**Name: K.Saisusmitha**
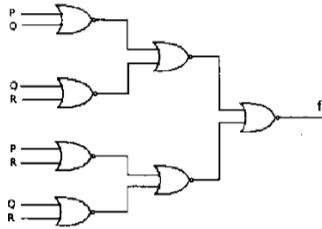**Batch: 2**
**ID: cometfwc018**
**Date: 9th July 2025**

# GATE CS 2010 – Question Number 31

## Question

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



**Figure: NOR Gate Logic Circuit**

## Solution

Let us denote:

$$A = \overline{P+Q}$$
$$B = \overline{Q+R}$$
$$C = \overline{A+B} = \overline{\overline{P+Q} + \overline{Q+R}}$$
$$D = \overline{P+R}$$
$$E = \overline{Q+R}$$
$$F = \overline{D+E} = \overline{\overline{P+R} + \overline{Q+R}}$$
$$f = \overline{C+F}$$

Substitute step-by-step:

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

This is a complex NOR-based logic expression. Let us test this against options. Let us evaluate for all combinations.

## Truth Table

| P | Q | R | f |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

**Truth Table of the Circuit**

This matches the output of option (A): $\overline{Q+R}$

## Correct Option: (A) $\overline{Q+R}$

## Hardware Implementation: Raspberry Pi Pico2W

## Components Required

| Component | Quantity |
|---|---|
| Raspberry Pi Pico2W / Arduino Uno | 1 |
| Push Buttons (Inputs for P, Q, R) | 3 |
| LED (Output indicator for f) | 1 |
| 220Ω Resistors (for LED current limiting) | 1 |
| 10kΩ Resistors (for button pull-downs) | 3 |
| Breadboard | 1 |
| Jumper Wires (Male-to-Male) | As required |
| USB Cable (Micro USB / USB-B for upload) | 1 |

**Table: Components Used for Hardware Implementation**

| Component | GPIO Pin | Role |
|-----------|----------|------|
| Button P | GP14 | Input |
| Button Q | GP15 | Input |
| Button R | GP16 | Input |
| LED f | GP13 | Output |
| GND | GND | Common ground |
| 3.3V | 3.3V | Pull-up |

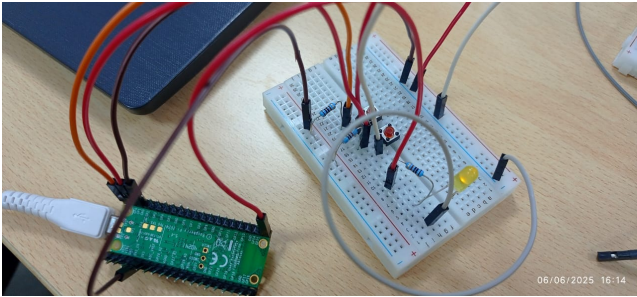**Pico2W Connection Table**



**Figure: Implementation of NOR logic circuit**

# GPIO Pin Connections (Pico2W)

## Upload Steps

1. Connect Pico2W via USB while holding BOOTSEL.

2. Flash MicroPython UF2 firmware.

3. Open Thonny IDE and select Pico2W.

4. Write logic for $\overline{Q+R}$ using digital inputs.

5. Observe LED output for input combinations.

# Hardware Implementation:Arduino Uno

## GPIO Connections

| Component | Arduino Pin | Role |
|-----------|-------------|------|
| Button P | D2 | Input |
| Button Q | D3 | Input |
| Button R | D4 | Input |
| LED f | D5 | Output |
| GND | GND | Ground |
| VCC | 5V | Pull-up |

**Arduino Pin Configuration**

## Upload Steps

1. Connect Arduino Uno via USB.

2. Open Arduino IDE, select port and board.

3. Write code for logic: $\overline{Q+R}$.

4. Upload and test using push buttons and LED.

# GitHub Repository

You can find the source files, circuit diagrams, and code at:
`https://github.com/aisusmitha/FWC.git`

# Conclusion

This question involved a multi-level NOR gate circuit. By simplifying step-by-step and evaluating truth table, we found that the expression simplifies to $\overline{Q+R}$. Hardware implementation verified using Raspberry Pi Pico2W and Arduino Uno confirms the correct logical behavior.

**Final Answer: (A)** $\overline{Q+R}$