IMGD 3xxx - HCI for Real, Virtual, and Teleoperated Environments:
## Electricity

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Overview

- So you've built some circuits, made some stuff blink, read values from devices, etc.

- Do you understand a little better what's going on with all this ECE stuff?

- Since almost none of you have any ECE background, how can I expect you to do this stuff?!?!??!
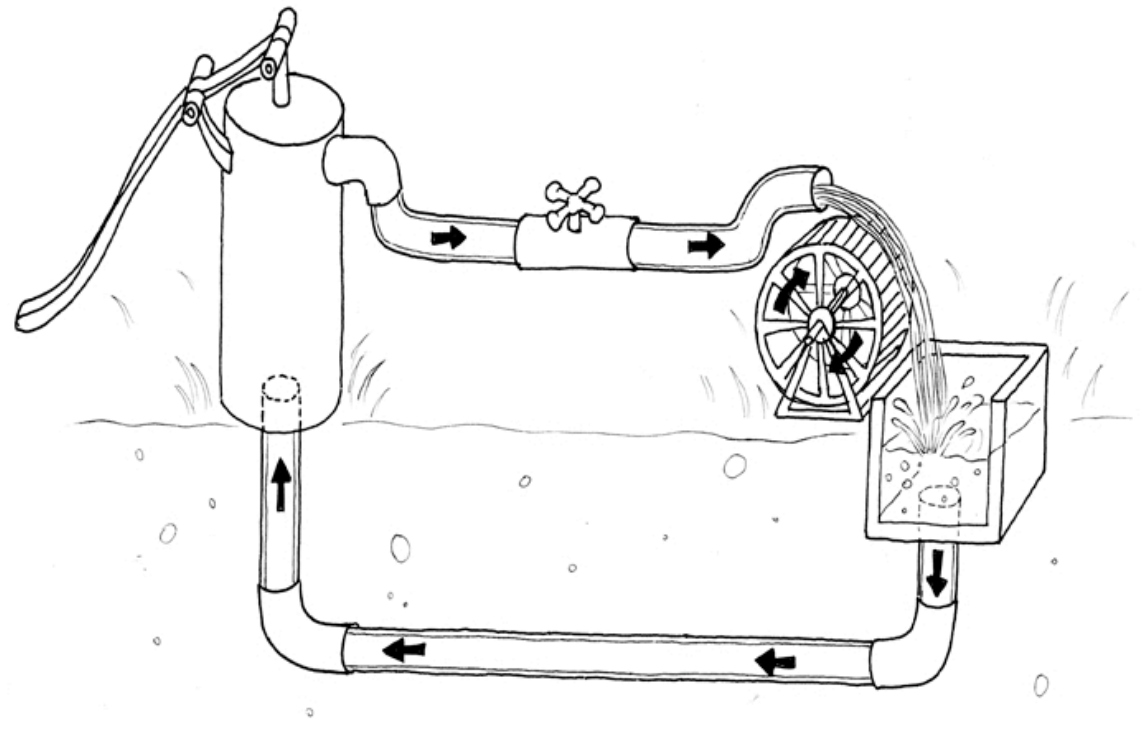
- Let's see what we know...

Simple Current Flow

- Parts of the system
  - Power source
  - Output device
    - Motor
  - Switch
  - Conduits
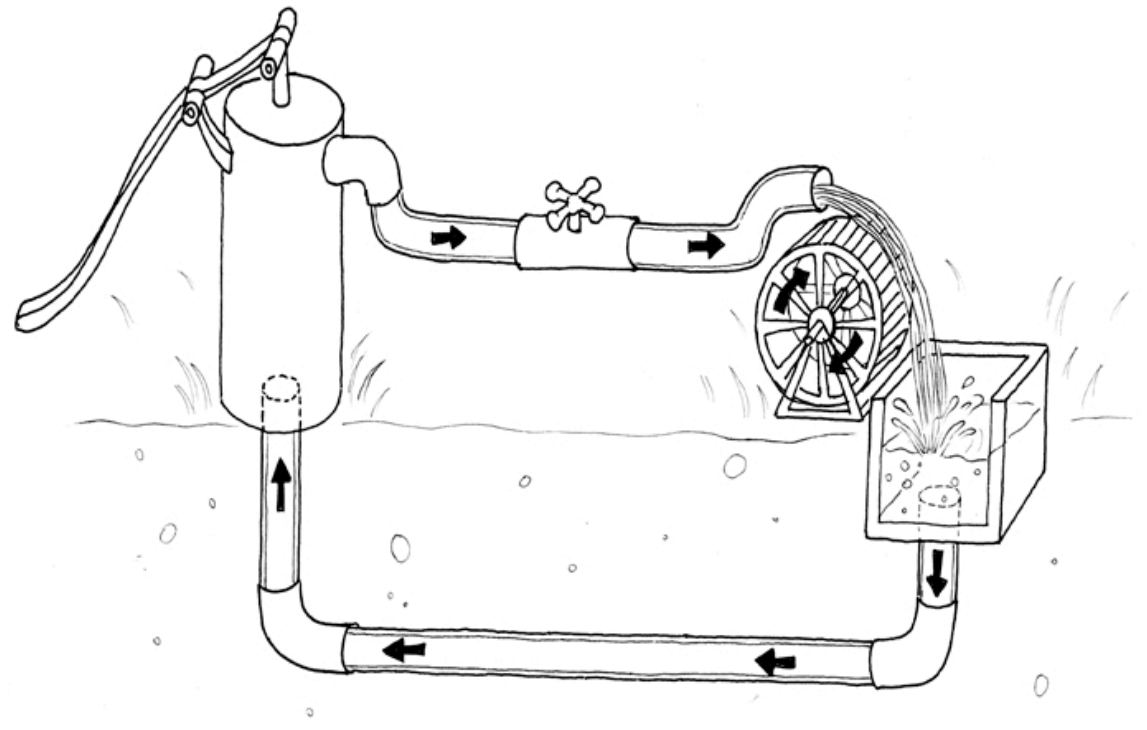
- What if you switch the **polarity**?
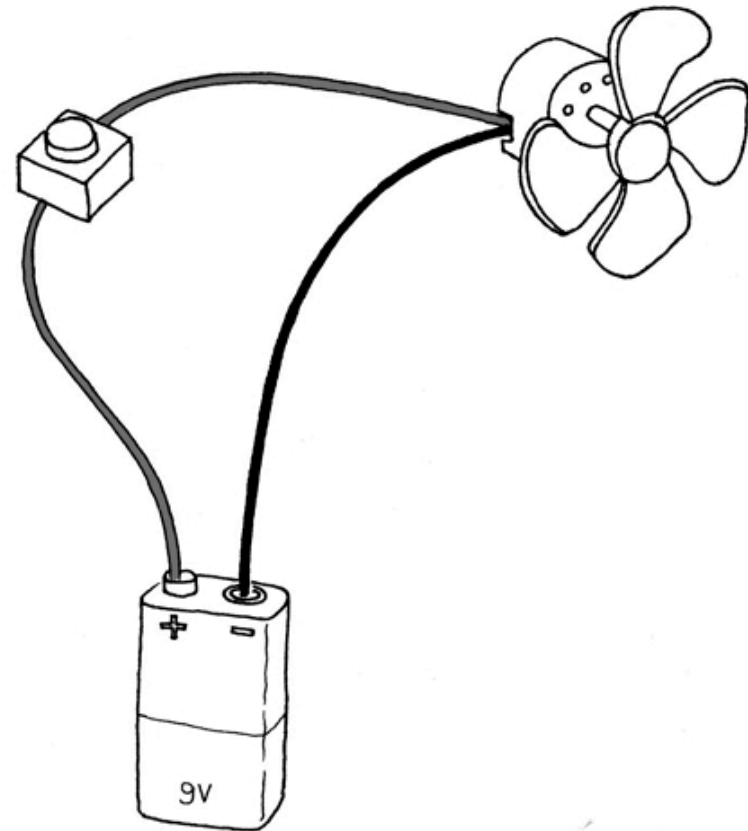
Water Analogy

- ☐ Water source and pump
  - ■ Battery
- ☐ Tap
  - ■ Switch
- ☐ Water wheel
  - ■ Motor
- ☐ Open tap, water drives the wheel

Water Analogy: Important Points

- ☐ Two factors
  - ■ Water Pressure
  - ■ Flow rate
- ☐ Governed by
  - ■ the power of the pump
  - ■ Size of the pipe/friction of wheel
- ☐ Larger pipe + stronger pressure = faster spin

Water Analogy: More Detail

- Larger pipes = less resistance
  - After some point, need more pressure to fill the pipe
- At some point, the wheel will breakdown
  - too much pressure!
- Some of the energy will come out as heat (from the wheel axel) or something else
  - Same in ECE
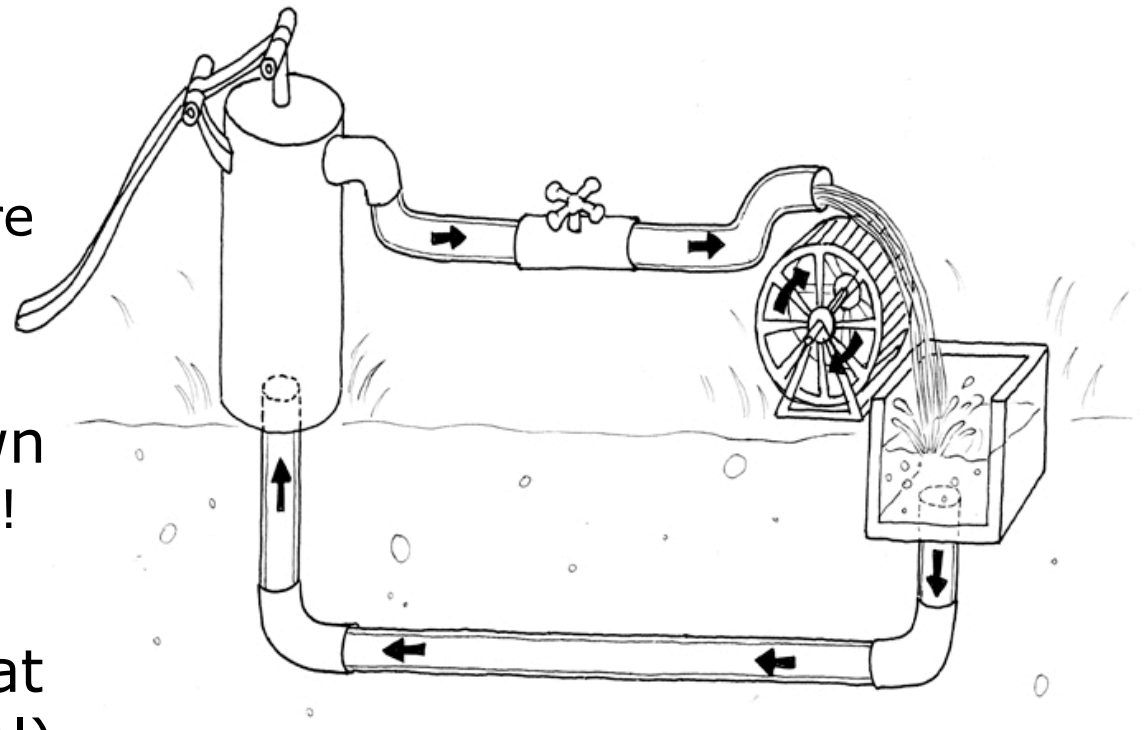
Making the Connection to ECE

☐ Pressure is produced by the pump

☐ Resistance produced by pipes

☐ Resistance produced by wheel

☐ The flow rate (e.g., liters/second)

☐ In ECE:
  ■ Power source (battery, wall wart) is the pump
  ■ Wires, resistors, etc. are the pipes
  ■ Devices are the wheel
  ■ Current is the flow rate

Making the Connection to ECE

- A 9V battery is a pump (9V of pressure)
  - Unit is **Volts (V)** named after the inventor of the battery

- Flow rate is called **current**, and is measured in amperes or **Amps (A)**
  - After André-Marie Ampère

- Higher voltage (pressure) lets you spin the wheel faster

- Higher flow rate (current) lets you spin a larger wheel

Making the Connection to ECE

- Resistance opposing the flow of current over any path is called **resistance**, and is measured in **Ohms (Ω)**
  - After German physicist Georg Ohm

- This guy also gave us an important law
  - **Ohm's Law** describes the relationship between current, voltage, and resistance.
  - The **resistance** in a circuit will determine the amount of **current** that will flow through it, given a certain **voltage** supply.

Ohm's Law

☐ If I measure the current from a 9V battery plugged into a simple circuit, the current will drop if I add more resistance.

☐ Formally stated:

R (resistance) = V (voltage) / I (current)

V = R * I

I = V / R

Watts (W)

- Rate of energy conversion

- Work is done at a rate of one watt when one ampere flows through a potential difference of one volt

    1W = 1V * 1A

- A 100 W bulb burning for 1 hour would consume 100 watt-hours (W-h)

- A 40 W bulb could burn for 2.5 hours and consume the same energy (100 W-h)

More Terms

- Capacitance
  - The ability for a body to hold a charge
  - Used for
    - Temporary power storage (UPS, laptops)
    - Smoothing a power signal

- Transistor
  - Solid-state electronic switch

- MOSFET
  - Metal–Oxide–Semiconductor Field-Effect Transistor
  - When a Voltage is present on a specific pin, current flows between the other two pins
  - Used to amplify or switch electronic signals

- Relay
  - Electrically operated switch
  - Current creates a magnetic field which "throws" the switch

Varying the Output

□ We've seen how easy it is to turn things ON and OFF
  - But this quickly becomes too limiting!

□ Given Ohm's Law, how can we change the brightness of an LED?
  - Increase the resistance
    - □ Maybe with a resistor ladder

□ How else?
  - Quickly blink it ON and OFF

Pulse-Width Modulation (PWM)

☐ Vary the percentage of time over a given period that an output is HIGH (or LOW)
  ◼ This is how traditional dimmer switches work

☐ Period
  ◼ Total time for the signal

☐ Duty Cycle
  ◼ Percentage of the period the signal is HIGH
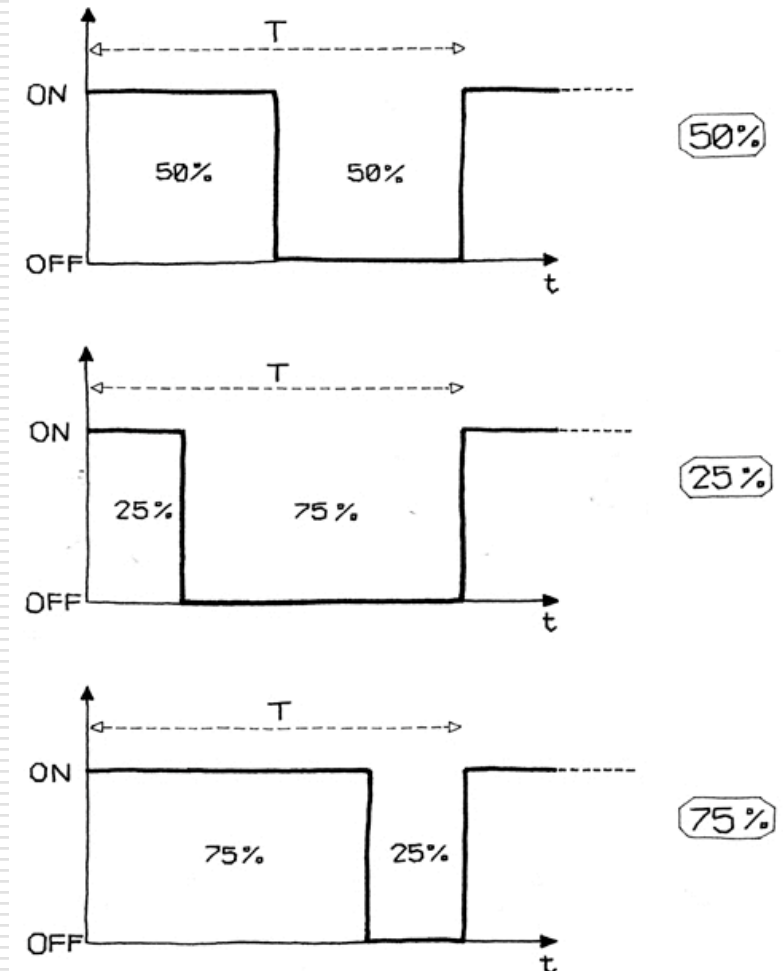
Persistence of Vision

□ Human eye won't notice down to a certain point

- http://hackedgadgets.com/2008/11/05/arduino-rotating-led-display/

Further Reading

- http://antonine-education.co.uk/electronics_as.htm