UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	:	**DECEMBER 2007**
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) With the aid of examples, explain the meaning of the following terms:

(i) majority carriers; (2 marks)
(ii) minority carriers. (2 marks)

(b) A low-power diode has the current-voltage characteristic given by the figures in the table below.

Forward voltage (V)	0	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
Forward current (mA)	0	1	5	28	65	120	175	240	330

The diode is connected in the circuit shown in Fig. 1.1.

(i) Draw the I-V characteristics of the diode; (4 marks)
(ii) Determine the current flowing in the diode; (2 marks)
(iii) Calculate the value of the load resister R_L; (2 marks)
(iv) Calculate the power dissipated in both the diode and the load resistor; (4 marks)

(c) A Zener diode regulator circuit is to provide a 24 V supply to a variable load. The input voltage is 30 V and a 24 V, 400 mW Zener diode is to be used. Calculate:

(i) the series resistance R_1 required and (4 marks)
(ii) the diode current when the load resistance is 2000 Ω. (3 marks)

(d) Fig. 1.2 shows the output characteristics of a transistor. Is the device n-p-n or p-n-p? Give reasons for your answer. (2 marks)

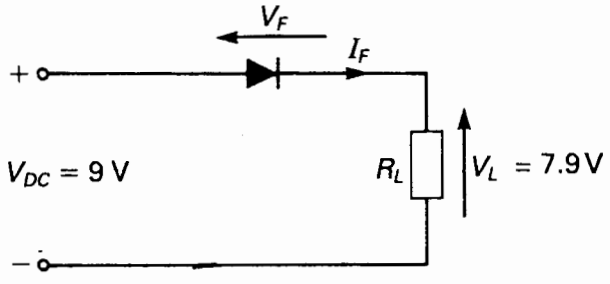


Fig. 1.1

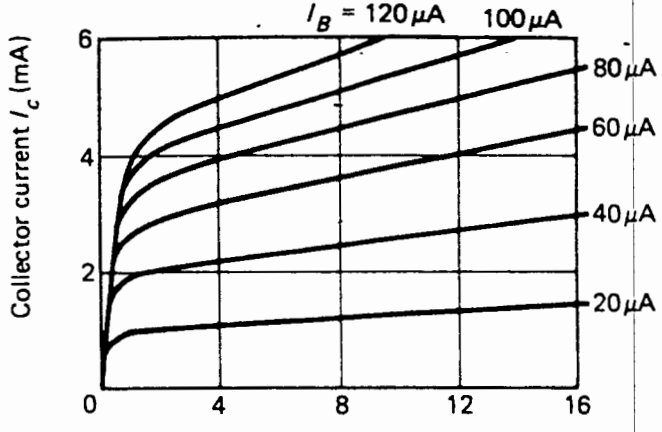


Fig. 1.2

QUESTION 2

(a) Draw the block diagram of an n-p-n transistor with its base-emitter junction forward biased and its collector-base junction reverse biased. Mark on the diagram the directions of the base current, the electrons in the collector region, and the holes in the emitter region. (3 marks)

(b) In Fig. 2.1, $V_{CC} = 12$ V, $I_C = 2$mA and $V_{BE} = 0.65$ V.

(i) Calculate R_3 when 1/10th of the supply voltage appears across R_3; (2 marks)
(ii) Calculate R_L, when $V_{CE} = V_{CC}/2$; (2 marks)
(iii) Calculate I_B when $h_{FE} = 100$ (2 marks)
(iv) Calculate R_2 when $I_{R2} = 10I_B$ (4 marks)

(c) (i) Draw the load line for a d.c. load of 400 Ω on the output characteristics given in Fig. 2.2. The operating point is at $I_B = 150$ μA and the supply voltage is 20 V. ***(Note:** Use the enlarged version of Fig. 2.2 given on page 7to draw the loadline).* (3 marks)

(ii) Calculate V_E, V_{CE} and collector-to-earth voltage when the emitter resistance is 100 Ω. (4 marks)

(iii) Determine the peak-to-peak output voltage when a sinusoidal voltage varies the base current by ± 50 μA. (5 marks)

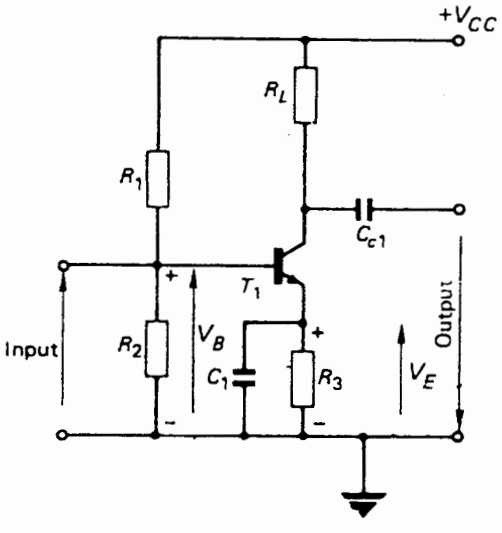


Fig. 2.1

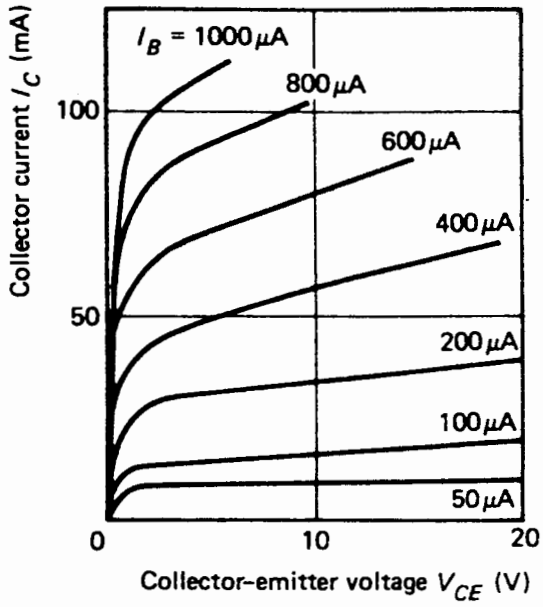


Fig. 2.2

QUESTION 3

(a) With the aid of a diagram, describe the principle of operation of an n-channel JFET. (8 marks)

(b) The drain-source voltage of a JFET is increased from 6 V to 7 V. The resulting increase in the drain current is 0.1 mA. Calculate the output resistance of the FET. Assume that there is zero change in the value of the gate-source voltage. (3 marks)

(c) Figure 3.1 shows both the mutual and drain characteristics of an n-channel JFET.

(i) Assuming that V_{DD} = 20 V, draw the load line for R_L = 2000 Ω on the drain characteristics and select the operating point V_{GS} = −2 V. (**Note**: *Use the enlarged version of Fig. 3.1 given on page 8 to draw the loadline*). (4 marks)

(ii) Determine from the drain characteristics the mutual conductance of the device when V_{GS} varies between the limits −1V and −3 V; (4 marks)

(iii) Calculate the voltage gain from the load line; (4 marks)

(iv) Calculate the theoretical voltage gain of a common source amplifier build using the JFET represented by the characteristics shown in Fig. 3.1. (2 marks)

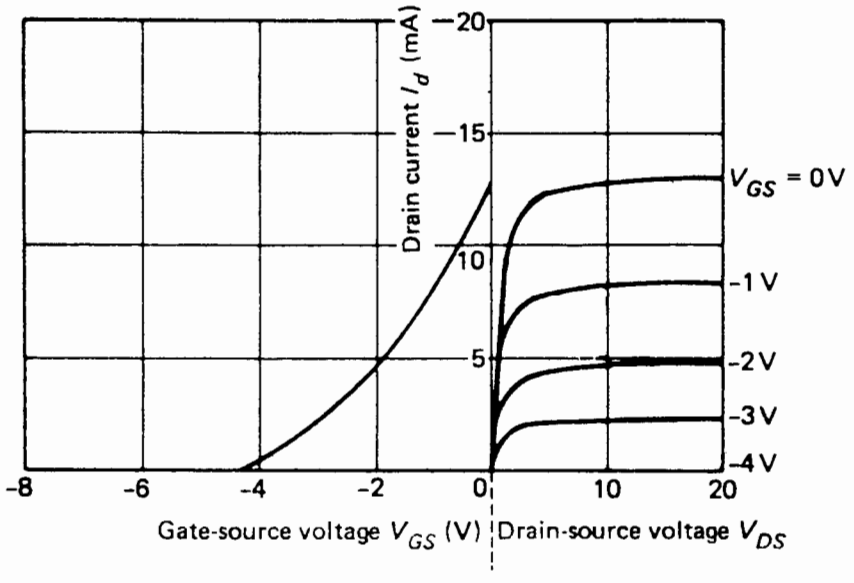


Fig. 3.1

QUESTION 4

(a) Explain, briefly, why a p-n junction diode acts as a rectifier. (2 marks)

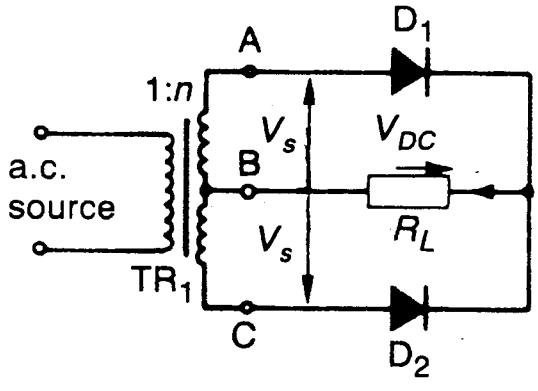
(b) How does the reverse saturation current of a p-n junction diode vary with temperature? (4 marks)

(c) The input transformer of a full-wave rectifier (Fig. 4.1) has a turns ratio of 9.58:1. The r.m.s. voltage at the secondary is 24 V. Calculate:

(i) the r.m.s. input voltage; (4 marks)
(ii) the peak current flowing in the 200 Ω load; (3 marks)
(iii) the d.c. current in the 200 Ω load. (4 marks)

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

(i) the value of the series resistor; (4 marks)
(ii) the diode current when the load resistance is 1000 Ω. (4 marks)



Assume that D_1 and D_2 represent silicon diodes.

Fig. 4.1

QUESTION 5

(a) What is meant by hybrid parameters? (3 marks)

(b) Consider a bipolar junction transistor with the following h-parameters: $h_{oe} = 6x10^{-5}S$, $h_{ie} = 1.2\ k\Omega$, and $h_{fe} = 150$. The transistor is used to build an amplifier with a collector resistance of 2 kΩ.

(i) Draw a detailed equivalent circuit of this amplifier and label it; (4 marks)
(ii) Calculate the voltage gain of the amplifier when h_{oe} is neglected; (3 marks)
(iii) Calculate the voltage gain when h_{oe} is taken into account. (4 marks)

(c) The application of a signal voltage of 7.5 mV peak between the base and emitter terminals of an n-p-n transistor causes the emitter current to vary by ± 0.5 mA about its d.c. value.

(i) Calculate the a.c. voltage developed across a 1.2 kΩ collector resistor when the common-base current gain, $\alpha = 0.99$; (3 marks)
(ii) Calculate the voltage gain of the circuit. (2 marks)

(d) An audio-frequency amplifier uses a FET with $r_{ds} = 10\ k\Omega$ and $g_m = 5$ mS. What value of drain load resistor is needed to give a voltage gain of -40? (3 marks)

(e) Explain what is wrong with the following statement. An n-p-n transistor is operated with its base-emitterjunction forward biased and its collector-basejunction reverse biased. When the base potential is made more negative, the collector current is reduced in value. (3 marks)

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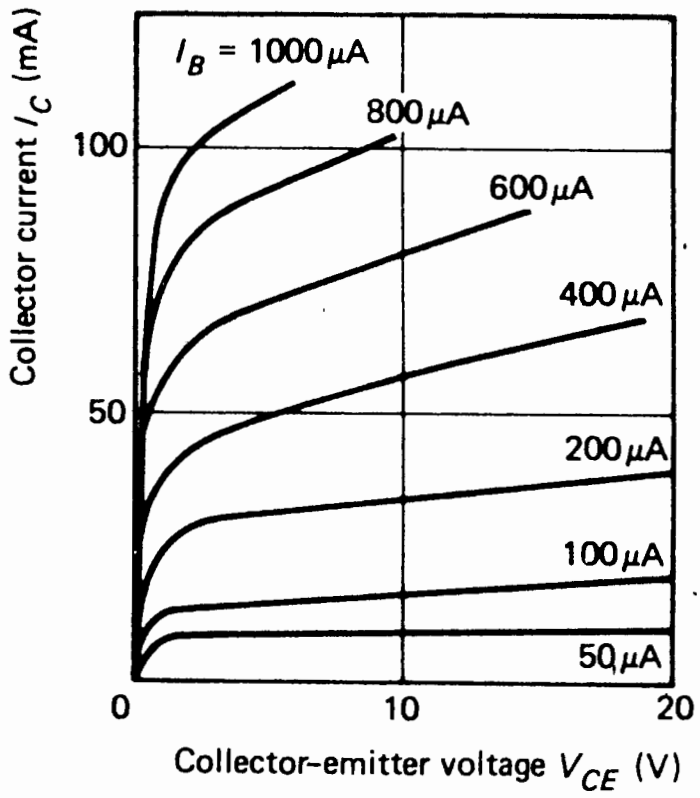
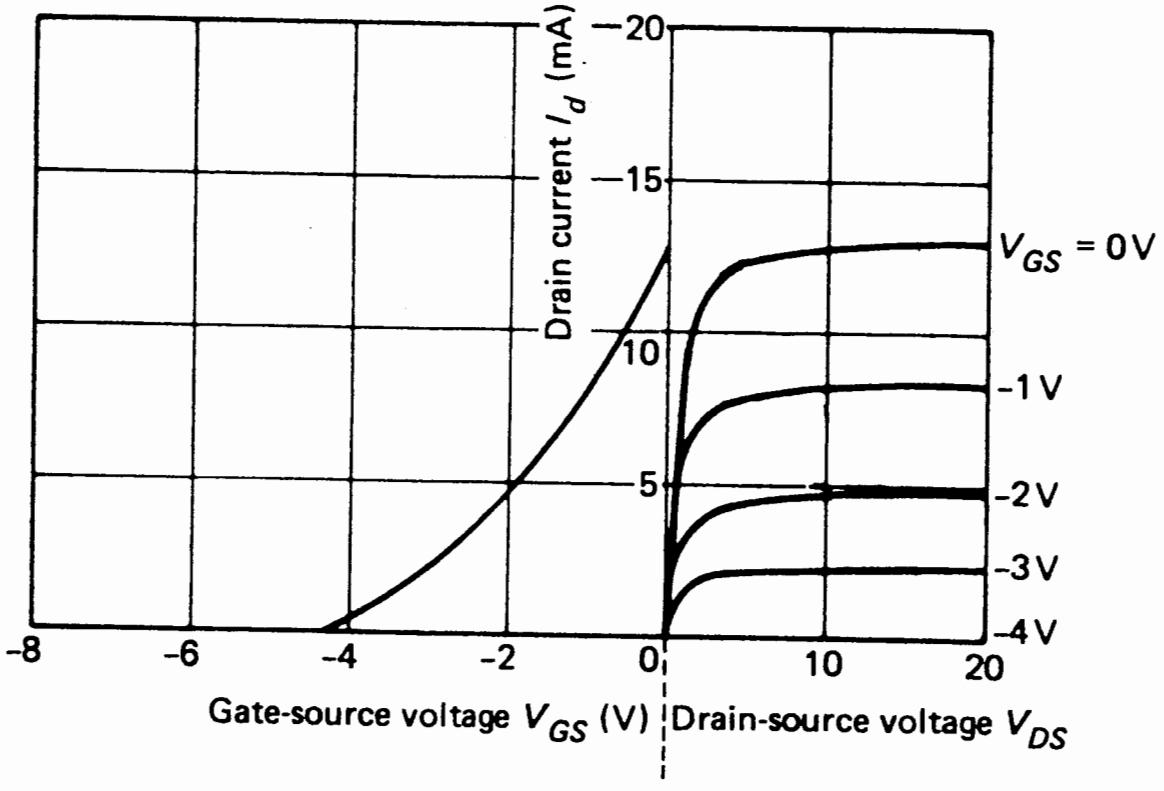
USE THE GRAPH BELOW TO ANSWER QUESTION 2 (c)(i)
(An enlarged version of Fig. 2.2)



NOTE: This graph should be handed in together with the answer book.

CANDIDATE'S EXAMINATION NUMBER.....

USE THE GRAPH BELOW TO ANSWER QUESTION 3 (c)(i)
(An enlarged version of Fig. 3.1)



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