IMPERIAL COLLEGE LONDON

B.Eng, M.Eng and ACGI Examinations 2018

Part 1

Department of Bioengineering

BE1-HEE1 Electrical Engineering 1

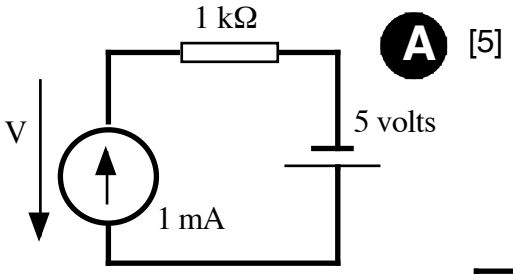
09 May 2018 **14.00 - 16.00**
Duration: 120 min

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

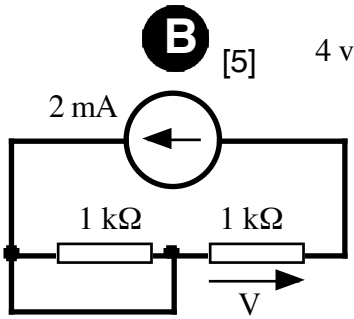
Marks for questions and parts of questions are shown next to the question. The marks for questions (and parts thereof) are indicative, and they may be slightly moderated at the discretion of the Examiner.

1 For each of the circuits A to H shown below calculate the value of the labelled constant voltage V or constant current I.

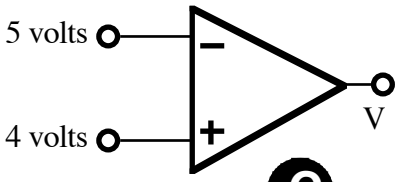
Assume that opamps are ideal, with output saturation voltages of +/- 10 volts.



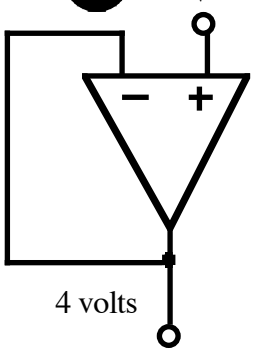
A [5]



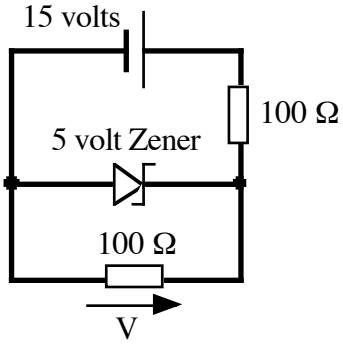
B [5]



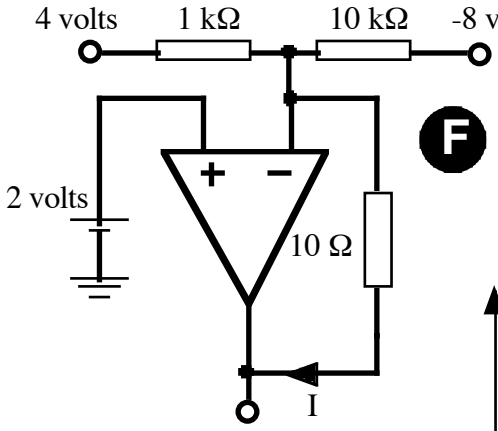
C [5]



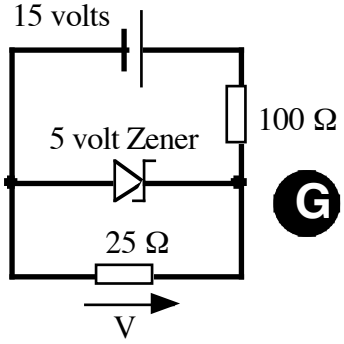
D [10]



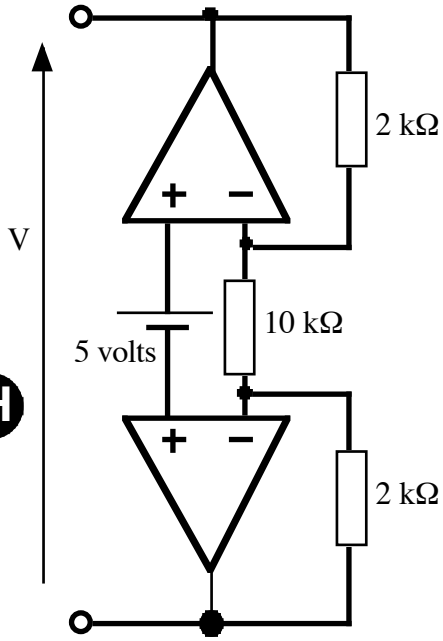
E [10]



F [20]



G [20]



H [25]

2

(a) The circuit of Figure 2(a) contains two opamps, each of which can be considered ideal and having output saturation voltages of +/- 10 volts.

The waveform of the voltage V is shown in Figure 2(b)

Provide a dimensioned sketch of the waveform of the current I over the time period from t=0 to t=10 msec. [40]

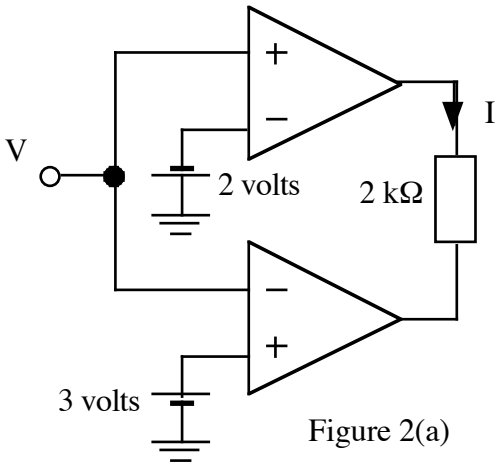


Figure 2(a)

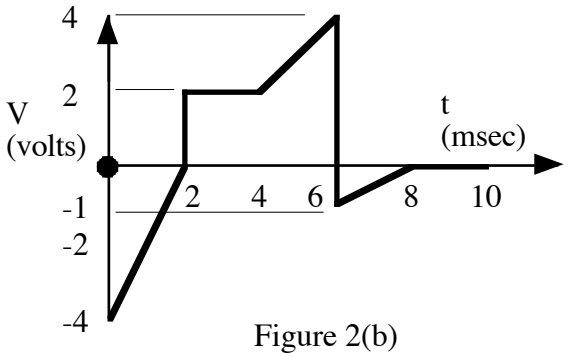


Figure 2(b)

(b) Provide a dimensioned sketch of the waveform of the voltage V in the circuit of Figure 2(c). Both opamps can be considered ideal and having output saturation voltages of +/- 10 volts. [40]

A voltage source of 10 volts in series with a resistor of 20 kΩ is now connected to the negative input of opamp **A** as shown in Figure 2(d)

What is the new frequency of the waveform of the voltage V? [20]

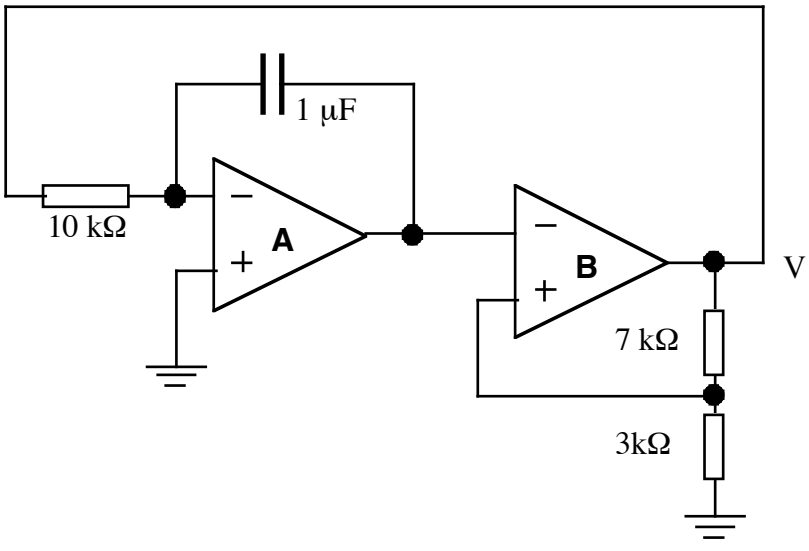


Figure 2(c)

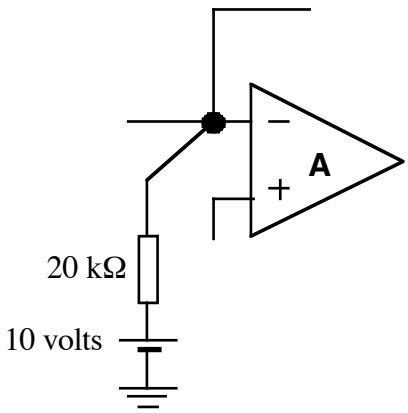


Figure 2(d)

3 (a) Use the Superposition Principle to find the value of the voltage V in the circuit of Figure 3(a) [20]

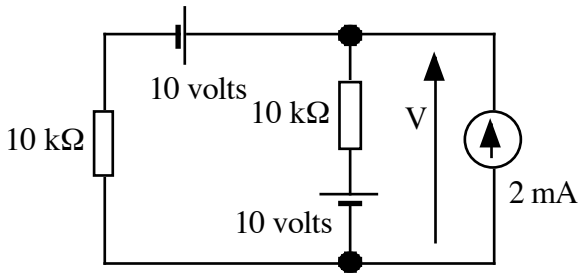


Figure 3(a)

(b) For the circuit of Figure 3(b), and using the voltage reference node indicated by the 'earth' symbol, write down *but do not solve* the nodal voltage equations describing the circuit. [30]

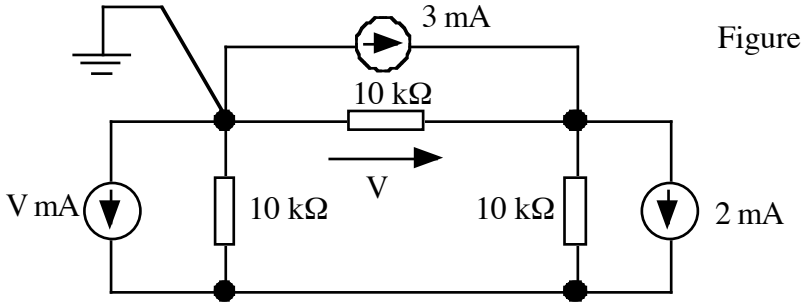


Figure 3(b)

(c) For the circuit of Figure 3(c), find the Thevenin Equivalent Circuit appropriate to terminals A and B [50]

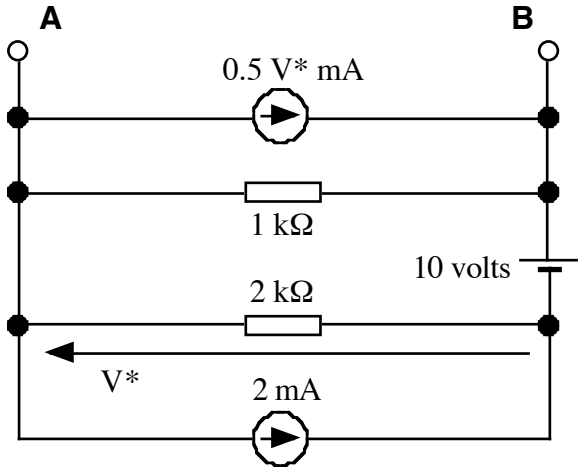


Figure 3(c)

4 (a) Sketch a dimensioned phasor diagram for the circuit shown in Figure 4(a), starting with the voltage v(t). [30]
What is the amplitude of the voltage $v_C(t)$? [15]
What is the phase relation between $v_C(t)$ and the source voltage $v_S(t)$? [10]

An inductor of 2 Henry is now connected across the resistor.
What is the new amplitude of the voltage $v_C(t)$? [15]
What is the new phase relation between the source voltage $v_S(t)$ and the current $i_S(t)$? [10]

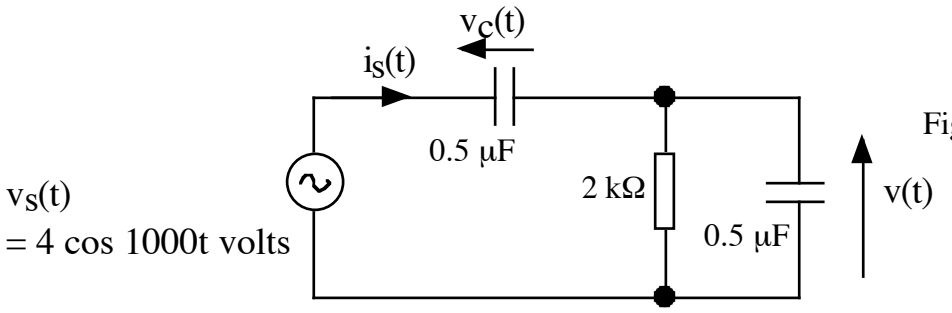


Figure 4(a)

(b) A customer requires an amplifier for which the requirements regarding frequency behaviour are of the form shown in the log-log plot of Figure 4(b): at any frequency the amplification magnitude $|V_o/V_{in}|$ must satisfy the indicated maximum and minimum levels.

The proposed amplier circuit is shown in Figure 4(c). Shown in Figure 4(d) are some circuits that, given suitable component values, might *or might not*, when substituted for the box with terminals X and Y in Figure 4(c), satisfy the requirements shown in Figure 4(b). Say which of the circuits of Figure 4(d), or none of them, could lead eventually to a satisfactory design. [20]

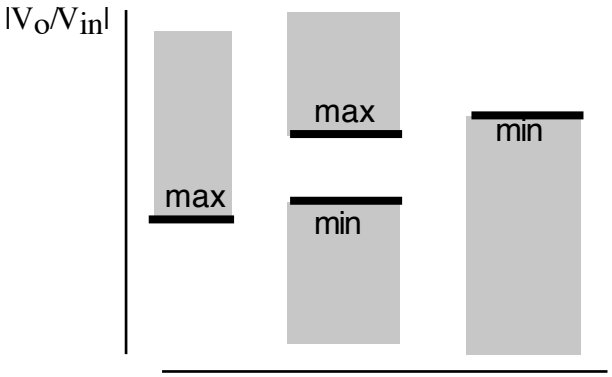


Figure 4(b)

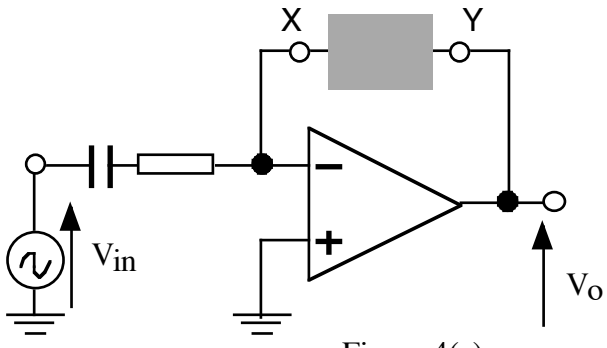


Figure 4(c)

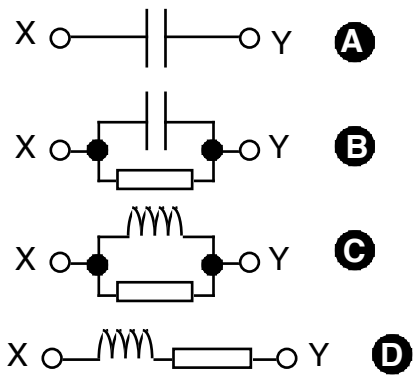


Figure 4(d)