COEP TECHNOLOGICAL UNIVERSITY, PUNE

(A Unitary Public University of Government of Maharashtra.)

END Semester Examination

Programme: B. Tech | **Semester: I**

Course Code: ES-04 | **Course Name: BEE**

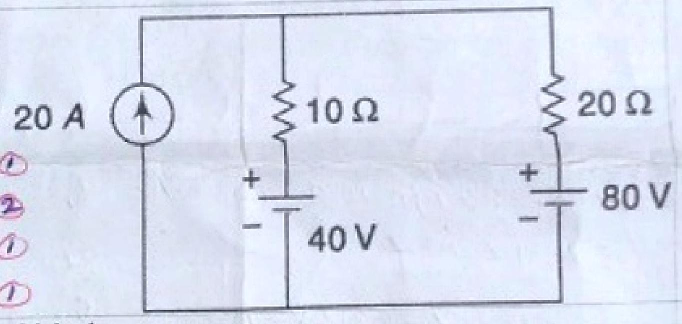
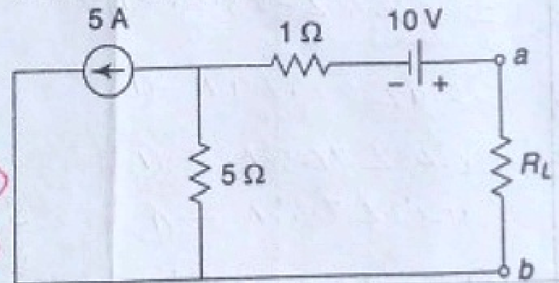
Branch: Mechanical Group | **Academic Year: 2023-24**

Duration: 3 Hrs | **Max Marks: 60**

Student PRN No. | | | | | | | | | |

Instructions:

1. Figures to the right indicate the full marks.
2. Mobile phones and programmable calculators are strictly prohibited.
3. Writing anything on question paper is not allowed.
4. Exchange/Sharing of stationery, calculator etc. is not allowed.
5. Write your PRN Number on Question Paper.

			Marks	CO	PO
Q1	a)	Use Norton's theorem to calculate the current flowing through the 20 Ω resistor. $I_{sc_1} = 20A(\downarrow)$ — ① $I_{sc} = 16A(\downarrow)$ — ② $R_N = 10\Omega$ — ① $I_L = 5.33A$ — ① ckt dia — ① 	6	1, 2	1-4
	b)	Find the value of R_L for which the power transferred to R_L is maximum and find the value of this maximum power. $R_L = R_i = 6\Omega$ — ② $I_{6\Omega} = 1.25A(\downarrow)$ — ③ $P_{max} = 9.375W$ — ① 	6	1, 2	1-4
Q2	a)	A 230 V, 50 Hz voltage is applied to a coil L = 5 H and R = 2 Ω is in series with a capacitance C. What value must C have in order that the voltage across the coil be 400 V?	6	1, 2	1-4
	b)	A balanced star connected load has an impedance of (2 + j3.46) Ω between line and neutral. If the voltage across phase R and neutral be 20∠–30° volts, find current in phases Y and B. What is the voltage from line Y to neutral. Also obtain V_{RB}.	6	1, 2	1-4

(12)

2) a)
$Z_{coil} = 1571\Omega$ — ①
$I = 0.2547\ A$ — ①
$Z_{eq} = 903\Omega$ — ①
$X_C = 667\Omega$ — ①
$C = 4.7\mu F$ — ②

2) b) $V_{RN} = 20\angle{-30^\circ}V$
$Z_{ph} = 2+j3.46$
$\cong 4\angle 60^\circ$

$V_{YN} = 20\angle{-150^\circ}V$ — ①
$V_{BN} = 20\angle{-270^\circ}V$ — ①
$V_{RB} = \sqrt{3}V_{ph} = 34.64\angle 0^\circ$ — ①

$I_{RN} = \dfrac{20\angle{-30^\circ}}{4\angle 60} = 5\angle 30^\circ A$ — ①

$I_{YN} = 5\angle(30-120) = 5\angle{-90^\circ}A$ — ①
$I_{BN} = \qquad = 5\angle{-210^\circ}A$ — ①

Q3	a)	Three impedances $(4 - j6)\ \Omega$, $(6 + j8)\ \Omega$ and $(5 - j3)\ \Omega$ are connected in parallel. Calculate the current in each branch when the total supply current is 20 A.	6	1, 2	1-4
	b)	An iron ring of circular cross-section of $5\times10^{-4}\ m^2$ has a mean circumference of 2 m. It has a saw-cut of 2×10^{-3} m length and is wound with 800 turns of wire. Determine the exciting current when the flux in the air gap is 0.5×10^{-3} Wb. μ_r of iron = 600 and assume areas of air gap and iron are same.	6	2	1-4
Q4	a)	A 1 kVA, single-phase transformer has an iron loss of 20 W and a full load copper loss of 40 W. Calculate its efficiency at (i) full load with p.f. of 0.8 lagging, (ii) half load unity power factor.	6	3	1-4
	b)	Draw schematic diagrams of DC shunt, DC series and DC compound motors and mention their applications.	6	4	1-4
Q5	a)	What is the function of switch fuse unit? State any two advantages and disadvantages of fuses.	4	5	1-4
	b)	Explain the use of MCB and ELCB in electrical wiring installations. Also give their typical specifications.	4	5	1-4
	c)	A residential flat has the following average electrical consumptions per day: 1) 4 tube lights of 20 watts working for 4 hours per day. → 0.32 kWh 2) 1 water heater rated 1.5 kW working for 1 hour per day. → 1.5 units 3) 1 water pump of 0.5 kW rating working for 2 hours per day. → 1 unit 4) 2 fans of 60 W rating working for 8 hours per day. → 0.96 unit Calculate the cost of energy per month (30 days) if 1 kWh of energy (i.e., 1 unit of energy) costs Rs. 6.	4	1, 5	1-4

3) a) $Y = Y_1 + Y_2 + Y_3 = 0.284 + j0.129$ — 2

$= 0.31 \angle 23.4^\circ$

$V = 64.5 \angle -23.4 V$ — 1

$I_1 = VY_1 = 8.9 \angle 32.79^\circ A$ — 1

$I_2 = VY_2 = 6.45 \angle 76.5^\circ A$ — 1

$I_3 = VY_3 = 11.03 \angle 7.5^\circ A$ — 1

$Z_1 = 0.077 + j0.115\ \Omega$, $Z_2 = 0.06 - j0.08\ \Omega$

$Z_3 = 0.147 + j0.088\ \Omega$

3) b) $S_1 = 5.29 \times 10^6$ AT/Wb — 1

$S_2 = 3.18 \times 10^6$ AT/Wb — 1

$S = S_1 + S_2$

$S = 8.48 \times 10^6$ AT/Wb — 2

$I = 5.3 A$ — 2

$S = \frac{NI}{\phi}$ & $\therefore I = \frac{S\phi}{N}$

4) a) $\eta_{F.L.} = 93.02\%$ — 3

$\eta_{H.L} = 94.34\%$ — 3

b) Schematic diagram → 1 Mark each

Application → 1 Mark each

5) c)

$= 30\left[\left(4 \times \frac{20}{1000} \times 4\right) + (1 \times 1.5 \times 1) + (1 \times 0.5 \times 2) + \left(2 \times \frac{60}{1000} \times 8\right)\right] \times 6$

$=$ Rs. 680.4 Marks

Rs 680.4 — 4 Marks

5) a) function → switch fuse unit → 2

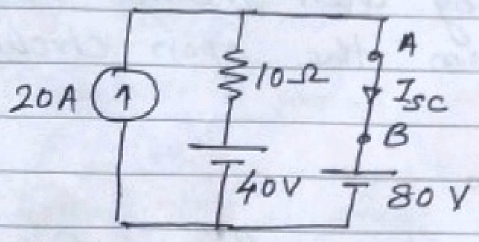
Advantage & disadvantages → 1 mark each

b) MCB use → 1, ELCB — 1

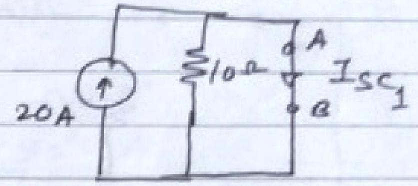
Specification — 2

Course: Basic Electrical Engineering
Exam: ESE (2024)
Model Answer & Marking Scheme

Q1 a)



Considering 20 A source acting alone

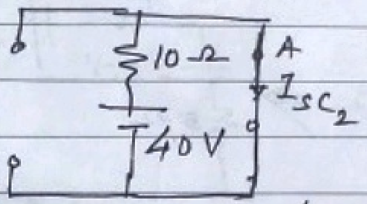


Short circuiting 20 Ω res.
... 1 mark

$\therefore I_{sc_1} = 20\ A$ from A to B

$I_{sc_1} = 20A$ (↓) — ①

Considering 40 V source acting alone -

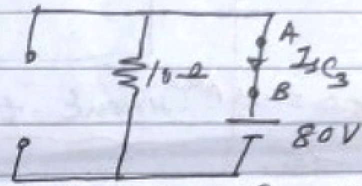


$I_{sc} = 16A$ (↓) — ②

$I_L \approx 5.33A$ (↓)

$\therefore I_{sc_2} = 40/10 = 4\ A$ from A to B

Considering 80 V source acting alone

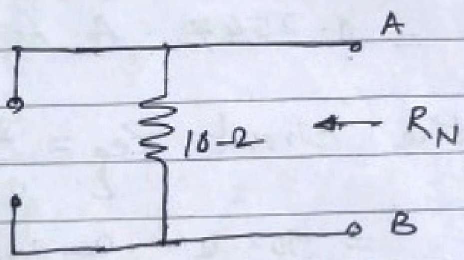


$\therefore I_{sc_3} = 80/10 = 8A$ from B to A

Applying superposition principle -

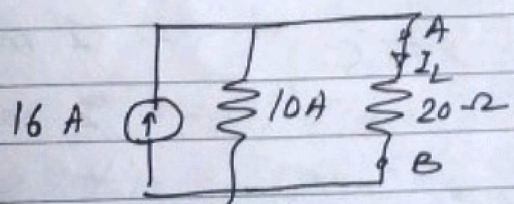
$I_{sc} = I_N = 20 + 4 - 8 = 16\ A$ from A to B (2 marks)

Now, removing all sources & replacing by their internal resistances -



$\therefore R_N = 10\ \Omega$ ... (1 mark)

$\therefore$ Norton's equivalent circuit -



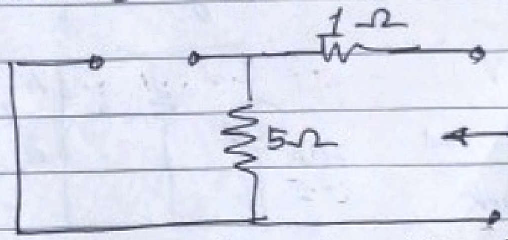
... 1 mark

$\therefore I_L = 16 \times \frac{10}{10+20}$

$= 5.33\ A$ from A to B

.... 1 mark

Q 1 b) Replacing all sources by their internal resistances and looking back from the open circuited terminals of R_L

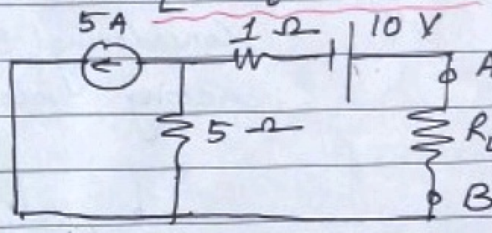


$R_i = 6\ \Omega$

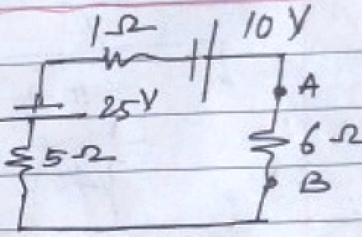
Power transferred will be maximum when

$R_L = R_i = 6\ \Omega$ ..... 2 marks

$R_L = R_i = 6\ \Omega$ — ②



⇒



$I_{6\Omega} = 1.25\,A$ (1) — ③

Current through $6\ \Omega$ res. $= \dfrac{15}{5+6+1} = 1.25$ A from B to A ... 3 marks

$P_{max} = 9.37\,W$ — ①

Maximum power $= I^2R = (1.25)^2 \times 6$
$= 9.375$ Watt ... 1 mark

Q2 a) Impedance of the coil $= \sqrt{R^2 + X_L^2}$

$Z_{coil} = \sqrt{2^2 + (2\pi \times 50 \times 5)^2} = 1570.8\ \Omega$ ... 1 mark

$Z_{coil} = 1570\ \Omega$ — ①

$\therefore$ Current $I = \dfrac{400}{1570.8} = 0.2547$ A ... 1 mark

$I = 0.254\,A$ — ①

Total impedance of the circuit $Z_{eq} = \dfrac{230}{0.2547}$
$= 903.21\ \Omega$ ... 1 mark

$Z_{eq} = 903\ \Omega$ — ①

$Z_{eq} = \sqrt{R^2 + (X_L - X_c)^2} = 903.21\ \Omega$

$X_c = 667\ \Omega$ — ①

$X_c = 667.6\ \Omega = \dfrac{1}{2\pi f C}$ ... 1 mark

$c = 4.7\,\mu F$ — ②

$\therefore C = 4.77\ \mu F$ ... 2 marks

b) $V_{RN} = 20\angle 30°$ V
$Z_{ph} = 2 + j\,3.46 \doteq 4\angle 60°\ \Omega$

$$I_{RN} = \frac{20\angle{-30^\circ}}{4\angle 60^\circ} = 5\angle{+30^\circ}\ A \quad \cdots 1\text{ mark}$$

$\therefore$ Current in Y phase $= 5\angle(+30-120)^\circ$

$5\angle{-90^\circ}$ $\qquad = 5\angle{-150^\circ}\ A \quad \cdots 1$ mark

Current in B phase $= 5\angle(-150-120)^\circ$

$5\angle{-210^\circ}$ $\qquad = 5\angle{-270^\circ}\ A \quad \cdots 1$ mark

or $= 5\angle 90^\circ\ A$ $\quad 150$

$20\angle{-150^\circ}$ $\quad V_{YN} = 20\angle(30-120)^\circ = 20\angle{-90^\circ}\ V \quad \cdots 1$ mark

$20\angle{-270}$ $\quad V_{BN} = 20\angle(-90^\circ-120)^\circ = 20\angle{-270^\circ}$

-150 $\qquad$ or $= \cancel{20\angle 150^\circ} \quad \cdots 1$ mark

$V_{RB} = \sqrt{3}\ V_{ph} = 34.64\ V$

$V_{RN} + V_{NB}$ $\qquad = 34.64\boxed{\angle 0^\circ}\ V \quad \cdots 1$ mark

Q3 a)

$Z_1 = (4-j6)\ \Omega \quad \therefore Y_1 = \dfrac{1}{(4-j6)} = 0.077 + j0.115$

$Z_2 = (6+j8)\ \Omega \quad \therefore Y_2 = \dfrac{1}{6+j8} = 0.06 - j0.08$

$Z_3 = (5-j3)\ \Omega \quad \therefore Y_3 = \dfrac{1}{5-j3} = 0.147 + j0.088$

$\therefore Y = Y_1 + Y_2 + Y_3 = 0.284 + j0.123 \quad \cdots 2$ marks

$= 0.31\angle 23.4^\circ$

Supply voltage $V = \dfrac{I}{Y} = \dfrac{20\angle 0^\circ}{0.31\angle 23.4^\circ}$

$= 64.5\angle{-23.4}\ V \quad \cdots 1$ mark

$I_1 = VY_1 = (64.5\angle{-23.4})(0.077 + j0.115)$

$= (64.5\angle{-23.4})(0.138\angle 56.19)$

$= 8.9\angle 32.79^\circ\ A \quad \cdots 1$ mark

$I_2 = VY_2 = (64.5\angle{-23.4})(0.06 - j0.08)$

$= (64.5\angle{-23.4^\circ})(0.1\angle{-53.13^\circ})$

$= 6.45\angle 76.5^\circ\ A \quad \cdots 1$ mark

$I_3 = VY_3 = (64.5\angle{-23.4^\circ})(0.147 + j0.088)$

$= (64.5\angle{-23.4^\circ})(0.171\angle 30.9^\circ)$

$= 11.03\angle 7.5^\circ\ A \quad \cdots 1$ mark

$\mu = \frac{B}{H}$ $H = \frac{NI}{l}$ $NI = Hl$ $NI = \frac{\phi}{\mu_0 \mu_r A} \times l$ iron

NI airgap

Q3 b) length of iron $= 2 - 2\times10^{-3}$

$= 1.998$ m

$l_{iron} = 2$ m

$l_{gap} = 2\times10^{-3}$ m

Reluctance of iron path $S_1 = \frac{l_{iron}}{\mu_0 \mu_r A}$

$S_1 = 5299859.6$ AT/Wb — 1

$= \frac{1.998}{4\pi\times10^{-7}\times600\times5\times10^{-4}}$

$S_2 = 3183098.9$ AT/Wb — 1

$= 5299859.6$ AT/Wb — 1 mark

Reluctance of air gap $S_2 = \frac{l_{gap}}{4\pi\times10^{-7}\times1\times5\times10^{-4}}$

$S = S_1 + S_2$

$S = 8482958.5$ AT/Wb — 2

$= \frac{2\times10^{-3}}{4\pi\times10^{-7}\times1\times5\times10^{-4}}$

$= 3183098.9$ AT/Wb ... 1 mark

Total reluctance, $S = S_1 + S_2$

$I = 5.3$ A — 2

$= 8482958.5$ AT/Wb ... 2 Marks

$S = \frac{NI}{\phi}$ $\therefore I = \frac{S\times\phi}{N}$

$I = 5.3$ A ... 2 marks

Q4 a) (i) $\eta_{FL} = \frac{1\times \cancel{1000}\ 1\times0.8}{1\times1\times0.8+0.02+(1)^2\times0.04}\times100$

$\boxed{\eta_{FL} = 93.02\ \% \quad ... \quad 3 \text{ marks}}$

$\eta_{HL} = \frac{0.5\times1\times1}{0.5\times1\times1+0.02+(0.5)^2\times0.04}\times100$

$\boxed{\eta_{H.L} = 94.34\ \% \quad ... \quad 3 \text{ marks}}$

b) Schematic diagrams – 1 mark each
Applications – 1 mark each

Q5 a) Function of switch-fuse unit - 2 marks
Advantages and disadvantages – 1 mark each

b) Use of MCB - 1 mark, ELCB - 1 mark
Specifications - 2 marks

c) Electricity bill = Units in kWh × Rate/unit

$= 30\left[\left(4\times\frac{20}{1000}\times4\right)+(1\times1.5\times1)+(1\times0.5\times2)+\left(2\times\frac{60}{1000}\times8\right)\right]\times6 =$ Rs. 580.4/-

Rs. = 545.4 — 4

... 4 marks