UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATION, JULY 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 ELEVEN (11) PAGES INCLUDING THIS PAGE

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

(a) In the circuit shown in Fig.Q1a, determine with reasoning whether the diode is conducting current or not. *(5 marks)*

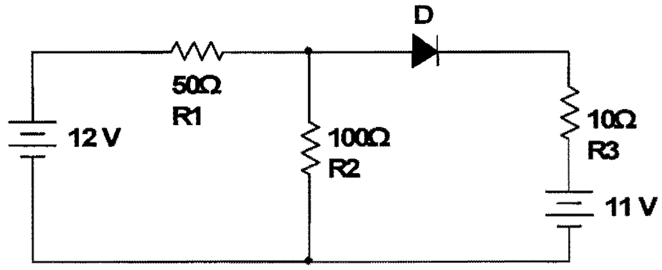


Fig.Q.1a

(b) The forward current in a pn-junction diode is increased from I_D to $5I_D$. By how much does its forward voltage drop change? *(5 marks)*

(c) Several diode circuits are to be operated using a +5 V d.c. supply. Determine the value of a resistor you would use to protect the diodes if

(i) A maximum of 15 mA of current is to be passed through a 3.3 V zener diode. *(1 mark)*

(ii) A maximum of 200 mA of current is to be passed through two rectifier diodes in series. *(2 marks)*

(iii) A maximum of 0.5 A of current is used for charging a 2.2 V lead-acid battery with a protection diode included to prevent the battery being discharged in the event of failure of the 5 V supply. *(2 marks)*

(d) In the a.c. application of a signal diode shown in Fig. Q.1d, the small signal a.c resistance r_d of a diode is used . Determine the value of r_d and hence voltage ratio v_o/v_{in} . Assume that the capacitors are short circuits at frequencies of interest. *(5 marks)*

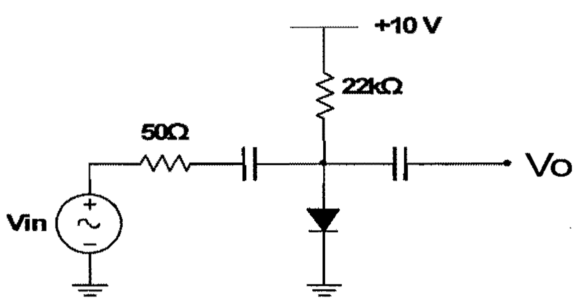


Fig.Q.1d

QUESTION 1 (continued)

(e) Determine, stating your arguments, the value of the voltage marked V_L in **Fig. Q.1e.** The transformer secondary supplies a sinusoidal voltage of 15 V r.m.s. *(5 marks)*

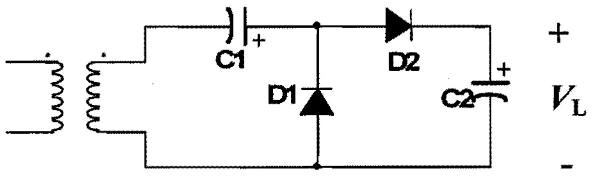


Fig. Q1.e

(f) Consider the two circuits shown in Fig. Q.1f, each of which is supplying a signal to a load of resistance 500 Ω:

(i) Find the value of the voltage V_o in Fig (a). *(2 marks)*

(ii) Find the value of the voltage V_o in Fig (b). *(2 marks)*

(iii) Hence state the function of the opamp in Fig (b)? *(1 mark)*

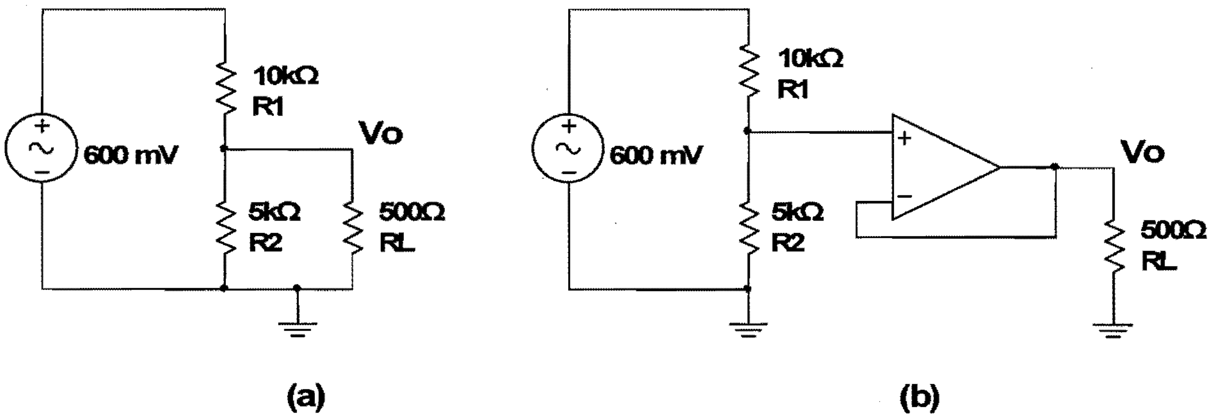


Fig. Q.1f

QUESTION 1 (continued)

(g) An amplifier has the small signal a.c. equivalent circuit shown in Fig. Q.1g. If $g_m = 350\ \text{mS}$, calculate the output voltage taken across the resistor R4. *(5 marks)*

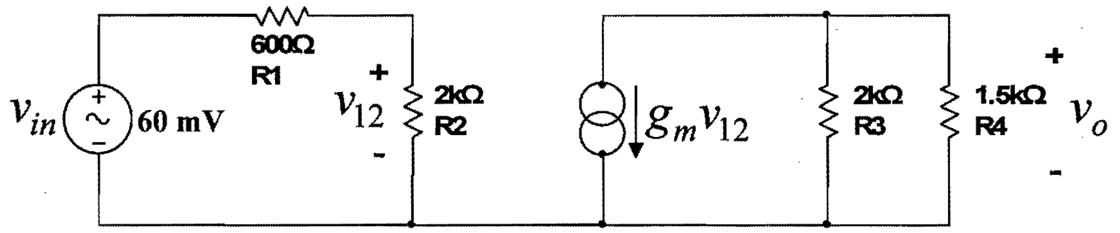


Fig. Q.1g

(h) Consider the circuit if a transistor biased as shown in Fig. Q.1h. Two currents, I_B and I_C, are defined as shown. Write down each of the following equations:

(i) Input loop equation including the base-emitter voltage. *(3 marks)*

(ii) Output loop equation including the collector-emitter voltage. *(2 marks)*

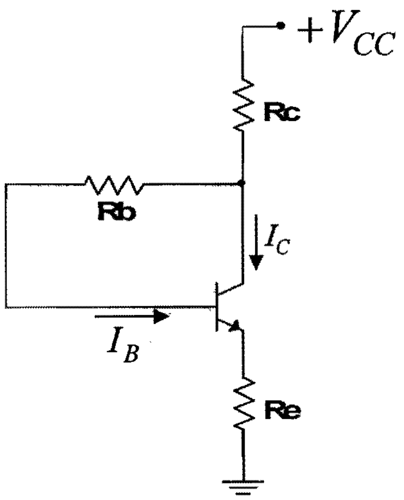


Fig. Q.1h

QUESTION 2 *(20 marks)*

A **full-wave bridge rectifier** with capacitor smoothing is shown in Fig.Q.2. The circuit is supplied with a sinusoidal a.c. voltage, $v_s = 24\sin(100\pi t)$ volts.

(a) Draw the complete circuit including the diode arrangement for the block labelled "bridge rectifier". *(3 marks)*

(b) Draw a neat sketch of the waveform of the output voltage v_o and clearly label key values of voltage and key values of time. *(3 marks)*

(c) Neglecting forward voltage drops of diodes, determine the following quantities:

- **(i)** The peak-to-peak magnitude of the output voltage. *(4 marks)*
- **(ii)** The average value of the output voltage load voltage. *(2 marks)*
- **(iii)** The Peal Inverse Voltage (PIV) in a diode. *(2 marks)*
- **(iv)** The peak diode current. *(6 marks)*

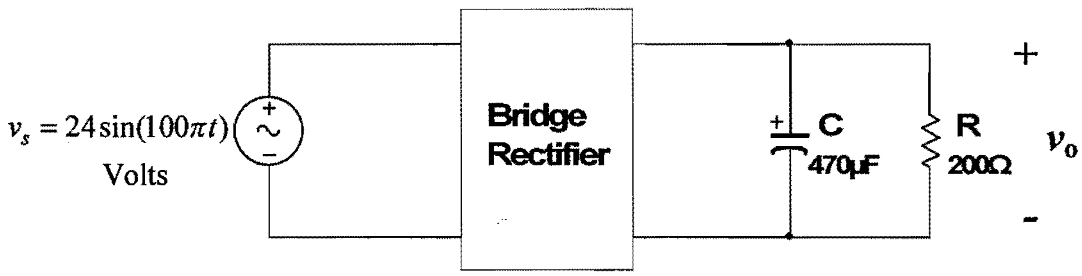


Fig. Q.2

QUESTION 3 ***(20 marks)***

A common emitter npn transistor amplifier works from a 12V supply. Determine suitable values of R_E, R_C, R_1, and R_2, so that the quiescent operating point is as stable as possible at $I_{CQ} = 5$ mA and $V_{CEQ} \approx V_{CC}/2$ as β varies between 200 and 300.

(20 marks)

QUESTION 4 ***(20 marks)***

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

(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_{in} of the circuit.

(10 marks)

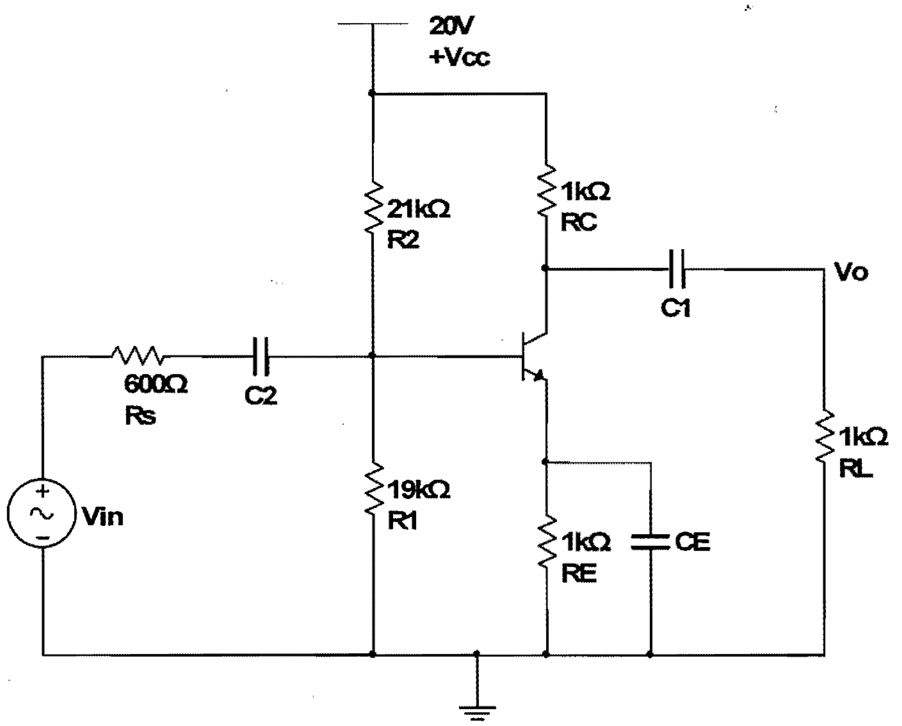


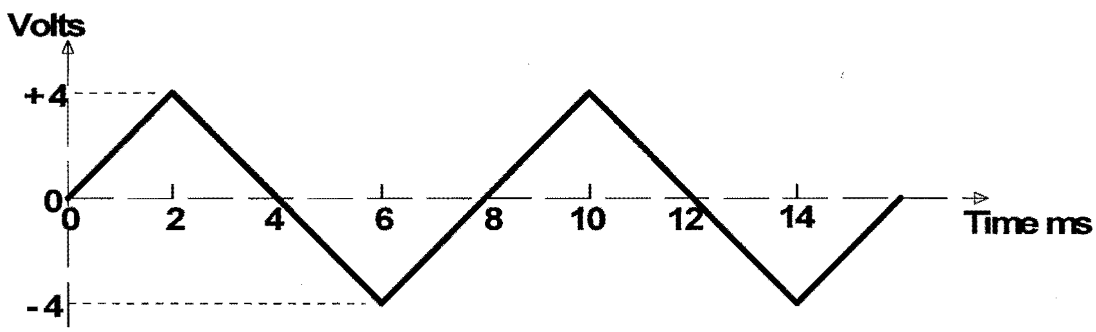
Fig. Q4

QUESTION 5 ***(20 marks)***

(a) Design an opamp-based summing amplifier to sum voltages v_1 and v_2 according to the formula $v_o = 2v_1 - 3v_2$, where v_o is the output voltage. You may use more than one opamp if necessary. *(6 marks)*

(b) The triangular waveform shown below is applied to the circuit shown in Fig. Q5b. Determine and sketch at least two cycles of the input and output signals of the circuit. A detachable template for the sketch is attached at the end of the question paper. Indicate key amplitude values in your sketch.

(7 marks)



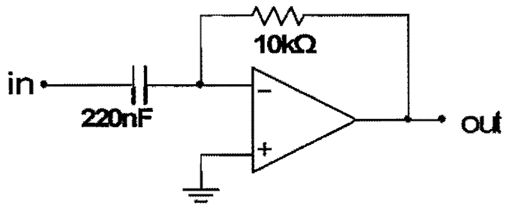
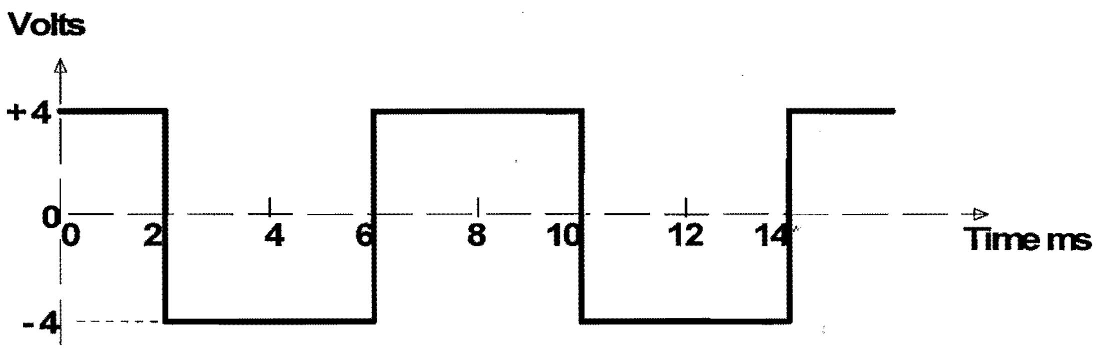


Fig. Q5b

QUESTION 5 (continued)

(c) The **square** wave signal shown below is applied to the circuit shown in Fig. Q5c. Determine and sketch at least two cycles of the output signal of the circuit. A detachable template for the sketch is attached at the end of the question paper. Indicate key amplitude values in your sketch. *(7 marks)*



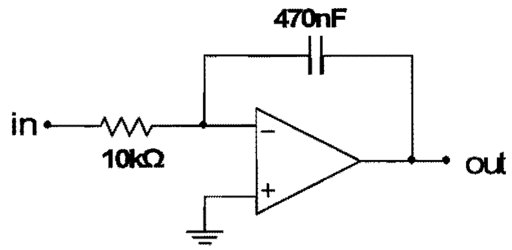


Fig. Q.5c

USEFUL INFORMATION AND FORMULAE

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

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

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:**

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

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

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.**

DETACHABLE SKETCH SHEET FOR QUESTION 5

I.D. No. ....