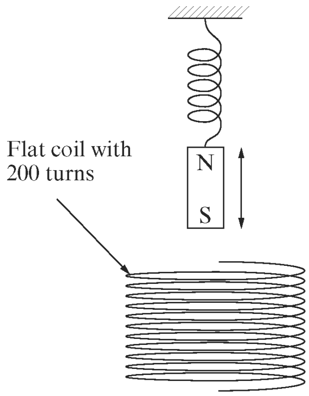
1. A strong magnet is held on a spring and performs simple harmonic motion near a flat coil as shown.



(a) Explain briefly why an alternating emf is induced in the coil. [3]

(b) (i) The induced emf varies in magnitude sinusoidally with a peak value of ±0.707 V. Calculate the rms value of the induced emf. [1]

(ii) State the value of the rate of change of flux through each turn of the coil when the peak value of 0.707 V is obtained and explain how you obtained your answer. [3]

(c) One end of the coil is connected with the other so that there is an induced current. Explain why the magnet's motion is now damped. [3]

2. *(a)* State the **two** laws of electromagnetic induction (Faraday's law and Lenz's law). [3]

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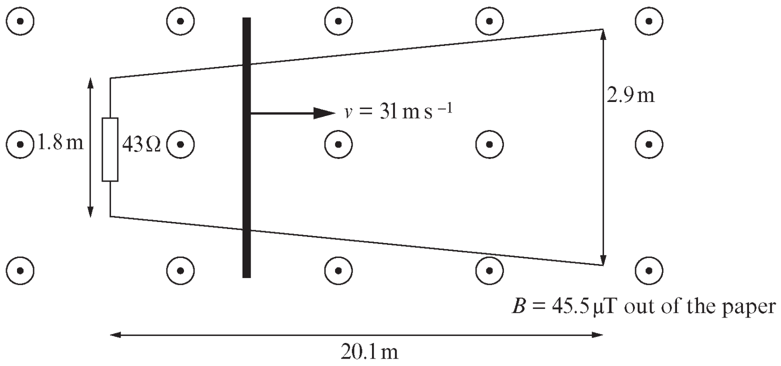
(b) A thick conducting bar is moved with constant speed over non-parallel conducting rails as shown below. The rails have negligible resistance and the *B*-field is uniform.



(i) Indicate the direction of the induced current on the diagram and explain how you arrived at your answer. [2]

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(ii) The conductor moves at a constant speed of $31\,\text{m s}^{-1}$. Use Faraday's law to explain why the induced emf increases. [2]

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(iii) The conductor starts moving from the end near the $43\,\Omega$ resistor. Calculate the mean current in the resistor when the conducting bar has travelled the full 20.1 m length of the track. [4]

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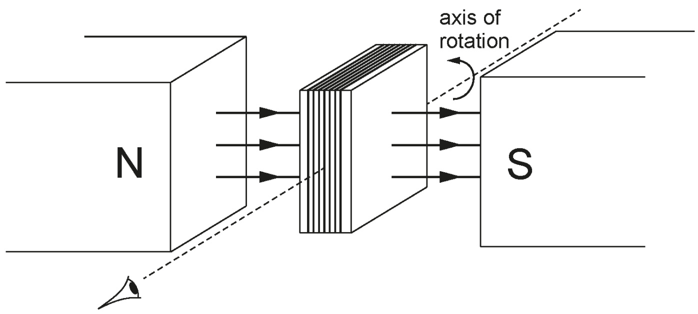
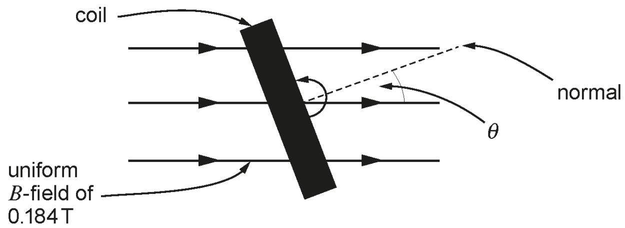
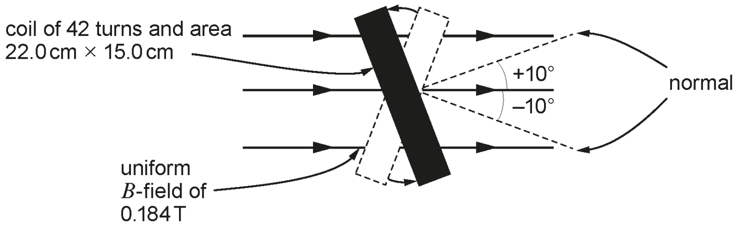
3. A rectangular coil rotates at a constant angular velocity within a uniform magnetic field. The coil has 42 turns and area 22.0 cm × 15.0 cm. The diagram below is a simplified 3D diagram of the coil when the magnetic field is perpendicular to the coil.



The second diagram is a 2D representation of the coil looking along the axis of rotation.



(a) (i) Calculate the flux **linkage** of the coil for the angles $\theta = -10°$ and $\theta = +10°$. [2]



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(ii) Explain why the mean induced emf is zero as the coil moves between $\theta = -10°$ and $\theta = +10°$. [1]

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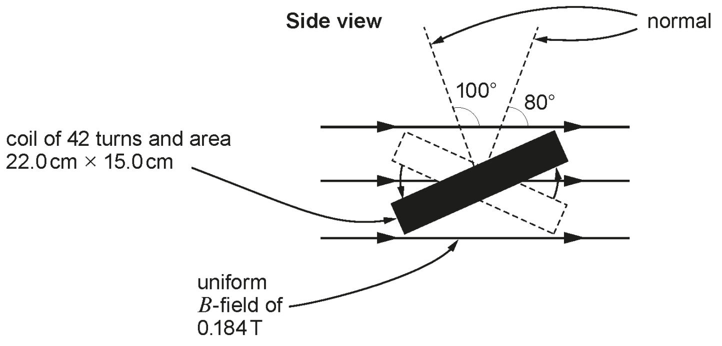
(b) Calculate the mean induced emf in the coil when the angle θ changes from 80° to 100° if the period of rotation of the coil is 0.100 s. [4]



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(c) An oscilloscope is used to display the sinusoidal emf in a different coil rotating at a frequency of 12.5 Hz and producing an **rms** pd of 12.0 V. The oscilloscope settings are 5 V per division (vertically) and 20 ms per division (horizontally). Sketch a trace that might be seen on the oscilloscope. (Space is provided for your workings.) [3]

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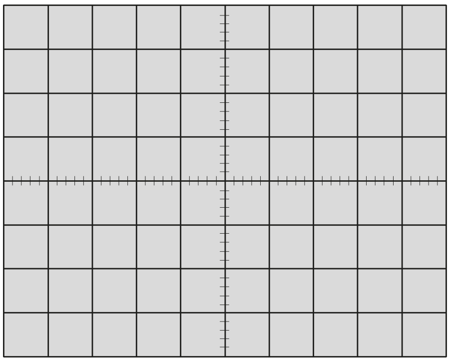
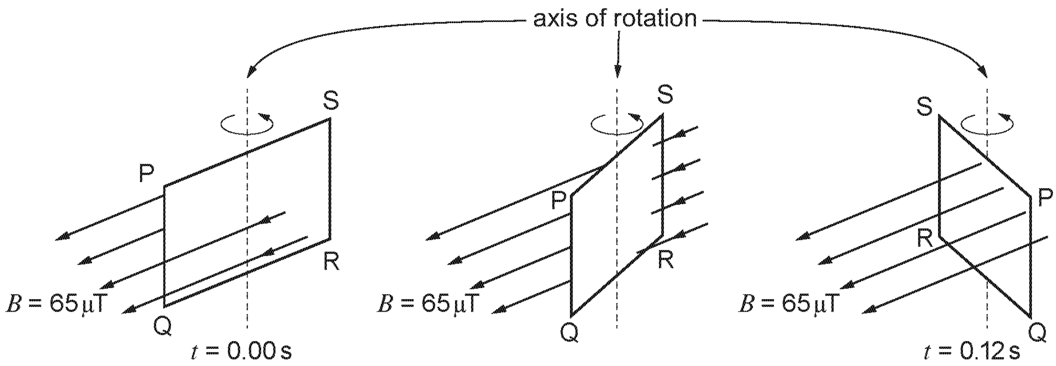


4. A large square loop has sides of length 0.815 m and is rotated through 90° in a uniform magnetic field of 65 μT. The diagrams show the same square loop at different times.



(a) Determine the magnetic flux through the square loop: [3]

(i) when t = 0.00 s (sides QR and SP are parallel to the B-field);

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(ii) and when t = 0.12 s (PQ, QR, RS and SP are perpendicular to the B-field).

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(b) The square loop is made of copper. Explain why there is a current in the loop as it is rotated. [2]

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(c) Explain how Lenz's law will give the direction of the forces acting on the sides PQ and RS as the square loop is rotated. [2]

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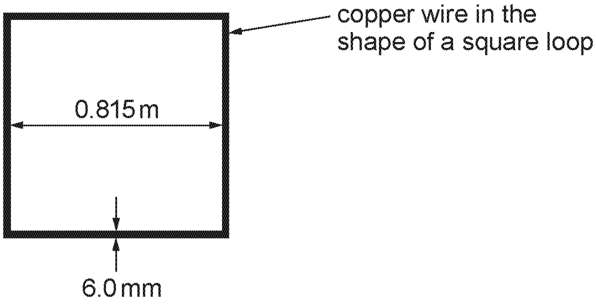
(d) The copper wire from which the square loop is made has a circular cross-section of diameter 6.0 mm. The resistivity of copper is $1.67 \times 10^{-8}\,\Omega\,m$. Calculate the **mean** current flowing through the square loop as it is rotated between t = 0.00 s and t = 0.12 s. [5]



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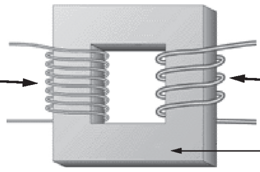
5. **Option A: Further Electromagnetism and Alternating Currents**

(a) Explain how an alternating current in the primary coil leads to an alternating emf in the secondary coil. [3]



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(b) State and explain briefly **three** ways in which the design of a transformer reduces energy losses. [3]

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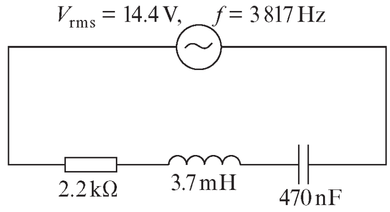
(c) (i) Calculate the reactances of the capacitor and inductor at the frequency shown. [3]



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(ii) How can you tell that this is the resonance frequency of the circuit? [1]

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(iii) Calculate the current at the resonance frequency of 3 817 Hz. [1]

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(iv) Calculate the current when the frequency is 38.17 kHz (the rms pd remains 14.4 V). [3]

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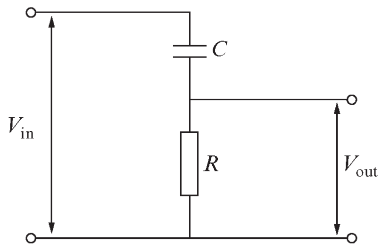
(d) (i) Explain why the circuit shown is a high pass filter. [3]



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(ii) $C = 470\,\text{nF}$ and $R = 2.2\,\text{k}\Omega$. Using a phasor diagram or otherwise, calculate the frequency when $V_{out} = \frac{1}{\sqrt{2}} V_{in}$. [Hint: $\cos 45° = \frac{1}{\sqrt{2}}$.] [3]

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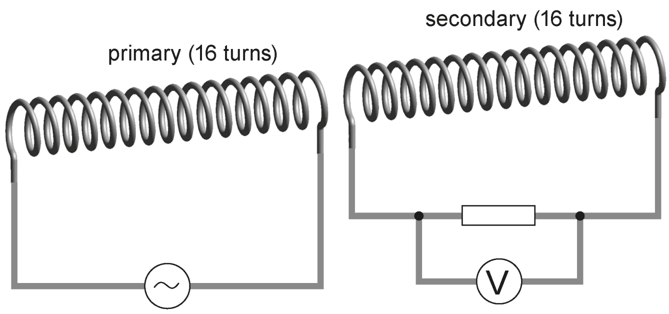
6. *(a)* A sinusoidal pd of 6 V (rms) and frequency 0.9 Hz is supplied to the primary solenoid.



(i) State how the reading on the voltmeter varies and explain what causes the voltmeter reading to vary. [4]

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(ii) Give a reason why the rms pd measured by the voltmeter will be much lower than 6 V. [1]

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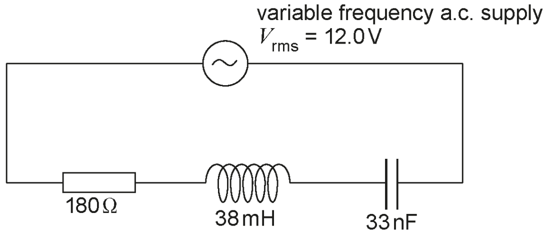
(b) For the following circuit:



(i) calculate the resonance frequency; [2]

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(ii) calculate the rms pd across each component at resonance. [4]

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(c) The frequency of the a.c. supply is now set to 5.8 kHz.

(i) Calculate the rms current. [3]

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(ii) Calculate the phase angle between the current and the applied pd (a phasor diagram may assist your calculation). [3]

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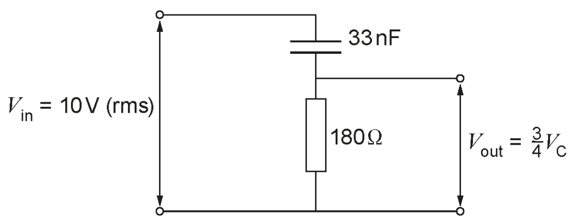
(d) In the high pass filter shown the rms output pd is $\frac{3}{4}$ of the rms pd across the capacitor.



Calculate the frequency of the input pd. [3]

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