Processor Performance Summary

Machine performance:

$$\text{CPU execution time for a program} = \text{Instructions for a program} * \text{CPI} * \frac{1}{\text{Clock rate}}$$

Better performance:

 number of instructions to implement computations

 CPI

 Clock rate

Improving performance must balance each constraint

Example: RISC vs. CISC

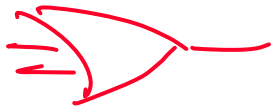
Motivation

Electronics an increasing part of our lives

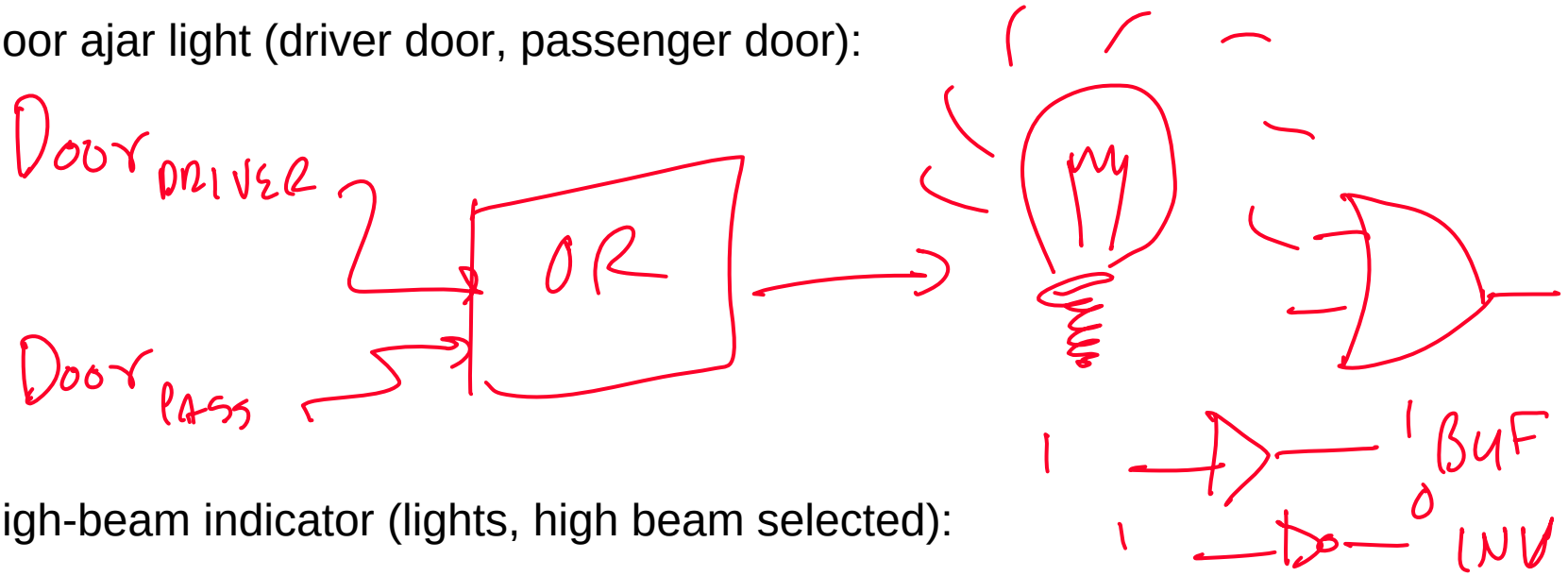
- Computers & the Internet
- Car electronics
- Robots
- Electrical Appliances
- Telephones

Class is an exercise in digital logic design & implementation

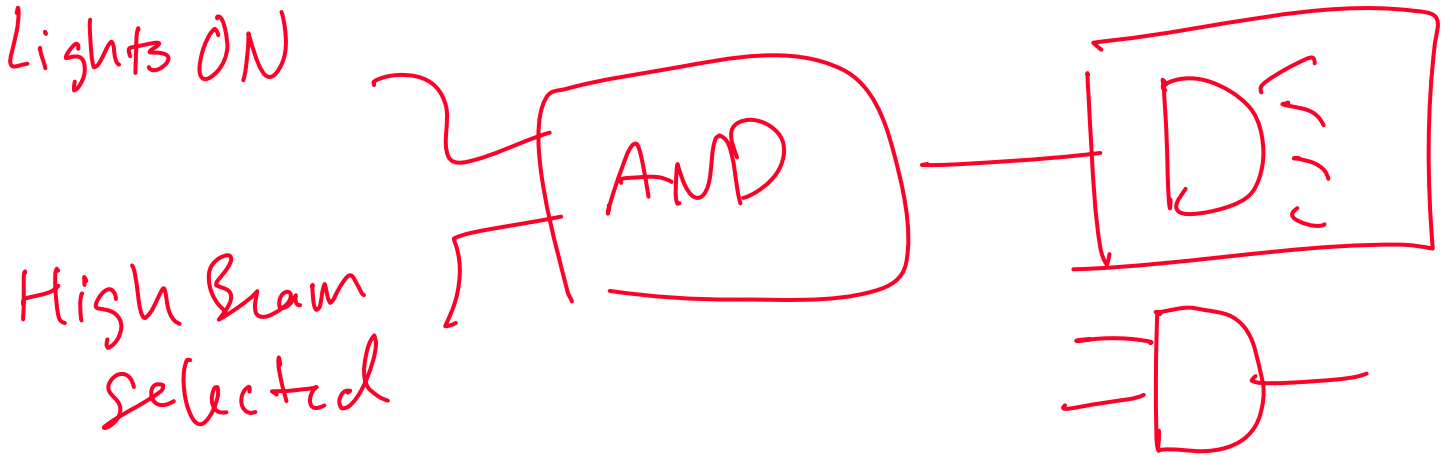
Example: Car Electronics



Door ajar light (driver door, passenger door):

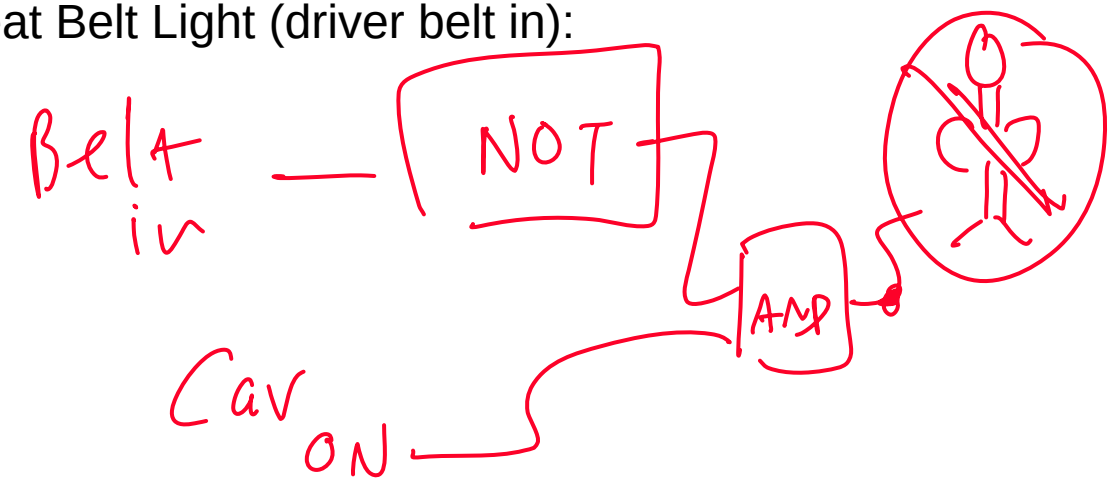


High-beam indicator (lights, high beam selected):

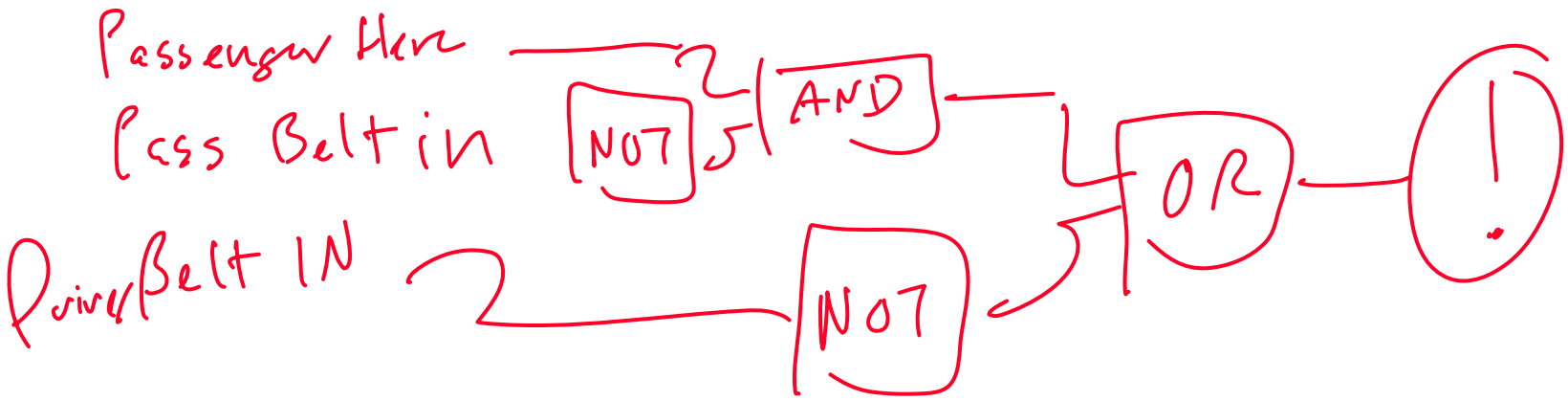


Example: Car Electronics (cont.)

Seat Belt Light (driver belt in):

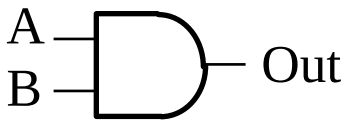


Seat Belt Light (driver belt in, passenger belt in, passenger present):



Basic Logic Gates

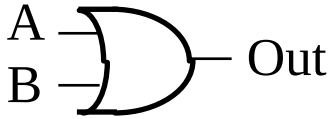
AND: If A and B are True, then Out is True



A	B	OUT
0	0	0
0	1	0
1	0	0
1	1	1

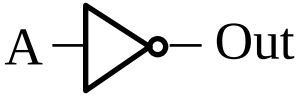
NAND

OR: If A or B is True, or both, then Out is True



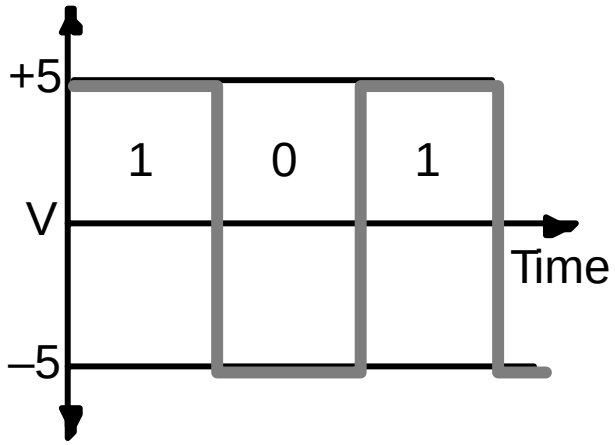
A	B	OUT
0	0	0
0	1	1
1	0	1
1	1	1

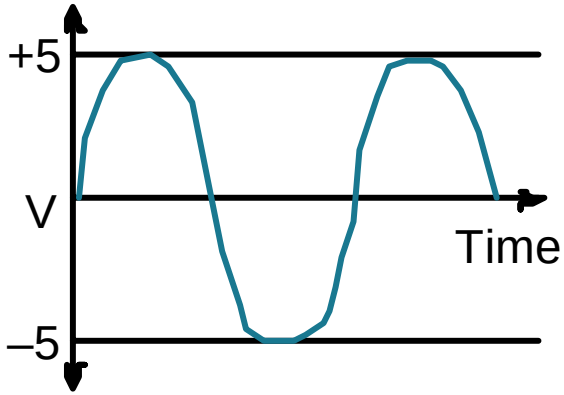
Inverter (NOT): If A is False, then Out is True



A	OUT
0	1
1	0

Digital vs. Analog





Digital:
only assumes discrete values

Analog:
values vary over a broad range continuously

Advantages of Digital Circuits

Analog systems:

- slight error in input yields large error in output

Digital systems:

- more accurate and reliable
- readily available as self-contained, easy to cascade building blocks

Computers use digital circuits internally

Interface circuits (i.e., sensors & actuators) often analog

Binary/Boolean Logic

- ***Two discrete values:***
  yes, on, 5 volts, TRUE, "1"
  no, off, 0 volts, FALSE, "0"

- ***Advantage of binary systems:***
  rigorous mathematical foundation based on logic

IF the garage door is open
AND the car is running
THEN the car can be backed out of the garage

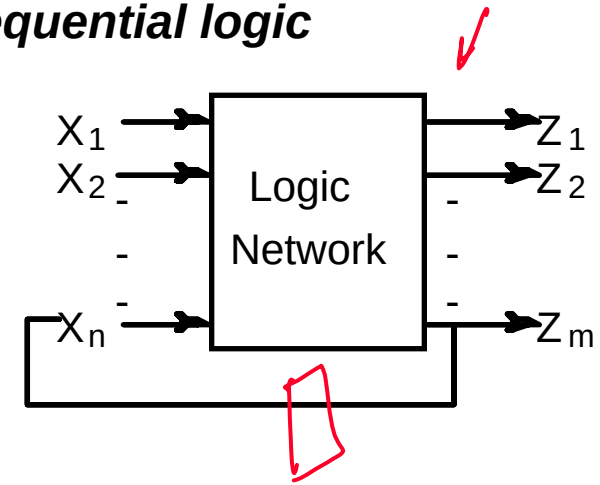
both the door must be open and the car running before I can back out

IF passenger is in the car
AND passenger belt is in
AND driver belt is in
THEN we can turn off the fasten seat belt light

the three preconditions must be true to imply the conclusion

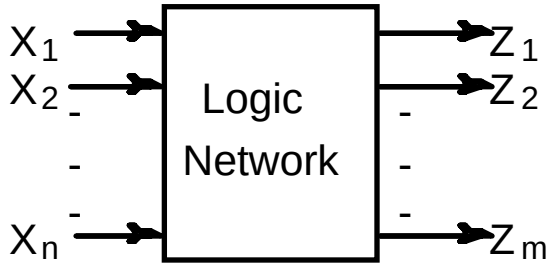
Combinational vs. Sequential Logic

Sequential logic



Network implemented from logic gates. The presence of feedback distinguishes between *sequential* and *combinational* networks.

Combinational logic

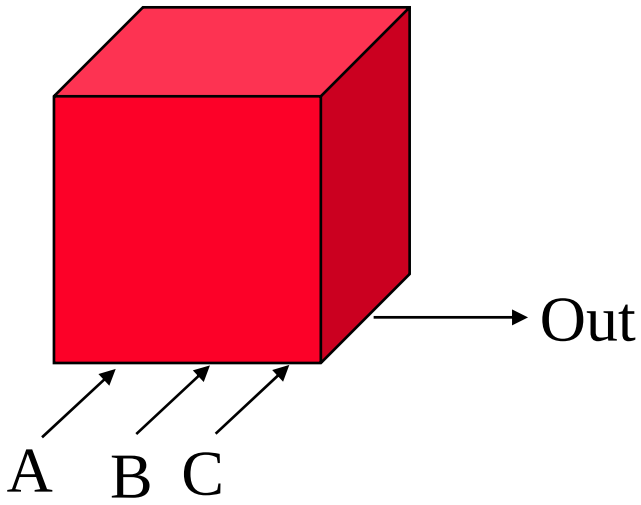


No feedback among inputs and outputs. Outputs are a function of the inputs only.

Black Box (Majority)

Given a design problem, first determine the function

Consider the unknown combination circuit a “black box”



Truth Table

A	B	C	Out
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

"Black Box" Design & Truth Tables

Given an idea of a desired circuit, implement it

Example: Odd parity - inputs: A, B, C, output: Out

A	B	C	OUT
0	0	0	0
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	1