PHYSICS

2006

Trial Examination 2

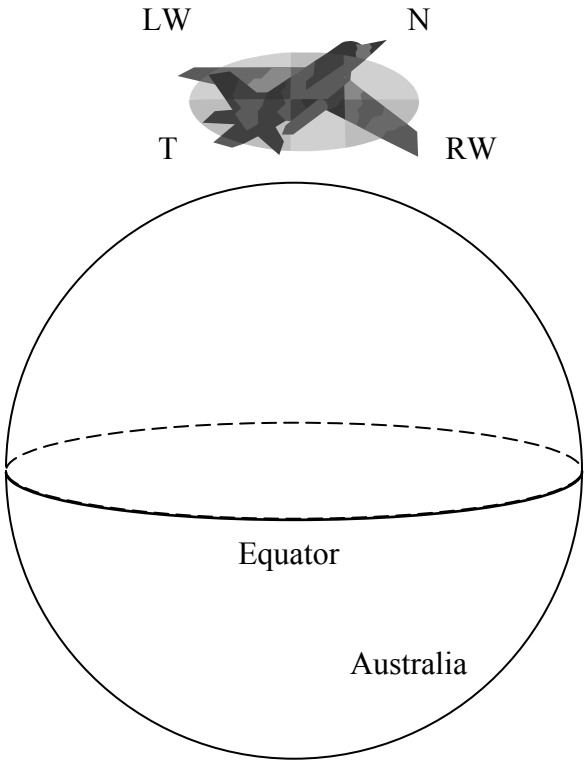
Electric power
Interactions of light and matter
Sound

SECTION A – Core

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

Area of study 1 – Electric power (40 marks)

An aero plane flies horizontally over the North Pole of the Earth.



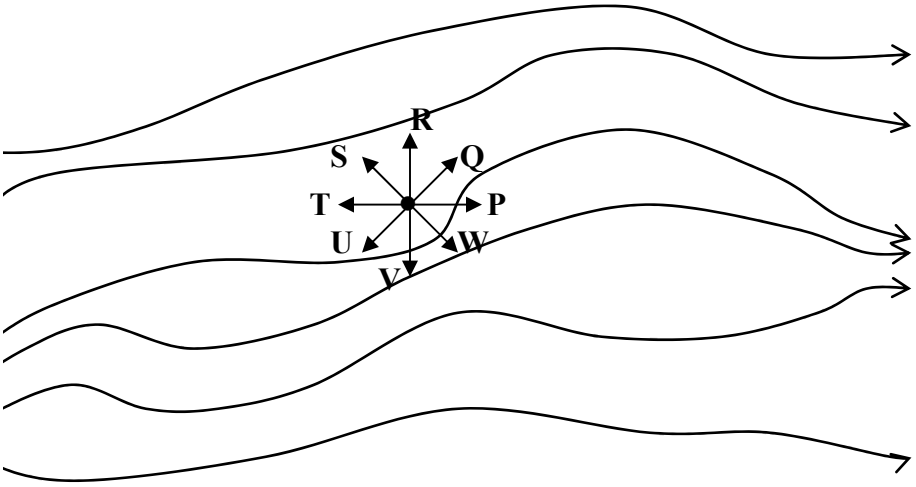
Question 1 Which part of the aero plane becomes negatively charged, the nose (N), the tail (T), the left wing tip (LW) or the right wing tip (RW)? Explain in terms of magnetic force on charges.

3 marks

Question 2 The aero plane makes a 90^{o} left-turn. Now which part of the aero plane becomes negatively charged, the nose (N), the tail (T), the left wing tip (LW) or the right wing tip (RW)?

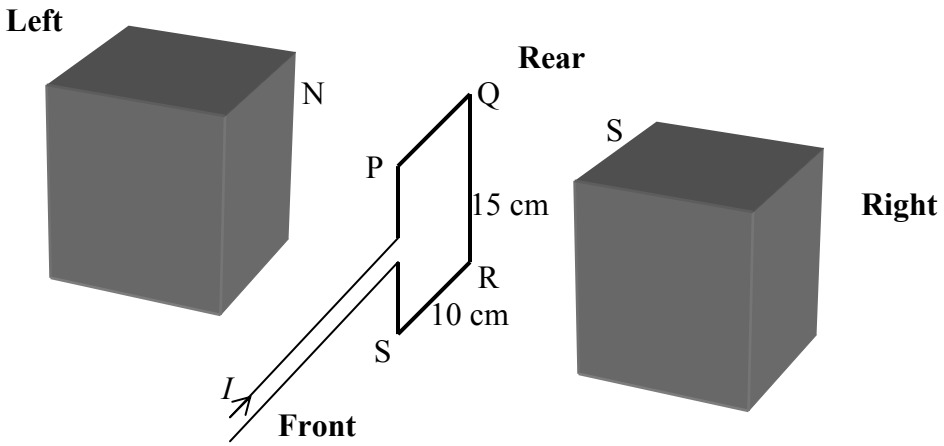
1 mark

In a certain region of space the magnetic field is represented by the magnetic field lines shown in the following diagram (2 dimensional).



Question 3 A compass is placed at the position indicated by the dot •. Which of the arrows (**P**–**W**) best shows the direction that the north pole of the compass will point to?

2 marks



A rectangular loop PQRS (15 cm by 10 cm) of 20 turns of insulated copper wire is placed between two opposite magnetic poles as shown in the diagram above. It shows the initial orientation of the loop. There is an electric current $I = 2.0\,\text{A}$ in the loop. The magnetic field is uniform $B = 0.5\,\text{T}$ between the poles.

Question 4 Calculate the magnitude of the magnetic force on side PQ of the rectangular loop.

N

2 marks

Question 5 Describe the effects of the magnetic force on the rectangular loop.

2 marks

Now the current is switched off (This information is for question 6 to 9).

Question 6 Determine the magnetic flux through each turn of the rectangular loop.

wb

2 marks

Question 7 The rectangular loop is made to rotate in the **clockwise** direction (seen from the front). Determine the direction of the induced current in the loop (clockwise or anticlockwise when it is viewed from the right).

1 mark

Question 8 If the rectangular loop is made to rotate in the **anticlockwise** direction (seen from the front). Determine the direction of the induced current in the loop (clockwise or anticlockwise, viewed from the right).

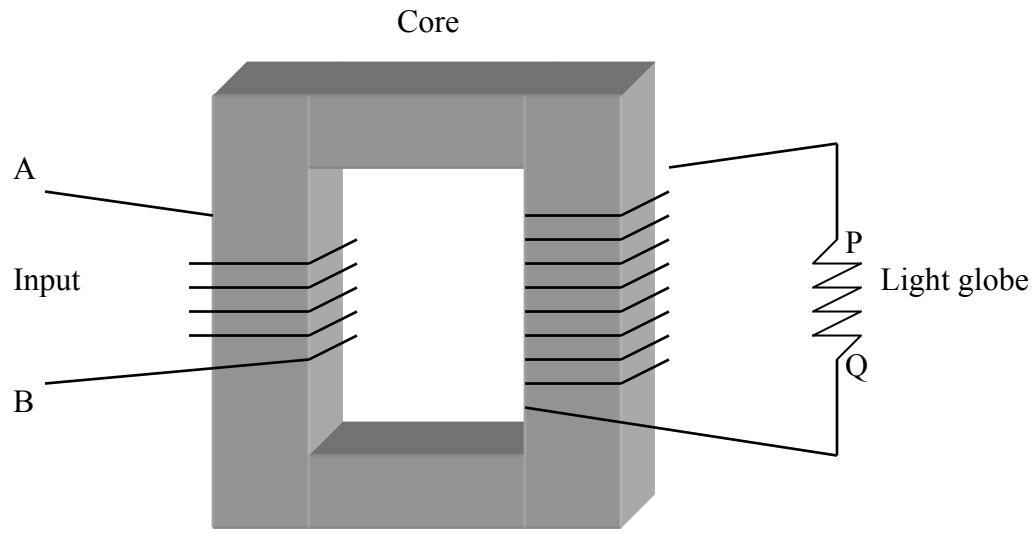
1 mark

Question 9 If the rectangular loop is made to rotate 2 revolutions in a second uniformly, calculate the magnitude of the average emf induced in a half of a revolution from the initial orientation.

volts

3 marks

The following diagram shows a simple transformer. The secondary coil has 400 turns of conducting wire. It is connected to a light globe rated 60 w 240 v. The voltage input to the primary coil is 48 v. The transformer is assumed to be 100% efficient.



Question 10 Which one or more of the following statements about the transformer is/are **not true**?

A. It is a step-down transformer.

B. The core of the transformer is made of copper.

C. The wires in the coils are insulated.

D. The output power equals the input power.

2 marks

Question 11 How many turns are required in the primary coil for the light globe to operate at its rated values?

2 marks

Question 12 Calculate the current in the primary coil when the light globe operates at its rated values.

A

2 marks

Question 13 At time *t*, the potential at A (refer to the diagram at the input side) is higher than the potential at B and decreasing. Which end (P or Q) of the light globe is at a higher potential at time *t*? **Explain your answer**.

4 marks

Question 14 The initial voltage supply is disconnected from the transformer and replaced by four fully charged 12-volt batteries in series. Which one of the following statements **is true**?

A. The light globe becomes brighter.

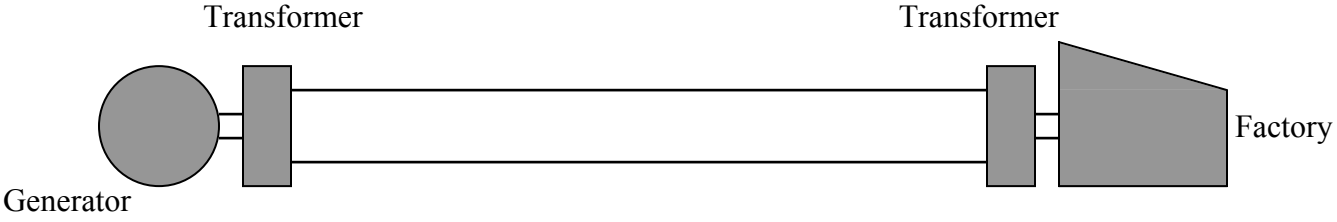
B. The light globe becomes less bright.

C. The light globe goes off.

D. The light intensity from the light globe becomes constant.

2 marks

A 50-Hz ac generator supplies power to a factory over a two-cable transmission line. The total resistance of the transmission line is $1.60\,\Omega$. The generator operates at its maximum power output of 250 kw. The output of the transformer next to the generator has a peak-to-peak voltage of 17.0 kv. Assume that all the transformers in the system are ideal.



Question 15 Calculate the rms current in the transmission line when the generator operates at maximum power.

A

3 marks

Question 16 Determine the peak-to-peak voltage (3 significant figures) input to the transformer next to the factory. **Explain your answer**.

v

3 marks

Question 17 Calculate the maximum power delivered to the factory.

w

3 marks

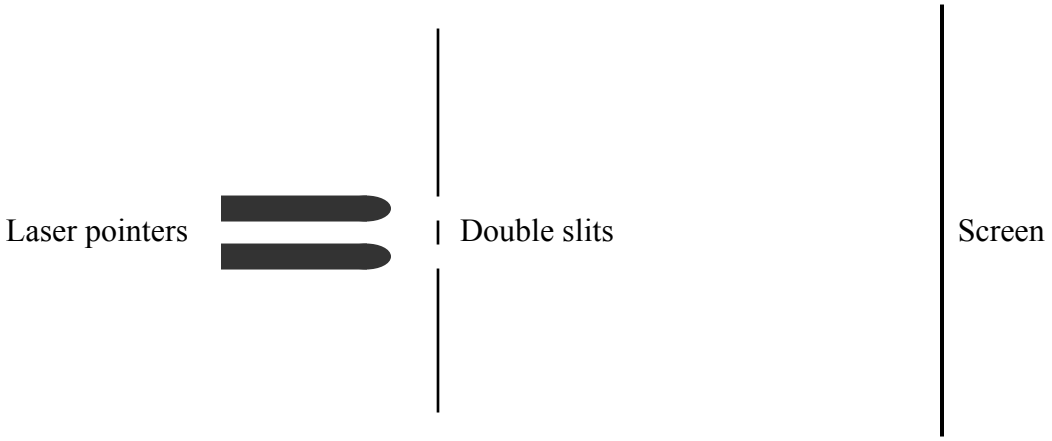
Question 18 Cost of electricity is 25 cents per kilowatt-hour. Calculate the weekly cost of power lost in the transmission line if the factory is in operation for 12 hours a day, 7 days a week, at maximum power.

$

2 marks

Area of study 2 – Interactions of light and matter (25 marks)

A student attempts to demonstrate the wave nature of light by Young's double-slit experiment with the following modification: Instead of light from a single slit illuminating the two slits, she uses two identical laser pointers for illumination, one for each slit.



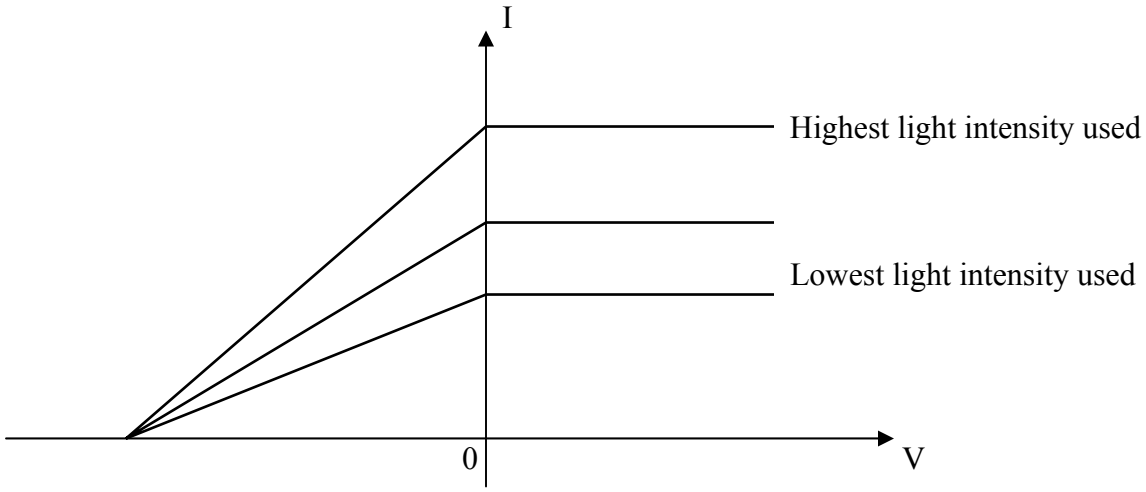
Question 1 Describe the appearance of the light falling on the screen from the double slits.

2 marks

Question 2 Explain your answer to question 1.

2 marks

A student conducts a photo-electric experiment in which she uses light of a particular frequency to shine on the metal plate of a photo-electric cell. She repeats the experiment a few times, each time with the same light (i.e. the same frequency) but different intensity. The following graph of photoelectric current I versus applied voltage V shows the data collected for three such experiments.



Question 3 The photoelectric current remains constant when the accelerating voltage increases. Explain this finding using Planck's photon model.

2 marks

Question 4 The photoelectric current increases with increasing light intensity. Explain this finding using Planck's photon model.

2 marks

Question 5 The photoelectric current decreases with increasing retarding voltage. Explain this finding using Planck's photon model.

2 marks

Question 6 The photoelectric currents for different intensities drop to zero at the same retarding voltage. Explain this finding using Planck's photon model.

2 marks

Question 7 In another photo-electric experiment the stopping voltage is found to be 1.8 v. Determine the maximum kinetic energy of the photoelectrons in electron-volts and in joules.

ev	J

2 marks

Under certain conditions X-rays and a beam of electrons produce similar diffraction patterns when they are directed at the same powdered target crystals.

Question 8 Which one or more of the following ideas is/are the accepted explanation for similar diffraction patterns?

A. X-rays is a beam of electrons.

B. The X-rays and the beam of electrons have the same energy.

C. X-rays shows particle-like properties.

D. A beam of electrons shows wave-like properties.

2 marks

Question 9 X-rays of frequency 1.0×10^{18} Hz is used to produce a diffraction pattern. What is the kinetic energy of an electron in a beam that could produce the same diffraction pattern?

J

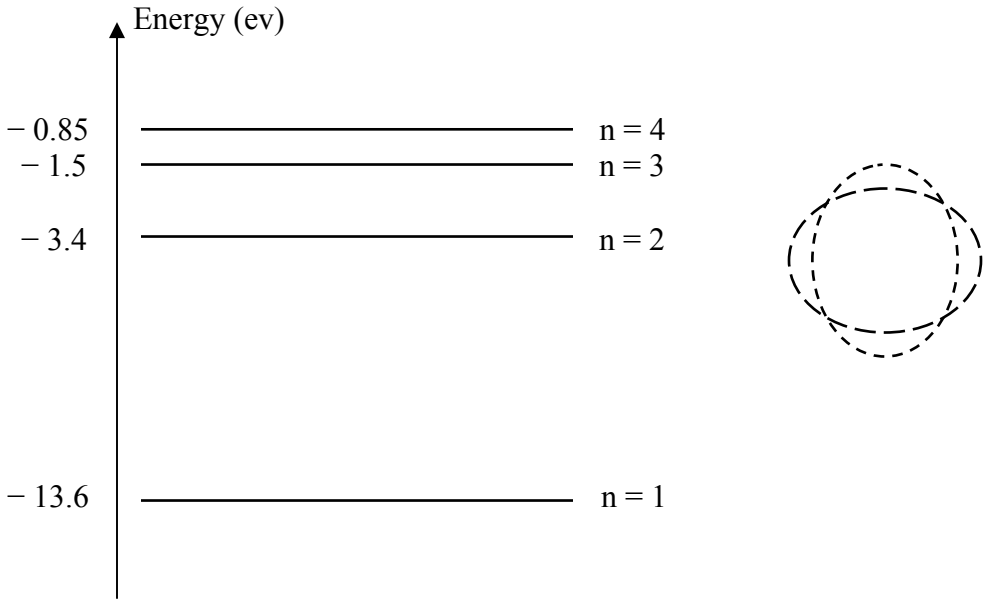
3 marks

Question 10 If the beam of electrons is replaced by a beam of neutrons with each neutron carrying the same momentum as each electron, would the same diffraction pattern be produced? **Explain your answer**.

Yes/No

2 marks

The following diagram shows the first three energy levels above the ground state for hydrogen. The electron in a hydrogen atom can be considered as a matter wave. The first excited state (n = 2) matter wave is shown below.



Question 11 Draw the second excited state (n = 3) matter wave in the box below.

2 marks

Question 12 Calculate the wavelength of the photon emitted when the electron in a hydrogen atom returns to the ground state from the second excited state.

nm

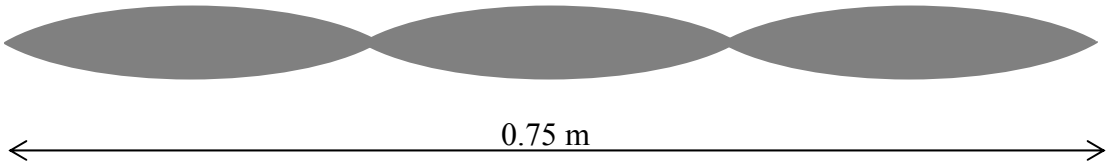
2 marks

SECTION B – Detailed studies

Detailed study 3 − Sound (25 marks)

Answer **all** the questions.

A 0.75 m long stretched copper wire is fixed at its ends. It is then sent into vibration as shown in the following diagram. The sound that it produces has a frequency of 150 Hz. The speed of sound travelling in air is 333 ms^{-1}.



Question 1 Determine the wavelength of the vibration.

	m

1 mark

Question 2 Determine the speed of the travelling waves in the wire.

	ms^{-1}

2 marks

Question 3 Which one or more of the following open pipes could resonate with this vibration of the copper wire? (Not drawn to scale)

A. 0.25 m

B. 1.11 m

C. 0.50 m

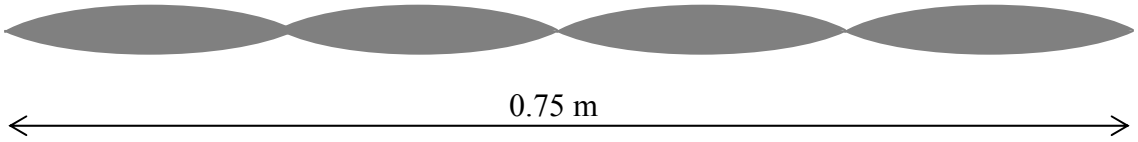
D. 2.22 m

E. 0.75 m

F. 3.33 m

2 marks

Now the same wire is sent into a different mode of vibration as shown in the following diagram.

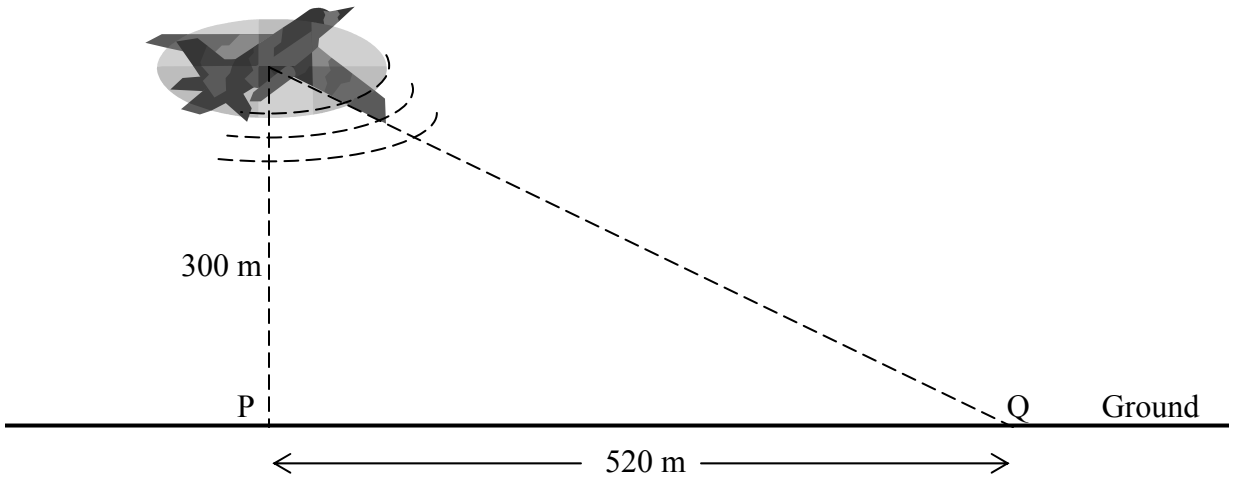


Question 4 What is the speed of the travelling waves in the wire?

	ms^{-1}

1 mark

The sound level of a low-flying fighter jet is measured at two locations on the ground. At location P directly below the fighter jet, the sound level is 102 dB. Assume that the reflection of sound from the ground is negligible. Refer to the diagram below for other measurements.



Question 5 Determine the sound level at location Q.

	dB

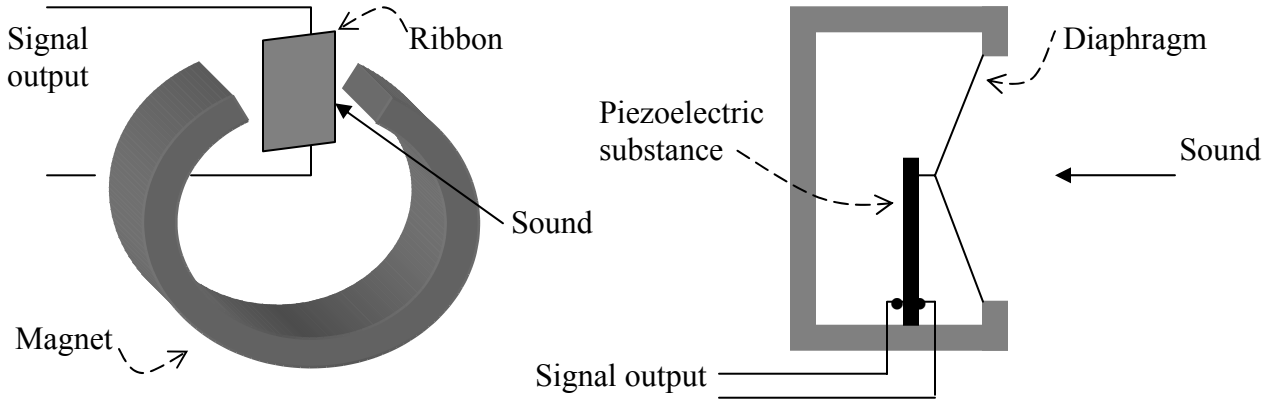
3 marks

Question 6 Estimate the acoustic power emitted by the fighter jet.

	kw

3 marks

The following diagrams show the construction of two types of microphones.



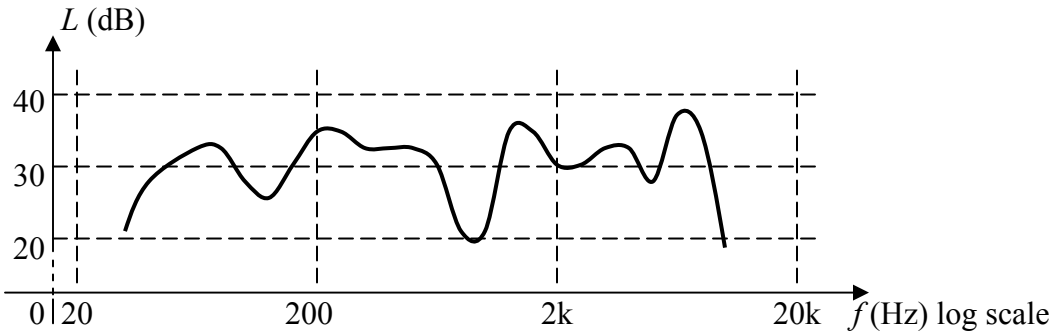
Microphone A Microphone B

Question 7 Identify the two types of microphones as dynamics, crystal, velocity or electret-condenser. Briefly explain the working of each microphone.

A	B

4 marks

The following graph shows the frequency response of a multi-speaker system (for questions 8, 9 and 10).



Question 8 Assess the fidelity of the system in terms of frequency response.

3 marks

Question 9 Explain why some frequencies are louder than others.

2 marks

Question 10 Estimate the value of the ratio $\frac{I_{2k}}{I_{200}}$, where I_{2k} is the sound intensity at 2k Hz and I_{200} is the sound intensity at 200 Hz.

2 marks

You will listen to more low frequency sound if you are in front of a speaker system that is located in the corner of a room.

Question 11 Explain this effect in terms of diffraction and reflection of sound.

2 marks

End of Exam 2