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90523

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Level 3 Physics, 2006

90523 Demonstrate understanding of electrical systems

Credits: Six
9.30 am Monday 20 November 2006

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, and the answer must be rounded to the correct number of significant figures and given with an SI unit.

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 2–10 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.

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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.

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

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

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \qquad R_T = R_1 + R_2 + \ldots \qquad \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

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

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} \qquad E = \tfrac{1}{2}LI^2 \qquad \tau = \frac{L}{R} \qquad I = I_{\mathrm{MAX}} \sin \omega t$$

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

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

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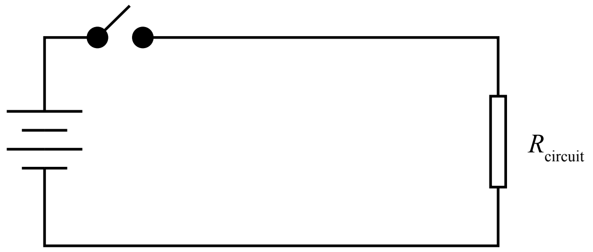
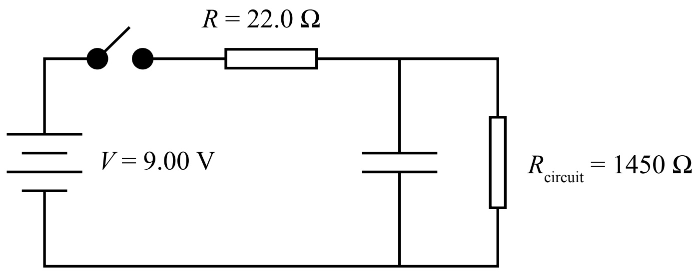
QUESTION ONE: SWITCH BOUNCE

When an ideal switch is closed, the contacts touch one another and the circuit is completed instantaneously. In many real switches the contacts will 'bounce' a few times before making permanent contact. This means that the circuit is switched on and off rapidly as the contacts bounce.



The effects of switch 'bounce' can be minimised using the circuit modification shown. Assume this modification is in place when answering the following questions.



(a) Describe the charge flow in the circuit when the switch first **closes** and completes the circuit.

(b) State why there will still be a current through $R_{circuit}$ when a bounce **opens** the switch and breaks the circuit.

When the switch is opened, the time constant for the circuit is 0.11 s.

(c) (i) Show that the capacitance of the capacitor has an unrounded value of 7.5862×10^{-5} F.

(ii) Round this value to the appropriate number of significant figures.

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(d) Calculate the charge on the capacitor plates when the voltage across them is 5.5 V.

charge =

(e) The time between the first contact completing the circuit and the first bounce breaking it is very short. Explain why the time constant for the charging circuit must be **even shorter**.

(f) Calculate the voltage across the capacitor when the circuit has been closed for some time (ie when the current in the circuit has become constant).

voltage =

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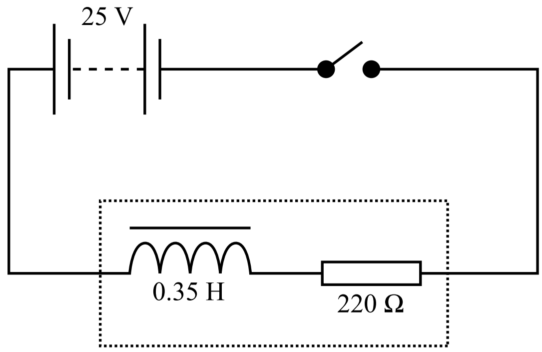
QUESTION TWO: SNUBBER SWITCH

In a DC inductor circuit there is an important difference between switching on and switching off.



In the circuit shown above, the inductor has inductance 0.35 H and has internal resistance of 220 Ω. The switch is closed, and after a time of 8.0×10^{-3} s, the circuit current has reached a value that is sufficiently close to the steady current value for any difference to be ignored.

(a) Show that the average voltage induced in the inductor during this time period is 5.0 V.

(b) Calculate the flux in the coil after this time period.

flux =

(c) Explain why, when the switch is opened, the **maximum** induced voltage will be much larger than when the switch is closed.

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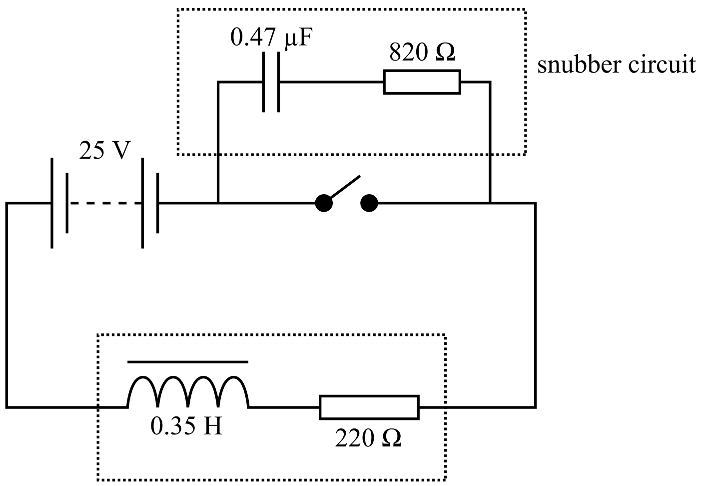
This very large induced voltage can sometimes cause arcing (a spark to travel) across the switch contact plates. One way to prevent this from happening, is to use a 'snubber' switch. (The sudden rise in voltage across the switch contact, caused by the contact opening, will be moderated by the capacitor's charging action.)

The diagram shows a simple snubber circuit connected across the switch. The capacitor has capacitance 4.7×10^{-7} F.



(d) After the switch has been opened and the voltage across the capacitor has reached a steady value, explain how this capacitor voltage will relate to the voltage of the source.

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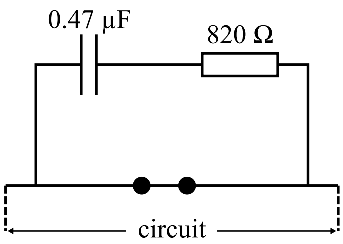
(e) By first calculating the charge on the capacitor (or otherwise), calculate the energy stored in the capacitor when the voltage across it is 25 V.

energy =

(f) When the switch is closed again (as shown in the diagram), explain what will happen to this stored energy.



(g) Explain why the presence of the **resistor** in the snubber circuit protects the switch.

QUESTION THREE: REED SWITCH

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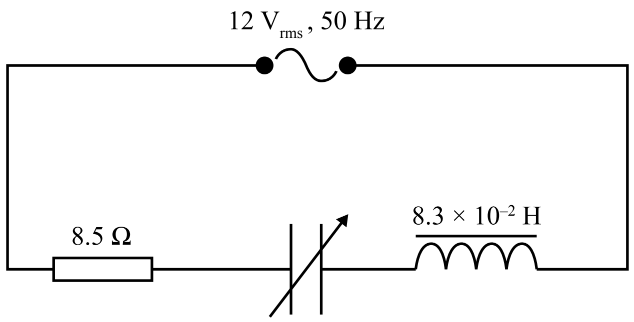
A reed switch is operated by a changing magnetic field. One way to change the magnetic field is to change the current in an inductor. This could be done using the circuit below.

In the circuit below, the 12 V supply has a frequency of 5.0×10^1 Hz.



(a) Calculate the angular frequency of the supply.

angular frequency = ______

(b) Show that the reactance of the inductor is 26 Ω.

(c) The current in the circuit is 0.42 A. Calculate the reactance of the capacitor.

reactance = ______

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(d) Explain how changing the capacitance of the capacitor affects the current in the circuit.

(e) Calculate the current in the circuit at resonance.

current =

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

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Question number