UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, MAY 2016

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 Q1 and any other 3 questions.**
2. Q1 carries 40 marks and other questions carry 20 marks each.
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 question you may assume reasonable values and state those assumptions.
6. A sheet containing useful formulae and other information which you may need is attached at the end.

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THIS PAPER HAS NINE (9) PAGES INCLUDING THIS PAGE

QUESTION 1 Compulsory ***(40 marks)***

(a) In the circuit shown in Fig.Q1a, determine the values of voltage V_o and current I_{R1}.

(5 marks)

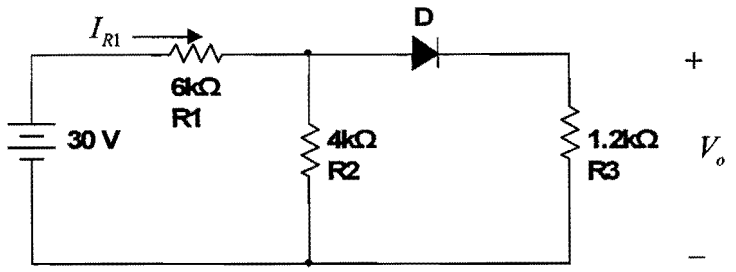

Fig.Q.1a

(b) The burglar alarm circuit shown in Fig. Q.1b is normally powered from the mains voltage. In the event of a mains power blackout, a backup battery of 12 V supplies the burglar alarm with power. Explain the role of diodes D1 and D2 in this application. *(5 marks)*

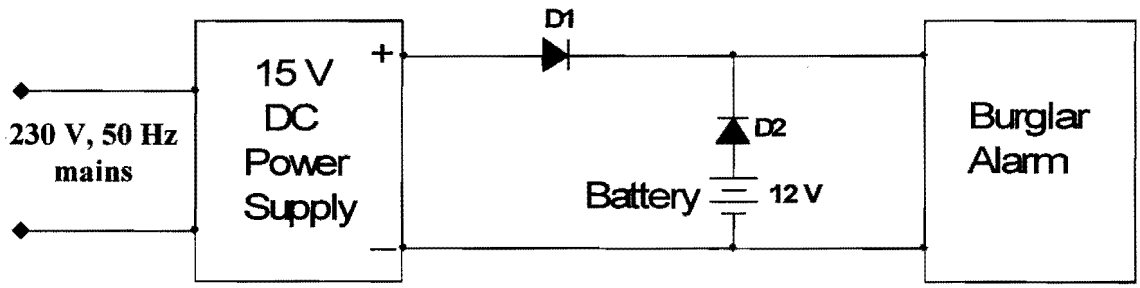

Fig.Q.1b

(c) For the zener diode circuit shown in Fig.Q.1c:

(i) Show that the zener diode is operating in the breakdown region. *(1 mark)*

(ii) Determine the zener diode current. *(2 marks)*

(iii) If the supply voltage is reduced slowly, determine the voltage at which the zener diode drops out (stops conducting)? *(2 marks)*

QUESTION 1 (continued)

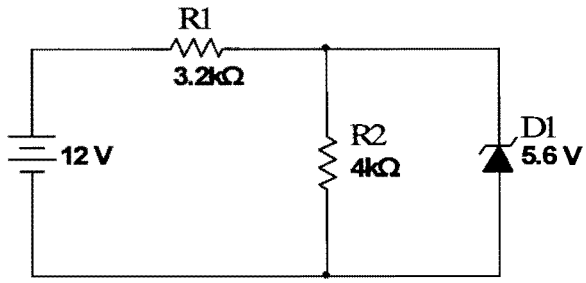

Fig.Q.1c

(d) In the a.c. application of a signal diode shown in Fig. Q.1d determine the voltage ratio v_o/v_{in}. Assume that the capacitors are short circuits at frequencies of interest. *(5 marks)*

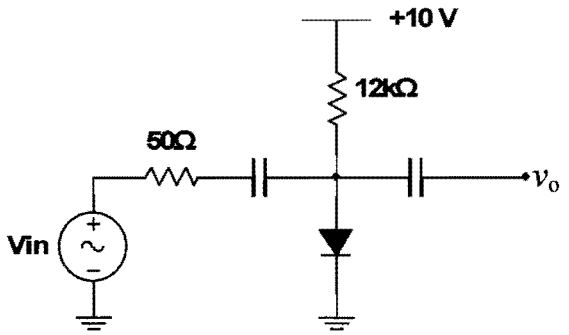

Fig.Q.1d

(e) Determine, stating your arguments, the value of the voltage marked V_L in **Fig. Q.1e.** Note that the transformer turns ratio is 1:2. *(5 marks)*

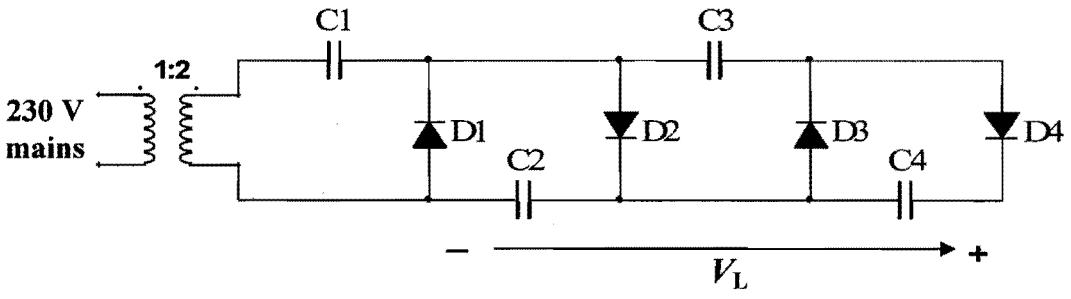

Fig. Q1.e

QUESTION 1 (continued)

(f) Design a circuit that lights up all 4 matched light emitting diodes (LEDs). Assume that each the diode has a forward voltage drop of 1.5 V and needs a current of at least 5 mA to light up well. Use a power supply voltage of 5 V. Hint: Decide whether you want series or parallel arrangement. (5 marks)

(g) Design an opamp based function whose inputs and output can implement the function

$$v_o = 8v_1 - 5v_2 \qquad \textit{(5 marks)}$$

(h) Consider the basic transistor circuit shown in Fig. Q.1h. Assume that the transistor used has $\beta_{dc} = 50$. Determine, giving explanations, the operating mode of the transistor with each of the following component values.

(i) $R_B = 1\ \text{M}\Omega,\quad R_C = 5\ \text{k}\Omega$ *(2 marks)*

(ii) $R_B = 100\ \text{k}\Omega,\quad R_C = 10\ \text{k}\Omega$ *(3 marks)*

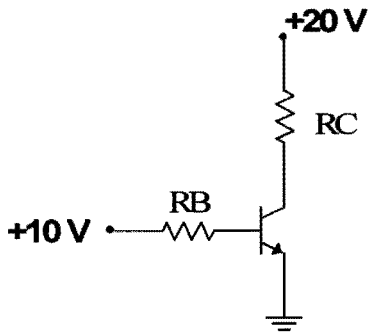

Fig. Q.1h

QUESTION 2 *(20 marks)*

A transformer **full-wave bridge rectifier** is fed from a 230 V, 50 Hz mains supply via a 230V/15V step down transformer. The output of the rectifier is connected to a load resistor R_L of 820 Ω in parallel with a smoothing capacitor C of 470 μF. Assume that the diodes have a voltage drop of 0.7 V when conducting.

Draw the circuit diagram and calculate the following: *(2 marks)*

(i) The average d.c. load current. *(7 marks)*

(ii) The ripple voltage at the load. *(2 marks)*

(iii) The average d.c. load voltage. *(2 marks)*

(iv) The PIV in a diode. *(2 marks)*

(v) The peak diode current. *(5 marks)*

QUESTION 3 *(20 marks)*

A common emitter npn transistor amplifier works from a 15 V supply. Determine suitable values of R_1, R_2, R_E so that the quiescent operating point is as stable as possible at $I_{CQ} = 10$ mA and $V_{CEQ} \approx V_{CC}/2$ as β varies between 100 and 200.

(20 marks)

QUESTION 4 ***(20 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 used are very large, perform a.c. analysis to find the gain v_o / v_s of the circuit. *(10 marks)*

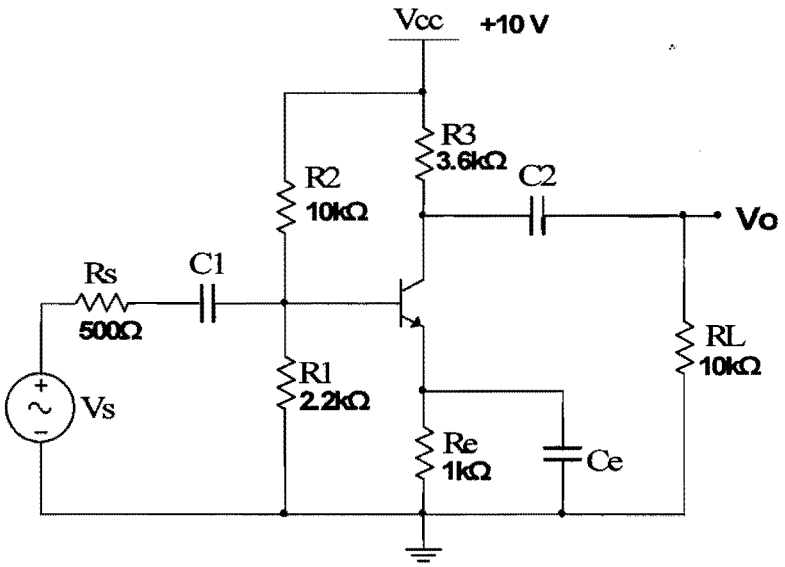

Fig. Q4

QUESTION 5 *(20 marks)*

(a) What is the output voltage of the circuit shown in Fig. Q.5a *(4 marks)*

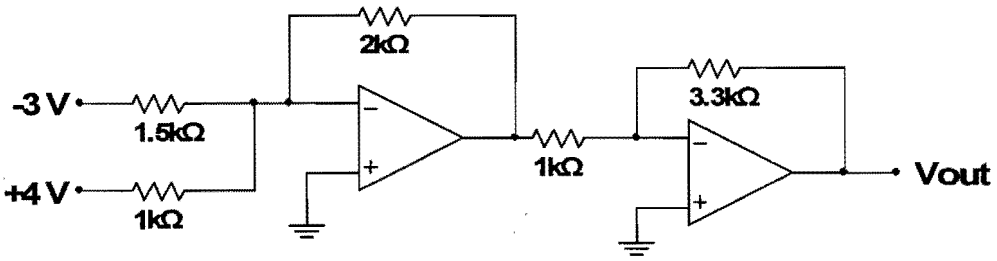

Fig. Q5a

(b) A **bipolar 3 V peak-to-peak triangular** wave of frequency 100 Hz is applied to the circuit shown in Fig. Q5b. Determine and sketch the output signal of the circuit. *(8 marks)*

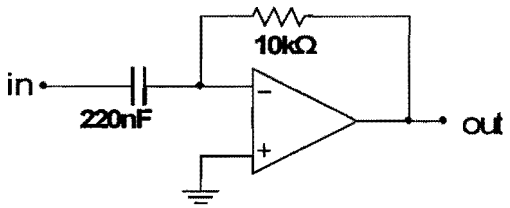

Fig. Q5b

(c) A bipolar **3 V peak-to-peak square** wave of frequency 200 Hz is applied to the circuit shown in Fig. Q5c. Determine and sketch the output signal of the circuit.

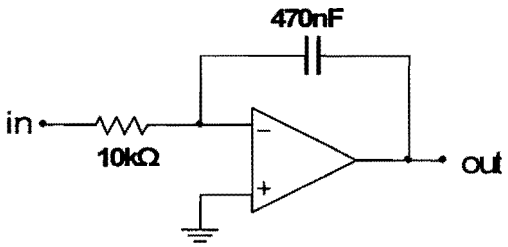

Fig. Q.5c

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} = *0.1* V and V_T =25 mV .**

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