UNIVERSITY OF SWAZILAND

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FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	:	**2010/2011**
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

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(a) Consider the simplified voltage regulator circuit shown in Fig. 1.1. Explain, briefly, how the circuit works and state the conditions to be satisfied in order for the circuit to give a constant d.c. voltage as well as ensure that the Zener diode is not damaged.
(10 marks)

(b) The input voltage of the regulator has a minimum value of 24 V and the peak-to-peak ripple voltage is 2 V. The Zener voltage is 6.2 V and the maximum power allowed in the diode is 0.9 W.

(i) Calculate the load current. (2 marks)

(ii) Calculate the current through the series resistor when the input voltage is maximum. (3 marks)

(iii) Calculate the maximum current that should be allowed through the diode. (2 marks)

(c) Fig. 1.2 is an illustration of a bridge rectifier. Derive an expression for the average current through the load resistor, with the aid of a labelled diagram. (8 marks)

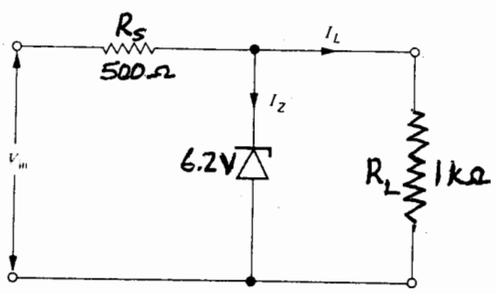

Figure 1.1

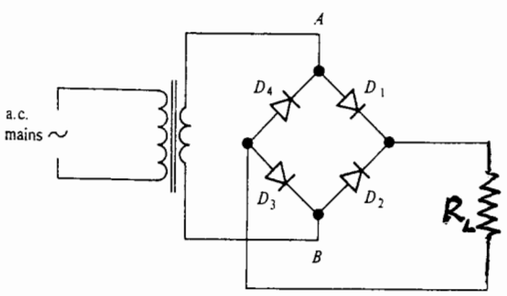

Figure 1.2

QUESTION 2

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(a) Consider a pnp (bipolar junction) transistor that is connected in the forward-active mode. Use a suitable diagram to explain how it works. (10 marks)

(b) Fig. 2.1 shows a simple bipolar junction transistor amplifier circuit. The specifications of the circuit are as follows:

Collector current, $I_C = 1.5$ mA
Collector-emitter voltage, $V_{CE} = 4.5$ V
Transistor dc current gain, $h_{FE} = 200$
Supply voltage, $V_{CC} = 9$ V
Base-emitter voltage, $V_{BE} = 0.6$ V

Calculate the following:

(i) The base-bias resistance, R_B. (4 marks)

(ii) The load resistance, R_L. (2 marks)

(c) The element values of the circuit shown in Fig. 2.2 are: $R_1 = 150$ kΩ, $R_2 = 37.5$ kΩ, $R_L = 7$ kΩ, $R_3 = 3$ kΩ and $V_{CC} = 9$ V. The d.c. current gain of the transistor is $\beta = 100$. Let $V_{BE} = 0.6$ V.

(i) Calculate the base voltage, V_B. (4 marks)

(ii) Calculate the collector current, I_C. (3 marks)

(iii) Calculate the collector-emitter voltage, V_{CE}. (2 marks)

Assume that $I_C \simeq I_E$ and that the current through resistor R_2 is approximately the same as the current through R_1, since I_B is very small.

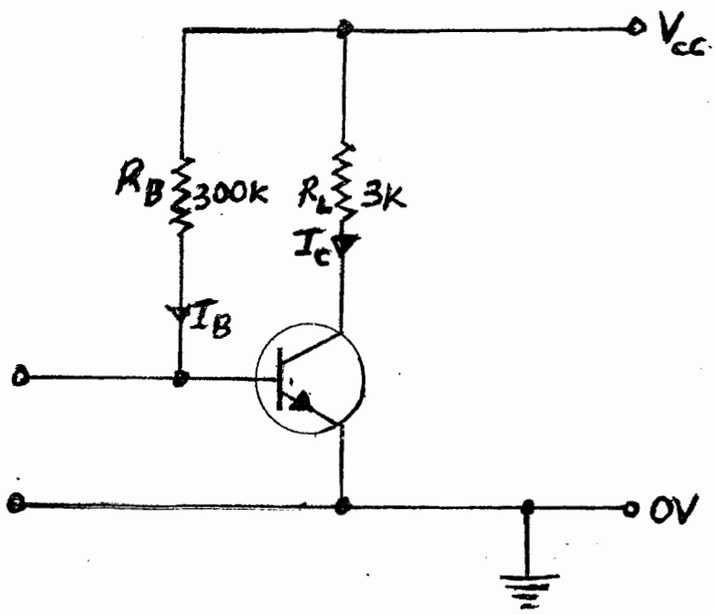

Figure 2.1

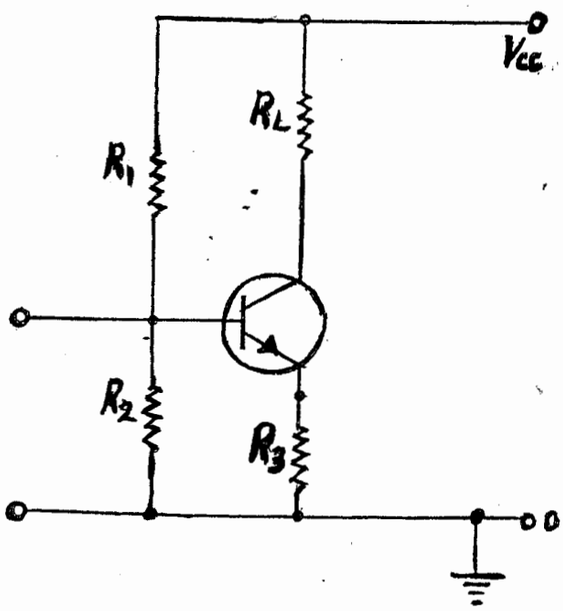

Figure 2.2

QUESTION 3

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(a) Discuss the principle of operation of a p-channel JFET, with reference to a schematic diagram of the JFET and its characteristics. (10 marks)

(b) (i) Draw the circuit diagram of a common-source amplifier stage in which the dc bias is obtained by means of a source resistor, R_S. The amplifier utilises an n-channel JFET. Label the amplifier circuit. (3 marks)

(ii) In what way is the dc bias influenced by R_S? (3 marks)

(c) An n-channel JFET has the data

Table 1. Data for an n-channel JFET

V_{DS} (V)	I_D (mA)	
	$V_{GS} = 0$ V	$V_{GS} = -2$ V
0	0	0
1	2	1
3	5.8	2.2
5	8.0	2.6
9	9.9	2.9
13	10.2	3.1
17	10.3	3.3

(i) Plot the drain characteristics. (3 marks)

(ii) Use the characteristics to determine the transconductance, g_m of the device at $V_{DS} = 12$ V and to calculate the drain resistance, r_d, for $V_{GS} = -2$ V. (6 marks)

QUESTION 4

(a) Consider the diode equation given below

$$I_D = I_S\left\{\exp\left(\frac{qV_D}{\eta k_B T}\right) - 1\right\}$$, where the symbols have the usual meaning.

For a forward-biased diode $\exp(qV_D/\eta k_B T) >> 1$.

Present the values of the diode current and voltage given in Table 2 in the form of a graph that would enable you to calculate the values of the constant η and the reverse saturation current, I_S.

Table 2. Current and voltage data for a forward-biased p-n diode

Forward voltage, V_D (V)	0.10	0.15	0.20	0.25	0.30
Forward current, I_D (mA)	0.005	0.02	0.10	0.40	1.5

(13 marks)

(b) The characteristics of the diode in the circuit shown in Fig. 4.1 are shown in Fig. 4.2.

(i) With the aid of a d.c. loadline, find the current flowing in the circuit. The applied d.c. voltage, V_S is 0.8 V. (7 marks)

(ii) Estimate the voltage across R_L. (2 marks)

(iii) Find the value of R_L that will allow 5 μA to flow in the circuit. (3 marks)

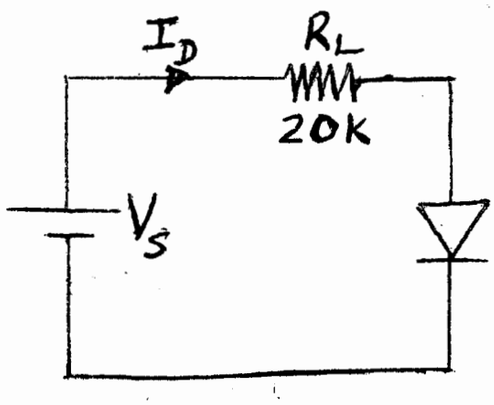

Figure 4.1

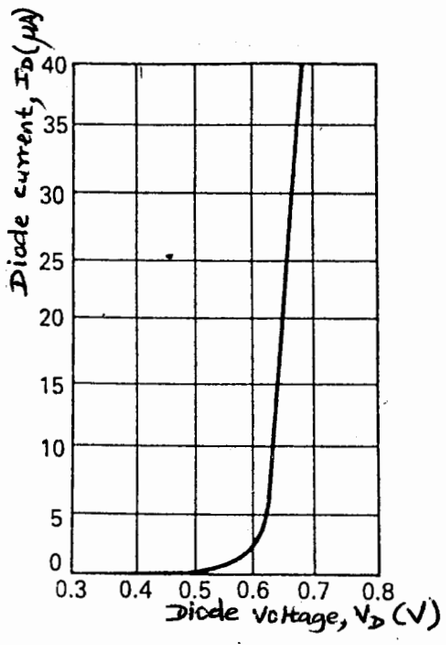

Figure 4.2

QUESTION 5

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(a) (i) Draw the circuit diagram of a full-wave rectifier which utilises a centre-tap transformer. (3 marks)

(ii) Explain how the rectifier works, with the aid of the input and output waveforms. (7 marks)

(b) Fig. 5.1 shows a half-wave rectifier with a reservoir capacitor of capacitance 10 μF. The peak value of the transformer secondary voltage is 30V (60 Hz) and the average current through the load is 10 mA.

(i) With reference to the transformer secondary voltage, show how the output voltage of the circuit varies with time. Label the waveforms. (3 marks)

(ii) Calculate the peak value of the ripple voltage. (4 marks)

(iii) Calculate the d.c. output voltage. (2 marks)

(c) In the USA, the a.c. power-line supplies 115 Vrms. This voltage is connected to the primary of a transformer with a turns ratio of 1/40.

Calculate the peak-to-peak value of the transformer secondary voltage. (6 marks)

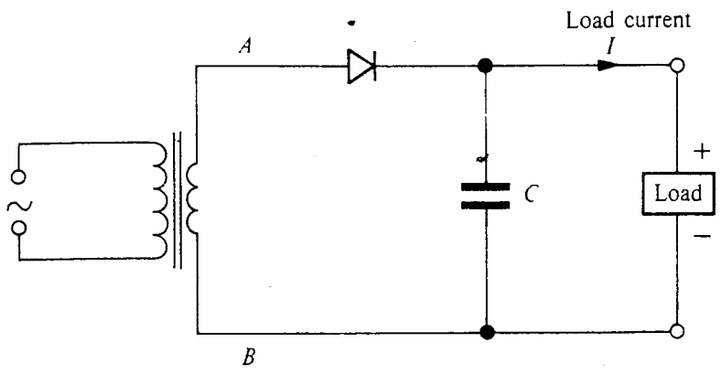

Figure 5.1