3.10 Equations to/from circuits

Equations to circuits

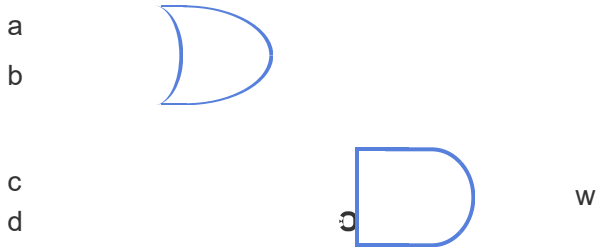
An equation is one way to represent a Boolean function. Another way is using a circuit.

An equation can be converted to a circuit by converting each operation to a gate. Conversion is done first for items within p term like cd', NOT is converted before AND or OR.

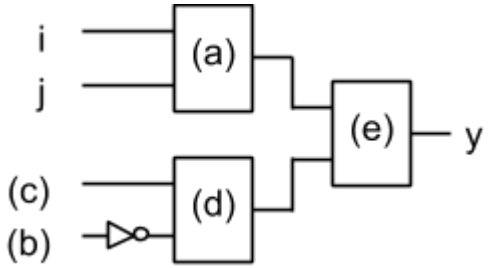
PARTICIPATION ACTIVITY 3.10.1: Convert equation to circuit.

Start 2x speed

w = (a + b)cd'



PARTICIPATION ACTIVITY 3.10.2: Converting an equation to a circuit.



Use the figure above to determine the missing value.
Original equation: y = ij + mn'

1) (a)

- AND
- OR
- NOT

2) (b)

- m
- n
- mn'
- i

3) (c)

- m
- n
- mn'
- i

4) (d)

- AND
-

OR

NOT

5) (e)

AND

OR

NOT

Example: Airbag enabler

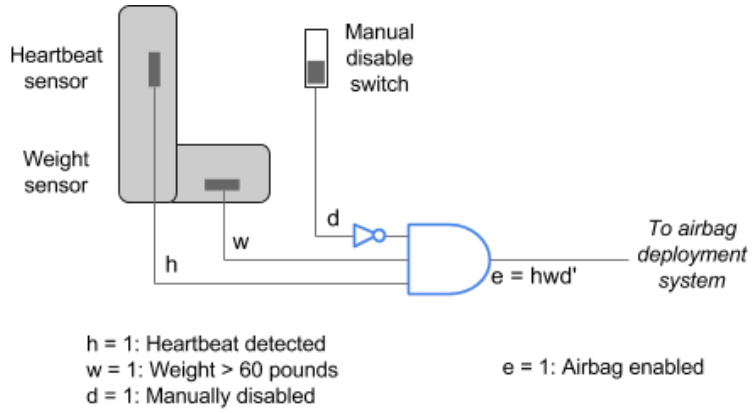
Figure 3.10.1: Airbags deployed.

Cars have airbags that deploy during an accident to reduce injuries to occupants. Airbags can harm kids, and aren't needed objects. Thus, cars have sensors to help detect whether an airbag should be enabled by a large enough human being seate

seat back sensor detects a heartbeat (h = 1). A seat bottom sensor indicates if over 60 pounds is detected (w = 1). A switch manually disable the airbags (d = 1). An output e indicates that the airbag is enabled (e = 1).

A designer specifies the system as: e = hwd' (heartbeat detected, and enabled if weight over 60, and not manually disabled)

Figure 3.10.2: Airbag enabler system.



PARTICIPATION ACTIVITY 3.10.3: Airbag example.

1) What is h if a heartbeat is detected?

Check Show answer

2) What is w if the sensed weight is 30 pounds?

Check Show answer

3) What is e if h = 1, w = 1, and d = 1?

Check Show answer

4) e becomes an input to another system, the airbag deployment system. That system has another input to detect a hard front-end collision (c = 1). That system's output a should be 1 if a hard collision is detected and the airbag is enabled. Write the equation for a.

Check Show answer

5) Write an equation to deploy the airbag (a = 1) only if a collision is detected (c = 1) and the airbag is enabled. Use input variables h, w, d, c only (do not use e). Order input variables alphabetically. Do not use parentheses.

Check Show answer

6) A light illuminates if the airbag is disabled. Which is the appropriate equation to turn on the light (o = 1)?
o = h'w'd
o = (hwd')'

(Note: Answer by re-typing one of the equations provided)

Check Show answer

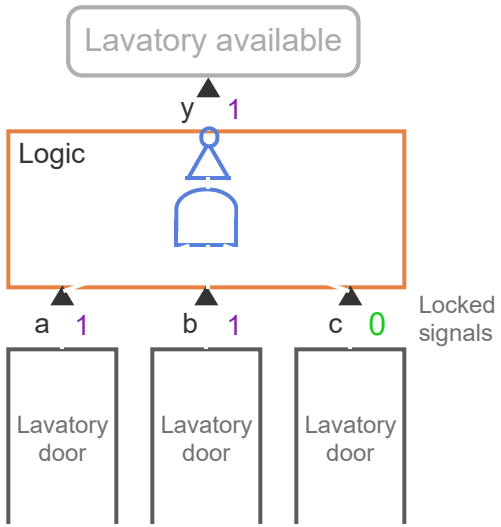
Example: Aircraft lavatory sign

Airplanes typically have a lighted sign to let passengers know if at least one of several lavatories (bathrooms) is available, s passengers can choose to stay seated until a bathroom becomes available. A designer may think about the logic as follows locked, the sign should be off, otherwise the sign should be on. From that thought, the designer may create an equation.

PARTICIPATION ACTIVITY 3.10.4: Aircraft lavatory sign.

Start 2x speed

y = (abc)'



PARTICIPATION ACTIVITY 3.10.5: Lavatory sign example.

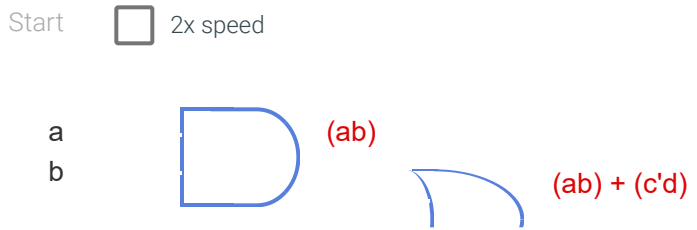
1) If a, b, c are all 1's, should the sign illuminate?
   - ○ Yes
   - ○ No

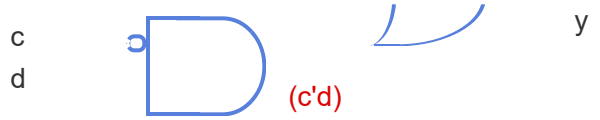
2) The designer created the equation y = (abc)', and then a circuit consisting of AND followed by ___.
   - ○ NOT
   - ○ OR

Circuits to equations

A circuit can be converted to an equation. Starting from the inputs, the process replaces gates by terms while moving towa labeling gate outputs along the way.

PARTICIPATION ACTIVITY 3.10.6: Circuit to equation.





y = (ab) + (c'd)

A circuit whose output value is determined solely by the present *combination* of input values is called a ***combinational circu*** combinational circuit is also called ***combinational logic***.

A circuit whose output values may depend on the past *sequence* of input values, and not just the present input values, is ca ***circuit***. This material discusses sequential circuits later.

PARTICIPATION ACTIVITY 3.10.7: Combinational vs. sequential circuits.

Indicate whether each description would involve a combinational or sequential circuit.

1) If one or more people are in a room, turn on the lights.
   - ○ Combinational
   - ○ Sequential

2) If the weight in an elevator exceeds 1500 pounds, sound an alarm.
   - ○ Combinational
   - ○ Sequential

3) If the sleep mode button is pressed and released, turn phone ringer off until the sleep mode button is pressed again.

- Combinational
- Sequential

4) Turn faucet on while motion is detected.
   - Combinational
   - Sequential

5) If the garage door button is pressed, turn motor on until garage door is fully opened.
   - Combinational
   - Sequential

CHALLENGE ACTIVITY 3.10.1: Convert the equation to a circuit.

Convert the equation provided to a circuit.

- Add gate to workspace: Click the gate image in the bottom-right.
- Create wire: Drag from a pin.
- Toggle input between 0 and 1: Click on input.
- Delete gate or wire: Select item then click "Delete selected item(s)".

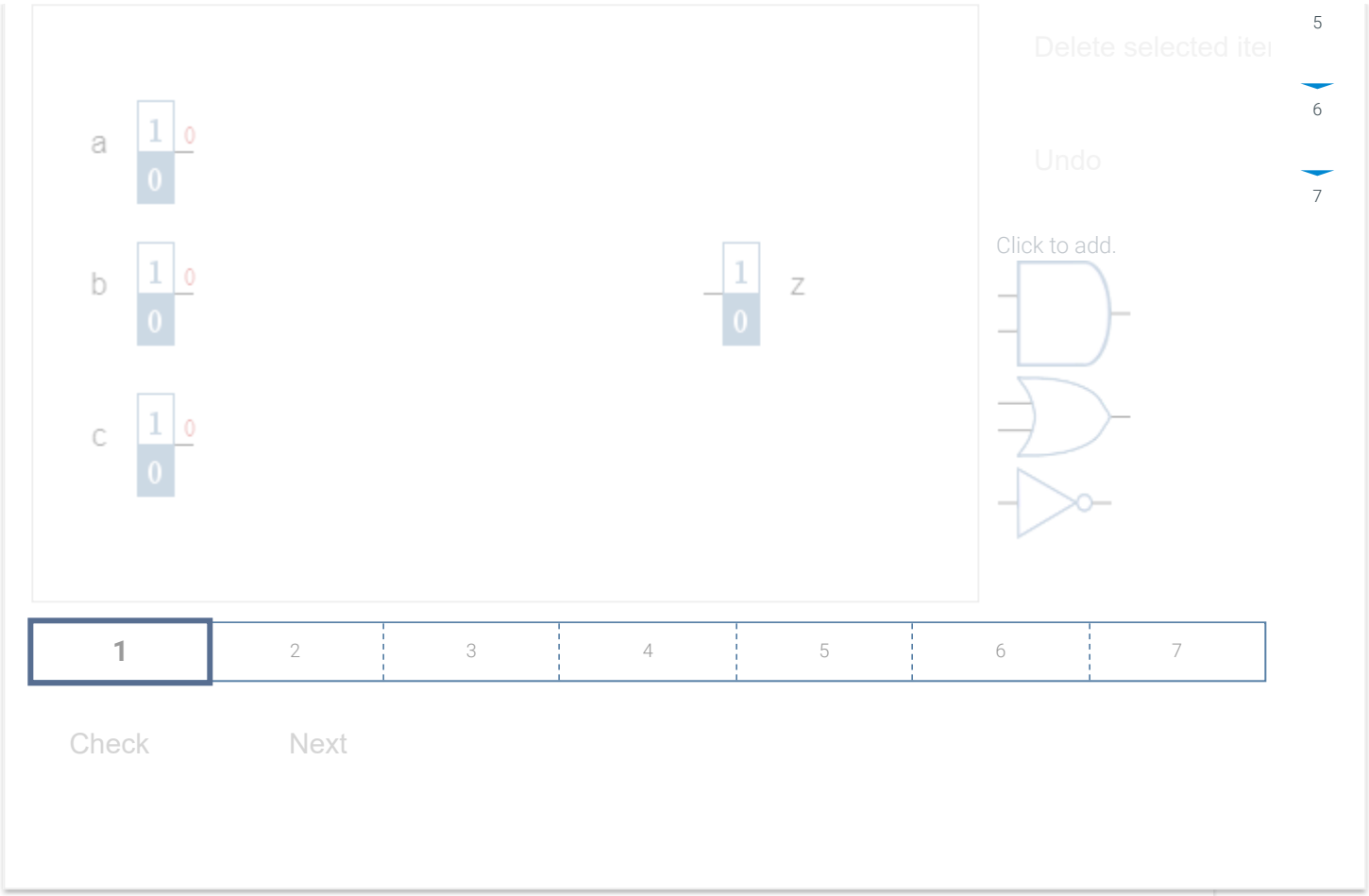
Start

1

2

3

4



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