3

4·40

SUPERVISOR'S USE ONLY

915260

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.

Achievement

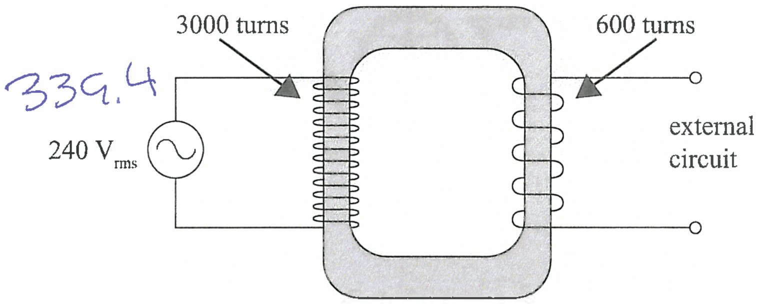
TOTAL 11

ASSESSOR'S USE ONLY

QUESTION ONE: AC

ASSESSOR'S USE ONLY

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.

$V_s = \frac{N_p}{N_s} V_p$ $= 1200 \, V_{rms}$

wrong substitution

na

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

$\sqrt{2} \times 1200 = 1697.1 \, V_{max}$

e

consequential error

a

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

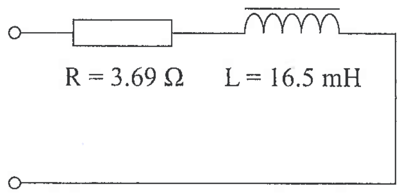
Rms values are used to describe AC voltages due to RMS is usually the average of a ~~wave~~ cycle voltage

na

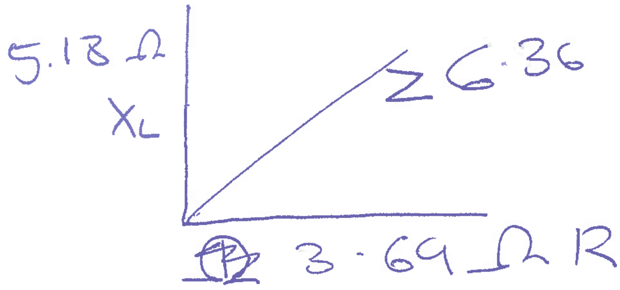
1.00

ASSESSOR'S USE ONLY

(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.



$X_L = (2\pi 50)\, 16.5 \times 10^{-3} = 5.18\ \Omega$

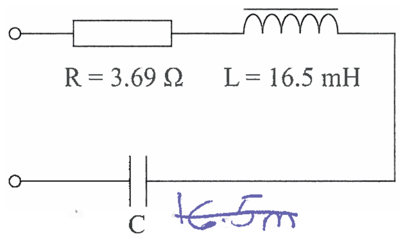
Correct X_L

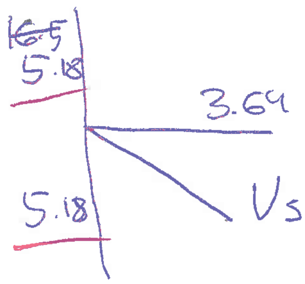
$A^2 + B^2 = C^2$ & correct Z

$5.18^2 + 3.69^2 = \underline{6.36}\ \Omega \leftarrow$ Impedance

M

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





Determine the rms voltage across the capacitor.

$\frac{5.18}{~~314.1592654~~} = ~~C = 0.016~~$ identified that $X_L = X_C$ at resonance

~~$5.18 \times 16.5 \times 10^{-3} = 0.08547$~~

~~1697.1~~ $\times$ ~~$\sin(314.1592654 \times 0.08547)$~~

~~$= 1678.6$ V~~

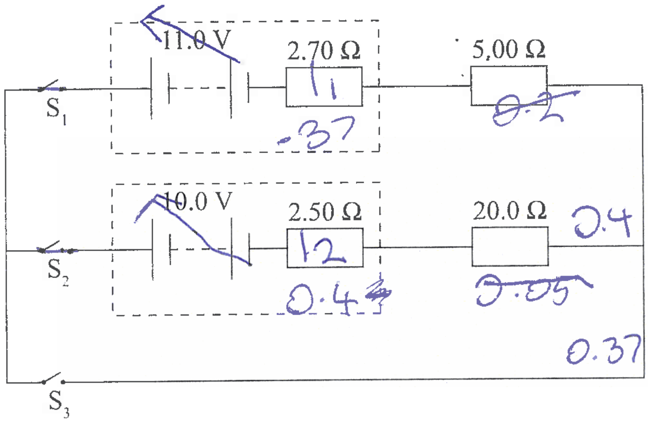
~~nø~~

a

A4

QUESTION TWO: BATTERIES

ASSESSOR'S USE ONLY



$V = \frac{\varepsilon}{3} - IR$

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.

~~I~~ $\frac{11}{2.7} = 4$ ~~4.07~~ ~~4.07A − 4~~ 1.43

Kirchhoffs voltage law says that sum of all voltage = supply. S2 supply is backwards ∴ 1V is remaining making I_2 0.4 ~~and~~ I_1 0.37

0.4 − 0.37 = 0.03 A

identified that PD = 1V

a

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

Explain your answer.

Current would be flowing ~~clockwise~~ ~~(left to r~~ Anticlockwise

Because conventional flow of electrons is from positive to negative and kirchhoffs point rule states that amps at a point must = 0

wrong explanation

na

ASSESSOR'S USE ONLY

(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.

(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.

~~V is decreasing~~ ~~The electromotive force is decreasing for the resistance~~
The resistance is increasing in internal thus the current must decrease to keep Emf & voltage the same.
In $P=IV$, the power delivered is decreasing because the circuit current is decreasing

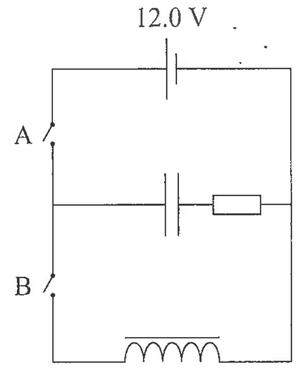
Correct explanation but incorrect to say that V is constant

m

A3

ASSESSOR'S USE ONLY

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 is~~ ~~Probably~~ The cap collects charge from the battery : if ~~the voltage is too much for the cap, it won't work ∴ it matches the battery as~~ until it is full, thes circuit is complete so the voltage has somewhere to go after.

a

(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.

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

$E = 0.0516$ J

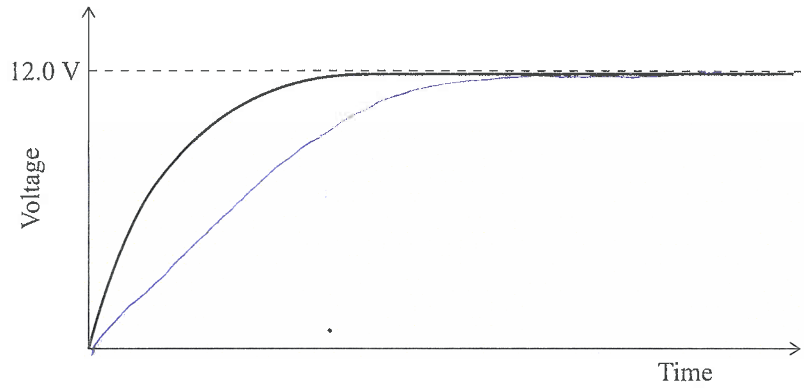
correct calculation

a

The voltage is constant so it won't discharge.

ASSESSOR'S USE ONLY

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



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

a

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.

The inductor has the purpose of opposing the flow of electrons because it generates something called back Emf: where V needs to be more than the force for the flow to contine. The stronger the magnetic field, the slower the flow to go through

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.

Energy flows through the new circuit. The energy stored in the capacitor goes into the resistor and some is used. The remainder of energy is used on the inductor (63% of remaining voltage) until there isn't enough voltage to oppose the back Emf.

a

idea that energy from capacitor is transferred to inductor

A4