VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA
NEW ZEALAND

**Trimester 2**
**Test 2 – 2022**

**ENGR 142**

**Engineering Physics**

**Time Allowed:** TWO HOURS

**CLOSED BOOK**

**Permitted materials:**

- 1 hand-written, single-sided, letter-sized A4 equation sheet (with only equations and/or circuit diagrams)
- non-programmable calculator
- pencil/pen

**Instructions:** Answer **All** questions.

Total marks: 60

Charge for an electron: $q_e = 1.6 \times 10^{-19}$ C.
1 mol = $6.022 \times 10^{23}$ atoms

**Problem 1 (12 marks)**

(a) An aluminium wire has a cross-sectional area equal to $4.0 \times 10^{-6}$ m$^2$ and carries a current of 5.0 A. Aluminium has a density of 2.7 g/cm$^3$ and a molar mass of 27 g/mol. Assume each aluminium atom carries one conduction electron per atom.

(i) Find the number density of aluminium in units: number of atoms/m$^3$.

**(4 marks)**

(ii) Find the drift speed of the electrons in the wire.

**(2 marks)**

(b) A tungsten wire 1.5 m long and 0.6 mm in diameter is connected to a source with a potential difference of 1.5 V. At 20 °C, 3.5 A of current flows through the wire.

(i) Find the resistivity of Tungsten at 20 °C.

**(2 marks)**

(ii) Determine the resistivity of Tungsten at 120 °C.

**(2 marks)**

(iii) Find the current in the wire at 120 °C.

**(2 marks)**

**Problem 2 (5 marks)**

The quantity of charge, $Q$ (in coulombs), that has passed through a surface of area 2.0 cm$^2$ varies with time according to the equation:

$$Q(t) = 4t^3 + 5t + 6$$

where $t$ is measured in seconds.

(a) Find the instantaneous current through the surface at $t = 4.0$ s.

**(2 marks)**

(b) Find the average current through the surface from $t = 2.0$ s to $t = 4.0$ s.

**(2 marks)**

(c) Find the value of the current density, as a function of time.

**(1 mark)**

**Problem 3 (13 marks)**

(a) The current in the circuit diagram to the right is 2.5 A.

(i) Determine the equivalent resistance in the circuit.

**(1 mark)**

(ii) Find the value of the unknown resistor, $R$.

**(2 marks)**

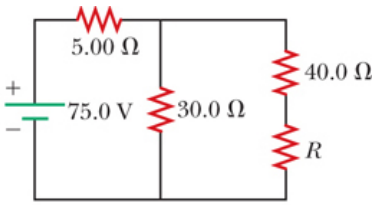


Figure for Problem 3a.

(b) Consider the circuit diagram to the right.

(i) Redraw the circuit diagram, clearly labelling the Kirchoff's loops that you will use to solve the problem.

**(1 mark)**

(ii) Using the Kirchoff's loops just drawn and the current directions as given in the problem, solve for the three unknown currents: $I_1$, $I_2$, and $I_3$.

**(4 marks)**

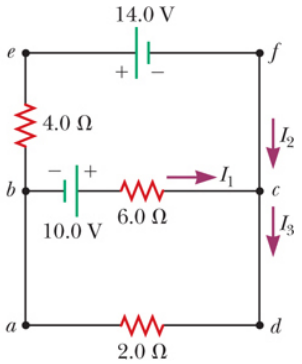


Figure for Problem 3b.

(c) In the circuit diagram to the right, the battery has an emf of 12.0 V, the inductor has an inductance of 3 mH and the capacitor a capacitance of 9.0 pF.

For time $t < 0$, the switch has been set to position $a$ for a long time, so that the capacitor is fully charged. At time $t = 0$, the switch is then thrown to position $b$, removing the battery from the circuit and connecting the capacitor directly to the inductor.

(i) Find the frequency of the oscillations in the circuit.

**(1 mark)**

(ii) Find the equation for the charge as a function of time.

**(2 marks)**

(iii) Determine the maximum current that flows in the circuit.

**(2 marks)**

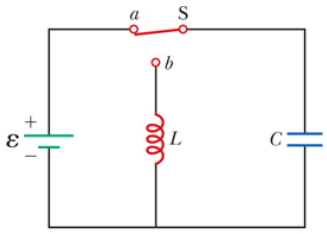


Figure for Problem 3c.

**Problem 4 (15 marks)**

Consider the circuit shown in the Figure below, where $R = 1000\Omega$, $C = 1\mu$ F and $L = 1$ mH. The input voltage $v_i$ is $v_i(t) = 100\cos(1000t + 45^o)$ V.

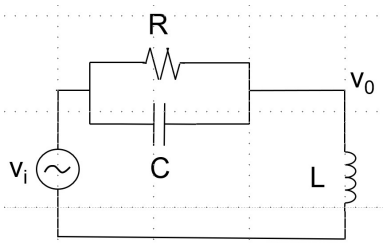


Figure for Problem 4.

(a) What is the voltage across the inductor?

**(8 marks)**

(c) Sketch the phasor diagram showing: the input voltage, voltage across the inductor, and the current through the inductor. *You do not need to draw the magnitudes to scale.*

**(7 marks)**

**Problem 5 (7 marks)**

(a) Design a first order filter which attenuates frequencies greater than 100 rad/s by 3 dB relative to the passband. Sketch the circuit diagram and clearly label all components.

**(3 marks)**

(b) For the filter in (a), find the attenuation (in dB) at 500 rad/s.

**(4 marks)**

**Problem 6 (8 marks)**

(a) Design a filter that passes a band of frequencies 100 rad/s wide centered approximately at 1000 rad/s. Your design should use a 1 $\Omega$ resistor. Sketch the circuit and clearly label all components.

**(5 marks)**

(b) Find the gain (in dB) at the resonant frequency.

**(1 mark)**

(c) Find the exact values of the cut-off frequencies.

**(2 marks)**

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