UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, MAY 2014

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	**BASIC ELECTRONICS**
COURSE NUMBER:	**EE221**
TIME ALLOWED:	**THREE HOURS**

INSTRUCTIONS:

1. There are five questions in this paper. **Answer any FOUR questions.**
2. Each question carries 25 marks.
3. Marks for different sections are shown on the right hand margin.
4. Show the steps clearly in all your calculations. This is because marks may be awarded for method and understanding, even if a final answer is incorrect.
5. If you think not enough data has been given in any questions you may assume reasonable values and state those assumptions.
6. A sheet containing useful formulae and other information is attached at the end.

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER HAS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION 1 ***(25 marks)***

(a) The forward current in a diode is 3.2 μA when the diode forward voltage drop is 0.48 V, and 3.5 mA when the diode forward drop is 0.71 V. Using the approximate diode equation for a diode in forward bias, find

(i) The value of the parameter *n* for the diode. *(5 marks)*

(ii) The value of the parameter I_s. *(5 marks)*

(b) In Fig.Q1b, a sinusoidal source of 100 V r.m.s. supplies a sinusoidal a.c. voltage to a circuit made up of diodes and resistors. Assume that the diodes are ideal.

(i) Determine the state of the diodes during each half-cycle of the supply. *(4 marks)*

(ii) Find the peak current in each of the resistors. *(7 marks)*

(iii) Draw a neat sketch of the current waveform in the 80-Ω resistor and label current amplitudes of interest. *(4 marks)*

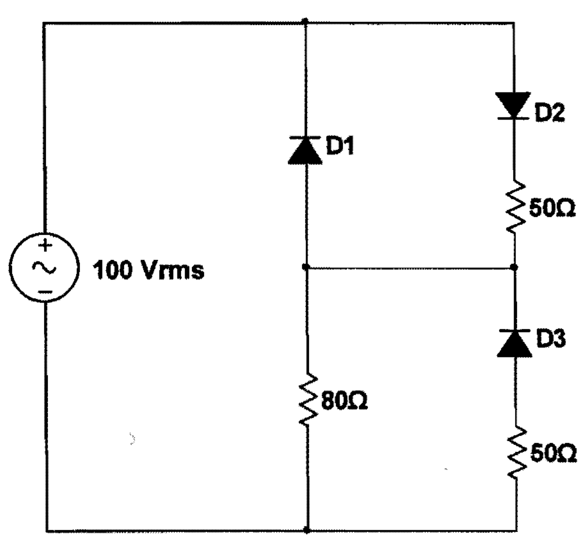

Fig. Q1b

QUESTION 2 ***(25 marks)***

(a) The diode circuit Fig. Q2a is supplied with an a.c. voltage of 100 mV. Assume that the capacitors in the circuit are short circuits at the operating frequencies. Calculate the output voltage v_o *(12 marks)*

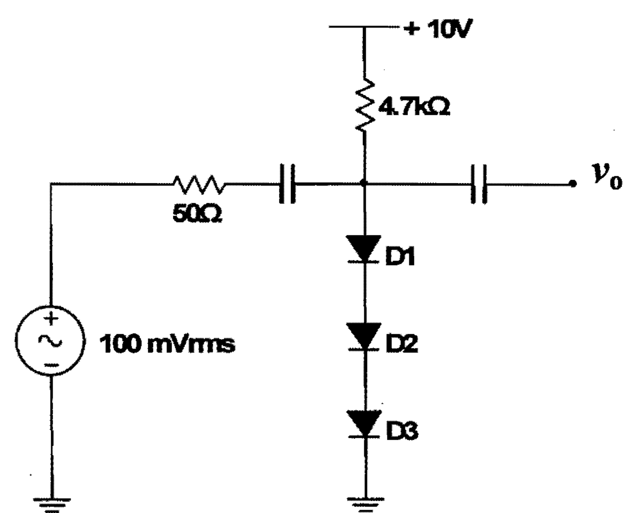

Fig. Q2a

(b) A full-wave bridge rectifier is fed from an a.c. supply $v_s = 120\sin(130\pi t)$ volts and supplies a load of 2.2 kΩ. A smoothing capacitor is used which gives a 5-V peak-to-peak ripple load voltage.

(i) Is it reasonable to assume that the diodes are ideal? Explain your answer. *(2 marks)*

(ii) Determine the average current in the load. *(2 marks)*

(iii) What value of smoothing capacitor is used? *(2 marks)*

(iv) Over what fraction of a cycle does each diode conduct? *(2 marks)*

(v) What peak inverse voltage rating should the diodes have? . *(2 marks)*

(vi) What peak current rating should the diodes have?. *(3 marks)*

QUESTION 3 ***(25 marks)***

(a) A transistor with $V_A = 80$ V is operated with a collector current of 4 mA and collector-emitter voltage of 12 V. The current gain β is 150.

(i) Find the parameters g_m, r_π and r_o at this operating point. *(6 marks)*

(ii) Draw the small signal ac equivalent circuit of the transistor. *(2 marks)*

(iii) If the transistor is supplied from a source of internal resistance 300 Ω and the effective collector load is 3 kΩ, find the voltage gain of the amplifier. Assume that the base bias resistors are very large compared with other resistors in the circuit.

(5 marks)

(b) A single-stage of a BJT is biased with two fixed power supplies of 5 V and 15 V as shown in Fig. Q3b. It is required that the collector current at the Q-point vary only between 3 mA and 4 mA when the transistor used has β ranging from 100 to 300. By solving simultaneous equations or otherwise, determine the values of R_E and R_B that would meet the operating point requirement.

(12 marks)

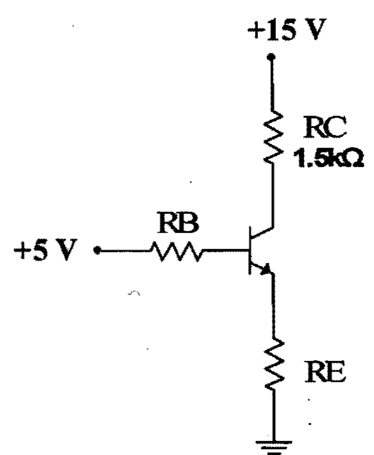

Fig. Q3b

QUESTION 4 ***(25 marks)***

Consider the circuit shown in Fig.Q4. You are given that the transistor used has $\beta = 80$.

(a) Determine the values of the following currents and voltages:

Base current, I_B
Quiescent collector current, I_{CQ}
Quiescent colector emitter voltage V_{CEQ}
Voltage at the emitter, V_E
Quiescent Collector voltage, V_{CQ}
Voltage at the base, V_B

(19 marks)

(b) If β is assumed to remain constant while R_C is increased, at which value of R_C will the transistor get saturated? Take $V_{CEsat} = 0.2$ V. *(6 marks)*

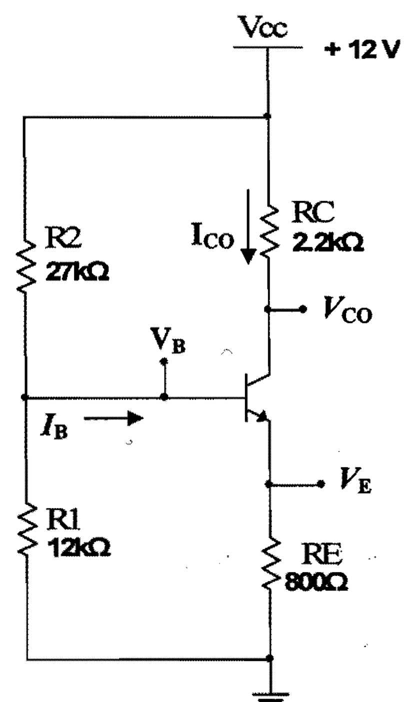

Fig. Q4

QUESTION 5 ***(25 marks)***

(a) **(i)** An ideal operational amplifier (opamp) must have infinite open loop gain. Name three other important characteristics it should have. *(3 marks)*

(ii) Draw a circuit diagram of an opamp-based amplifier whose input and output can implement the expression $V_o = -10V_1 - 22V_2$ *(6 marks)*

(iii) The amplifier in (ii) is constructed using a non-ideal opamp whose open loop gain is 2000, obtain the actual input-output expression the amplifier will implement. *(5 marks)*

(b) An opamp circuit is shown in Fig. Q 5b. The input voltage V_{in} = 500 mV r.m.s. Find the value of R_f so that the power dissipated in R_L is 48 mW. *(6 marks)*

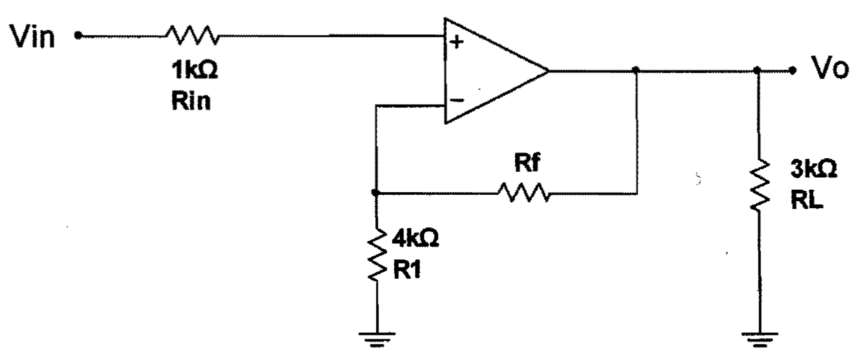

Fig. Q5b

(c) A square wave signal has a frequency of 100 Hz and amplitude ±0.5 V. Design an opamp-based circuit to change this signal into a triangular wave varying between ±4 V. Assume that only capacitors with values of 22 nF, 33 nF, or 47 nF are available for use in your design. *(5 marks)*

USEFUL INFORMATION AND FORMULAE

1. **E12 Range:** **10 12 15 18 22 27 33 39 47 56 68 82**

2. **Diode:** $i_D = I_S\left(e^{\frac{v_D}{nV_T}} - 1\right) \approx I_S e^{\frac{v_D}{nV_T}}$

3. **BJT:** $i_C = \alpha I_S\left(e^{\frac{v_{BE}}{V_T}} - 1\right)\left(1 + \frac{V_{CE}}{V_A}\right)$

4. **Rectification:**

$$V_r = \frac{V_m T_p}{R_L C}$$

$$\theta_c = \sqrt{\frac{2V_r}{V_m}}$$

$$i_{Dave} = \frac{V_m}{R_L}\left(1 + \omega T_p\sqrt{\frac{2V_m}{V_r}}\right)$$

$$i_{Dmax} = \frac{V_m}{R_L}\left(1 + 2\omega T_p\sqrt{\frac{2V_m}{V_r}}\right)$$

5. **Unless otherwise stated, assume that V_{BEon} = 0.7 V , V_{CEsat} = *0.2* V and V_T =25 mV .**

6. **Unless otherwise stated assume that opamps are ideal.**