UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2009/2010

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 6 PAGES, INCLUDING THIS PAGE.

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QUESTION 1

(a) With the aid of a labelled circuit diagram, describe, in detail, how a d.c. power supply works. The circuit should include a full-wave rectifier, a smoothing filter and a regulator. Explain, clearly, how the a.c. mains voltage is converted into a constant voltage. (11 marks)

(b) Consider a 12 V, 480 mW Zener diode stabilizer circuit. The maximum voltage at the input of the circuit is 20 V and the load current is 10 mA. Calculate

(i) the series resistance required and (5 marks)

(ii) the Zener diode current when the load resistance is 2 kΩ. (4 marks)

(c) Calculate the average output voltage of a full-wave rectifier if the mains supply voltage is 240 V rms and the step-down transformer turns ratio is 8:1. (5 marks)

QUESTION 2

(a) Sketch a typical set of output of characteristics for an n-p-n transistor and then use them to explain

(i) how the collector current depends on the base current, (2 marks)
(ii) how the collector current depends on the collector-emitter voltage (4 marks)

(b) A common-emitter stage is based on an npn silicon transistor with the following parameters:

$h_{ie} = 4\ k\Omega$, $h_{re} = 10^{-4}$, $h_{fe} = 200$, $h_{oe} = 2.0 \times 10^{-5}\ \Omega^{-1}$.

The load resistor has a value of 1 $k\Omega$.

With the aid of a complete h-equivalent circuit (rather than an approximate one), derive exact expressions and then calculate the values of each of the following:

(i) the current gain; (6 marks)

(ii) the input impedance; (5 marks)

(iii) the voltage gain; (6 marks)

(iv) the power gain achieved. (2 marks)

QUESTION 3

(a) (i) Draw the diagram of a circuit you would use in an experiment to determine the drain and transfer characteristics of the n-channel JFET. Label the diagram fully. (2 marks)

(ii) Sketch a typical transfer characteristic curve and label it. (2 marks)

(b) 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 in the drain current of 0.5 mA. Calculate the drain resistance of the FET. (4 marks)

(c) The drain characteristics of an n-channel JFET are shown in Fig. 1. The transistor is used in an amplifier with a 25 V supply and a load resistor, R_D of 12.5 kΩ.

(i) At what values of I_D and V_{DS} does the loadline meet the axes. Explain. (5 marks)

(ii) Choose a suitable quiescent point on the loadline and estimate the quiescent values of I_D, V_{GS} and V_{DS}. (2 marks)

(iii) What is the power dissipated in the transistor under quiescent conditions? (2 marks)

(d) Draw the low-frequency small-signal model of the JFET amplifier shown in Fig. 2 and explain the significance of each element. (8 marks)

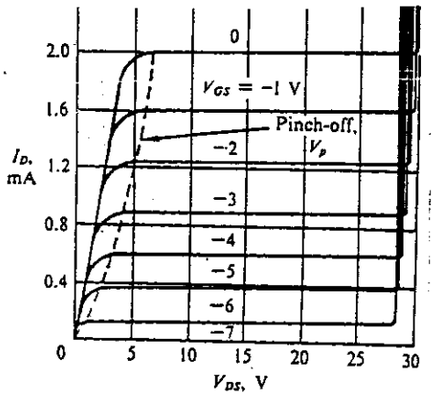

Fig. 1

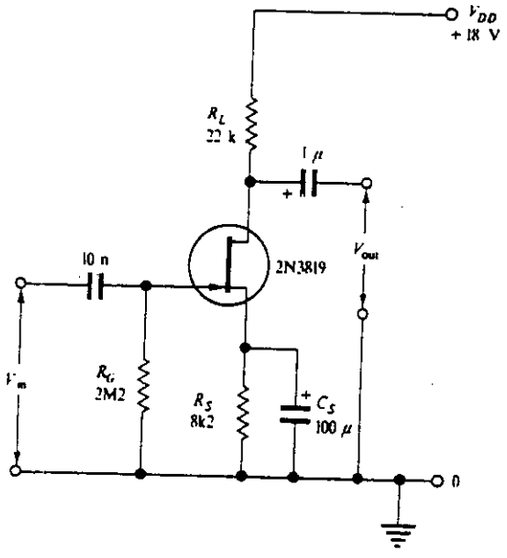

Fig. 2

QUESTION 4

(a) With the aid of the Czochralski method of growing single crystals, illustrated in Fig. 3, explain how the apparatus works by stating how you would grow a single crystal of silicon. (8 marks)

(b) The resistivity of an intrinsic silicon material is very high and of the order of kiloohms. Explain how you would increase its conductivity, with reference to the crystal structure of silicon and relevant energy band diagram(s). (10 marks)

(c) A p-n junction diode is connected in series with a d.c. motor which has a resistance, $R_L = 200\ \Omega$. A d.c. power supply is then connected across the series combination, as shown in Fig. 4. Use the I-V characteristics of the diode, shown in Fig. 5, and the loadline concept, to estimate the current through R_L. (7 marks)

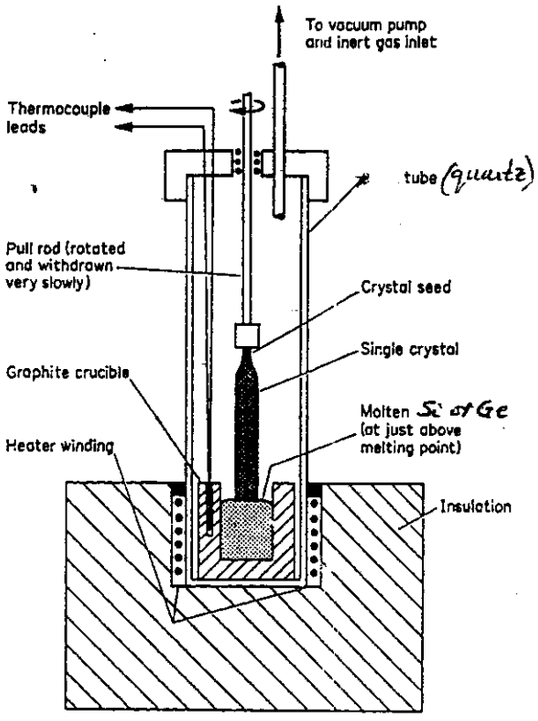

Fig. 3

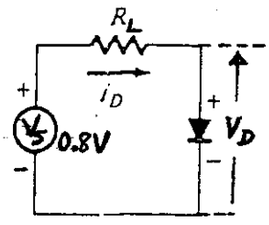

Fig. 4

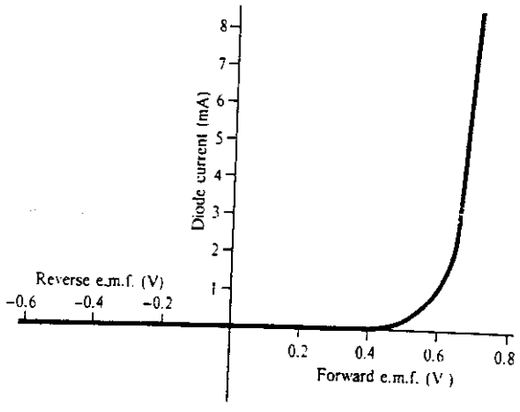

Fig. 5

QUESTION 5

The following table is based on the characteristics of a junction field effect transistor:

Table 1. Data for a junction field effect transistor

V_{GS} (V)	- 5	- 4	- 3	- 2	- 1
I_D (mA)	0.8	0.2	3.5	5.5	7.3

(a) (i) Which type of FET can be represented by the data given in Table 1? (1 mark)

(ii) Draw a graph using this data. (3 marks)

(b) Draw a simple common-source amplifier, with $V_{DD} = 24$ V, $R_D = 2$ kΩ and the source resistance $R_S = 390$ Ω. The gate should be effectively at ground potential. (4 marks)

(c) With reference to your circuit and graph [Sections 5 (a) and (b)], determine the quiescent values of I_D and V_{DS} and when the operating point corresponds to $V_{GS} = - 2$ V. (5 marks)

(d) Determine, as exact as possible, the voltage amplification of the amplifier?(4 marks)

(e) In the circuit shown in Fig. 6, the voltage at the emitter was measured and found to be - 7 V. If $\beta = 50$, find I_E, I_B, I_C, and V_C. (8 marks)

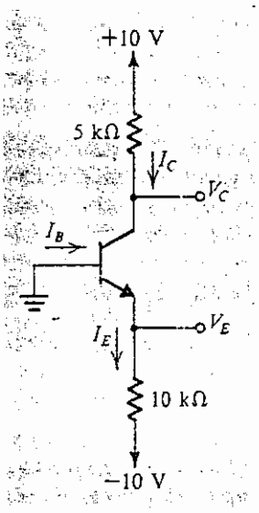

Fig. 6