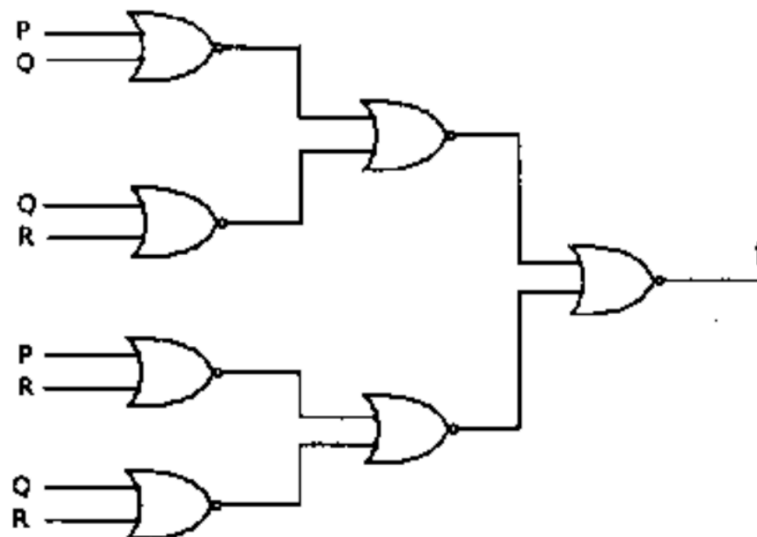


## NOR Gate Circuit — Boolean Expression & Hardware Verification

### Question

What is the Boolean expression for the output  $f$  of the combinational logic circuit of NOR gates given below?



**Required:** Find the Boolean expression for  $f$  and verify it using hardware.

### Question Analysis

All gates are NOR. For a NOR gate:

$$\text{NOR}(X, Y) = \overline{X + Y}$$

### Top branch

$$X_1 = \overline{P + Q}, \quad X_2 = \overline{Q + R}$$

These feed a NOR:

$$A = \overline{X_1 + X_2} = \overline{\overline{P + Q} + \overline{Q + R}} = (P + Q)(Q + R)$$

---

## Bottom branch

$$Y_1 = \overline{P + R}, \quad Y_2 = \overline{Q + R}$$

These feed a NOR:

$$B = \overline{Y_1 + Y_2} = \overline{\overline{P + R} + \overline{Q + R}} = (P + R)(Q + R)$$

## Final NOR

$$f = \overline{A + B}$$
$$f = \overline{(P + Q)(Q + R) + (P + R)(Q + R)}$$

Factor  $(Q + R)$ :

$$f = \overline{(Q + R)((P + Q) + (P + R))}$$
$$(P + Q) + (P + R) = P + Q + R$$

Using absorption:

$$(Q + R)(P + Q + R) = (Q + R)$$

$$\boxed{f = \overline{Q + R}}$$

## Truth Table

$P$	$Q$	$R$	$f = \overline{Q + R}$
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

## Hardware Implementation

The above problem is implemented and tested in hardware using Arduino UNO board. We used 7447 and a common anode seven segment display to display output  $f$  as 0 or 1 for inputs  $P, Q, R$  as per the truth table and verified the expression.

---

# Required Components & Pin Connections

## Components

S.No	Component
1	Arduino UNO Board
2	Breadboard
3	7447 IC (BCD to 7-segment driver)
4	Seven Segment Display (Common Anode)
5	Resistors: 220Ω (for segments)
6	Jumper Wires
7	USB Cable

## Arduino → 7447 (BCD Inputs)

7447 Input	7447 Pin	Arduino Pin
A (LSB)	7	D5
B	1	D6
C	2	D7
D (MSB)	6	D8

## 7447 Power & Control Pins

- 7447 pin 16 (VCC) → +5V
- 7447 pin 8 (GND) → GND
- pin 3 (LT) → +5V
- pin 4 (BI/RBO) → +5V
- pin 5 (RBI) → +5V

## 7447 → Seven Segment (Common Anode)

- Connect both COM pins of the 7-segment display → +5V
- Connect 7447 outputs to segments **through 220Ω resistors**:

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7447 Output	7447 Pin	Segment
a	13	A
b	12	B
c	11	C
d	10	D
e	9	E
f	15	F
g	14	G

---

## Logic Description

- From Boolean simplification:

$$f = \overline{Q + R}$$

- To show  $f$  on 7-segment using 7447, we send BCD:

$$f = 0 \Rightarrow DCBA = 0000 \Rightarrow \text{Display } 0$$

$$f = 1 \Rightarrow DCBA = 0001 \Rightarrow \text{Display } 1$$

## Arduino Source Code (Auto Cycling)

```
#include <Arduino.h>
```

```
const int A_pin = 5;
const int B_pin = 6;
const int C_pin = 7;
const int D_pin = 8;
```

```
void setup() {
  pinMode(A_pin, OUTPUT);
  pinMode(B_pin, OUTPUT);
  pinMode(C_pin, OUTPUT);
  pinMode(D_pin, OUTPUT);
}
```

```
void loop() {
  for (int n = 0; n < 8; n++) {

    int P = (n >> 2) & 1;
    int Q = (n >> 1) & 1;
    int R = (n >> 0) & 1;
```

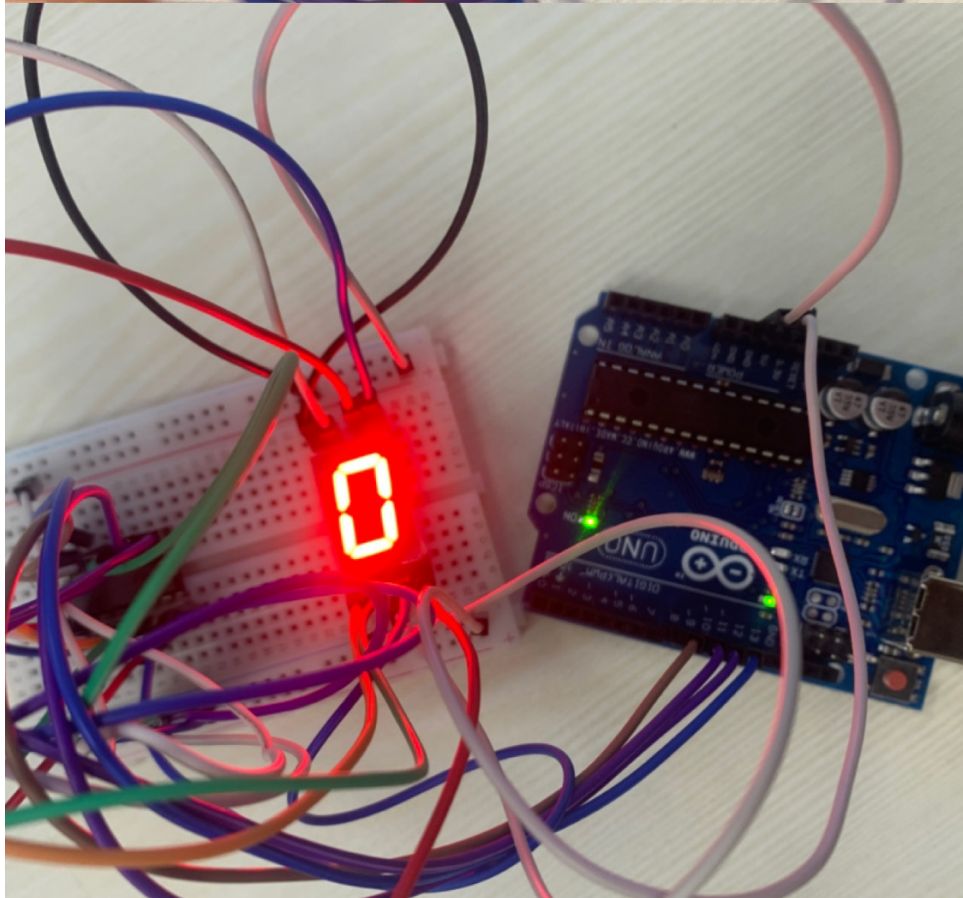
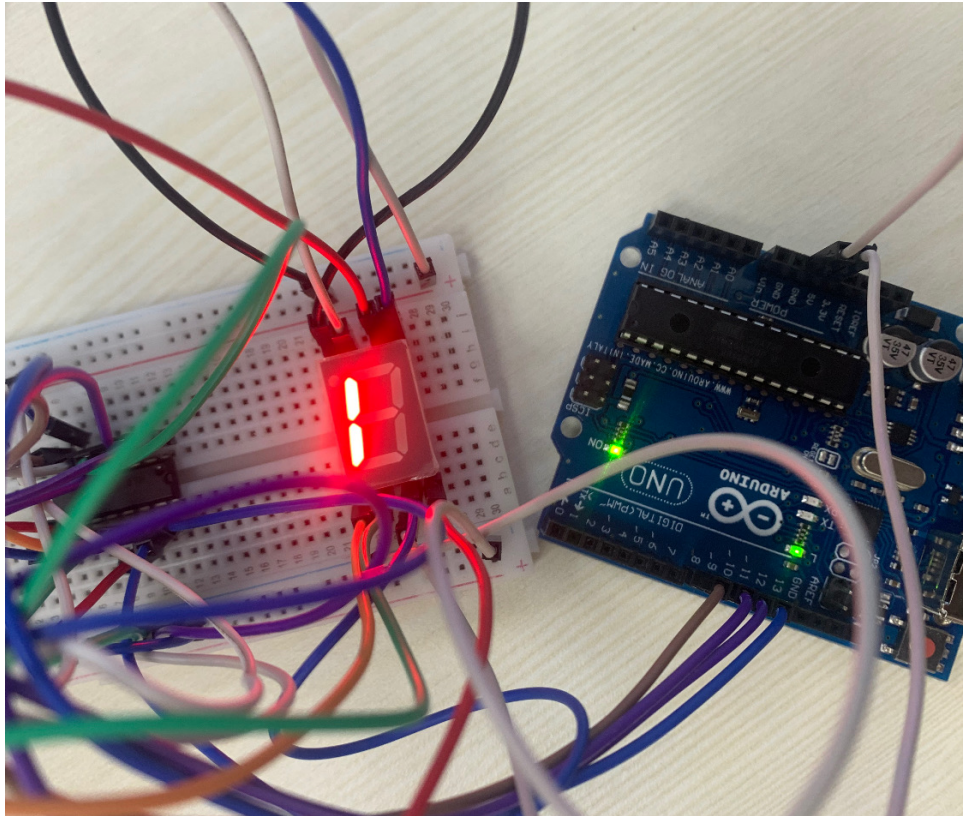
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```
int f = !(Q || R);

digitalWrite(A_pin, f);
digitalWrite(B_pin, LOW);
digitalWrite(C_pin, LOW);
digitalWrite(D_pin, LOW);

delay(1000);
}
}
```

## Setup / Output Image



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## Experimental Truth Table

$P$	$Q$	$R$	Observed $f$ (7-seg)
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

## Conclusion

From the truth table and hardware verification, the NOR circuit output is confirmed as:

$$f = \overline{Q + R}$$

Hence the correct option is  $\overline{Q + R}$ .