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SUPERVISOR'S USE ONLY

91526

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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Physics, 2014

91526 Demonstrate understanding of electrical systems

2.00 pm Tuesday 25 November 2014
Credits: Six

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of electrical systems.	Demonstrate in-depth understanding of electrical systems.	Demonstrate comprehensive understanding of electrical systems.

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 attempt ALL the questions in this booklet.

Make sure that you have Resource Booklet L3–PHYSR.

In your answers use clear numerical working, words and/or diagrams as required.

Numerical answers should be given with an SI unit, to an appropriate number of significant figures.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–8 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.

Not Achieved

TOTAL 05

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QUESTION ONE: AC

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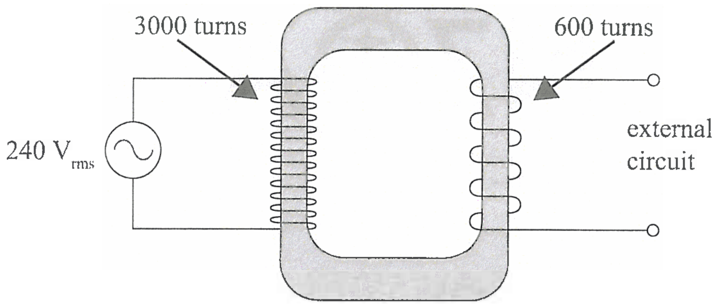
The ideal transformer shown below has 3000 turns in its primary coil, and 600 turns in the secondary coil. A 240 V_{rms} AC power supply is connected across the primary coil. The secondary coil is connected to an external circuit.



(a) (i) Calculate the rms voltage across the external circuit.

$240 \times 3000 = 720000$

$V_{RMS} = \frac{V_{max}}{\sqrt{2}} = \frac{720000}{\sqrt{2}} = \frac{509116.88}{600} = 848 V$

incorrect formula

na

(ii) Calculate the peak voltage across the external circuit.

$V_{max} = \sqrt{2} V_{RMS}$

$V_{max} = \sqrt{2} \times 848.582$

$= 1200V$

c

a

(b) Explain why rms values are often used to describe AC voltages.

This is because alternating current changes / alternates all the time, and so to get a proper value for it, we must take the RMS values of it instead.

Vague explanation

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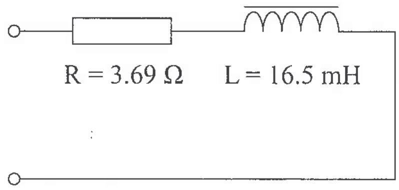
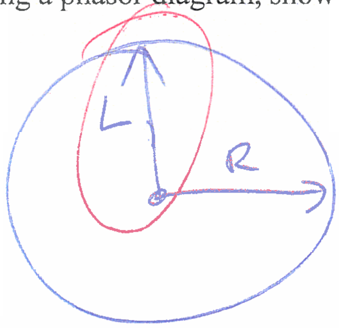
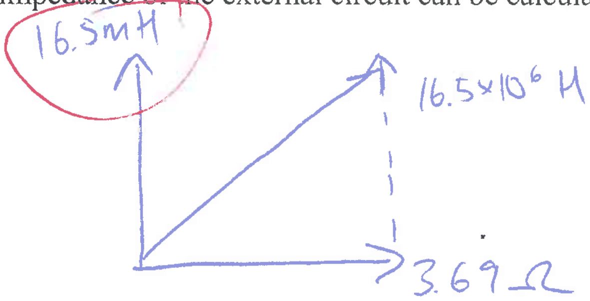
(c) The external circuit consists of a resistor and an inductor as shown.
The frequency of the power supply is 50.0 Hz. f



By drawing a phasor diagram, show how the impedance of the external circuit can be calculated.





Vector diagram shown, use pythagoras to calculate the impedence

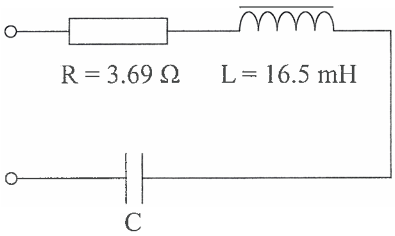
$Z = \sqrt{R^2 + L^2}$ incorrect formula

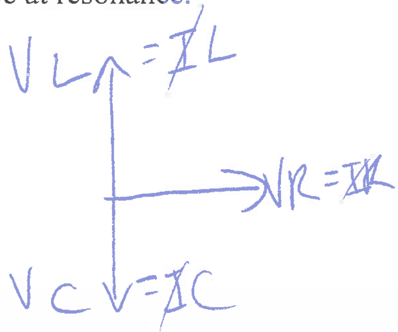
$= \sqrt{3.69^2 + (16.5\times10^6)^2}$

$= 16500000$

na

(d) A capacitor is added to the external circuit, causing the circuit to be at resonance.





Determine the rms voltage across the capacitor.

$V = \sqrt{R^2 + (L-C)^2}$

$V = \sqrt{3.69^2 + }$

no understanding of resonance

na

N1

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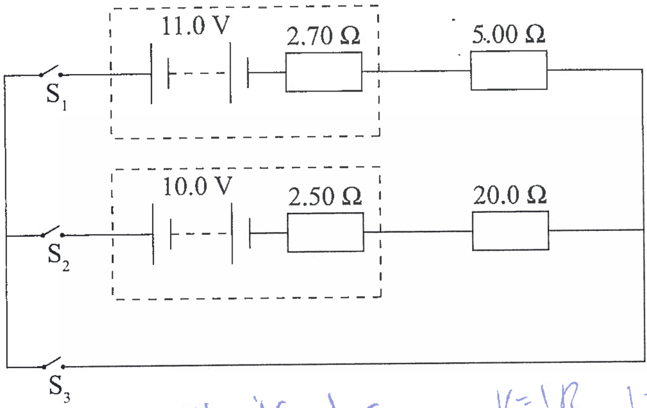
QUESTION TWO: BATTERIES



V ~~V~~ $V - Ir$ $V = IR$ $I = \frac{V}{R}$

The circuit diagram shows two batteries connected into a circuit. The internal resistance, r_1, of the 11.0 V battery is 2.70 Ω, and the internal resistance, r_2, of the 10.0 V battery is 2.50 Ω.

(a) Switches S_1 and S_2 are closed and switch S_3 is left open.

Show that the current in the circuit is 0.0331 A.

Tot $V = 11 - 2.7I + 5I = 11 + 2.3I$

$V = 10 - 2.5I + 20I = 10 + 17.5I$

$11 + 2.3I + 10 + 17.5I = V_{tot}$

$21 + 19.8I = V_{tot}$

incorrect formula

na

(b) In which direction will the current be flowing through switch S_1?

Explain your answer.

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(c) Switch S_3 is now closed so all three switches are closed.

Show, using Kirchhoff's laws, that the current through switch S_3 is 1.87 A.

Kirchoff's current law states that no energy is lost at a junction.

na

(d) Switch S_1 is now opened, leaving switches S_2 and S_3 closed. After this circuit has been operating for some time, the 10.0 V battery starts to go flat. A student suspects that this is caused by an increase in the internal resistance.

Explain what effect a changing internal resistance has on the power delivered to the 20.0 Ω resistor.

A full answer will include some sample calculations.

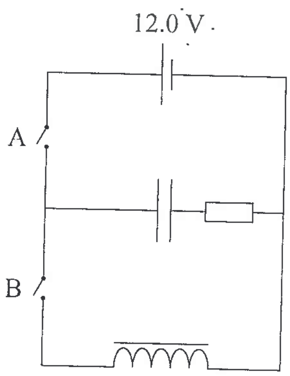
If the internal resistance reaches say 3Ω, this means according to ~~V=Ir~~ V = U − Ir, the 10V battery voltage will decrease. So supply voltage decreases and since power is given by P = IV, power and voltage are directly proportional and so the power delivered to 20.0Ω resistor will be less.

identified that Power would be less

a

N1

QUESTION THREE: ENERGY



(a) In the circuit above, switch B is kept open and switch A is closed, allowing charge to flow onto the plates of the capacitor.

Explain why the voltage of the capacitor rises to the voltage of the battery.

The charge from the battery build up on each side of the capacitor plates, one side with positive charge and the other with electrons, until it reaches the voltage that the battery had

(b) When the capacitor in the circuit above is fully charged, it carries a charge of 8.60×10^{-3} C.

Calculate the energy stored in the capacitor when it is fully charged.

$E = \frac{1}{2} QV = \frac{1}{2} \times 8.6 \times 10^{-3} \times 12$

$= 0.0516 \text{ J}$

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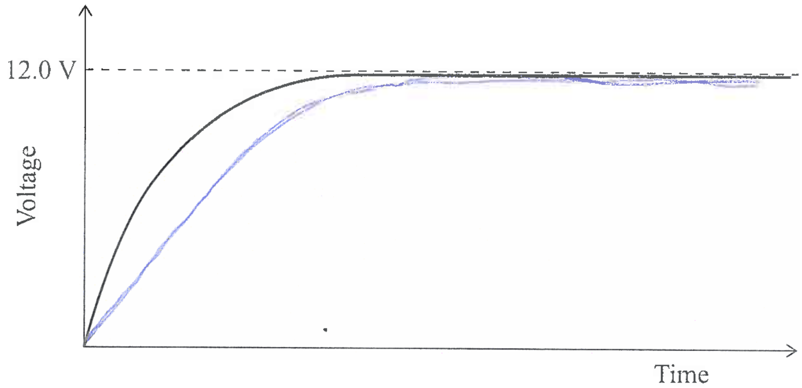
(c) The graph below shows the relationship between voltage and time as the capacitor charges.



a

Sketch another curve on the graph to show the effect of an increased resistance on the charging of the capacitor.

Now switch A is opened and switch B is closed. The current changes with time.

(d) Explain the effect that inductors have on currents that change with time.

$T = \frac{L}{R}$ $R = \frac{V}{I}$ $T = \frac{LI}{V}$ T = time constant I = current

The inductance of Inductors is proportional to the currents changing with time, and so however the current changes, the inductance will at the same rate.

no understanding of effect of inductor on current

na

(e) Discuss how energy is stored in the capacitor and inductor at the instant switch B is closed, and then while the capacitor is discharging.

When switch B is closed, energy goes to both inductor and capacitor. When the capacitor is discharging it loses its ~~voltage or charge~~ energy at an exponential decreasing rate of 63% so after the first time constant, the capacitor would decrease (12V × 0.367 = 4.414V,) to 4.41V and then (4.41×0.367) 1.62V and so on. So the energy in the capacitor decreases at an exponential rate.

na

A3