UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, SECOND SEMESTER MAY 2012

FACULTY OF SCIENCE

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. If you think not enough data has been given in any question you may assume any reasonable values.
5. 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 current in a diode at T = 300 K is 1 μA at $v_D = 0.45$ V and 2 mA at $v_D = 0.75$ V. What is the value of n and I_S for this diode? *(8 marks)*

(b) A full-wave rectifier has the following specifications:

Rectified voltage	=	10 V average
Supply frequency	=	50 Hz
Load current	=	200 mA average
Maximum output ripple	=	100 mV peak-to-peak

Calculate:

i. The phase angle at which the diodes start to conduct.

ii. The peak diode current.

(c) A diode bridge rectifier circuit delivers 0.1 mA average current and 15 V average voltage to a load. The a.c. source is from 240 V, 50 Hz mains via a step down transformer. The peak-to-peak ripple is 0.4 V.

i. Draw the circuit configuration. *(2 marks)*

ii. Taking into account the diode voltage drops, find suitable stepped down voltage for the transformer. *(4 marks)*

iii. Determine the value of smoothing (reservoir) capacitor suitable for realizing the given specifications. *(4 marks)*

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

(a) The circuit in Fig. Q2a is used as the basis for an electronic switch. The value of the load resistor is 2.7 kΩ and β for the transistor varies between 110 and 800.

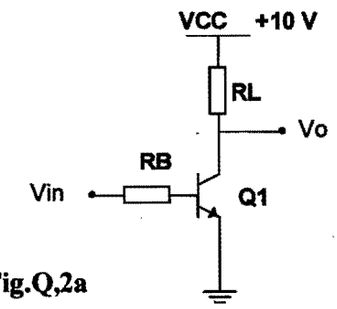

Fig.Q,2a

i. Specify a value of R_B that ensures that the transistor switches fully ON with an input voltage of 5 V. Assume that $V_{CEsat} = 0.3$ V. *(7 marks)*

ii. Sketch comparative input and output voltages on the same axes when the input is a square wave varying between 0 V to 5 V. *(2 marks)*

(b) For the BJT circuit shown in Fig.Q2b, calculate the values of R_b and R_c that give a collector current of 1 mA and a collector to emitter voltage of 5 V. Assume $\beta = 100$.

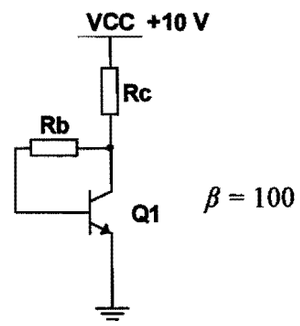

Fig.Q,2b

(c) A Common-Emitter npn transistor amplifier works from a 20 V supply. Design a bias circuit using a resistive voltage divider at the base so that the quiescent collector current is $I_{CQ} = 2$ mA and $R_C = 2$ kΩ. Assume β = 100. *(10 marks)*

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

(a) Describe briefly the main distinctive characteristic features of an ideal *operational amplifier* (opamp). *(5 marks)*

(b) Using an ideal opamp sketch and design:

i. An inverting amplifier with a voltage gain of -33 V/V and input resistance of 1 kΩ minimum. *(5 marks)*

ii. A non-inverting amplifier with gain 16 V/V and input resistance 10 kΩ minimum. *(5 marks)*

(c) Consider the opamp circuit shown in Fig.Q3c. The opamps may be considered ideal. Find an expression for the output v_o in terms of the inputs v_1, v_2 and v_3 . *(10 marks)*

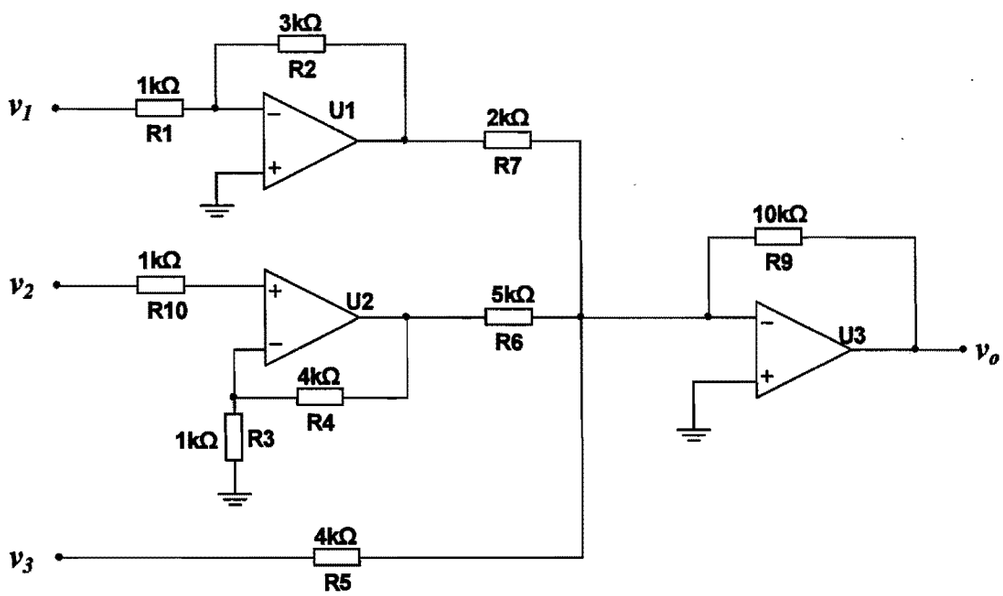

Fig. Q.3c

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

(a) A zener diode of specification 4.7V/400 mW is used to stabilize the voltage produced by a dc supply of nominal voltage 20 V. Under a normal load current of 20 mA, the zener diode should draw a current of 5 mA.

(i) What is the output voltage of the supply and how is this set? *(2 marks)*

(ii) Specify a suitable standard value of series resistor which can be used to protect the zener diode. *(4 marks)*

(iii) Determine whether or not the zener diode power rating is adequate for operation under the worst possible operating conditions. *(3 marks)*

(b) (i) Define the parameters g_m, r_π, V_A and r_o as used in the description of small-signal a.c. behaviour of a transistor.. *(4 marks)*

(ii) A transistor with V_A=175 V is operated with a collector current of 2 mA and collector-emitter voltage of 9 V. The forward current gain is 150. Find the small signal ac equivalent circuit of the transistor at this operating point. *(7 marks)*

(c) (i) Draw a circuit which can be used to change a 4 V peak-to-peak triangular wave of frequency 500 Hz into a 10 V peak-to-peak square wave. *(2 marks)*

(ii) Specify the values of components which can be used in your circuit. *(3 marks)*

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

(a) (i) Find a simplified Boolean expression for the circuit shown in Fig.Q5a.

(ii) Draw the implementation of your simplified expression. *(10 marks)*

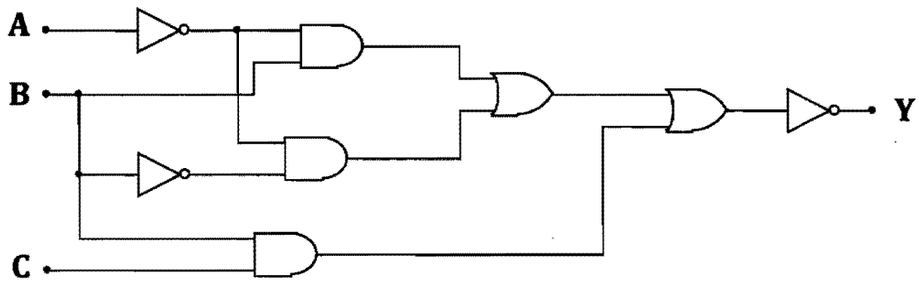

Fig. Q.5a

(b) Set up a Truth Table and obtain a simplified Boolean expression which represents the following logical statement:

***Z* is 1 if at least two of *W*, *X* and *Y* are 1, otherwise Z is 0.** *(8 marks)*

(c) Simplify the following Boolean expression

$$Z = \overline{A}\,\overline{B} + BC + ABC + \overline{A}B\overline{C}$$ *(7 marks)*

USEFUL INFORMATION AND FORMULAE

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

2. **Diode:** $i_D = I_S\left(e^{\frac{nv_D}{V_T}} - 1\right)$

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:** $\Delta V = \frac{V_m T}{C R_L}$, $\theta_C = \omega\Delta t = \sqrt{\frac{2\Delta V}{V_m}}$, $i_{Dave} = I_L\left(1 + \pi\sqrt{\frac{2V_m}{\Delta V}}\right)$

$$i_{Dmax} = I_L\left(1 + 2\pi\sqrt{\frac{2V_m}{\Delta V}}\right)$$

5. **Selected Boolean:** $A + AB = A$ $A(A + B) = A$

$A + \bar{A}B = A + B$ $A(\bar{A} + B) = AB$