IMPERIAL COLLEGE LONDON

B.Eng, M.Eng and ACGI Examinations 2016
Part 1

Biomedical Engineering

BE1-HEE1 Electrical Engineering 1

Tuesday, 17 May 2016 **13.30-15.30pm**

Duration: 120 min

The paper has 4 questions.
Answer all 4 questions.
Each question is worth 100 marks.

Marks for questions and parts of questions are shown next to the question. The marks for questions (and parts thereof) are indicative, and they may be slightly moderated at the discretion of the Examiner.

1 All the opamps in the circuits shown below can be assumed ideal and with an output voltage that saturates at +10V and -10V.

(a) Determine the value of the voltage V with respect to the implied reference voltage in each of the circuits A to C shown in Figure 1a [5]

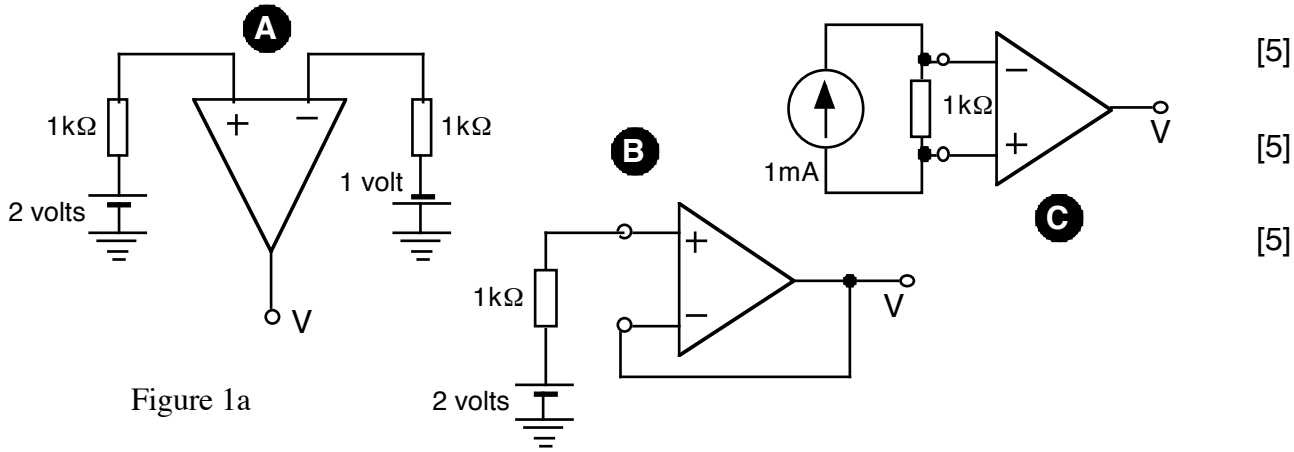

Figure 1a [5]

[5]

(b) For the circuit of Figure 1b find the range of the voltage V for which no current will flow in the 10 kΩ resistor. [20]

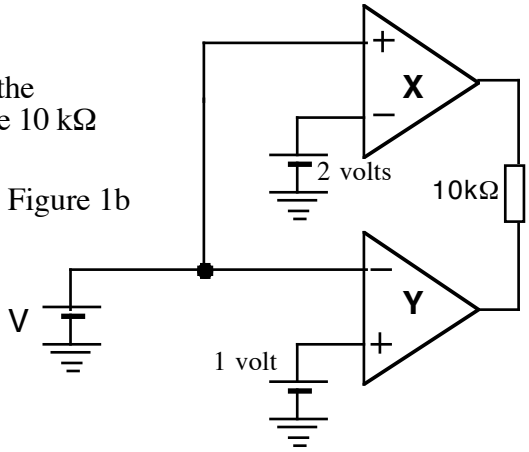

Figure 1b

(c) In the circuit of Figure 1c the voltage V is initially at -8 volts. What is the value of VA? The value of V now rises. At what value of V does the voltage VA change, and to what value? [30]

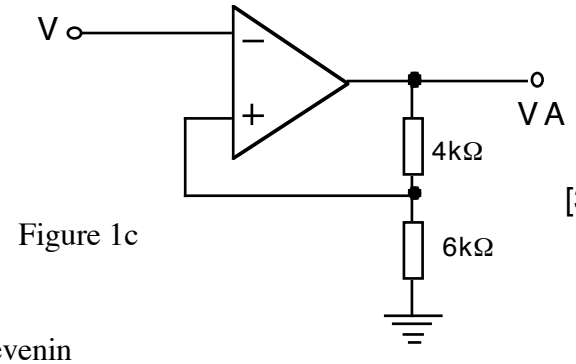

Figure 1c

(d) Refer to the circuit of Figure 1d. Find the Thevenin model of the circuit to the left of AA' and hence the Thevenin model of the circuit to the left of BB'. What is the value of the voltage V? [35]

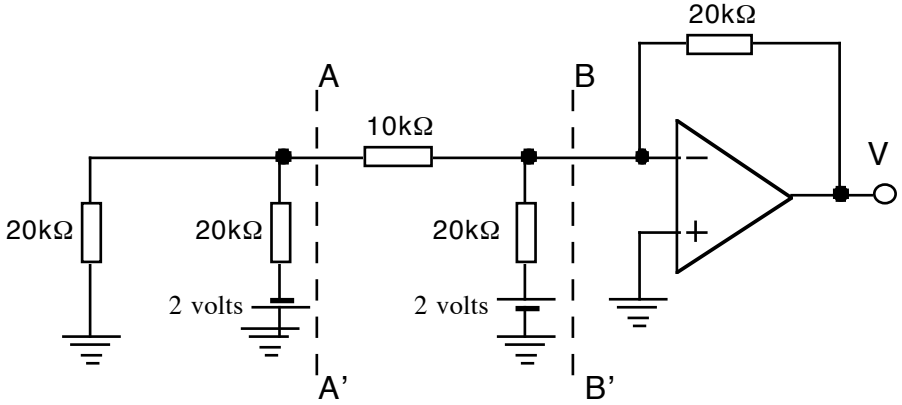

Figure 1d

2

(a) For each of the circuits in Figure 2a calculate the approximate value of the voltage V and the power dissipated by the Zener diode. In each case the Zener diode has a Zener voltage of 5 volts. [15]

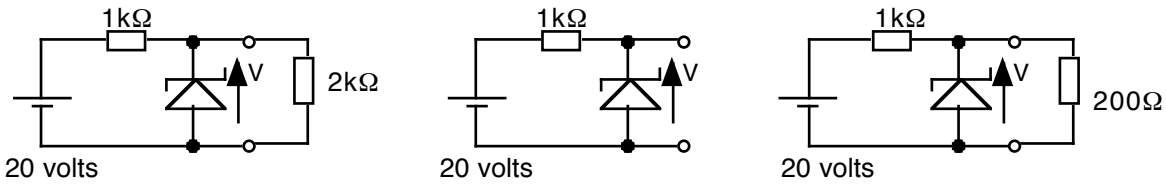

Figure 2a

(b) The nonlinear device X in the circuit of Figure 2b is characterized by the voltage~current relation shown in Figure 2c. By using a load-line construction find the value of the voltage V and hence the voltage VA across the 3kΩ resistor. Provide a sketched load-line construction to support your answer. [25]

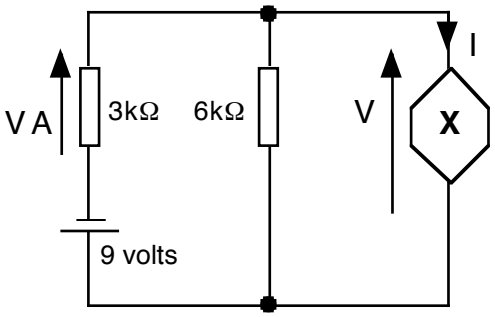

Figure 2b

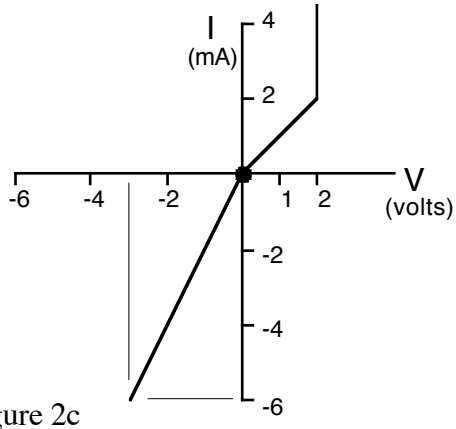

Figure 2c

(c) A bioengineering application requires a well-regulated voltage supply of 10 volts. Using a circuit containing a voltage supply of approximately 20 volts, a Zener diode of your choice and a resistor, propose a suitable circuit that will provide, across two terminals, a voltage approximating closely to 10 volts as the current drawn from those terminals varies between zero and 200 mA. [40]

(d) In the circuit you have proposed in answer to question (c) above, assume that the voltage source of approximately 20 volts changes in value by 2 volts. Use a change circuit to find the resulting change in the stabilized voltage if 200 mA is being drawn from the circuit. Assume that the Zener diode resistance RZ is 10 ohms. [20]

(a) For each of the two circuits shown in Figure 3a derive expressions for both the impedance and admittance between terminals A and B in terms of the radian frequency ω and the component values [10]

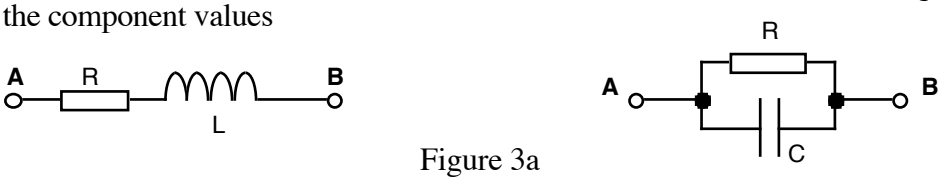

Figure 3a

(b) Three circuits are shown in Figure 3b. For each circuit derive an expression for the (complex) voltage amplification **V**o/**V**in. [30]

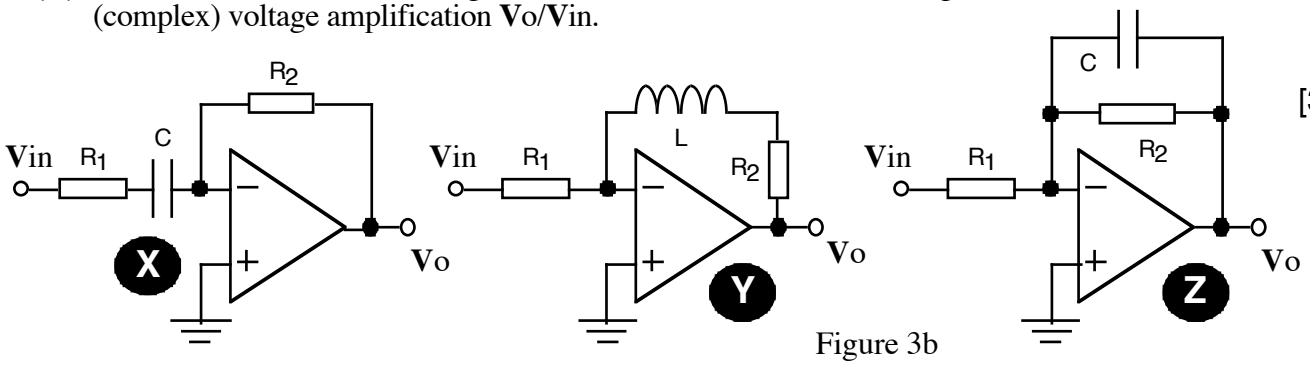

Figure 3b

(c) Figure 3c shows asymptotic (log-log) plots of the magnitude of the voltge amplification versus radian frequency for four circuits. Say which plot corresponds to each of the three circuits of Figure 3b [15]

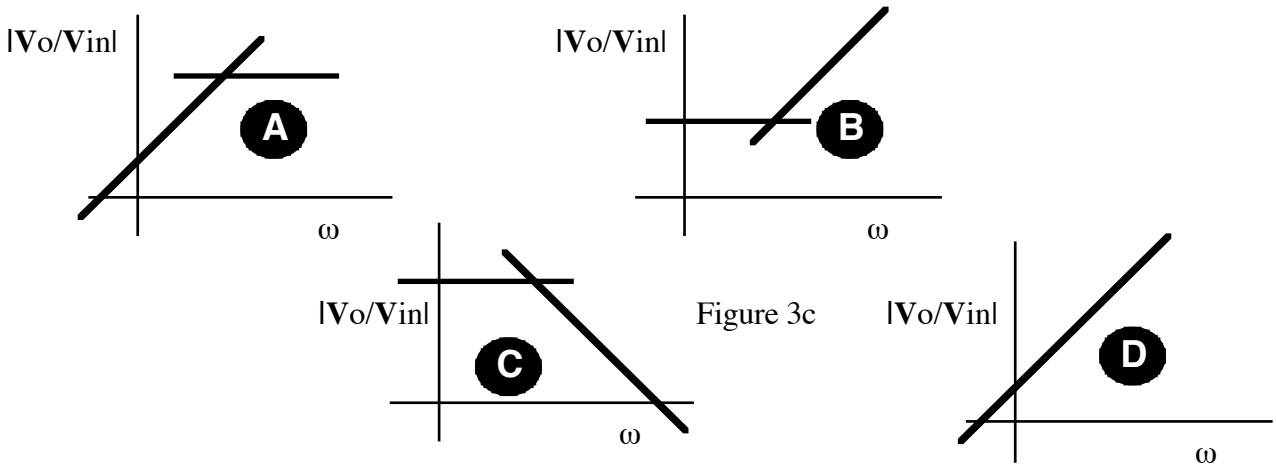

Figure 3c

(d) For each circuit of Figure 3b derive an expression for the radian frequency at which its asymptotic plots of |**V**o/**V**in| versus ω intersect. [15]

(e) A customer requires a circuit whose voltage amplification magnitude plotted against frequency on a log-log plot must satisfy the requirements shown in Figure 3d (equal scales for |**V**o/**V**in| and ω). The actual variation of |**V**o/**V**in| versus ω must not intersect any of the shaded regions. Sketch a circuit containing one opamp that should satisfy the requirement of Figure 3d when appropriate component values are chosen, but do not calculate those values. [30]

Figure 3d

(a) Find the value of the voltage V and current I in each of the four circuits shown in Figure 4a. [20]

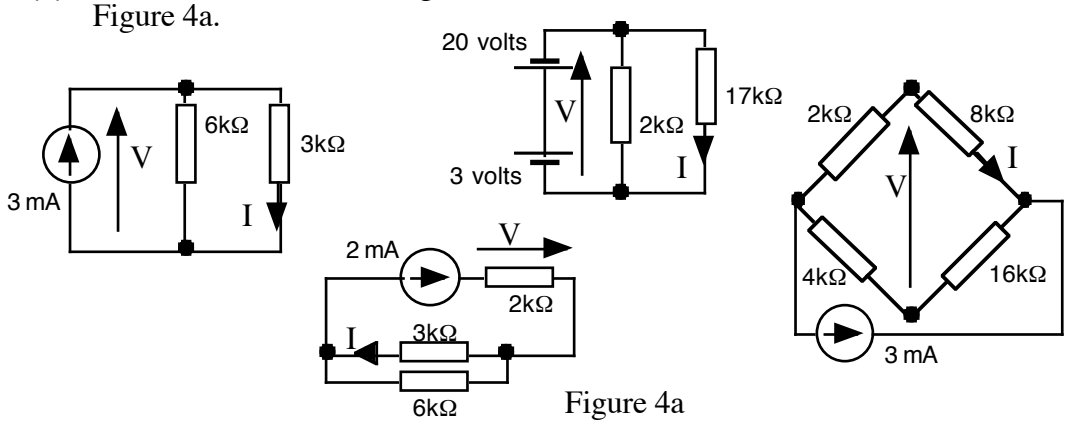

Figure 4a

(b) Use the Superposition Principle to find the current I in the circuit of Figure 4b. [25]

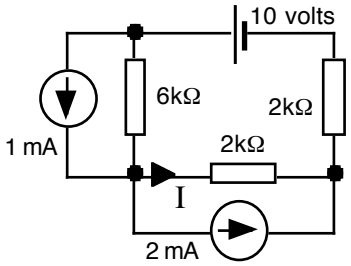

Figure 4b

(c) Write down the nodal voltage equation associated with the circuit of Figure 4c which contains a voltage-controlled current source. [30]

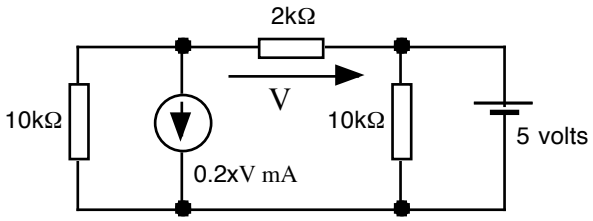

Figure 4c

(d) Find the Thevenin model of the circuit between the terminals A and B in Figure 4d [25]

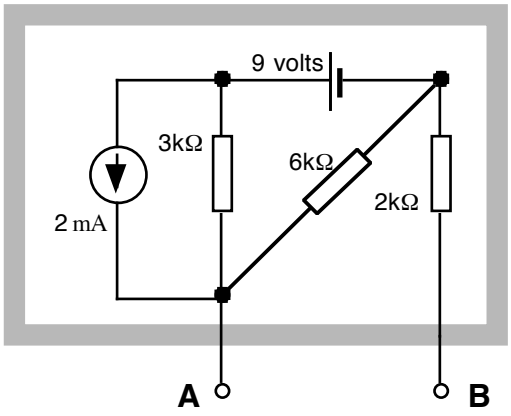

Figure 4d