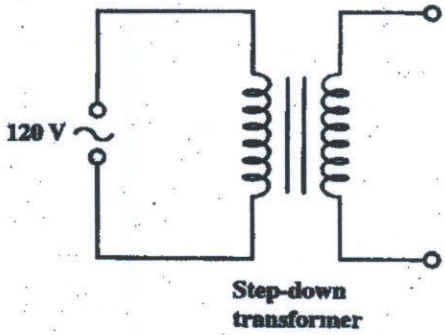
(ii) Sketch the output when $V_i = 10 \text{ Sin } \omega t$, where $\omega = 100$ rad s^{-1}, including appropriate numerical values on the scales.

[2 marks]

Total 10 marks

(b) You need to produce an approximately 4 V DC output from an AC power supply whose output is shown in Figure 2*b*. You have available a transformer, a capacitor, a diode, a cathode ray oscilloscope and a resistor to represent the load.

(i) On the diagram below, complete the design of a circuit to achieve this objective, using all of these components.



[1 mark]

(ii) Figure 2*b* shows the output voltage from the AC power supply.

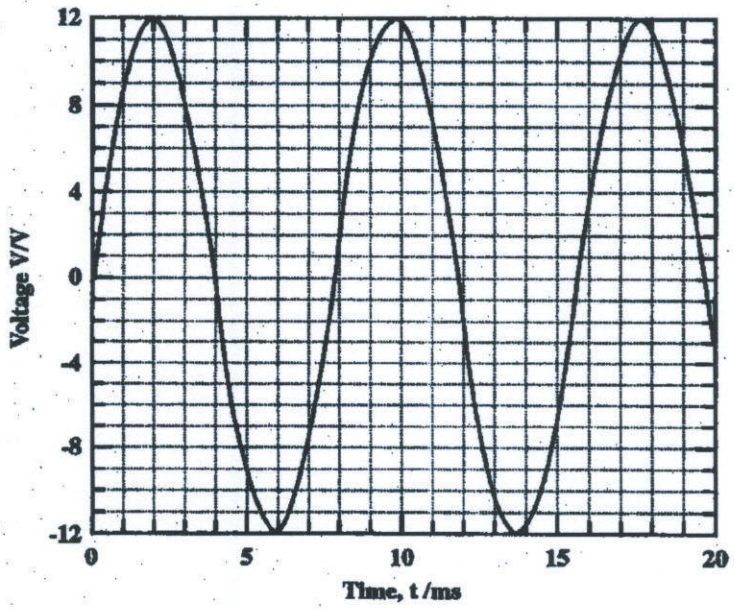


Figure 2*b*

On Figure 2*b*, sketch the output voltage that would be seen on the oscilloscope. **[2 marks]**

Total 10 marks

GO ON TO THE NEXT PAGE

6. (a) An alternating signal is represented by the equation:

$V = 150 \sin (400 \pi t)$ (V is in mV and t in seconds.)

(i) What is the frequency of the signal?

[1 mark]

(ii) What is the period?

[1 mark]

(iii) Find the r.m.s. voltage of the signal.

[2 marks]

(iv) Using the axes below, draw the graph to show how the voltage varies with time.

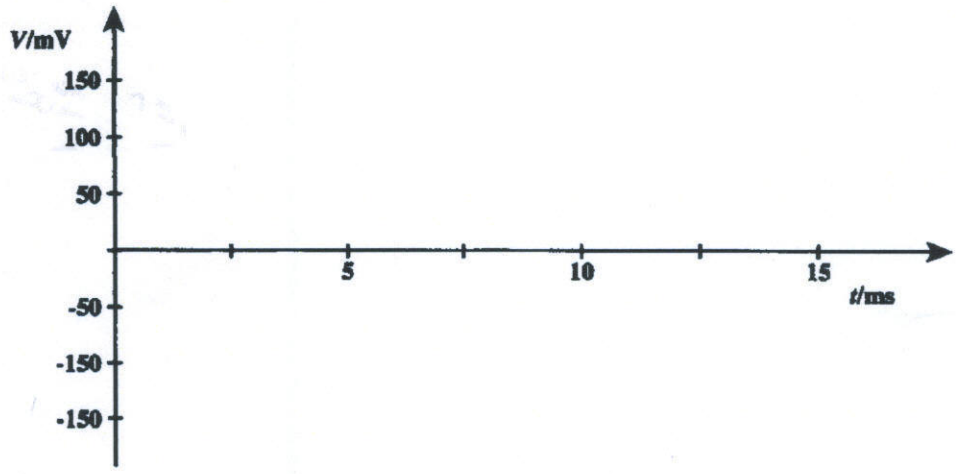


Figure 6

[3 marks]

4. (a) Figure 4 shows how the value of an alternating current changes with time.

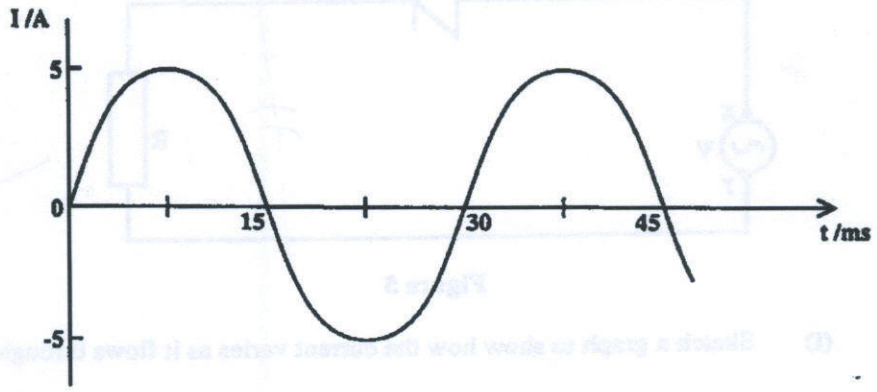


Figure 4

Find the

(i) amplitude of the current

_____

[1 mark]

(ii) period

_____

_____

[1 mark]

(iii) frequency.

_____

_____

[1 mark]

(b) For the waveform represented in Figure 4, write an equation which represents how the alternating current, I, varies with time, t.

_____

_____

_____

[2 marks]

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(c) A diode is connected in series with a resistor of resistance, R, to an a.c. supply as shown in Figure 5.

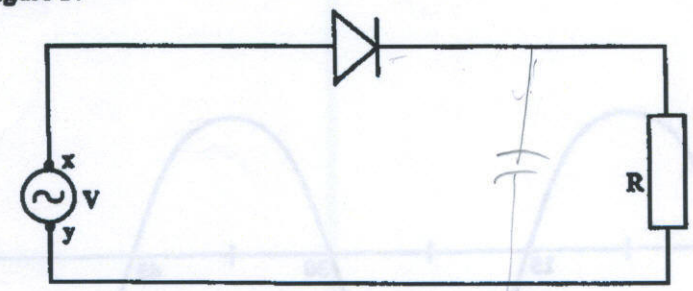

Figure 5

(i) Sketch a graph to show how the current varies as it flows through the resistor. [2 marks]

(ii) To smoothen the rectified potential difference across the resistor, a capacitor is placed in the circuit of Figure 5. Indicate on Figure 5 where you would place this capacitor. [1 mark]

(iii) Show on the graph you sketched in part (c) (i) the effect on the current of placing the capacitor in the circuit. [1 mark]

(iv) On the sketched graph, label the region where the capacitor is being charged. [1 mark]

Total 10 marks

MODULE 2

Answer EITHER Question 6 OR Question 7

6. (a) Figure 4 shows the internal distribution of charge of a p–n junction with no applied bias. The net current through the junction is I_D and the voltage across the junction is V_D.

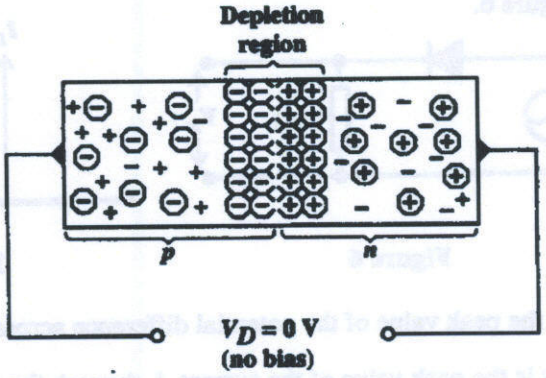

Figure 4

(i) Explain what is meant by the 'depletion region' and state how it arises.

(ii) Draw a similar diagram to show the junction under forward bias. Indicate the direction of the current, I_D, and comment on the thickness of the depletion region in this case.

(iii) Explain why a current flows for forward bias but the current is virtually zero in reverse bias. **[8 marks]**

(b) A number of Light Emitting Diodes (LEDs) can be combined to form an electronic display. One of the most common electronic displays is the seven-segment indicator. Figure 5 shows the seven-segment indicator and its schematic diagram. The voltage drop for each LED is 2.0 V.

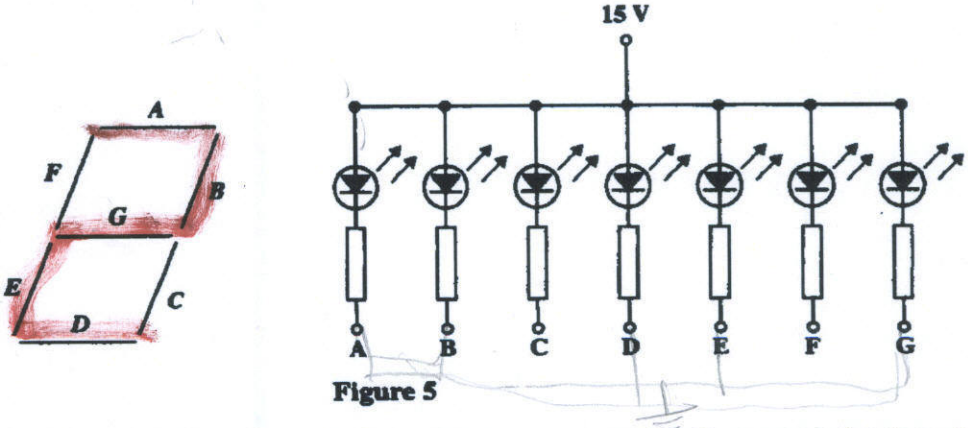

Figure 5

(i) For the LED indicator, indicate which segments should be grounded to form the number 2.

(ii) If the current in each segment is 20 mA, calculate the TOTAL current for this character.

(iii) Calculate the value of ONE of the identical protective resistors used in the display. **[5 marks]**

(c) The silicon diode in Figure 6 has a characteristic curve like that shown in Figure 7. It is connected to a sinusoidal supply with a peak voltage of 1.5 V, and a 1 kΩ resistor as shown in Figure 6.

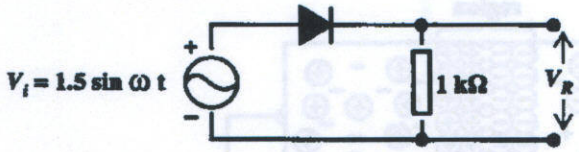

Figure 6

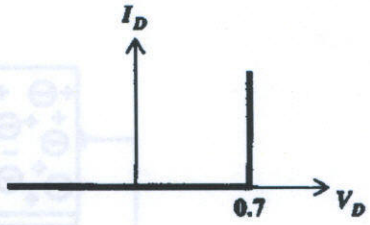

Figure 7

(i) Find the peak value of the potential difference across the 1 kΩ resistor.

(ii) What is the peak value of the current, I, through the resistor?

(iii) Sketch the waveforms for V_i, I and V_R, using the same scale on the t-axis for each sketch graph. [Each complete cycle should occupy at least 8 cm on the *t-axis* of your drawing.]

[7 marks]

Total 20 marks

SECTION A

Attempt ALL questions. You MUST write in this answer booklet. You must NOT spend more than 30 minutes on this section.

1. A teacher asks one of her students to test the $I - V$ characteristic of a diode to be used in a control circuit. The student suspects that the current, I, is related to the voltage, V, by the relation $I \propto V^n$.

(a) (i) Draw a circuit diagram that could be used to examine the $I - V$ characteristic of the diode.

[2 marks]

(ii) Explain how the readings would be taken.

[2 marks]

(b) The graph in Figure 1 shows the $I - V$ characteristic that was obtained for the diode.

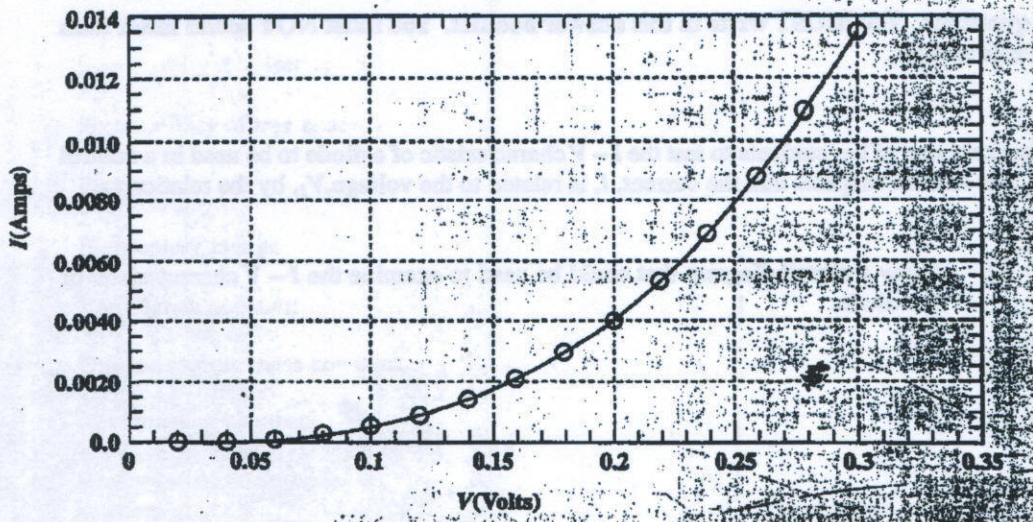

Figure 1

(i) Assume that $I = AV^n$ and use the graph to determine the value of n.

[4 marks]

(ii) Deduce the FULL equation relating the current, I, to the voltage, V, for the diode.

[2 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

4. (a) Explain what is meant by EACH of the following:

(i) P-type semiconductor

_____

_____

[1 mark]

(ii) N-type semiconductor

_____

_____

[1 mark]

(iii) Doping, as applied to semiconductors

_____

_____

[1 mark]

(iv) Depletion region

_____

_____

[1 mark]

(b) Suggest ONE application of a p-n junction diode.

_____

[1 mark]

(c) Figure 3 shows a combination of two silicon diodes in a circuit.

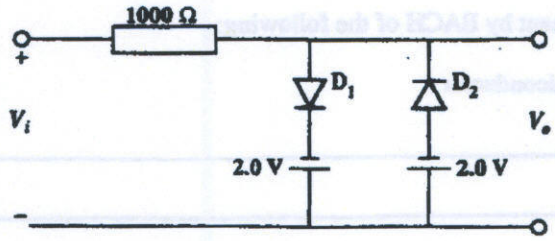

Figure 3

The characteristic I – V curve for the diodes is shown in Figure 4.

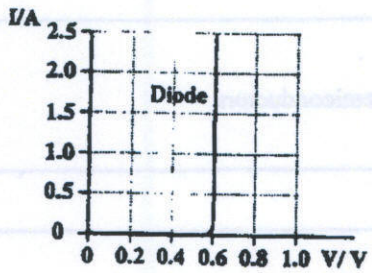

Figure 4

(i) Calculate the value of the output voltage, V_o, when

a) $V_i = 10$ V

_____

_____

_____

[2 marks]

b) $V_i = -10.0$ V.

_____

_____

_____

[1 mark]

GO ON TO THE NEXT PAGE

2. (b) Another student had available two diodes, two similar power supplies and a resistor and designed a circuit as shown in Figure 2.

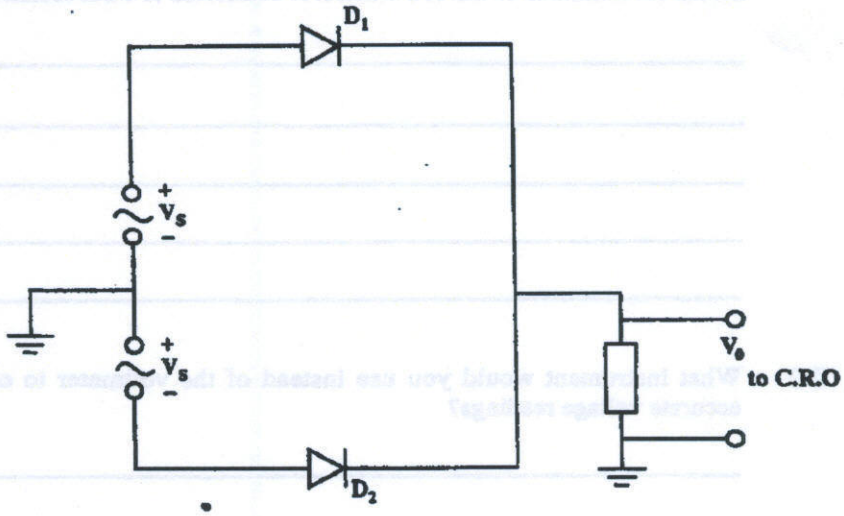

Figure 2

(i) Briefly describe what happens to D_1 and D_2 as 1 cycle of voltage V_s is applied to the circuit.

_____

_____

[2 marks]

(ii) Sketch the waveform you would expect to see on the cathode ray oscilloscope (c.r.o).

[1 mark]

(iii) Compare the output waveforms from 2. (a) (i) and 2. (b) (i).

_____

_____

[1 mark]

Total 10 marks

GO ON TO THE NEXT PAGE

1. (iii) Hence, calculate the current through the circuit and the potential difference across the terminals of the cell when it is connected to a 3Ω resistor.

[3 marks]

(iv) What instrument would you use instead of the voltmeter to obtain MORE accurate voltage readings?

[1 mark]

Total 10 marks

2. (a) A professor asks one of his students to design a circuit to give full wave-rectification using four diodes.

(i) Draw a circuit to show how the student may design such a circuit using four diodes.

[4 marks]

(ii) How can the student modify this circuit to give half-wave rectification.

[2 marks]

GO ON TO THE NEXT PAGE

2. (a) In relation to a semi-conductor

(i) explain what is meant by

a) P-type material

_____

_____

_____

[1 mark]

b) N-type material

_____

_____

_____

[1 mark]

c) the depletion region.

_____

_____

_____

[1 mark]

(ii) Draw a diagram of a junction transistor and draw the transistor symbol.

[2 marks]