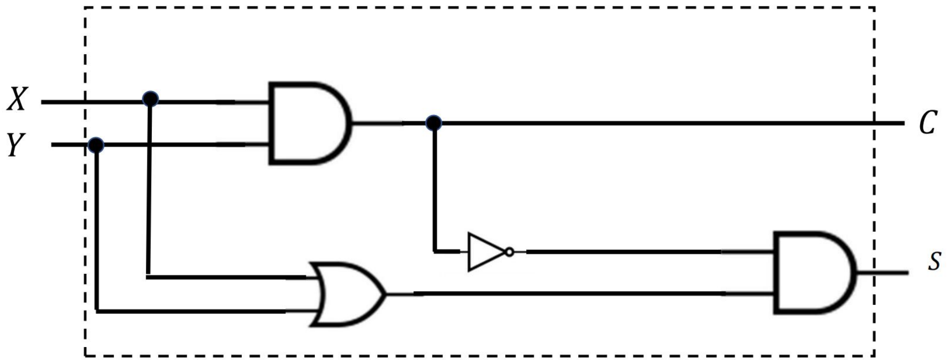
# Circuits

250H

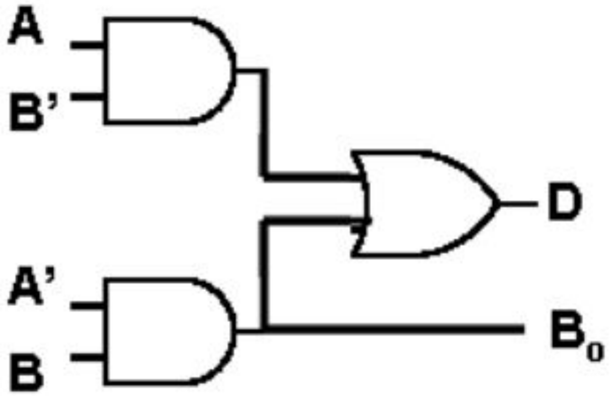
# Half Adders

| X | Y | C | S |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |



# Half Subtractors

| X | Y | D | B |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |



# Exclusive OR

| X | Y | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

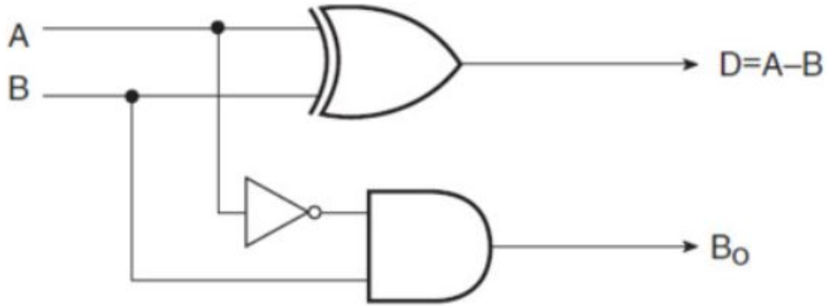
# Exclusive OR

| X | Y | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

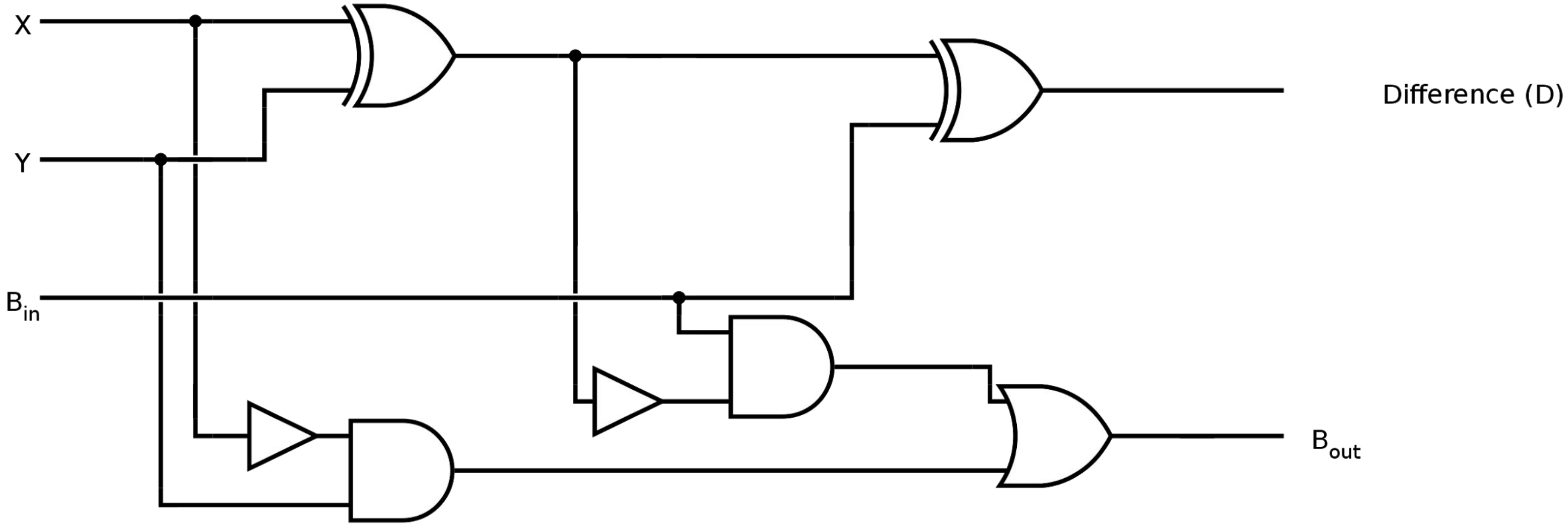
Wait didn’t we just see that column

# Half Subtractors

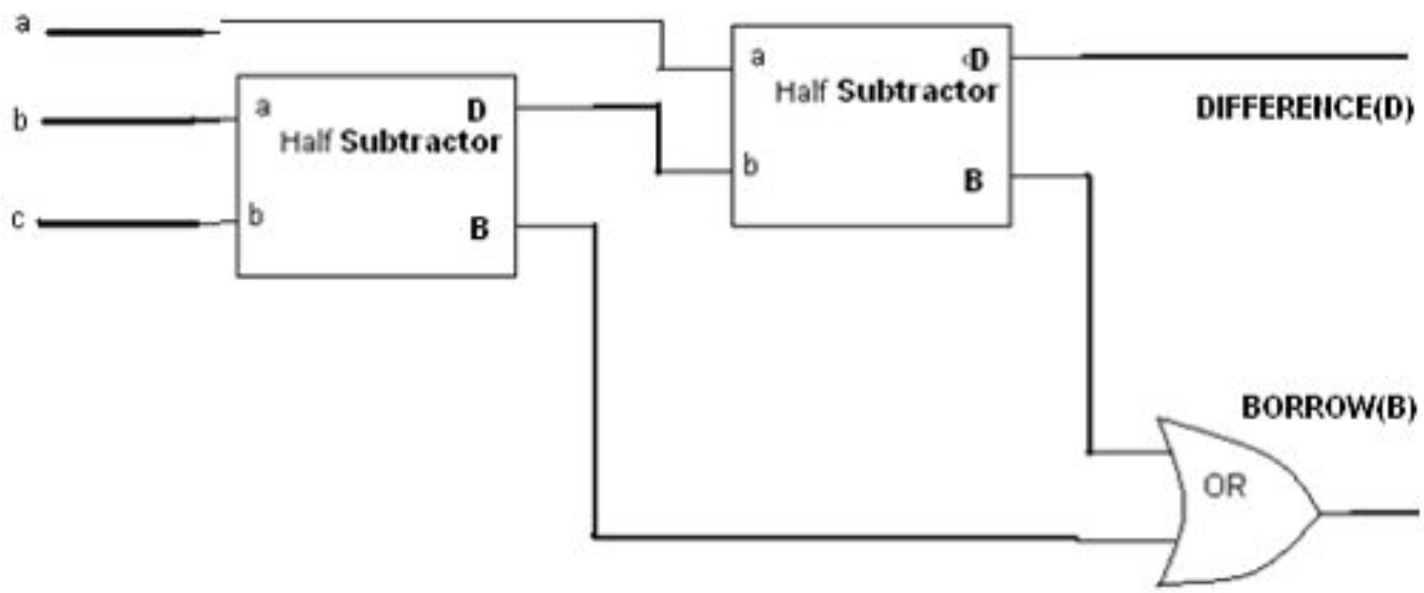
| X | Y | D | B |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |



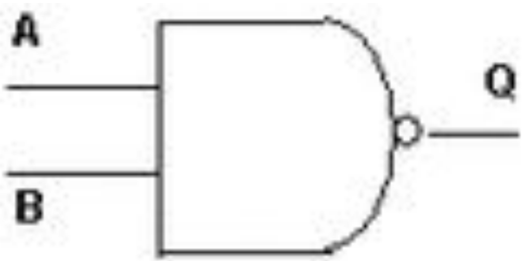
# Full Subtractors



# Full Subtractors

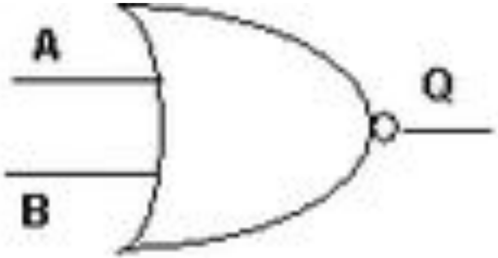


# Nand and Nor




NAND

| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |




NOR

| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

# Nand and Nor

- Any circuit can be created with only Nand and Nor gates

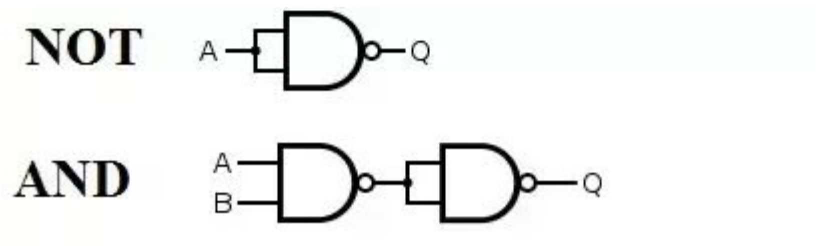
# Nand and Nor

- Any circuit can be created with only NAND and NOR gates
- In Breakout Rooms, Try and create NOT, AND, and OR using only NAND gates
    - This one was my fault
    - MAKE FRIENDS AND TALK TO EACH OTHER!!!!
    - STOP BEING ME

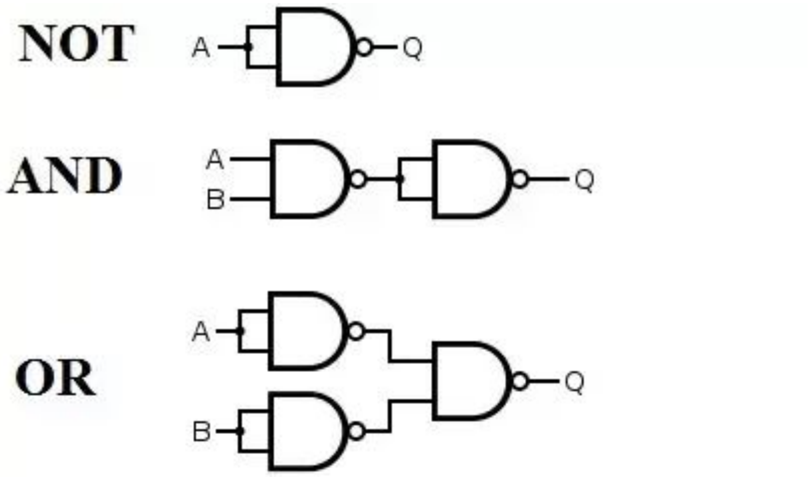
# Building Gates with NAND

NOT 

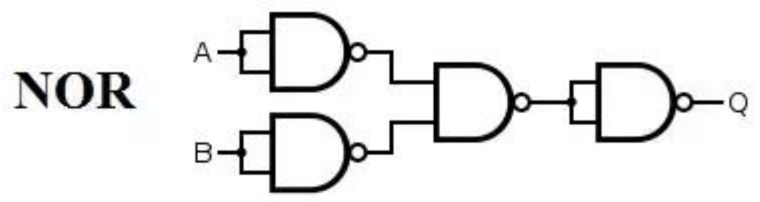
# Building Gates with NAND



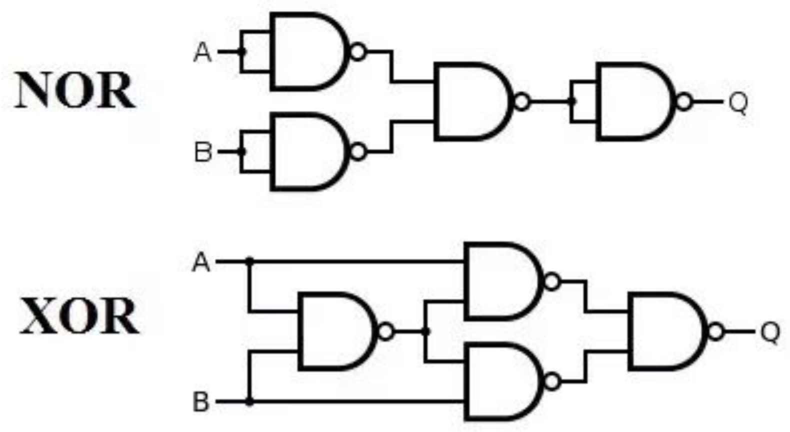
# Building Gates with NAND



# Building Gates with NAND



# Building Gates with NAND



# Boolean Algebra Identities

□ **TABLE 3**
**Basic Identities of Boolean Algebra**

| | | | | |
|---|---|---|---|---|
| 1. | $X + 0 = X$ | 2. | $X \cdot 1 = X$ | |
| 3. | $X + 1 = 1$ | 4. | $X \cdot 0 = 0$ | |
| 5. | $X + X = X$ | 6. | $X \cdot X = X$ | |
| 7. | $X + \overline{X} = 1$ | 8. | $X \cdot \overline{X} = 0$ | |
| 9. | $\overline{\overline{X}} = X$ | | | |
| 10. | $X + Y = Y + X$ | 11. | $XY = YX$ | Commutative |
| 12. | $X + (Y + Z) = (X + Y) + Z$ | 13. | $X(YZ) = (XY)Z$ | Associative |
| 14. | $X(Y + Z) = XY + XZ$ | 15. | $X + YZ = (X + Y)(X + Z)$ | Distributive |
| 16. | $\overline{X + Y} = \overline{X} \cdot \overline{Y}$ | 17. | $\overline{X \cdot Y} = \overline{X} + \overline{Y}$ | DeMorgan's |

# Prove using Algebraic Manipulation

| | | | | | |
|---|---|---|---|---|---|
| 1. | $X + 0 = X$ | 2. | $X \cdot 1 = X$ | |
| 3. | $X + 1 = 1$ | 4. | $X \cdot 0 = 0$ | |
| 5. | $X + X = X$ | 6. | $X \cdot X = X$ | |
| 7. | $X + \overline{X} = 1$ | 8. | $X \cdot \overline{X} = 0$ | |
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| 10. | $X + Y = Y + X$ | 11. | $XY = YX$ | Commutative |
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$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

# Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

# Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}(\bar{Y} + Y) + Y(\bar{X} + X) = \bar{X} + Y$$

# Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\left(\bar{Y} + Y\right) + Y\left(\bar{X} + X\right) = \bar{X} + Y$$

$$\bar{X}(1) + Y(1) = \bar{X} + Y$$

Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}(\bar{Y} + Y) + Y(\bar{X} + X) = \bar{X} + Y$$

$$\bar{X}(1) + Y(1) = \bar{X} + Y$$

$$\bar{X} + Y = \bar{X} + Y$$

# Let's Check with Truth Tables

| X | $\bar{X}$ | Y | $\bar{Y}$ | $\bar{X}\bar{Y} + \bar{X}Y + XY$ | $\bar{X} + Y$ |
|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 1 |

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

# Let's Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?

# Let's Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8

# Let's Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8
- How many gates on the right?

# Let's Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8
- How many gates on the right?
  - 2

# Let's Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8
- How many gates on the right?
  - 2
- 2 is much better than 8