



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Examination Answer Books

12 Pages

Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.

Complete, fold and seal
(see note 2 below)

SURNAME: Neale

FORENAME(S): Matthew

1	Student Number	NEA 20856038
2	Title of Examination Paper	Electrical Principles Theory
3	Module Code	GOEE 5001
4	Date and Time of Examination	15/May/2025 1:35
5	Examination Venue	68860
6	Seat Number	B3

7	Number of Answer Books handed in	1
---	----------------------------------	---

List the numbers of the questions you have attempted	Office Use
1	
2	
3	
4	
Q1	13
Q2	21
Q3	9
Q4	20
Total	63/100

(Gweler yr ochr arall am y fersiwn Cymraeg)

63% ✓

1 a.

$$Z(s) = 2s + \frac{1000}{s} + 6$$

$$R = 6 \Omega$$

$$L = 2 H$$

$$C = \frac{1}{C(s)}$$

$$C = \frac{1000}{(s)}$$

$$\text{So } C = \frac{1000}{1} = 1000 F$$

$$b) 3e^{3t} \cos(2t) + t^2 + 0.75$$

$$\mathcal{L}\{3e^{3t} \cos(2t) + t^2 + 0.75\} = 3 \frac{s-3}{(s-3)^2 + 2^2} + \frac{2}{s^3} + \frac{0.75}{s}$$

$$\mathcal{L} = 3 \frac{s-3}{(s-3)^2 + 2^2} + \frac{2}{s^3} + \frac{0.75}{s}$$

$$ii) \sin(4t)e^t + 5e^{-3t}$$

$$\mathcal{L}\{\sin(4t)e^t + 5e^{-3t}\}$$

$$iii) e^{2t} (3 - t^2) + \frac{3\pi}{2}$$

$$\mathcal{L} = 3e^{2t} -$$

Q113/30Q1a2/5Q1b3/10

$$1) \mathcal{L}\{\cosh(2t) + e^{-2t}\} = \mathcal{L}\{\cosh(2t) + e^{-2t}\}$$

$$\mathcal{L} = \frac{s-1}{(s-1)^2 - 2^2} + \frac{1}{s+2}$$

$$2) \mathcal{L}\{e^{2t} e^{-4t} t^3 - 3e^t \sin(e^2 t)\}$$

$$\mathcal{L}\{e^{2t} e^{-4t} t^3 - 3e^t \sin(e^2 t)\}$$

$$3) V(t) = 80e^{-10t} \text{ V for } t \geq 0$$

$$R = 4 \Omega \quad L = 0.5 \text{ H}$$

$$L \frac{di}{dt} + Ri = V(t)$$

$$\text{so } 0.5 \frac{di}{dt} + 4i = 80e^{-10t} \text{ V}$$

$$0.5 \mathcal{L}\left\{\frac{di}{dt}\right\} + 4 \mathcal{L}\{i\} = \mathcal{L}\{80e^{-10t}\}$$

$$0.5 s I(s) + 4 I(s) = \frac{80}{s+10}$$

$$I(s) = I(s)(0.5s + 4) = \frac{80}{s+10}$$

$$I(s) = \frac{80}{(0.5s + 4)(s + 10)}$$

$$I(s) = \frac{320}{(s + 4)(s + 10)}$$

Q1C

8/15

$$I(s) = \frac{+60 \cdot 320}{(s+4)(s+10)} = \frac{A}{(s+4)} + \frac{B}{(s+10)}$$

$$I_s = \frac{320}{(s+4)(s+10)} = \frac{320}{s+10} + \frac{320}{s+4} = \frac{A}{s+10} + \frac{B}{s+4}$$

$$\text{let } s = -4$$

$$320 + 60 = A(-4+4) + B(-4+10)$$

$$320 + 60 = A(0) + B(6)$$

$$I(s) = \frac{80}{(s+4)(s+10)}$$

2.

$$b. f(x) = \begin{cases} 1 & \text{if } -\pi \leq x < 0 \\ 0 & \text{if } 0 \leq x < \pi \end{cases}$$

and function is periodic with $f(x+2\pi) = f(x)$

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} [a_n \cos nx + b_n \sin nx]$$

$$a_0 = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) dx \quad \checkmark$$

$$a_0 = \frac{1}{\pi} \int_{-\pi}^0 f(x) dx + \frac{1}{\pi} \int_0^{\pi} f(x) dx \quad \checkmark$$

$$a_0 = \frac{1}{\pi} \int_{-\pi}^0 1 dx + \frac{1}{\pi} \int_0^{\pi} 0 dx \quad \checkmark$$

$$\text{So } a_0 = \frac{1}{\pi} \int_{-\pi}^0 1 dx \quad \checkmark$$

$$a_0 = \frac{1}{\pi} (x)_{-\pi}^0 \quad \checkmark$$

$$a_0 = \frac{1}{\pi} (\pi) \quad \checkmark$$

$$a_0 = 1 \quad \checkmark$$

$$\text{then } a_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos nx dx \quad \checkmark$$

$$a_n = \frac{1}{\pi} \int_{-\pi}^0 f(x) \cos nx dx + \frac{1}{\pi} \int_0^{\pi} f(x) \cos nx dx \quad \checkmark$$

$$a_n = \frac{1}{\pi} \int_{-\pi}^0 1 \cos nx dx + \frac{1}{\pi} \int_0^{\pi} 0 \cos nx dx \quad \checkmark$$

$$a_n = \frac{1}{\pi} \int_{-\pi}^0 \cos nx dx \quad \checkmark$$

Q221/30Q2a0/5Q2b21/25

$$a_n = \frac{1}{\pi} \int_{-\pi}^{\pi} 1 \cos nx \, dx$$

$$a_n = \frac{1}{\pi} \left(\frac{\sin nx}{n} \right)_{-\pi}^{\pi}$$

$$a_n = \frac{1}{n\pi} (\sin nx)_{-\pi}^{\pi}$$

$$a_n = \frac{1}{n\pi} (\sin \pi - \sin 0)$$

$$a_n = 0$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin nx \, dx$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^0 f(x) \sin nx \, dx + \frac{1}{\pi} \int_0^{\pi} f(x) \sin nx \, dx$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^0 1 \sin nx \, dx + \frac{1}{\pi} \int_0^{\pi} 0 \sin nx \, dx$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^0 1 \sin nx \, dx$$

$$b_n = \frac{1}{\pi} \left(-\frac{\cos nx}{n} \right)_{-\pi}^0$$

$$b_n = \frac{1}{n\pi} (-\cos nx)_{-\pi}^0$$

$$b_n = \frac{1}{n\pi} (-\cos 0) - (-\cos \pi)$$

$$b_n = \frac{1}{n\pi} (-0.99 - 1)$$

$$b_n = \frac{1}{n\pi} (-1.99)$$

So when odd $b_n = \frac{-1.99}{n\pi}$

When even $b_n = 0$

$$f(x) = a_0 + a_1 \cos x + a_2 \cos 2x + a_3 \cos 3x \dots$$

$$+ b_1 \sin x + b_2 \sin 2x + b_3 \sin 3x$$

$$f(x) = \frac{1.99}{\pi} \left(\frac{1}{3} \sin 3x + \frac{1}{5} \sin 5x + \frac{1}{7} \sin 7x + \frac{1}{9} \sin 9x + \frac{1}{11} \sin 11x \right)$$

2

Thermin's equivalent circuit

$$V_{Th} = \frac{R_2}{R_1 + R_2} \times V \quad V_{Th} = \frac{8 - 6j}{4 + 8 - 6j} \times 10V$$

$$V_{Th} = \frac{8 - 6j}{12 - 6j} \times 10V$$

$$V_{Th} = \left(\frac{8 - 6j}{12 - 6j} \times \frac{12 + 6j}{12 + 6j} \right) \times 10V$$

$$V_{Th} = \left(\frac{96 + 72j + 48j - 36j^2}{144 - 72j + 72j - 36j^2} \right) \times 10V$$

$$V_{Th} = \left(\frac{96 + 36 - 24j}{144 + 36} \right) \times 10V$$

$$V_{Th} = \left(\frac{132 - 24j}{180} \right) \times 10V$$

$$V_{Th} = \left(\frac{132}{180} - \frac{24j}{180} \right) \times 10 \quad V_{Th} = 0.73 - 0.13j \text{ Hov}$$

Calculation
mistake

$$V_{Th} = 0.73 - 0.13j \text{ or } 0.73 \angle -0.7^\circ$$

$$Z_{Th} = \frac{Z_1 \times Z_2}{Z_1 + Z_2} + Z_3$$

$$Z_{Th} = \frac{(4\Omega)(8 - j6\Omega)}{(4\Omega) + (8 - j6\Omega)} + j5$$

$$Z_{Th} = \frac{32 - 24j\Omega}{12 - j6} + j5$$

Q3

9/20

Q3a

9/10

$$Z_{Th} = \frac{32 - 24j \Omega + 5j \Omega}{12 - 6j \Omega}$$

$$Z_{Th} = \left(\frac{32 - 24j}{12 - 6j} - \frac{12 + 6j}{12 + 6j} \right) + 5j \Omega$$

$$Z_{Th} = \left(\frac{384 - 288j + 192j - 144j^2}{144 - 72j + 72j - 36j^2} \right) + 5j \Omega$$

$$Z_{Th} = \left(\frac{384 + 144 - 96j}{144 + 36} \right) + 5j \Omega$$

$$Z_{Th} = \left(\frac{528 - 96j}{180} \right) + 5j \Omega$$

$$Z_{Th} = \left(\frac{528}{180} - \frac{96j}{180} \right) + 5j \Omega$$

$$Z_{Th} = (2.93 - 0.53j) + 5j \Omega$$

$$Z_{Th} = 2.93 + j4.47 \Omega \text{ or } 5.34 \angle 56.7^\circ \Omega$$

b) for maximum power drawn

$$Z_L = Z_{Th}$$

$$\text{So } Z_L = 8 - 6j \Omega$$

$\times \underline{0}$

c. $P = I^2 R$

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

$$I = \frac{10 \angle -0.7^\circ}{5.34 \angle 56.7^\circ}$$

$$I = 2.06 \angle -57.4^\circ \text{ A}$$

$$\text{So } P = (2.06)^2 \cdot 5.34$$

$$P = 21.57 \text{ W}$$

Q3b

0/3

Q3c

0/7



Question No.

Examiner Only

4.

$$a) Z_A = 10 + 6j\Omega \quad Z_B = 8 + 4j\Omega \quad Z_C = 12 + 8j\Omega$$

$$Z_1 = \frac{(Z_A Z_B) + (Z_B Z_C) + (Z_C Z_A)}{Z_A}$$

$$Z_1 = Z_A Z_B = (10 + 6j)(8 + 4j)$$

$$Z_A Z_B = 80 + 48j + 48j + 24j^2$$

$$Z_A Z_B = 80 - 24 + 88j$$

$$Z_A Z_B = 56 + 88j$$

$$Z_B Z_C = (8 + 4j)(12 + 8j)$$

$$Z_B Z_C = 96 + 64j + 48j + 32j^2$$

$$Z_B Z_C = 96 - 32 + 112j$$

$$Z_B Z_C = 64 + 112j$$

$$Z_C Z_A = (12 + 8j)(10 + 6j)$$

$$Z_C Z_A = 120 + 80j + 72j + 48j^2$$

$$Z_C Z_A = 120 - 48 + 152j$$

$$Z_C Z_A = 72 + 152j$$

$$Z_1 = \frac{(56 + 88j) + (64 + 112j) + (72 + 152j)}{10 + 6j}$$

$$Z_1 = \frac{192 + 352j}{10 + 6j} \times \frac{10 - 6j}{10 - 6j}$$

$$Z_1 = \frac{1920 + 3520j - 1152j - 2112j^2}{100 + 60j - 60j + 36j^2}$$

$$Z_1 = \frac{4032 + 2368j}{100 + 36j}$$

$$Z_1 = \frac{4032}{136} + \frac{2368j}{136}$$

$$Z_1 = 29.65 + 17.4j\Omega$$

$$\text{or } 34.38 \angle 30.42^\circ$$

Q4

20/20

Q

4a

10/10

5

$$Z_2 = \frac{Z_a Z_b + Z_b Z_c + Z_c Z_a}{Z_b}$$

$$Z_2 = \frac{(56 + 88j) + (64 + 112j) + (72 + 152j)}{8 + 4j} \Omega$$

$$Z_2 = \frac{192 + 352j}{8 + 4j} \times \frac{8 - 4j}{8 - 4j} \Omega$$

$$Z_2 = \frac{1536 + 2816j - 768j - 1408j^2}{64 + 32j - 32j - 16j^2} \Omega$$

$$Z_2 = \frac{1536 + 1408 + 2048j}{64 + 16j} \Omega$$

$$Z_2 = \frac{2944 + 2048j}{80} \Omega$$

$$Z_2 = \frac{2944}{80} + \frac{2048j}{80} \Omega \quad Z_2 = 36.8 + 25.6j \Omega$$

$$Z_2 = 36.8 + 25.6j \Omega$$

or $44.8 \angle 34.8^\circ \Omega$

$$Z_3 = \frac{Z_a Z_b + Z_b Z_c + Z_c Z_a}{Z_c}$$

$$Z_3 = \frac{(56 + 88j) + (64 + 112j) + (72 + 152j)}{12 + 8j} \Omega$$

$$Z_3 = \frac{192 + 352j}{12 + 8j} \times \frac{12 - 8j}{12 - 8j} \Omega$$

$$Z_3 = \frac{192 + 352j}{12 + 8j} \times \frac{12 - 8j}{12 - 8j}$$

$$Z_3 = \frac{2304 + 4224j - 1536j - 2816j^2}{144 + 96j - 96j - 64j^2}$$

$$Z_3 = \frac{2304 + 2816 + 2688j}{144 + 64}$$

$$Z_3 = \frac{5120 + 2688j}{208}$$

$$Z_3 = \frac{5120}{208} + \frac{2688}{208} = 24.61 + 12.92j$$

$$Z_3 \approx 24.61 + 12.92j$$

$$\text{or } 27.8^\circ \angle 27.7^\circ$$

b) v.

$$b) \quad v(t) = 300 \cos(2\pi 120t) + 100 \cos(4\pi 120t) \text{ V}$$

$$i(t) = 15 \cos(2\pi 120t - 30^\circ) + 5 \cos(6\pi 120t + 60^\circ) \text{ A}$$

$$V_{RMS} = \sqrt{V_0^2 + \sum_{n=1}^{\infty} \left(\frac{V_n^2}{2}\right)}$$

$$V_{RMS} = \sqrt{0 + \frac{(300^2 + 100^2)}{2}} \quad V_{RMS} = 223.6 \text{ V}$$

$$I_{RMS} = \sqrt{I_0^2 + \sum_{n=1}^{\infty} \left(\frac{I_n^2}{2}\right)} \quad I_{RMS} =$$

$$I_{RMS} = \sqrt{0 + \frac{(15^2 + 5^2)}{2}} \quad I_{RMS} = 11.18 \text{ A}$$

$$ii) \quad P_{av} = V_0 I_0 + \sum_{n=1}^{\infty} \left(\frac{V_n I_n}{2}\right) \cos(\theta_n - \phi_n)$$

$$P_{av} = (300)(15)$$

$$P_{av} = 0 + \frac{(300)(15)}{2} \cos(-30^\circ)$$

$$P_{av} = 1948.55 \text{ W}$$

$$P.F. = \frac{P}{S}$$

$$S = V_{RMS} \times I_{RMS} = 223.6 \text{ V} \times 11.18 \text{ A}$$

$$S = 2499.8 \text{ VA}$$

$$P.F. = \frac{1948.55}{2499.8} = 0.78$$