BANGLADESH UNIVERSITY OF PROFESSIONALS

Military Institute of Science and Technology

B.Sc. in Mechanical Engineering,

Term Final (Spring) Examination 2022: Aug-Sept 2022

Student Group: 0 < Earned Credit Hours ≤ 36

Subject: EECE-159, Fundamentals of Electrical Engineering

Time: 3.00 hours **Full Marks: 120**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question-1** in **Section-A** and **Question-5** in **Section-B** are compulsory
c. Answer any other **TWO** questions out of **THREE** from each section.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** and **abbreviations** used have their usual meanings

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SECTION-A

Question 1 (Compulsory)

a. In many practical situations, a circuit is designed to provide power to a load. There are applications in areas such as communications where it is desirable to maximize the power delivered to a load. **10**

Now, state and derive the **Maximum Power Transfer Theorem** in a circuit. Illustrate the relationship between power and load resistance in a graph with necessary scaling. Also, establish the expression for the maximum power with respect to Thevenin voltage and Thevenin resistance.

b. Analyze the value of R_L that will draw the maximum power from the rest of the circuit in Fig. 1(b). Also, determine the maximum power. **10**

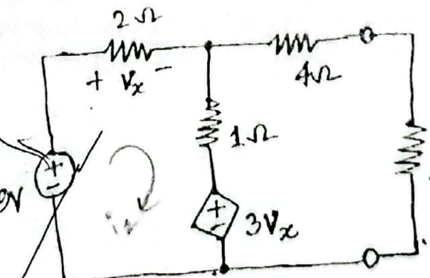


Fig. 1(b)

c. Compute the equivalent resistance R_{ab} for the circuit in Fig. 1(c) and use it to find current i. **10**

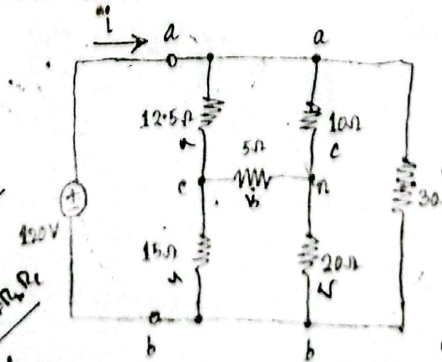


Fig. 1(c)

$I = \frac{V}{R}$

P = VI

$R_{IN} = \frac{R_a R_b + R_a R_c}{R_a + R_b + R_c}$

Question 2

a. Find the node voltages in the circuit if Fig. 2(a). 10

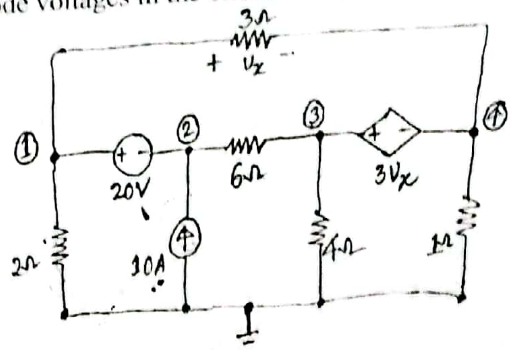


Fig. 2(a)

b. Use mesh analysis to find the current I_o in the circuit of Fig. 2(b). 10

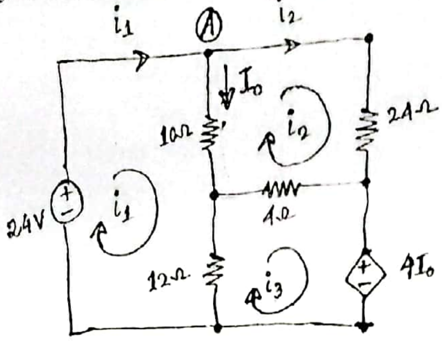


Fig. 2(b)

$I = \frac{V}{R} = \frac{1}{R}V$

$= GV$

$I = \frac{V}{R}$

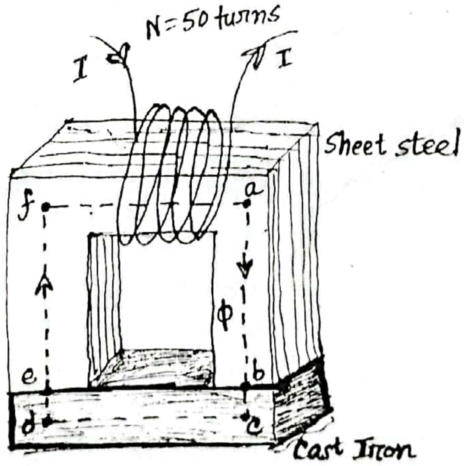
$10 I_o = V$

c. Illustrate the Wye network and Delta network with necessary figures. What are their alternative names? For a balanced network, derive the expression for Delta to Wye conversion. 10

Question 3

a. Explain Hysteresis. Illustrate a regular B/H curve indicating necessary parameters. Briefly explain the overall scenario in your own word. 06

b. The electromagnet in Fig. 3(b) has made up a section of cast iron. Determine the current, I required to establish the indicated flux in the core. 10



$20 i_1 - j_2 = 4 i_2 - 4 i_3$

$i_n - 5 i_2 + 4 i_3 = 0$

$\phi \frac{di}{dt}$

$l_{ab} = l_{cd} = l_{ef} = l_{fa} = 4$ in.

$l_{bc} = l_{de} = 0.5$ in.

Area (throughout) = 1 in.^{2}

$\phi = 3.5 \times 10^{-4}$ Wb

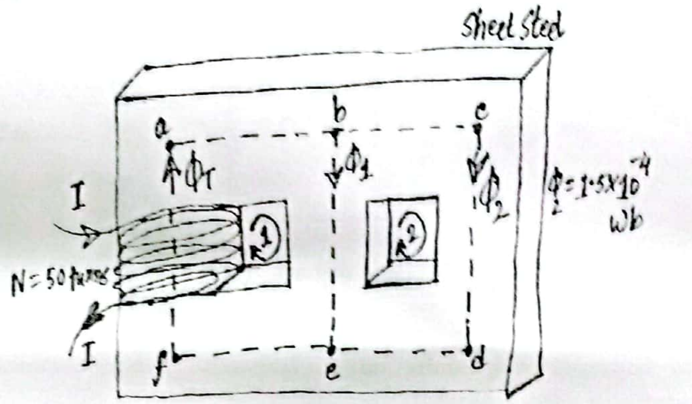
Fig. 3(b)

Use the following values from Table-3(b) extracted from the B/H curve for additional information required

Table-3(b)

Material Used	Flux Density (T)	Magnetizing Force (At/m)
Cast Steel	0.2	170
	0.5	280
Sheet Steel	0.542	70
	0.10	20
	0.25	40
	0.97	160
	1.22	400
Cast Iron	0.542	1600
	0.39	1000
	0.503	1500

c. Determine the current, I required to establish a flux of $1.5 \times 10^{4}\ wb$ in the section of the core indicated in Fig. 3(c). Also determine the permeability and relative permeability for each section. 14



$l_{bcde} = l_{efab} = 0.2m$

$l_{be} = 0.05m$

Cross-sectional area $= 6\times10^{-4}\ m^2$ throughout

Fig. 3(c)

Use the following values from Table-3(b) extracted from the B/H curve for additional information required.

Question 4

a. For a conductor immerged in a magnetic field, derive the following expression, where all the symbols have their conventional meanings: 08

$$e = -Blv \sin\theta$$

b. A conducting rod AB showed in Fig. 4(b) makes contact with metal rails AD and BC, which are 50 cm apart in a uniform magnetic field of $B = 1.0\ wb/m^2$ perpendicular to the plane ABCD. The total resistance (assumed constant) of the circuit ABCD is 0.4 Ω. 12

i) What is the direction and magnitude of the $e.m.f.$ induced in the rod when it is moved to the left with a velocity of $8\ m/s$?

ii) What force is required to keep rod in motion?

iii) Compare the rate at which mechanical work is done by the force, F with the rate of development of electric power in the circuit

$R = \rho\frac{L}{A}$

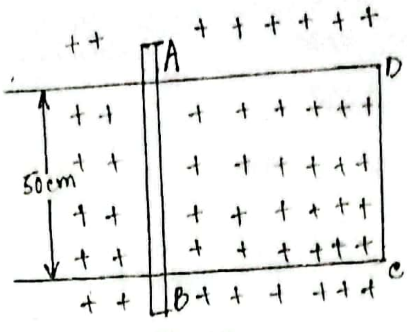


Fig. 4(b)

c. The time variation of the flux linked with a coil of 500 turns during a complete cycle is as follows: **10**

$$\phi = 0.04\left(1 - \frac{4t}{T}\right)\ wb\ ;0 < t < \frac{T}{2}$$

$$\phi = 0.04\left(\frac{4t}{T} - 3\right)\ wb\ ;\frac{T}{2} < t < T$$

Where T represents time period and equals $0.04\ s$. Sketch the waveforms of the flux and induced $e.m.f.$ and also determine the maximum value of induced $e.m.f.$

SECTION-B

Question 5 (Compulsory)

a. Apply superposition theorem to determine the value of v_o in the circuit as shown in Fig. 5(a). **10**

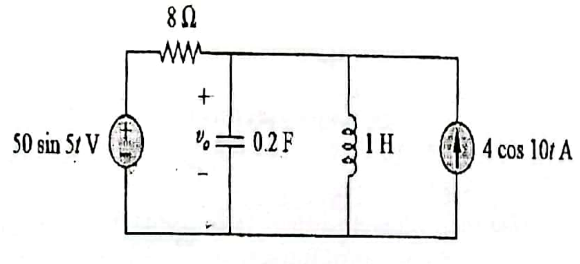


Fig. 5(a)

b. In the balanced three phase $Y - \Delta$ system as shown in Fig. 5(b). Compute the line currents and the average power delivered to the load. **12**

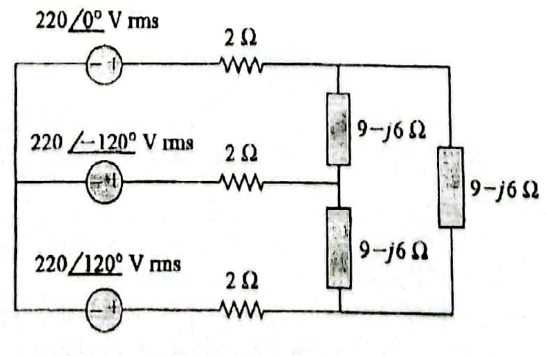


Fig. 5(b)

$I_m = V_m/2$

cos ωt + 30°

$\frac{1}{0.215 + 10.01 i}$

sin ∓ cos ωt

+ cos ωt

sin ωt − 180°

c. A balanced Δ- connected load having an impedance $20 - j15\ \Omega$ is connected to a Δ-connected, positive-sequence generator having $V_{ab} = 300\angle 0^\circ\ V$. Compute the phase currents of the load and the line currents 08

Question 6

a. If $V_o = 20\angle 45^\circ\ V$ in the circuit as shown in Fig. 6(a), determine the value of I_s. 10

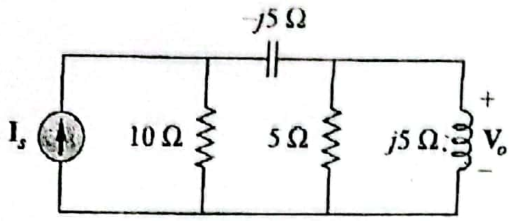


Fig. 6(a)

0.357 ∠33.66

0.27

0.27 ~~0.20~~

0.28 ∠95.08

0.1∠0

b. At terminals $a - b$, obtain the thevenin equivalent circuit for the network depicted in Fig. 6(b). Consider $\omega = 10\ rad/s$. 10

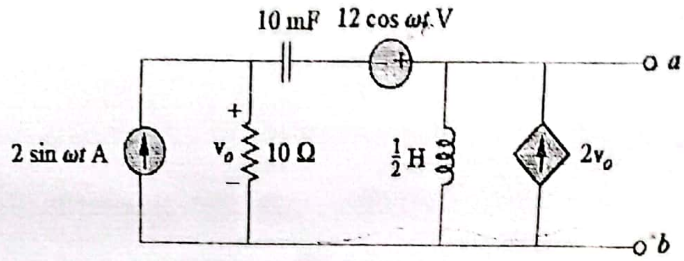


Fig. 6(b)

c. For the system as shown in Fig. 6(c), derive the expression of instantaneous power absorbed by an arbitrary combination of circuit elements under sinusoidal excitation and show that, the average power over one cycle delivered to the load can be given by- 10

$$P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$$

Where, all the symbols have their usual meanings.

$V_{rms} \cdot I_{rms}$.

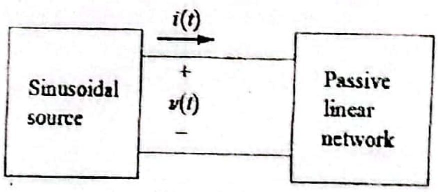


Fig. 6(c)

Question 7

a. Calculate the effective value of the current waveform as shown in Fig. 7(a) and the average power delivered to a 12 Ω resistors when the current is passed through the resistor. 10

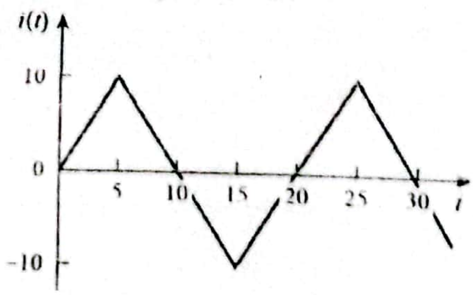


Fig. 7(a)

b. In the circuit as shown in Fig. 7(b), find the value of Z_L that will absorb the maximum power and also determine the value of the 10 maximum power.

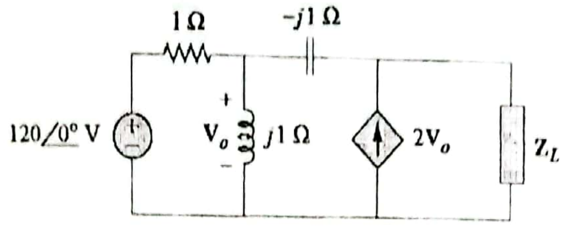


Fig. 7(b)

c. Determine the wattmeter reading of the circuit as shown in Fig. 7(c). **10**

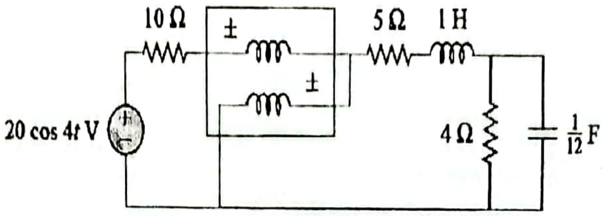


Fig. 7(c)

Question 8

a. For the circuit as shown in Fig. 8(a), determine the value of I_o. **08**

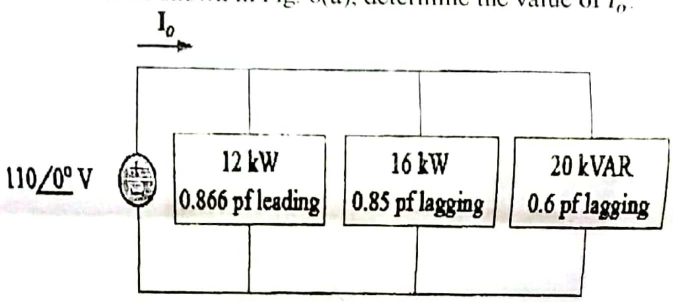


Fig. 8(a)

b. Prove that, the total instantaneous power in a balanced three phase system is constant- it does not change with time as the instantaneous power of each phase does. **08**

c. Two balanced loads are connected to a 240 kV rms 50 Hz line, as shown in Fig. 8(c). Load 1 draws 30 kw at a power factor of 0.6 $lagging$. While load 2 draws 45 $KVAR$ at a power factor of 0.8 $lagging$. Assuming abc phase sequence, determine the followings: **14**

i). The complex, real and reactive power absorbed by the combined load.

ii). The line currents, and

iii). The $KVAR$ rating of the three capacitors Δ- connected in parallel with the load that will raise the power capacitance of each capacitor.

$\frac{1}{1} + \frac{1}{j1}$

$1 + 1j$

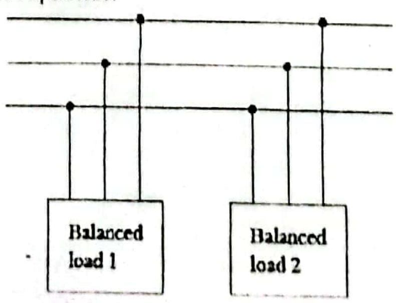


Fig. 8(c)