UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE AND ENGINEERING
DEPARTMENT OF PHYSICS

MAIN EXAMINATION, DECEMBER 2017

TITLE OF PAPER	:	ELECTRONICS 1
COURSE NUMBER	:	PHY 311
TIME ALLOWED	:	THREE HOURS
INSTRUCTIONS	:	Answer **FOUR** (4) questions only.
	:	Each Question carries **25 Marks**
	:	Marks for different Sections are shown in far Right margin.

THIS PAPER HAS 7 PAGES, INCLUDING THIS ONE.

DO NOT OPEN THE PAPER UNTIL PERMISSION IS GRANTED BY THE INVIGILATOR.

1. (a) What are semiconductor materials? [2]

   (b) Define energy gap of a semiconductor. [1]

   (c) Describe the dynamics of the formation of the depletion region. [6]

   (d) Sketch the charge density (ρ), electric field (E), and electric potential (V) of a pn-junction. [3]

   (e) Describe the steps you would undertake to determine the conduction state of an ideal diode? [4]

   (f) The table below shows the I-V characteristics of a low voltage diode connected as shown in Figure 1.

Forward voltage (V)	0	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4
Forward current (mA)	0	1	5	28	65	120	165	240	330

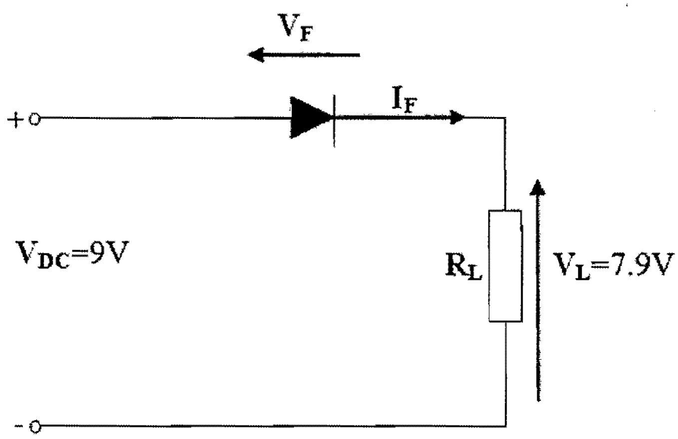


Figure 1: Low voltage diode

(i)Draw the I-V characteristics of the diode. [2]

(ii) Determine the current flowing in the diode. [4]

(iii) Calculate the value of the load resistor R_L [1]

(iv) Calculate the power dissipated in both the diode and R_L. [2]

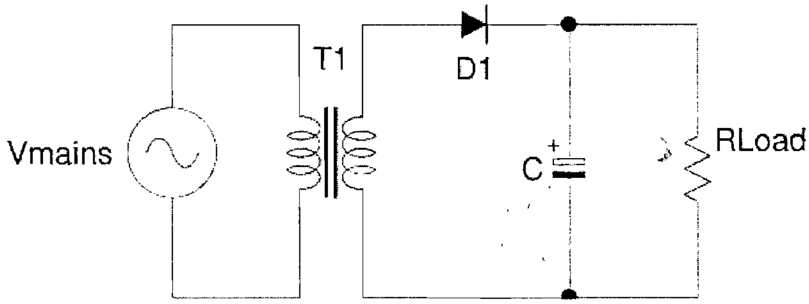


Figure 2

2. (a) Figure 2 shows the circuit diagram for a simple d.c. power supply.

   (i) Explain the operation of the circuit with reference to the function of each component within the circuit. [7]

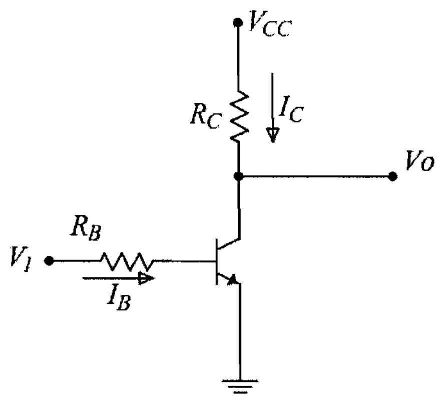
   (ii) Sketch the voltage across RLoad as a function of time showing its relationship to the secondary voltage from the transformer. [2]

   (iii) The transformer is connected to a 220 V rms mains supply at 50 Hz and has a step-down turns ratio of 10:1.Calculate the peak secondary voltage from the transformer. [2]

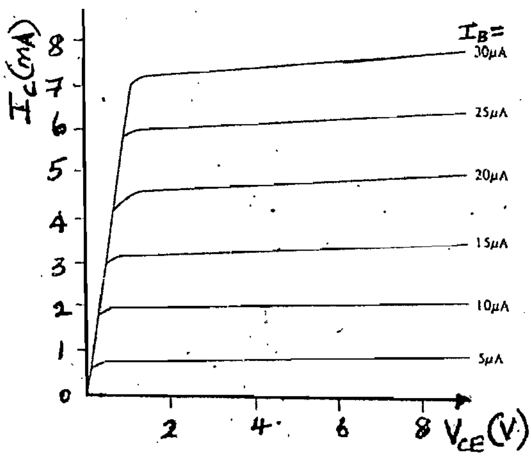
   (b) Consider the basic BJT inverter amplifier circuit in Figure 3a.

   (i) Sketch the transfer characteristics of the amplifier, indicating the operation regions, Q-Point, input signal and output signal. [5]

   (ii) What factor would lead the output signal to be clipped? [1]



(a)



(b)

(c) The output characteristics of a typical BJT is shown in Fig 3b.

(i) Draw the load line for a power supply of $V_{CC} = 8\ V$ and collector resistor $R_C = 1.14\ k\Omega$.**(Use the enlarged characteristics in Figure 7 on the last page.)** [4]

(ii) Choose an appropriate operating point on the characteristics and estimate the Quiescent values of I_B,V_{CE} and I_C. [4]

3. (a) Consider an npn-transistor shown in Figure 4. Show that $\beta = \alpha/(1-\alpha)$, where $\alpha = I_C/I_E$ and $\beta = I_C/I_B$. [3]

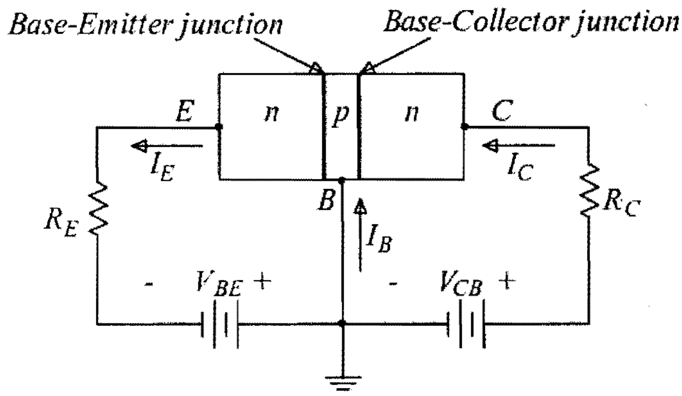


Figure 4: Biasing voltages of npn transistor

(b) Sketch the I-V characteristics of the above transistor, indicating the operating regimes. [6]

(c) Briefly explain the operating regions mentioned in (b) above. [4]

(d) Define the hybrid parameters of the transistor in Figure 4 in terms of the d.c. currents and voltages . [2]

(e) Describe how you would determine the hybrid parameters of a bipolar transistor from the input and output characteristics of the transistor. [6]

(f) Draw the small-signal equivalent circuit of a bipolar transistor containing a current-dependent voltage source. [2]

(g) A bipolar transistor with a forward current gain $\beta = 100$ passes a collector current of 26mA. Estimate the input resistance of the transistor. [2]

4. (a) Consider the circuit of the basic common-emitter amplifier shown in Figure 5.

   (i) State the uses of C_1 and C_E. [2]

   (ii) Why are the resistors R_1 and R_2 included in the circuit? [1]

(b) In Figure 5 $V_{CC} = 12V$, $I_C = 2mA$ and $V_{BE} = 0.65V$.

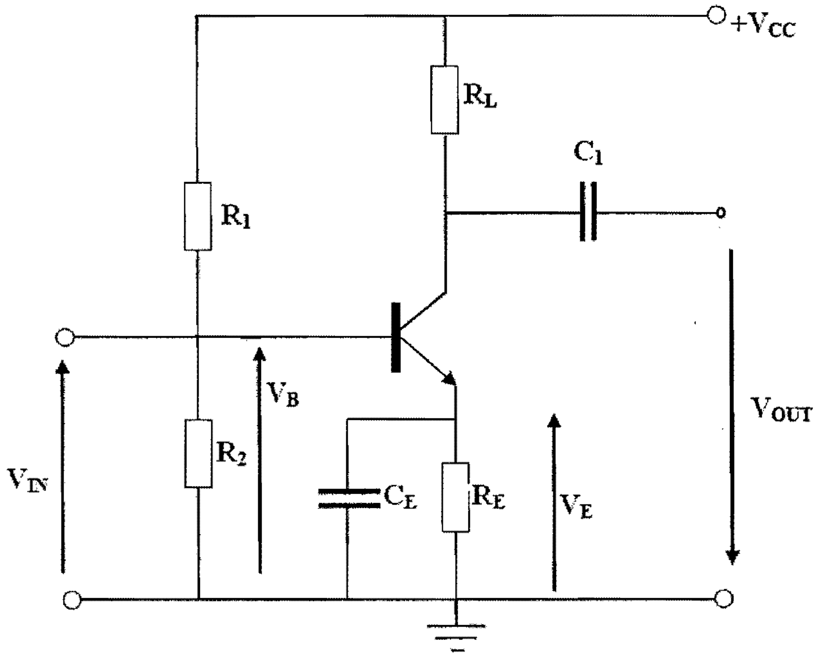


Figure 5: Common Emitter Amplifier

   (i) Calculate R_E when $1/10th$ of the supply voltage appears across it. [4]

   (ii) Calculate R_L when $V_{CE} = V_{CC}/2$. [4]

   (iii) Calculate I_B given that $\beta = 100$. [2]

   (iv) Determine the value of R_2 when $I_{R_2} = 10I_B$. [4]

(c) A Zener diode stabilizing circuit has an input voltage of 18 V and a diode current of 8 mA to give 10 V across a load resistor of 1200 Ω. Calculate

   (i) the value of the series resistor, [5]

   (ii) the diode current when the load resistor is 1000 Ω. [3]

5. (a) Sketch the structure and circuit symbol of an n-channel JFET. [2]

(b) Draw the output characteristics of of an n-channel JFET and indicate the operating regions. [4]

(c) Describe briefly the dynamics of operation in the regions mentioned in (b). [3]

(d) If the drain current I_D is a function of V_{DS} and V_{GS}, derive the small-signal equation for I_D and draw the small-signal equivalent circuits for n-channel JFETs in terms of voltage dependent voltage source. [5]

(e) Consider the N-channel MOSFET amplifier given in Figure 6 below. $I_{DS} = \frac{K}{2}(V_{GS} - V_T)^2$, $V_{DD} = 5V$, $R_L = 2\ k\Omega$, $K = 1\ mA/V^2$, and $V_T = 1V$. You can ignore the r_d of the MOSFET. C_C is the input coupling capacitor and you can assume it is infinitely large.

(i) Write an expression for the transistor bias point V_{GSQ} as a function of V_{DD}, R_a and R_b. [1]

(ii) Determine the required ratio R_a/R_b such that the MOSFET transconductance $g_m = 1\ mA/V$. [5]

(iii) What is the voltage bias point of the output V_{out}? [3]

(iv) Draw the small-signal model for the amplifier. [2]

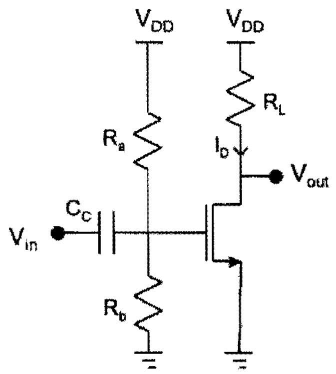


Figure 6: MOSFET amplifier

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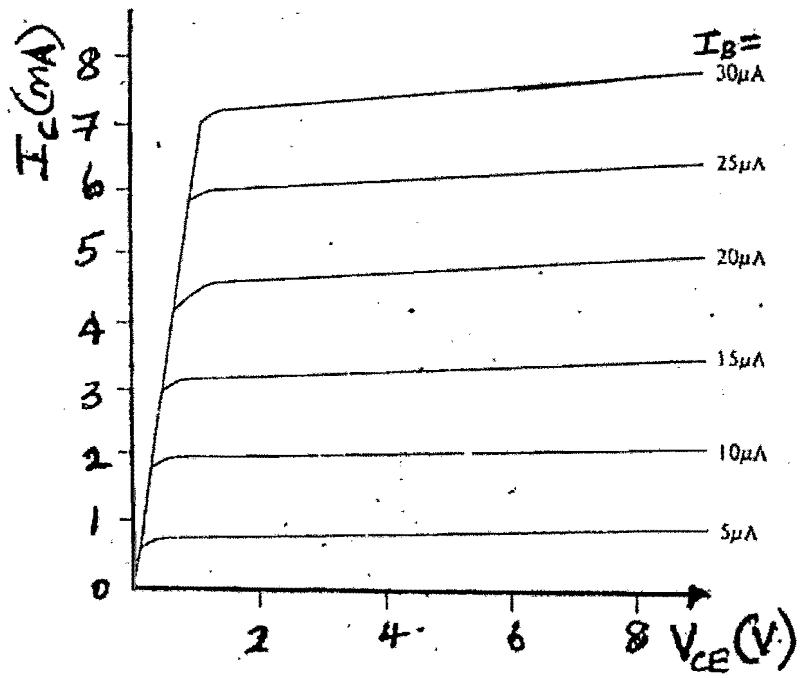

Figure 7