and it is illuminated by light of 600 nm wavelength. Discuss (include some calculations) the effect (if any) of the illumination on the lithium surface.

3 marks

A beam of X-ray is directed at a target (powdered aluminium). Photo 1 shows the scattering pattern of X-rays. The experiment is repeated with a beam of electrons instead of a beam of X-ray. The electron energy was chosen so that the scattering pattern of the electrons matches that of the X-rays, photo 2.

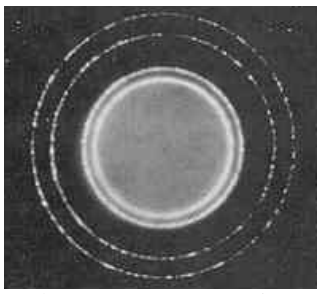


Photo 1: X-ray scattering

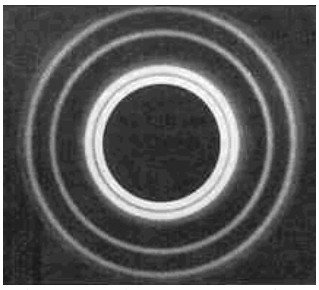


Photo 2: Electron scattering (Fundamental of Physics – D. Halliday et al)

Question 7 The two photographs show (choose the best one or more of the following alternatives):

A. The particle nature of electromagnetic radiation.

B. The wave nature of matter.

C. The dual (wave and particle) nature of electromagnetic radiation.

D. The dual (wave and particle) nature of matter.

E. Electromagnetic radiation is the same as matter.

2 marks

Question 8 The wavelength of the X-ray used to produce photo 1 is 0.13 nm. What is the de Broglie wavelength of the electrons used to produce photo 2? 2 marks

Question 9 Calculate the voltage required to accelerate an electron from rest in order for it to have the de Broglie wavelength calculated in Question 8.

3 marks

Question 10 Explain the appearance of dark lines in the sun's otherwise continuous spectrum. 2 marks

Question 11 A spectral line at 480 nm appears in the sun's spectrum. What is the energy (J) of a photon of this wavelength?

2 marks

J

Question 12 The wave theory of matter can explain the appearance of dark lines in the sun's spectrum. Explain this statement.

2 marks

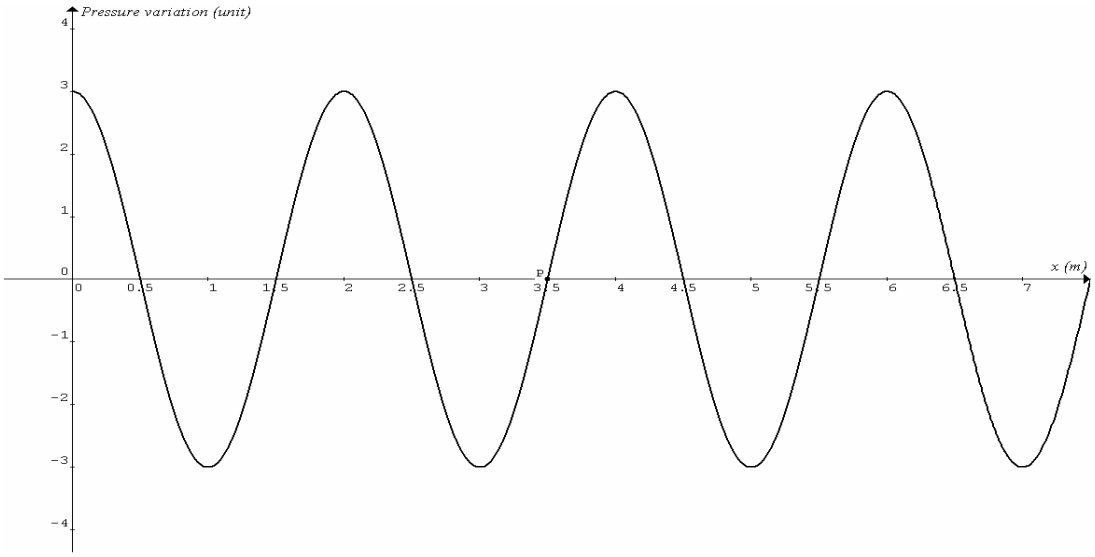
SECTION B – Detailed studies

Detailed study 3 – Sound (26 marks)

Answer **all** the questions.

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

The graph shows the pressure variation of a single-frequency sound at a particular time against the distance from a source. The speed of sound is 338 ms^{-1}. Point P is 3.5 m directly in front of the source.

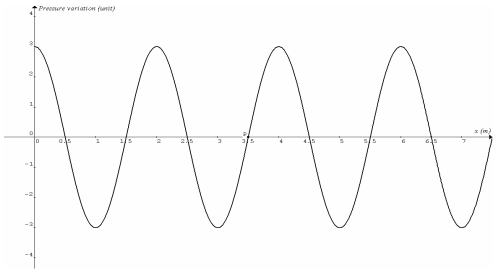


Question 1 The period (ms) of the sound wave is closest to

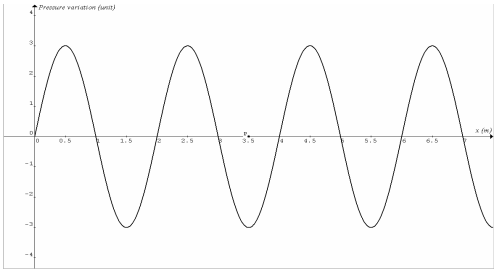
A. 2 B. 6 C. 169 D. 0.0059

Question 2 A quarter of a period after the particular time, the graph of the pressure variation against the distance from a source is closest to

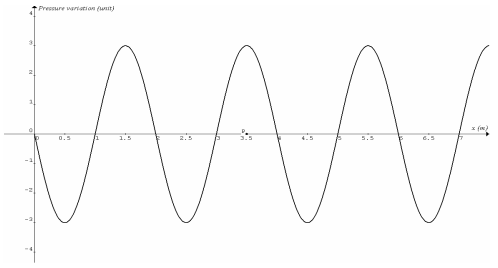
A.



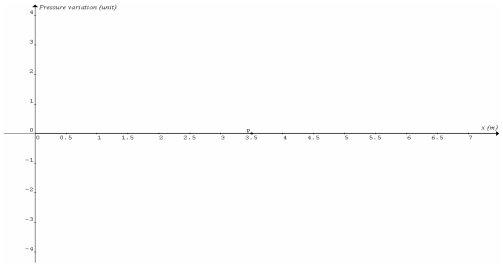
B.



C.



D.



Question 3 If point P is a smoke particle, at the particular time it is

A. at rest.

B. moving downwards.

C. moving towards the source.

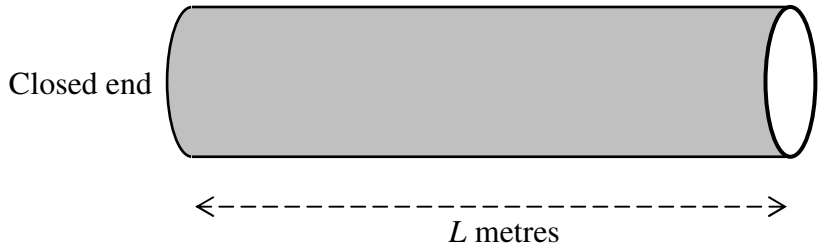
D. moving away from the source.

Question 4 5 m away from a firecracker exploding in the air outdoor, the sound level is 81 dB. At 15 m away the sound level (dB) is closest to

A. 9 B. 27 C. 70 D. 75

Use the following information to answer Questions 5, 6 and 7

A closed cylindrical tube is made to resonate at its **fifth** harmonic of 845 Hz. The tube is L metres long. The speed of sound is 338 ms^{-1} on a particular day. Ignore end correction.



Question 5 At a distance of $\frac{1}{3}L$ metres from the closed end inside the tube, the air pressure

A. varies at its maximum amplitude.

B. shows no variation.

C. varies at less than its maximum amplitude.

D. varies at its minimum amplitude.

Question 6 The value of L is closest to

A. 0.1 B. 0.3 C. 0.5 D. 0.8

Question 7 Now there is one (and only one) change to the setup, namely the closed end of the tube is made open. Which one of the following statements is true?

A. The tube stops resonating.

B. The tube keeps on resonating at its fifth harmonic.

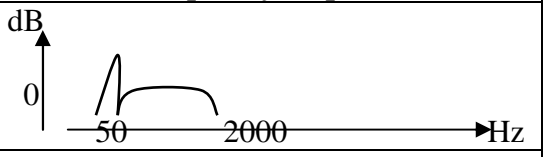
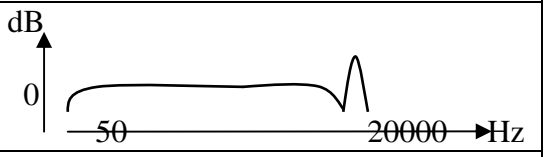
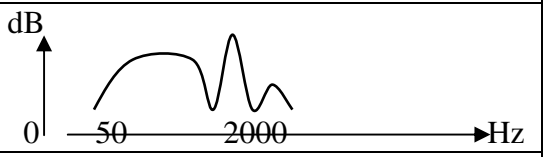
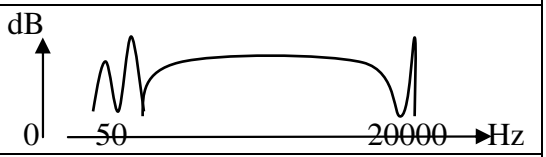
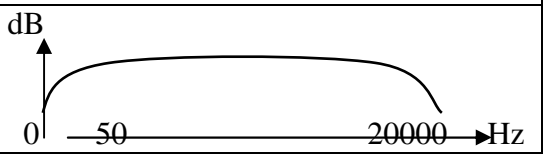
C. The tube resonates at its fourth harmonic.

D. The tube resonates at its sixth harmonic

Use the following information to answer Questions 8 and 9

Type	Frequency range (Hz)
Human voice	80 - 1100
Human hearing	20 – 20 000
Musical instruments	20 – 12 000

Price and frequency response graph of six items of sound equipment:

Item	Price	Description	Frequency response
1	$50	Microphone	
2	$200	Microphone	
3	$500	Microphone	
4	$20	Loudspeaker system	
5	$250	Loudspeaker system	
6	$1000	Loudspeaker system	

Question 8 Which one of the following combinations of microphone and loudspeaker system is the cheapest and gives the performance required for a **lecture theatre**?

A. Item 2 and item 6

B. Item 2 and item 5

C. Item 1 and item 4

D. Item 3 and item 6

Question 9 Which one of the following combinations of microphone and loudspeaker system is the cheapest and gives the performance required for a **concert hall**?

A. Item 2 and item 6

B. Item 2 and item 5

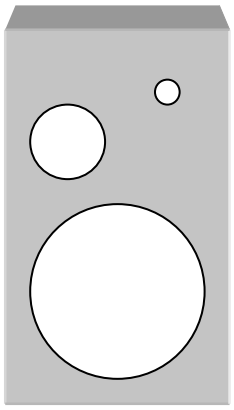
C. Item 1 and item 4

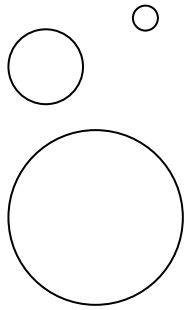
D. Item 3 and item 6

Use the following information to answer Questions 10 and 11

The performance of three loudspeakers (tweeter, midrange and woofer) mounted on the front baffle of an enclosure is compared with the performance of another three loudspeakers identical to the first three. These three are suspended in the air facing the same direction.

Enclosed loudspeakers





Naked loudspeakers

Question 10 The enclosed loudspeakers perform better than the naked ones because (select the best choice)

A. the sound waves from the naked loudspeakers diffract and interfere with each other.

B. the sound energy from the naked loudspeakers spreads out in all directions.

C. the sound waves generated at the front and back of each naked loudspeaker interfere destructively.

D. the sound waves from the naked loudspeakers diffract less than the sound waves from the enclosed ones.

Question 11 The diameter of the tweeter loudspeaker is smaller than that of the woofer (select the best choice)

A. so that the tweeter loudspeaker diffracts high frequency sound waves to the same extent as the woofer loudspeaker diffracts low frequency sound waves.

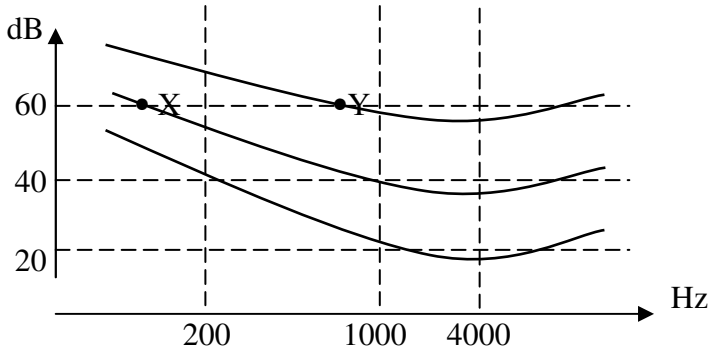
B. so that the tweeter loudspeaker diffracts high frequency sound waves to a greater extent than the woofer loudspeaker diffracts low frequency sound waves.

C. because high frequency sound waves diffract to a greater extent than low frequency sound waves.

D. because tweeter loudspeaker diffracts sound waves to a greater extent than woofer loudspeaker does.

Use the following information to answer Questions 12 and 13

The following diagram shows 3 equal loudness contours. Two sounds are marked as X and Y.



Question 12 The two sounds X and Y

A. have the same sound intensity level and the same phon level.

B. have the same sound intensity level but different phon level.

C. have the same phon level but different sound intensity level.

D. have different phon level and different sound intensity level.

Question 13 The phon level of sound X is closest to

A. 37. B. 40. C. 53. D. 60.

End of Exam 2

