Introduction

Philipp Koehn

29 August 2019

Administrative

- **Instructor:** Philipp Koehn (phi@jhu.edu)
- **TA:** TBD
- **Class:** Monday, Wednesday, Friday 10-10:50, Hackerman B17
- **Textbooks (recommended, not required):**
  - *"How Computers Work"*, Roger Young
  - *"Code"*, Charles Petzold
  - *"Computer Organization and Design"*, Patterson and Hennessy
  - *"Computer Systems"*, Bryant and O'Hallaron
- **Course web site:** http://www.cs.jhu.edu/~phi/csf/
- **Grading**
  - 7 assignments (10% each)
  - midterm exam (10%)
  - final exam (20%)

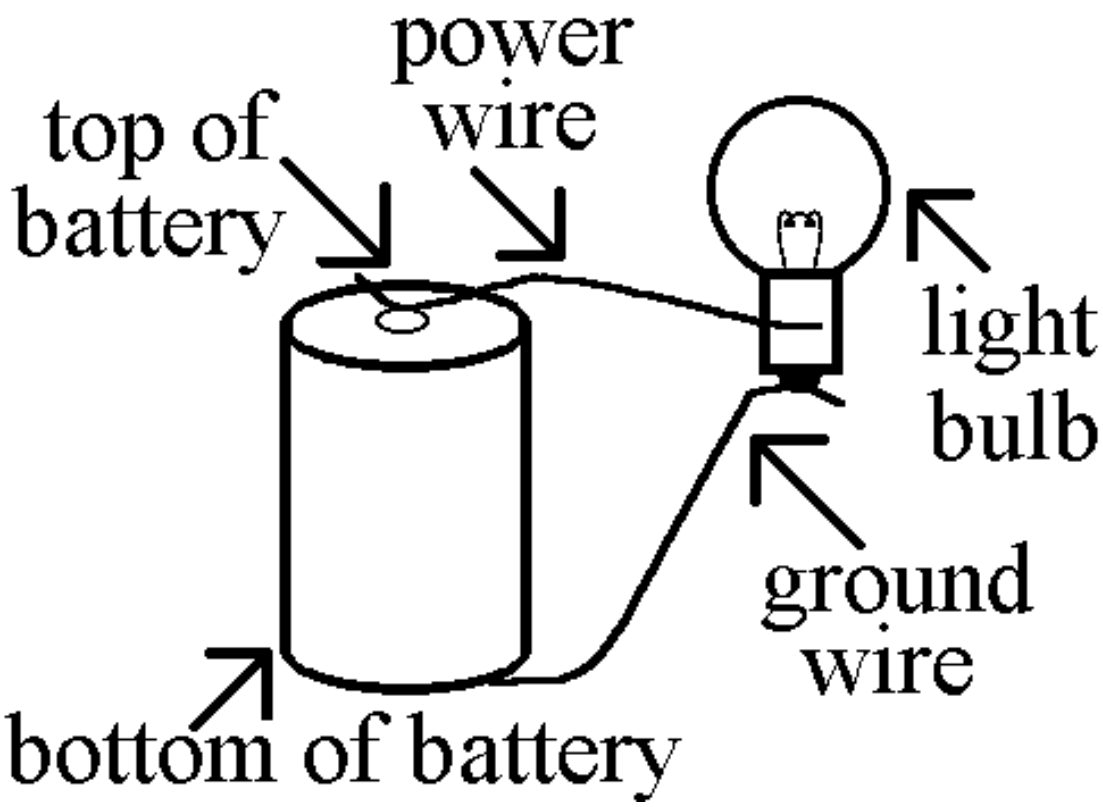
Magic?

Main Topic Areas

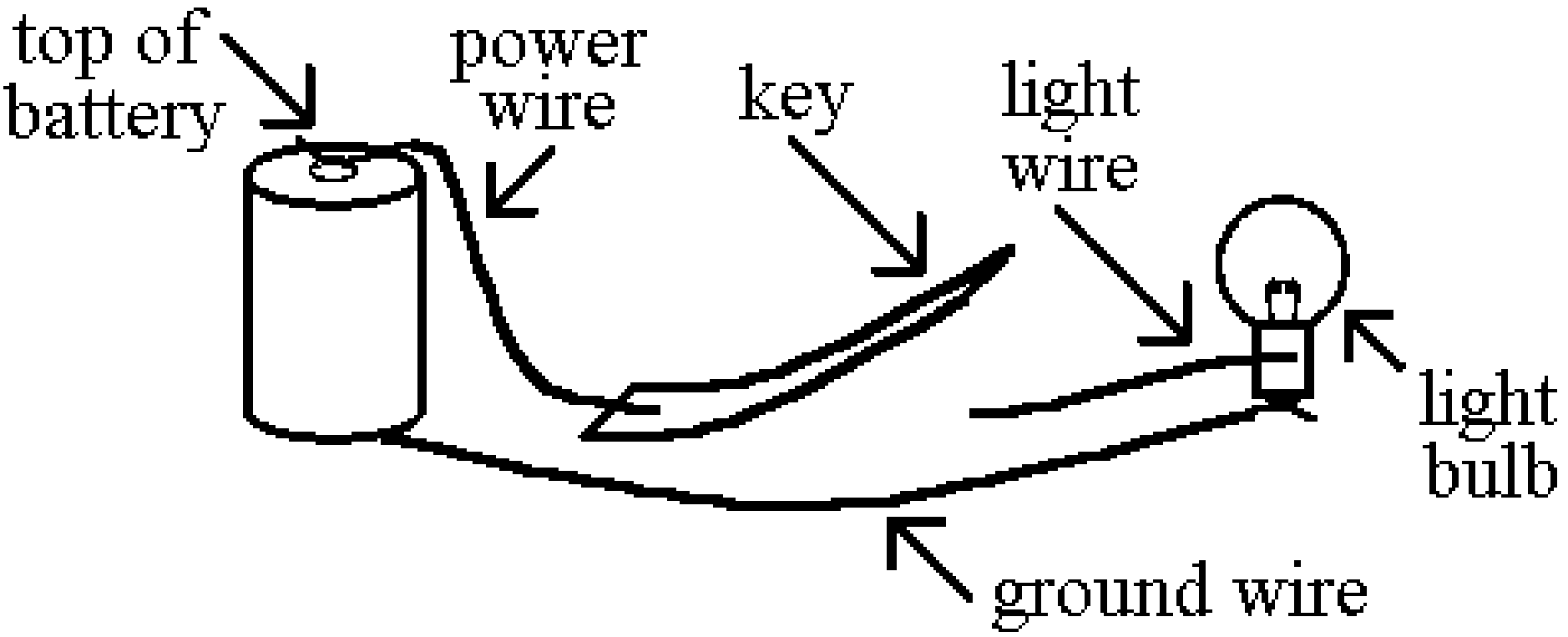
- Digital circuits (3 lectures)
- Programmable Processor (2 lectures)
- 6502 CPU: Stack, Subroutines (4 lectures)
- Midterm
- MIPS: Branch Prediction, Cache (10 lectures)
- x86: Dynamic Linking, Virtual Memory (8 lectures)
- Threads (3 lectures)
- Networking (3 lectures)

light bulb

Light Bulb


power
wire
top of
battery
light
bulb
ground
wire
bottom of battery

Light Bulb with Switch



0 and 1

What can you do with 0 and 1?

everything

Math

- Encode number with binary system

decimal	binary
0	0
1	1
2	10
3	11
4	100
8	1000
16	1 0000
32	10 0000
64	100 0000
128	1000 0000
255	1111 1111

It's good to know the powers of 2:

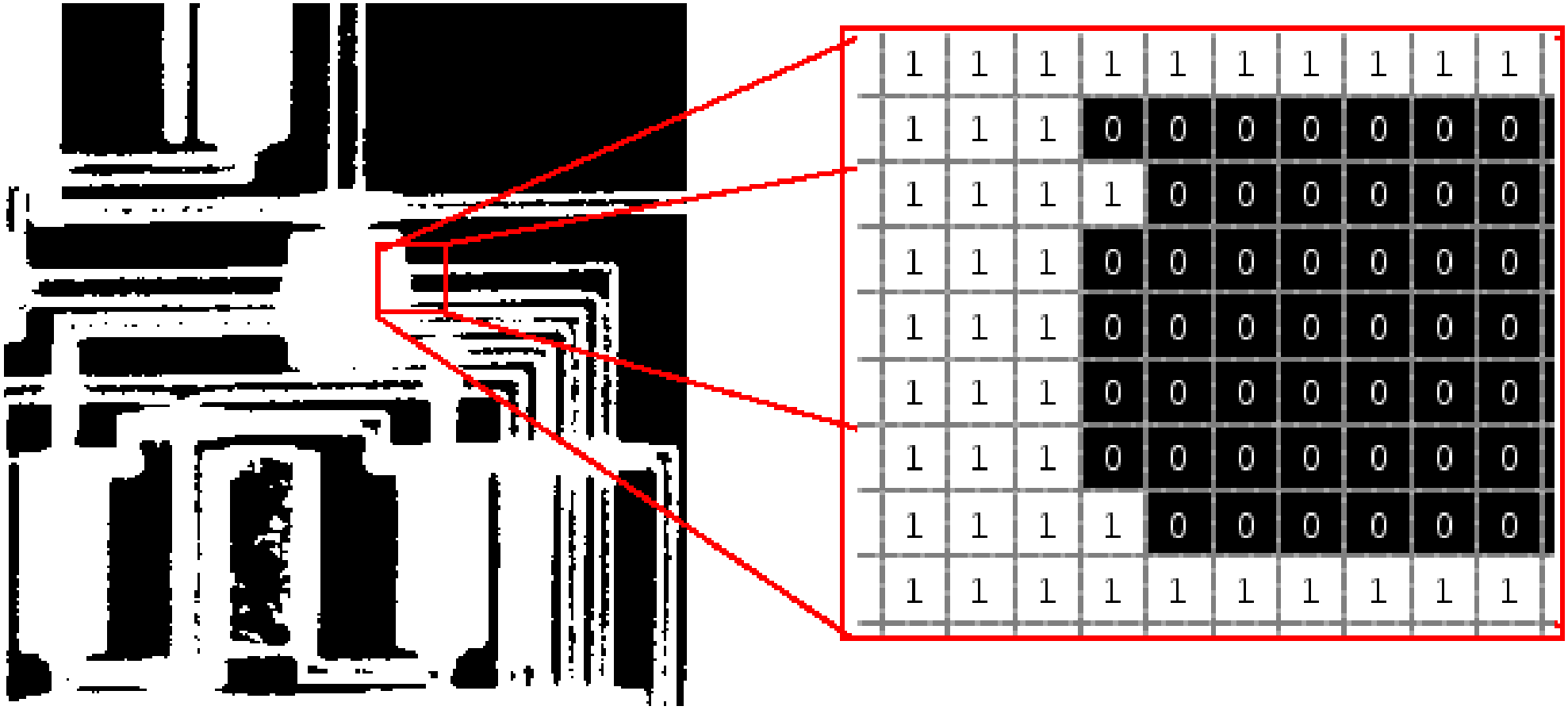
$2^9 = 512,\ 2^{10} = 1024,\ 2^{11} = 2048,\ 2^{12} = 4096$

$2^{13} = 8192,\ 2^{14} = 16384,\ 2^{15} = 32768,\ 2^{16} = 65536$

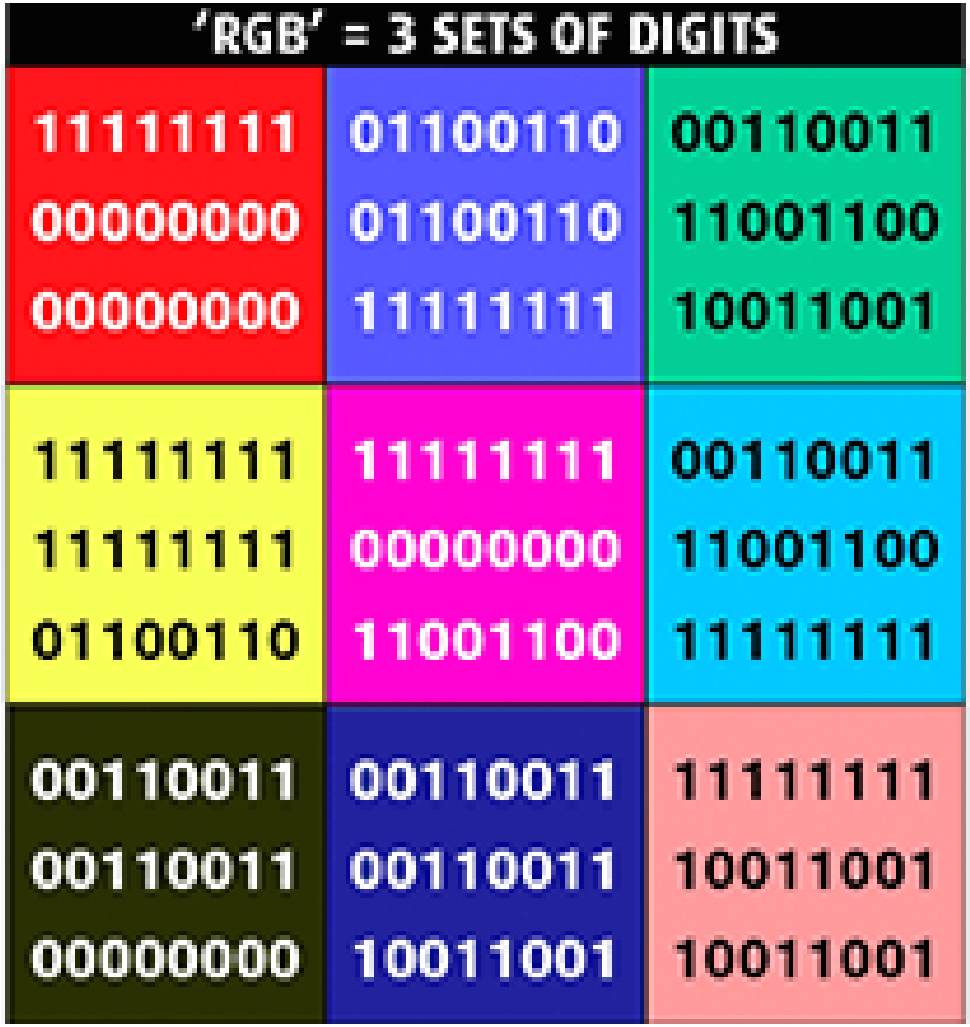
Text

ASCII	0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1	0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1	0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1	0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1
0 0 0 0	NU	SH	SX	EX
0 0 0 1	DL	D1	D2	D3
0 0 1 0		!	"	#
0 0 1 1	0	1	2	3
0 1 0 0	@	A	B	C
0 1 0 1	P	Q	R	S
0 1 1 0	`	a	b	c
0 1 1 1	p	q	r	s

Images


1 1 1 1 1 1 1 1 1 1
1 1 1 0 0 0 0 0 0 0
1 1 1 1 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 0
1 1 1 1 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1 1

Color


'RGB' = 3 SETS OF DIGITS
11111111 01100110 00110011
00000000 01100110 11001100
00000000 11111111 10011001
11111111 11111111 00110011
11111111 00000000 11001100
01100110 11001100 11111111
00110011 00110011 11111111
00110011 00110011 10011001
00000000 10011001 10011001

Boolean operators

AND

- Truth table

A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

OR

- Truth table

A	B	A OR B
0	0	0
0	1	1
1	0	1
1	1	1

NOT

- Truth table

A	NOT A
0	1
1	0

All you Need is AND, OR, NOT

- Truth table

A	B	A * B
0	0	1
0	1	0
1	0	0
1	1	0

- Operation: NOT (A OR B)

  (also called NOR)

All you Need is AND, OR, NOT

- Truth table

A	B	A * B
0	0	1
0	1	1
1	0	1
1	1	0

- Operation: NOT (A AND B)

  (also called NAND)

All you Need is AND, OR, NOT

- Truth table

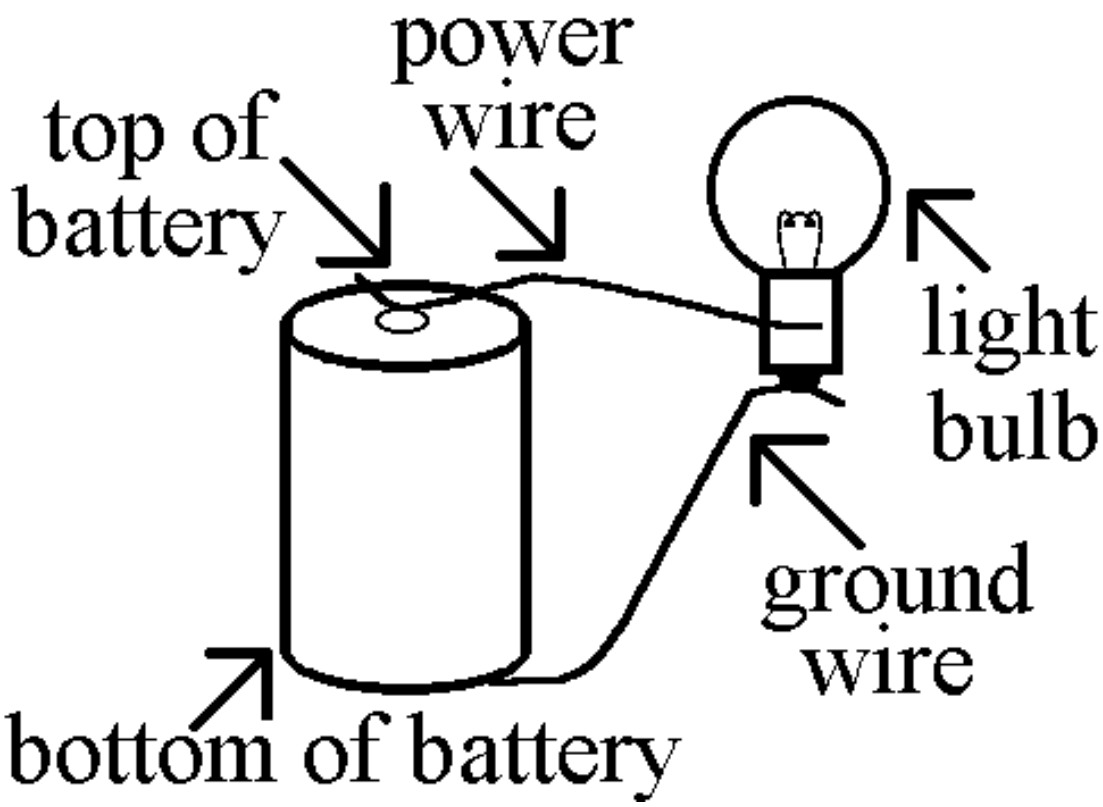
A	B	A * B
0	0	0
0	1	1
1	0	1
1	1	0

- Operation: (A OR B) AND NOT (A AND B)

  (also called XOR)

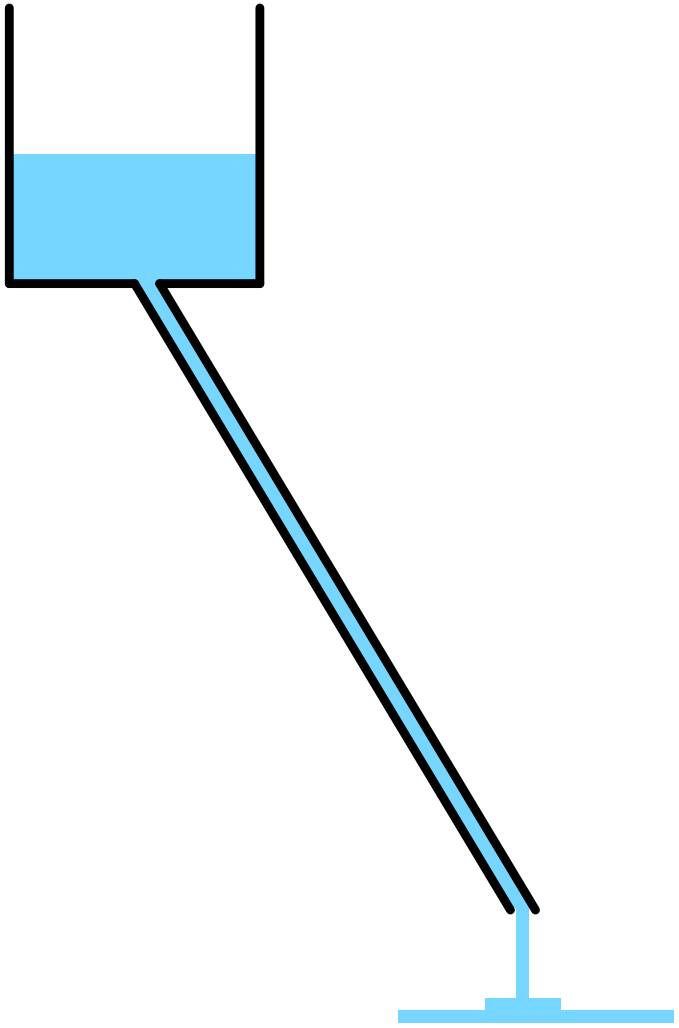
hardware

Still Magic?


power
wire
top of
battery
light
bulb
ground
wire
bottom of battery

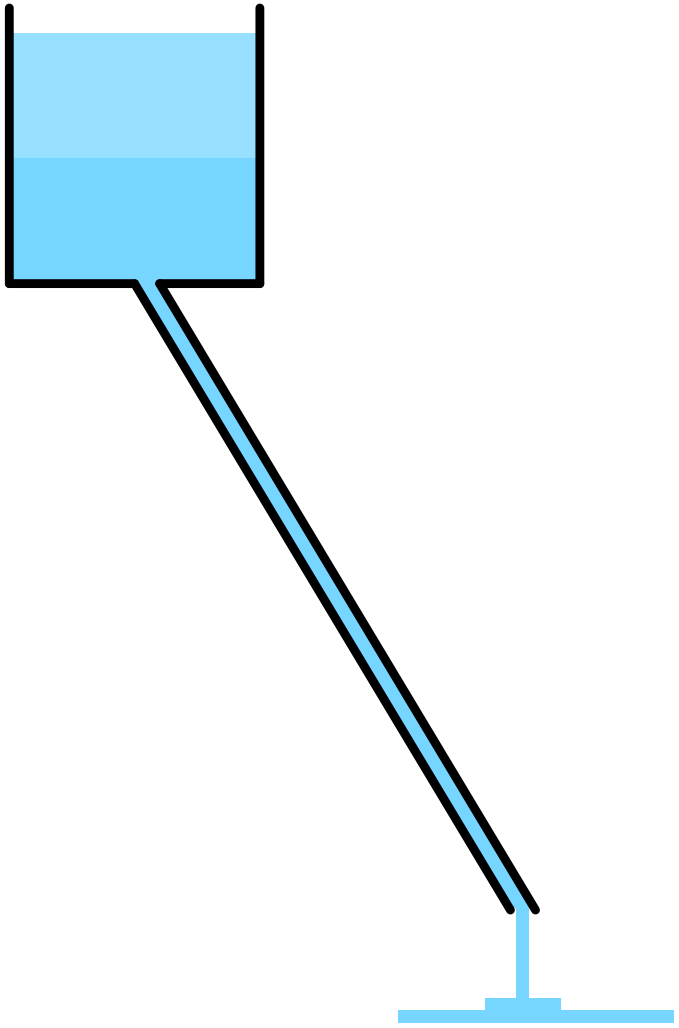
```
water
```

Flow of Water



- Water is stored in bucket
- Gravity pulls water through pipe
- Core concepts
  - water pressure
  - size of the pipe
  - amount of water flow per time unit

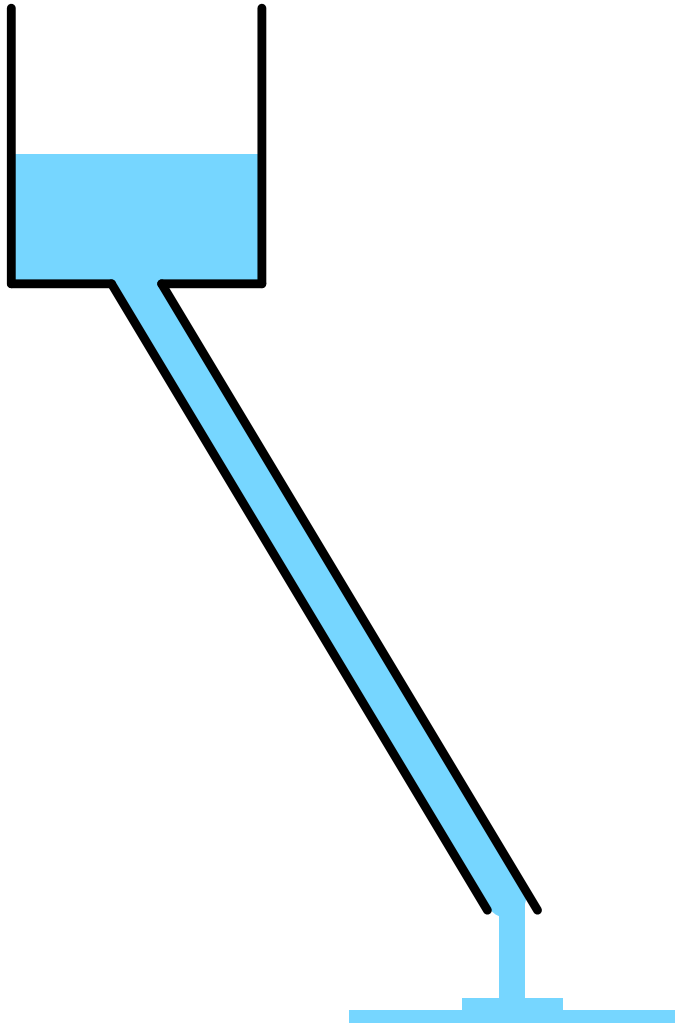
More Pressure



- Bucket filled twice as much
- Double water pressure

$\Rightarrow$ Double water flow

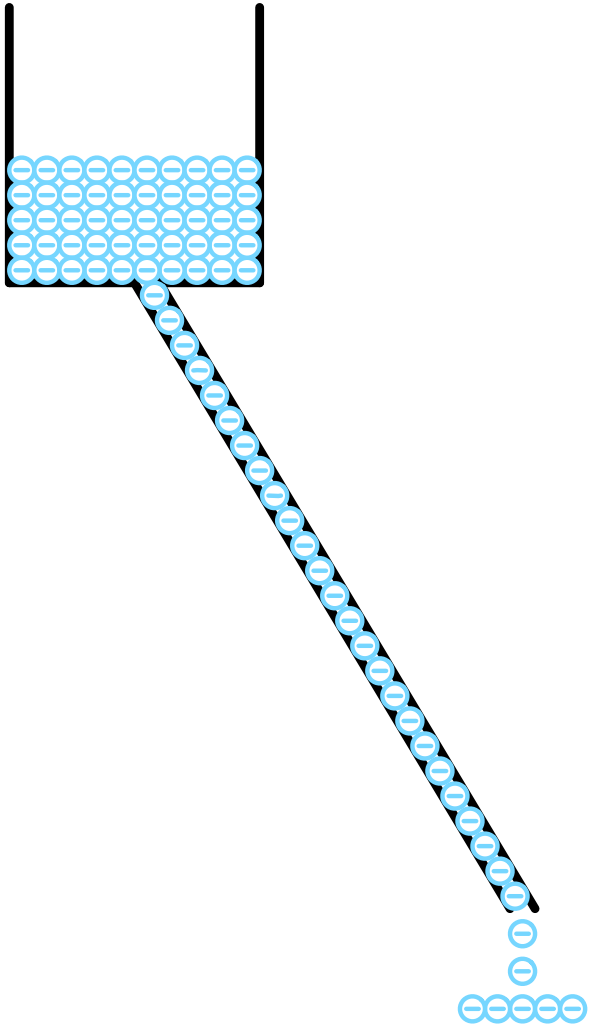
Bigger Pipe



- Pipe twice as big
- Twice as much water in pipe

$\Rightarrow$ Double water flow

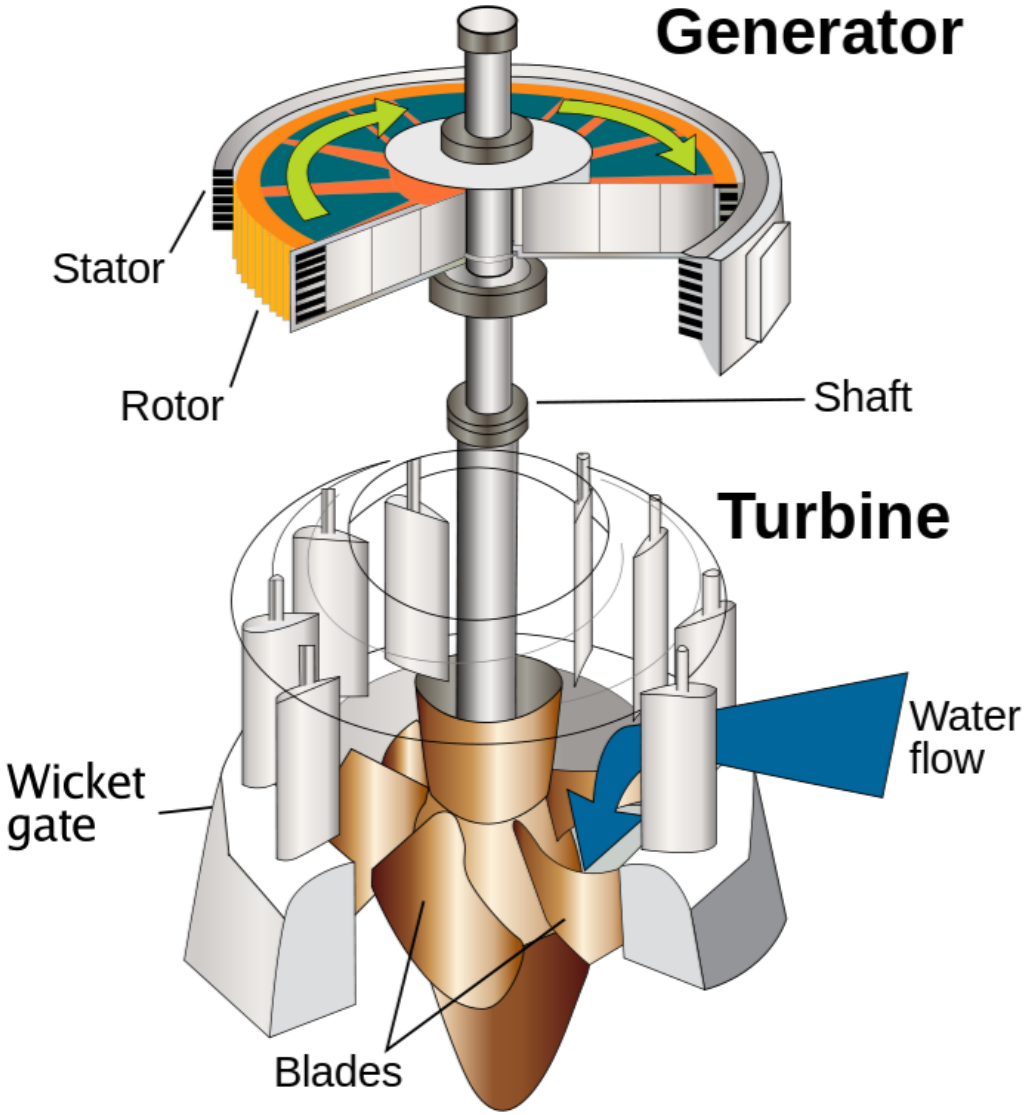
Electricity



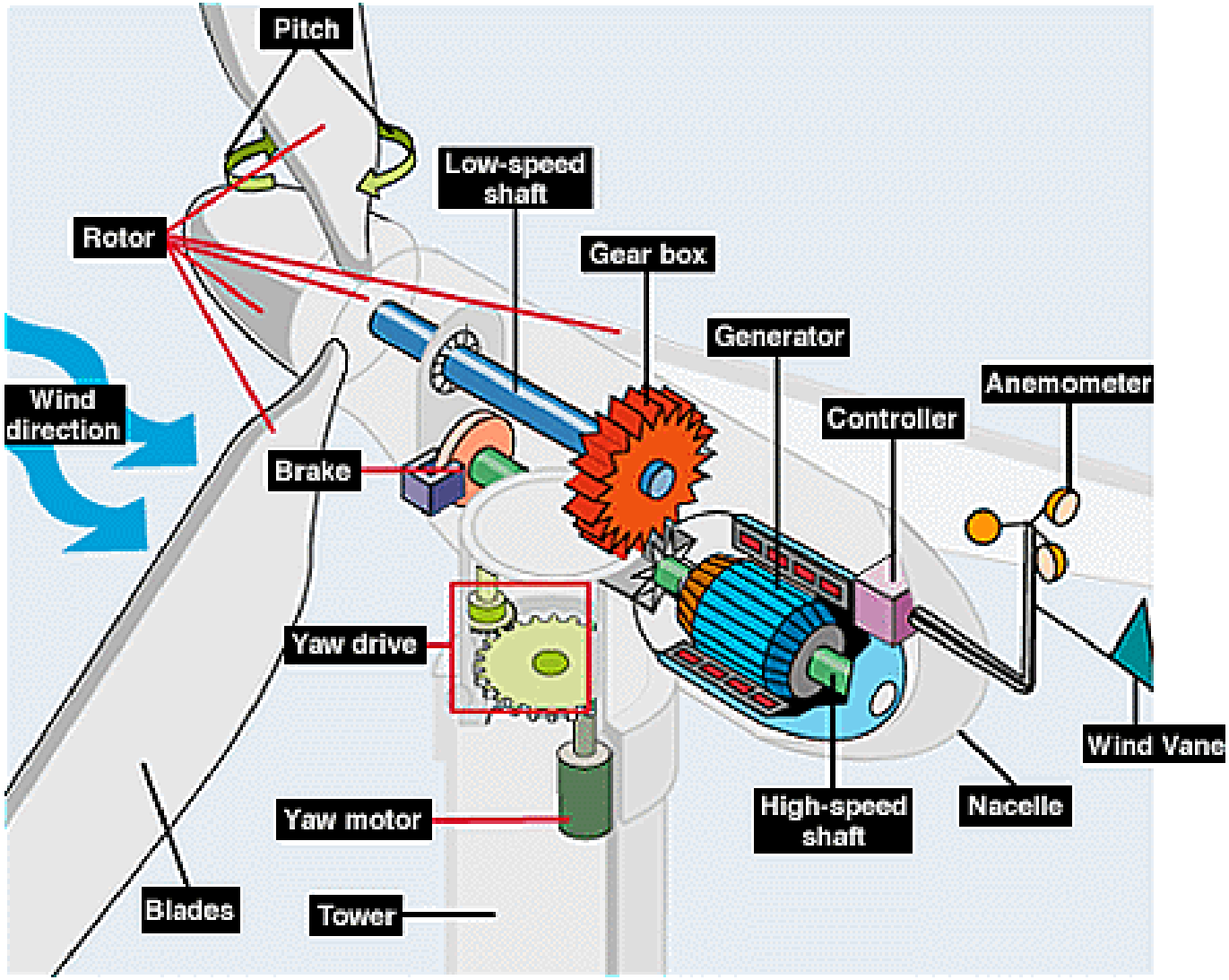
- Electrons are stored in battery
- Electric field pulls electrons through wire
- Core concepts
  - **voltage** = electron pressure
  - **ampere** = size of the pipe
  - **watt** = amount of electrons flow per time unit
  - **watt hour** = amount of electrons
- 1 kWh costs about 10 cents

generating electricity

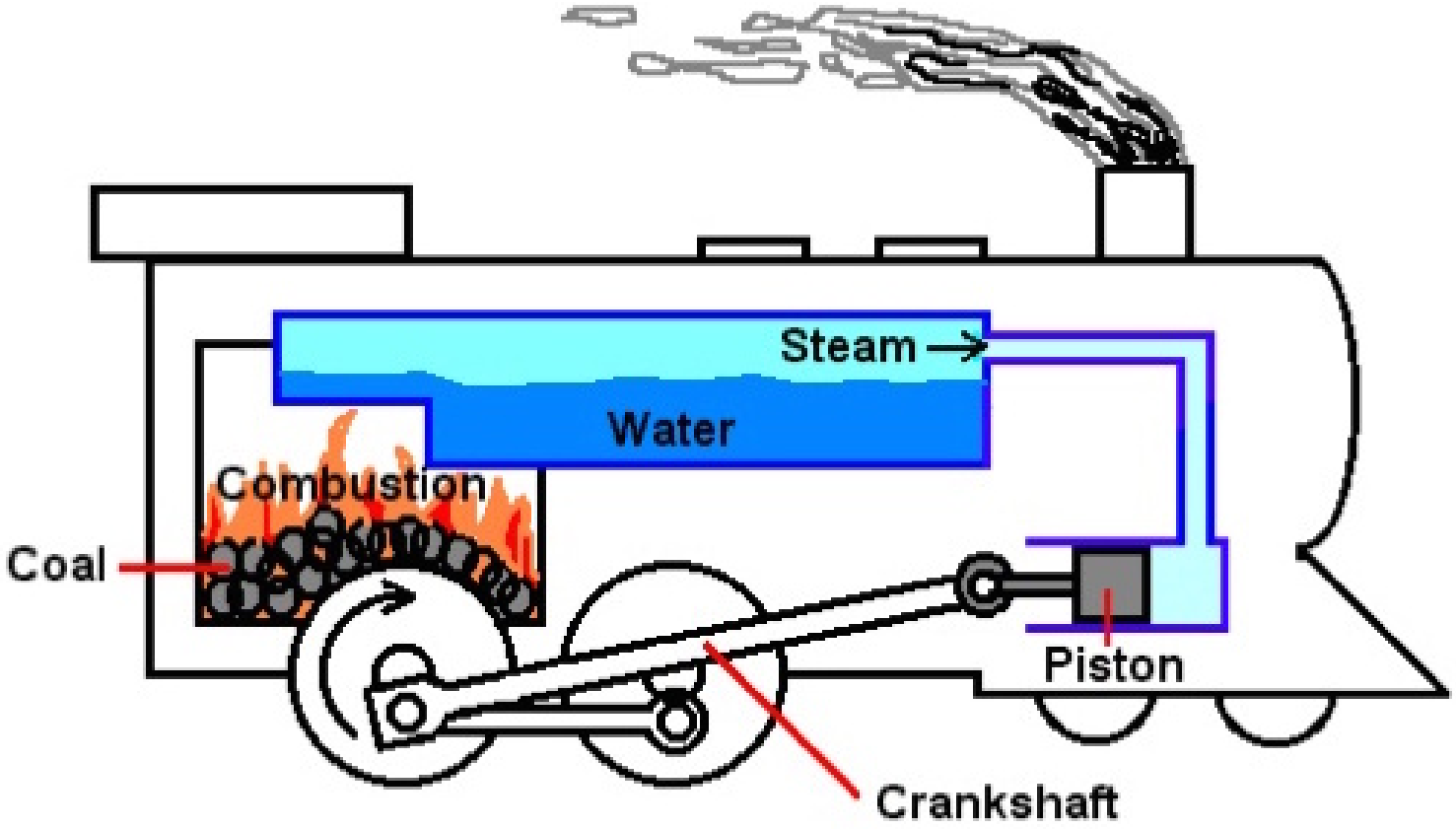
Water Power


Generator
Stator
Rotor
Shaft
Turbine
Water
flow
Wicket
gate
Blades

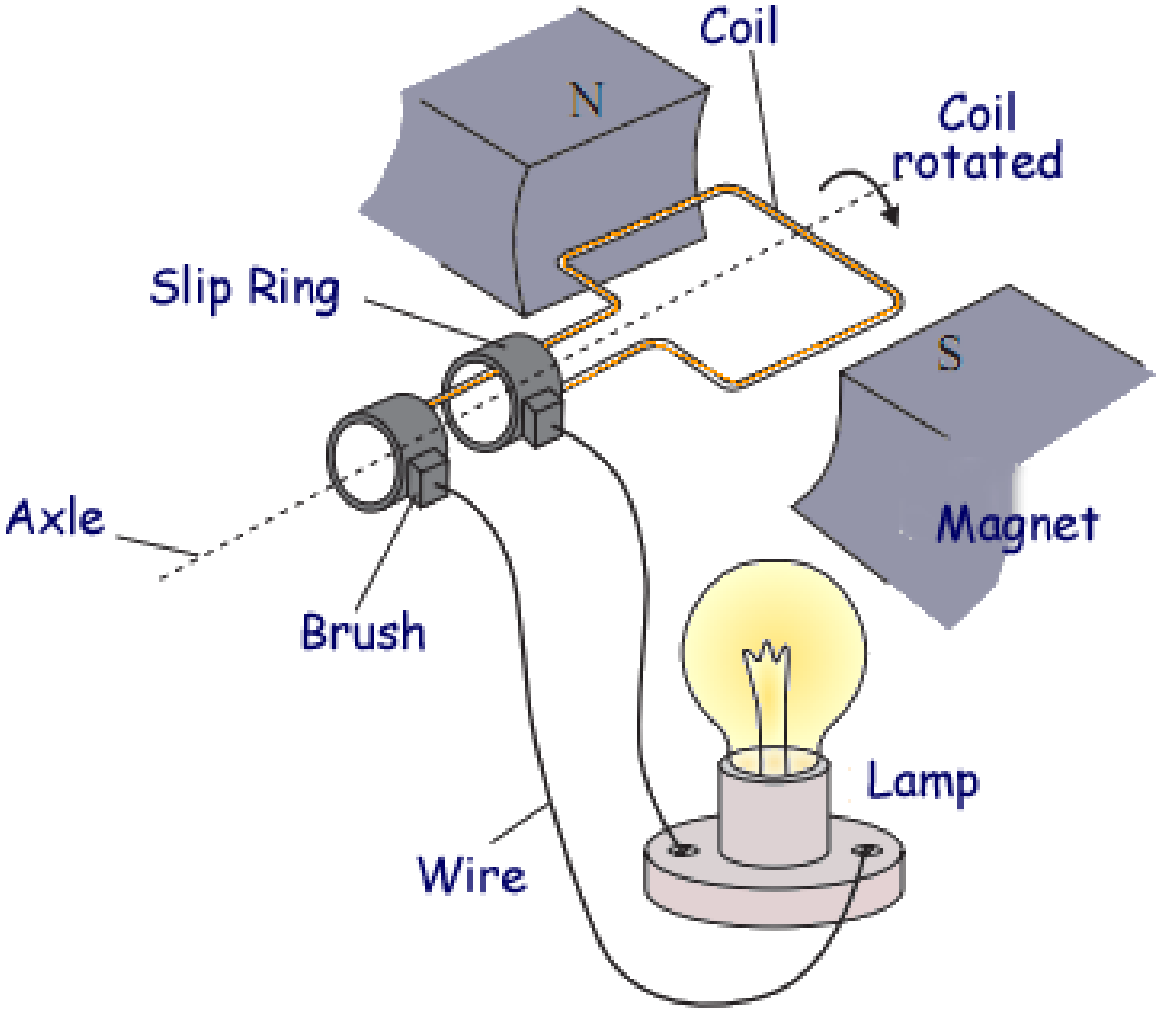
Wind Power


Pitch
Low-speed shaft
Rotor
Gear box
Generator
Anemometer
Wind direction
Controller
Brake
Yaw drive
Wind Vane
High-speed shaft
Nacelle
Yaw motor
Blades
Tower

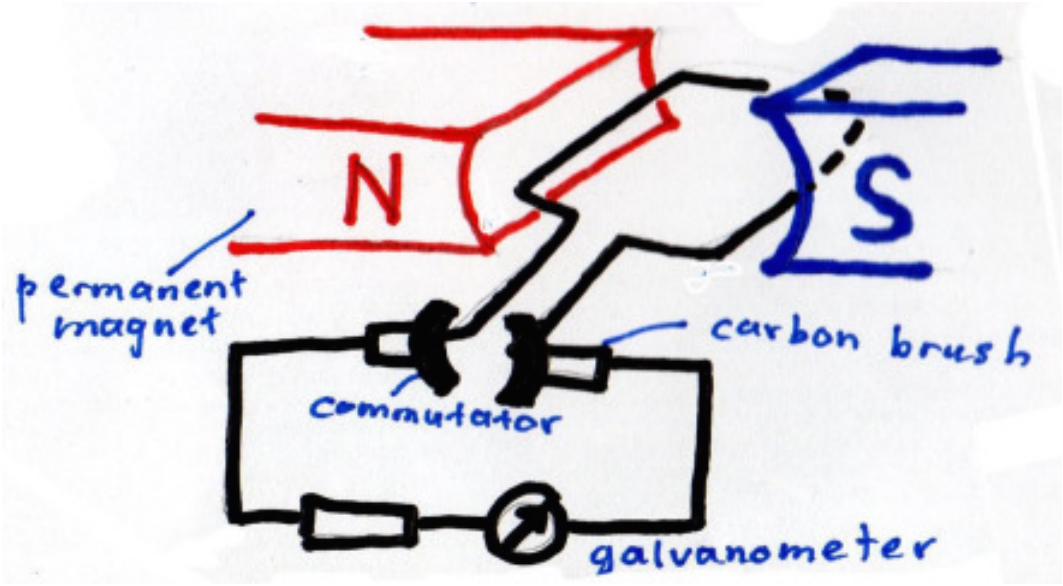
Steam Power

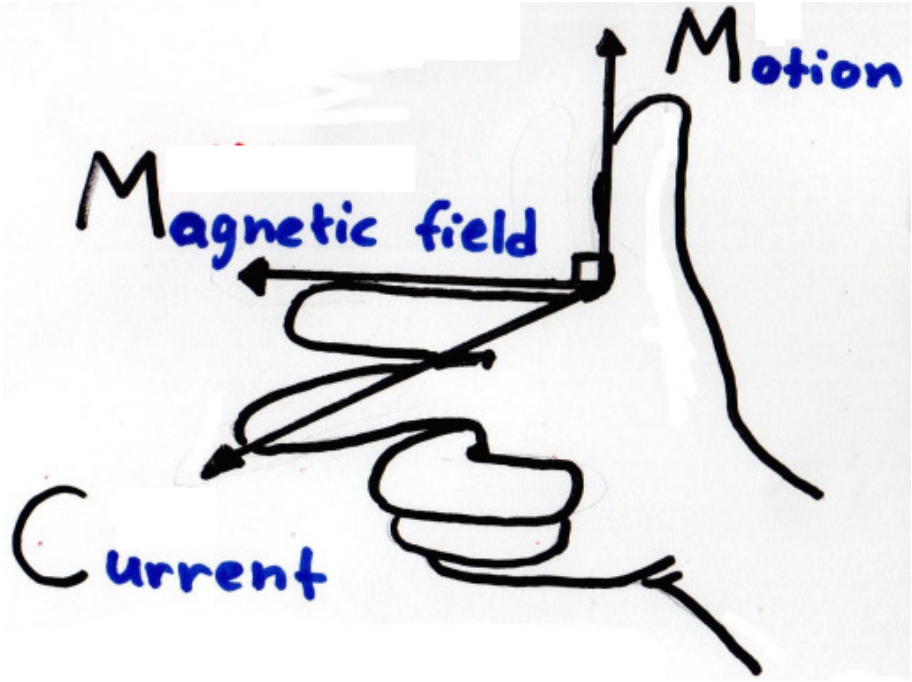


Electric Generator

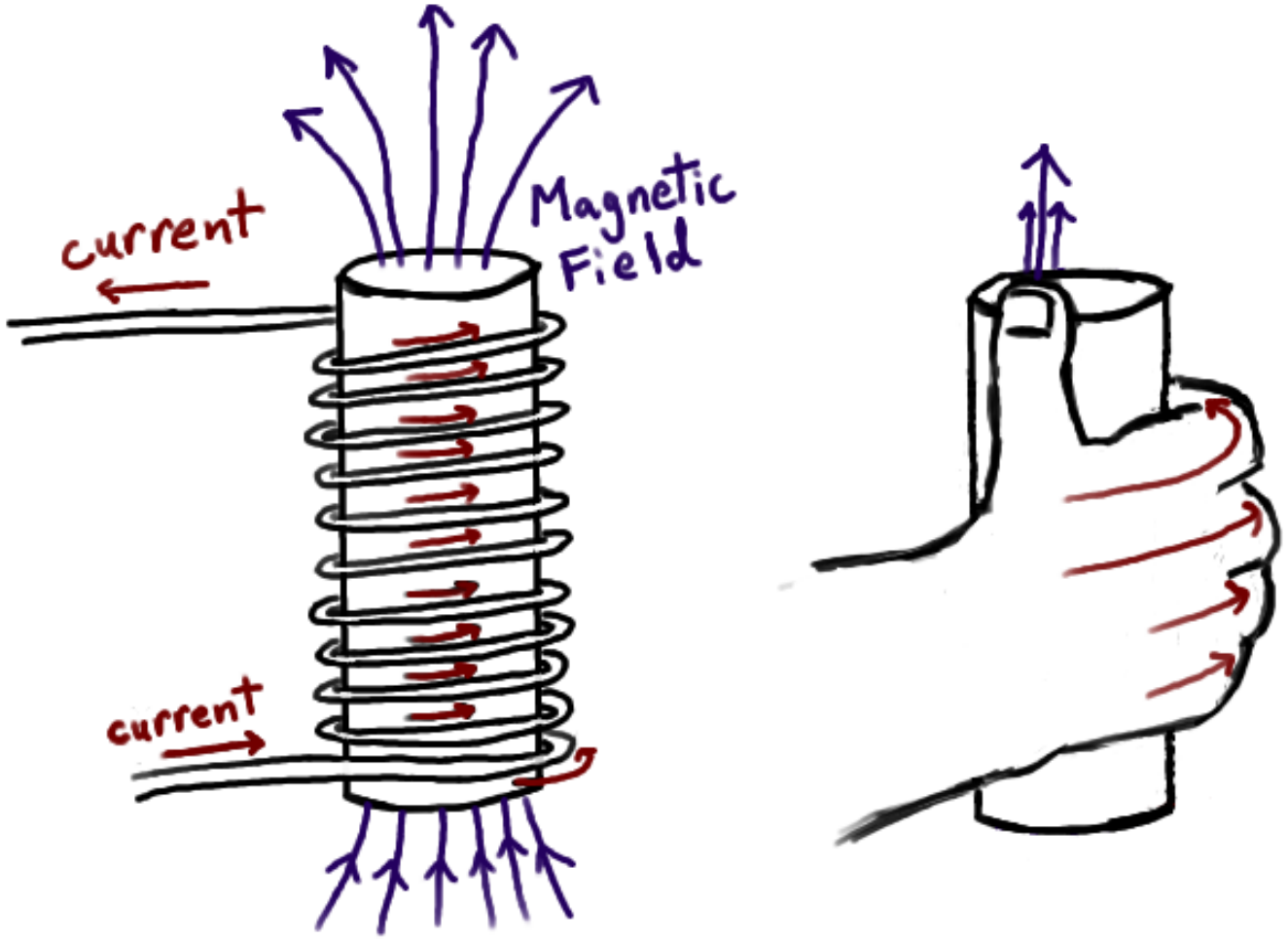


Right Hand Rule



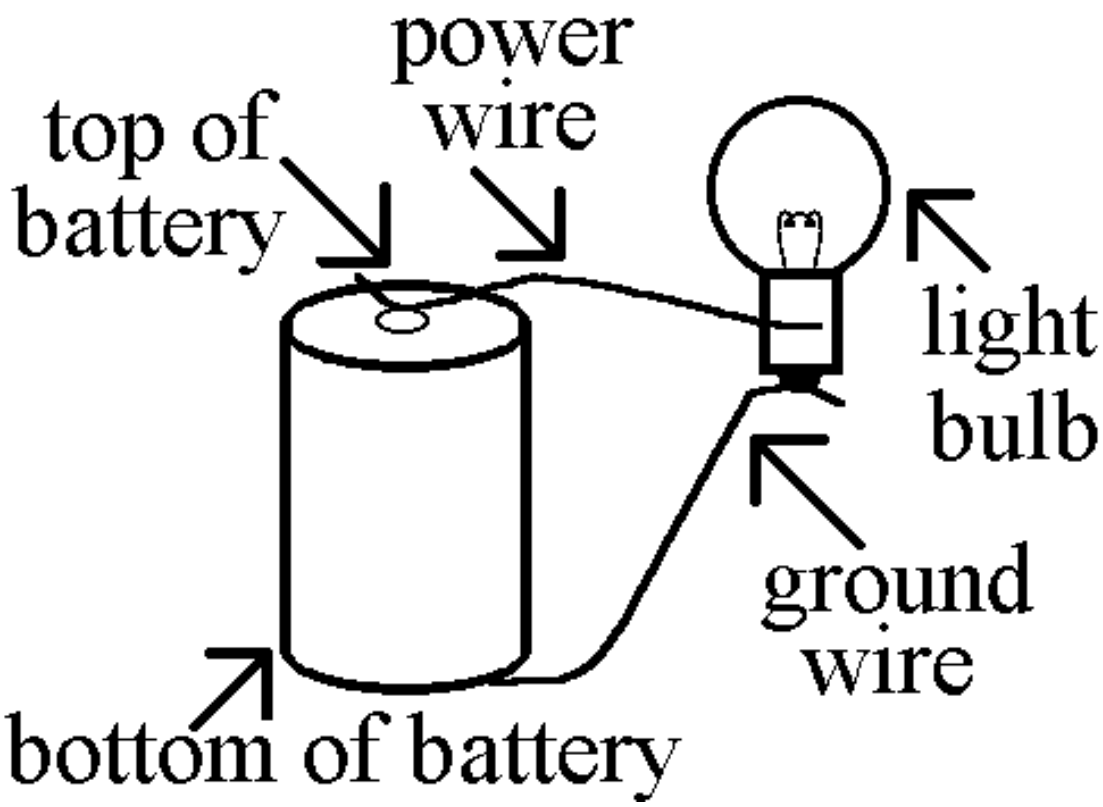


Creating a Magnetic Field

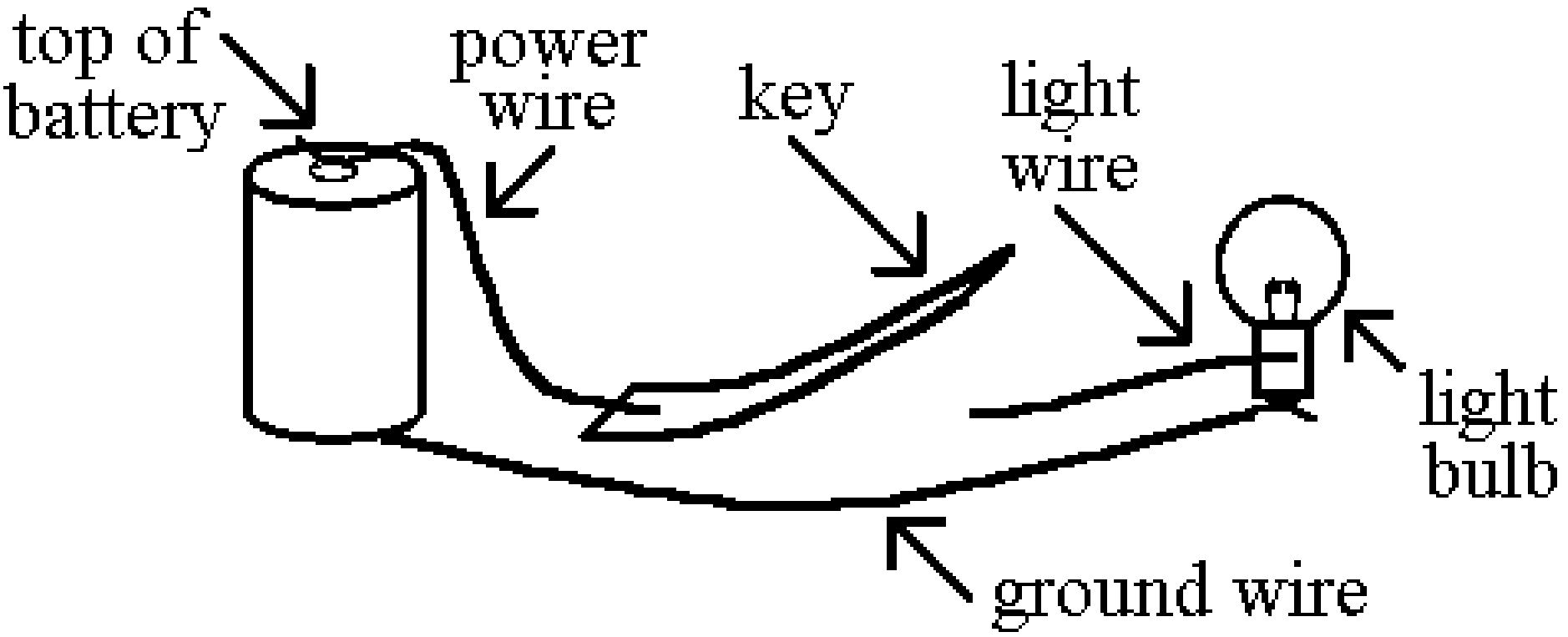


circuits

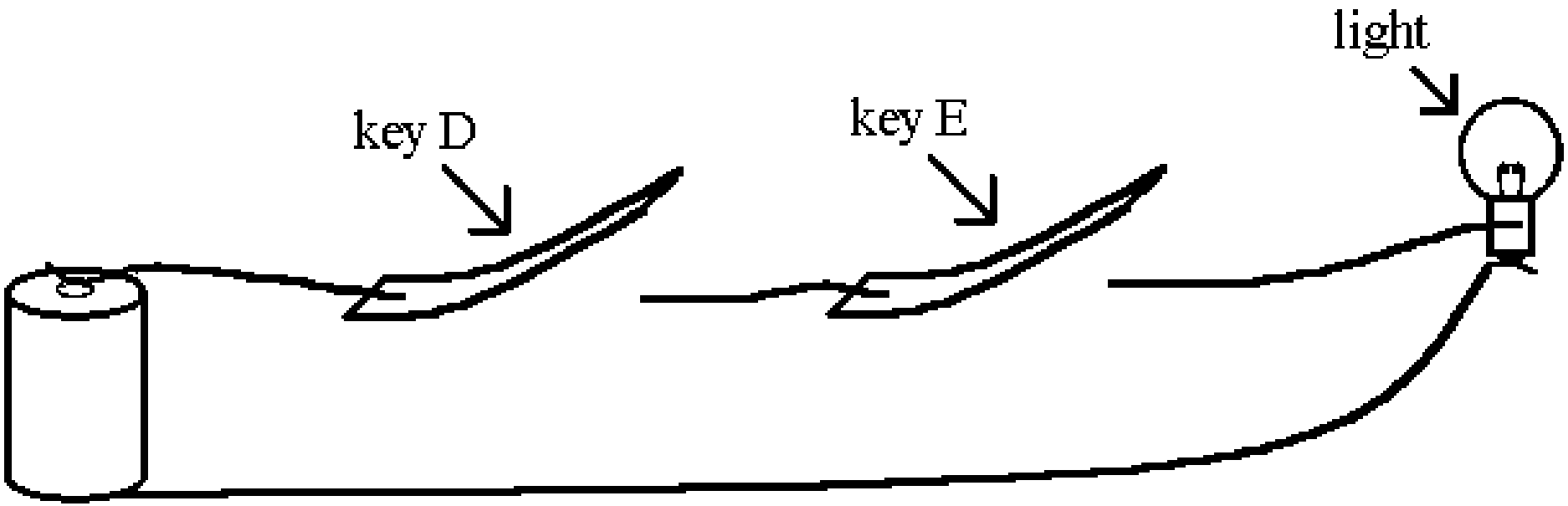
Light Bulb


power
wire
top of
battery
light
bulb
ground
wire
bottom of battery

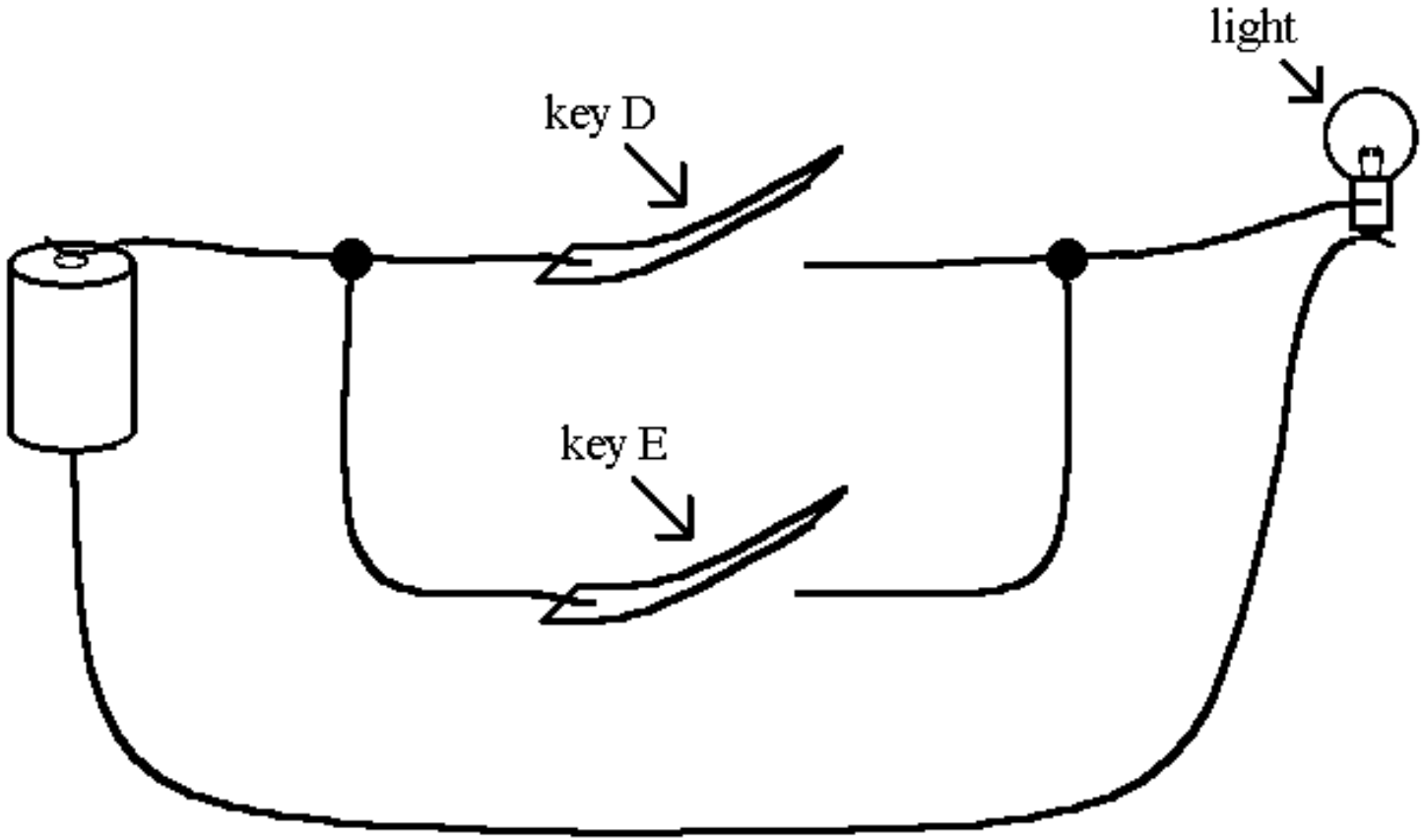
Light Bulb with Switch



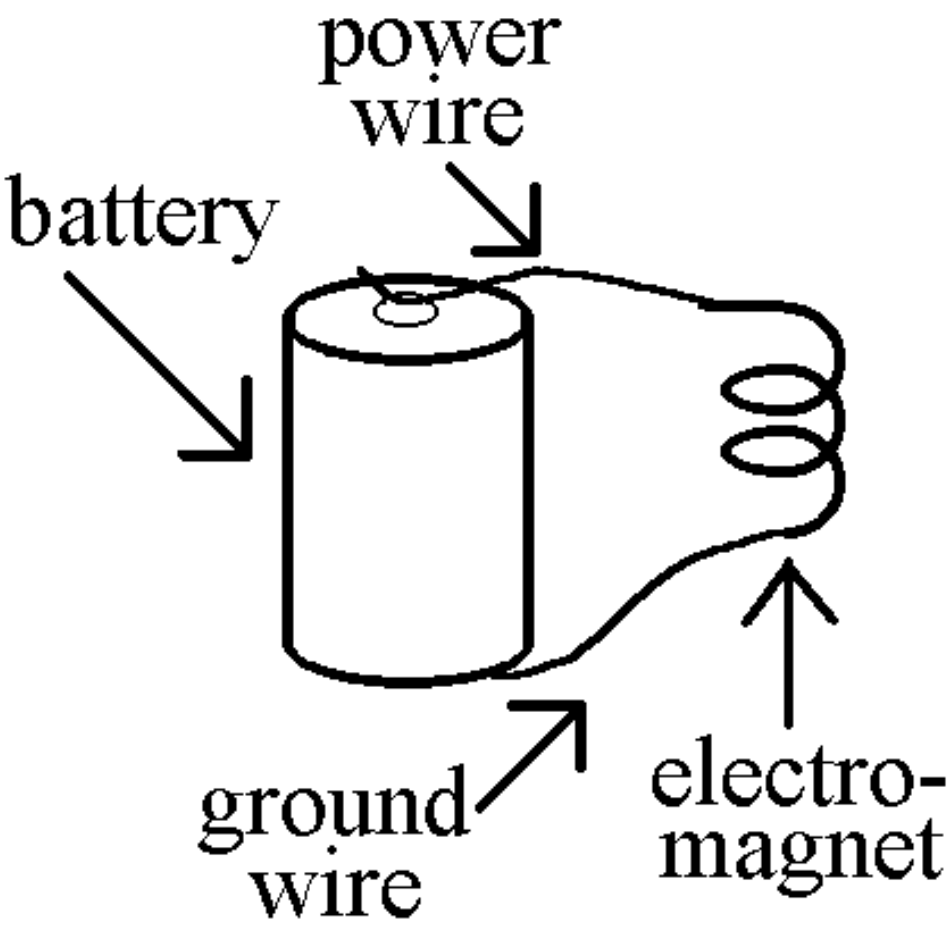
AND



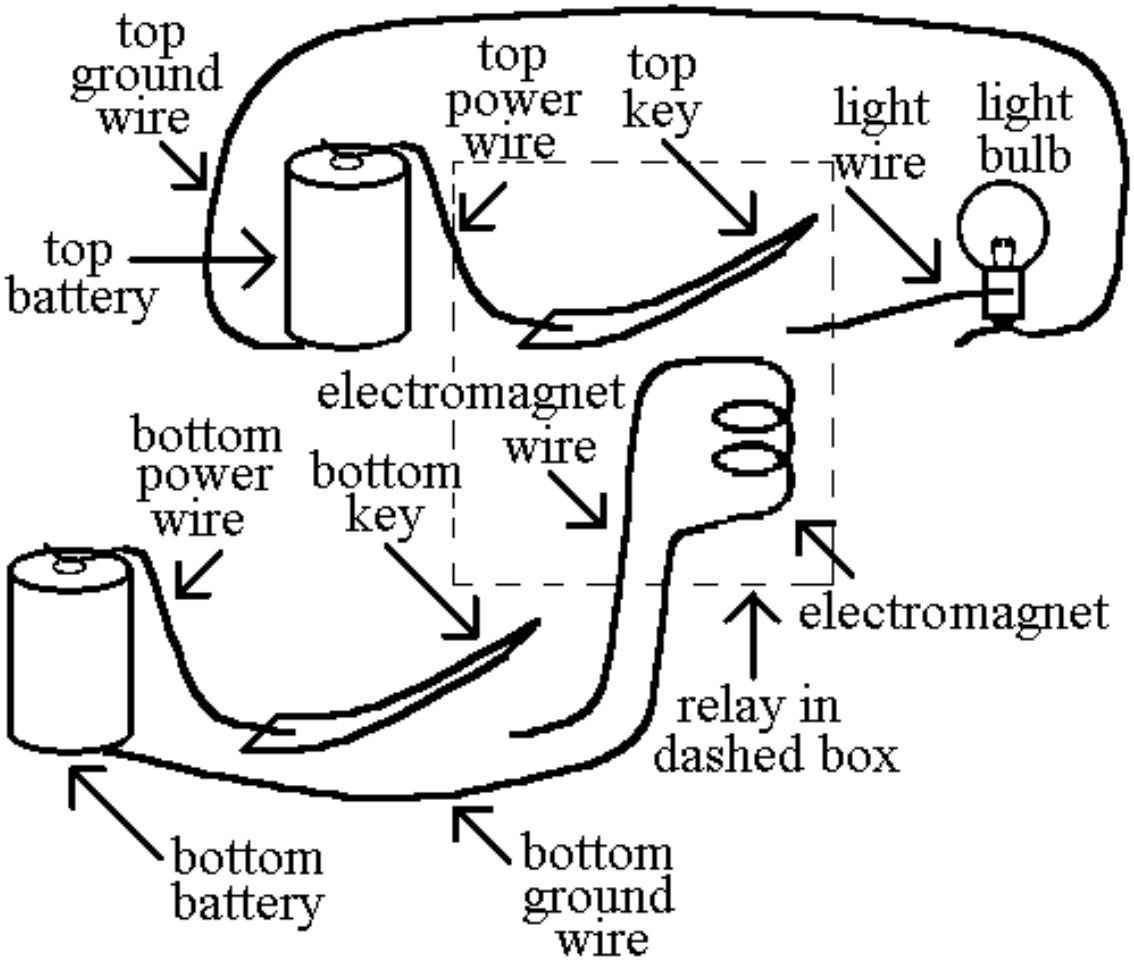
OR



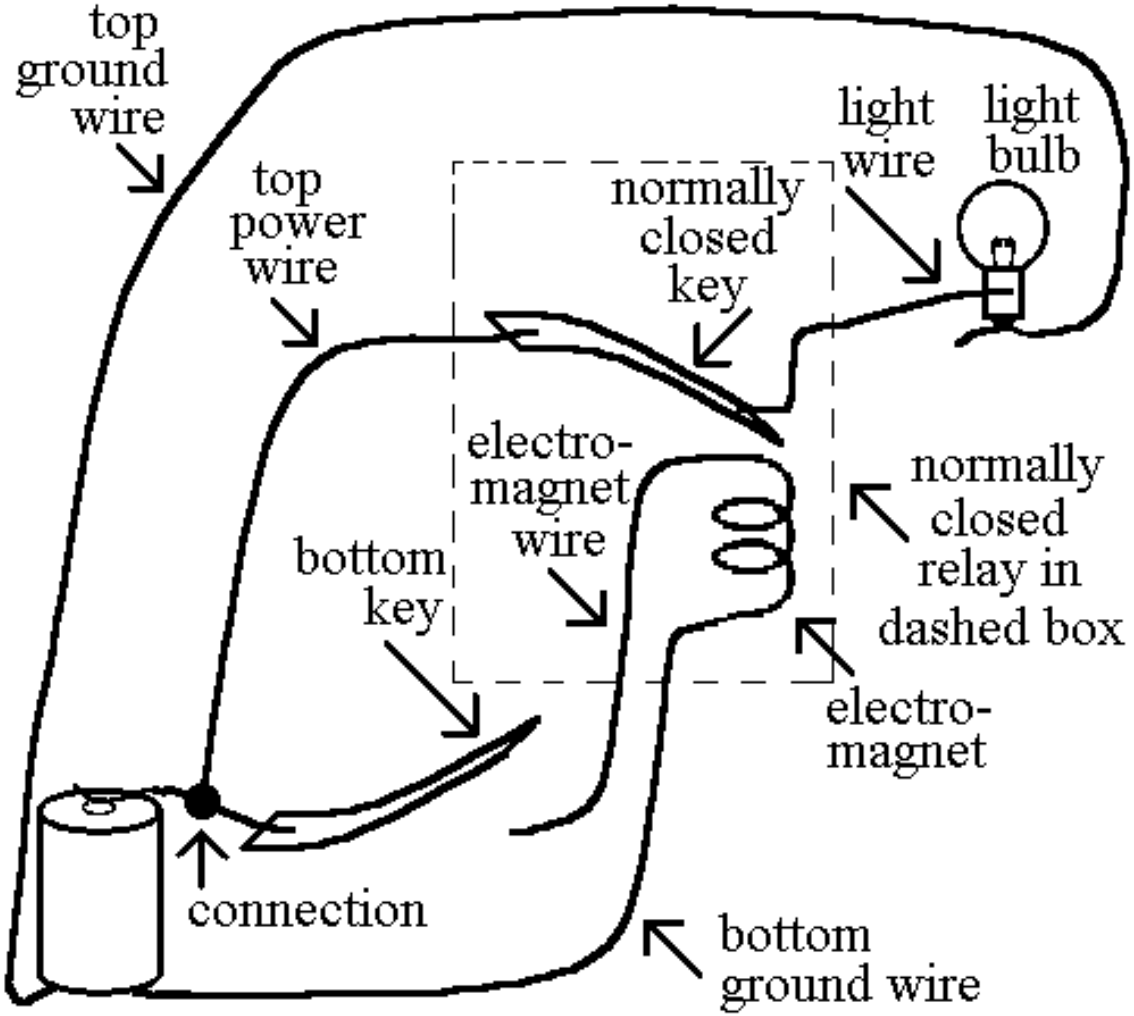
Electromagnet



Relay

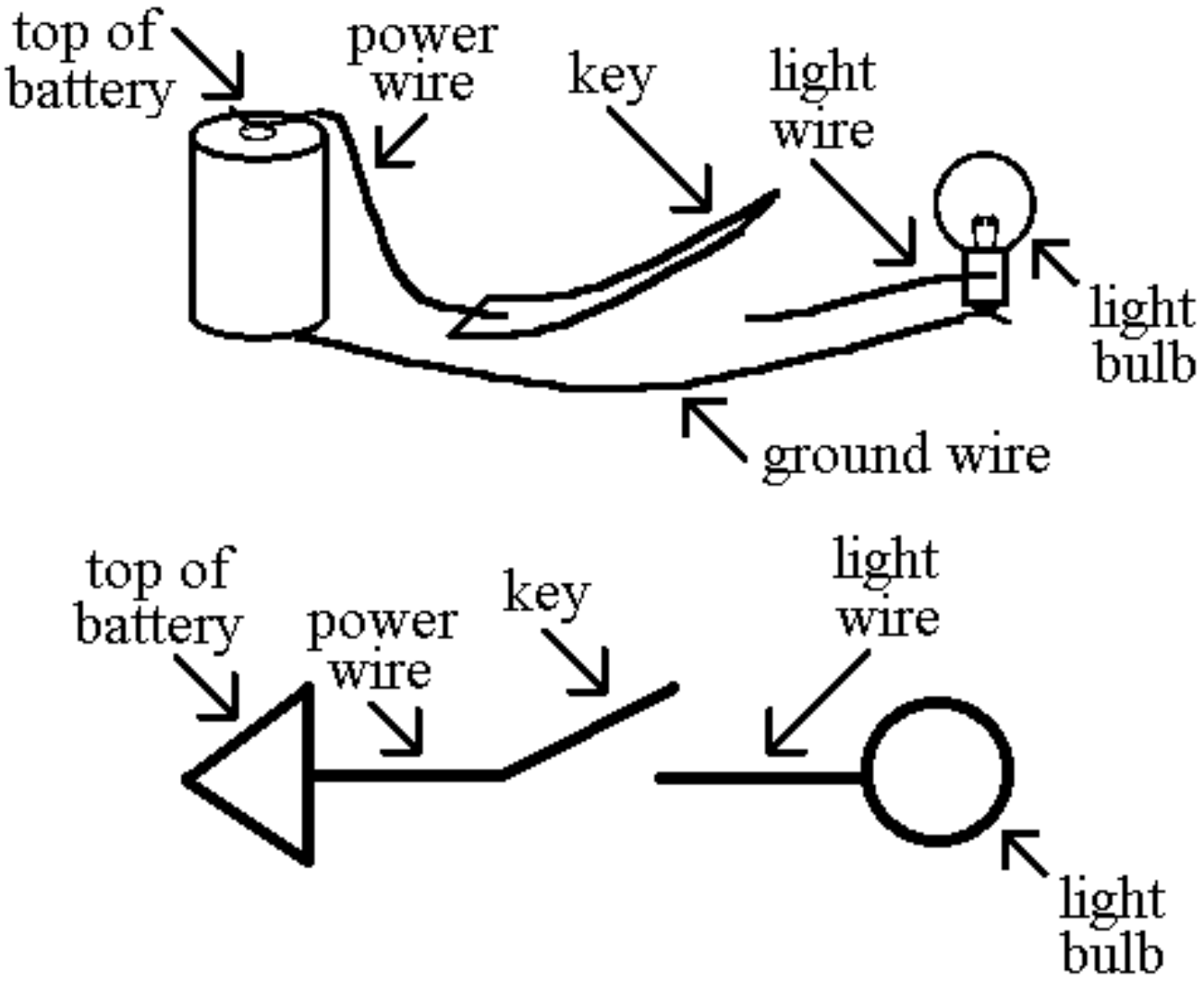

top
ground
wire
top
power
wire
top
key
light
wire
light
bulb
top
battery
electromagnet
wire
bottom
power
wire
bottom
key
electromagnet
relay in
dashed box
bottom
battery
bottom
ground
wire

Normally Closed Relay: NOT

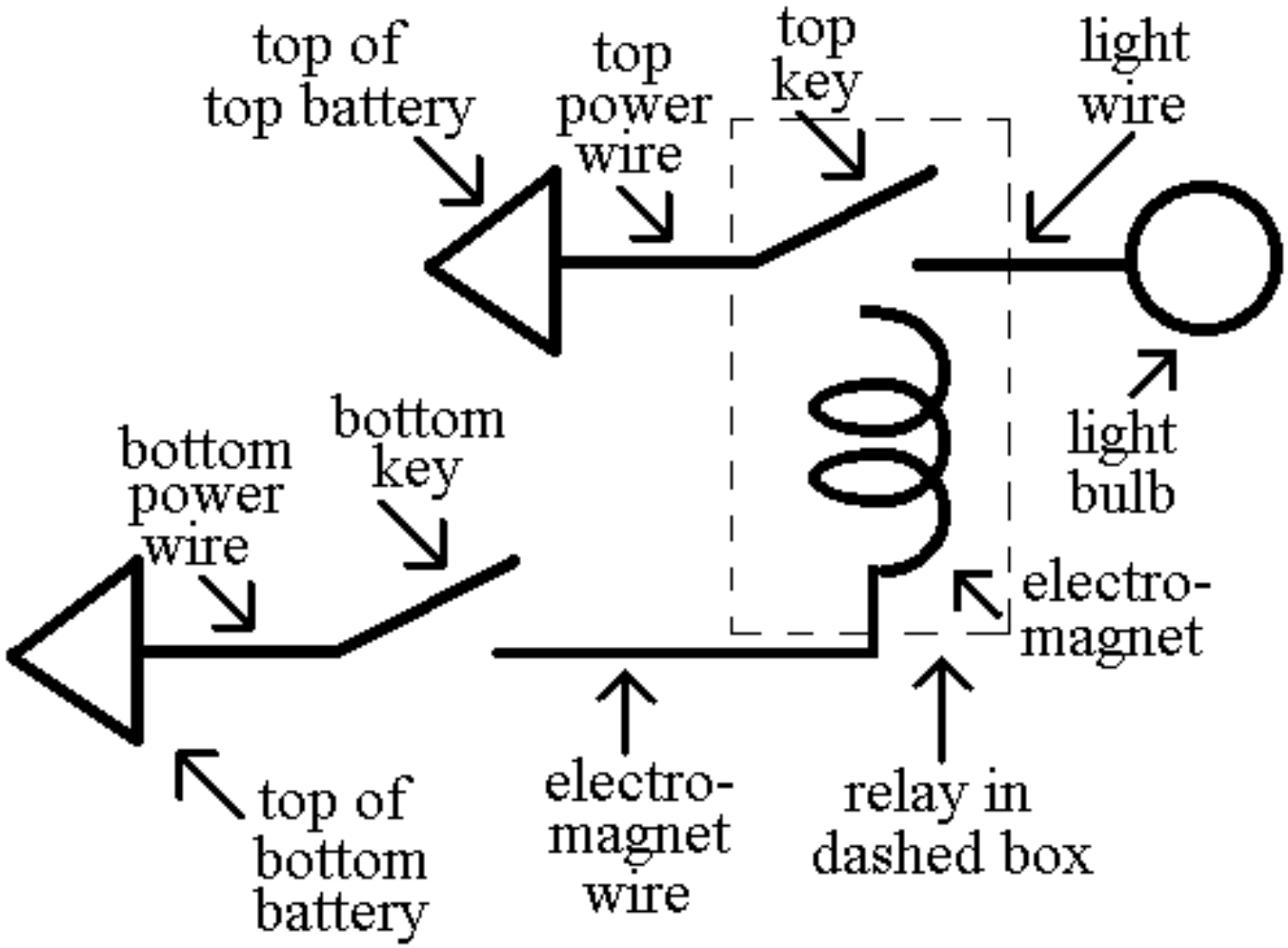


gates

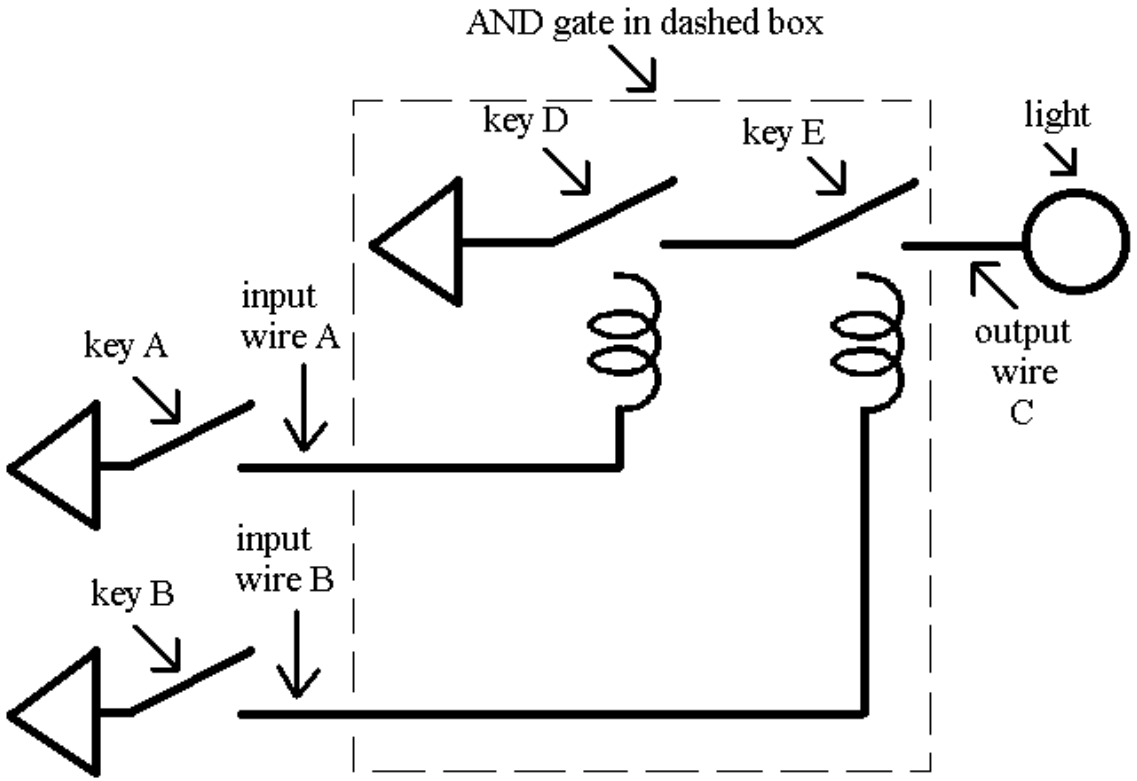
Light Bulb with Switch



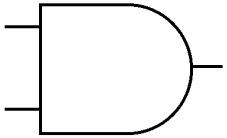
Relay


top of
top battery
top
power
wire
top
key
light
wire
light
bulb
bottom
power
wire
bottom
key
electro-
magnet
top of
bottom
battery
electro-
magnet
wire
relay in
dashed box

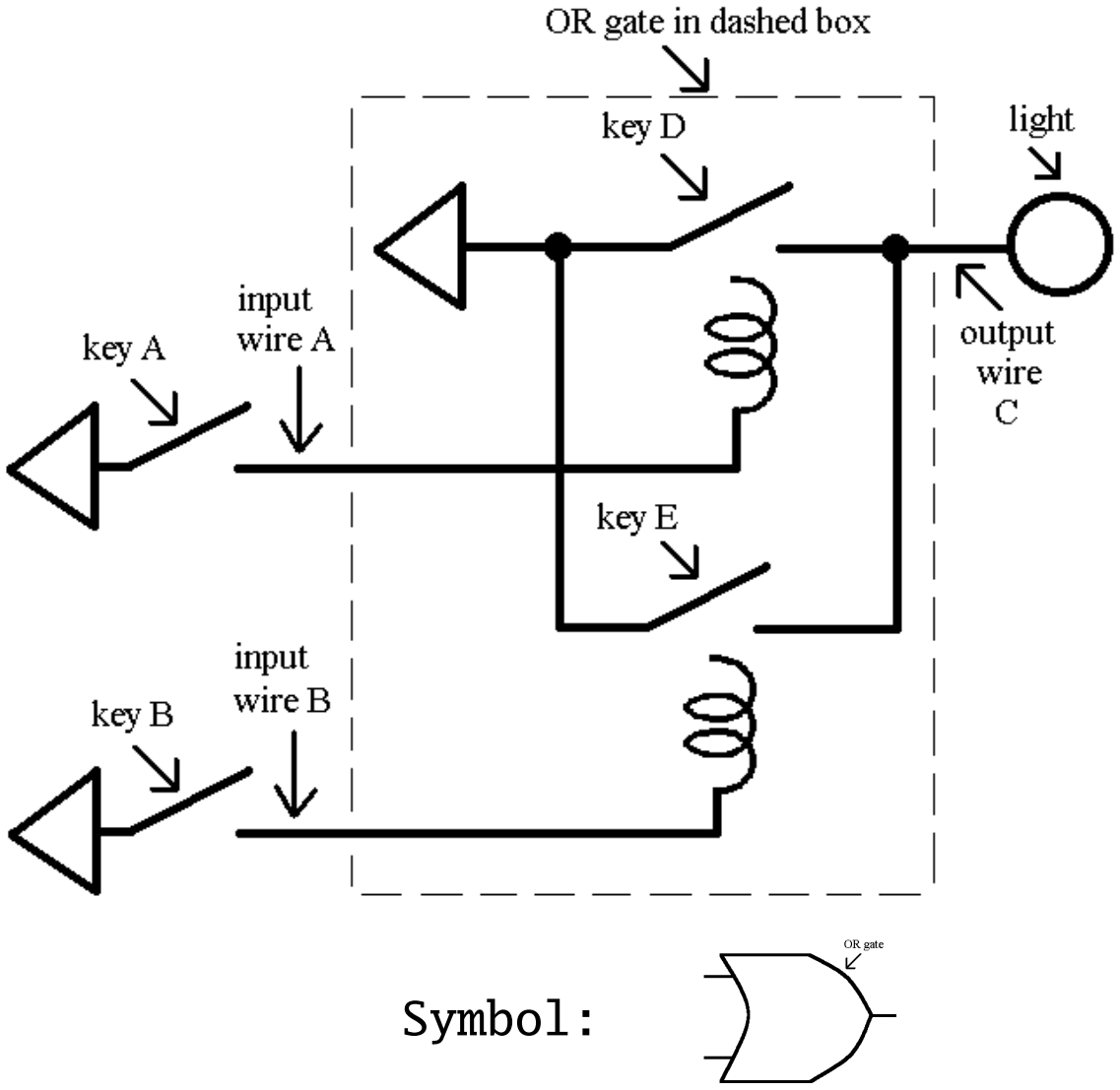
AND Gate



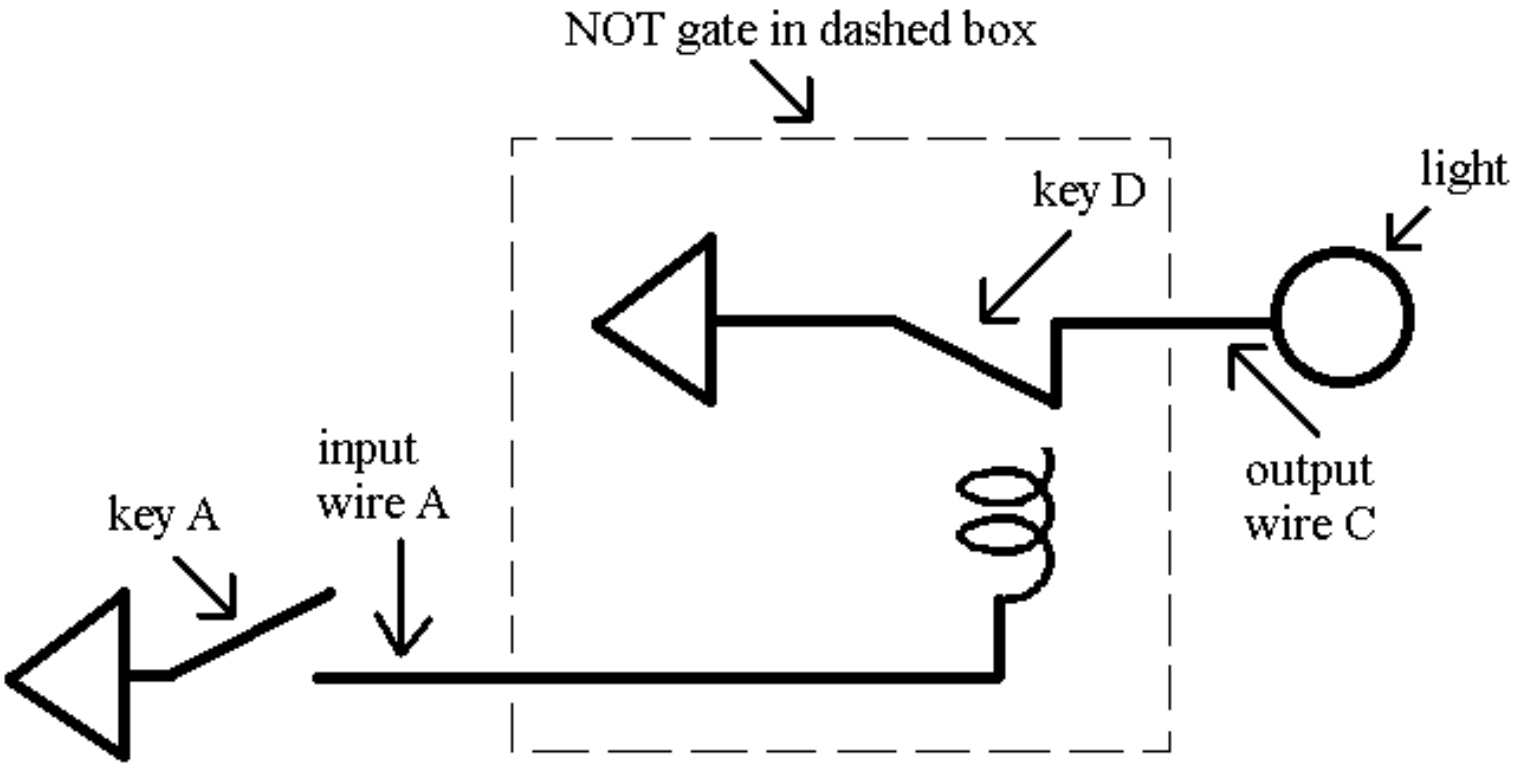
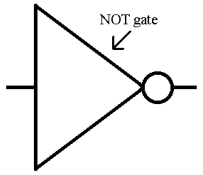
Symbol:



OR Gate


OR gate in dashed box
key D
light
input
wire A
key A
output
wire
C
key E
input
wire B
key B
Symbol:
OR gate

NOT Gate



Symbol: