Homework – 3.1
For each of the logic gates specified below;

(a) Sketch the appropriate *ANSI* symbol and *BS3939* symbol
(b) Construct the truth table for the gate having *Inputs* A & B and *output* Z.

Gates – AND, NOT, NAND, NOR, OR, & XOR.

Homework – 3.2
A vehicle can be started only when the following conditions are satisfied.

- the brake is ON.
- the gearbox is in NEUTRAL.
- The seat belt is ENGAGED.

(a) What single logic device can be used to accomplish this, and construct the truth table for this circuit.
(b) If only two input NAND gates are available, draw the logic diagram with the outputs of each gate clearly identified.

Homework – 3.3
A central heating boiler will ignite if there is a demand for hot water or if the room temperature is below a set level but only if the pilot light is lit.
Draw the logic circuit diagram that satisfies the condition and construct the truth table for the output.

Homework – 3.4

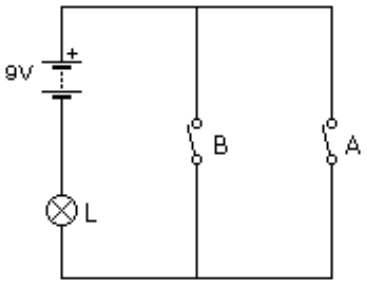


Figure 3.4.1

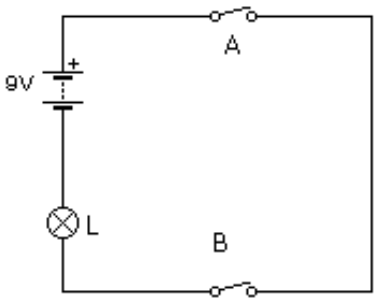


Figure 3.4.2

The electrical circuits shown in *figures 3.4.1 & 3.4.2* can be regarded as logic gates with inputs A & B and output Z.

(a) Sketch the equivalent gates.

(b) Refering to figure 3.4.3,
  (i) Regarding switches A, B, & C as inputs and lamp L as output, construct a truth table for the system assuming a **closed** switch is **high** and the lamp **on** is **high**.
  (ii) Illustrate this system using 2 input logic gates. Show the output of each gate.

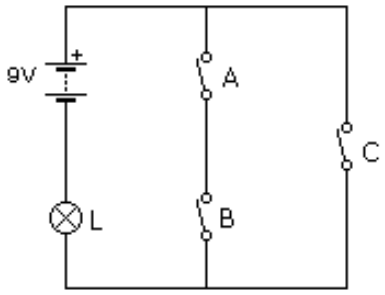
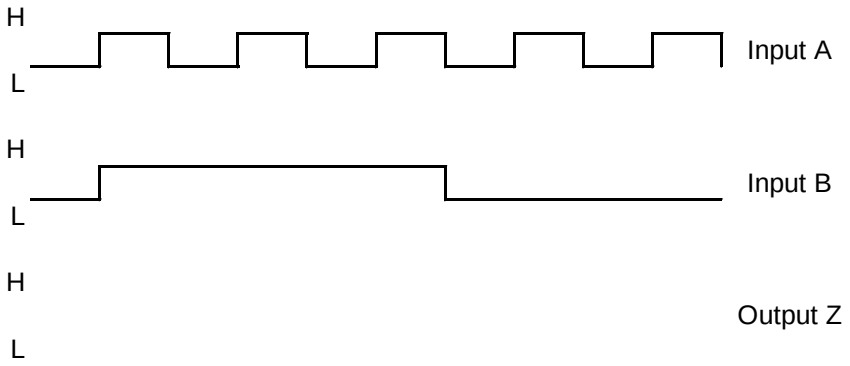


Figure 3.4.3

(c) The diagram below shows the voltage waveforms applied to inputs *A* and *B* of standard two input logic gates.



(i) Carefully copy this diagram and in the space provided sketch in relevant position of the output waveform for an *AND* gate.
(ii) Repeat this for two input *NAND, OR, NOR, X-OR* and *X-NOR* gates.

Homework – 3.5
The *NAND* gate is known as a 'universal logic gate' since it may be used to produce all other types of gate functions. Construct diagrams showing how *AND, OR, NOT, NOR, X-OR*, and *X-NOR* gates can be produced using only two input *NAND* gates. Indicate the output of each gate in the circuit.

Homework – 3.6
Write the truth table for each of the gate circuits shown below.

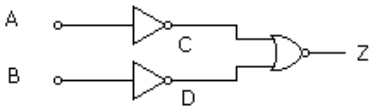


Figure 3.6.1

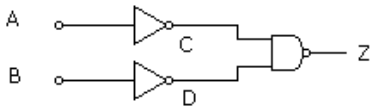


Figure 3.6.2

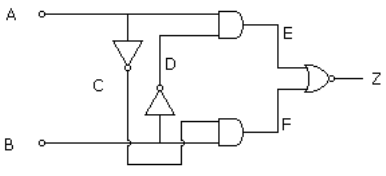


Figure 3.6.3

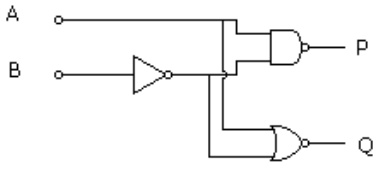


Figure 3.6.4

Homework – 3.7
For the circuits shown in *Q3.6.1, 2, 3 & 4* above construct the equivalent circuits using *NAND* gates only.

Homework – 3.8

(a) For the gates listed in *Q1* write the boolean expressions for the outputs.

(b) Write down the boolean expression for the gates shown in *figure's 3.8.1, 3.8.2, 3.8.3, 3.8.4*.

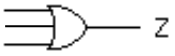


Figure 3.8.1

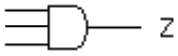


Figure 3.8.2

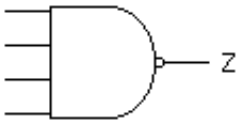


Figure 3.8.3

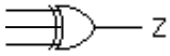
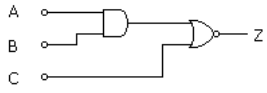
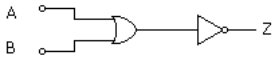


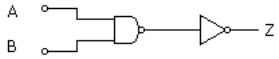
Figure 3.8.4

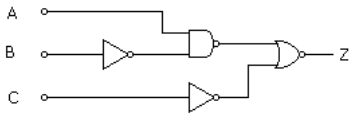
Homework – 3.9

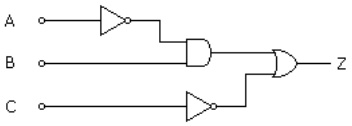
Derive the boolean expression for each of the circuits shown in the *figures* below, and construct the truth table.

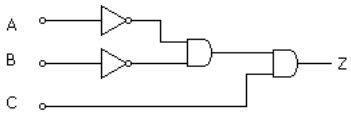












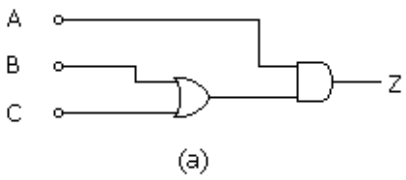
Homework – 3.10

For each of the pairs of circuits shown

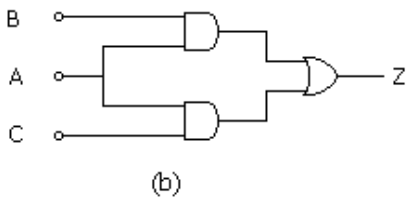
(a) Write the boolean expression.

(b) Construct their truth table and show they are equivalent

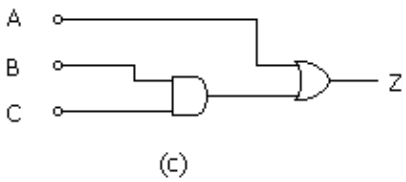
(c) Draw equivalent arrangements using only 2 input *NAND* gates.



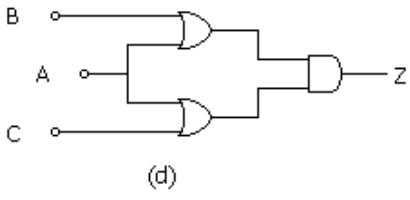
(a)



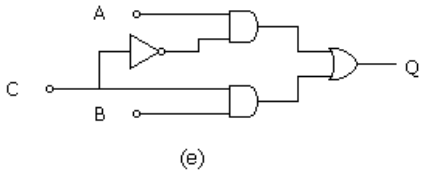
(b)



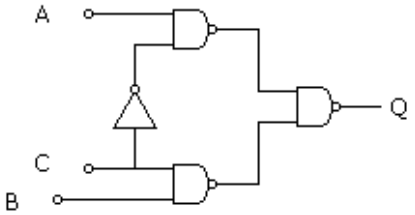
(c)



(d)



(e)



(f)

Homework – 3.11
Write the boolean equation for the following truth tables.

A	B	C	Z
0	0	0	**1**
0	0	1	**0**
0	1	0	**0**
0	1	1	**1**
1	0	0	**0**
1	0	1	**0**
1	1	0	**0**
1	1	1	**1**

(a)

A	B	C	Z
0	0	0	**0**
0	0	1	**0**
0	1	0	**0**
0	1	1	**1**
1	0	0	**0**
1	0	1	**0**
1	1	0	**1**
1	1	1	**1**

(b)

A	B	C	Z
0	0	0	**0**
0	0	1	**1**
0	1	0	**0**
0	1	1	**0**
1	0	0	**0**
1	0	1	**1**
1	1	0	**0**
1	1	1	**0**

(c)

Homework – 3.12
For each of the following boolean equations, draw a logic circuit diagram.

(a) $F = A + B + C + D$ *(using only two input gates)*

(b) $Z = \overline{A} + (\overline{B \cdot C})$

(c) $F = (\overline{A \cdot B}) \cdot \overline{C}$

(d) $Z = A + B + (C \cdot D)$

Homework – 3.13
A food processing plant uses four different liquids, *U, V, X & Y,* in an automatic production process. Level sensors in a tank containing liquid 'X', and a similar tank containing liquid 'Y' send a logic 1 signal to the control system when the level exceeds a set value. Also sensors send a logic 1 signal to the control system when the temperature of liquids *U,* and *V,* full below a set value.
Design a control system which will give an audible warning when *both* liquids *X* and *Y* exceed the set level, a visual warning when the temperature of *both* liquids *U* & *V* drop below the set value and a signal to shut down the plant if liquid U or V is at too low a temperature.
Convert the circuit to NAND gates only.

Homework – 3.14
A chemical process involves maintaining the difference in pressure of two gases ***A*** and ***B*** within prescribed limits. Pressure sensors *a* and *b* detect the pressure of each gas and the signals obtained are processed to produce a logic 1 output if the difference in pressure between ***A*** and **B** are too great. A logic 1 signal is also produced by each sensor *a* and *b* when the pressure of each gas exceeds a maximum safe operating pressure. Design a logic system which will shut down the process by producing a logic 1 if the pressure difference is too great, or the pressure of either gas exceeds the safe pressure. Construct the circuit to use *NAND* gates only.

Homework – 3.15
Design a logic circuit having 3 logic input signals *A, B*, and *C* which may be either logic 1 or logic 0, such that the output will be logic 1 when the *majority* of inputs are at logic 1.

(a) Draw up a truth table for this system and from this derive the boolean expression.

(b) Draw the logic circuit diagram using a selection from the full range having up to 4 inputs each.

Homework – 3.16
A simple arithmetic and logic unit (ALU) has these inputs *A, B*, and *C* and output *F*. In operation,

When C = 0, output F = 1 when A = B; and
When C = 1, output F = 1 when A = B = 1.

(a) Using the above data construct the truth table for this unit.
(b) Derive the boolean equation for the output *F*.
(c) Using *NOT* gates and 2 input *AND* gates and 2 input *OR* gates, construct the logic circuit diagram.
(d) Draw the simplified equivalent NAND gate circuit and express this as a boolean expression.

Homework – 3.17
(a) Construct a truth table for a 2 input exclusive *OR* gate.
i.e. the output **F is 1 when A = 1, B = 0** and
F is 1 when A = 0, B = 1.
(b) Write down the boolean expression.
(c) Draw a logic circuit diagram for this function using *NOT, AND*, and *OR* gates only.
(d) Draw the equivalent *NAND* gate circuit for this function.

Homework – 3.18
Logic gates are available in integrated circuit 'packages' the two most common types being the **TTL** and **CMOS** families.
(a) What do the acronyms **TTL** and **CMOS** mean.
(b) Compare the performance of each type with reference to
(i) Power supply.
(ii) Current requirements.
(iii) Input impedance.
(iv) Switching speed.
(v) Fan out.
(vi) Unused outputs.