



MACHAKOS UNIVERSITY

University Examinations 2019/2020 academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 304: AC CIRCUIT THEORY

DATE: 22/1/2021

TIME: 2.00-4.00 PM

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

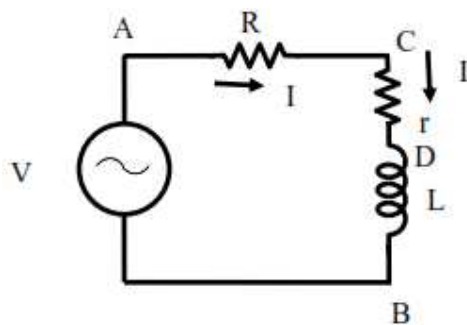
QUESTION ONE (COMPULSORY)

- a) State the advantages of the AC over DC. (3 marks)
- b) Calculate the phasor current through a $100\ \Omega$ resistor assuming a voltage of $V_{rms} \angle 0^\circ$ applied across it. (2 marks)
- c) Define impedance, and write down the mathematical expression in a series RLC circuit. With the help of a diagrammatic representation, show the relationship between z , X_L and X_C . (5 marks)
- d) Define resonance in a series RLC circuit. Write down the mathematical expression for resonant frequency. State the sufficient conditions for the phenomenon of resonance to occur. (3 marks)
- e) Sketch a plot for the average power as function of the driving angular frequency ω in a driven RLC circuit. (3 marks)
- f) Compute the power factor for each of the following cases;
 - i. $z = 100 \angle -30^\circ$ (1 mark)
 - ii. $100 + i50\ \Omega$ (2 marks)
- g) An inductor is connected to an AC voltage source. The inductor has an inductance of 1 H and is connected to a 120 V 60 Hz line. Determine the current flow in this circuit. (3 marks)

- h) Write down the mathematical expression for Inductance, L . State the factors the inductance of an inductor is dependent on. (3 marks)
- i) Write down the transformer equation. Distinguish between a step-up and a step-down transformer. (3 marks)
- j) Distinguish between the RL high-pass filter and the low-pass filter. (2 marks)

QUESTION TWO

- a) A resistor, R is connected in series with an iron-cored choke coil, L . The circuit draws a current of 5A at 240 V, 50 Hz. The voltages across the resistor and the coil are 120 V and 200 V respectively.



Calculate,

- i. The resistance, reactance and impedance of the coil (6 marks)
- ii. The power absorbed by the coil, and (2 marks)
- iii. The power factor (pf) of the input current (2 marks)
- iv. Solution
- b) Using phasor diagrams, show the relationships between current and voltage in a series RLC circuit. Using the phasor representation, write down the expression for the voltage supplied by the AC source. (3 marks)
- c) An RL high-pass filter, represented by the circuit shown in figure 1 has an inductor with internal resistance R .

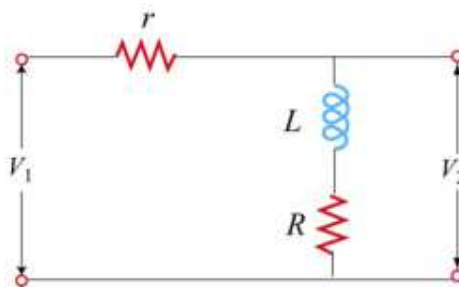
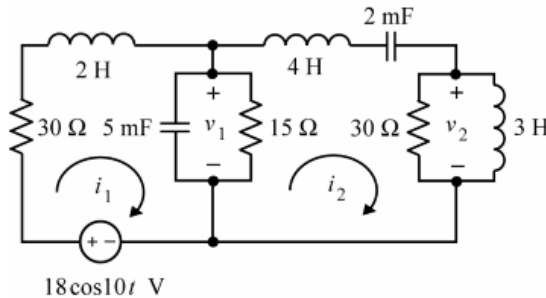


Figure 1.

- i. Find V_{20}/V_{10} , the ratio of the maximum output voltage V_{20} to the maximum voltage V_{10} . (4 marks)
- ii. Suppose $r = 15.0\Omega$, $R = 10.0\Omega$ and $L = 250 \text{ mH}$. Determine the frequency at which $V_{20}/V_{10} = 1/2$. (3 marks)

QUESTION THREE

- a) Determine the nodes voltages, $v_1(t)$ and $v_2(t)$, and the mesh currents, $i_1(t)$ and $i_2(t)$, for the circuit shown. (10 marks)



- b) If you built a Full-wave bridge rectifier (without using a transformer) with a $1 \text{ k}\Omega$ resistor and a $4.7 \mu\text{F}$ capacitor to convert an AC input voltage of 30 volts peak-to-peak at 1 kHz to a DC voltage.
 - i. Determine the approximate DC voltage across the load resistor. (2 marks)
 - ii. Determine the peak Revers voltage across each of the 4-diodes in the circuit (3 marks)
- c) Compute the reactance of a $10 \mu\text{F}$ capacitor at a frequency of;
 - i. 10 kHz (1 mark)
 - ii. 1 MHz (1 mark)
- d) Draw the phasor diagram of the following signal. $V = 300V_{rms} - j150V_{rms}$. (Use a scale of $1 \text{ cm} = 100 V_{rms}$). (3 marks)

QUESTION FOUR

- a)
 - (i) Define a phasor and state its properties. (3 marks)
 - (ii) Sketch a phasor diagram for a purely resistive circuit. (3 marks)
- b) Define a transformer and discuss briefly how it operates. (6 marks)
- c) A sinusoidal voltage $V(t) = 200V \sin \omega t$ is applied to series RLC circuit with $L = 10.0 \text{ mH}$, $C = 100 \text{ nF}$ and $R = 20.0 \Omega$. Determine the following quantities.
 - i. The resonant frequency. (2 marks)
 - ii. The amplitude of the current at resonance. (2 marks)
 - iii. The quality factor Q of the circuit, and (2 marks)
 - iv. The amplitude of the voltage across the inductor at the resonant frequency. (2 marks)

QUESTION FIVE

a) A series RLC circuit with $L = 160 \text{ mH}$, $C = 100 \mu\text{F}$, and $R = 40.0 \Omega$ is connected to a sinusoidal voltage $V(t) = 40.0 \text{ V} \sin \omega t$, with $\omega = 200 \text{ rad/s}$.

i. Determine the impedance of the circuit. (4 marks)

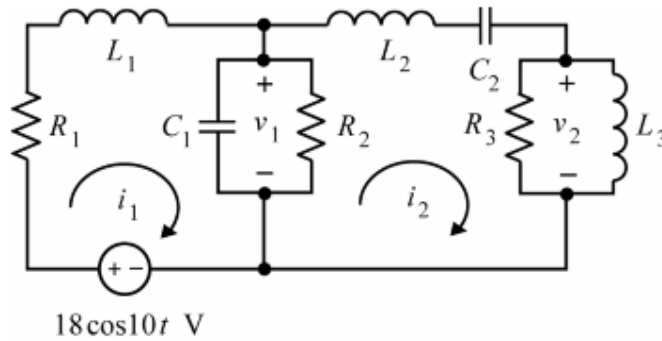
ii. Let the current at any instant in the circuit be $I(t) = I_0 \sin(\omega t - \phi)$. Find I_0 . (2 marks)

iii. Determine the phase ϕ . (4 marks)

b) In this circuit, the node voltages are;

$v_1(t) = 3.318 \cos(10t - 39.3^\circ) \text{ V}$ and $v_2(t) = 4.452 \cos(10t - 12.7^\circ) \text{ V}$, and the mesh currents are;

$i_1(t) = 0.439 \cos(10t - 25.9^\circ) \text{ A}$ and $i_2(t) = 0.2099 \cos(10t - 57.7^\circ) \text{ A}$.



Determine the values of the resistances, inductances and capacitances. (10 marks)