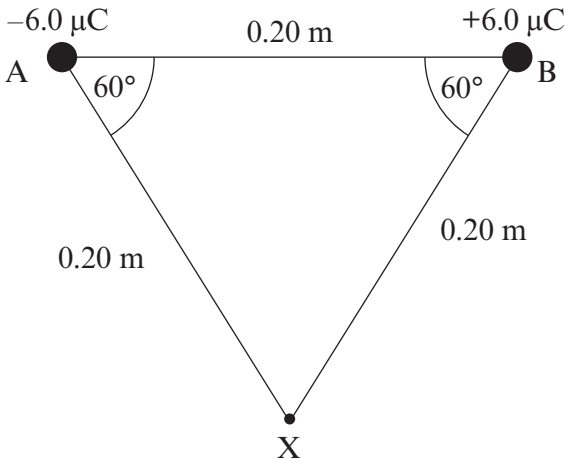
Examiner only

6. Two point charges of –6.0 μC and +6.0 μC are arranged at points A and B respectively as in the diagram. Point X lies as shown, with ABX being an equilateral triangle.



(a) Indicate clearly on the diagram the directions of

(i) the electric field at X due to the charge at A (label it E_A), [1]

(ii) the electric field at X due to the charge at B (label it E_B), [1]

(iii) the resultant (net) electric field at X due to the charges at A and B (label it E_R). [1]

(b) Calculate the magnitude of the resultant electric field at X, showing your working clearly. [3]

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(c) Point Y is at a distance 0.40 m to the right of B.

(i) Determine the electric potential at Y. [3]

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(ii) Calculate the work required to bring a small charge of +2.0 μC from a distant point to Y. [2]

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(iii) The small charge has a mass of $5{\cdot}0 \times 10^{-3}$ kg. If it is released from rest at point Y, determine its speed when it returns to a distant point. [2]

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7.

	Mean radius of planetary orbit / m	Orbital period / year
Earth	149.6×10^9	1.00
Jupiter	778.6×10^9	11.86

(a) State Kepler's three laws of planetary motion. [3]

(b) Show that the data above are consistent with Kepler's third law. [3]

Examiner only

(c) Explain what is meant by centripetal acceleration. [1]

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(d) Calculate the mass of the Sun. [4]

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THERE ARE NO MORE QUESTIONS IN THE EXAMINATION

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3. *(a)* (i) A capacitor has plates of area 8.2×10^{-4} m^2 and a separation of 0.77 mm. Calculate the capacitance of the capacitor assuming that there is air (or a vacuum) between the plates. [2]

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(ii) Keeping the dimensions of the capacitor the same, how could you increase its capacitance? [1]

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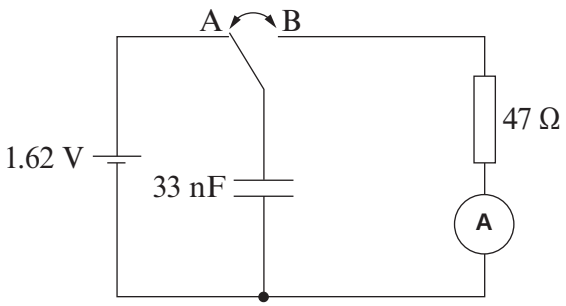
(b) Another capacitor is charged and discharged using the following circuit.



(i) Calculate the charge stored by the capacitor when fully charged. [2]

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(ii) The fully charged capacitor is now discharged through the 47 Ω resistor by moving the switch to B. Calculate the charge still remaining on the capacitor after it has been discharging for 50.0 μs and comment on the magnitude of your answer. [3]

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(iii) The capacitor is charged and discharged a total of 20 000 times per second. Calculate the average current through the ammeter. [2]

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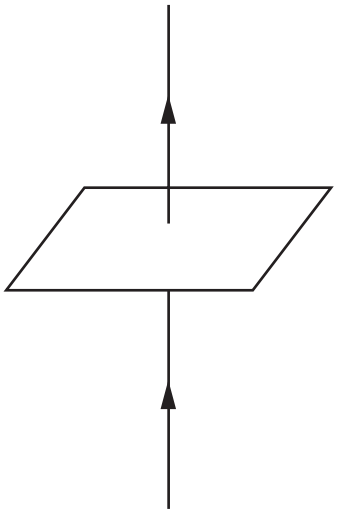
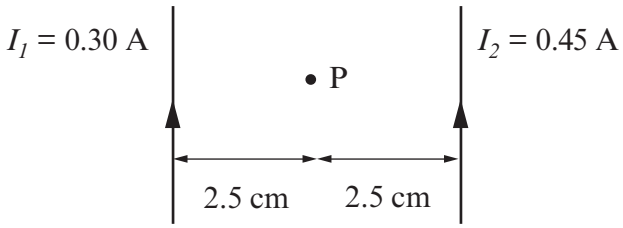
Examiner only

4. *(a)* Sketch the magnetic field due to the current-carrying wire shown. [2]



(b) Two long, straight wires carry currents as shown.



(i) Calculate the resultant magnetic field strength at point P in the above diagram and **state its direction**. [4]

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Examiner only

(ii) Explain why there is an attractive force between the two long wires in the diagram on the opposite page. [3]

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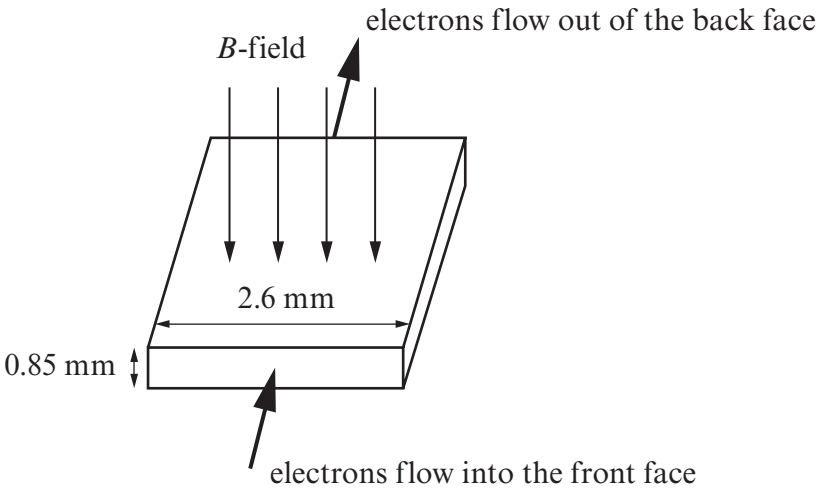
Examiner only

5. Electrons flow through a gold wafer which is used as a Hall probe.



(a) Explain which face of the wafer becomes negatively charged due to the Hall effect. [3]

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(b) The electric field due to the Hall voltage is 3.2×10^{-6} V m^{-1}. Calculate the Hall voltage. [2]

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Examiner only

(c) The following equation is used in conjunction with the Hall effect: $eE = Bev$. State what the forces eE and Bev are and explain why they are equal. [2]

(d) The current flowing in the wafer is 0.82 A and the concentration of free electrons in gold is 5.9×10^{28} m^{-3}. Calculate the magnetic field strength, B. [Hint: Use $I = nAve$] [3]

Examiner only

6. *(a)* State Faraday's law of electromagnetic induction. [2]

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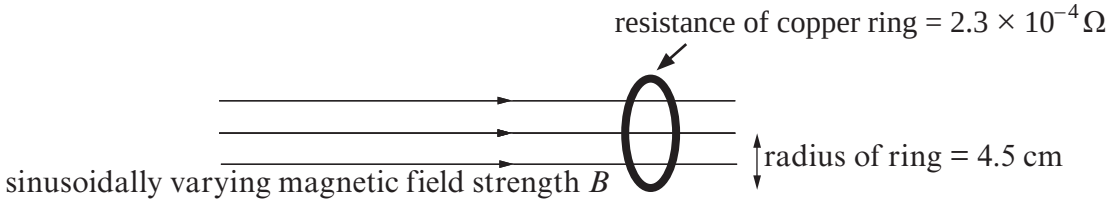
(b) A circular copper heating ring works by being placed in a sinusoidally varying magnetic field. A large sinusoidal current is then induced in the ring and the ring becomes hot (see below).



(i) The maximum rate at which the magnetic field strength changes is 72 T s^{-1}. Show that the maximum current flowing in the ring is approximately 2000 A. [4]

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(ii) Calculate the rms value of the induced current. [2]

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(iii) Calculate the mean power dissipated in the heating ring. [2]

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Examiner only

Option D: Biological Measurement and Medical Imaging

C11. *(a)* (i) Ultrasound can be used to carry out two different types of test, an amplitude scan (A-scan) and a brightness scan (B-scan). State the differences in the type of information obtained from an A-scan and a B-scan. [2]

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(ii) Give an example of when a B-scan would be used in medicine. [1]

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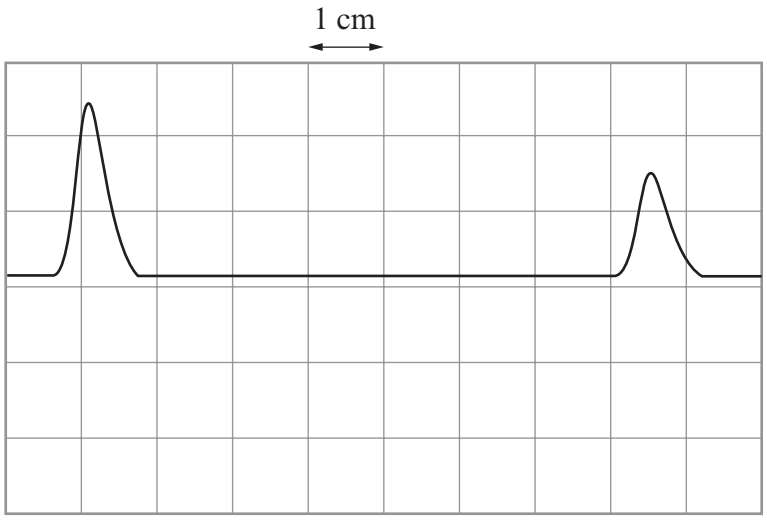
(iii) An A-scan is used to determine the thickness of a layer of skin and fat in a patient's body. The grid below shows the interval between the initial pulse and the reflected pulse on a cathode ray oscilloscope (CRO). The time base is set so that 1 cm represents 2 μs.



(I) If the speed of ultrasound in skin and fat is 1.45×10^3 m s^{-1}, calculate the thickness of the layer of skin and fat. [3]

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Examiner only

(II) How would the trace on the opposite page change if no gel was placed between the ultrasonic probe and the patient's skin? [1]

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(b) (i) X-ray tubes use a hot wire to produce electrons. What happens to the X-ray output if the current to the hot wire increases? Explain your answer. [2]

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(ii) An X-ray tube accelerates electrons through a potential difference of 80 kV, giving a **beam** current of 0.45 A. Calculate:

(I) the number of electrons reaching the target every second; [1]

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(II) the maximum photon energy of the X-rays produced. [1]

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(iii) Computerised axial tomography (CT scans) use a rotating X-ray tube to build up high contrast images of slices through the body. Explain why CT scans are **not** offered for regular checking of healthy patients. [1]

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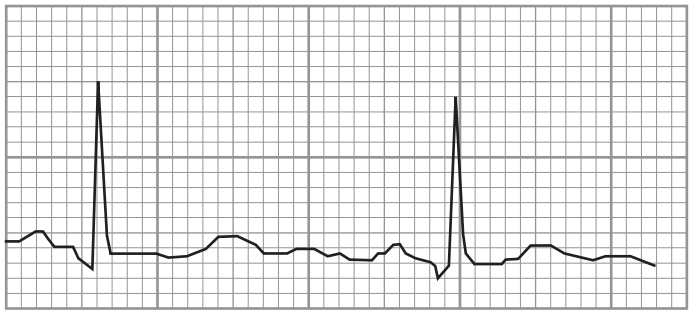
Examiner only

(c) Electrodes are placed on a healthy patient in order to record the electrical behaviour of the heart. One trace obtained is shown below.



Complete the graph by adding suitable axes, scales and units. [3]

(d) Explain, briefly, how Magnetic Resonance Imaging (MRI) can produce detailed images of slices through the body. [3]

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(e) When using ionising radiation in medicine the different types of radiation are given a Quality, or Q factor. Do beta particles have a higher, lower or the same Q factor as alpha particles? Explain your answer. [2]

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