BINDURA UNIVERSITY OF SCIENCE EDUCATION

PHYSICS AND ENGINEERING DEPARTMENT

HPH446: ADVANCED ELECTRONIC SYSTEMS

TIME: 3 HOURS

INSTRUCTIONS

Answer **question one** in Section A and **any three** questions from Section B. Section A carries 40 marks and each question in Section B carries 20 marks.

SECTION A

1 (a) What are the two types of BJT transistors? Give a brief description of each. [4]

(b) What are the different configurations of a BJT transistor? How do you identify the different configurations? [6]

(c) In a common base connection, current amplification factor is 0.9. If the emitter current is 1 mA, determine the value of base current. [5]

(d) Give any two assumptions made for analysing ideal op-amps. [2]

(e) Using specific examples, distinguish between the following number systems:

(i) Decimal [2]
(ii) Binary [2]
(iii) Octal [2]
(iv) Hexadecimal [2]

(f) Convert

(i) 34 to binary [2]
(ii) 324 to BCD [2]
(iii) 3B29 to binary [2]
(iv) 450 to hexadecimal [2]
(v) 5BC to decimal [2]

(g) Fig. 1.1 shows a 5-bit switch register. By opening and closing the switches, you can set up different binary numbers.

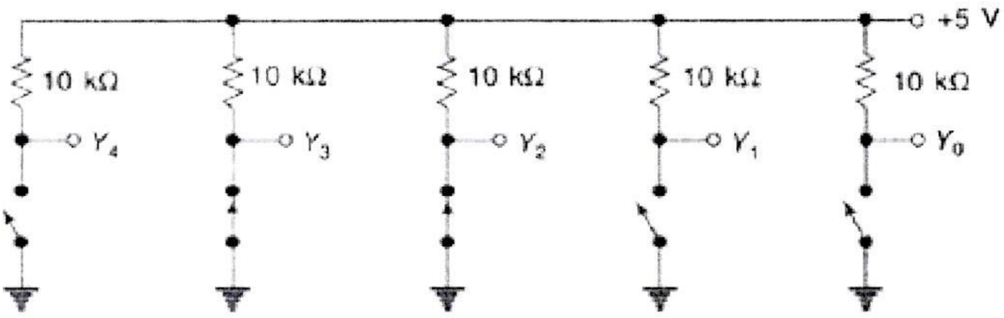


Fig. 1.1

"HIGH" output voltage stands for binary 1 and "LOW" output voltage for binary 0. What is the number sored in the switch register? [5]

SECTION B

2 Below are six rules of Boolean algebra.

- $A + \overline{A} = 1$
- $A + A = A$
- $A + 1 = 1$
- $AA = A$
- $A + AB = A$
- $A + \overline{A}B = A + B$

Determine which rule (or rules) are being used in the following Boolean reductions:

$$\overline{DF} + \overline{DFC} = \overline{DF}$$

$$1 + G = 1$$

$$B + AB = B$$

$$\overline{FE} + \overline{FE} = \overline{FE}$$

$$XYZ + \overline{XYZ} = 1$$

$$GQ + Q = Q$$

$$\overline{H}\,\overline{H} = \overline{H}$$

$$\overline{CD} + \overline{CD} = \overline{CD}$$

$$EF(EF) = EF$$

$$CD + \overline{C} = \overline{C} + D$$

$$CD + \overline{C} = \overline{C} + D$$

$$LNM + ML = LM$$

$$A\overline{G}F\overline{C} + F\overline{C}\,\overline{G} = F\overline{C}\,\overline{G}$$

$$\overline{M} + 1 = 1$$

$$\overline{BC} + BC = 1$$

$$ABC + CAB = BCA$$

$$S + STV\overline{Q} = S$$

$$\overline{DE}(R + 1) = \overline{DE}$$

[20]

3 Like real-number algebra, Boolean algebra is subject to the laws of *commutation*, *association*, and *distribution*. These laws allow us to build different logic circuits that perform the same logic function. Fig. 3.1 shows some equivalent circuit pairs.

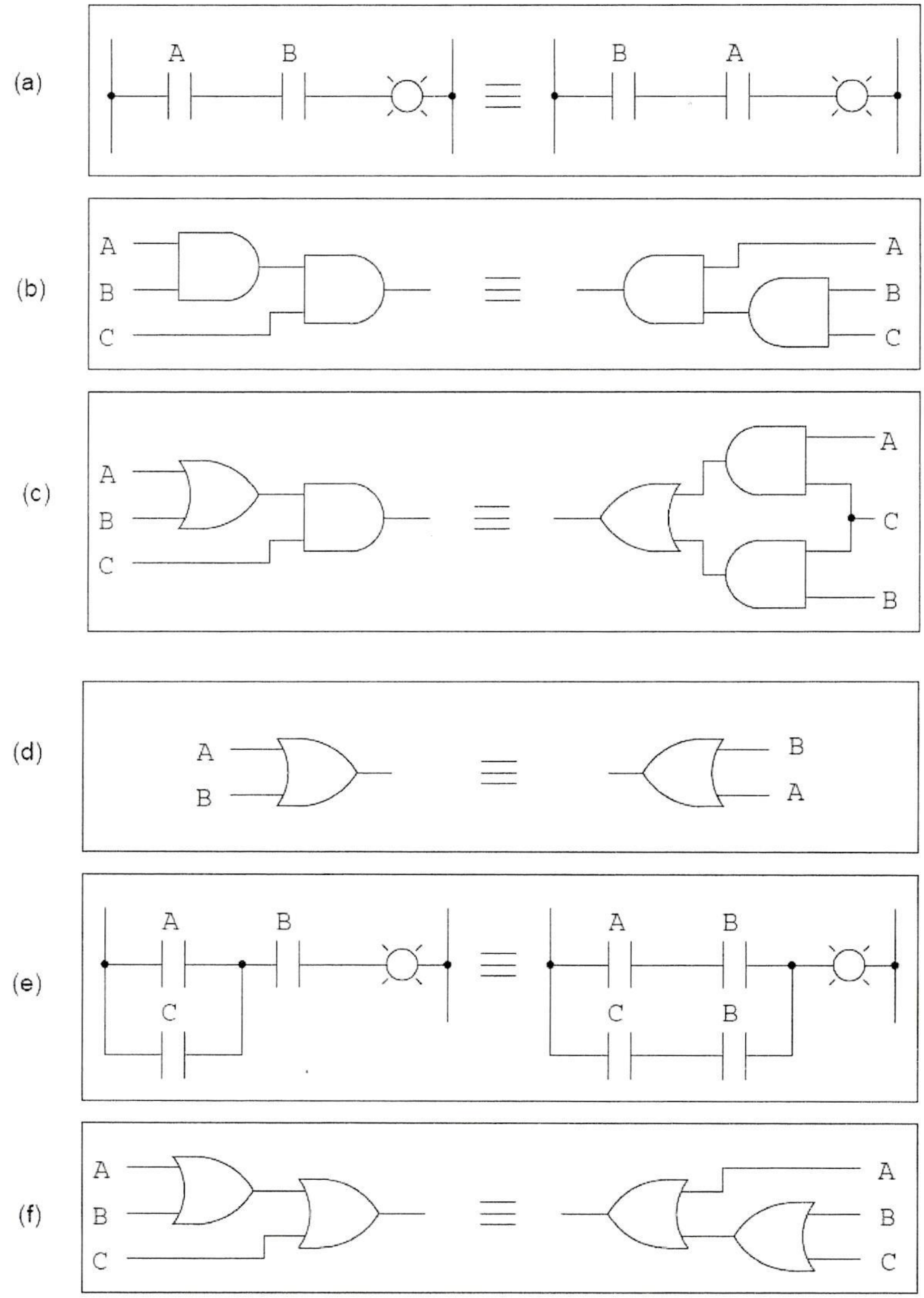


Fig. 3.1

For each of the equivalent circuit pairs shown, write the corresponding Boolean law next to it: [20]

4 Fig. 4.1 shows a transistor circuit and the corresponding characteristic curves.

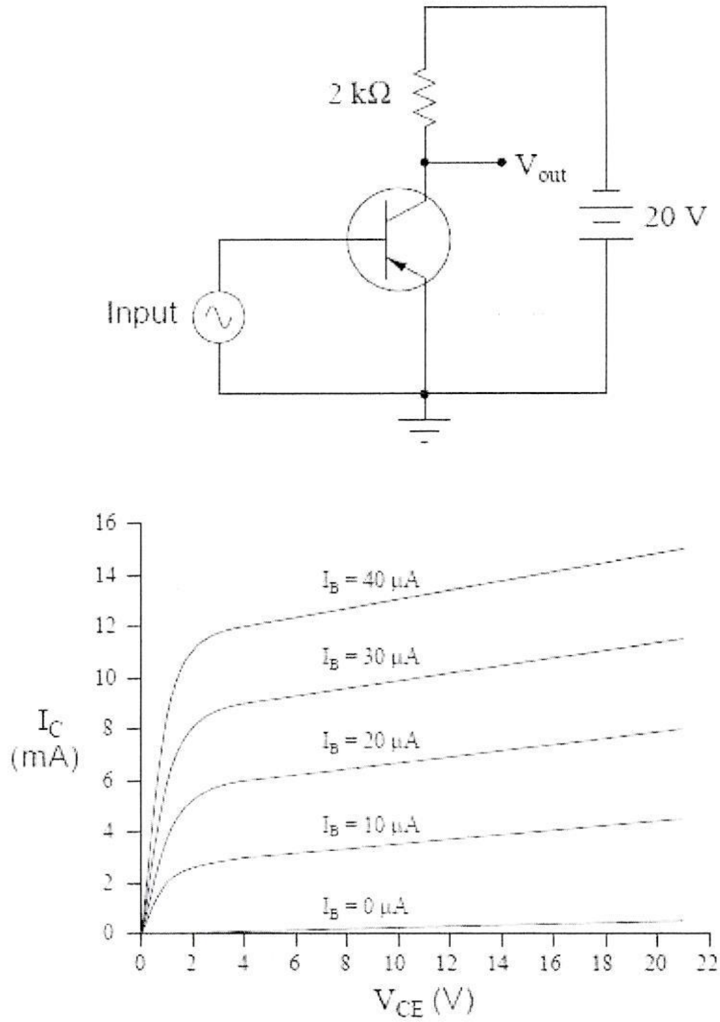


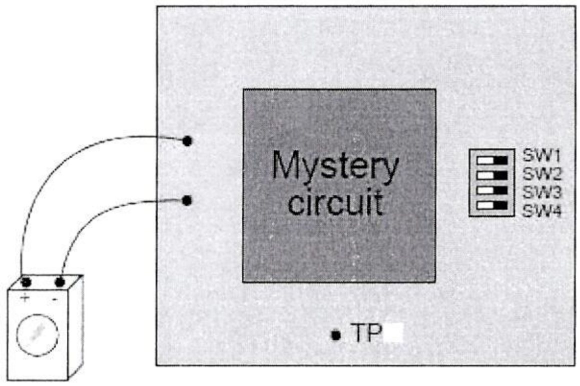
Fig. 4.1

(a) By performing necessary calculations, superimpose the load line for this circuit on top of the transistor's characteristic curves: [12]

(b) Then, determine the amount of collector current in the circuit at the following base current values:

(i) $I_B = 10\ \mu A$ [2]
(ii) $I_B = 20\ \mu A$ [2]
(iii) $I_B = 30\ \mu A$ [2]
(iv) $I_B = 40\ \mu A$ [2]

5 Suppose you were faced with the task of writing a Boolean expression for a logic circuit, the internals of which are unknown to you. The circuit has four inputs, each one set by the position of its own micro-switch (SW) and one output as shown in Fig. 5.1.



SW1	SW2	SW3	SW4	TP
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

Fig. 5.1

By experimenting with all the possible input switch combinations, and using a logic probe to "read" the output state (at test point TP), you were able to write the truth table describing the circuit's behaviour. Based on this truth table "description" of the circuit:

(a) write an appropriate Boolean expression for this circuit. [10]

(b) draw a logic gate circuit equivalent to the Boolean expression. [10]

6 A seven segment decoder is a digital circuit designed to drive a very common type of digital display device: a set of LED (or LCD) segments that render numerals 0 to 9 at the command of a four-bit code as shown in Fig. 6.1.

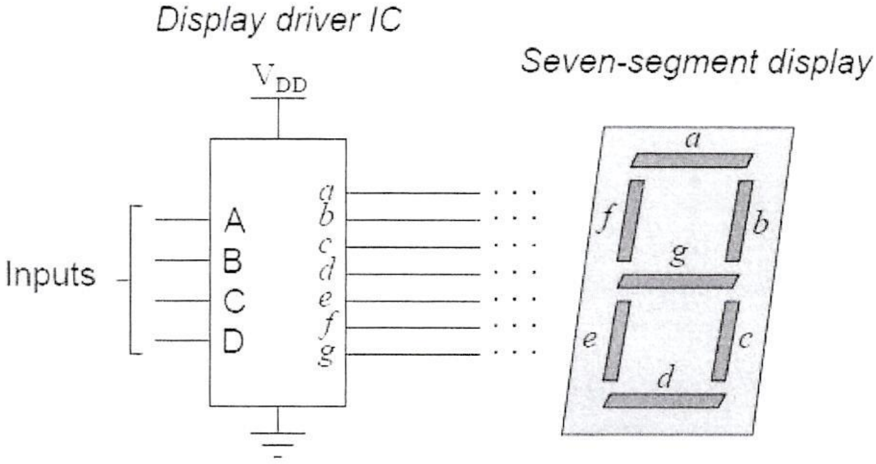


Fig. 6.1

The behaviour of the display driver IC may be represented by a truth table with seven outputs: one for each segment of the seven-segment display (a to g). In Table 6.1, state "1" output represents an active display segment, while state "0" output represents an inactive segment: For example a digit 0 is displayed for the output states indicated.

Table 6.1 Truth table for the seven-segment display

D	C	B	A	a	b	c	d	e	f	g	Display
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1								1
0	0	1	0								2
0	0	1	1								3
0	1	0	0								4
0	1	0	1								5
0	1	1	0								6
0	1	1	1								7
1	0	0	0								8
1	0	0	1								9

Copy and complete Table 6.1 for the output states which allow digits 1 to 9 to be displayed. [20]