This question paper consists of 5 pages and a 2-page formula sheet.
INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers correctly according to the numbering system used in this question paper.
4. ALL the calculations must be shown.
5. ALL the final answers must be approximated to THREE decimal places.
6. Start each QUESTION on a new page.
7. Write neatly and legibly.

QUESTION 1

Calculate the current through the 12 Ω resistor in FIGURE 1 below. Use Thevenin's method.

FIGURE 1
QUESTION 2

Study FIGURE 2 below and calculate the following:

2.1 The total impedance of the circuit (6)
2.2 The current in each branch (4)

![FIGURE 2]

QUESTION 3

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1.1 - 3.1.5) in the ANSWER BOOK.

3.1.1 Varactor diodes are semi-conductor diodes that are current dependent.

3.1.2 Varicap's mode of operation depends on the capacitance that exists at the PN-junction when reverse biased.

3.1.3 Zener diodes are used instead of the normal PN-junction diodes for large forward currents.

3.1.4 The polarity of an external source in a PN-junction is such that it opposes the barrier potential.

3.1.5 The tunnel diode can be used as a voltage regulator. (5 × 1)

3.2

![FIGURE 3]

Use FIGURE 3 above to calculate the following:
3.2.1 The output direct-current voltage
3.2.2 The output ripple voltage
3.2.3 The ripple factor across the first capacitor
3.2.4 The ripple factor across the second capacitor

QUESTION 4

4.1 Demonstrate with the aid of a circuit diagram, how a uni-junction transistor can be used to trigger a silicon-controlled rectifier.

4.2 The following information is given for a transistor amplifier:

- Output impedance = 10 Ω
- Input power = 500 mW
- Input voltage = 10 V
- Output power = 700 W

Calculate each of the following:

4.2.1 Power gain in dB
4.2.2 Voltage gain in dB
4.2.3 Current gain in dB

QUESTION 5

5.1 Give FIVE reasons why operational amplifiers are popular building blocks.

5.2 The input voltage of an operational amplifier whose output voltage is 180° out of phase with the input is 0.5 V. The output voltage is 5 V and the feedback resistance is 10 kΩ. Calculate the value of the input resistance.

5.3 Draw the circuit diagram of the operational amplifier in QUESTION 5.2 above.

5.4 Name THREE operational amplifiers that use input and feedback impedances.

5.5 An operational amplifier has low input impedance and low voltage gain. TRUE or FALSE?
QUESTION 6

6.1 Show with the aid of a neat, labelled diagram and explain how a diac and a triac can be used to control the speed of a small AC motor. Also show the input and output waveforms. (7)

6.2 State FOUR applications of an SCR. (4)

6.3 Draw the equivalent circuit of an SCR by means of TWO transistors. Clearly show the gate, cathode and anode. (4) [15]

QUESTION 7

7.1 Design a circuit that, when the photodiode is illuminated switches the lamp on and when the photodiode is not illuminated, the lamp switches off. (5)

7.2 Discuss, with the aid of a sketch, the operation of a Bourdon tube as used to measure angular displacement. (5) [10]

QUESTION 8

FIGURE 4 below shows a block diagram of a function generator. Label the numbers (1 – 10) by writing only the answer next to the question number in the ANSWER BOOK.

[10]

TOTAL: 100
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FORMULA SHEET

\[
\frac{1}{R_T} = \left( \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n} \right) \quad R_T = \frac{R_1R_2}{R_1 + R_2} \quad V_2 = \frac{R_2}{R_1 + R_2} \times \frac{V_T}{1}
\]

\[Z = \sqrt{R^2 + (X_L - X_c)^2} \quad \text{Cos } \theta^o = \frac{R}{Z} \quad P = I^2R \quad P = \frac{V^2}{R} \quad P = VTCos\theta\]

\[P = V \cdot I \quad F_r = \frac{1}{2\pi\sqrt{LC}} \quad Q = \frac{X_L}{R} \quad OF = \frac{1}{R} \sqrt{\frac{L}{C}}\]

\[I_i = \sqrt{I_0^2 + (I_c - I_L)^2} \quad Z = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_c} - \frac{1}{X_L}\right)^2}} \quad N_1 \quad N_2 = \frac{V_1}{V_2} = \frac{I_2}{I_1}\]

\[V_{rms/wgk} = 0.707 \ V_m \quad i = I_s \left( \frac{e^{kt} - 1}{kT} \right) \quad R = \frac{kT}{qi} \quad V_{R} = \frac{V_{NE} - V_{PL}}{V_{FL}}\]

\[V_{ave/wgk} = 0.637 \ V_m\]

\[f = \frac{1}{t} \quad \text{Rate of change} = -\frac{V_{in}}{CR_{in}}\]

\[V_{dc} / V_{gs} = 0.318 \ V_m \quad V_{dc} / V_{gs} = 0.637 \ V_m\]

\[V_{rms} / V_{wgk} = 0.385 \ V_m \quad PIV = V_m \quad \text{or/of} \quad 2 \ V_m\]

\[V_{rms} / V_{wgk} = \frac{V_r (p - p)}{2\sqrt{3}} \quad V_{dc} / V_{gs} = V_m - \frac{V_r (p - p)}{2}\]

\[r = \frac{V_{rms} / V_{wgk}}{V_{dc} / V_{gs}} \quad V_{rms} / V_{wgk} = \frac{V_{dc} / V_{gs}}{R_L 2\sqrt{3} FC}\]

\[V_{dc} / V_{gs} = V_m \quad \frac{I_{dc} / I_{gs}}{2FC} \quad r = \frac{I_{dc} / I_{gs}}{V_{dc} / V_{gs} 2\sqrt{3} FC}\]

\[V_{rms} / V_{wgk} = \frac{X_c}{\sqrt{R^2 + X_c^2}} \times \frac{V_{rms} / V_{wgk}}{1}\]

\[V^'_{dc} / V_{gs} = \frac{R_L}{R_L + R_S} \times \frac{V_{dc} / V_{gs}}{1} \quad V^'_{rms} / V_{wgk} = \frac{V_{rms} / V_{wgk}}{(2\pi f)^2 LC}\]
\[ R_{in} = \frac{V_{be}}{I_b} \quad R_{out} / R_{uit} = \frac{V_{ce}}{I_c} \quad R_c = \frac{V_{cc}}{I_c} \quad V_{out} / V_{uit} = R_{C} \frac{dV_i}{dt} \]

**Static current gain** \[ = \frac{I_{out / uit}}{I_{in}} \]

**Dynamic current gain** \[ = \frac{\Delta I_{out / uit}}{\Delta I_{in}} \]

\[ V_{cc} = V_{RC} + V_{ce} \quad V_{ce} = V_{ce} - V_{RC} \quad R = \frac{P_f}{a} \]

\[ A_p = 10 \log \frac{P_{out / uit}}{P_{in}} \quad A_v = 20 \log \frac{V_{out / uit}}{V_{in}} \quad A_l = 20 \log \frac{I_{out / uit}}{I_{in}} \]

**Static voltage gain** \[ = \frac{V_{out / uit}}{V_{in}} \]

**Dynamic voltage gain** \[ = \frac{\Delta V_{out / uit}}{\Delta V_{in}} \]

\[ hie = \frac{\Delta V_{in}}{\Delta I_{in}} = \frac{\Delta V_{be}}{\Delta I_{b}} \quad V_{ce} = \text{constant} \]

\[ hre = \frac{\Delta V_{in}}{\Delta V_{out / uit}} = \frac{\Delta V_{be}}{\Delta V_{ce}} \quad I_{b} = \text{constant} \]

\[ hfe = \frac{\Delta I_{out / uit}}{\Delta I_{in}} = \frac{\Delta I_{c}}{\Delta I_{b}} \quad V_{ce} = \text{constant} \]

\[ hoe = \frac{\Delta I_{out / uit}}{\Delta V_{out / uit}} = \frac{\Delta I_{c}}{\Delta V_{ce}} \quad I_{b} = \text{constant} \]

\[ V_{out / uit} = \frac{R_f}{R_{in}} \times V_{in} \]

\[ V_{out / uit} = \left(1 + \frac{R_f}{R_{in}}\right) V_{in} \]

\[ V_{out / uit} = - \frac{1}{CR_{in}} \int V_{in}(t) \, dt \]

**Boltzmann's constant** \[ = 1.38 \times 10^{-23} \text{ J/K} \]

**Electron charge** \[ = 1.6 \times 10^{-19} \text{ C} \]

**NB:** Any applicable formula may be used.