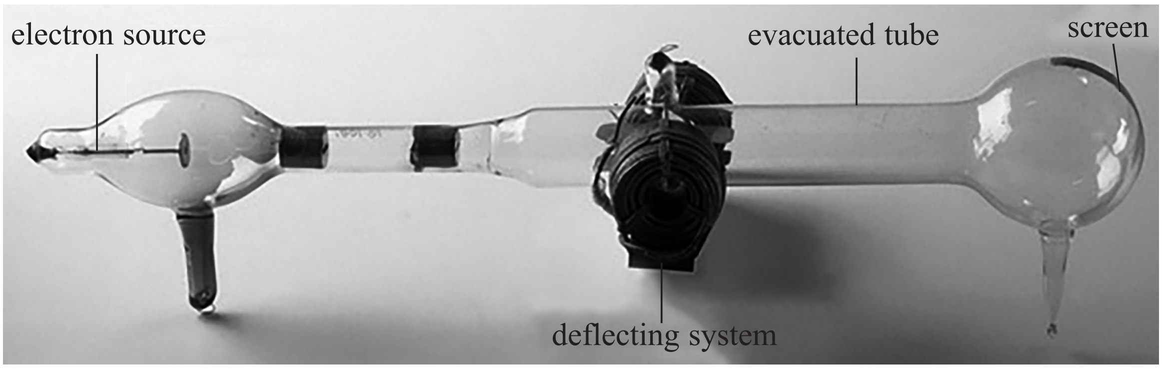
7 At the end of the 19th century, J.J. Thompson used electric and magnetic fields to deflect beams of charged particles. A photograph of his apparatus is shown.



Electrons were accelerated through a potential difference to produce a beam of high-energy electrons. The beam was then deflected in perpendicular directions by the magnetic and electric fields. The final position of the beam on the screen was determined by the charge and mass of the electrons.

(a) Explain how electrons from the source become a beam of high-energy electrons.

(2)

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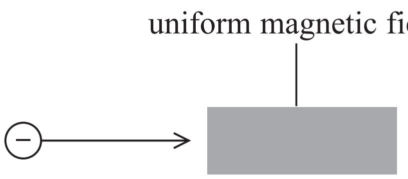
(b) An electron is travelling left to right and enters a region of uniform magnetic field as shown below. The direction of the magnetic field is perpendicular to the direction of travel of the electron.



(i) The magnetic field deflects the electron in the direction up the page.

Explain the direction of the magnetic field that would produce this deflection.

(2)

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(ii) Explain why the electron would travel in a circular path if no other forces acted on it.

(2)

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(c) In a modern version of Thompson's experiment, a uniform electric field of electric field strength E is applied so that the electric and magnetic forces on the electrons are equal and in opposite directions.

(i) Show that for electrons to be undeflected their velocity must be given by

$$v = \frac{E}{B}$$

where B is the magnetic flux density of the magnetic field.

(2)

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(ii) The beam is produced by accelerating electrons through a potential difference of 250 V. The electric field strength is $1.4 \times 10^4\,\text{V m}^{-1}$. The magnetic flux density is 1.5×10^{-3} T.

Calculate the value of the specific charge e/m for the electron using this data.

(3)

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e/m = ...

(d) In his original experiments, Thompson determined the specific charge of a range of particles. His results indicated that the specific charge of an electron is about 2000 times bigger than that for a hydrogen ion.

Deduce what conclusion can be made from this information.

(1)

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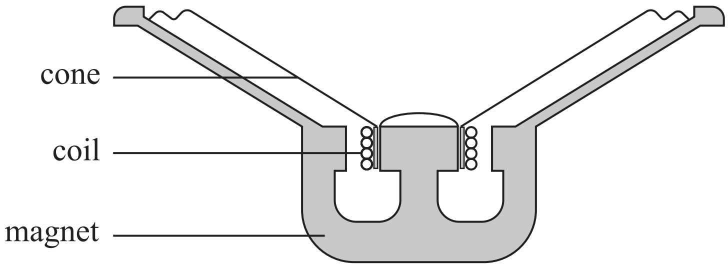
(Total for Question 7 = 12 marks)

9 A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate. The loudspeaker is mounted in a wooden box. A cross-section through the loudspeaker is shown.



A student made the following observations:

- when an alternating potential difference (p.d.) is applied to the coil, the cone oscillates
- the frequency of oscillation is the same as the frequency of the p.d.
- at particular frequencies, the box vibrates with a large amplitude.

*(a) Explain these observations.

(6)

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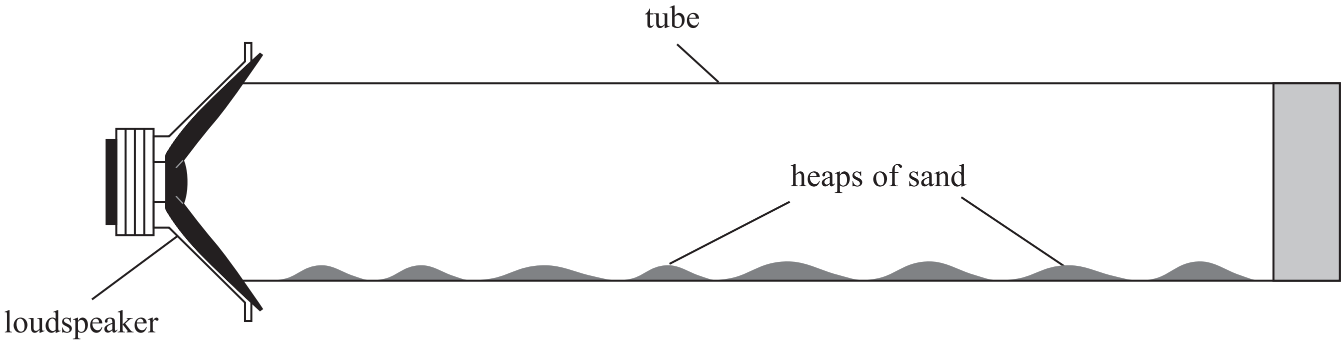
(b) The student connected a signal generator to the loudspeaker, and placed the loudspeaker near to one end of a long tube containing sand. The student adjusted the signal generator until the sand collected in small heaps as shown.



(i) Explain why the sand collects in heaps.

(4)

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(ii) The student determined the distance *d* between the centres of adjacent heaps.

Describe the procedure she should follow to determine an accurate value for *d*.

(3)

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(iii) Assess whether the experimental data is consistent with a value for the speed of sound of 340 m s^{-1}.

signal generator frequency = 3.25 kHz.

d = 5.1 cm

(3)

(Total for Question 9 = 16 marks)

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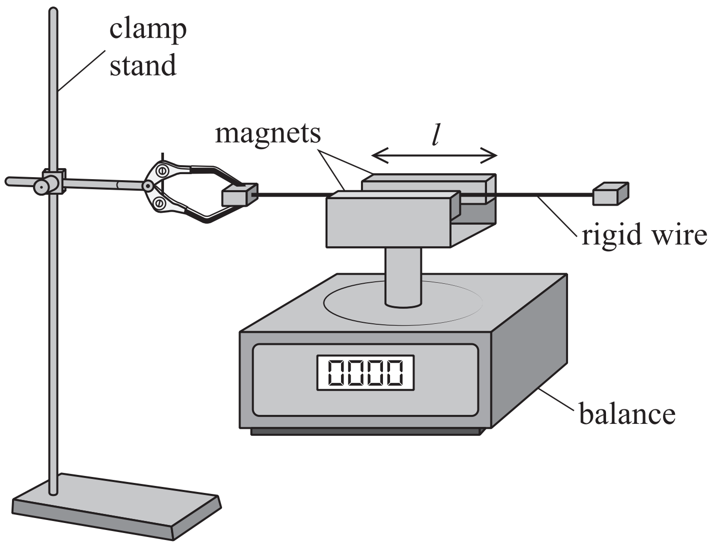
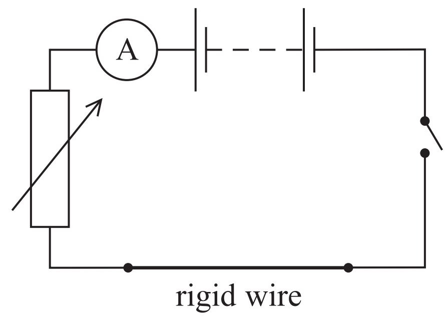
Answer ALL questions in the spaces provided.

1 A student set up the apparatus shown. A length of rigid wire was held horizontally by a clamp in a uniform magnetic field of flux density *B*.
The circuit connected to the rigid wire is also shown.





With the switch open, the balance was set to zero. When the switch was closed a current *I* in the circuit was recorded by the ammeter and the reading on the balance increased.

(a) The length *l* of wire in the magnetic field was 15.5 cm. When the current in the circuit was 4.55 A, the reading on the balance increased by 5.65 g.

Calculate the magnetic flux density *B* in the region of the rigid wire.

(3)

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B = ...

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P 6 7 0 9 8 A 0 2 3 6

(b) The student wrote the following statement

"The balance could read to the nearest 0.01 g, which makes my values for the magnetic force both accurate and precise."

Comment on this statement.

(3)

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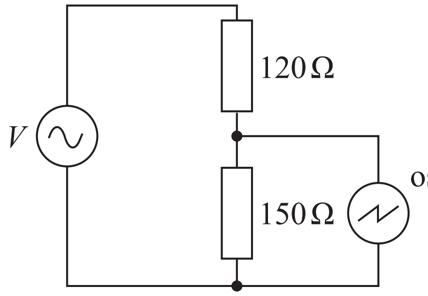
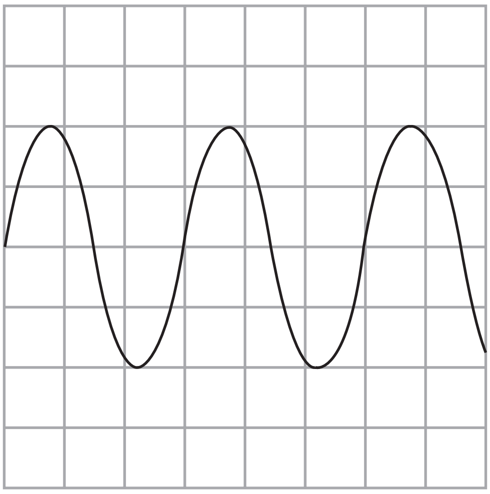
(Total for Question 1 = 6 marks)

7 A student connected the output from a source of alternating potential difference (p.d.) to a series resistor combination.

She connected an oscilloscope across the 150 Ω resistor as shown.



(a) The trace obtained on the oscilloscope is shown below.



(i) Determine the peak p.d. across the 150 Ω resistor.

y-sensitivity of oscilloscope = 2.0 V per division

(2)

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Peak p.d. across 150 Ω resistor = ...

(ii) Calculate the root mean square (r.m.s.) value of the current in the circuit.

(3)

r.m.s. value of current = ...

(iii) Calculate the power dissipated in the circuit.

(3)

Power dissipated in circuit = ...

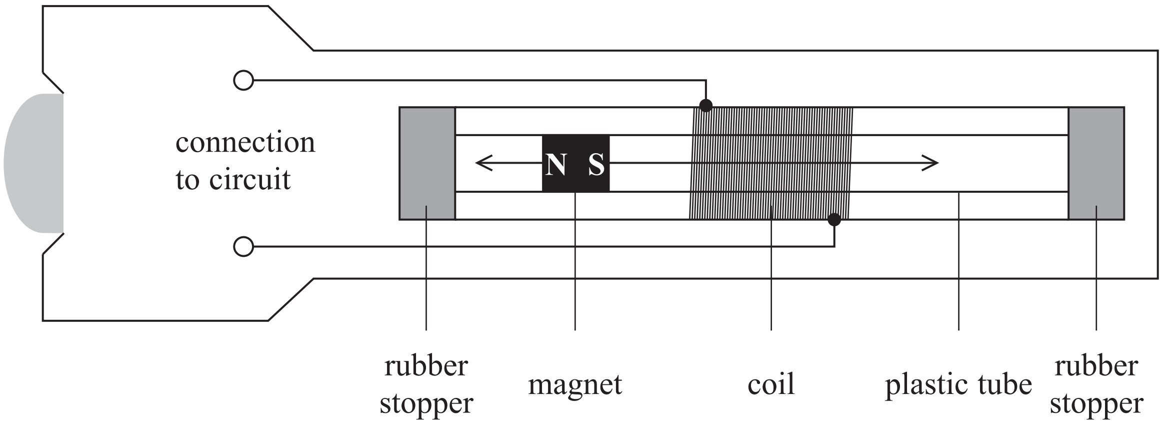
(b) Another student suggested that a voltmeter would be more accurate than using an oscilloscope to determine the magnitude of the p.d.

Comment on this suggestion.

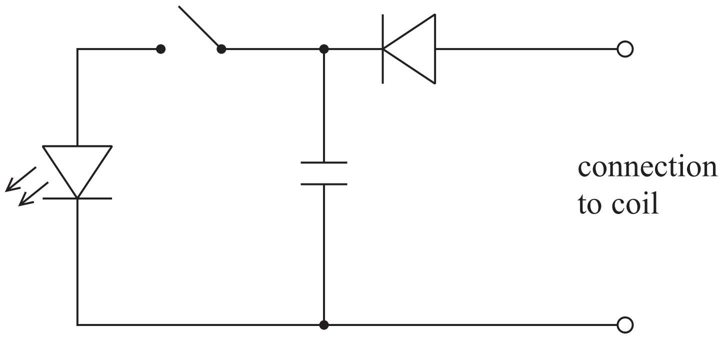
(3)

(Total for Question 7 = 11 marks)

*5 The diagram shows a 'shaker torch'. When the torch is shaken, a strong magnet moves forwards and backwards through a copper coil, powering a light-emitting diode (LED).



Each time the magnet moves through the coil a current pulse is generated. The coil is connected to a capacitor via a diode, as shown.



Once the torch has been shaken for a few minutes the switch is closed and the LED lights for a short while.

Explain how the shaker torch is able to light the LED.

(Total for Question 5 = 6 marks)