UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATIONS, JULY 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. Clearly state **the units** of any values you calculate.
5. If you think not enough data has been given in any question you may assume any reasonable values.
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 32 μA when the diode forward voltage drop is 0.5 V, and 4.5 mA when the diode forward drop is 0.72 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)*

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

(b) The forward voltage in a diode which has n=1 is increased by 0.06V. By what factor does its forward current change? *(5 marks)*

(c) In Fig.Q1c, a 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 behaviour of the diodes during each half-cycle. *(2 marks)*

(ii) Find the peak current in each of the resistors. *(4marks)*

(iii) Sketch and clearly label the current waveforms in each resistor. *(4 marks)*

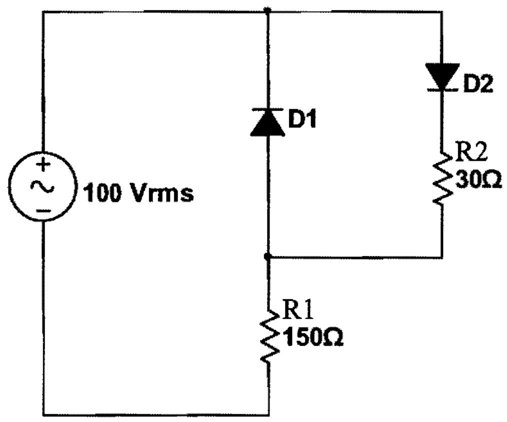

Fig. Q1c

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

(a) (I) Draw the circuit of a mains-operated full-wave diode bridge rectifier with capacitor smoothing. *(3 marks)*

(II) A full-wave bridge rectifier is supplied with a voltage $20\sin 100\pi t$ volts and feeds a load of 100 Ω with C = 2000 μF. Assuming that the diode voltage drop is 0.7 V and may not be neglected, determine

(i) The load voltage. *(3 marks)*

(ii) The peak-to-peak ripple voltage. *(3 marks)*

(iii) The peak inverse voltage across each diode. *(3 marks)*

(iv) The peak current in the diodes. *(3 marks)*

(b) Figure Q.2b shows a simple application of a zener diode.

(i) Explain the operation of the circuit. *(2 marks)*

(ii) If R_L is removed from the circuit, find the power dissipated in the diode. *(3 marks)*

(iii) Find the range of R_L during which the zener diode is not conducting. *(3 marks)*

(iv) If a minimum current of 5 mA must be maintained in the zener diode for proper operation of the circuit, find the minimum value of R_L which may be used. *(2 marks)*

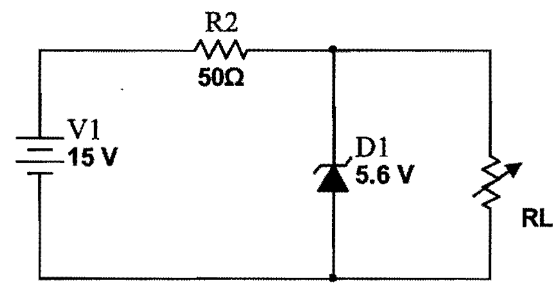

Fig.Q2b

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

(a) Consider the circuit shown in Fig.Q3a. Determine the quiescent values of base current, collector current and collector-emitter voltage when

(i) The current gain $\beta = 50$ *(6 marks)*

(ii) The current gain $\beta = 300$ *(7 marks)*

(ii) Comment on the two results above. *(2 marks)*

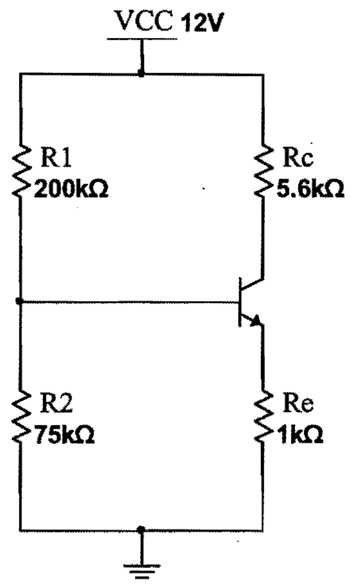

Fig. Q3a

(b) A transistor is biased as shown in Fig.Q3b. Determine the quiescent operating point of the transistor, assuming that $\beta = 100$. *(10 marks)*

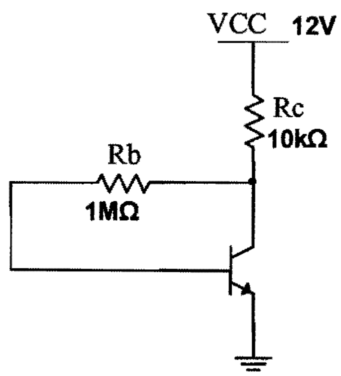

Fig.Q3b

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

(a) (i) List 3 important characteristics of an ideal opamp. *(3 marks)*

(ii) Show that the voltage gain of the opamp-based circuit in Fig.Q4a is given by

$$\frac{v_o}{v_{in}} = -\left(\frac{R_4}{R_3}\right)\left(\frac{R_2R_3}{R_1R_2+R_2R_3+R_3R_1}\right)$$ *(12 marks)*

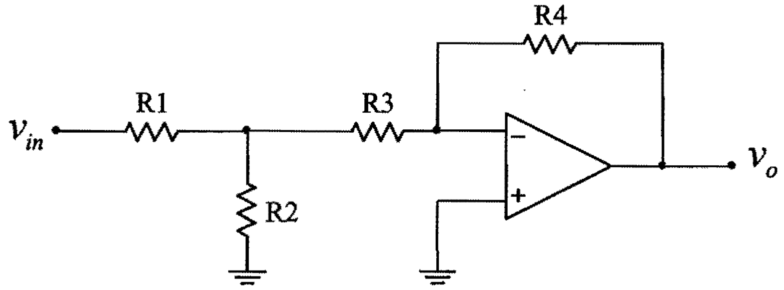

Fig.Q4a

(b) Consider the opamp-based circuit shown in Fig.Q4b.

(i) Show that the output voltage and input voltages are related by

$$v_o = -\frac{1}{RC}\int_0^t (v_1+v_2)dt$$ *(5 marks)*

(ii) Hence find the output voltage when $R = 100$ kΩ, $C = 1$ μF, $v_1 = 3\cos 10t$, $v_2 = 5\sin 20t$

(5 marks)

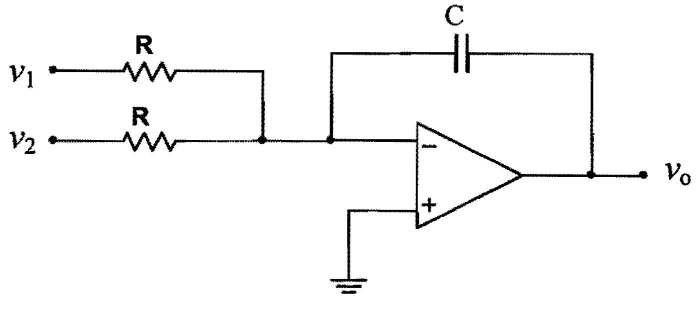

Fig.Q4b

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

(a) A transistor with V_A=75 V is operated with a collector current of 2 mA and collector-emitter voltage of 10 V. The current gain is 150.

(i) Find the parameters g_m, r_π, 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 400 Ω and the effective collector load is 2.7 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 500 Hz with its amplitude changing between -5 V to +5 V and outputs a bipolar (+ and -) square-wave of same frequency but with amplitude oscillating between -10 V to +10 V. The phase relationship is that the square wave is positive whenever the triangular wave is decreasing in amplitude.

(i) Draw a sketch of the two waveforms and mark the amplitude and time axes. *(3 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. *(3 marks)*

(iv) Specify the components of your circuit, assuming all the components used are available in the E12 range. *(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. **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.**