



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

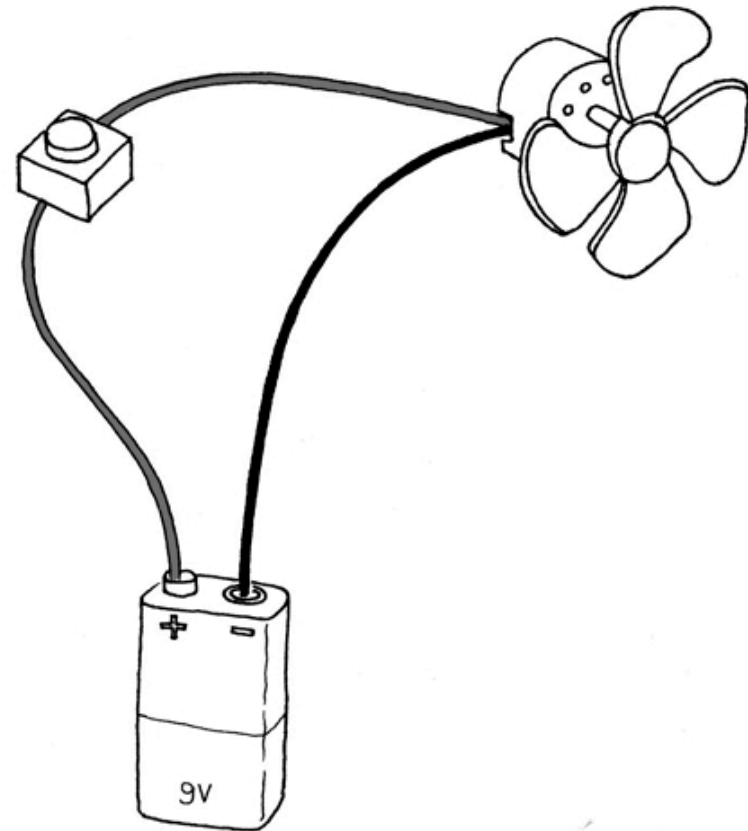
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Overview

- ❑ 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...

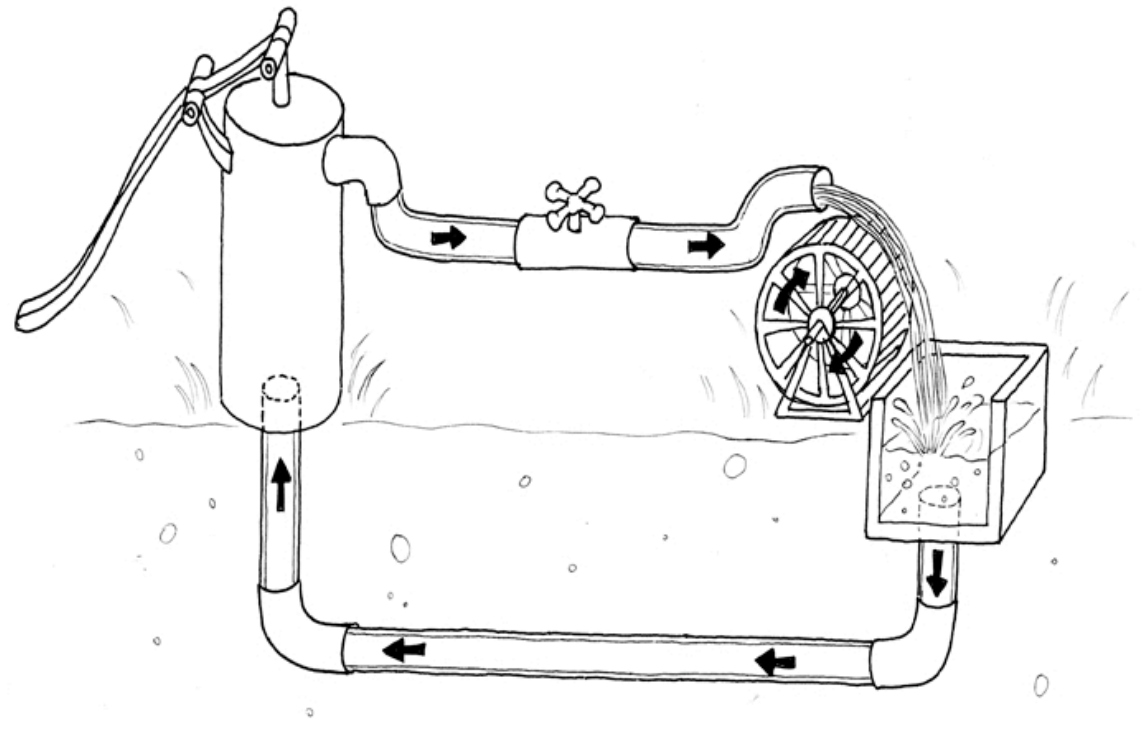
Simple Current Flow

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



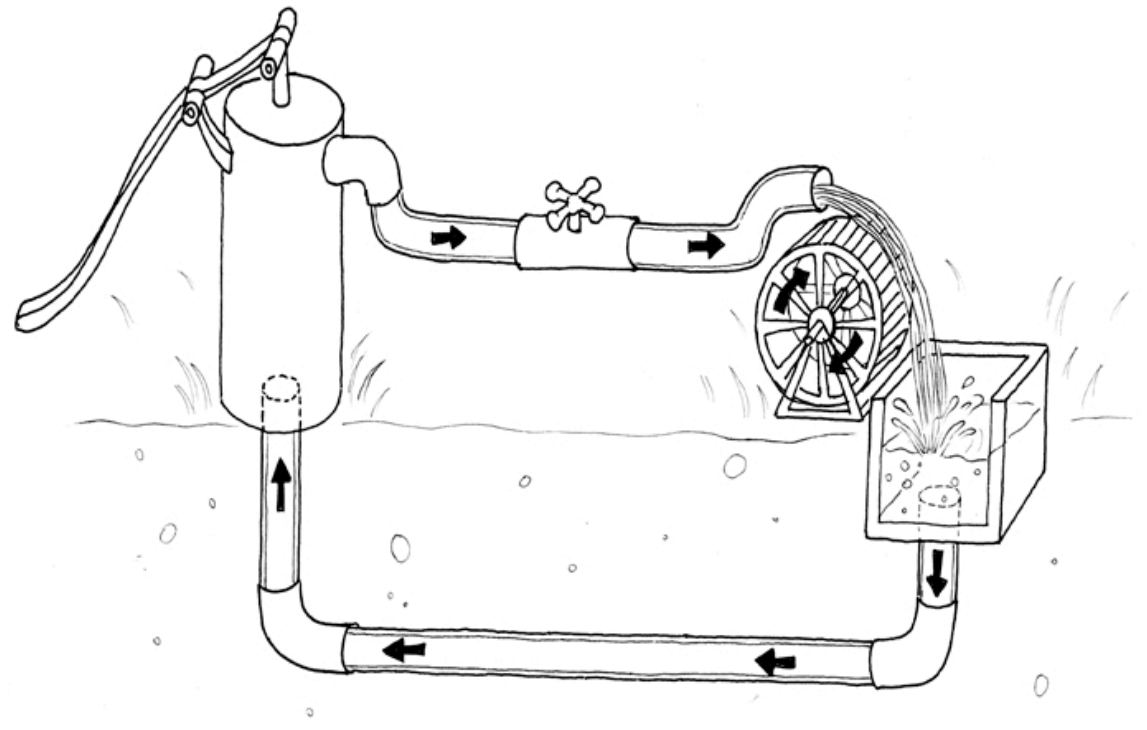
Water Analogy

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



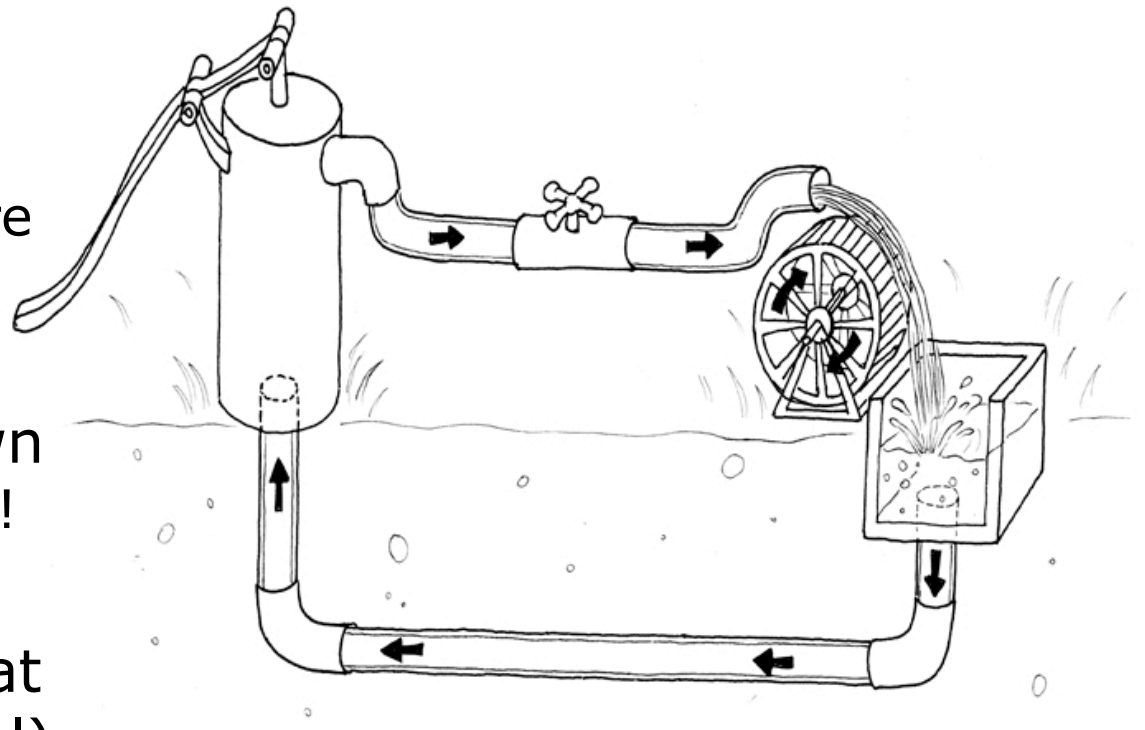
Water Analogy: Important Points

- 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 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:

$$R \text{ (resistance)} = V \text{ (voltage)} / I \text{ (current)}$$

$$V = R * I$$

$$I = V / R$$

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 1 watt-hour (W-h)
 - A 40 W bulb could burn for 2.5 hours and consume the same energy (1 W-h)

More Terms

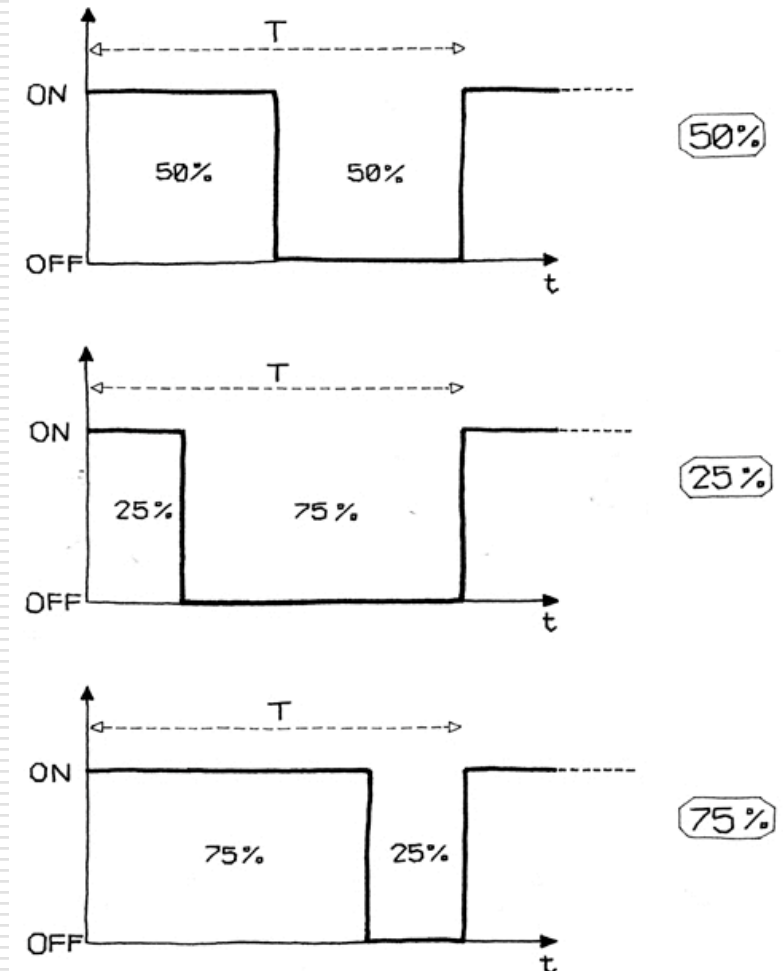
- Capacitance
 - The ability for a body to hold a charge
 - Used for
 - Temporary power storage (UPS, laptops)
 - Smoothing a power signal
- Transistor
 - Solid-state electronic switch
- MOSFET
 - Metal–Oxide–Semiconductor Field-Effect Transistor
 - When a Voltage is present on a specific pin, current 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