

9. A gas-fired boiler provides room-heating or hot water, but not both simultaneously. The boiler is controlled by a combinational logic system. The inputs and outputs of the logic system are shown below.

INPUTS

- Timer T (= 1 when room heating is required)
 Overheat sensor S (= 1 if boiler overheats)
 Flow sensor F (= 1 when a hot tap is open)

OUTPUTS

- Pump P (= 1 to turn pump on)
 Gas valve G (= 1 to open gas valve)

The pump is always switched off when a hot tap is open.

If all hot taps are closed, the pump turns on when room heating is required, or if the boiler overheats.

An incomplete truth table for the logic system is shown in Figure Q9.

Timer (T)	Overheat Sensor (S)	Flow Sensor (F)	Pump (P)	Warning Light (W)	Gas Valve (G)
0	0	0		0	0
0	0	1		0	1
0	1	0		1	0
0	1	1		1	0
1	0	0		0	1
1	0	1		0	1
1	1	0		1	0
1	1	1		1	0

Figure Q9

- (a) Write down the values for pump P as they should appear in the truth table shown in Figure Q9. 1
- (b) Write a Boolean expression for output G in terms of inputs T, S and F. 1
- (c) Draw a logic diagram for output G using AND, OR and NOT gates. 3
- (d) Draw a NAND-equivalent circuit for output G. Simplify where appropriate. 2
- The controller circuit-board has a supply voltage of 12 V.
- (e) State whether TTL or CMOS integrated circuits are more suitable for this application. Justify your answer. 1
- (f) State **two** disadvantages of CMOS logic devices compared with TTL devices. 1
- (9)**

[END OF SECTION A]

[Turn over

Attempt all the questions in this Section. (Total 60 marks)

1. A logic circuit for the control of an industrial stamping machine is shown in Figure Q1.

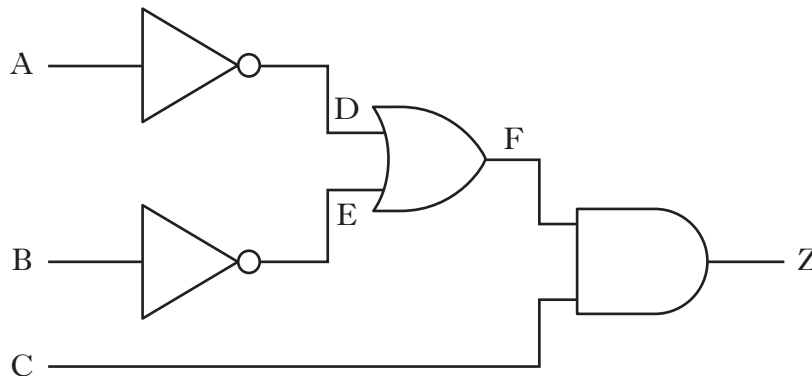


Figure Q1

- (a) Write a Boolean expression for the output Z in terms of the inputs A , B and C . 1
- (b) Draw a truth table for the logic circuit.
Include in the table the intermediate logic values D , E and F . 2

The logic circuit is constructed using TTL integrated circuits. At one stage during testing, all of the input pins were **unconnected**.

- (c) State the logic values of the inputs A , B and C , and the output Z , for the conditions stated above. 1

The circuit shown in Figure Q1 could be replaced by an equivalent logic circuit constructed entirely from NAND gates.

- (d) Draw this equivalent logic circuit. Simplify where appropriate. 3
- (7)**