2017/2018 SEMESTER 2 EXAMINATION

Diploma in Aerospace Electronics (DASE)
Diploma in Computer Engineering (DCPE)
Diploma in Engineering with Business (DEB)
Diploma in Electrical & Electronic Engineering (DEEE)
Diploma in Energy Systems & Management (DESM)
Common Engineering Programme (DCEP)
1$^{st}$ Year FT

**PRINCIPLES OF ELECTRICAL & ELECTRONIC ENGINEERING I (PEEEI)**

Time Allowed: 2 Hours

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Instructions to Candidates

1. The examination rules set out on the last page of the answer booklet are to be complied with.

2. This paper consists of **TWO** sections:
   Section A - 10 Multiple Choice Questions, 2 marks each.
   Section B - 8 Short Questions, 10 marks each.

3. **ALL** questions are **COMPULSORY**.

4. **All questions are to be answered in the answer booklet**. Start each question in Section B on a new page.

5. Fill in the Question Numbers, in the boxes found on the front cover of the answer booklet under the column "Questions Answered".

6. This paper contains **11** pages, inclusive of formulae sheet.

## SECTION A

## MULTIPLE CHOICE QUESTIONS (20 marks)

1. Please **tick** your answers in the **MCQ box** on the inside of the front cover of the answer booklet.

2. No marks will be deducted for incorrect answers.

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**A1.** A transformer has a coupling coefficient of 0.9 between the primary and secondary coil. If the inductance of the primary coil is 900 mH and that of the secondary coil is 100 mH, calculate the mutual inductance between the 2 coils.

(a) 90 mH
(b) 270 mH
(c) 810 mH
(d) 900 mH (2 marks)

**A2.** A direct current of 200 mA flows through a 20 mH coil for 50 ms. What is the induced voltage across the coil at the end of 50 ms?

(a) 0 V
(b) 4 V
(c) 10 V
(d) 80 V (2 marks)

**A3.** An magnetic material is suitable for making a good permanent magnet if it has high

(a) reluctance
(b) flux
(c) magnetomotive force
(d) retentivity (2 marks)

**A4.** A length of copper wire has a resistance of 0.2 Ω. If its length is increased by 5 times and the radius is halved, what is the new resistance of the copper wire?

(a) 0.1 Ω
(b) 1.0 Ω
(c) 2.0 Ω
(d) 4.0 Ω (2 marks)

**A5.** If sine wave A has a positive-going zero crossing at $10^0$ and sine wave B has a positive-going zero-crossing at $20^0$, which one of the following statements is true?

(a) Sine wave A leads sine wave B by $20^0$
(b) Sine wave A lags sine wave B by $20^0$
(c) Sine wave A leads sine wave B by $10^0$
(d) Sine wave A lags sine wave B by $10^0$ (2 marks)

**A6.** In Figure A6, the supply current $I_s$ is

(a) 0 mA
(b) 0.5 mA
(c) 1 mA
(d) 2 mA

(2 marks)

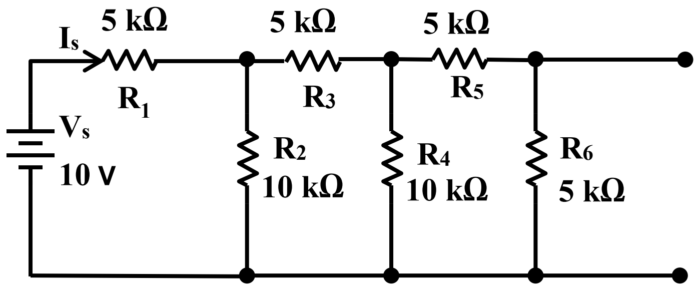


**Figure A6**

**A7.** In Figure A6, the voltage across resistor $R_2$ is

(a) 0 V
(b) 5 V
(c) 7.5 V
(d) 10 V (2 marks)

**A8**. In Figure A6, if $R_2$ is shorted, the supply current $I_s$ will be

(a) 0 A
(b) 0.67 mA
(c) 1 mA
(d) 2 mA (2 marks)

**A9.** Which one of the following statements is **incorrect**?

(a) The transformer windings are magnetically isolated.
(b) The turns ratio of a step-up transformer is greater than 1
(c) In a transformer, the output power is approximately equal to the input power.
(d) The transformer primary and secondary circuits are electrically isolated from each other. (2 marks)

**A10.** A coil of 500 turns with a magnetic path length of 10 cm is used to produce a magnetising force of 1000At/m. What is the current flowing through the coil?

(a) 0.2 A
(b) 2 A
(c) 20 A
(d) 200 A (2 marks)

## SECTION B

## SHORT QUESTIONS (80 marks)

**B1.** Using the Superposition Theorem, determine the current $I_1$ flowing through $R_1$ as shown in Figure B1. (10 marks)

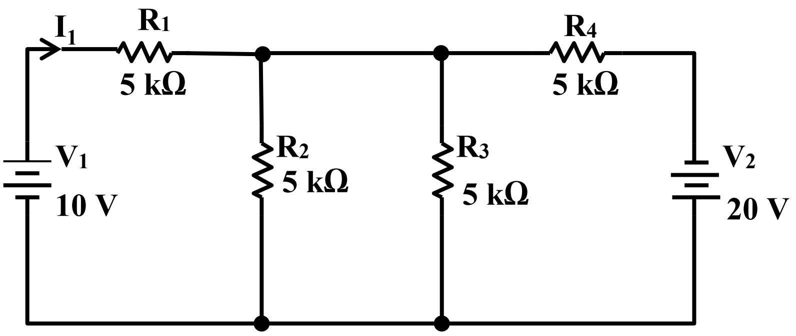


**Figure B1**

**B2.** With reference to Figure B2, calculate

(a) the total supply current $I_s$; (3 marks)
(b) the voltage at point B with respect to ground ($V_B$); (3 marks)
(c) the voltage at point A with respect to ground ($V_A$). (4 marks)

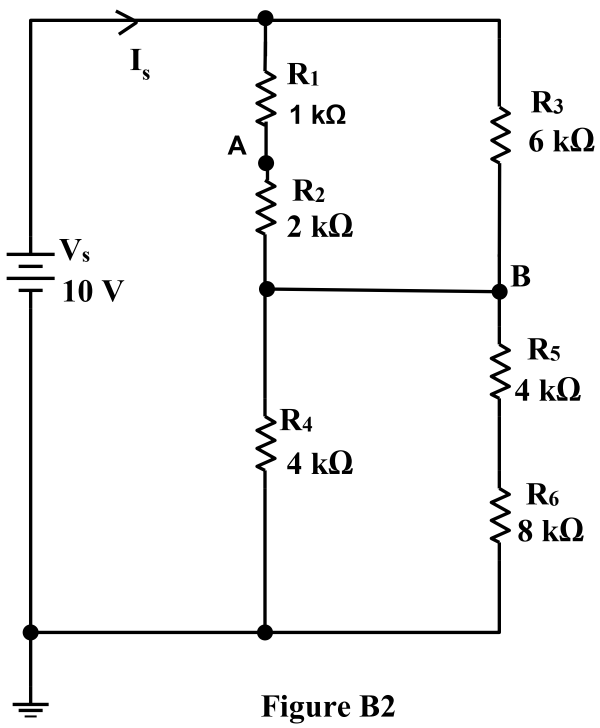


**Figure B2**

**B3.** A circular metal ring has a mean circumference of 15 cm and a cross-sectional area of 120 $cm^2$. A coil of 2000 turns is wound on the metal ring. It produces a magnetic flux of 55 μWb in the ring when a dc current flows through the coil. The relative permeability ($\mu_r$) of this metal ring is 500. Calculate:

(a) the magnetic flux density in the metal ring; (3 marks)
(b) the reluctance of the metal ring; (3 marks)
(c) the dc current flowing through the coil. (4 marks)

**B4.** With reference to Figure B4, calculate:

(a) the total capacitance $C_T$; (2 marks)
(b) the charge stored by each capacitor; (2 marks)
(c) the voltage across each capacitor. (6 marks)

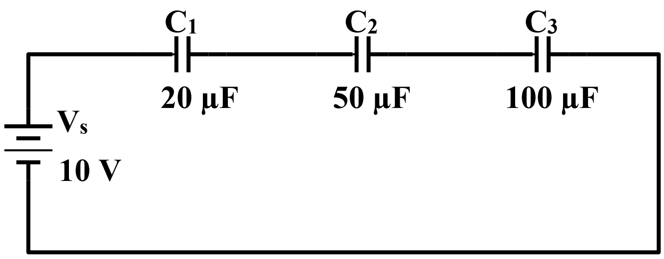


**Figure B4**

**B5.** A sinusoidal voltage of $V_s = 28.28 \sin(100\pi t)$V is applied to the circuit as shown in Figure B5. Calculate:

(a) the frequency of the supply voltage $V_s$; (2 marks)
(b) the peak-to-peak value of the supply current $I_s$; (4 marks)
(c) the rms voltage across $R_2$. (4 marks)

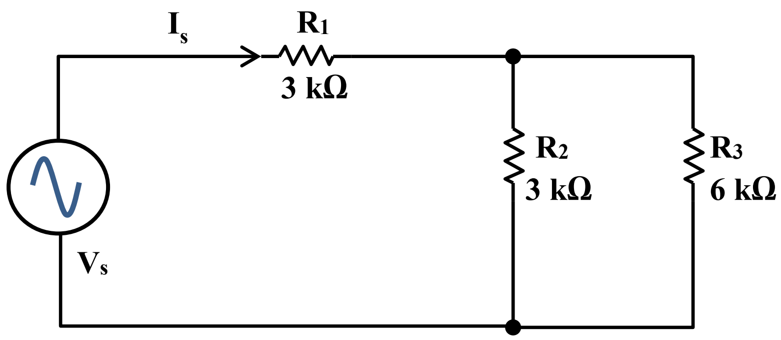


**Figure B5**

**B6.** A transformer has 2000 turns in its primary winding and 500 turns in its secondary winding. An ac supply is applied to the primary side of the transformer. The secondary voltage of 55 V is connected to a resistive load of 10 Ω. Determine:

(a) the turns ratio; (2 marks)
(b) the primary voltage; (2 marks)
(c) the primary and secondary currents; (4 marks)
(d) the power dissipated in the load. (2 marks)

**B7.** (a) A 10 mH coil is wound on a cylindrical core having a length of 20 cm and a cross-sectional area of $4 \times 10^{-3}$ m$^2$. Calculate the number of turns of the coil required if the core material has a permeability of $0.35 \times 10^{-3}$ H/m. (4 marks)

(b) Calculate the value of a second inductor that is required to be connected in parallel to the 10 mH inductor in order to produce a total inductance of 8 mH. (3 marks)

(c) If a voltage of 10 kV is induced in an inductor by a current flowing through it and changing at a rate of $5 \times 10^6$ A/s, calculate the value of this inductor. (3 marks)

**B8.** In the circuit of Figure B8, the time constant (τ) of the RC circuit is 50 ms. The capacitor is initially uncharged. The switch is initially open and then closed at t = 0s. Determine:

(a) the value of the resistance R; (2 marks)
(b) the voltage across the capacitor at t = 50 ms; (3 marks)
(c) the voltage across the resistor at t = 10 ms; (3 marks)
(d) the charging current flowing through the resistor at t = 0 s, (2 marks)

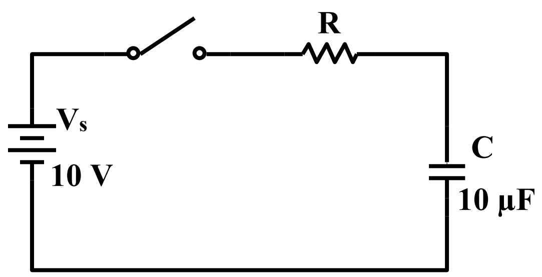


**Figure B8**

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# Formulae List

**Resistors:**

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

Resistance in series, $R_T = R_1 + R_2 + \ldots\ldots\ldots + R_n$

Resistance in parallel, $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$ for n resistors

Resistance in parallel, $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$ for 2 resistors

Power dissipation in resistor, $P = VI$ $\quad P = I^2R$ $\quad P = \frac{V^2}{R}$

**Energy, Work Done, Charge, Power:**

$W = QV$ $\quad P = \frac{W}{t}$ $\quad I = \frac{Q}{t}$

$6.25 \times 10^{18}$ electrons ➔1C of negative charge

**Ohm's Law:**

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

**Kirchhoff's Voltage Law:**

$\sum$ Voltage rises = $\sum$ Voltages drops in a closed circuit.

**Kirchhoff's Current Law:**

$\sum$ Incoming currents = $\sum$ Outgoing currents at a node

**Voltage Divider Rule:**

$V_x = \frac{R_x}{R_T} V_s$

**Current Divider Rule:**

Branch current $I_x = \frac{R_T}{R_x} I_T$ for any number of parallel branches

$I_1 = \frac{R_2}{R_1 + R_2} I_T$ **or** $I_2 = \frac{R_1}{R_1 + R_2} I_T$ for **2** parallel branches only

**Capacitors:**

Q(coulombs) = V(volts) x C(farads)

Energy Storage, $W = \frac{1}{2} C V^2$ (Joules)

$\varepsilon_o = 8.85 \times 10^{-12}$ F/m $\quad\quad \varepsilon = \varepsilon_o \varepsilon_r$

Capacitance $= \frac{\text{Area (A)}\times\varepsilon}{\text{distance (d)}}$ Farad

Increasing exponential voltage $v(t) = V_F\ (1 - e^{\frac{-t}{RC}})$

Decreasing exponential voltage $v(t) = V_i\ e^{\frac{-t}{RC}}$

Total capacitance for "n" capacitors in series, $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$

Total capacitance for "n" capacitors in parallel, $C_T = C_1 + C_2 + \cdots + C_n$

**Magnetism & Electromagnetism:**

$$\text{Flux } (\phi) = \frac{\text{Magnetomotive force } (\mathcal{F}_m, \text{At})}{\text{Reluctance } (\mathcal{R}, \text{At/Wb})} \text{Weber (Wb)}$$

$$\text{Flux density, B} = \frac{\text{Flux } (\phi, \text{Wb})}{\text{Area perpendicular to flux } (\text{A}, \text{m}^2)} \text{ Tesla (T)}$$

Magnetomotive Force ($\mathcal{F}_m$) = N (number of turns) x I (Current, A)

$$\text{Magnetising force (H)} = \frac{\mathcal{F}_m}{\text{length of material } (l, m)} \text{At/m}$$

$$\text{Reluctance } (\mathcal{R}) = \frac{\text{length } (l, m)}{\text{permeability } \left(\mu, {}^{\text{Wb}}/_{\text{At. m}}\right) \text{x crosssection area } (\text{A}, \text{m}^2)} \text{At/Wb}$$

$\mu_o = 4\pi \times 10^{-7}$ Wb/At.m $\quad\quad \mu = \mu_o\mu_r$

**Inductors:**

Voltage induced in a coil due to current changes, $e(t) = L\frac{di(t)}{dt}$

Voltage induced in a coil due to flux changes, $e(t) = N\frac{d\Phi(t)}{dt}$

Energy Storage, $W = \frac{1}{2} L I^2$ (Joules)

Inductance, $L = \frac{N^2\mu A}{l}$ (Henry)

Increasing exponential current in an inductor $i(t) = I_F\ (1 - e^{\frac{-Rt}{L}})$

Decreasing exponential current in an inductor $i(t) = I_i\ e^{\frac{-Rt}{L}}$

for "n" inductors in series, $L_T = L_1 + L_2 + \dots\dots\dots + L_n$

for "n" inductors in parallel, $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}$

**Transformer:**

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$, $\frac{I_s}{I_p} = \frac{N_p}{N_s}$, $V_p I_p = V_s I_s = \text{transformer rating}$

$k = \frac{\phi_{1-2}}{\phi_1}$, $L_M = k\sqrt{L_1 L_2}$, Turns ratio $n = \frac{N_s}{N_p}$

**AC Voltages and Currents:**

$I_{rms} = I_p / \sqrt{2} = 0.7071\ I_p$ $\quad I_{p-p} = 2I_p$ $\quad I_{av} = 2I_p/\pi = 0.637I_p$

$V_{rms} = V_p / \sqrt{2} = 0.7071\ V_p$ $\quad V_{p-p} = 2V_p$ $\quad V_{av} = 2V_p/\pi = 0.637V_p$

| No. | Answers | No. | Answers | No. | Answers |
|---|---|---|---|---|---|
| | **SECTION A (MCQs)** | | | | |
| A1 | **b** | B1 | **2.5 mA** | B5a | **50 Hz** |
| A2 | **a** | B2a | **2 mA** | B5b | **11.312 mA** |
| A3 | **d** | B2b | **6 V** | B5c | **7.997 V** |
| A4 | **d** | B2c | **8.67 V** | B6a | **0.25** |
| A5 | **c** | B3a | **4.583 mT** | B6b | **220 V** |
| A6 | **c** | B3b | **19894.37At/Wb** | B6c | **$I_S$ = 5.5 A, $I_P$ = 1.375A** |
| A7 | **b** | B3c | **0.547 mA** | B6d | **302.5 W** |
| A8 | **d** | B4a | **12.5 µF** | B7a | **37.80** |
| A9 | **a** | B4b | **125 µC** | B7b | **40 mH** |
| A10 | **a** | B4c | **$V_1$=6.25 V, $V_2$=2.5 V, $V_3$ = 1.25 V** | B7c | **2 mH** |
| | | | | B8a | **5 kΩ** |
| | | | | B8b | **6.32 V** |
| | | | | B8c | **8.187 V** |
| | | | | B8d | **$I_{charging}$ = 2 mA** |