VICTORIA
UNIVERSITY OF WELLINGTON
TE WHARE WĀNANGA
O TE ŪPOKO O TE IKA A MĀUI

# ENGR142 2020, 2nd Trimester

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| Name | |
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| ID | |

| Problem | 1 | 2 | $\sum$ |
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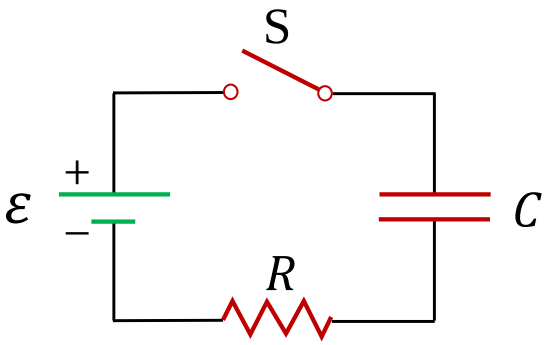
| Marks | | | |

# Final test 20th October, 2020

**Problem 1:** DC circuits *(20 Marks)*

(a) The circuit below shows an $RC$ circuit that is to be connected to the battery at time $t = 0$.




(a.1) Using Kirchhoff's rules find the governing differential equation for the circuit in the figure after the switch has been closed. You may use $Q/C$ for the voltage drop across the capacitor.

[4 marks]

(a.2) By inserting it into the differential equation you derived in (a.1), show that

$$Q(t) = \varepsilon C \left(1 - e^{-\frac{t}{RC}}\right)$$

describes how the current varies with time.

[4 marks]

(a.3) When using a battery of emf $\varepsilon$ to build up current $I$ in an inductor in series with a resistor $R$, application of Kirchhoff's loop rule gives

$$\varepsilon - IR - L\frac{dI}{dt} = 0,$$

which has a solution

$$I(t) = \frac{\varepsilon}{R}\left(1 - e^{-\frac{R}{L}t}\right).$$

Draw the corresponding circuit diagram and comment on similarities and differences between this $RL$ circuit and the $RC$ circuit above and its current.

[4 marks]

(a.4) By relating Faraday's law to the magnetic flux created by the current through a coil, explain how an emf is induced through self-inductance. You may either use equations or explain in words.

[4 marks]

(b) Consider a 1.0 metre long Nichrome wire with a radius of 0.5 cm. The electrical resistivity of Nichrome is $1.0 \times 10^{-6}$ Ωm.

(b.1) What would happen to the *electrical resistance* of the Nichrome wire if its length was doubled?

[1 mark]

(b.2) What would happen to the *electrical resistivity* of the Nichrome wire if its length was doubled?

[1 mark]

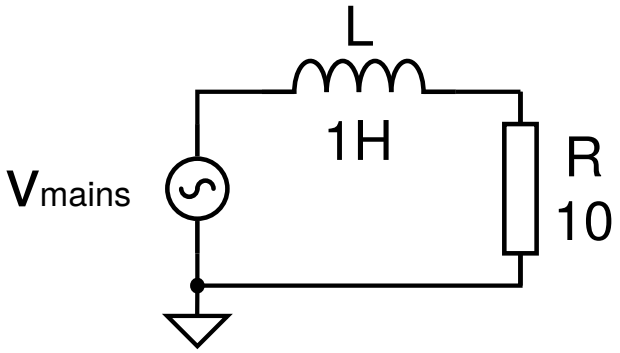
(b.3) What would happen to the *electrical resistance* of the Nichrome wire if its radius was doubled?

[1 mark]

(b.4) If a potential difference of 10 V is maintained across the Nichrome wire what current will flow in the wire?

[1 mark]

**Problem 2 :** Transformer circuit *(20 Marks)*




A transformer has a winding that has the equivalent circuit shown in the diagram. The winding is connected to the mains voltage, which has a frequency of 50 Hz and an rms voltage of 230 V.

(a) What is the impedance of the transformer winding? Express your answer with magnitude and phase and correct units.

[5 marks]

(b) What current will flow through the winding? Express your answer as both a phasor and also as a function of time. **Hint**: You should assume the mains voltage has zero phase.

[4 marks]

(c) What are the power factor, the real power and the reactive power in the circuit?

[4 marks]

(d) Why do we use rms quanitities when performing power calculations for ac circuits?

[2 marks]

(e) We could modify the winding circuit to be resonant by adding a capacitor in series with the resistor and inductor. What capacitor value would we need to use if we wanted to have the resonant frequency be at the mains frequency?

[3 marks]

(f) Explain qualitatively what we would need to do if we wanted to make a sharper resonance.

[2 marks]