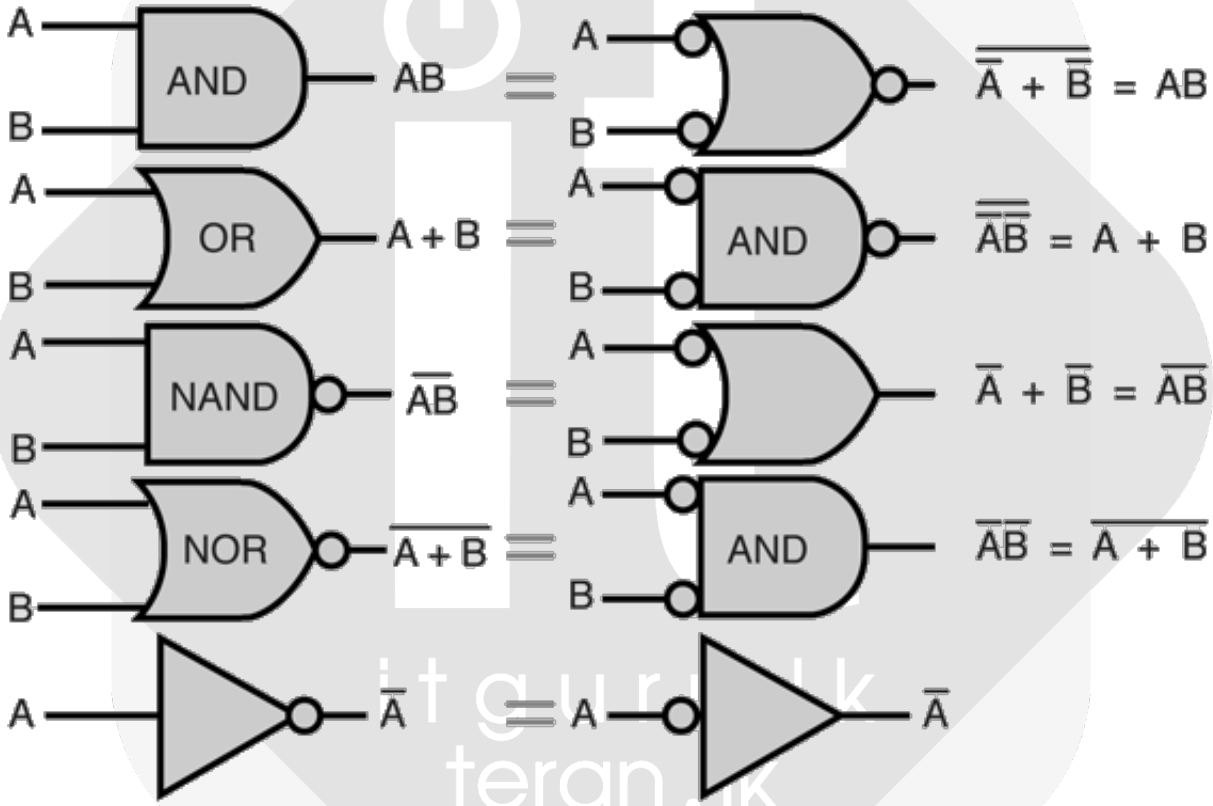
LOGIC GATES

PRACTICE QUESTIONS



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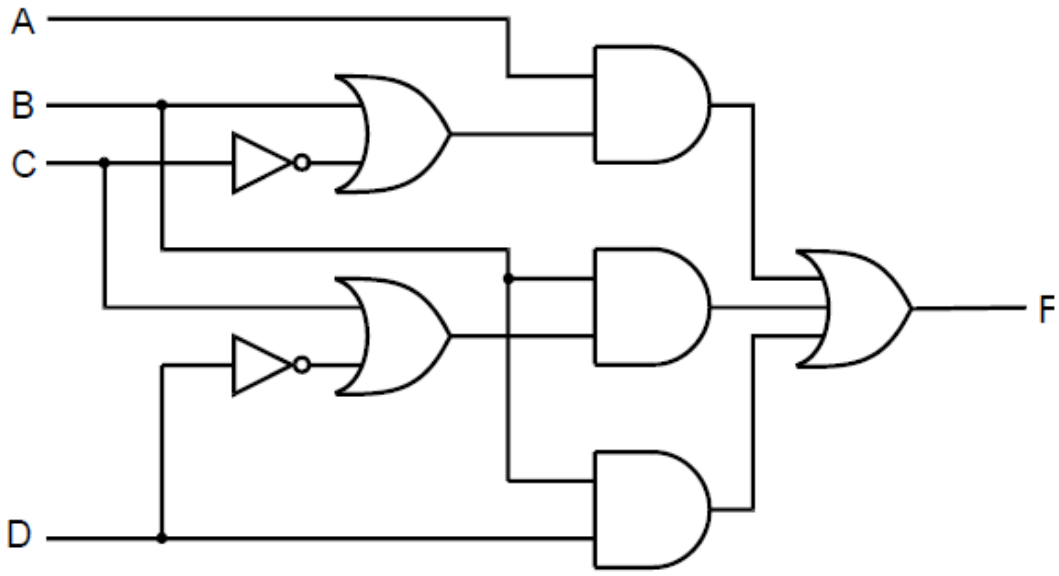
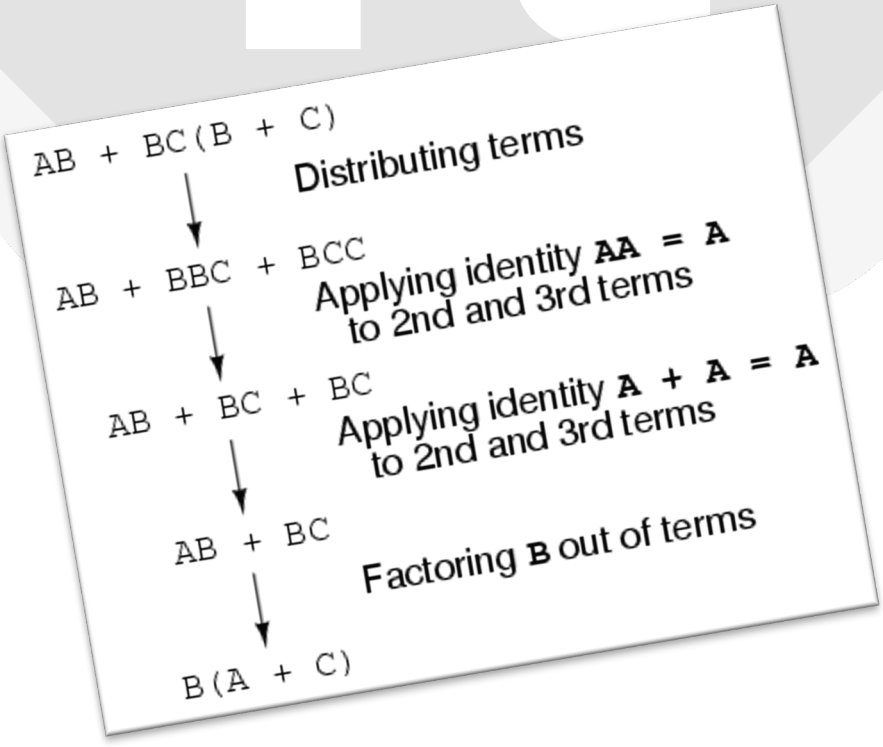
Model Question - 1

a) Draw a truth table to give the value of F in terms of inputs A, B, C, and D for the following circuit. You must include columns for all intermediate values (i.e., the outputs of all the other gates). Please order the inputs in your truth table A, B, C, and D.



b) Derive a simplified Boolean expression for F in terms of A, B, C, and D.

c) Using your simplified expression for F, design a new circuit that performs the same function.



2012 – Paper 2 -Part B – Q1

(b) A fan in a room can be on (1) or off (0). A control system is required to operate the fan efficiently with the following conditions/functionalities.

1. The fan can manually be switched on or off.
2. The timer will be either on or off.
3. The sensor will detect whether the environment is cold or hot.
4. The fan will automatically be switched on when the timer is on and the sensor indicates the environment is hot.

The following table assigns Boolean values for the above conditions / functionalities.

Condition / Functionality	Boolean Value
Fan switched on manually	1
Fan switched off manually	0
Timer is on	1
Timer is off	0
Sensor detects cold environment	1
Sensor detects hot environment	0

I. Draw a logic circuit by using a combination of AND, OR, and NOT gates to implement the above control system.

II. Construct a truth table to represent the functionality of the above system.

III. Write a Boolean expression (not simplified) to represent the truth table constructed in the (b) III above

Model Question - 2

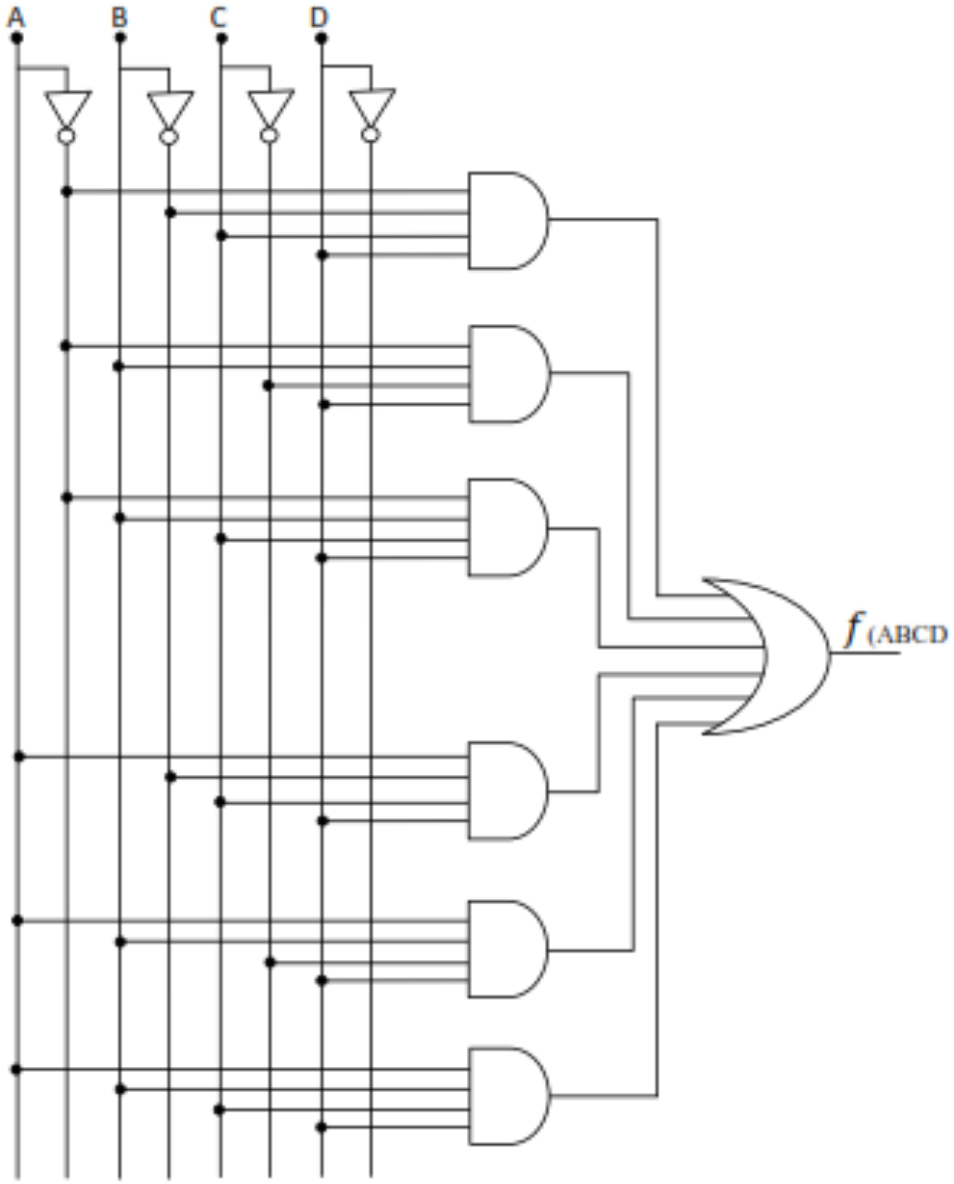
a) A circuit has four natural binary encoded inputs D, C, B, A where D is the most-significant bit. These values represent 0 to 15 in decimal. It has a single output F. F is 1 if the input on D, C, B, A is in the range 3 to 7 (inclusive) or 12 to 15 (inclusive). Construct a truth table for this system.

b) From the truth table derive an expression for the output of the circuit in its most simplified form.

c) Draw a circuit to implement the voting mechanism using AND, OR and NOT gates.

2012 – Seminar Paper

(c). Answer the following questions considering the following logic circuit.



(i) Draw the truth table considering for every AND gate that output is 1.

(ii) Write down the Boolean expression for the output of the above circuit using a truth table.

(iii) Simplify the above expression using Boolean algebra or Karnaugh (K-Map).

(iv) Design the logic circuit for the answer you have obtained in above (iii).

(v) Convert the Boolean expression you obtained for the above part (ii) to Product of Sum (POS).

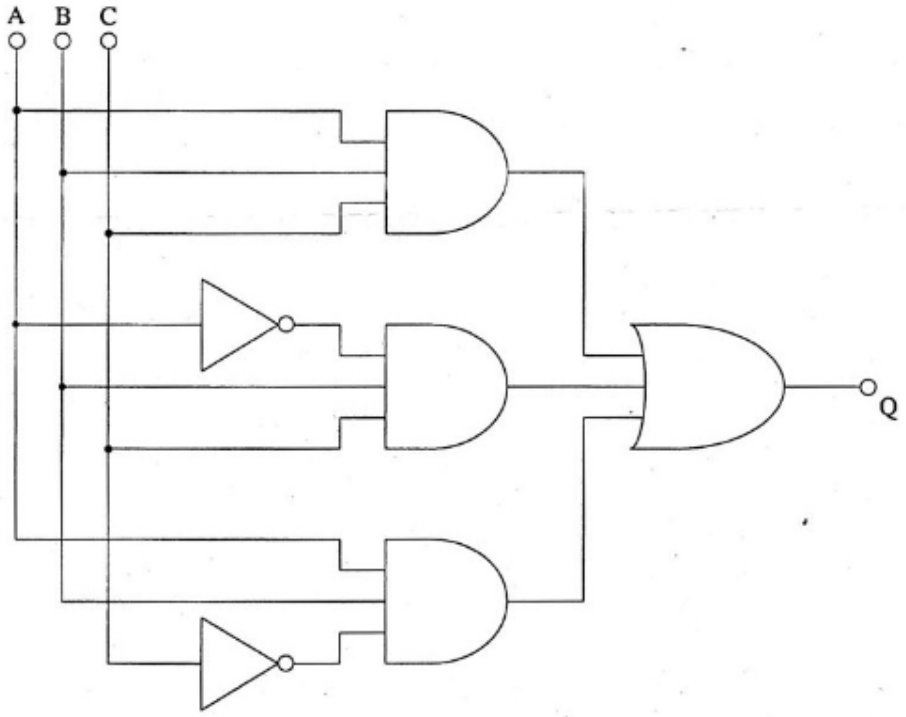
2013 – Paper 2 -Part B – Q1

a) A fire alarm system consists of three sensors Sl, S2 and S3 to detect smoke, flame and heat respectively. A sensor can either be active (sends the logical value 1) or inactive (sends the logical value 0). The system automatically triggers the fire alarm when at least two of the sensors are active.

(i) Construct the truth table to represent the functionality of the above fire alarm system.

(ii) Derive the Boolean expression to represent the above truth table.

(b) Consider the logic circuit shown here to answer the sections (i) and (ii) below:



(i) Write and simplify the Boolean expression for the above circuit using Boolean algebra. Show all the workings and algebraic rules .used for the simplification.

(ii) Construct the logic circuit using a combination of only AND, OR and NOT gates for the simplified Boolean expression obtained in section b(i) above.

2014 – Paper 2 -Part B – Q1

An alarm system has been designed to detect break-ins by using three detectors. They are a motion detector, a glass break detector and a blackout detector. A detector can either be active (sends the logical value 1) or inactive (sends the logical value 0).
The system automatically detects a break-in and triggers the alarm (sends the logical value 1) only when all the three detectors are simultaneously active, or the blackout detector, and anyone of the remaining detectors are active.

(a) Construct a truth table to represent the functionality of the above alarm system.

(b) (i) Derive the Boolean expression to represent the truth table constructed in section (a) above.

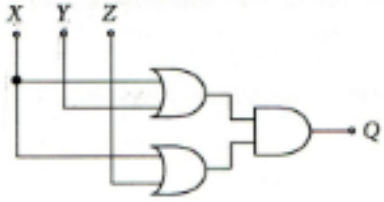
(ii) Simplify the Boolean expression obtained in section (b) (i) above, using Boolean algebra. Clearly show all the workings and Boolean algebraic rules used for this simplification.

(iii) Construct the logic circuit for the simplified Boolean expression obtained in section (b) (ii) above.

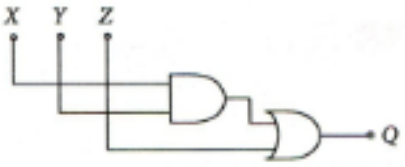
(c) The analysis of the past incidents where the alarm triggered reveals that break-in attempts have been made only during blackouts. Do you agree with the above statement? Justify your answer.

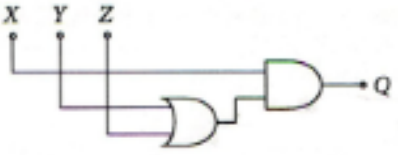
2014 – Paper 1

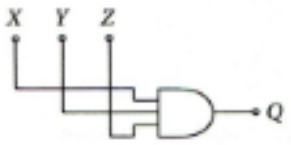
12. Consider the following logic circuit:



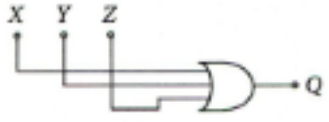
Which of the following circuit diagrams represents a simplified version of the above circuit?

(1)


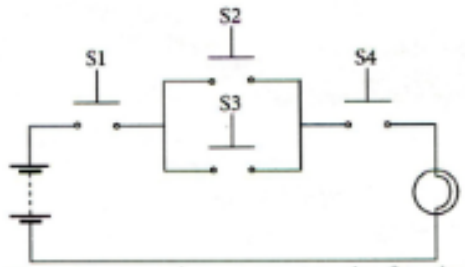
(2)


(3)


(4)


(5)


13. Consider the following circuit with four push button switches namely: S1, S2, S3, and S4. These four switches can either be in pushed or released states which are represented by 1 and 0 respectively. (Note: In the circuit given below, all the switches are in released state having value 0.)



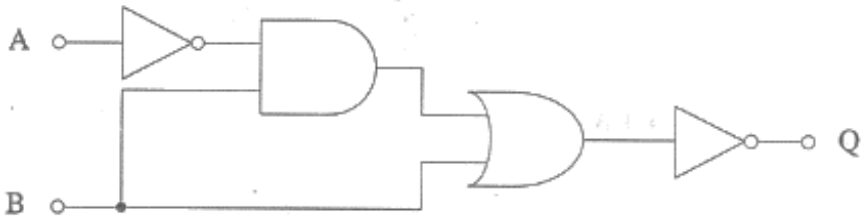
Which of the following Boolean expressions represents the function of the bulb, if the on state of the bulb is represented by the value 1?

(1) S1 + (S2 . S3) + S4 (2) (S1 + S2) . (S3 + S4) (3) (S1 . S2) + (S3 . S4)
(4) S1 . S4 . (S2 + S3) (5) S2 + (S1 . S4) + S3

2013 – Paper 1

1. The Boolean expression $(x+y).(x+z)$ simplifies to .....
(1) x . (2) x . (y+z) (3) x . y . z (4) x+y . z (5) x+y+z

2. Which of the following Boolean expressions represents the output (Q) of the circuit shown below? A and B are inputs.



(1) $A'.B'+A.B'$
(2) $A'.B'+A.B$
(3) $A.B+A'.B'$
(4) $A'.B+A.B'$
(5) $A'.B+A'.B'$

9. Which of the following is an **incorrect** Karnaugh Map layout to represent a Boolean function of four (4) Boolean variables a, b, c and d?

(1)

ab\cd	01	00	10	11
01				
00				
10				
11				

(2)

ac\bd	01	00	10	11
01				
00				
10				
11				

(3)

ab\cd	01	00	11	10
01				
00				
11				
10				

(4)

ad\bc	11	10	00	01
11				
10				
00				
01				

(5)

ac\bd	00	10	11	01
00				
10				
11				
01				

2012 – Paper 1

26. What would be the result if the following Boolean expression is simplified?

$F(x,y) = \overline{xy}(\overline{x}+y)(y+\overline{y})$

(1) $\overline{x}$ (2) $\overline{y}$ (3) x (4) y (5) xy

27. Which of the following Boolean expressions represents the output of the given logic circuit?

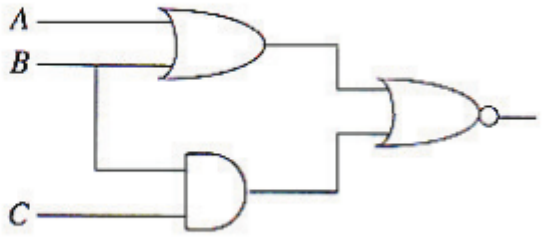
(1) $\left(\overline{A+B}\right)+\left(\overline{B \bullet C}\right)$

(2) $\left(\overline{A+B}\right) \bullet \left(\overline{B \bullet C}\right)$

(3) $\overline{\left(A+B\right)+\left(B \bullet C\right)}$

(4) $\left(\overline{A \bullet B}\right)+\left(\overline{B \bullet C}\right)$

(5) $\overline{\left(A \bullet B\right)+\left(B+C\right)}$



2011 – Paper 1

27. Which of the following would be the result if the Boolean expression $F(x,y)=\left(\overline{x+y}\right).\left(\overline{\overline{x}+\overline{y}}\right)$ is simplified by using De Morgan's Law?

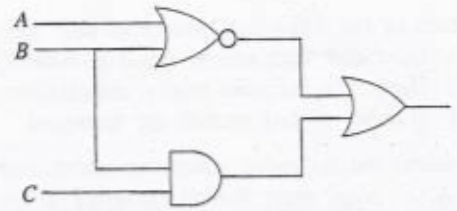
(1) x (2) y (3) 0 (4) 1 (5) $x.y$

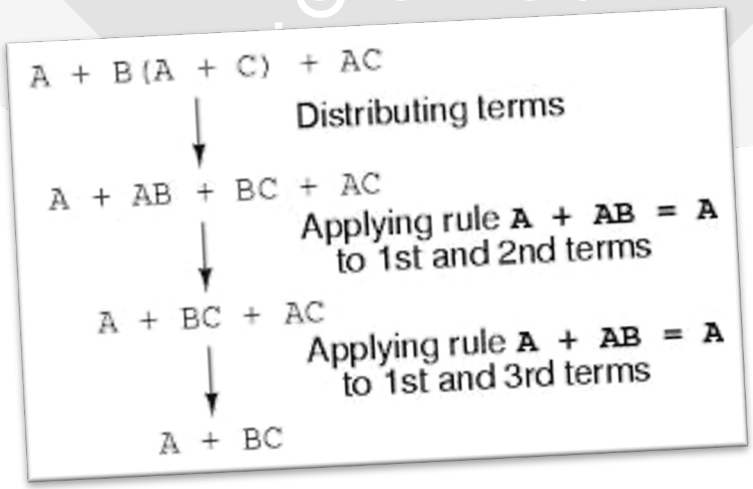
28. Which of the following Boolean expressions represents the given logic circuit?

(1) $\left(\overline{A+B}\right)+\left(B+C\right)$ (2) $\left(A+B\right)+\left(B.C\right)$

(3) $\left(\overline{A+B}\right)+\left(\overline{B+C}\right)$ (4) $\left(\overline{A.B}\right)+\left(B.C\right)$

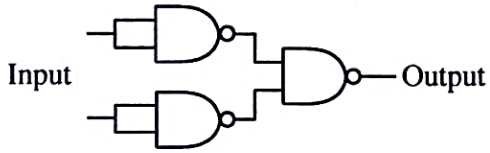
(5) $\left(\overline{A+B}\right)+\left(B.C\right)$





2015 – Paper 1

11. Consider the following combinatory circuit implemented using universal gates:



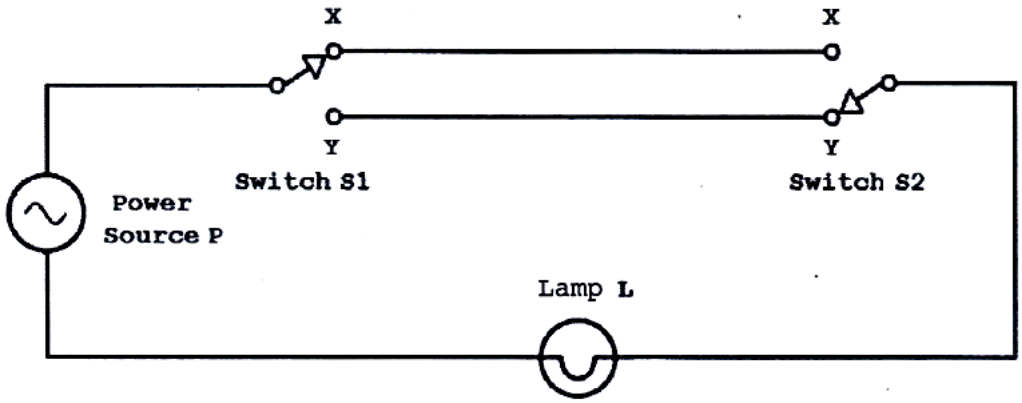
The above circuit is equivalent to a/an

(1) AND Gate. (2) OR Gate. (3) NAND Gate. (4) NOR Gate. (5) NOT Gate.

2015 – Paper 2 – Part B

1. (a) Explain how to derive a Boolean expression from a given truth table.

(b) In residential electrical wiring, the following circuit has been used to operate a light in a staircase.



As in the above circuit, two switches S1 and S2 are installed at the bottom and the top of the staircase to operate the lamp L. The lamp turned on by using the switch S1 at the bottom of the staircase can be turned off by using the switch S2 at the top of the staircase. Further, the lamp turned on by using switch S2 at the top of the staircase can also be turned off by using the switch S1 at the bottom of the staircase. Moreover, the lamp L turned on by a switch can be turned off by the same switch.

Assume that the connections to positions X and Y of a switch in the above circuit are represented by the truth values 1 and 0 respectively and the turned on and turned off states of the lamp L are represented by the truth values 1 and 0 respectively.

(i) Construct a truth table to represent the functionality of the above circuit.

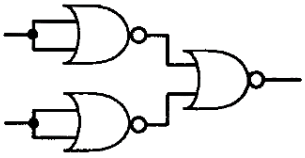
(ii) Derive a Boolean expression to represent the truth table obtained in section (i) above.

(iii) What is the logic gate which is equivalent to the functionality of the Boolean expression obtained in section (ii) above?

(iv) Construct a logic circuit for the Boolean expression obtained in section (ii) above with NOT, AND and OR gates only.

2016 – Paper 1

11. Consider the following logic circuit implemented using universal gates:



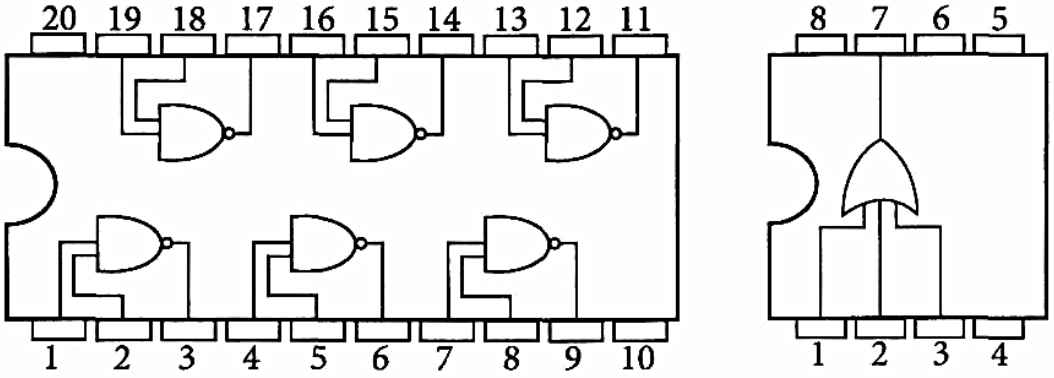
The above circuit is equivalent to a/an

(1) NOT Gate. (2) AND Gate. (3) OR Gate. (4) NAND Gate. (5) NOR Gate.

2016 – Paper 2 -Part B – Q1

1. The top secret recipe for making milk rice at the restaurant chain SLFC is kept in an electronic safe at their head office. The lock (L) of the safe can either be in locked or unlocked states represented by logical truth values 0 and 1 respectively. This lock has three different key holes K1, K2 and K3 each with a unique key. These three keys are in the custody of three directors of SLFC. The lock opens when **at least two keys** are inserted into the corresponding key holes. The situation where the corresponding key is properly inserted into any key hole is represented by the logical truth value 1 and all the other situations are represented by the logical truth value 0.

Assuming that only the following Integrated Circuits (ICs) are available, construct a logic circuit to operate the lock (L) of the safe, by using the truth tables and Boolean algebra. Clearly show the truth tables, Boolean expressions and the Boolean algebraic rules used to construct your circuit.



2017 – Paper II – Part B – Q2

1. A switch (A), a temperature sensor (B) and a timer (C) of an air-conditioner determine turned on and turned off states of the air-conditioner. Turned on and turned off states of the air-conditioner as well as the 'ON' and 'OFF' states of the switch, temperature sensor and the timer are represented by the logical values 1 and 0, respectively.

The air-conditioner can be turned on or off manually by setting the switch to its 'ON' or 'OFF' states, respectively.

The temperature sensor detects the temperature in the room. The temperature sensor sets its state as 'ON' or 'OFF' when the detected temperature is respectively higher or lower than a pre-defined temperature value. The air-conditioner is automatically turned on or off when the detected temperature is respectively higher or lower than the pre-defined temperature value.

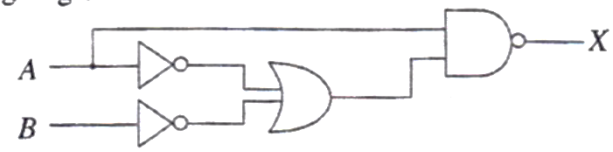
The timer sets its state as 'OFF' until it reaches a preset time value and sets the state as 'ON' once it reached. The air-conditioner is automatically turned off when the timer reaches the preset time value.

(a) Construct a logic circuit using only NOR gates to control the air-conditioner. Clearly show truth table, Boolean expression and Boolean algebraic rules used for simplification. Assume that the electricity is always supplied to the air-conditioner.

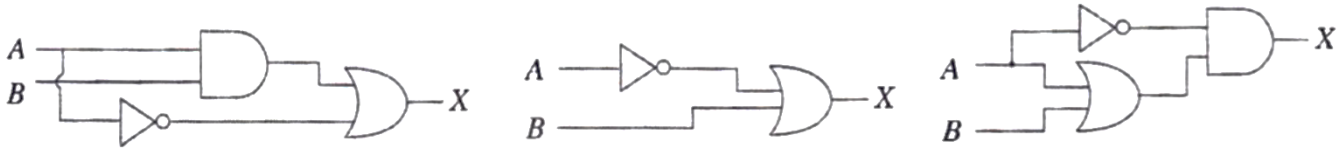
(b) The user of the air-conditioner says that the switch is not required for the operation of the air-conditioner. Do you agree with this statement? Justify your answer.

2018 – Paper I

22. Consider the following logic circuit.



Which of the following circuit/s is/are equivalent to the above circuit?



I II III

(1) I only (2) II only (3) III only (4) I and II only (5) All I, II and III

2018 – Paper II – Part B – Q1

1. Suppose a logic circuit needs to be implemented for a digital system that has three inputs A, B and C and one output Z. Its behaviour is as follows:

If the input C=1, the output Z has the value of A.

If the input C=0, then output Z has the value of B.

(a) Obtain the truth table for the output Z.

(b) Write down **either** a sum of products (SOP) **or** a product of sums (POS) Boolean expression for Z.

(c) Simplify the Boolean expression for Z obtained in (b) above.

(d) Using the simplified expression in (c) above, construct a logic circuit for the system using **either** 2-input NAND gates only **or** 2-input NOR gates only.

Prototype Paper for New Syllabus 2019 - Part B – Q1

1. In a fish tank, the health of goldfish depends on the pH value of the water, temperature and oxygen level of the water in the tank. A sensor based control system is to be developed to make a healthy environment for the survival of gold fish by maintaining appropriate levels of pH value, temperature and oxygen level of the water of the fish tank. For this purpose a pH sensor (A), a temperature sensor (B) and an oxygen sensor (C) are to be used to measure the pH level, temperature and oxygen level of the water respectively.
The following table shows the status of each sensor with the relevant binary values to be emitted by the sensors.

Sensor	Status	Binary values
A	pH value from 6 to 8 pH value not within 6 to 8	0 1
B	Temperature between 55 and 80 Fahrenheit Temperature not within 55 and 80 F	0 1
C	Oxygen is less than a given value Oxygen is greater than or equal to given value	0 1

The binary value '0' indicates the appropriate condition for the goldfish.

An automatic waterfall is connected to the fish tank. The waterfall starts automatically when the temperature is not within the range or the oxygen level is less than the given value. The waterfall stops automatically to save the power consumption when the temperature is at the range and the oxygen level is high. When the pH value of the water is out of the given range, a bulb in the tank is lighted.

The start and stop states of the waterfall are represented by the binary values "1" and "0" respectively.

Construct a logic circuit to implement the function of the waterfall. Give the truth table and boolean expression.

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