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90523

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NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

For Supervisor's use only

Level 3 Physics, 2008

90523 Demonstrate understanding of electrical systems

Credits: Six
9.30 am Tuesday 25 November 2008

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions in this booklet.

For all numerical answers, full working must be shown. The answer should be given with an SI unit to an appropriate number of significant figures.

For all 'describe' or 'explain' questions, the answers should be written or drawn clearly with all logic fully explained.

Formulae you may find useful are given on page 2.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

For Assessor's use only	**Achievement Criteria**		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Identify or describe aspects of phenomena, concepts or principles. ☐	Give descriptions or explanations in terms of phenomena, concepts, principles and / or relationships. ☐	Give explanations that show clear understanding in terms of phenomena, concepts, principles and / or relationships. ☐
Solve straightforward problems. ☐	Solve problems. ☐	Solve complex problems. ☐
Overall Level of Performance (all criteria within a column are met) ☐		

You are advised to spend 55 minutes answering the questions in this booklet.

You may find the following formulae useful.

$$V = Ed \qquad \Delta E = Vq \qquad E = \tfrac{1}{2}QV \qquad Q = CV \qquad P = VI$$

$$C = \frac{\varepsilon_o \varepsilon_r A}{d} \qquad C_T = C_1 + C_2 + C_3 + \ldots \qquad \tau = RC \qquad V = IR$$

$$\frac{1}{C_{\mathrm{T}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \qquad R_{\mathrm{T}} = R_1 + R_2 + \ldots \qquad \frac{1}{R_{\mathrm{T}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

$$\phi = BA \qquad \varepsilon = -L\frac{\Delta I}{\Delta t} \qquad \varepsilon = -\frac{\Delta \phi}{\Delta t} \qquad \varepsilon = -M\frac{\Delta I}{\Delta t}$$

$$\frac{N_{\mathrm{p}}}{N_{\mathrm{s}}} = \frac{V_{\mathrm{p}}}{V_{\mathrm{s}}} \qquad E = \tfrac{1}{2}LI^2 \qquad \tau = \frac{L}{R} \qquad I = I_{\mathrm{MAX}} \sin \omega t$$

$$V = V_{\mathrm{MAX}} \sin \omega t \qquad I_{\mathrm{MAX}} = \sqrt{2}\, I_{\mathrm{rms}} \qquad V_{\mathrm{MAX}} = \sqrt{2}\, V_{\mathrm{rms}} \qquad X_c = \frac{1}{\omega C}$$

$$X_L = \omega L \qquad V = IZ \qquad \omega = 2\pi f \qquad f = \frac{1}{T}$$

QUESTION ONE: TORCH INVESTIGATION

Jess is investigating a torch to find out the characteristics of the battery and the lamp. The torch uses a filament lamp. The filament is a long coil of fine wire that heats up and glows when it carries sufficient current. For the purposes of calculation, assume that the resistance of the filament remains constant.

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Close-up of a filament in a lamp.
http://content.answers.com/main/content/wp/en/thumb/2/24/300px-Thermionic_filament.jpg

Assessor's use only

Jess measures the battery voltage when the lamp is switched off and finds the voltage to be 6.12 V. When Jess switches on the lamp, the voltage drops to 5.87 V. The current through the lamp is then 0.743 A.

(a) Name the term used for the potential difference measured when no current is drawn from the battery.

(b) Show that the working resistance of the lamp is 7.90 Ω.

(c) Show that the internal resistance of the battery is 0.336 Ω.

(d) Describe and explain what would be observed if a battery with a higher internal resistance was used in the torch. (Assume that the resistance of the lamp remains constant.)

(e) Calculate the current that travels through the battery if a second identical lamp is connected in parallel with the first lamp.

current = _____

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Jess suggests that it could take a few milliseconds for the lamp to reach full brightness when it is switched on, and that the lamp's filament coil could be acting as an inductor.

(f) Assuming the time constant for the filament is 1.2 ms calculate the inductance of the filament coil. Give your answer to the correct number of significant figures.

inductance = _____

(g) Inductance can be defined from the equation $\varepsilon = -L\frac{\Delta I}{\Delta t}$.

Use **this definition** to explain why an inductor would delay a bulb reaching full brightness after it is switched on.

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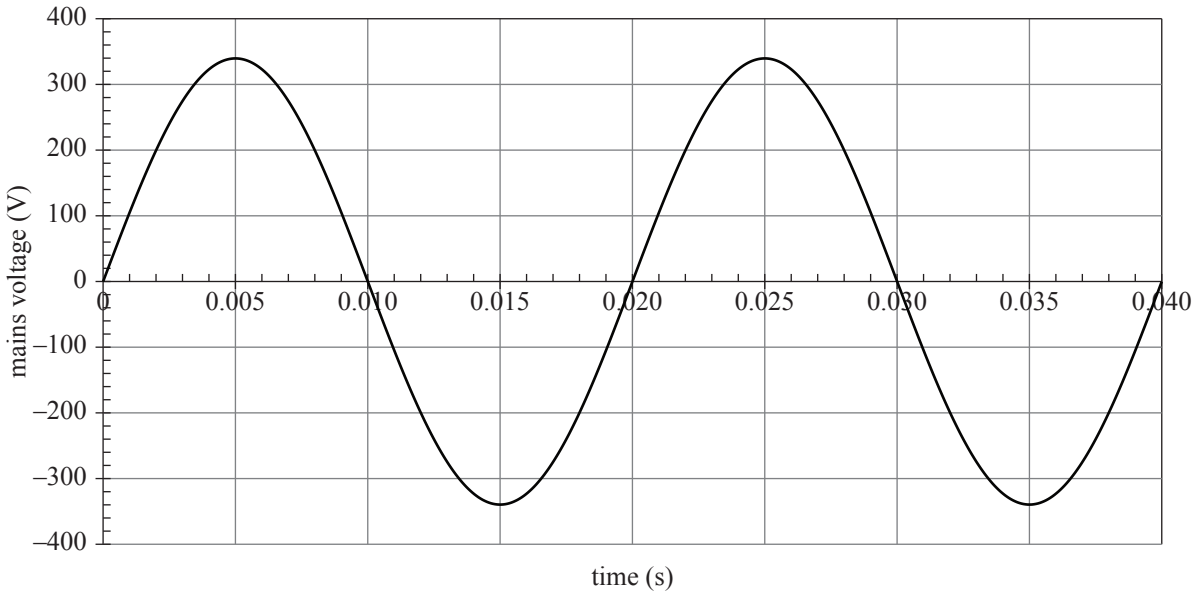
The lamp is connected to an AC supply from a transformer. The supply for the transformer is a 50 Hz mains supply, with a peak voltage of 340 V. The graph below shows the variation of the mains supply with time.



(h) Use the graph to show that the maximum rate of change of voltage in the primary coil of the transformer is approximately 100×10^3 V s^{-1}.

(i) The output of the transformer from the secondary coil is labelled '6 V AC'. The lamp connected to this output appears to light with the same brightness as it did when it was connected to the battery.

Explain whether the 6 V from the secondary coil of the transformer output is a peak value or an rms value.

(j) The current in the primary coil changes at a maximum rate of 8.7 A s^{-1}.

Calculate the mutual inductance of the transformer.

mutual inductance = _____

QUESTION TWO: THE INDUCTION COOKER

Assessor's use only

Sam has an induction cooker and wants to find out how it works.

After doing some research, Sam finds that it operates by having a coil of wire underneath an insulating surface. A high frequency alternating current is passed through the coil with a frequency of 27.0×10^3 Hz.

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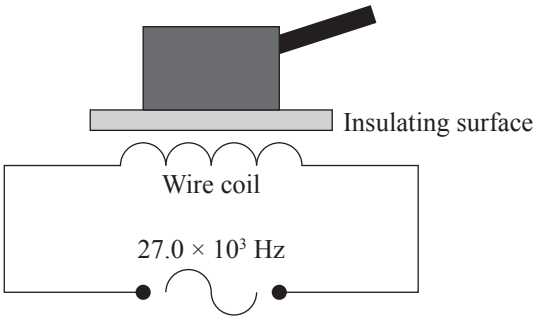
www.zealux.com/images/cookers/ZLIC180675.jpg



(a) The arrangement can be used to generate heat within a **metal** pan placed above the coil.

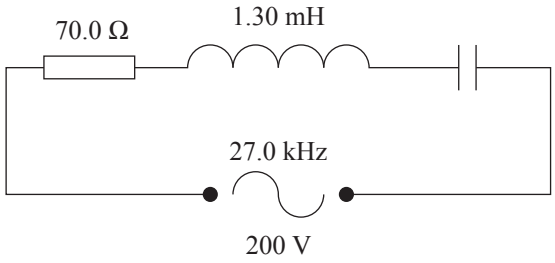
Explain how this occurs.

The coil used in a particular induction cooker is found to have an inductance of 1.30 mH.

(b) Show that when the frequency of the alternating current is 27.0×10^3 Hz, the reactance of the coil is 221 Ω.

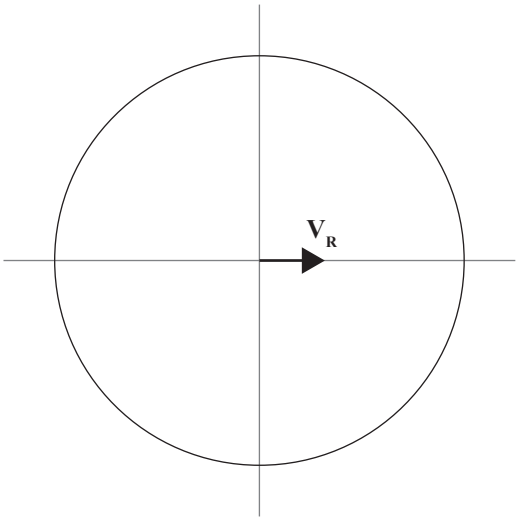
Assessor's use only

In reality the inductor is part of an LCR circuit as shown below. The resistor has a resistance of 70.0 Ω and the capacitor has a reactance of 358 Ω at 27.0×10^3 Hz.



(c) Show that the capacitance of the capacitor is 1.65×10^{-8} F.

The phasor diagram below shows the phasor representing the resistor voltage.



(d) On the phasor diagram sketch the phasors representing:

(i) the capacitor voltage

(ii) the inductor voltage

(iii) the supply voltage.

(Distances and angles should show the approximate relative size and direction of each phasor.)

(e) Calculate the rms current flowing in this LCR circuit if the rms value of the supply voltage is 200 V.

rms current = _____

Assessor's use only

(f) Placing an iron saucepan on the hob increases the heating effect of the coil.

Explain how an **iron** cooking pan close to the coil alters the inductance of the coil.

_____

_____

(g) The iron saucepan has the effect of bringing the circuit to its resonance condition.

Describe the condition for resonance in an AC circuit.

_____

_____

(h) Calculate the rms current in the circuit at resonance.

_____

_____

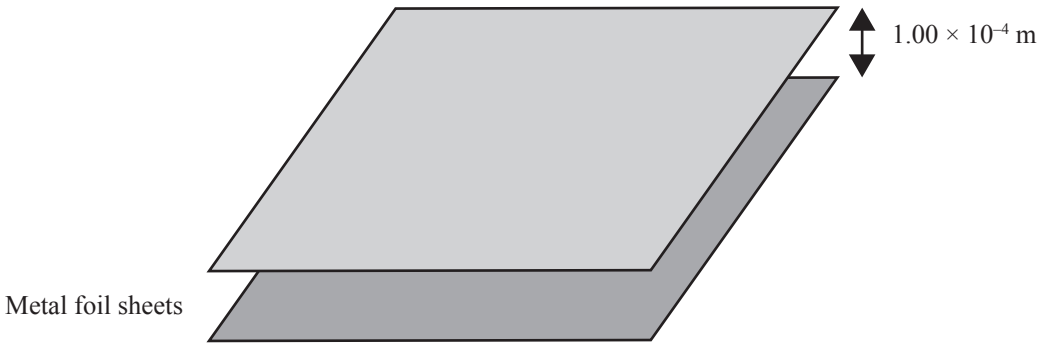
rms current = _____

QUESTION THREE: THE CAPACITOR

Assessor's use only

The permittivity of free space = 8.84×10^{-12} F m^{-1}

The capacitor in the induction cooker has a capacitance 1.65×10^{-8} F. Sam wanted to make a capacitor of this capacitance using two metal foil sheets.



The two sheets of foil are separated by a layer of air 1.00×10^{-4} m thick.

(a) Calculate the area of the foil sheets that Sam should use.

area = _____

(b) State two ways that Sam could increase the capacitance using the same pieces of foil.

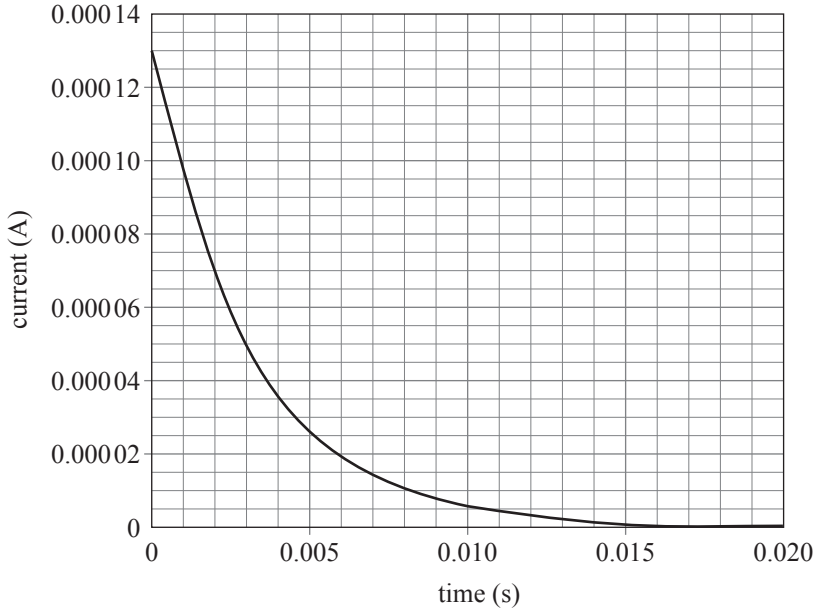
(1) _____

(2) _____

Assessor's use only

After making the capacitor, Sam checked the value of its capacitance by charging it in a circuit in series with a resistor and a 19.5 V DC supply.
A graph of current versus time for the charging circuit is shown below.

Graph of current vs time



(c) Show that the resistance of the resistor is 150 k Ω.

(d) Determine the actual capacitance of the capacitor.

capacitance = _____

Extra paper for continuation of answers if required.
Clearly number the question.

Assessor's use only

Question number