UNIVERSITY OF ESWATINI
FACULTY OF SCIENCE AND ENGINEERING
DEPARTMENT OF PHYSICS

MAIN EXAMINATION, DECEMBER 2018

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 6 PAGES, INCLUDING THIS ONE.

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

1. (a) Define the following

    (i) Intrinsic semiconductor [1]

    (ii) Doping [1]

    (iii) pn-junction. [1]

   (b) Sketch a bridge rectifier and the output (without a smoothening capacitor) and explain how it works. [5]

   (c) Assume that a smoothening capacitor C was connected across the load resistor of the bridge rectifier. With the aid of a schematic diagram of the variation of the output signal with time, show that the ripple voltage, V_r can be written as [7]

$$V_r = \frac{I_{av}}{2fC},$$

   where I_{av} is the d.c. current and f is the frequency.

   (d) Modify the bridge circuit in (b) above to obtain a voltage doubler circuit and sketch the output signal if the input is sinusoidal. [4]

   (e) Consider the circuit in Figure 1 .

    (i) Using the Zener diode model, obtain the load line equation for the circuit. [4]

    (ii) Sketch the I-V characteristics of the diode together with the load line. [2]

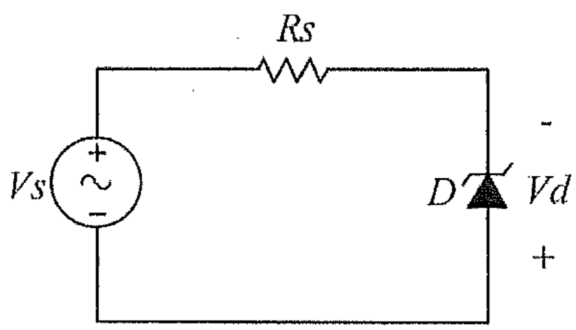
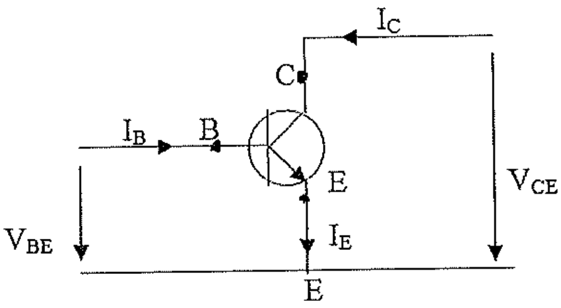
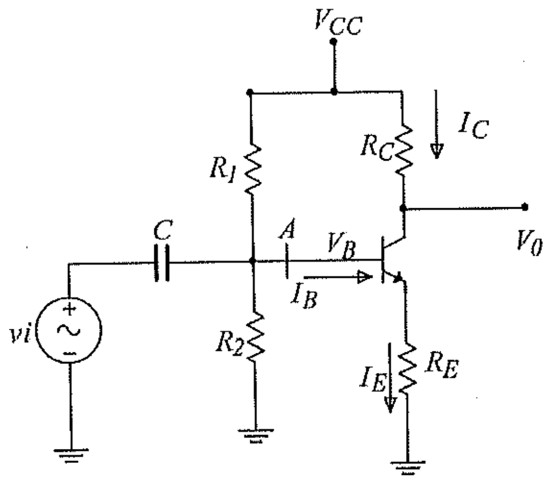


Figure 1

2. (a) With reference to Figure 2a, calculate the current gains α and β when $I_B = 14.46\ \mu A$ and $I_E = 1.46\ mA$. The base-emitter voltage is 0.7 V. [4]



(a)



(b)

(b) The table below shows the results of some dc measurements performed in the circuit of a npn BJT.

Fixed V_{CE1}		Fixed V_{CE2}	
$I_B\ (\mu A)$	$I_C\ (mA)$	$V_{BE}\ (V)$	$I_B\ (\mu A)$
100	9	0.65	100
120	11.2	0.66	150

(i) Determine approximate value of β with respect to the operating point. [3]

(ii) Find the value of h_{ie} at the operating point. [3]

(c) For the circuit in Figure 2b, $V_{CC} = 15V$, $R_C = 5.1\ k\Omega$, $R_E = 3.9\ k\Omega$, $R_1 = 10\ k\Omega$ and $R_2 = 4.7\ k\Omega$.

(i) Determine the values of I_E, I_C, V_{RC}, V_{RE} and V_{CE}. [10]

(ii) If the minimum value of β is 50, find the maximum possible value of I_B. Assume $V_{BE} = 0.7V$. [2]

(iii) Determine the input resistance r_{be} of the transistor. [3]

3. (a) With the aid of a diagram(s) and characteristics, discuss the principle of operation of the n-channel JFET. [12]

(b) Write the equation relating the drain current, I_D in terms of V_{GS} of an n-channel JFET. [3]

(c) Sketch the small signal equivalent circuit of a common-source amplifier in terms of a current dependent voltage source. [3]

(d) An n-channel JFET with a saturation current $I_{DSS} = 6mA$ and pinch-off voltage $V_P = -6V$ is used in the self-bias circuit of Figure 3. Given that $V_{DD} = 12V$, $R_D = 1.5$ kΩ and $R_S = 500Ω$, determine the operating point (I_D, V_{DS} and V_{GS}). [7]

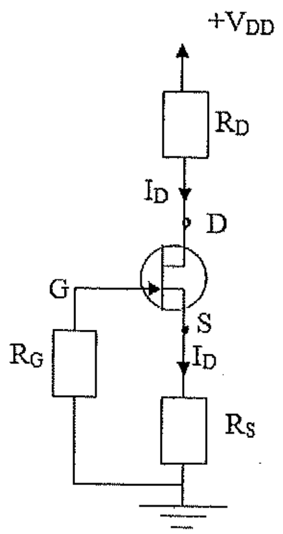


Figure 3: Self-bias circuit of a JFET

4. (a) Draw the circuit diagram of a constant current source using a junction FET. [3]

(b) Show that the internal resistance of the current source may be expressed as [7]

$$R_i \simeq \mu \left(1 - \sqrt{\frac{I_D}{I_{DSS}}}\right) \frac{|V_P|}{I_D}.$$

(c) In a JFET source follower, the FET has a transconductance $g_m = 15\ m\Omega^{-1}$. The source resistor $R_S = 5$ kΩ. Find the voltage gain A_v and the output resistance R_o. [3]

(d) Using schematic diagrams, mention the difference between the depletion-mode and enhancement-mode MOSFETs. [5]

(e) The biasing circuit in Figure 4 has the following circuit values: $V_{DD} = 18V$, $R_1 = 300$ kΩ, $R_2 = 150$ kΩ, $R_D = 500\ \Omega$ and $R_S = 4$ kΩ. If the n-channel JFET has $I_{DSS} = 8mA$ and $V_P = -4V$, determine the operating point. [7]

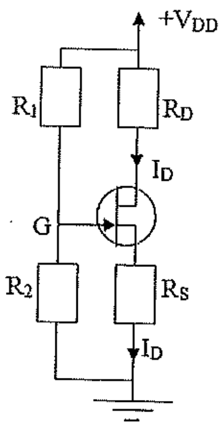


Figure 4

5. (a) Draw the small-signal equivalent circuit diagram of a common collector amplifier. [3]

(b) Show that the voltage gain is expressed as [9]

$$A_v = \frac{\beta + 1}{\beta + 1 + \frac{r_{be}}{R_E} + \frac{r_{be}}{r_{ce}}}$$

(c) Simplify A_v when $r_{be} << \beta R_E$ and $r_{be} << \beta r_{ce}$. [3]

(d) Given that $R_1 = 130$ kΩ, $R_2 = 150$ kΩ, $R_E = 7.5$ kΩ, and $\beta = 100$, calculate

(i) the working point (I_B, I_C and V_{CE}), [6]

(ii) input resistance R_{in}. [4]
Hint: $R_{in} \approx R_P(\beta R_E + r_{be})/[R_P + \beta R_E + r_{be}]$.

END