No part of the candidate evidence in this exemplar material may be presented in an external assessment for the purpose of gaining credits towards an NCEA qualification.

91526

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NZQA

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.**

Merit

**TOTAL** 17

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## QUESTION ONE: AC

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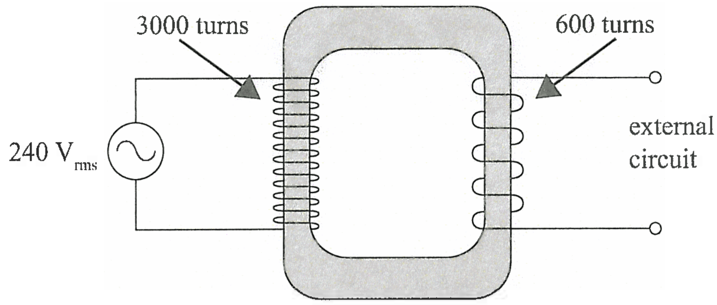
The ideal transformer shown below has 3000 turns in its primary coil, and 600 turns in the secondary coil. A 240 $V_{rms}$ AC power supply is connected across the primary coil. The secondary coil is connected to an external circuit.




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

$V_s = \frac{V_p N_s}{N_p} = \frac{(240)(600)}{(3000)}$

$V_s = 48\ V$

A

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

$V_{max} = \sqrt{2}\, V_{rms} = \sqrt{2}(48)$

$V_{max} = 68\ V$ (2sf) $= 67.88...V$

A

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

rms values make it possible to directly compare voltages and currents across components.

no idea that it produces same power as DC or that average voltage = 0

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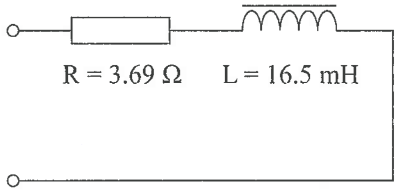
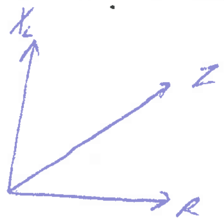
(c) The external circuit consists of a resistor and an inductor as shown.
The frequency of the power supply is 50.0 Hz.




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




$X_L = \omega L = 2\pi f L$

$= 2\pi(50.0)(16.5\times10^{-3})$ correct calculation

$X_L = 5.18\,\Omega$

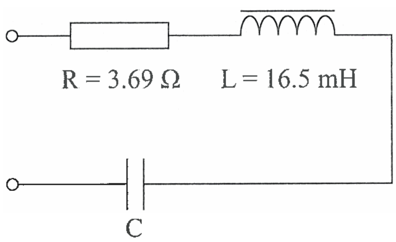
by pythagoras from above ∴ $Z^2 = R^2 + X_L^2$

$Z = \sqrt{(3.69)^2 + (5.18)^2}$

$Z = 6.36\,\Omega$ (3sf)

m

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




Determine the rms voltage across the capacitor.

~~$Z = \sqrt{R^2 + (X_L - X_C)^2}$~~ At resonance ~~$X_L = X_C$~~

~~$40.5 = \sqrt{13.61} + (X_L - X_C)^2$~~

~~$5.18 - X_C = \sqrt{40.5 - 13.61}$~~

9

M5

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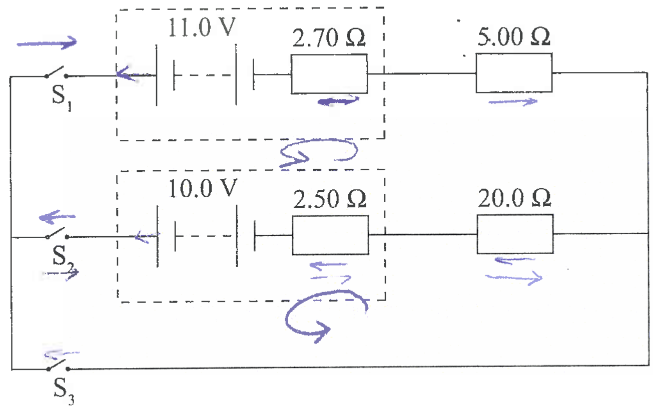
## QUESTION TWO: BATTERIES




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.

$V_{Total} = 11.0 - 10.0 = 1V$

$R_{Total} = 2.50 + 20.0 + 5.00 + 2.70$

$= 30.2 \Omega$

$V = IR \quad = I = \frac{V}{R} = \frac{1}{30.2}$

$= 0.0331125....$

$I = 0.0331 A$

m

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

Explain your answer.

The current will flow through the circuit in the ~~same~~ opposite direction as the voltage is calculated, i.e. to the. ~~left~~ right as the arrow shows, ~~away~~ from towards the high energy end of the component.

wrong explanation

na

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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.

$I_{S_3} = I_{S_1} + I_{S_2}$

$= 1.429 + 0.44A$

$= 1.872 \therefore$

$I_{S_3} = 1.87A$

$I_{S_1} = \frac{11.0}{5.00+2.70}$

$= 1.429\ A$

$I_{S_3} = \frac{10.0}{2.50+20.0}$

$= 0.\dot{4}$

m

(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.*

An increase in the internal resistance (r) of the battery, will decrease the voltage of the battery i.e. $V = \mathcal{E} - r$. Power is proportional to the voltage of the circuit ($P = VI$) and therefore this will cause a decrease in power also, such that less power may be delivered to the resistor.

i.e. if $\mathcal{E} = 2$, $r = 0.5$ or $1$, $V = 1$

$V = 2 - 0.5$ or $V = 2 - 1$

$= 1.5$ or $= 1$

$\therefore P = (1.5)(1)$ or $P = (1)(1)$

$P = 1.5$ or $P = 1$

$1.5 > 1$

m

calculation shows that $\mathcal{E}$ is constant, and V & P decrease (M) but incorrect to show that I is constant (no E)

M6

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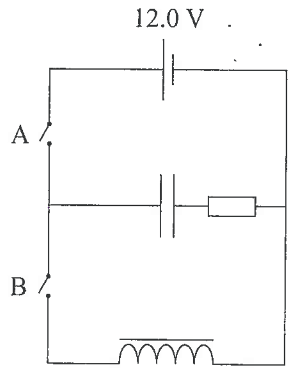
## QUESTION THREE: ENERGY




(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.
(Q)

Q = CV. Charge (voltage) on the capacitor is directly proportional to the voltage of the battery (V), so the capacitor can hold an equal voltage to the battery.

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

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

$E = \frac{1}{2}QV = \frac{1}{2}(8.60 \times 10^{-3})(12.0)$

$E = 0.0516$ J

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

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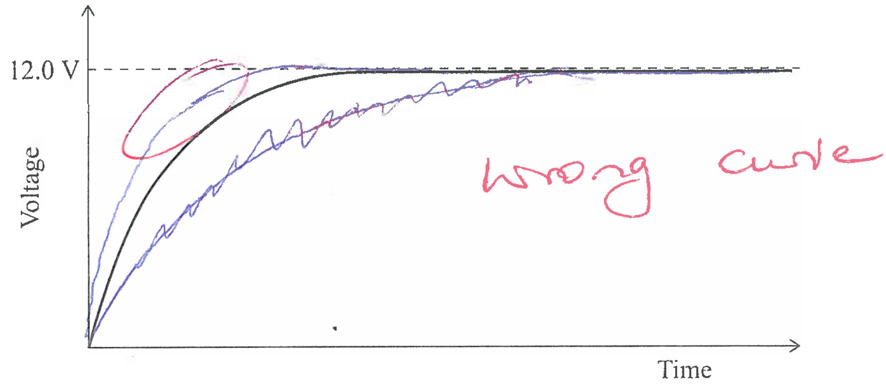


$V \propto R$

$C \propto \frac{t}{V}$

$\tau = RC$

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

na

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.

An inductor produces a back emf to slow the voltage, which in turn, also slows the rate of decay of current over time such the time constant ($\tau$) increases.//

no reference to changing flux due to changing current

m

(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.

As switch B is closed the fully capacity of energy is stored in the capacitor and on discharge, the energy of the capacitor decays proportionally to the voltage. The energy of the inductor increases proportionally to the voltage as the switch is closed, and then again as the capacitor discharges.//

Shows relationship between E & V in capacitor no reference to inductor.

m

m6