UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
SCHOOL OF ELECTRICAL AND INFORMATION ENGINEERING

ELEN2008 Electric Circuits:
EXAMINATION 2014

Internal Examiners: Dr Estelle Trengove
External Examiner: Prof Ivan Hofsajer

TOTAL MARKS: 100
TIME: 3 hours

Instructions

Answer **ALL** questions. There are 110 possible marks, but the paper will be marked out of 100.

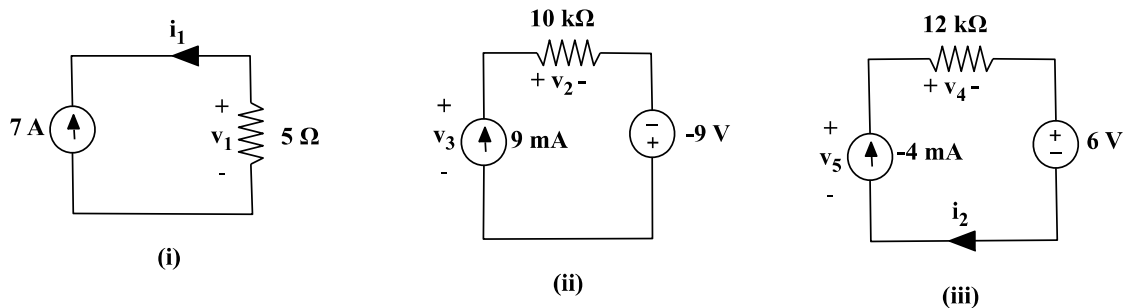## Knowledge Area 1: Concepts [30 marks]

Question 1 [20 marks]

Figure 1: Three circuits containing resistors and sources

a) Find i_1, i_2, v_1, v_2, v_3, v_4 and v_5 for the three circuits shown in Figure 1.

(7 marks)

b) State whether each source in Figure 1 is supplying or absorbing power and how much power is being supplied/absorbed.

(10 marks)

c) Describe and use a sketch to show an example of when the model of an ideal voltage source breaks down.
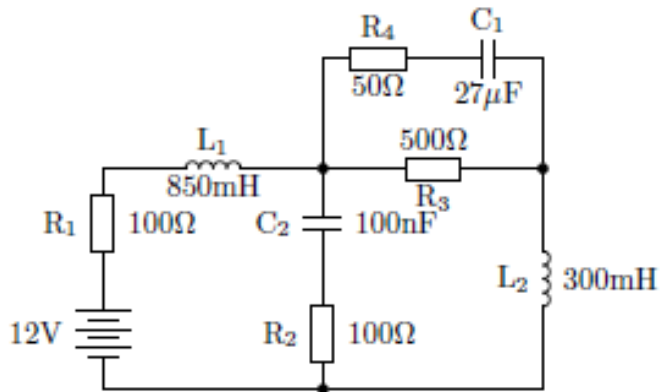
(3 marks)

Question 2 (10 marks)

Figure 2: A complex circuit containing inductors, capacitors and resistors

For the circuit shown in Figure 2, determine the voltage across, the current through and the magnitude of the impedance of each element. To answer this question, you must reproduce Table 1 in your answer book and fill in all the values.

(10 marks)

Table 1: Values for elements in Figure 2

Element	Voltage	Current	Impedance
R_1			
R_2			
R_3			
R_4			
L_1			
L_2			
C_1			
C_2			

Knowledge Area 2: Analysis techniques [40 marks]

Question 3 (25 marks)

a) Consider the circuit shown in Figure 3. Use **mesh** analysis to set up simultaneous equations and solve your simultaneous equations to find values for the mesh currents.

(10 marks)

b) Use the solutions to your mesh analysis to find i_2 for the circuit shown in Figure 3.

(2 marks)

c) Consider the circuit shown in Figure 3. Use **superposition** to find i_2 for the circuit shown in Figure 4. Note: You should obtain the same value for i_2 as in Question 3 (b) – use this to check your own work.   (6 marks)

d) Find and sketch the Thévenin equivalent at terminals *a* and *b* of the circuit in Figure 3. (Note: You may use values obtained in sections (a), (b) and (c).)   (7 marks)
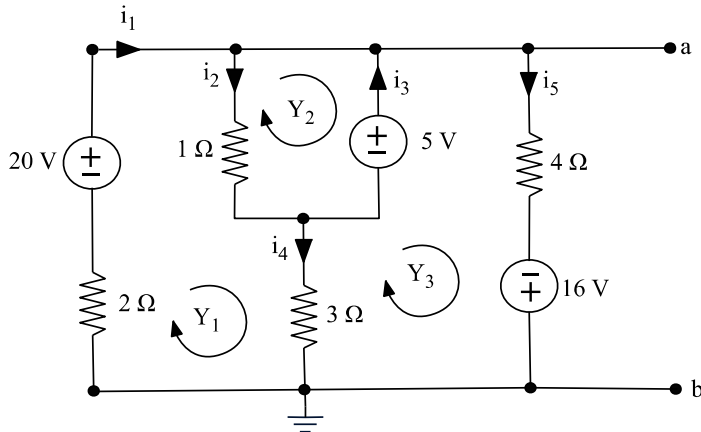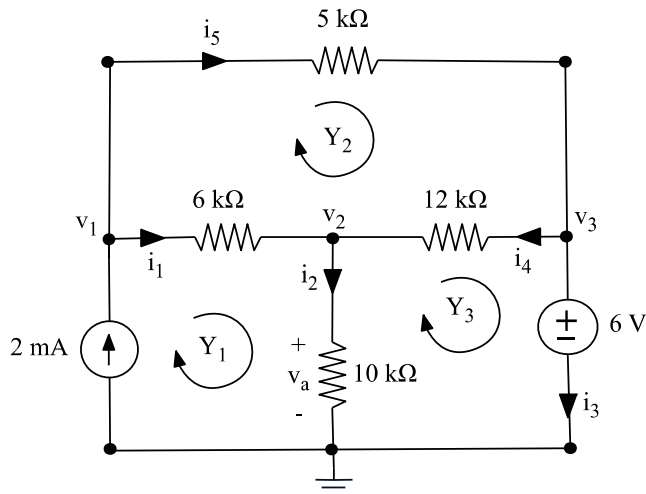

Figure 3: Circuit containing resistors and sources

Question 4 (15 marks)

Figure 4: Resistive circuit with a voltage and a current source

a) Consider the circuit shown in Figure 4. Use **nodal** analysis to determine the simultaneous equations needed to solve for all the unknowns. Simplify the equations and group like terms together, so that the equations are in a form that can easily be entered into a matrix.

(10 marks)

b) Solve the equations obtained in section (a) and use your answers to calculate the voltage v_a for the circuit in Figure 4.   (5 marks)

Knowledge Area 3: Laboratory concepts and techniques [20 marks]
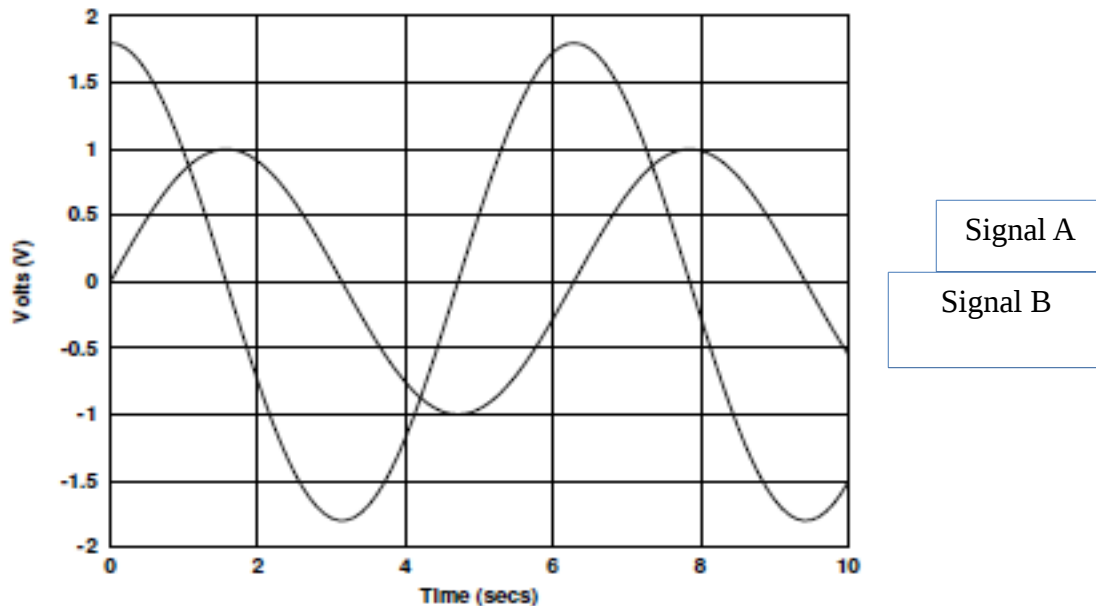
Question 5 (10 marks)

Figure 5: Two sinusoidal signals

Referring to Figure 5, determine the following:

a) Measure the phase shift between the two signals and give it in degrees and in radians;
b) The peak to peak voltage of both signals;
c) The period of both signals;
d) The frequency of both signals.

Question 6 (10 marks)

a) In the laboratory, you use an AC power supply to apply a sinusoidal wave with a peak voltage of 10V and a frequency of 1kHz to the circuit in Figure 6. Choose resistor R_2 in Figure 6 (i) such that $V_{out} \approx 0.9V_{p-p}$. On the oscilloscope, you use one probe to display the input voltage and the other probe to display the voltage across R_2. Draw a rough sketch of what you would expect to see on the oscilloscope display.   (4 marks)

b) Now you replace resistor R_2 with a 1μF capacitor. On the oscilloscope, you use one probe to display the input voltage and the other probe to display the voltage

across the capacitor. Draw a rough sketch of what you would expect to see on the oscilloscope display.   (3 marks)

c) On the power supply you turn the frequency to 0Hz. On the oscilloscope, you use one probe to display the input voltage and the other probe to display the voltage across the capacitor. Draw a rough sketch of what you would expect to see on the oscilloscope display.   (3 marks)
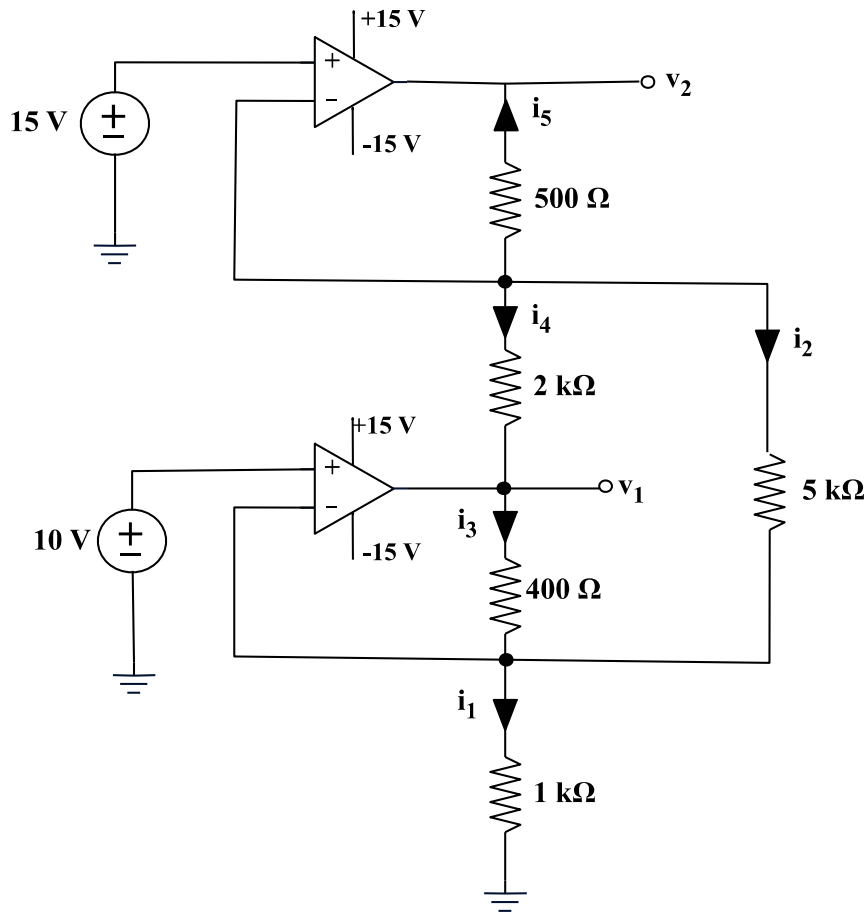
$10\ V_{p-p}$ 1 kΩ R_2

(i)

$10\ V_{p-p}$ 1 kΩ   1 µF

(ii)
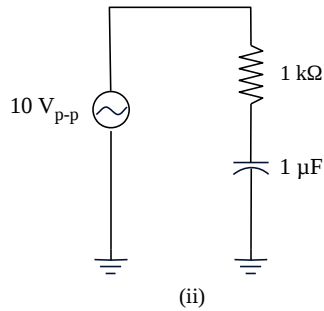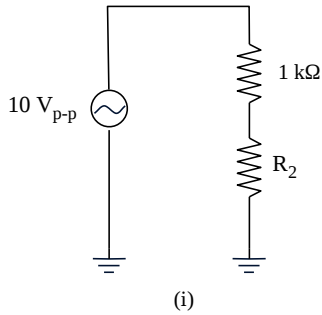
Knowledge Area 4: Complex real circuits [20 marks]

Question 7 (20 marks)

Figure 7: An operational amplifier circuit

Analyse the circuit in Figure 7 and then determine v_1 and v_2.

END OF EXAM