Solutions

QJZ

Carleton UNIVERSITY

FINAL
EXAMINATION
DECEMBER 2004

DURATION: 3 HOURS

No. of Students: 282

Department Name & Course Number: ELEC 2501A,B,C
Course Instructor(s) T.G. Ray and Q.J. Zhang

AUTHORIZED MEMORANDA
Self-contained electronic calculator with memory cleared.

Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy to a proctor. This question paper has twelve **pages.**

This examination question paper may not **be taken from the examination room.**

In addition to this question paper, students require: an examination booklet yes☐ no☒
Approx. 10 blank sheets of paper for rough work. **a Scantron sheet yes☐ no☒**

INSTRUCTIONS and INFORMATION:

1. PRINT YOUR NAME AND STUDENT NUMBER CLEARLY.

NAME:

NUMBER:

marks/1: ___

2. ATTEMPT ALL QUESTIONS.

3. PUT YOUR FINAL ANSWERS ONLY IN THE SPACE PROVIDED.

4. FULL MARKS FOR EACH QUESTION ARE INDICATED.
Part marks are possible depending on the question.

5. THE EXAM MARKS TOTAL 100.

Faculty Use Only:

Page	1	2	3	4	5	6	7	8	9	10	11	12
Marks	1											

Q1. RMS Value and Power **(15 marks)**

a) For the periodic waveform in Figure 1:

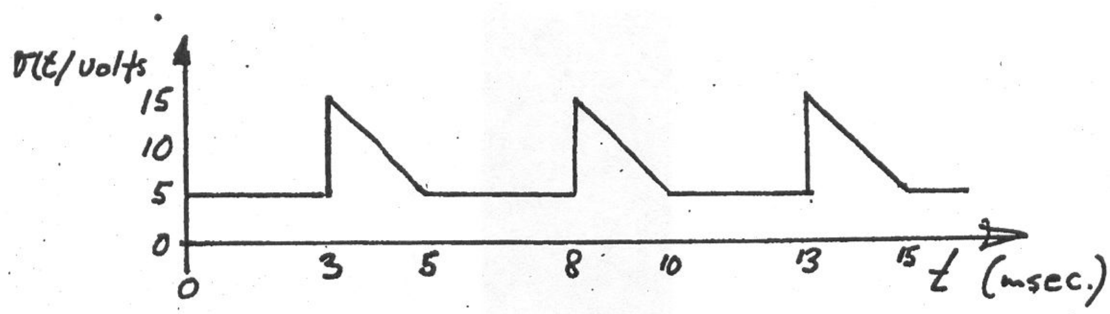


Figure 1.

ai) What are the equations for the parts of the waveform?

Answer: v(t) = 5 volts, $0 < t < 3$ msec etc.

$-5000t + 30$, $3 < t < 5$ msec etc. marks /3:__

aii) Using the equations above, what is the equation for calculating the RMS value of the waveform?

Answer: RMS= $\sqrt{\frac{1}{.005}\left[\int_{0}^{.003} 5^2 dt + \int_{.003}^{.005} (-5000t+30)^2 dt\right]}$ marks /3:__

aiii) What is the RMS value of the waveform?

Answer: RMS= 7.64 volts RMS marks /2:__

1b) Find the power that is absorbed or supplied by each of the elements in the following circuit:

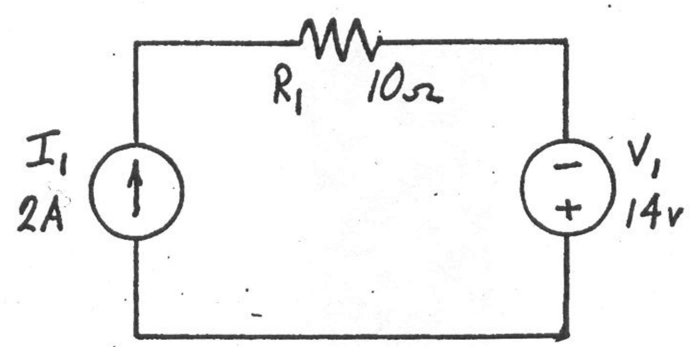


Figure 2.

Answer: Power in I_1: -12 watts

Power in R_1: +40 watts

Power in V_1: -28 watts marks/3:____

1c) Given the circuit of Figure 3:

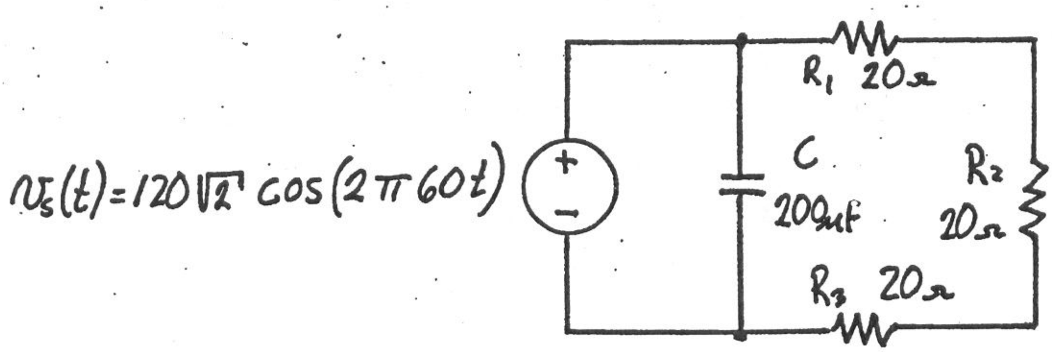


Figure 3.

What is the average power dissipated in each of R_1 and C?

Answer: Average power in R_1 is 80W watts marks/3: __

Average power in C is 0 watts marks/1: __

Q2. Thevenin, Norton and Superposition **(21 marks)**

a) For the circuit shown in Figure 4, find the **Thevenin** equivalent source between the terminals A and B.

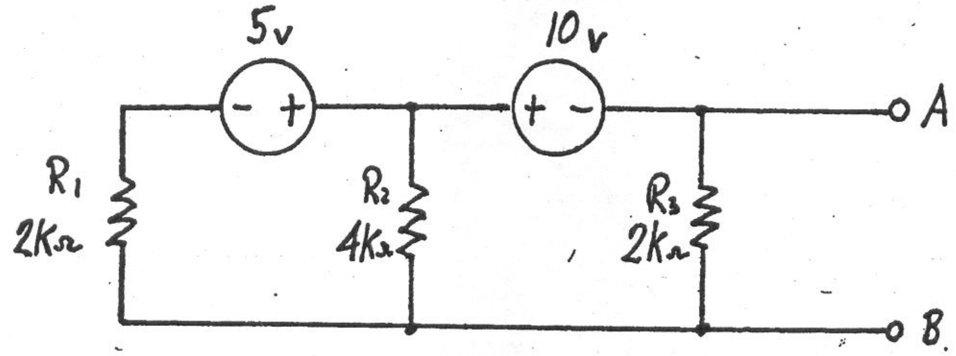
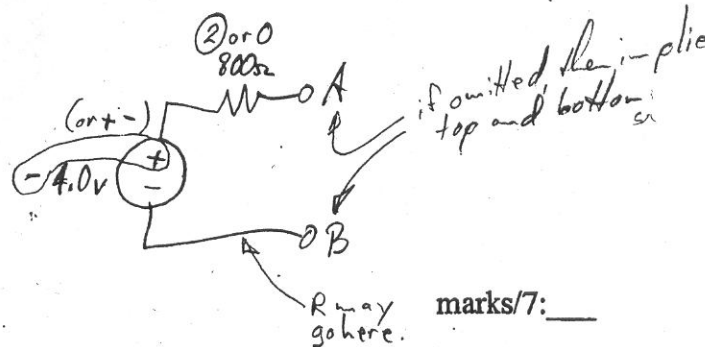


Figure 4.

Answer: Thevenin equivalent source:



marks/7:___

b) For the circuit shown in Figure 5, find the **Norton** equivalent source between the terminals A and B.

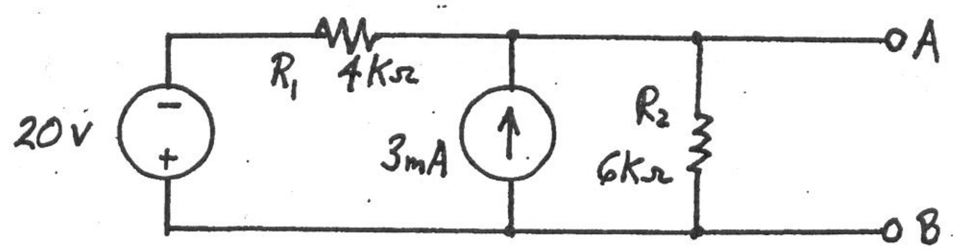
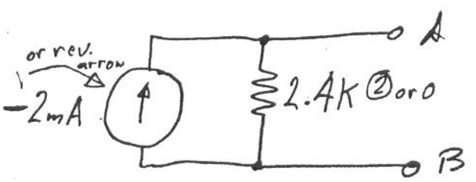


Figure 5.

Answer: Norton equivalent source:



marks/7:___

2c) For the circuit shown in Figure 6:

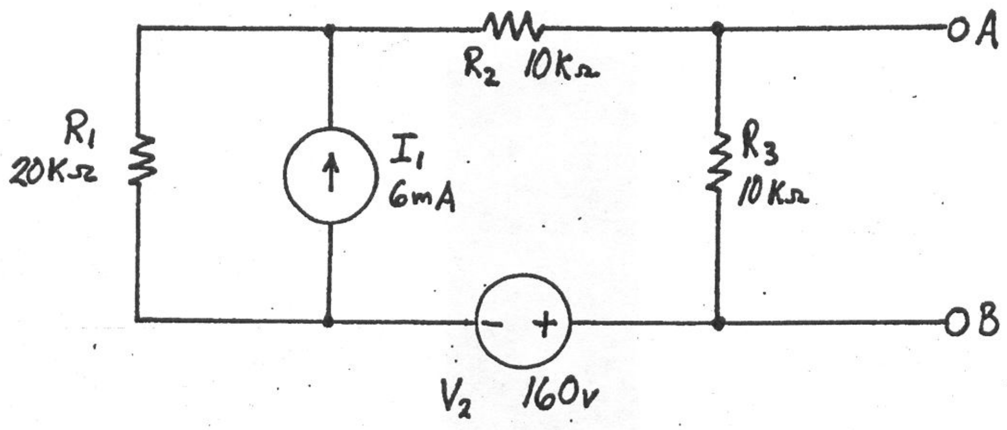


Figure 6.

Use superposition to find the contribution of each source to the output voltage V_{AB}, and then find the total output voltage V_{AB}.

Answer: Contribution to V_{AB} made by the source I_1: +30v marks/3: ___

Contribution to V_{AB} made by the source V_2: − 40v marks/3: ___

Total V_{AB} using superposition theorem: − 10v marks/1: ___

Q32

Q3. <u>Nodal Analysis and Loop Analysis</u> **(12 marks)**

a) Given the circuit in Figure 7:

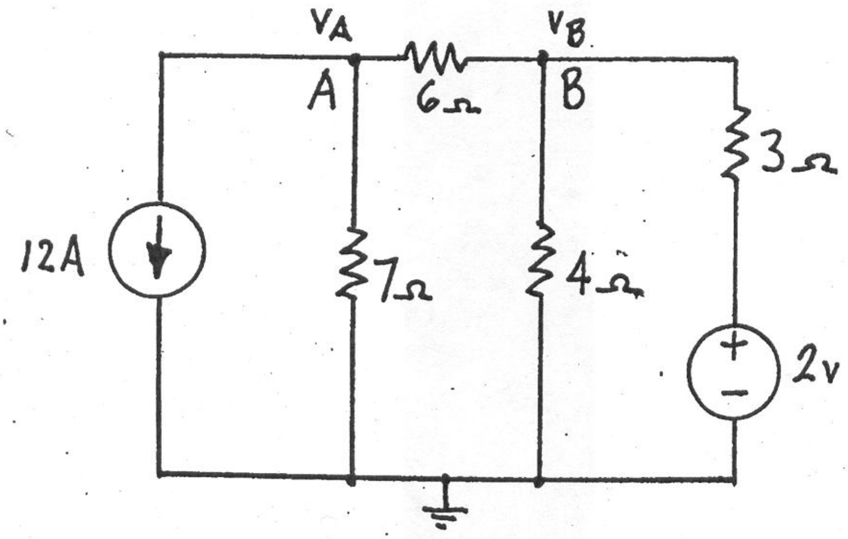


Figure 7.

Write the nodal equations at nodes A and B, using the convention that currents entering a node are positive.

Answer: At node A: $-12A + \frac{0 - V_A}{7\Omega} + \frac{V_B - V_A}{6\Omega} = 0$ marks/3: ____

At node B: $\frac{V_A - V_B}{6\Omega} + \frac{0 - V_B}{4\Omega} + \frac{2v - V_B}{3\Omega} = 0$ marks/3: ____

b) Given the circuit of Figure 8:

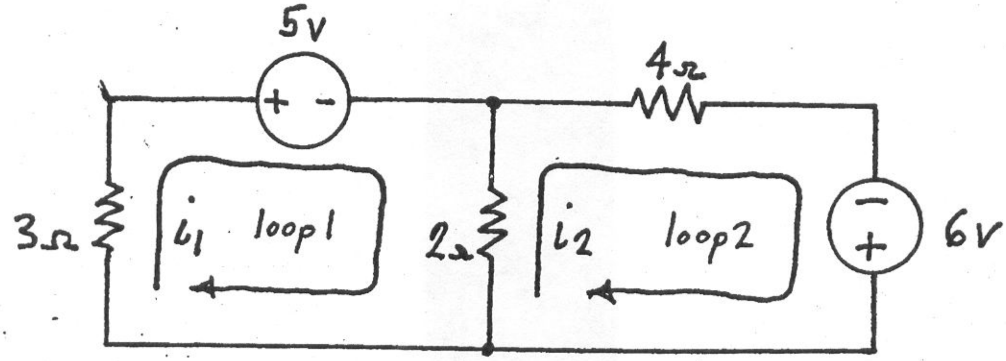


Figure 8.

Write the loop equations for the two loops.

Answer: Around loop1: $+3i_1 + 5V + 2(i_1 - i_2) = 0$ marks/3: ___

Around loop2: $+2(i_2 - i_1) + 4i_2 - 6V = 0$ marks/3: ___

(18 marks)

Q4. Phasor Analysis

Note: Answers may be in either polar or Cartesian form, but still must be simplified, e.g. 15 ∠ 30° volts, or e.g. 30-j27 ohms.

a) For the circuit given in Figure 9:

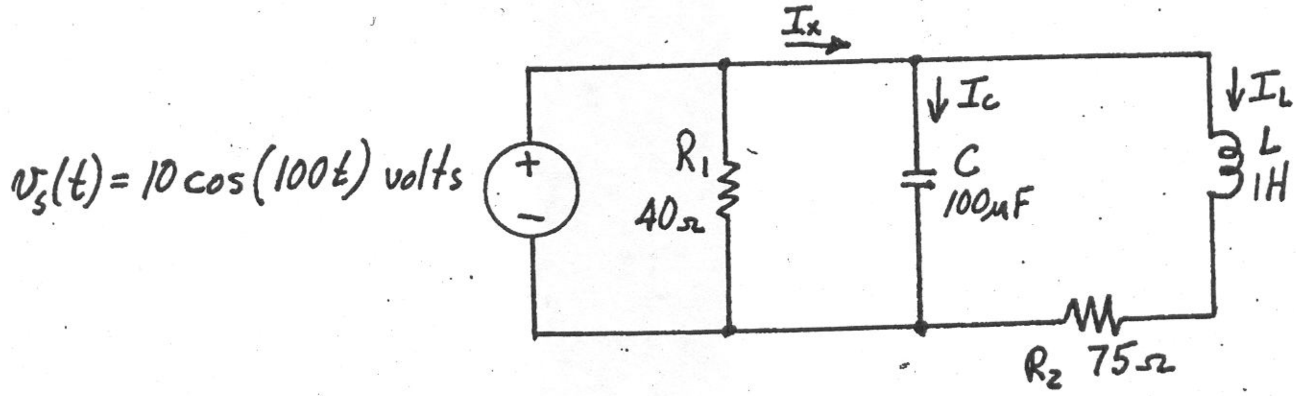


Figure 9.

a i) Find the impedance of the capacitor and the impedance of the inductor.

Answer: Z_C = $-j100$ (or $100\angle -90°$) marks /2: ___

Answer: Z_L = $+j100$ (or $100\angle +90°$) marks /1: ___

a ii) Find the capacitor and inductor currents as phasors.

Answer: I_C = $0.1\angle +90°$ Amps (or $0.1j$ Amps) marks /2: ___

Answer: I_L = $0.08\angle -53.13°$ (or $0.048 - j0.064$) marks /4: ___

a iii) Find the current I_x as a phasor.

Answer: I_x = $0.048 + j0.036$ (or $0.06\angle 36.87°$) marks /2: ___

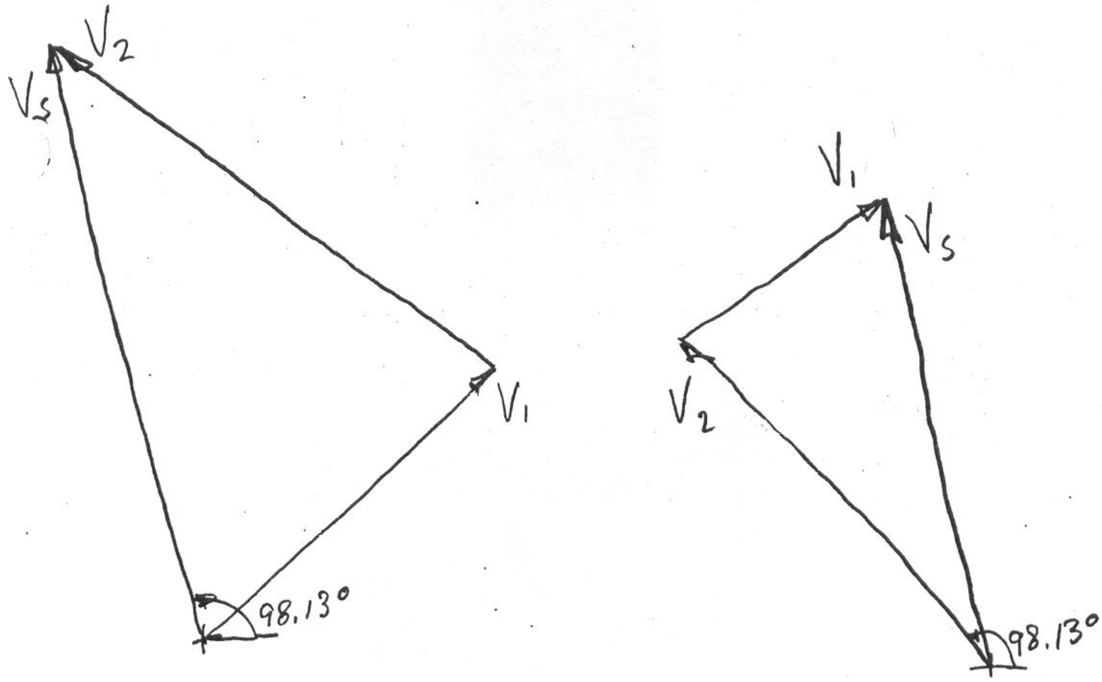
b) Given the KVL phasor equation $V_S = V_1 + V_2$ in which $V_1 = 30 \angle +45°$ volts and $V_2 = 40 \angle +135°$ volts: $V_S = V_1 + V_2 = (21.21 + j21.21) + (-28.28 + j28.28)$

b i) Calculate V_S as a phasor: (or $50.0 \angle +98.13°$).

Answer: V_S = $-7.07 + j49.49$ volts marks /2: ___

b ii) For $V_S = V_1 + V_2$, show KVL is satisfied in a clear phasor diagram, approximately to scale:

Answer: Phasor diagram showing KVL:



marks/3: ___

c) A series RLC resonant circuit has L = 0.1 mH. What value of C is required to make the circuit resonate at a frequency of 100,000 Hz? $\omega_0 = \frac{1}{\sqrt{LC}}$.

Answer: C = 0.023 µF 1µF worth ① marks /2: ___

Q5. Frequency Response and Bode Plots (11 marks)

Given the transfer function $H(j\omega) = V_{OUT} / V_{IN} = j20\omega / (1+j0.1\omega)$:

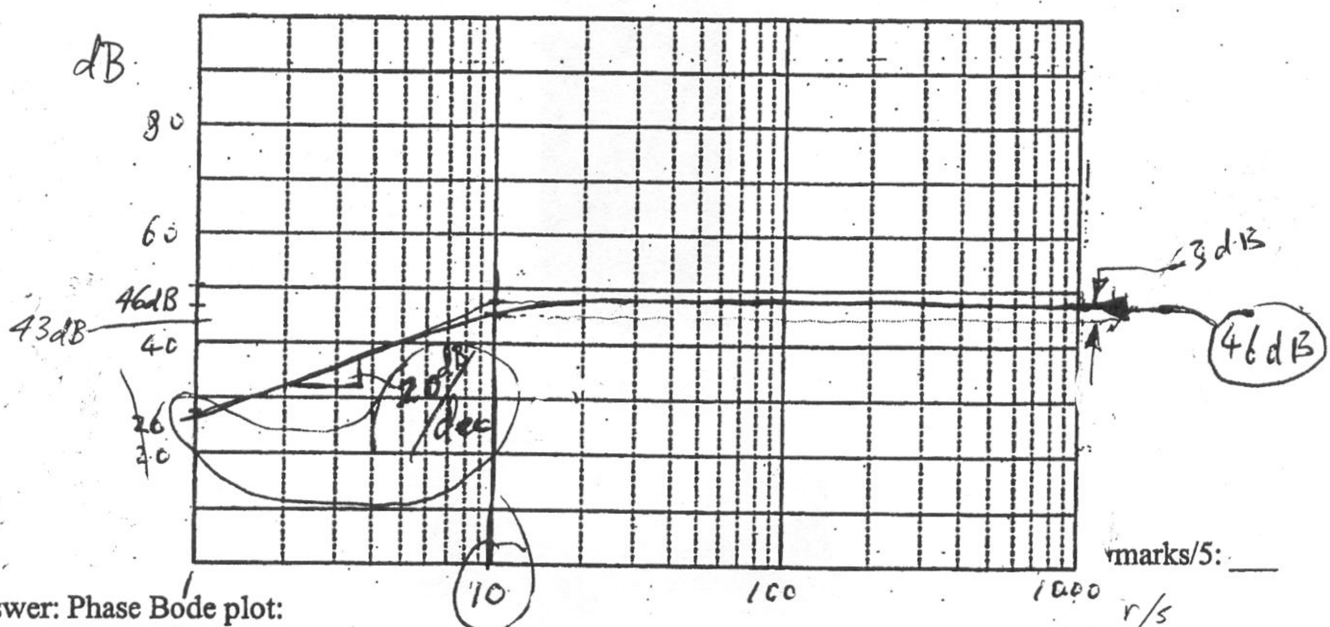
a) What is the value of the corner frequency in radians per second?

Answer: The corner frequency is 10 Rad/s marks/2: ___

1.59 Hz

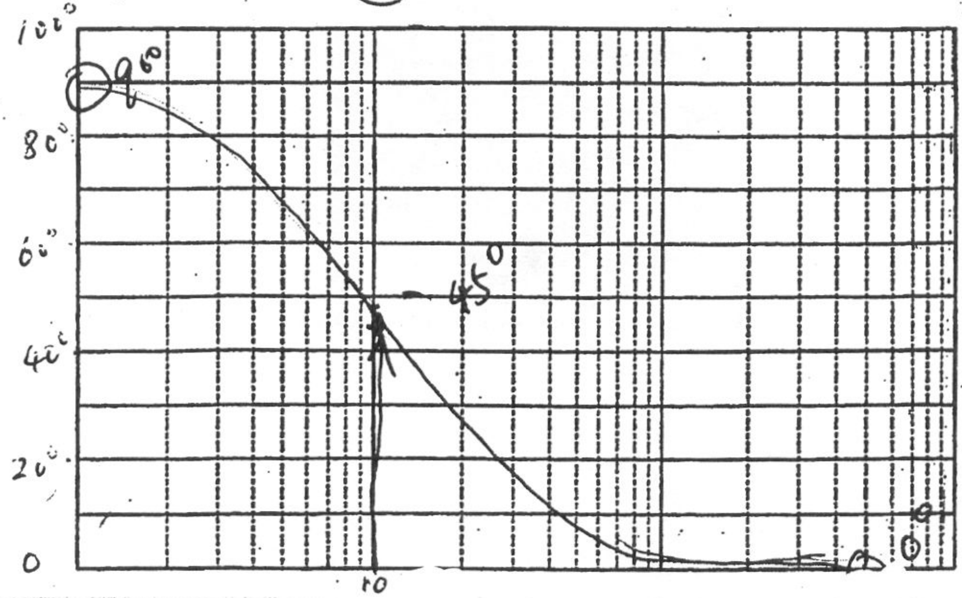
b) Draw the magnitude and phase Bode plots, clearly indicating the ***important values*** on each of them.

Answer: Magnitude Bode Plot:



marks/5: ___

Answer: Phase Bode plot:



marks/4: ___

Q6. Transient Analysis **(22 marks)**

a) In the circuit of Figure 10, switch S is closed for all $t<0$. At $t=0$ the switch is opened.

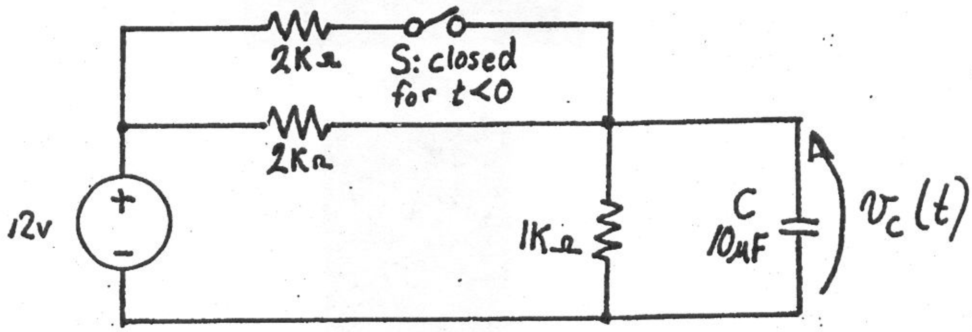


Figure 10.

a i) Find the voltage across the capacitor, v_C, for $t<0$.

Answer: For $t<0$, v_C = 6 V marks /1:___

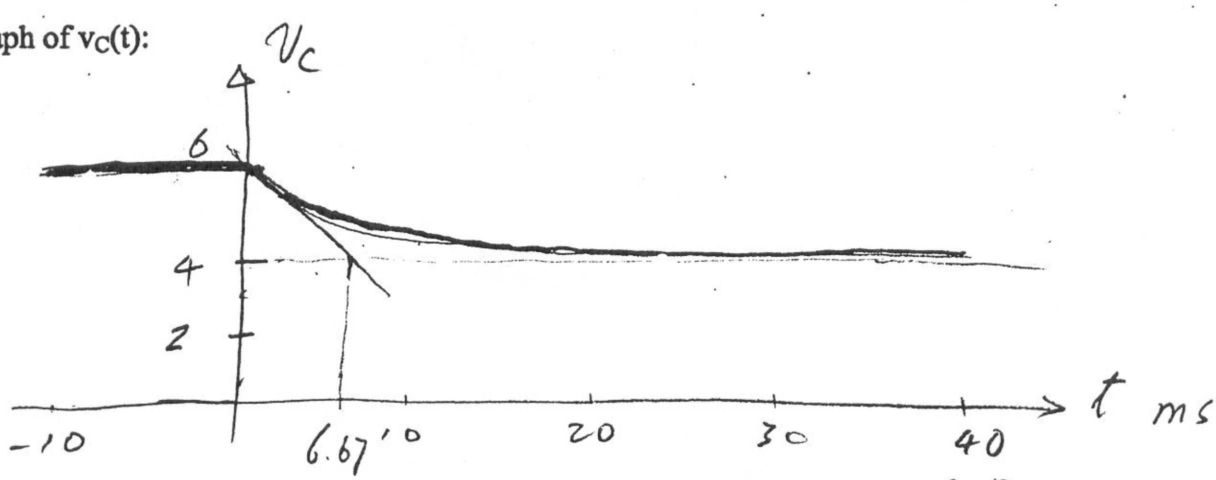
a ii) Derive an expression for the voltage across the capacitor, $v_C(t)$, for $t>0$.

$V_F + (V_I - V_F)e^{-\frac{t}{\tau}}$

Answer: For $t>0$, $v_C(t)$= $4 + 2e^{-\frac{t}{6.67ms}}$ marks /7:___

a iii) Sketch $v_C(t)$ from t = -10 msec. to t = + 40 msec. clearly showing the time constant and its relationship to the waveform.

Answer: Graph of $v_C(t)$:



marks /3:___

a iv) If the response above is interrupted at t= +8 msec by the switch being closed, derive a new equation for $v_C(t)$ for t> +8 msec.

Answer: For t>+8 msec., $v_C(t)$= $6 - 1.4\, e^{-\frac{(t-8ms)}{5ms}}$ marks /5:___

b) In the circuit shown below in Figure 11, switch S is closed for all t<0. At t=0 the switch is opened.

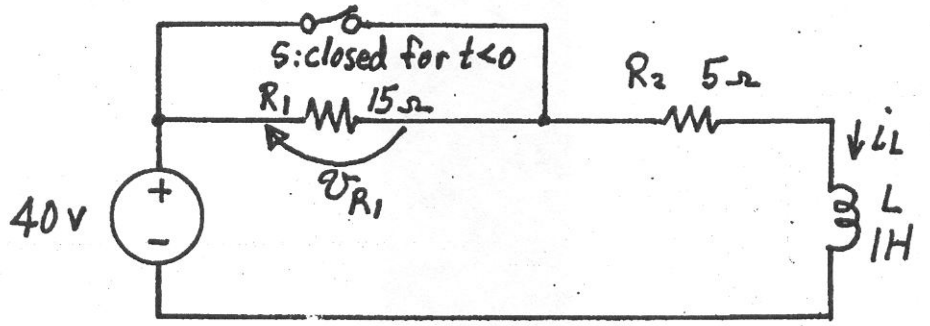


Figure 11.

b i) Find the inductor current, i_L, just before the switch is opened.

Answer: i_L = 8 A marks /2:___

b ii) Find v_{R1} at the instant just after the switch is opened.

Answer: v_{R1}= 120 V marks /2:___

b iii) Find the final value of v_{R1}.

Answer: v_{R1}= 30 V marks /1:___

b iv) Find the time constant for the response of v_{R1} for t>0.

$R_{eq} = 20\Omega$

Answer: Time Constant = $\frac{L}{R} = 0.05$ = 50ms marks /1:___

Have a safe and happy holiday!