# GLASGOW COLLEGE UESTC

**Exam paper**

## Circuits Analysis and Design (UESTC 2022)

**Date: 28th Dec. 2020**
**Time: 19:00-21:00**

**Attempt all PARTS. Total 100 marks**

**Use one answer sheet for each of the questions in this exam.**
**Show all work on the answer sheet.**

**For Multiple Choice Questions, use the dedicated answer sheet provided.**

**Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.**

**An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.**

**All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.**

**The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.**

**Attempt all PARTS**

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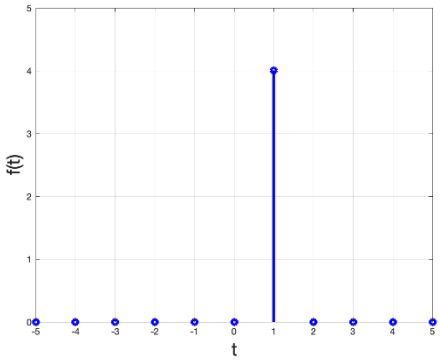
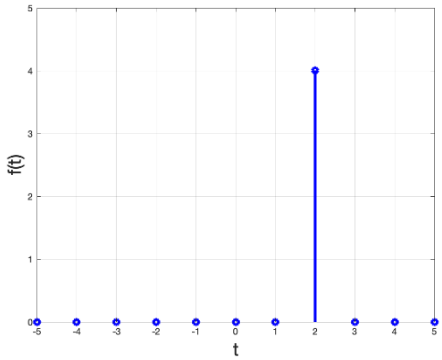
Q1 Choose a single answer to each of the following multiple-choice questions in the answer sheet provided. Make sure that you provide your answers in the answer sheet, not on this paper.

(1) The spectrum of the signal $f(t) = 4\delta(t-1)$ can be plotted as in one of the following graphs. Choose the one that is correctly illustrating the signal. [2]

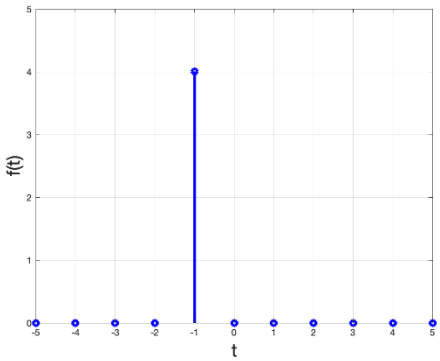
A.



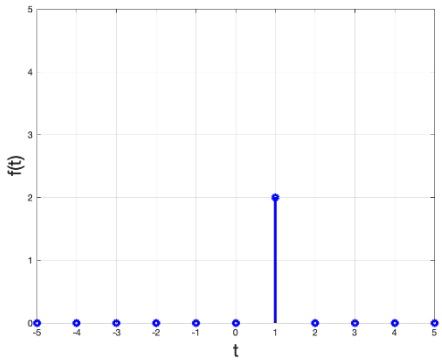

B.



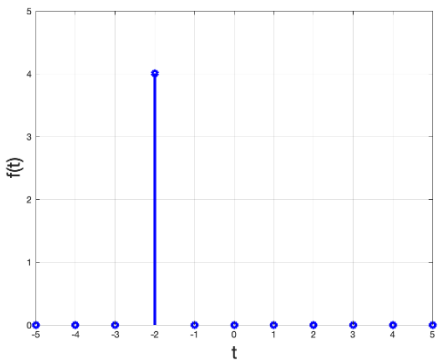

C.




D.




E.

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(2) A circuit has two resistors connected in parallel to a voltage source. If $V = 3V$, $R_1 = 3k\Omega$ and $R_2 = 6k\Omega$, value of $I_1$ can be given as one of the following. Select the correct value [2]

A. 1mA
B. 2mA
C. 3mA
D. 4mA
E. 1W

(3) Which one of the following Kirchhoff's Voltage Law equations describe the circuit given in Figure ***Q1.3***? [2]

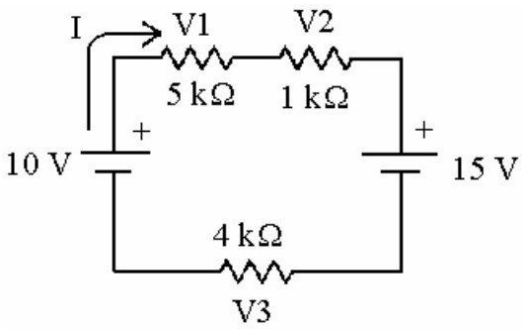


***Figure Q1.3***

A. +10 V - $V1$ - $V2$ + 15 V - $V3$ = 0
B. +10 V + $V1$ + $V2$ - 15 V + $V3$ = 0
C. +10 V - $V1$ - $V2$ - 15 V - $V3$ = 0
D. -10 V - $V1$ - $V2$ + 15 V - $V3$ = 0
E. None of these answers

(4) Select one answer that completes the statement below correctly:

A loop of a circuit is a closed path starting from a node and returning to _____. [2]

A. The ground
B. The voltage source
C. The same node
D. The same mesh
E. None of these answers

(5) Select one answer that completes the statement below correctly:

The inductor acts as a _____ circuit for a dc voltage. [2]

A. Open
B. Short
C. Low pass filter
D. High pass filter
E. None of these answers

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(6) Write the phasor of the current source $I(t) = 20\cos(2\pi 500t + 45°)$ [2]

A. $20e^{j500}$
B. $20e^{j45}$
C. $20e^{-j\pi/4}$
D. $20e^{j\pi/4}$
E. None of these answers

(7) If an inductor is traversed in the direction of current, and the time rate of change of current is positive as illustrated in Figure ***Q1.7***, according to Lenz's law, the induced current generated from the induced emf will flow in the _____ direction. [2]

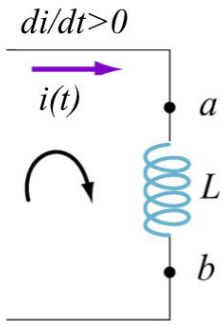


***Figure Q1.7***

A. Same
B. Opposite
C. Left
D. Right
E. Both left and right

(8) If the voltage across a capacitor of capacitance 100μF is given $v(t) = 50t - 200\ V$ for $3 \leq t < 4$, the current through the capacitor is: [3]

A. 1mA
B. -1mA
C. 0
D. -5mA
E. 5mA

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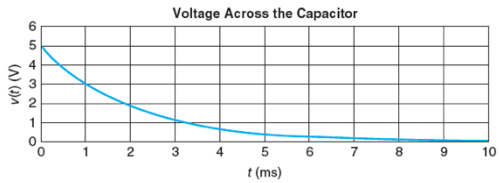
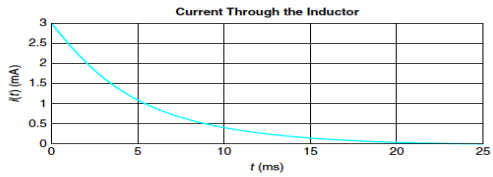
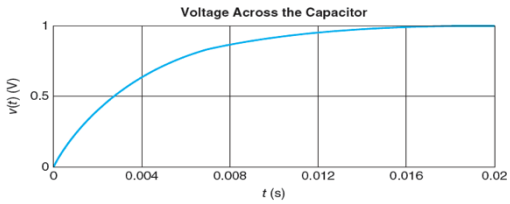
(9) Which of the curves given in Figure ***Q1.9*** show the example of the natural response of a circuit? Note: the following figures may come from different circuits [2]



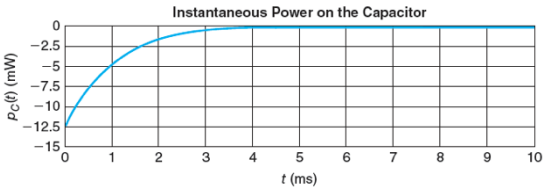

(i)




(ii)




(iii)




(iv)

***Figure Q1.9***

A. (i) and (ii)
B. (iii) and (iv)
C. (iii)
D. (i), (ii) and (iv)
E. All of them

(10) To design a difference amplifier using an OP-AMP, we connect ____to external signal sources. [2]

A. Inverting input terminal only
B. Noninverting input terminal only
C. Either inverting or noninverting input terminal
D. Both inverting and noninverting input terminals
E. Ground terminal

(11) The second order filters can be implemented in a series or parallel ___circuit. [2]

A. RL
B. RC
C. RLC
D. LR
E. None of these answers

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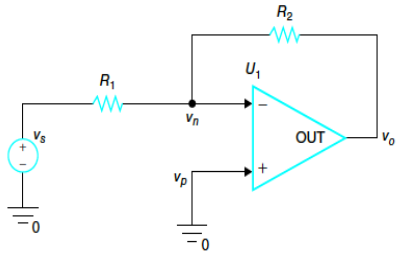
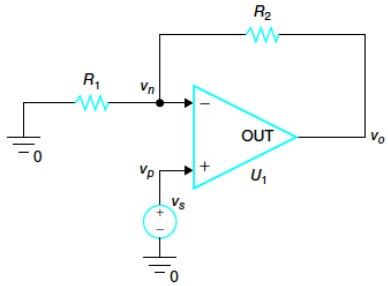
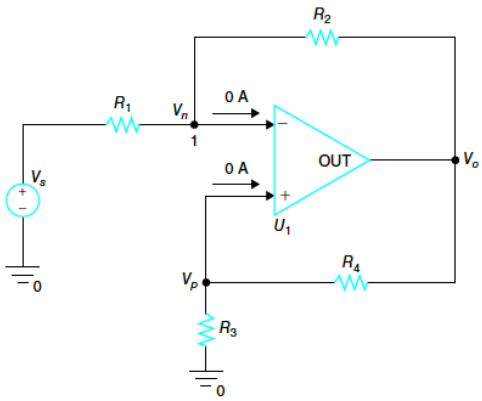
(12) Which statement is correctly describing the circuits given in Figure ***Q1.12***? [2]




(i)




(ii)




(iii)

***Figure Q1.12***

A. Circuit (i) is noninverting configuration of an OP-AMP
B. Circuit (ii) is inverting configuration of an OP-AMP
C. Circuit (iii) is inverting configuration of an OP-AMP
D. Circuit (i) and (ii) both are inverting configuration of an OP-AMP
E. None of these answers

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Q2 For the circuit given in Figure ***Q2***:

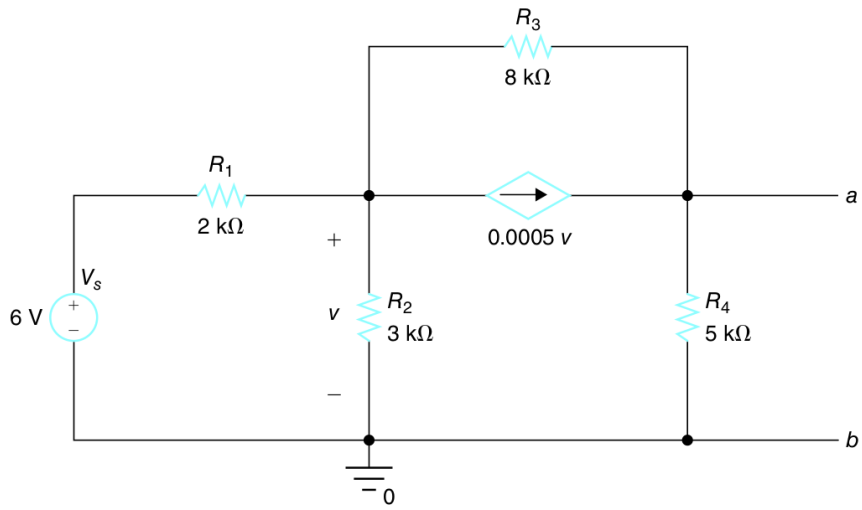


***Figure Q2***

(a) Find the open circuit voltage between terminals *a* and *b*. [8]

(b) Short circuit terminals *a* and *b* and draw the resulting circuit. Also, find the short circuit current. [8]

(c) Using your calculations in Part (a) and (b), find the Thévenin resistance for the circuit. [3]

(d) Draw the Thévenin equivalent for the given circuit. [3]

(e) If a load resistance $R_L$ is connected to the circuit in Part (d), what should be the value of this resistance to maximize the power transfer? Also, find the value of maximum power. [3]

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Q3 (a) Sketch the theoretical frequency response of the linear gain of a first order low pass filter, indicating the value of the gain in pass-band and at the cut-off frequency. [3]

(b) Having the choice of components including a resistor $R$=100Ω and an inductor $L$=15 mH, calculate the cut-off frequency of your low-pass filter. [3]

(c) Sketch the circuit diagram of the filter and calculate the expression for its frequency response with input $V_{in}$ and output $V_{out}$ as a function of $\omega$. [6]

(d) Verify if it is a LPF, HPF, BPF or BSF by calculating the value of the gain at 3 frequencies, at cut-off frequency, at a frequency ten times above the cut-off frequency and at a frequency ten times below the cut-off frequency. [6]

(e) Assume that the value of the resistor has a tolerance of ±10%. How would this affect the cut-off frequency and what would be the minimum and maximum cut-off frequencies expected? [4]

(f) Explain what modifications to the components of this filter you could make in order to increase its cut-off frequency. [3]

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Q4 For the circuit given in Figure ***Q4.1***, Switch 1 (SW1) has been closed for a long time before it is opened at $t = 0s$. Switch 2 (SW2) is closed at $t = 0.2s$. The voltage source is $V_S$ and the current source is $I_S$. Four resistors are labelled as $R_1$, $R_2$, $R_3$, and $R_4$. The capacitor is labelled as $C$.

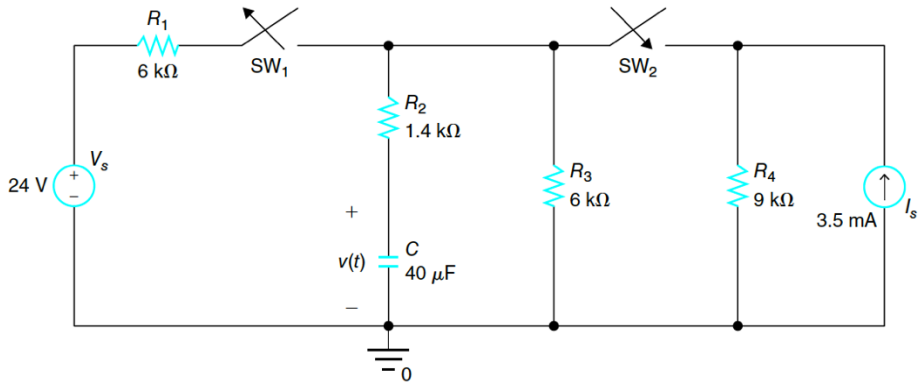


***Figure Q4.1***

(a) Find the initial voltage $v_0$ across the capacitor at $t = 0s$; that is $v(0) = V_0$. [5]

(b) Find the voltage $v(t)$ across the capacitor for $0 \leq t < 0.2s$. [5]

(c) Find the voltage $v(t)$ across the capacitor at $t = 0.2s$. [2]

(d) Find the voltage $v(t)$ across the capacitor for $0.2s \leq t$. [8]

(e) Draw the voltage curve on the graph given in Figure ***Q4.2*** (copy the graph in your answer book and draw the curve on it). [5]

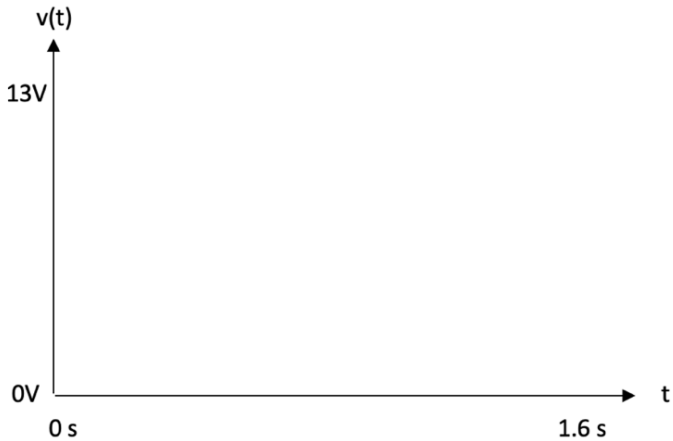


***Figure Q4.2***

End of question paper