INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Non programmable scientific calculator.

This paper consists of EIGHT questions in TWO sections; A and B.
Answer THREE questions from section A and TWO questions from section B.
ALL questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

This paper consists of 7 printed pages.

Candidates should check the question paper to ascertain that all
the pages are printed as indicated and that no questions are missing.
SECTION A: ELECTRONICS TECHNOLOGY

Answer any THREE questions from this section.

1. (a) (i) State two types of materials used in the production of light emitting diodes (LED).
   (ii) With the aid of a diagram, explain the principle of operation of Light emitting diodes (LED).  
       (7 marks)

(b) (i) Explain ‘tunnelling’ phenomenon with respect to tunnel diode.
   (ii) Draw the voltage-current (V-I) characteristics of a tunnel diode.  
       (6 marks)

(c) With the aid of a diagram, explain the principle of operation of an n-channel enhancement MOSFET.  
    (7 marks)

2. (a) Define the following with respect to digital systems:
   (i) flip - flop;
   (ii) decoder.  
    (2 marks)

(b) With the aid of a circuit diagram and waveforms, explain the operation of a centre - tapped transformer full-wave rectifier.  
    (8 marks)

(c) A half-wave rectifier has a diode resistance of 1 kΩ and a load resistance of 1 kΩ.
The input voltage is 310 V peak. Determine the:
   (i) peak current;
   (ii) average current;
   (iii) dc output power.  
    (6 marks)

(d) With the aid of a diagram, describe the construction of N-channel JFET.  
    (4 marks)

3. (a) State two applications of unijunction transistor (UJT).  
    (2 marks)

(b) (i) Draw and label an operational amplifier (op - amp) differentiator circuit.
   (ii) Derive the expression for the output voltage in (b) (i).  
    (7 marks)
(c) (i) Define 'input offset current' with respect to operational amplifiers.

(ii) **Figure 1** shows an inverting operational amplifier. Determine:

(I) \( I_{in} \)

(II) \( V_o \)

(III) \( I_L \)

(IV) \( I_{o} \)  

(8 marks)

(d) Draw a logic circuit diagram of a half-adder.  

(a) (i) Define 'fan out' with respect to logic gates.

(ii) Distinguish between combinational and sequential logic circuits citing **one** example in each case.  

(b) Perform the following operations using binary arithmetic:

(i) \( (93)_{16} + (DE)_{16} \)

(ii) \( (7)_{10} - (11)_{10} \)  

(8 marks)
Figure 2 shows a circuit diagram of a staircase lighting, the bulb is controlled by two switches, $S_1$ and $S_2$.

![Circuit Diagram]

**Fig. 2**

**KEY:**

- **ON** = 1
- **OFF** = 0

(i) Draw a truth table for the system;
(ii) Write the logic equation of the operation;
(iii) Implement the logic equation using NOT, AND and OR gates.  

(7 marks)

5.  
(a) State two applications of shift registers.  
(2 marks)

(b) A 6-bit, R - 2R ladder Digital-to-Analogue converter has a reference voltage of 6.5 V. Determine the:

(i) resolution;
(ii) output voltage for the input binary data word 011100.  

(5 marks)

(c) A bipolar junction transistor has $\beta = 150$. The emitter current $I_E$ is 10 mA. Determine the:

(i) collector current;
(ii) base current.  

(6 marks)

(d) A PROM memory of $2k \times 16$ is expanded to $16k \times 16$. Determine the:

(i) number of $2k \times 16$ PROM chips required;
(ii) number of address lines in the expanded memory;
(iii) number of address lines used for decoding.  

(7 marks)
6/ (a) Define the following with respect to control systems:
(i) control;
(ii) transfer function; (2 marks)

(b) State three merits of an open-loop control system. (3 marks)

(c) Figure 3 shows a block diagram of a control system. Using block diagram reduction technique, determine the transfer function of the system. (7 marks)

(d) Figure 4 shows a signal flow graph of a control system. Determine the transfer function. (8 marks)
7. (a) (i) State three merits of polar plots.

(ii) Describe the Nyquist stability criterion. (5 marks)

(b) Draw the response curves of the following test signals:

(i) unit step;
(ii) unit impulse. (4 marks)

(c) A second order system with damping ratio $\xi$ of 0.5 and angular frequency $\omega_n$ of 6 rad/sec is subjected to a unit step input. Determine the:

(i) rise time;
(ii) peak time;
(iii) settling time;
(iv) peak overshoot. (8 marks)

(d) Draw the torque-speed characteristic curves for a varying control voltage, $E$ of an a.c servo motor. (3 marks)

8. (a) Define the following with respect to Bode plots:

(i) octave;
(ii) phase crossover frequency. (2 marks)

(b) A control system has an open loop transfer function given by:

$$G(s)H(s) = \frac{k}{s(s + 3)(s + 5)}$$

Determine the:

(i) number of:

(I) poles;
(II) zeroes;
(III) loci;
(IV) asymptotes.

(ii) angles of asymptotes. (8 marks)

(c) List three demerits of lag compensation. (3 marks)
(d) Figure 5 shows a lag compensation network. Show that its transfer function is given by:

\[ T.F. = \frac{s\hat{\zeta}_2 + 1}{s(\hat{\zeta}_1 + \hat{\zeta}_2) + 1} \]  

where \( \hat{\zeta}_1 = R_1C \)
\( \hat{\zeta}_2 = R_2C \)

(7 marks)