Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2008-2009 (2 hours)

Circuits and Signals 1

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. **a.** State in words, Kirchhoff's first and second laws applied to circuits. In each case, also state why it is physically unreasonable if these laws were broken. **(6)**

b. Using Kirchhoff's laws in the circuit of figure 1(a), construct independent equations which will allow the solution of the currents in each branch. Using these equations, calculate the current in each branch.

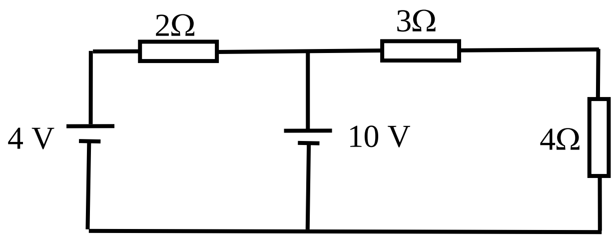

Figure 1a **(8)**

c. Find the node voltages at points A and B for the circuit shown in figure 1b.

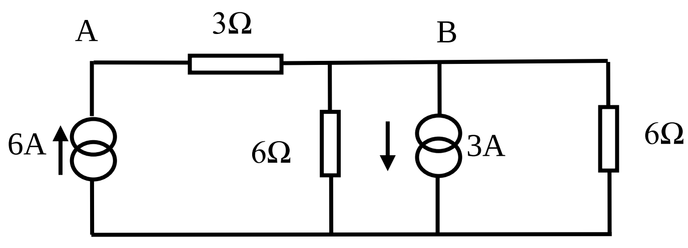

Figure 1b

(6)

2. **a.** Sketch the diagrams necessary to show how a phasor (rotating vector) can **(6)**

represent the sinusoidal variation of voltage or current, including how relative phase angle can be taken into account.

b. A sinusoidal voltage source is connected across a series combination of a resistor, capacitor and inductor, sketch the phasor diagram representing the voltage across each component and the current through the circuit.

From this phasor diagram and sketches of how the impedance of each component varies as a function of frequency, identify the resonance condition for the circuit. **(6)**

c. Derive the expression (show all working) for the resonant angular frequency for the circuit of figure 2.

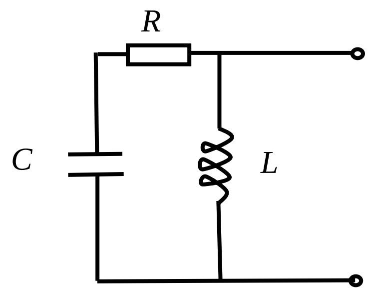

Figure 2 **(8)**

3. a. Capacitance is defined as charge stored per unit voltage across the plates of the capacitor. From this and the definition of current (charge flow per unit time), derive an expression for the current through a capacitor in terms of voltage across it. From this result derive a second expression that describes the voltage across a capacitor in terms of the current through it. What type of voltage-time variation across a capacitor would give rise to a constant current flow with time? **(8)**

b. For the circuit of figure 3a derive an expression for the current, i, as a function of time after the switch is moved from A to B at time $t = 0$. It is assumed that prior to $t = 0$ a steady state current is flowing.

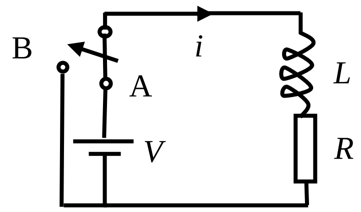

Figure 3a **(6)**

c. Find the current through the inductor in figure 3b. What are the real and imaginary components of the current supplied by the 20 V voltage source. What is the magnitude of the source current.

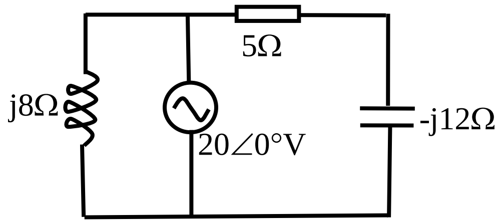

figure 3b **(6)**

4. a. Define how voltage and power ratios are expressed in dB. Why are these quantities sometimes expressed in this form? **(4)**

b. A low-pass RC filter consists of a capacitor in series with a resistor where the output voltage is taken across the capacitor. Derive an expression for the frequency response of the filter in terms of the output voltage divided by the input voltage. Identify the cut-off frequency and, by considering the amplitude frequency response at frequencies greater than the cut-off frequency, explain why you cannot achieve an infinitely sharp 'roll-off' in the response. **(8)**

By considering a decade change in the frequency, show that the slope of the amplitude response at frequencies much higher than the cut-off frequency for such a circuit is always 20 dB/decade. **(4)**

c. The circuit of figure 4 is to be used to filter out 30 kHz interference from a system. The Q for the circuit ($= R\sqrt{\frac{C}{L}}$) is 5 and the resonance condition is $f_R = \frac{1}{2\pi\sqrt{LC}}$. Calculate the required values for *L* and *C*.

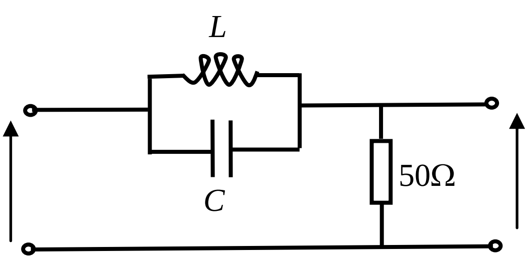

figure 4 **(4)**

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