UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, MAY 2017

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	**BASIC ELECTRONICS**
COURSE NUMBERS:	**EE221/EEE222**
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.**

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

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 each diode in the diagram is conducting current or not. Hence find the value of the voltage Vo. *(5 marks)*

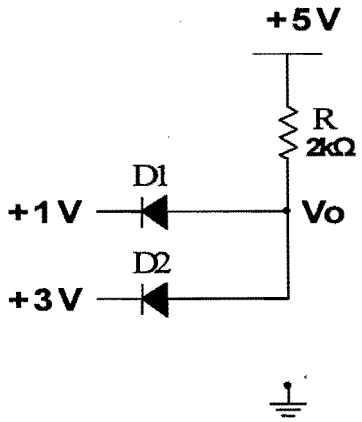


Fig.Q.1a

(b) A diode in forward bias has $V_D = 0.7$ V at I_D=1 mA and $n = 1$. If this diode is operated with $V_D = 0.6$ V, what will be the value of its current I_D? *(5 marks)*

(c) Several diode circuits are to be operated using a +10 V d.c. supply. Determine the value of a E12 range resistor you would use to protect the diodes, if

(i) A maximum of 15 mA of current is to be passed through a 2.7 V zener diode. *(1 mark)*

(ii) A maximum of 20 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 10 V supply. *(2 marks)*

(d) A transistor circuit is required for switching on and off the current in a collector load of 1200 Ω. The load takes a current of 20 mA when on, and a transistor with β in the range 200 to 600 is available. Design a suitable transistor-based circuit (by specifying a base resistor) for switching the load on and off from a 0 to +5 V switching pulse at the base. *(5 marks)*

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 12 V r.m.s. *(5 marks)*

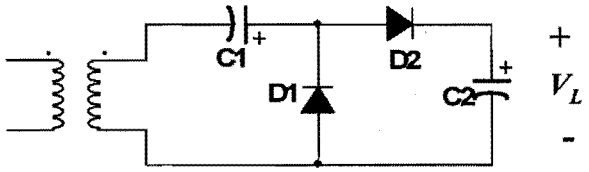


Fig. Q1.e

(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)*

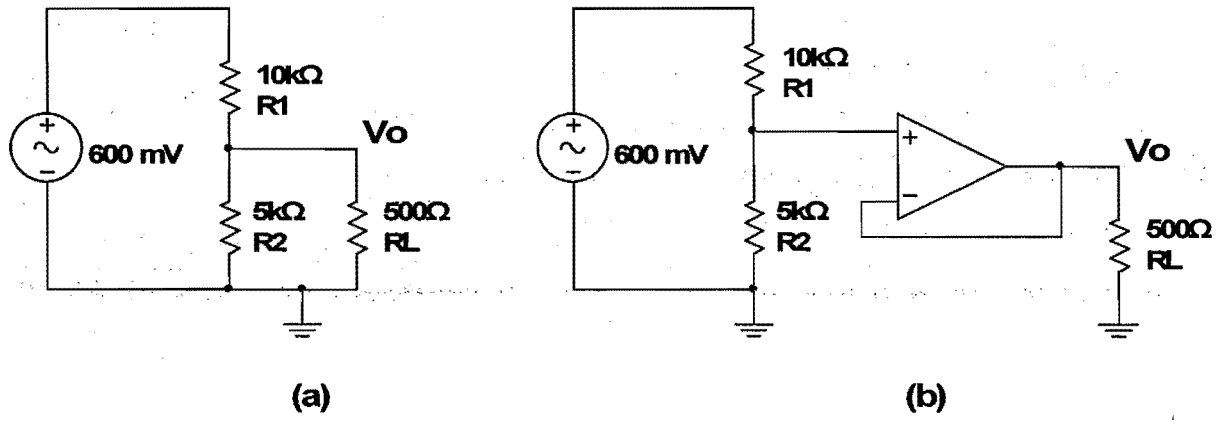


Fig. Q.1f

(g) An NPN transistor has an i_C vs v_{CE} slope of 3.5×10^{-5} S at $I_C = 3$ mA. If the transistor is operated at $I_C = 30$ mA what will be the value of its ac output resistance r_o? *(5 marks)*

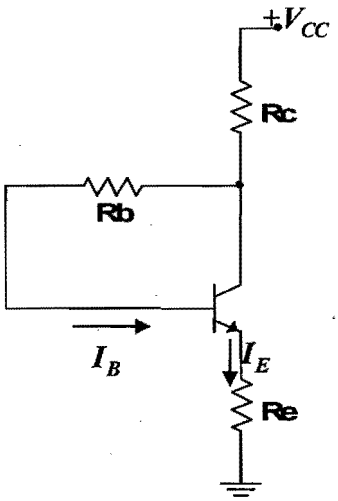
QUESTION 1 (continued)

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

(i) Input loop equation including the base-emitter voltage. *(2 marks)*

(ii) Output loop equation including the collector-emitter voltage. *(3 marks)*

Fig. Q.1h



QUESTION 2 *(20 marks)*

(a) A **full-wave bridge rectifier** with capacitor smoothing is shown in Fig.Q.2a. The circuit is supplied with a sinusoidal a.c. voltage, $v_s(t) = 26\sin(100\pi t)$ volts.

(i) Draw the complete circuit including the diode arrangement for the block labelled "bridge rectifier". *(2 marks)*

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

i. The peak-to-peak magnitude (ripple) of the output voltage. *(3 marks)*

ii. The average value of the load current in R. *(3 marks)*

iii. The Peal Inverse Voltage (PIV) in a diode. *(2 marks)*

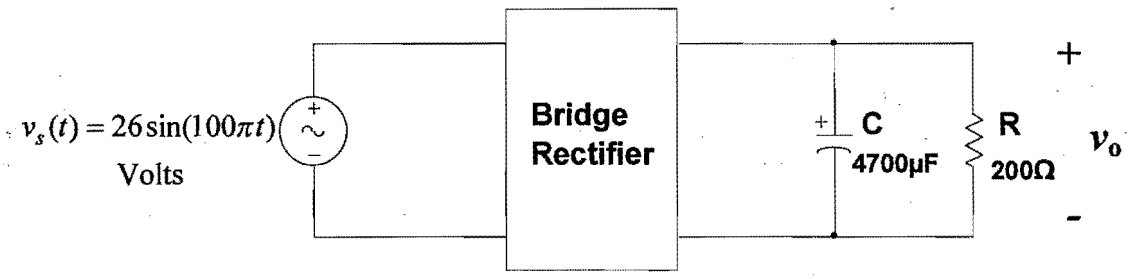


Fig. Q.2a

(b) For the zener diode circuit shown in Fig. Q.2b,

(i) Calculate the values of I_S, I_L and I_Z for $R_L = 200\ \Omega$. *(5 marks)*

(ii) If the zener diode has a maximum power dissipation of 500mW calculate the minimum and maximum values of R_L which can be safely used in the circuit to ensure a constant output voltage. *(5 marks)*

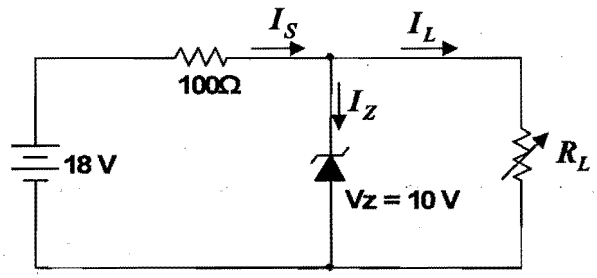


Fig. Q.2b

QUESTION 3 *(20 marks)*

A common emitter npn transistor amplifier works from a 15V supply. Design a biasing circuit (i.e. 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 $I_{CQ} = 4$ mA and $V_{CEQ} \approx V_{CC}/2$ as β varies between 100 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)*

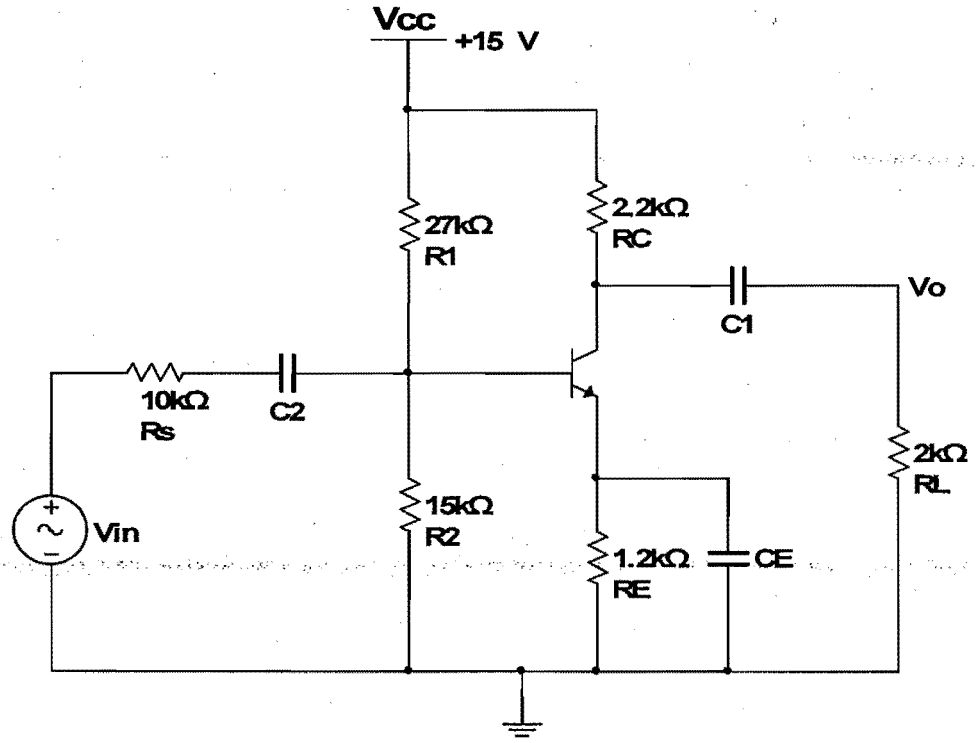


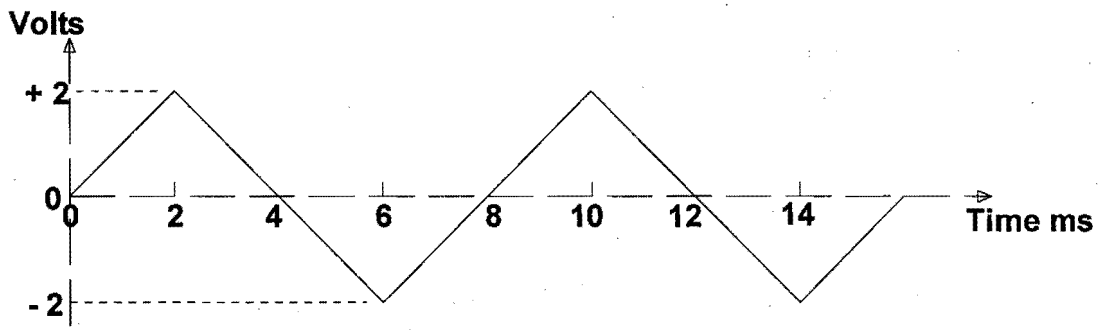
Fig. Q4

QUESTION 5 *(20 marks)*

(a) Design an opamp-based summing amplifier or subtractor to combine voltages v_1 and v_2 according to the formula $v_o = v_1 - 4v_2$, where v_o is the output voltage. You may use more than one opamp if necessary, but you must specify values of all resistors you use. *(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 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.

(6 marks)



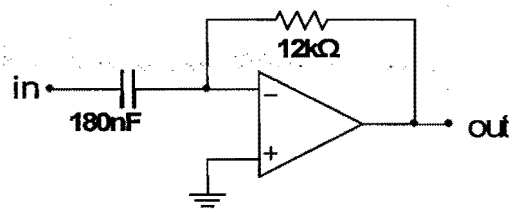


Fig. Q5b

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. *(8 marks)*

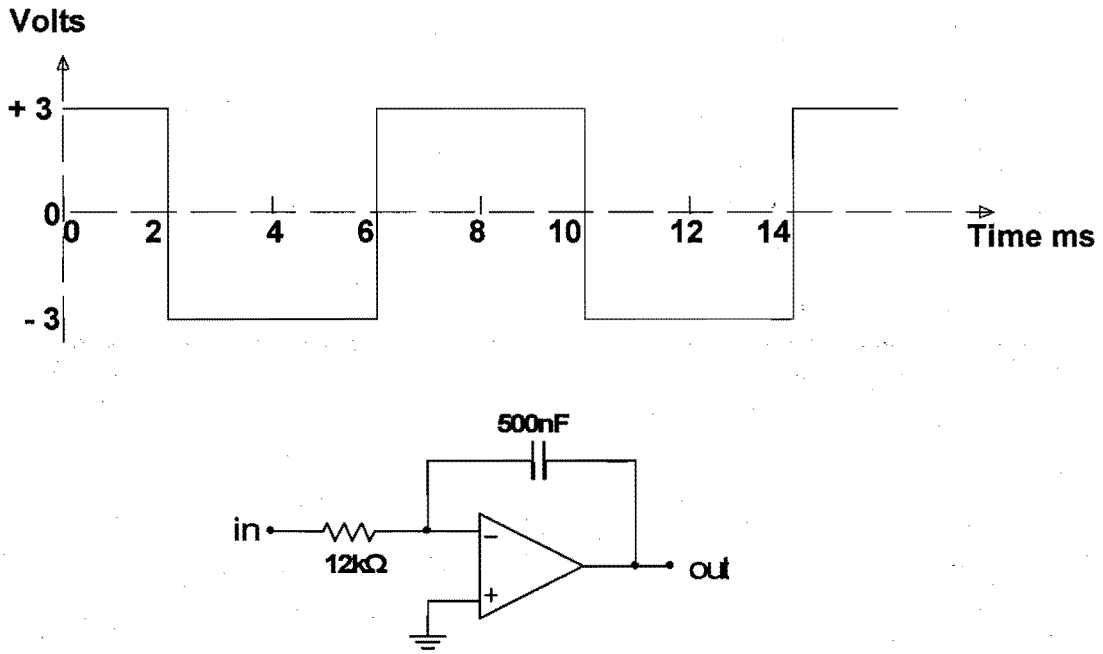


Fig. Q.5c

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:** $i_C = \alpha I_S\left(e^{\frac{v_{BE}}{V_T}} - 1\right)\left(1 + \frac{V_{CE}}{V_A}\right)$, $g_m = \frac{I_{CQ}}{V_T}$, $r_\pi = (1+\beta)\frac{V_T}{I_{CQ}}$, $r_o \approx \frac{V_A}{I_{CQ}}$

4. **Rectification and smoothing:**

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

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.**

DETACHABLE SKETCH SHEET FOR QUESTION 5

I.D. No. .....