UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2007/2008

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

THIS PAPER HAS 6 PAGES, INCLUDING THIS PAGE.

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QUESTION 1

(a)   Explain how you would fabricate a p-channel JFET.   (7 marks)

(b)   With the aid of a diagram(s) and characteristics, discuss the principle of operation of the p-channel JFET.

                                                                                        (8 marks)

(c)   (i)   Draw the small signal model of a JFET common source amplifier;   (3 marks)
        (ii)   With the aid of the diagram, show that the gain of the amplifier is given by
                                                                                        (4   marks)

$$\frac{v_o}{v_i} = -g_m \left[\frac{1}{r_d} + \frac{1}{R_D} \right]^{-1}$$

(d)   In a JFET source follower, the FET used has a transconductance g_m of 15 mΩ^{-1}. The source resistor $R_s = 5k\Omega$. Find the voltage gain A_v and the output resistance.

                                                                                        (3 marks)

QUESTION 2

(a)   In the United States the ac power-line voltage is nominally 115 V rms. This voltage is connected to the primary of a transformer with a turns ratio of 1/50. What is the peak-to-peak secondary voltage? (4 marks)

(b)   For the half-wave rectifier of Fig. 2.1 with $R_L = 10$ kΩ,

        (i)   What are the dc output current and voltage? (5 marks)

        (ii)   If R_L in Fig. 2.1 is 100 Ω, what is the average dc output voltage? (2 marks)

        (iii)   What would be the dc output voltage if the rectifier is used with a capacitor filter of 10 μF? (6 marks)
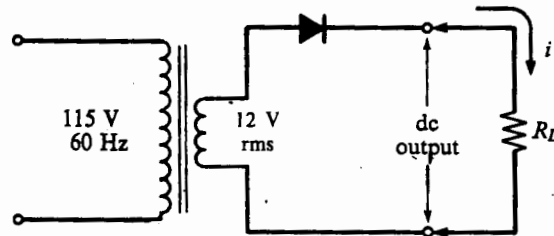

Fig. 2.1

(c)   In the Zener diode regulator shown in Fig. 2.2, $V_z = 5.1$ V, and the Zener diode has a maximum power rating $P_{maz} = 500$ mW. Find the required value of R_s if V = 10 V, $R_L = 100$ Ω and the power dissipation is to be no more than 150 mW. (8 marks)
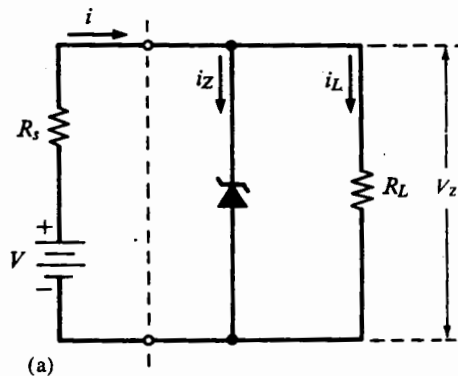

Fig. 2.2

QUESTION 3

(a) With the aid of a diagram, describe the principle of operation of a pnp (bipolar junction) transistor in the forward-active mode. (10 marks)

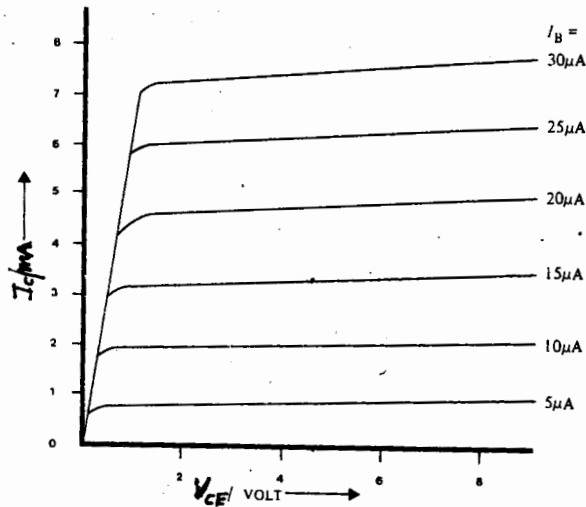(b) The characteristics of a typical bipolar junction transistor (npn) are given in Fig. 3.1.

Fig. 3.1

(i) Draw the loadline for supply voltage $V_{CC} = 8\,V$ and collector resistor $R_C = 1k\Omega$. (First: Determine the intercepts of the loadline). (4 marks)

(ii) Choose the best operating point Q for an amplifier which uses this transistor, and then estimate the quiescent values of I_B, V_{CE} and I_C. Justify your choice. (3 marks)

(c) The amplifier stage of Fig. 3.2 utilises an npn transistor in the C-E connection. If $I_E = 3\,mA$, $V_{CE} = 8\,V$, $V_E = 6\,V$, calculate values of the following: R_C, R_E and V_B. (Assume that $V_{BE} = 0.6\,V$)
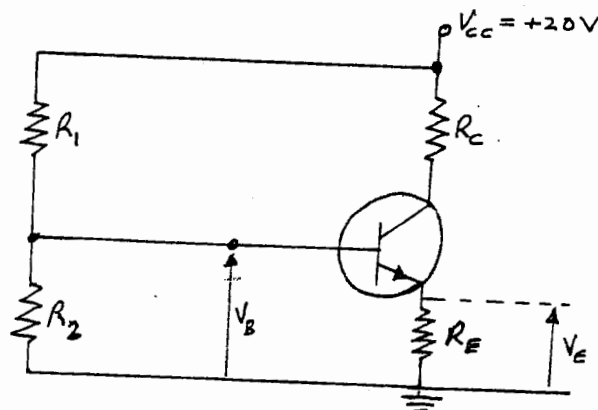
(8 marks)

Fig. 3.2

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QUESTION 4

(d)   Draw and label a diagram that illustrates how you would obtain the drain and transfer characteristics of an n-channel JFET.   (3 marks)

(e)   Sketch and label typical drain and transfer characteristic curves.   (4 marks)

(f)   Use the curves to:

   (i)   explain the use of a JFET as a voltage controlled resistor;   (3 marks)
   (ii)   explain how you would determine the mutual conductance.   (4 marks)

(d)   When the gate-source voltage of a JFET is held at a constant value it is found that a change in the drain-source voltage of 2 V produces a change of $0.5\ mA$ in the drain current. Calculate the drain resistance, r_d of the FET.   (5 marks)

(e)   Consider the JFET amplifier in Fig. 4.1.

$V_{DD} = 15$ V
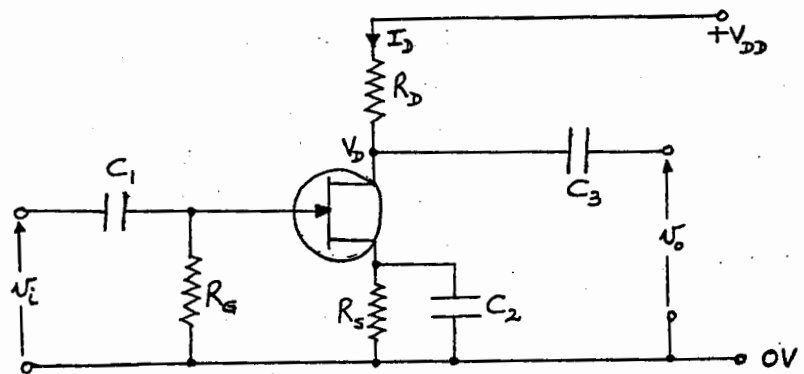$R_D = 4.7\ k\Omega$
$g_m = 10$ mA/V
$R_s = 1k\Omega$

Fig. 4.1

(i)   If the self-bias value of $V_{GS} = -1.0$ volt, what is the bias value of the drain current, I_D?   (2 marks)
(ii)   Calculate the quiescent value of V_D.   (2 marks)
(iii)   Calculate the voltage gain of the amplifier.   (2 marks)

QUESTION 5

(a)   A 9.1 V, 1.3 W Zener diode has a minimum current requirement of 20 mA and is to be used in a voltage regulator circuit. The supply voltage is $20\,V \pm 10\%$ and the constant load current is 30 mA.

   (i)   Draw the circuit diagram of the voltage regulator circuit and label it;
                                                                          (2 marks)
   (ii)   Calculate the series resistance;   (7 marks)
   (iii) Calculate the power dissipated in the diode when the supply voltage is 22 V.
                                                                          (5 marks)

(b)   A half-wave rectifier circuit consists of a diode and a load resistor R_L. It operates on an a.c. mains supply of 240 V r.m.s. with a step-down transformer having a turns ratio T of 1/3. Calculate

   (i)   the peak value of the secondary voltage and   (3 marks)
   (ii)   the average value of the voltage across R_L.   (2 marks)

(c)   A 100 μF capacitor is used to smooth the output of a half-wave rectifier. The peak voltage at the transformer secondary is 56 V (50 Hz) and the average current through the load is $15\,mA$.

   (i)   Calculate the peak value of the ripple voltage   (4 marks)
   (ii)   Calculate the average output voltage.   (2 marks)