UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, SECOND SEMESTER MAY 2013

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. If you think not enough data has been given in any question you may assume any reasonable values.
5. 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) A diode has a forward voltage drop of 0.7 when conducting 1 mA of current at room temperature. When this diode is connected to the circuit shown in Fig. Q1a, the forward voltage drop changes to 0.74 V. Assuming that the temperature stays constant and that $n = 1$.

(i) Find the value diode current when the forward voltage drop is 0.74V. *(8 marks)*

(ii) Find value of the resistor R used in the circuit. *(2 marks)*

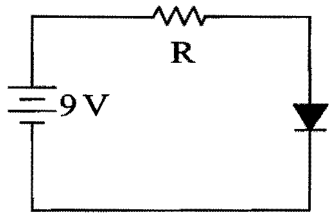

Fig. Q1a

(b) The current in a diode is increased by a factor of 4 (quadrupled). By how much will its forward voltage drop change? *(5 marks)*

(c) In Fig.Q1.c assume that the diodes are ideal. Find the currents in all the resistors and all the diodes. Hint: First determine which diodes are forward biased. *(10 marks)*

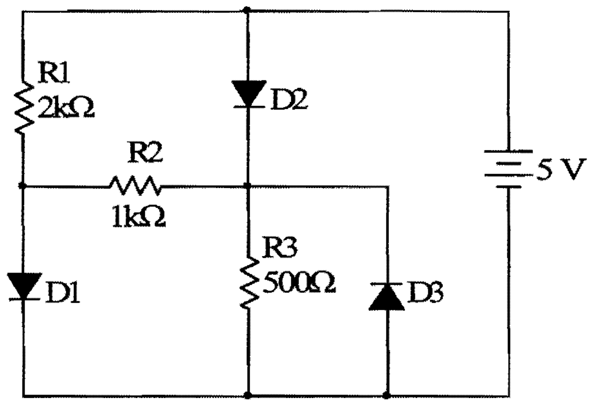

Fig. Q1.c

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

(a) A half-wave rectifier circuit is used to charge a 12 V battery from a mains transformer which supplies 15 V r.m.s, voltage at 50 Hz. Assuming that the diode is ideal, find the value of a suitable current-limiting resistor which may be placed in series with the diode so that the average charging current is limited to 0.5 A when the battery voltage is 12 V. Hint: Note that the diode will only conduct when the voltage across it is greater than the battery voltage.

(12 marks)

(b) (i) Draw the circuit of a full-wave diode bridge rectifier and briefly explain its operation.

(6 marks)

(ii) A full-wave bridge rectifier supplies 12 V average d.c. voltage to a load which draws 200 mA average current. The rectifier uses a smoothing capacitor to give a ripple of 0.4 V or less across the load. If the supply frequency is 50 Hz, what minimum value of smoothing capacitor may be used? *(7 marks)*

QUESTION 3 *(25 marks)*

Consider the circuit shown in Fig.Q3. You are given that the transistor used has $\beta = 130$.

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

Base current, I_B

Quiescent collector current, I_{CQ}

Voltage at the emitter, V_E *(19 marks)*

Quiescent Collector voltage, V_{CQ}

Voltage at the base, V_B

(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)

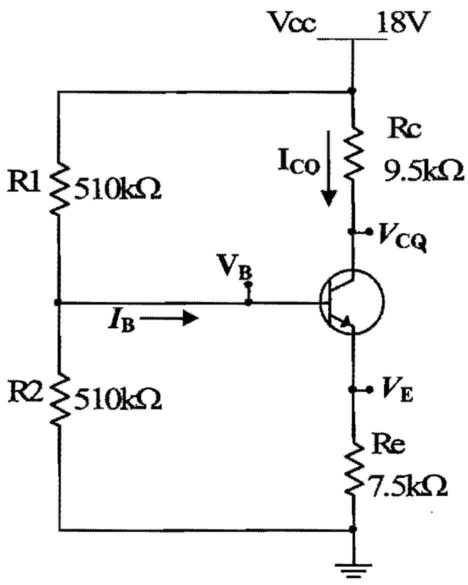

Fig. Q3

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

(a) List 5 characteristics of an ideal opamp. *(5 marks)*

(b) (i) Draw the circuit of an **inverting** opamp-based amplifier and the circuit of a **non-inverting** opamp-based amplifier. *(4 marks)*

(ii) Derive the expression for the gain of a non-inverting opamp-based amplifier. *(5 marks)*

(c) Consider the opamp-based circuit shown in Fig.Q4c.

(i) Write down the expression for the output voltage gain v_o / v_1 when $v_2 = 0$ and $v_1 \neq 0$. *(3 marks)*

(ii) Write down the expression for the output voltage gain v_o / v_2 when $v_1 = 0$ and $v_2 \neq 0$. Note that this circuit will have a voltage divider. *(4 marks)*

(iii) Find the output voltage when $v_1 = 50$ mV and $v_2 = 30$ mV. Hint circuit responds to the difference of the input voltages. *(4 marks)*

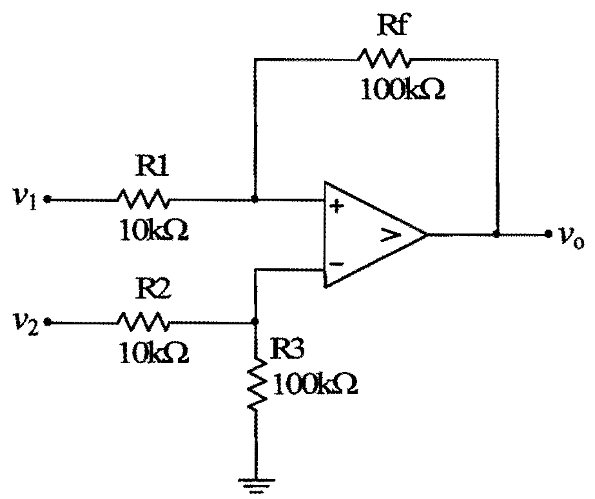

Fig.Q4c

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

(a) A transistor with V_A=150 V is operated with a collector current of 3 mA and collector-emitter voltage of 10 V. The forward current gain is 120.

(i) Find the parameters g_m, r_π, V_A and r_o at this operating point. *(5 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 200 Ω and the effective collector load is 2 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 circuit is to be designed which takes an input triangular wave of frequency 1000 Hz with its amplitude changing between -5 V to +5 V and outputs a bipolar (+ and -) square-wave of same frequency but with amplitude varying between -3 to +3V.

(i) Draw a sketch of the two waveforms. *(2 marks)*

(ii) Draw a suitable opamp-based circuit that can be used to effect the waveform change. *(2 marks)*

(iii) Derive a formula that can help you in your design. *(5 marks)*

(iv) Specify the components of your circuit, assuming all the components used are available in the E12 range. *(4 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. **Half wave rectifier:** $V_r = \frac{V_m T}{CR_L}$, $\theta_C = \omega\Delta t = \sqrt{\frac{2V_r}{V_m}}$, $i_{Dave} = I_L\left(1 + \pi\sqrt{\frac{2V_m}{V_r}}\right)$

   $i_{Dmax} = I_L\left(1 + 2\pi\sqrt{\frac{2V_m}{V_r}}\right)$

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.**