UNIVERSITY OF KWAZULU-NATAL

School of Engineering
Electrical, Electronic & Computer Engineering

ENEL2EL - Electrical Engineering
Main Examination, May/June 2026

Time allowed: 3 hours

Instructions to Candidates:

1. Answer **All Questions in Section A** and **All Questions in Section B**
2. **USE A SEPARATE ANSWER BOOK FOR EACH SECTION**
3. The marks for each question/section are indicated.
4. Answers should show sufficient working steps to indicate the solution method used.
5. Any additional examination material is to be placed in the answer book and must indicate clearly the question number and the Student I.D. number

Examiners

Mr. Christophe Tambwe (Section A)
Dr. Remy Tiako (Section B)

Independent Moderator

Dr. B. Mthethwa

SECTION A [50 Marks, Weight: 50 %]: Answer All Questions
(USE A SEPARATE BOOKLET FOR THIS SECTION)

Question A1 **[30 Marks]**

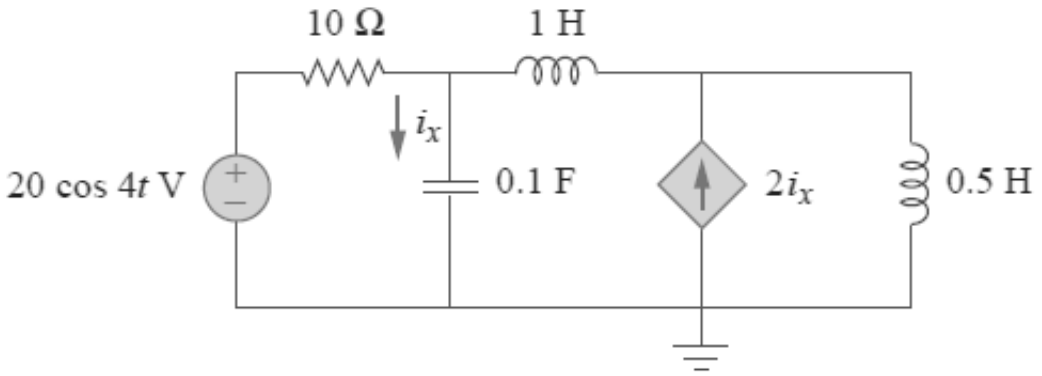

Fig Q1 (a)

a) For the circuit shown in Fig Q1 (a), operating at an angular frequency of $\omega = 4$ rad/s:

i) Convert the circuit into the phasor domain and, taking the bottom conductor as the reference (ground), use nodal analysis to write the nodal equations. **[6]**

ii) Express the equations in matrix form and solve the node voltages using Cramer's Rule **[5]**

iii) Determine the current i_x (downward through the capacitor) in phasor form. **[1]**

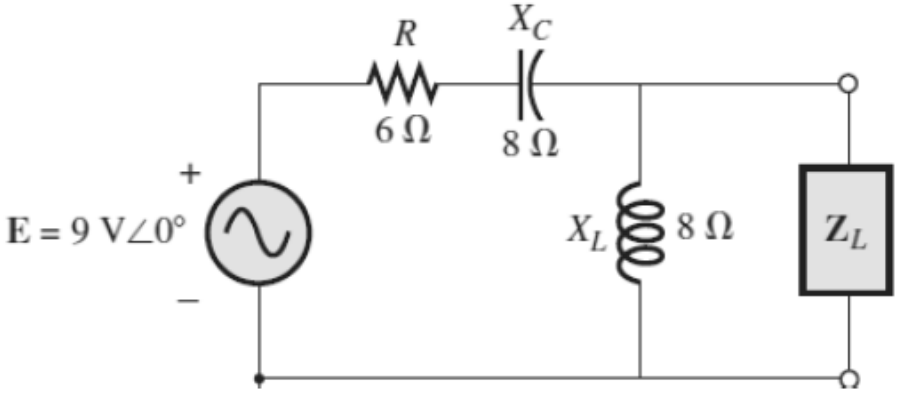

Fig Q1 (b)

b) For the electrical circuit shown in Fig. Q1(b), the load impedance Z_L is to be adjusted to achieve maximum average power transfer to the load:

i) Determine the Thevenin equivalent impedance Z_{th} seen from the load terminals **[2]**

ii) Determine the Thevenin equivalent voltage V_{th} across the open-circuited load terminals. **[2]**

iii) Using the maximum power transfer theorem, determine the value of the load impedance Z_L for maximum power transfer. **[2]**

iv) Determine the maximum average power that can be absorbed by R_L **[2]**

c) A series-connected load draws a current $i(t) = 8\cos(150\pi t + 20°)$ when the applied voltage is $v(t) = 240\cos(150\pi t - 10°)$.

i) Calculate the apparent power delivered to the load. **[3]**

ii) Determine the power factor of the circuit and indicate whether it is leading or lagging **[2]**

iii) Determine the component values (resistance, inductance, and/or capacitance) that make up the series-connected load. **[5]**

Question A2 **[20 Marks]**

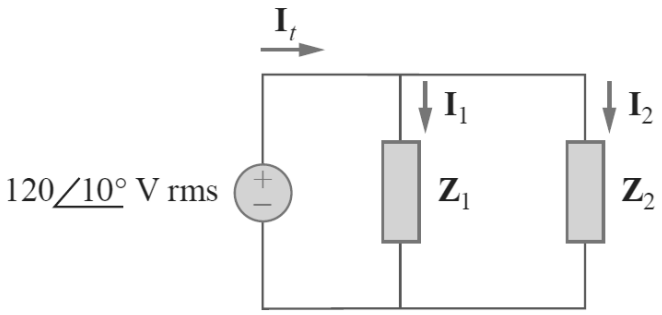

Fig Q2(a)

a) In the circuit of Fig Q2(a), two impedances are connected across an AC source. The impedances are given as: $Z_1 = 60\angle -30°\ \Omega$ and $Z_2 = 40\angle 45°\ \Omega$.

i) Find the RMS current through each impedance **[2]**

ii) Find the complex power absorbed by each impedance and the total complex power. **[3]**

iii) Calculate the total apparent power $|S_t|$ **[1]**

iv) Determine the total real power **[1]**

v) Find the total reactive power **[1]**

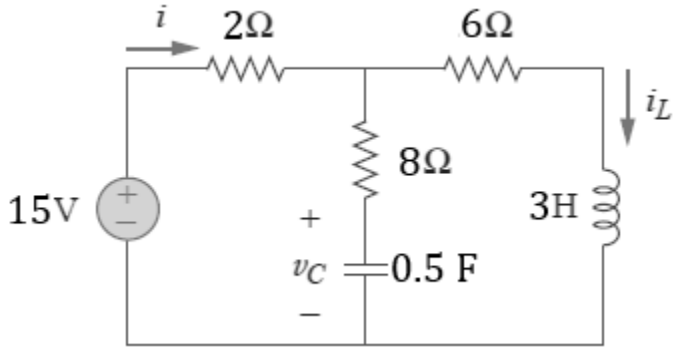

Fig Q2(b)

b) Consider the electrical circuit shown in Fig. Q2(b).

i) Assuming steady-state DC conditions, determine the current through the inductor i_L and the voltage across the capacitor v_C. **[2]**

ii) Determine the energy stored in the capacitor and the energy stored in the inductor. **[2]**

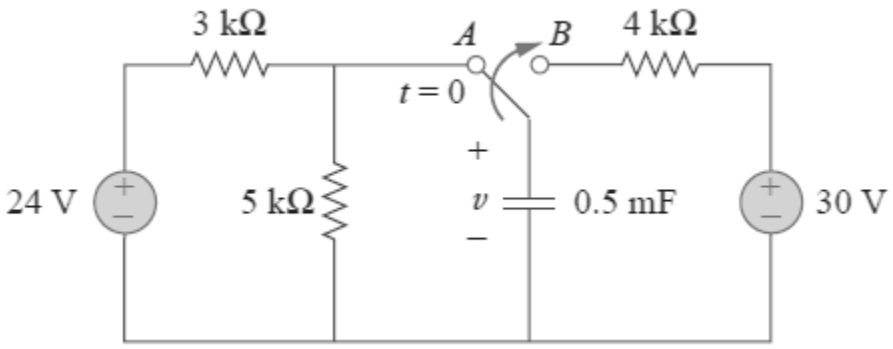

Fig. Q2(c)

c) The switch in the circuit shown in Fig. Q2(c) has been in position A for a long time. At $t = 0$, the switch is moved to position B.

i) Determine an expression for the capacitor voltage $v(t)$ for $t > 0$. **[6]**

ii) Calculate the value of the capacitor voltage at $t = 1$ s and $t = 4$ s **[2]**

SECTION B [50 Marks, Weight: 50 %]: Answer all in Parts A & C and any 3 questions from Part B
(USE A SEPARATE BOOKLET FOR THIS SECTION)

Part A: *Select the Appropriate Answer Within the Bracket* **[5 MARKS]**

(a) A 2 cm long coil has 10 turns and carries a current of 750 mA. The magnetic field intensity is:... [**225 At/m; 675 At/m; 450 At/m; 375 At/m]**

(b) In an electromechanical energy conversion device like a DC machine, what serves as the coupling field that facilitates the transfer between electrical and mechanical energy?.....
[the thermal field; the electric field; the magnetic field; the gravitational field]

(c) What is the primary function of a commutator and brush assembly in a DC generator?.....
[to increase the magnetic flux in the air gap; to regulate the speed of the prime mover; to reduce the heat generated in the armature; to convert internal AC voltage to external DC voltage]

(d) In the equivalent circuit model of a practical transformer, a shunt resistance R_c is included to represent……..
[the leakage reactance of the primary side; the insulation resistance between windings; the equivalent resistance due to hysteresis and eddy current losses; the resistance of the copper windings]

(e) When a transformer transfers energy from the primary winding to the secondary winding, which of the following parameters typically remains constant?.....
[frequency; impedance; voltage; current]

(1)x5 = [5]

Part B: *Solve Any Three Questions* **[30 Marks]**

1. A 20-kVA, 2400/240, 60 Hz transformer has the following resistance and reactance values: Rp = 0.8 Ω, Xp = 3 Ω, Rs = 0.0084 Ω, Xs = 0.028 Ω, Rc = 104 kΩ, Xm = 1kΩ. The transformer is supplying full-load at unity power factor. Draw an annotated approximate equivalent circuit referred to the secondary side and find the magnitude of the voltage across the magnetizing reactance referred to the secondary side. **[10]**

2. A DC shunt generator operating at full load has armature resistance, field current and load current of 0.05 Ω , 6.50 A and 120 A respectively. Determine the terminal voltage if the generator is lap-wound with 360 conductors, running at 800 rpm, and has a flux per pole of 0.075 Wb. **[10]**

3. A mild steel ring has a mean diameter of 80 mm and a uniform cross-sectional area of 300 mm^2. Calculate the MMF required to produce a flux of 500 μwb. Assume μ_r = 1200. **[10]**

4. A 200 kVA, 50 Hz single-phase transformer of turn ratio equal to 5 gave the test results as shown in **Table 1**:

Table 1: Test Results

Open circuit test on secondary side	400 V	5 A	3.75 kW
Short circuit test on the primary side	150 V	100 A	1 kW

Calculate the core loss resistance referred to the primary side and the equivalent winding resistance referred to the secondary side. **[10]**

Part C: **[15 Marks]**

The magnetic core shown in **Fig. 1** is made of cast iron, with its corresponding B–H characteristic provided in **Fig. 2**. The core is symmetrical about the centre limb. A magnetizing coil of (N = 60) turns is connected to a 38 V DC supply. All dimensions are given in millimetres, and each of the two air gaps has a length of 0.4 mm.

Draw an analogous electric circuit of the magnetic core showing MMF and reluctances and determine the resistance of the magnetizing coil in **Fig. 1** when flux densities of 0.15 T in each air gap and 0.3 T in the centre limb are established. Neglect the effects of flux fringing. **[15]**

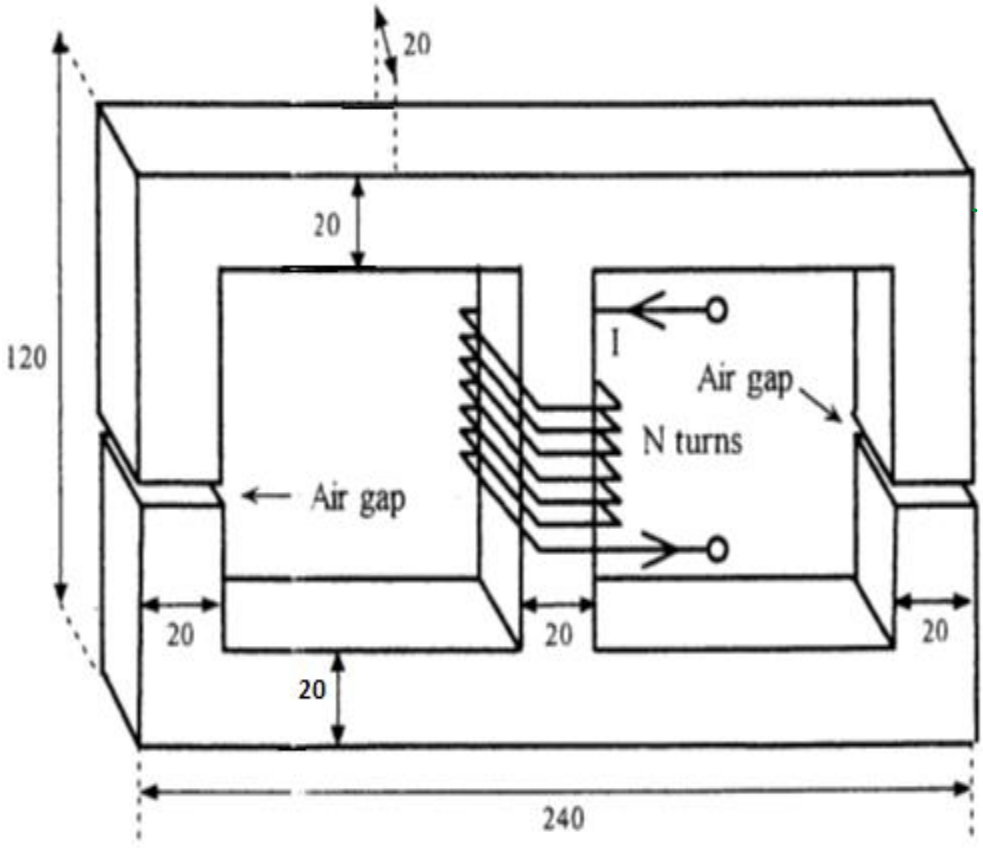

Fig. 1: Cast Iron Magnetic Core

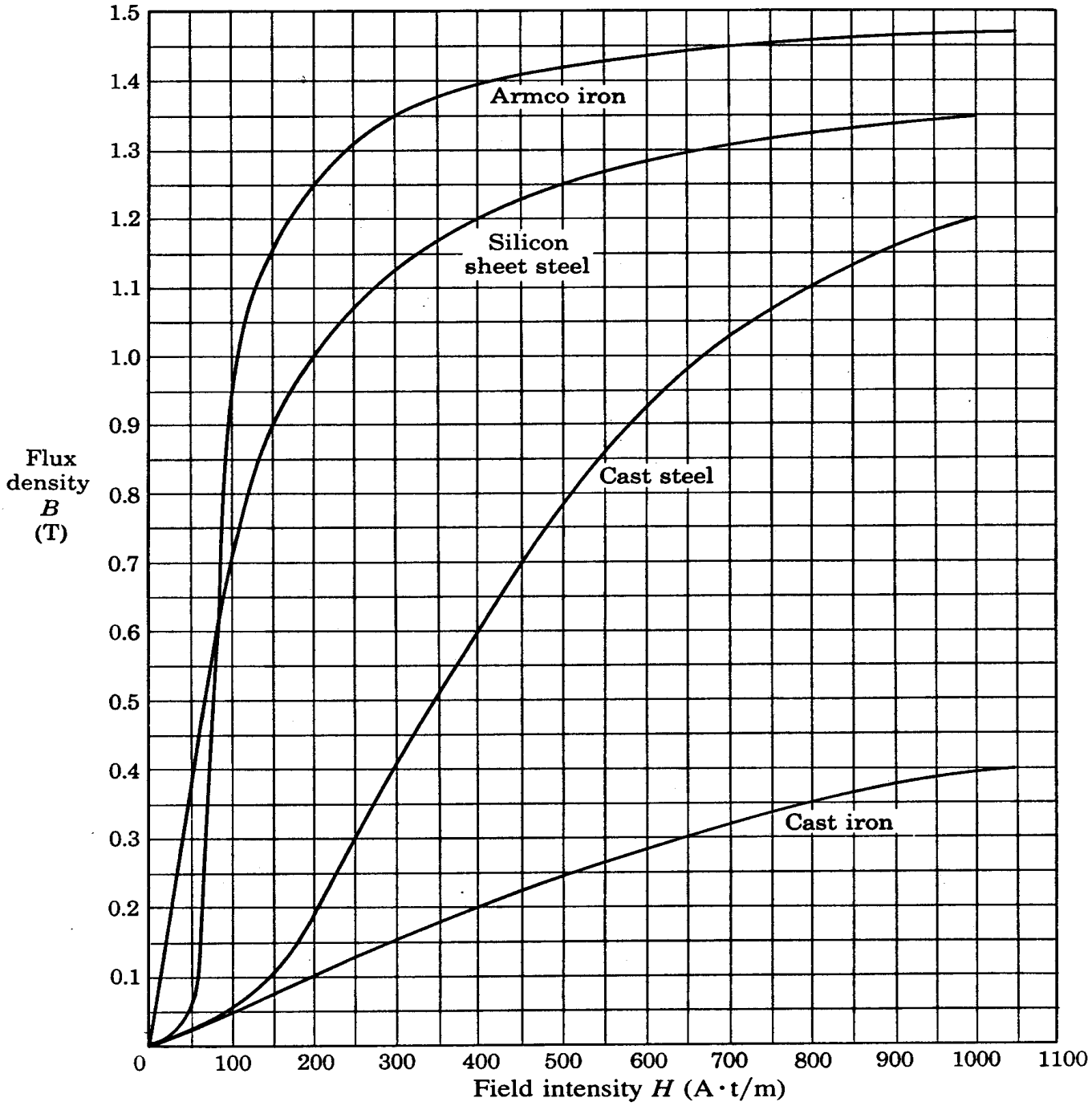

Fig. 2: B-H Curve of Some Ferromagnetic Materials