UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, MAY 2015

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) What is the change in voltage across a forward-biased diode at constant temperature when the current in it increases by a factor of 10? *(5 marks)*

(b) In the circuit shown in Fig.Q1b, determine the values of voltage V_o and current I_{R1} when

(i) $V_1 = -2$ V *(5 marks)*

(ii) $V_1 = +8$ V *(5 marks)*

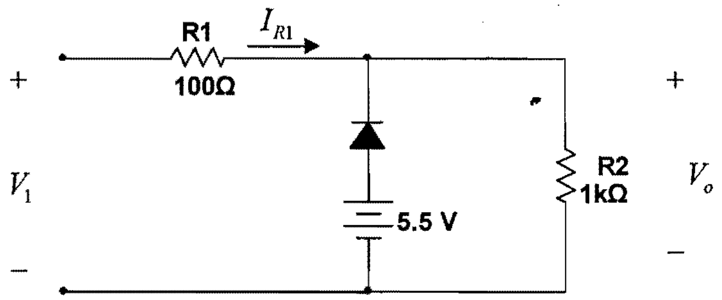

Fig.Q.1b

(c) For the circuit in Fig. Q1c find the minimum value of R_L for which the output voltage V_L is just 5.6 V. *(5 marks)*

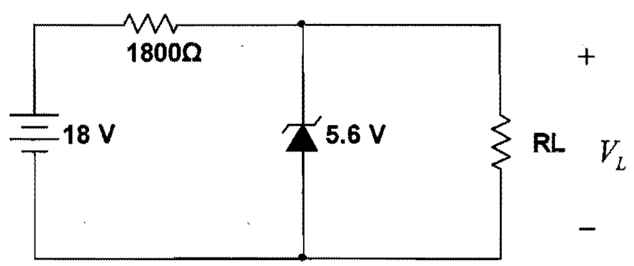

Fig.Q.1c

(d) Briefly explain how current flows in extrinsic semiconductor materials. *(5 marks)*

QUESTION 2 *(25 marks)*

(a) **(i)** Draw a circuit diagram of a d.c. voltage amplifier that can give a d.c. output voltage of $4V_m$ from an input a.c. voltage of $V_m \sin \omega t$, and *(5 marks)*

(ii) Describe the operation of the circuit you have drawn. *(5 marks)*

(b) A transformer full-wave bridge rectifier is fed from a 230 V, 50 Hz mains supply. The rectifier is connected to a load resistor 120 Ω in parallel with a smoothing capacitor C. The transformer has a secondary voltage of 9 V r.m.s. and the ripple in the output rectified smoothed voltage is required to be no more than 0.3 V. Assume that the diodes have a voltage drop of 0.7 V when conducting.

(i) Draw a circuit diagram of the rectifier showing all of its components. *(4 marks)*

(ii) Determine the required value C. *(3 marks)*

(iii) Determine the conduction angle of the diodes. *(4 marks)*

(iv) Find the peak current in the diodes. *(4 marks)*

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

(a) A single stage BJT transistor is used for switching on a load of 40 Ω connected to its collector. The load takes 250 mA and the transistor has β is between 80 and 200.

(i) Design a suitable circuit for switching the load on and off from a 0 to 5 V switching pulse. The circuit should minimize power dissipation in the transistor. Assume that $V_{CEsat} = 0.1$ V. *(9 marks)*

(ii) What is the average power dissipation of your circuit? *(1 mark)*

(b) The common emitter npn transistor amplifier shown in Fig.Q3b works from a 15 V supply. Given that $R_C = 1.8\ \text{k}\Omega$, determine suitable values of R_1, R_2, R_E so that the quiescent operating point is as stable as possible at $I_{CQ} = 3$ mA and $V_{CEQ} = 6$ V as β varies between 100 and 200. *(15 marks)*

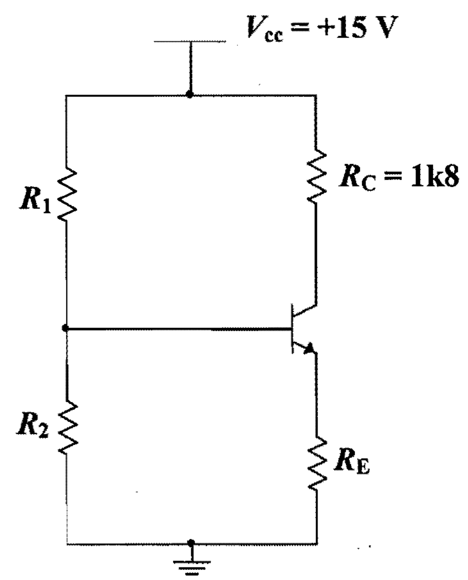

Fig.Q3b

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

Consider the circuit shown in Fig.Q4. You are given that the transistor used has $\beta = 100$ and $V_A = 75$ V.

(a) Perform d.c. analysis to find the operating point, I_C and V_{CE}, of the transistor.

(10 marks)

(b) Assuming that the capacitors C_1, C_2, and C_e are very large and therefore short circuits at frequencies of operation, perform a.c. analysis to find the gain v_o / v_s of the circuit.

(15 marks)

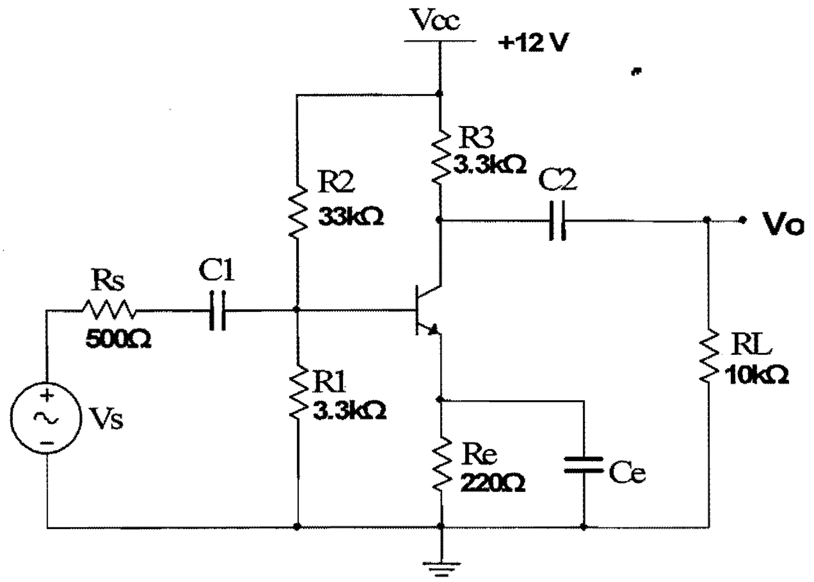

Fig. Q4

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

(a) (i) What is meant by a 'virtual ground'? *(2 marks)*

(ii) Why is the minus input of an inverting opamp amplifier virtually grounded? *(2 marks)*

(iii) Explain why the minus terminal of a non-inverting amplifier opamp amplifier is not virtually grounded. *(2 marks)*

(b) Design the following amplifiers using ideal opamps and only resistor values available in the E12 series of values.

(i) An inverting amplifier with input impedance of at least 5 kΩ and gain of -50. *(5 marks)*

(ii) A non-inverting amplifier with a gain of 13. *(5 marks)*

(c) Consider the opamp-based circuit shown in Fig. Q5c.

(i) Using superposition, derive an expression for the output voltage V_o in terms of the input voltages V_1, V_2, V_3 and resistors R_1, R_2, R_3. *(5 marks)*

(ii) If $R_1 = 2\ \text{k}\Omega$, $R_2 = 5\ \text{k}\Omega$, and $R_3 = 20\ \text{k}\Omega$, obtain the expression is implemented? *(2 marks)*

(iii) Is it possible to implement the expression $V_o = -V_1 - V_2 + V_3$? Explain your answer. *(2 marks)*

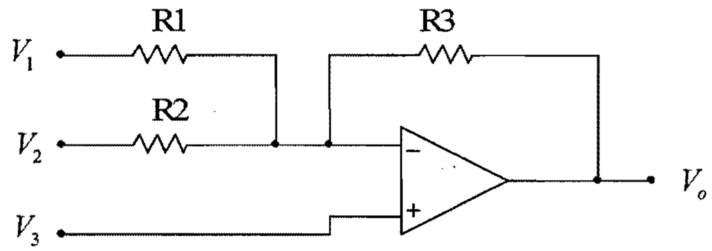

Fig. Q.5c

SELECTED 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. **Rectification:**

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

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

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

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

4. **Unless otherwise stated, assume that V_{BEon} = 0.7 V , V_{CEsat} = *0.1* V and V_T =25 mV .**

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