UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	:	**2008/2009**
TITLE OF PAPER	:	**ELECTRONICS I**
COURSE NUMBER	:	**P311**
TIME ALLOWED	:	**THREE HOURS**
INSTRUCTIONS	:	**ANSWER ANY FOUR OUT OF FIVE QUESTIONS**
		EACH QUESTION CARRIES 25 MARKS
		MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN.

THIS PAPER HAS 8 PAGES, INCLUDING THIS PAGE.

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QUESTION 1

(a) (i) At what forward voltage does a diode for which the ideality factor, $\eta = 2$ conduct a current equal to $1000I_S$? (4 marks)

(ii) Determine the current, in terms of I_S, that flows in the same diode when its forward voltage is 0.7 V. (3 marks)

(b) With the aid of diagrams, discuss the principle of operation of a p-n junction diode. Comment on the effect of forward and reverse biasing the diode. (10 marks)

(c) A Zener regulator circuit of the form shown in Figure 1.1 is to be designed to establish a constant output of 6.8 V from a fixed 10 V supply. The load current requirement is fixed at 100 mA. The Zener is to be biased at 20 mA.

(i) Determine the value of R_s required. (6 marks)

(ii) If the load is accidentally removed from the Zener, determine the maximum diode current. (2 marks)

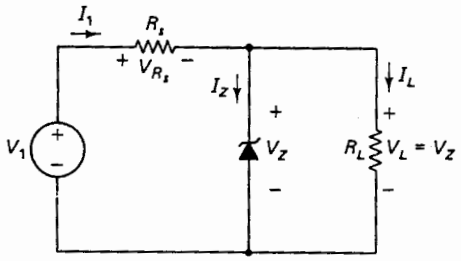

Figure 1.1

QUESTION 2

(a) Sketch a bridge rectifier (without a smoothing capacitor) and explain how it works. (6 marks)

(b) Imagine that a smoothing capacitor of capacitance C has been added across the load resistor of the bridge rectifier. With the aid of a schematic diagram that shows the variation of the output of this circuit with time, show that the ripple voltage, V_r can be expressed as follows:

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

where I_{av} represents the d.c. current and f stands for the frequency of the output. (6 marks)

(c) Assume that the transformer secondary delivers a 60-Hz sinusoidal waveform of 12 V (rms) to the circuit described in (b) above and that the load resistance $R_L = 100\ \Omega$.

(i) Find the value of *C* that results in a ripple voltage not larger than 1 V peak-to-peak. (5 marks)

(ii) What is the average load current? (2 marks)

(d) A certain unfiltered half-wave rectifier circuit of the form shown in Figure 2.1 is powered by the 120 V rms ac power system, and the turns ratio is $N_1 : N_2 = 6 : 1$.

Determine:

(i) the rms secondary voltage (2 marks)

(ii) the peak secondary voltage (2 marks)

(iii) the dc load voltage. (2 marks)

Neglect any diode and transformer losses.

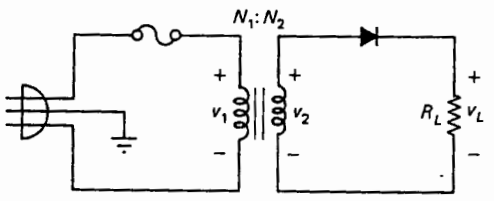

Fig. 2.1

QUESTION 3

(a) With reference to Figure 3.1, calculate the current gains α and β when the base current is 14.46 μA and the emitter current is to be 1.460 mA. The base-emitter voltage is 0.7 V. (4 marks)

(b) Some dc measurements performed on a particular bipolar junction transistor with a fixed collector-emitter voltage yield the following data:

$I_B(\mu A)$	$I_C(mA)$
100	9
120	11.2

Determine the approximate value of β(a.c.) with respect to the operating point. (2 marks)

(c) Consider a simple bipolar junction transistor amplifier of the form shown in Figure 3.2. Assume that for a specific set of operating conditions, the peak values of input and output voltages are V_{ip} = 12 mV and V_{op} = 2.16 V, respectively.

Determine the voltage gain **A** between input and output terminals. (3 marks)

(d) (i) For the circuit of Figure 3.3, determine I_E, I_C, V_{RC}, V_{RE}, and V_{CE}. (10 marks)

(ii) If the minimum value of β_{dc} for the transistor is 50, determine the maximum possible value of I_B. Consider V_{BE} to be 0.7 V. (3 marks)

(e) Some dc measurements performed in the base circuit of a particular *npn* transistor with a fixed collector-emitter voltage yield the following data:

$V_{BE}(V)$	$I_B(\mu A)$
0.65	100
0.66	150

Determine the appropriate value of h_{ie} at the operating point. (3 marks)

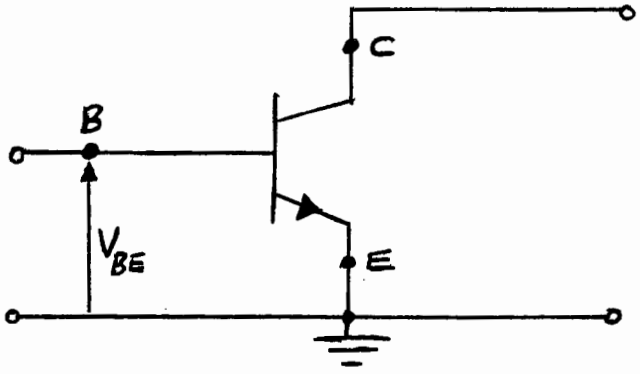

Fig. 3.1

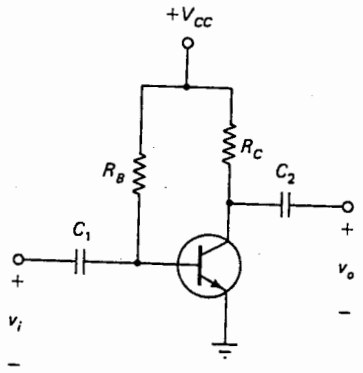

Fig. 3.2

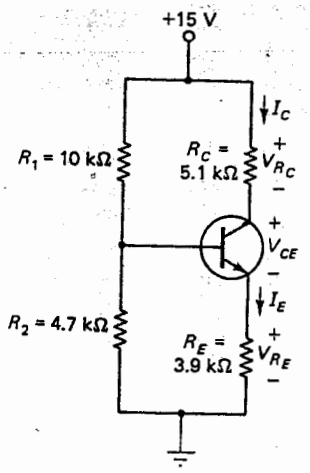

Fig. 3.3

QUESTION 4

(a) (i) Determine the drain conductance and drain resistance values associated with lines (1), (2) and (3) for the hypothetical junction field effect transistor characteristics of Figure 4.1. (6 marks)

(ii) Comment on the variation of the drain resistance with V_{GS}. What behaviour does the junction field effect transistor exhibit in this region. (2 marks)

(b) For the idealized junction field effect transistor drain characteristics of Figure 4.2, construct the transfer characteristic. (6 marks)

(c) A certain *n*-channel junction field effect transistor has a gate-source cutoff voltage of -5 V and a zero-bias drain current of 12 mA. Assume that the transistor is biased with a gate-source voltage of -2 V.

Determine the ideal drain current in the pinch-off region. (3 marks)

(d) Some dc measurements performed on an *n*-channel junction field effect transistor with a fixed drain-source voltage yield the following data:

V_{GS} (V)	I_D (mA)
-2	8
-1.9	8.6

Determine the approximate value of g_m in the region of operation. (2 marks)

(e) With the aid of the circuit diagram of a common-source amplifier, draw the small signal model of the amplifier and label it. (6 marks)

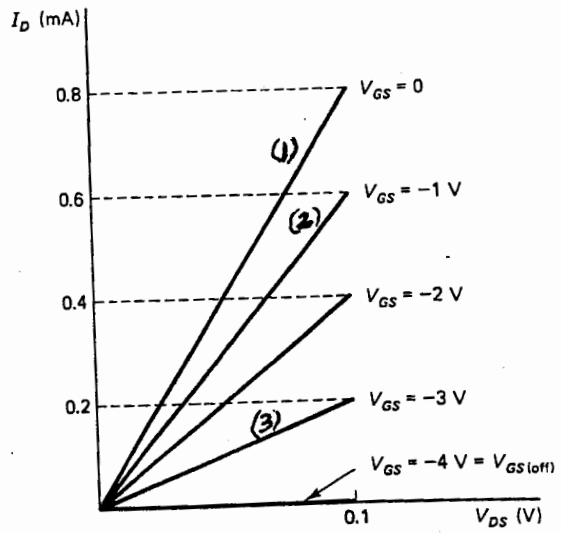
I_D (mA)
0.8
0.6
0.4
0.2
$V_{GS} = 0$
$V_{GS} = -1$ V
$V_{GS} = -2$ V
$V_{GS} = -3$ V
$V_{GS} = -4$ V = $V_{GS(off)}$
(1)
(2)
(3)
0.1
V_{DS} (V)

Fig. 4.1

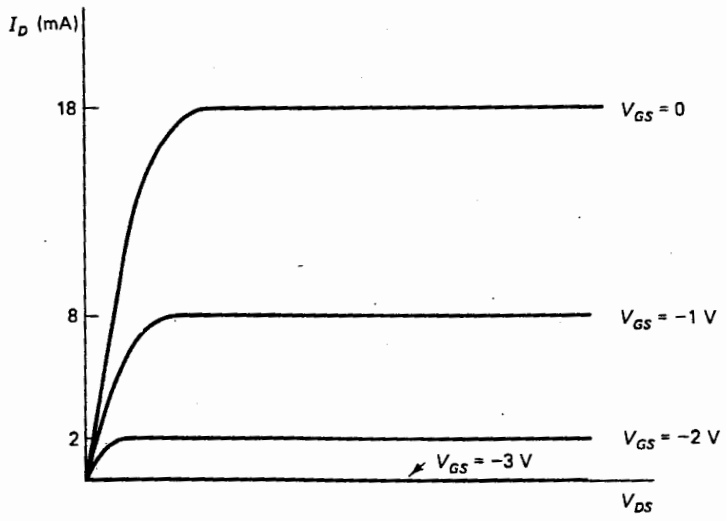
I_D (mA)
18
8
2
$V_{GS} = 0$
$V_{GS} = -1$ V
$V_{GS} = -2$ V
$V_{GS} = -3$ V
V_{DS}

Fig. 4.2

QUESTION 5

(a) Consider the differential amplifier shown in Figure 5.1. Determine

(i) the differential and common-mode input voltages. (4 marks)

(ii) the differential gain for $I_C = 1$ mA and (3 marks)

(iii) the common-mode rejection ratio. (4 marks)

(b) (i) Draw the circuit diagram of a source follower. (3 marks)

(ii) Derive an expression for the voltage gain of the source follower and verify that it is approximately unity. (9 marks)

(iii) Calculate the output resistance of the source follower when g_m is 20 mS. (2 marks)

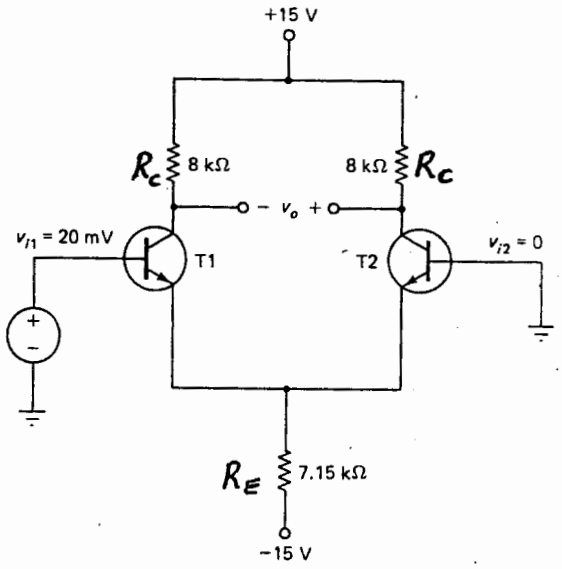

Fig. 5.1