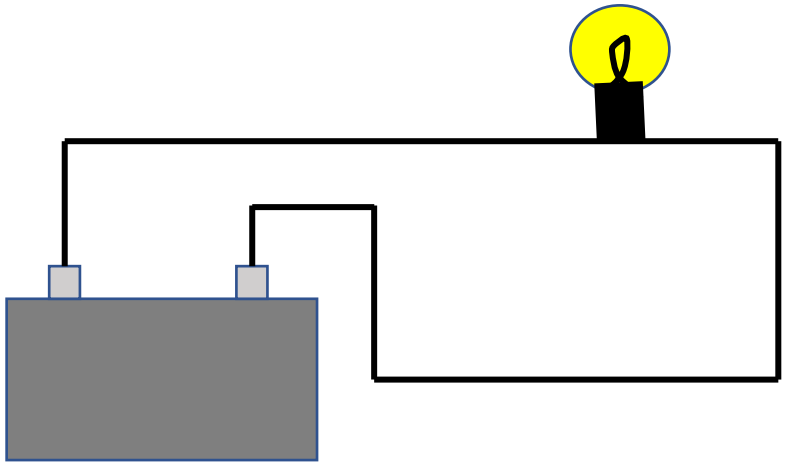
Basic Auto Electrical Concepts

Northern Illinois Fiero Enthusiasts

April 13, 2019 by Art Hall



$E=I\ R$

$E/R = I$

$E/I = R$

$R_1 + R_2 + R_3 = R_T$

$1/R_1 + 1/R_2 + 1/R_3 = 1/R_T$

$P = I \times E$

Useful, but not always required

Review Basics

Volts – Electrical Potential

Amps (Amperes) –Electron Flow

Ohms – Electrical Resistance

Water Analogy

Volts – Water Pressure (psi)

Amps – Water Flow or Current (Gals/min)

Ohms – Flow Resistance (roughness)

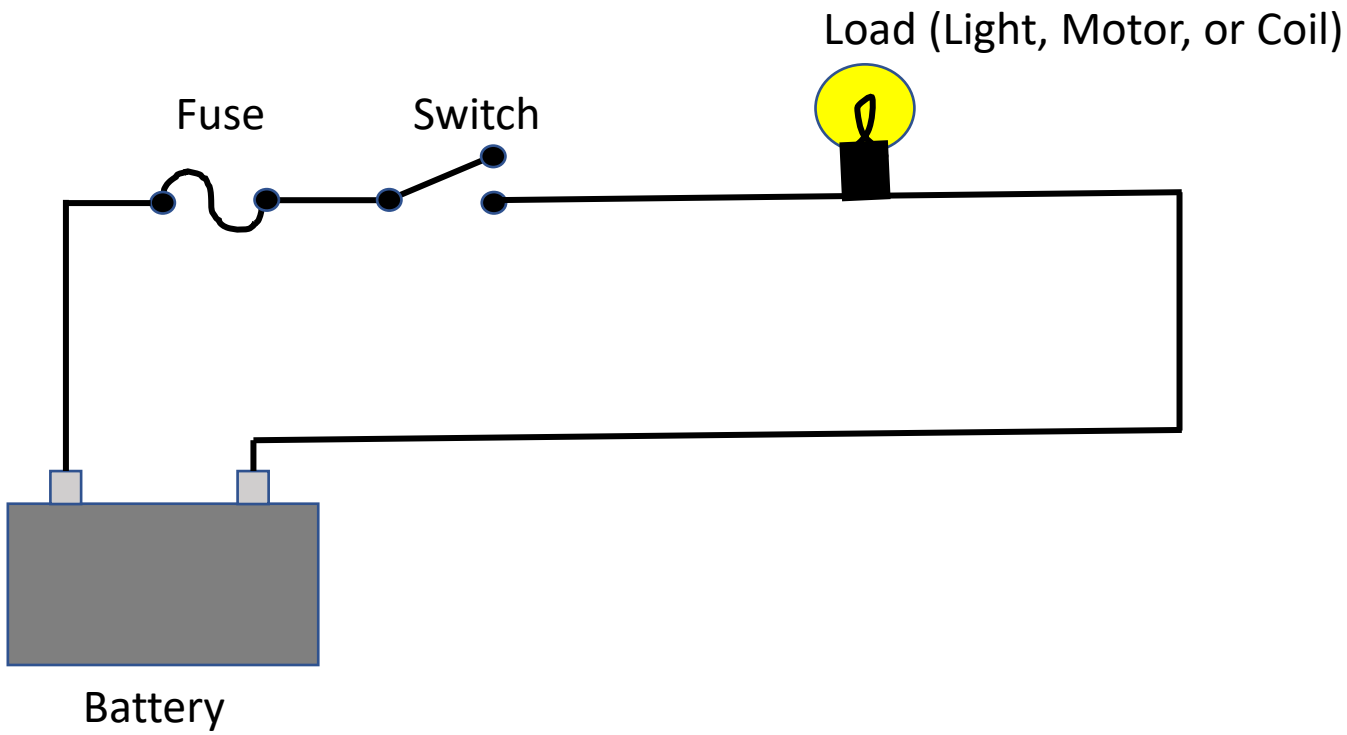
How I Remember

Volts – V large pressure at the point

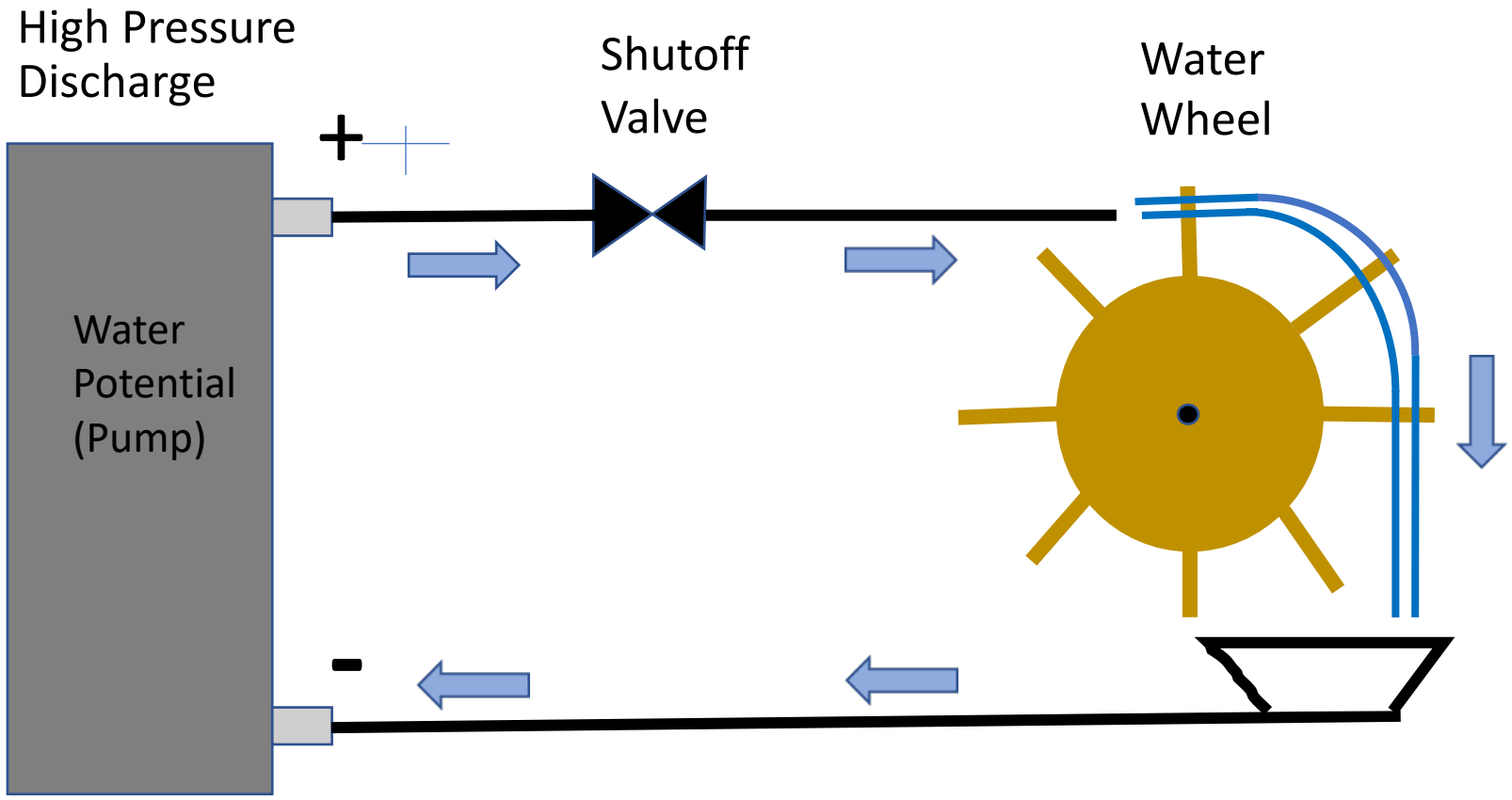
Amps – *Am*ount *p*a*s*sing

Ohms – O obstacle to flow

Simple Circuit



Water Analogy



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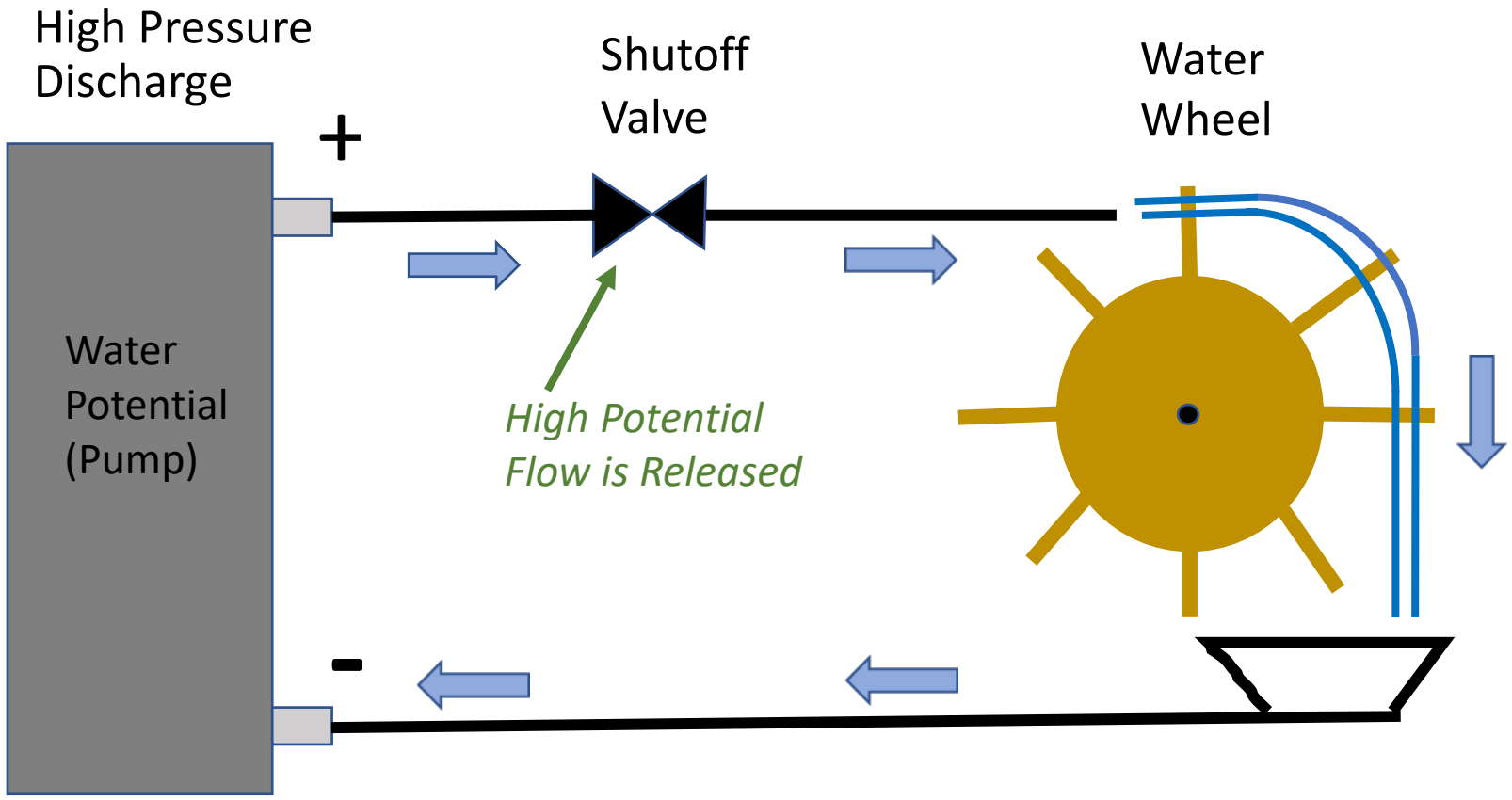

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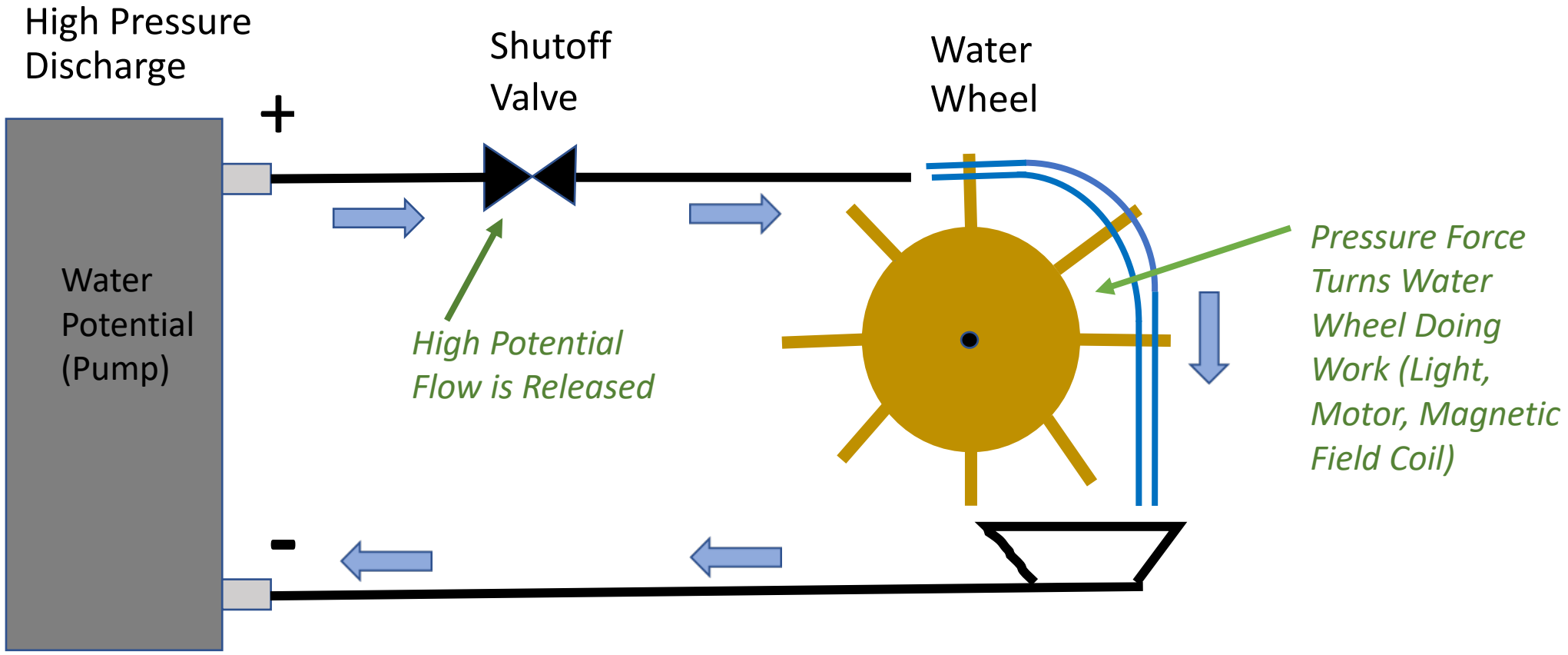

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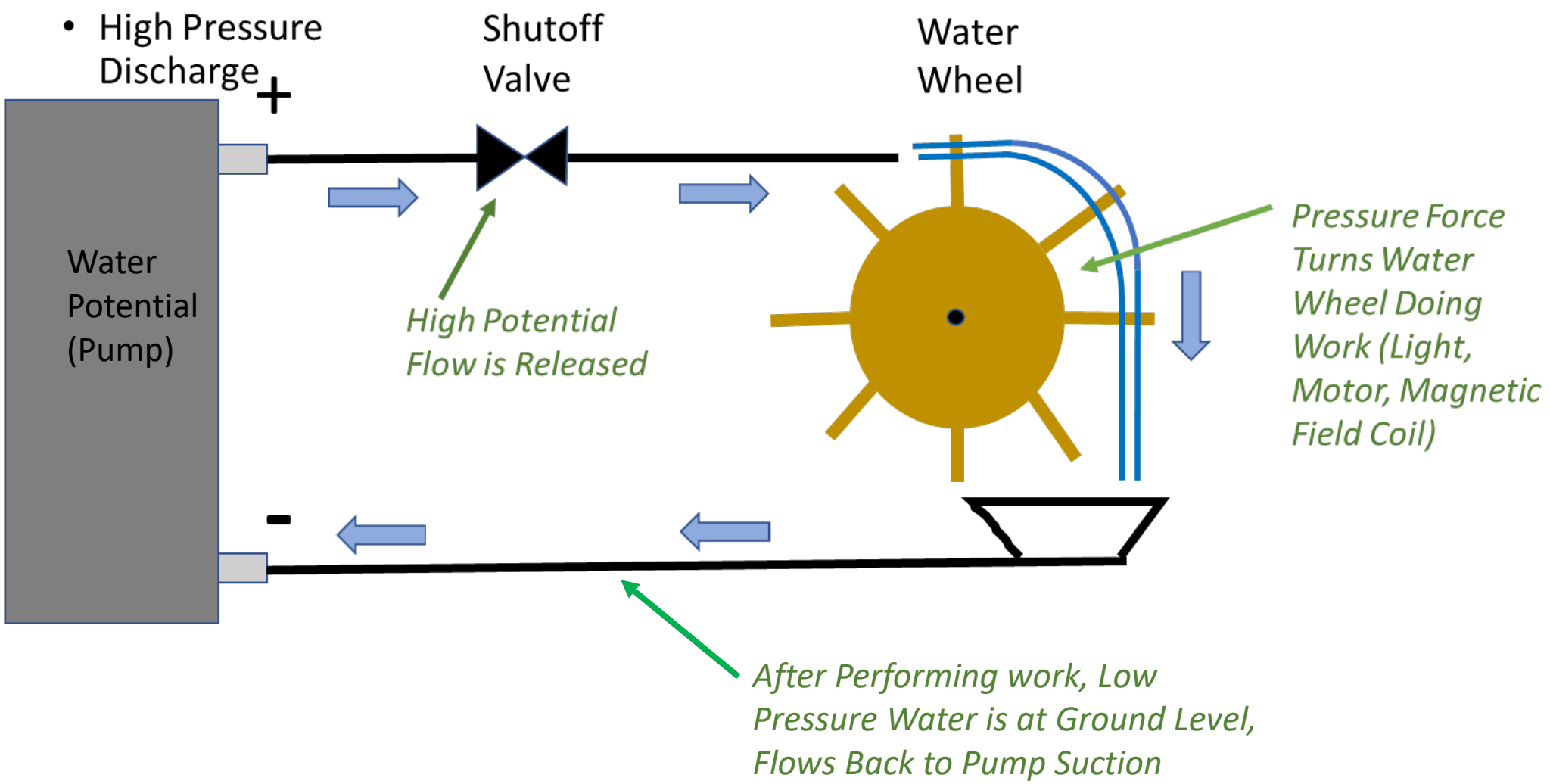
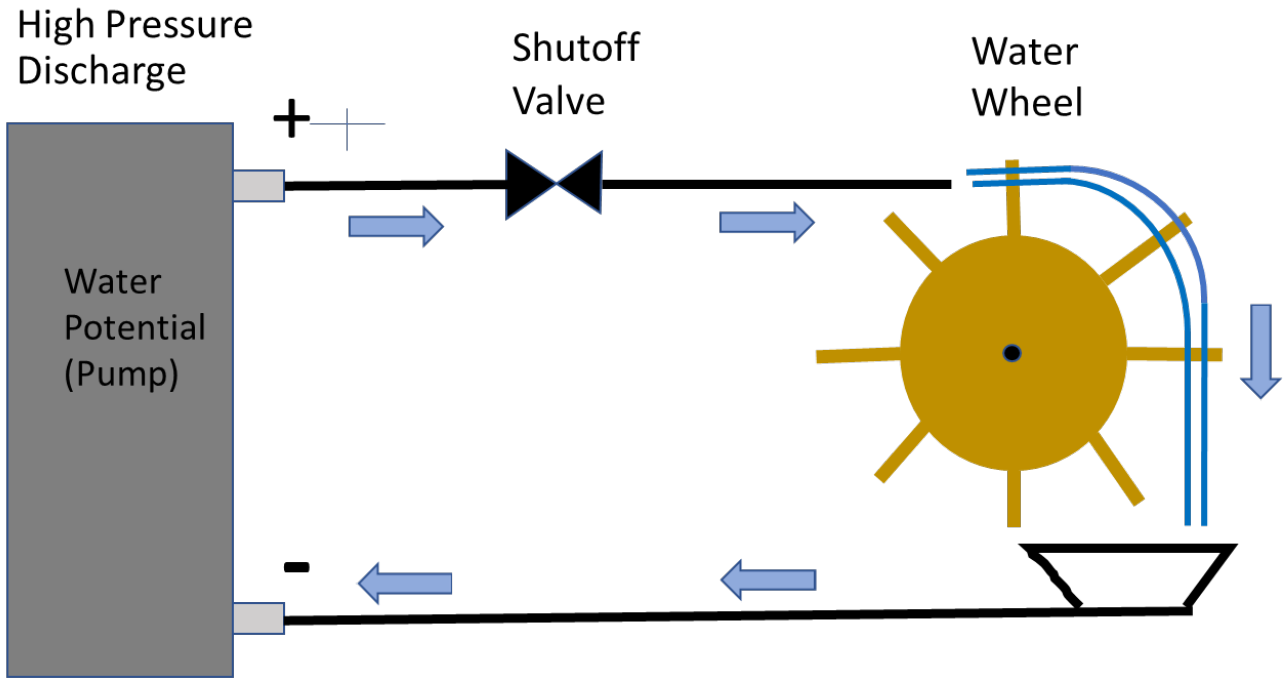


Differences in the Electrical World



After flowing past the last load in the circuit, all pressure is depleted, i.e. zero potential energy remains in the flow stream.

The circuit only takes as much current that it requires, often taking less current after starting operation.

The Digital Multi-meter (DMM) is Useful in Diagnosing Electrical Problems

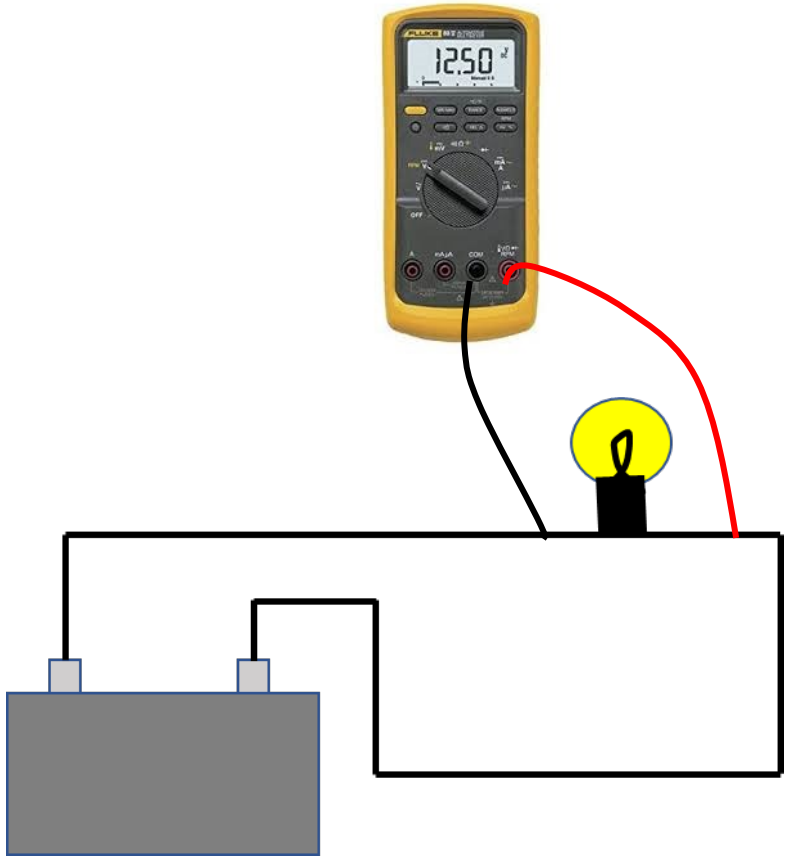
The DMM is Really 3 tools in 1.

1. A Voltmeter

2. An Ohmmeter

3. An Ammeter

A voltmeter measures the difference in electrical potential between 2 points in a circuit. The circuit can remain “intact”.

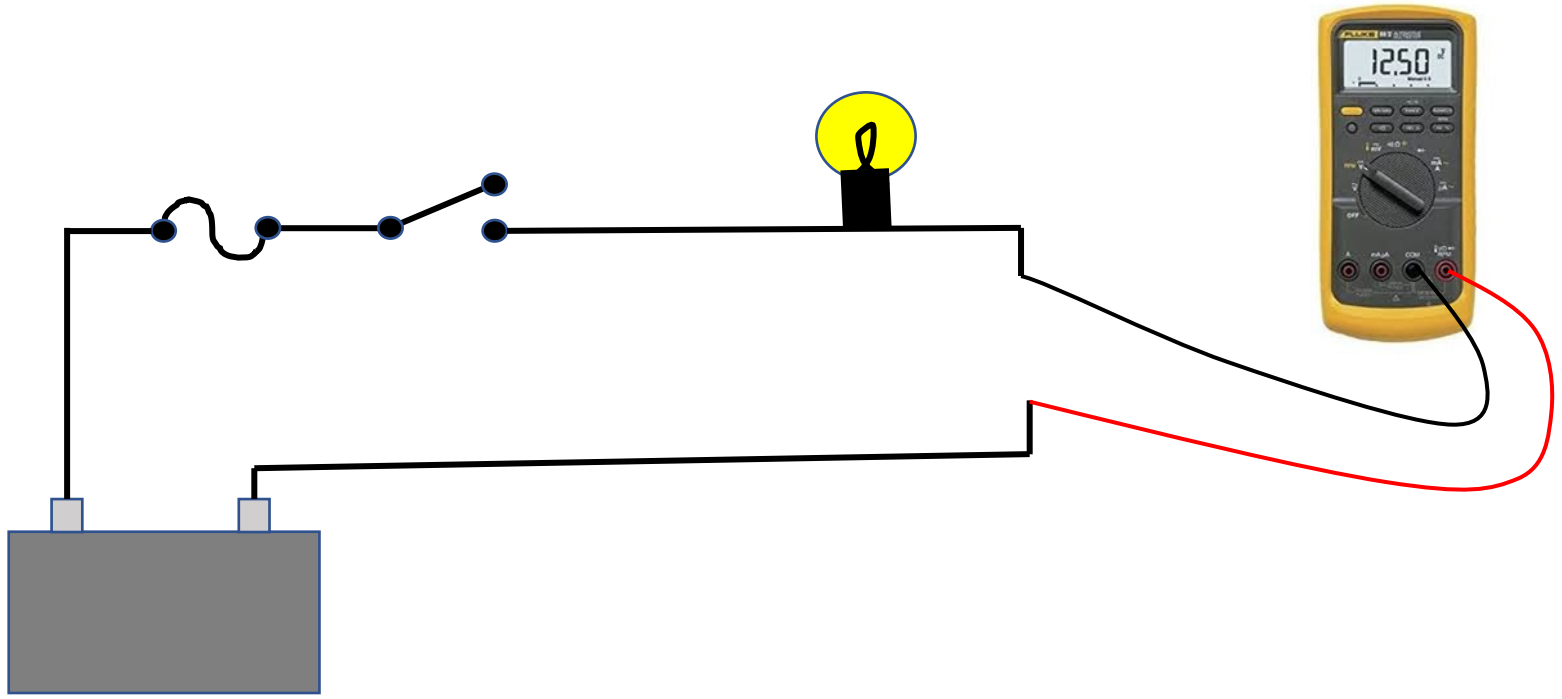


An ohmmeter measures resistance.

The component must be isolated from the circuit. The ohmmeter serves as a battery source in the circuit, sending a small current from its probe and measuring what is returned.

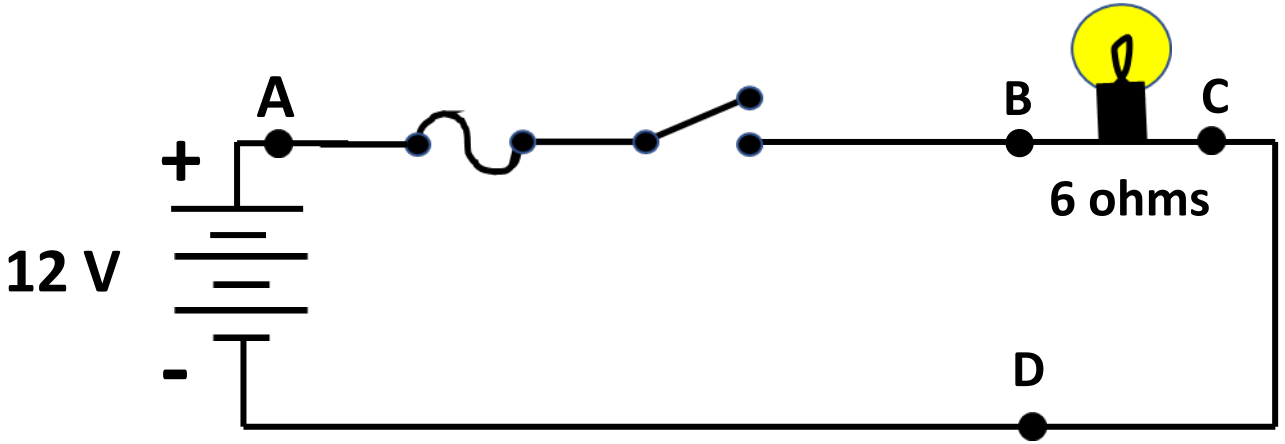
It also serves as a continuity checker, verifying that there is an electrical path between two points.

An ammeter measures the current flow in a circuit.
The circuit must be “broken” and the probes attached at each of the two ends to complete the circuit.



This is rarely done. Usually an amp clamp tool is used that measures the magnetic field around a wire, which is converted to an amperage reading.

What is the Expected Voltage Reading?



A to B ?

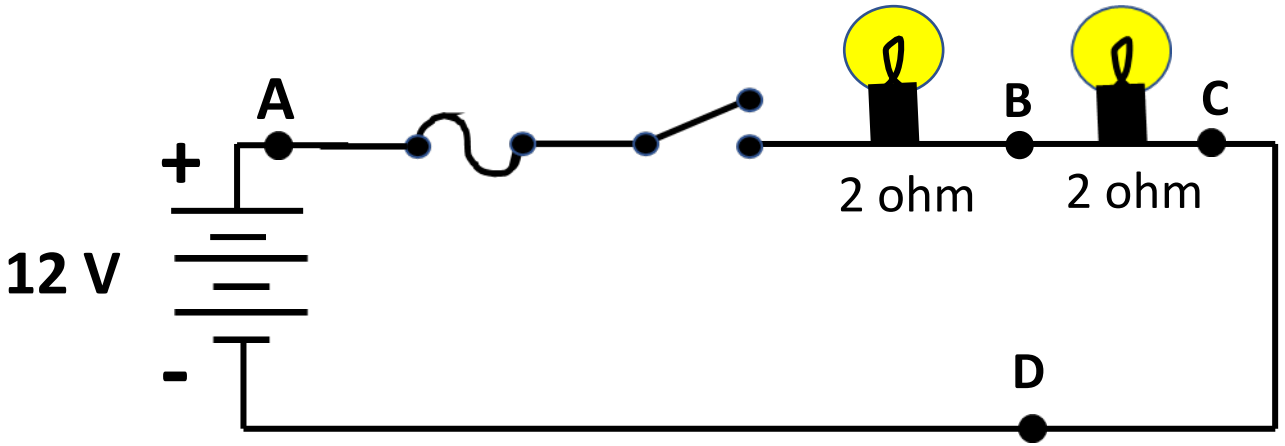
B to C ?

C to D ?

A to D ?

What is the current in the circuit at A? B? C? D?

What is the Expected Voltage Reading?



A to B ?

B to C ?

C to D ?

A to D ?

What is the current in the circuit at A? B? C? D?

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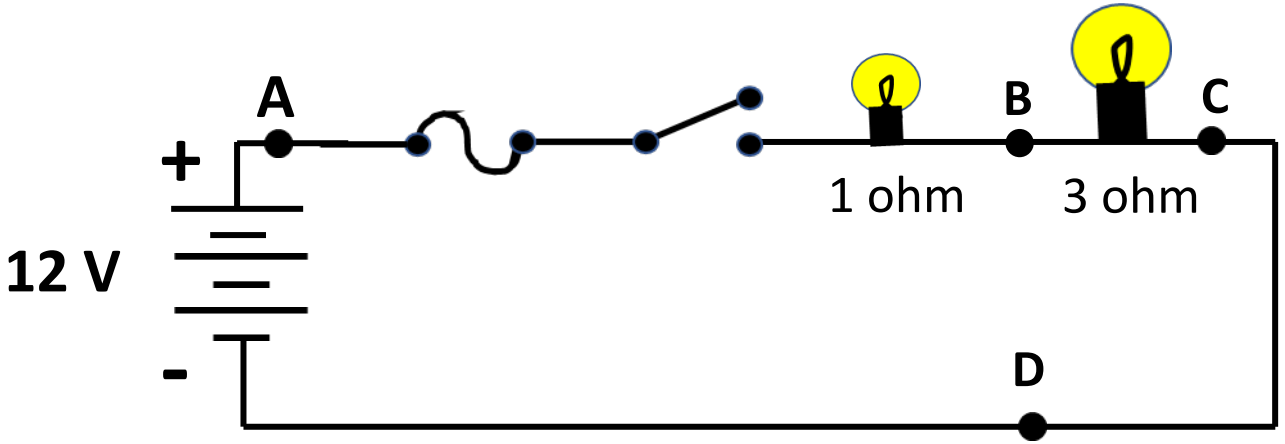


A to B ?

B to C ?

C to D ?

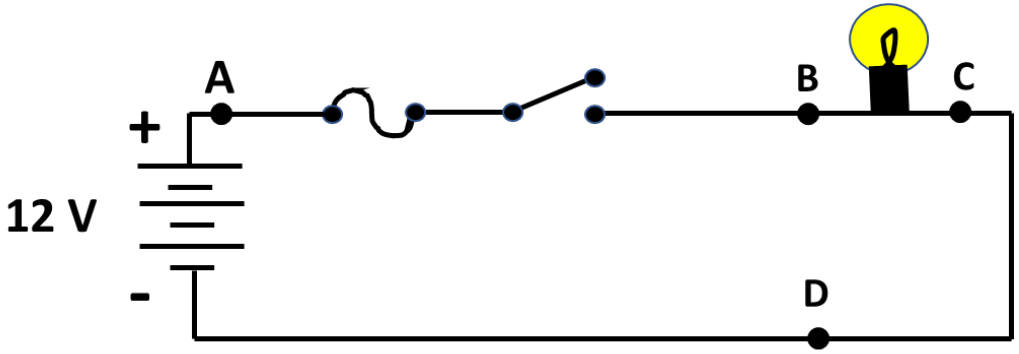
A to D ?

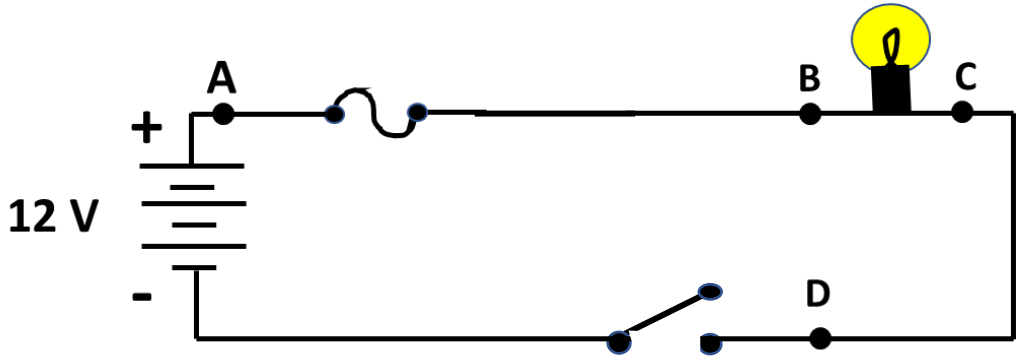
What is the current in the circuit at A? B? C? D?

Conventional Theory – Electrons Flow from Positive to Negative

Circuit Before Load – Power Side
Circuit After Load - Ground Side

Location of switch impacts voltage readings of an open circuit

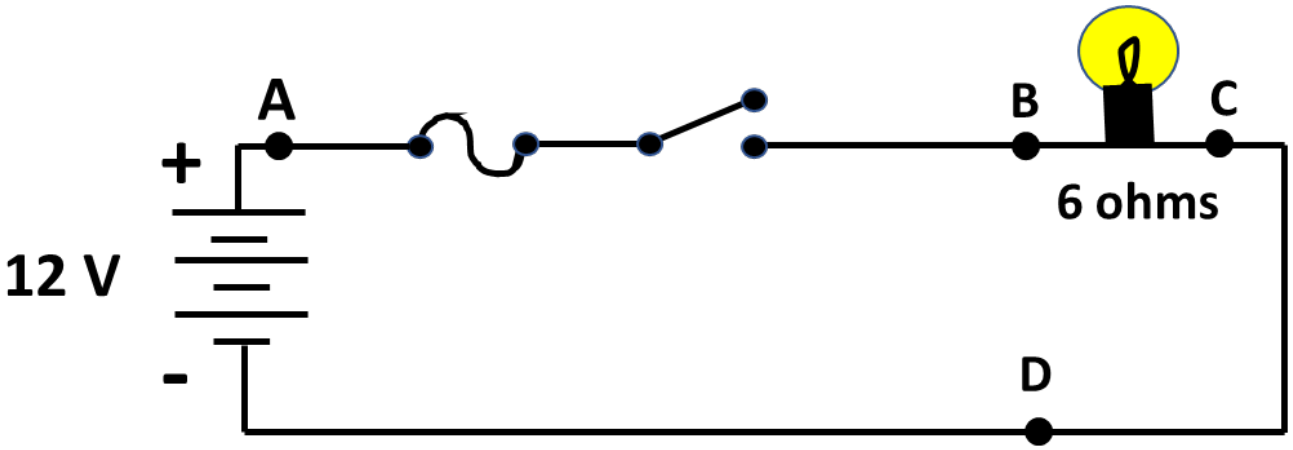




Voltage Drop Testing

Check wires for bad connections and corrosion, causing an unexpected resistance in the circuit.

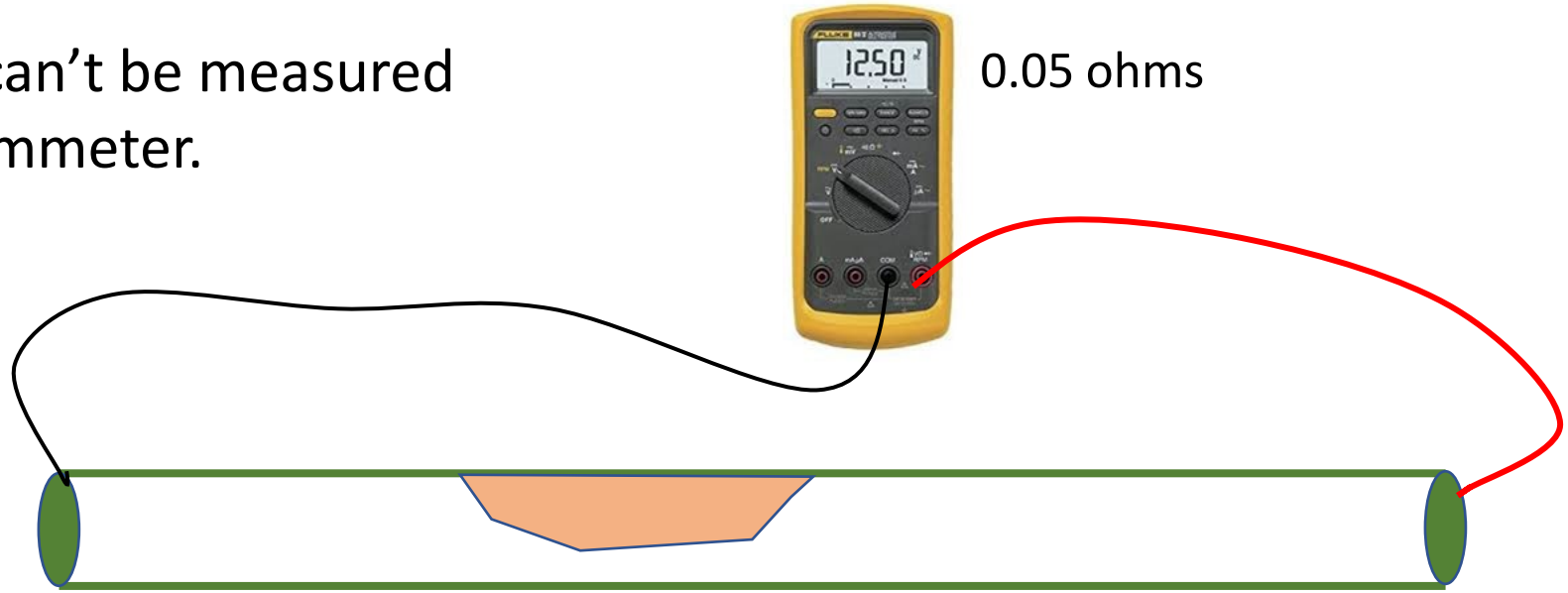
The only expected source of resistance is the load. Any other source is unwanted and will effect how the circuit works.



What if the voltmeter reading between points A-B was 8 volts?

What if the voltmeter reading between C –D was 2 volts?

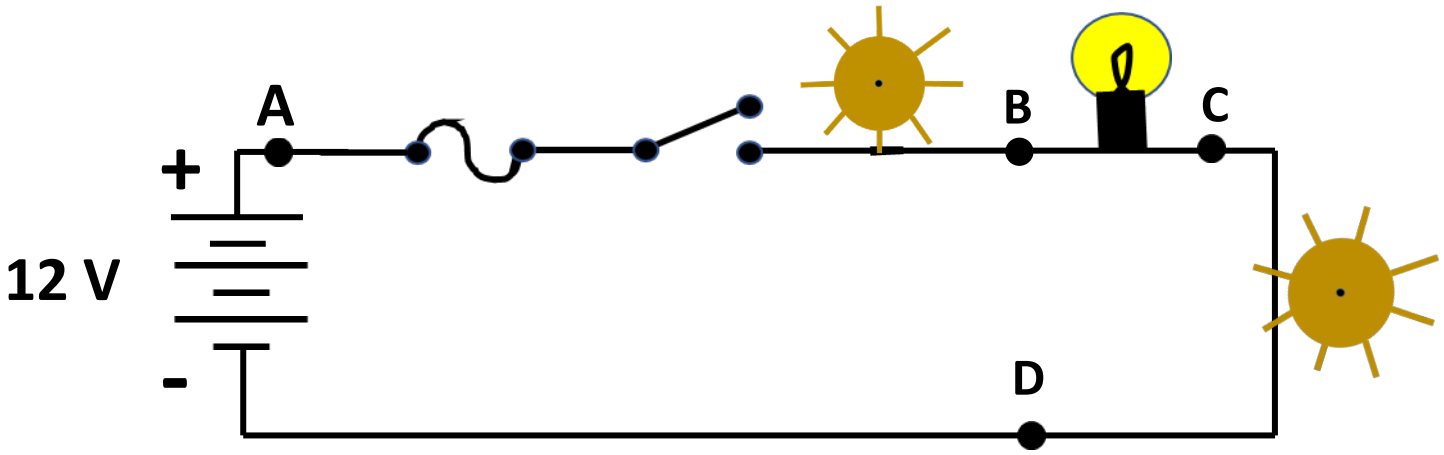
Corrosion can’t be measured with an ohmmeter.



The small voltage in an ohmmeter only needs a few strands of wire to get by corrosion, similar to a “kink” in a garden hose.

During operation, the few remaining strands of good wire could get hot, which would further increase resistance.

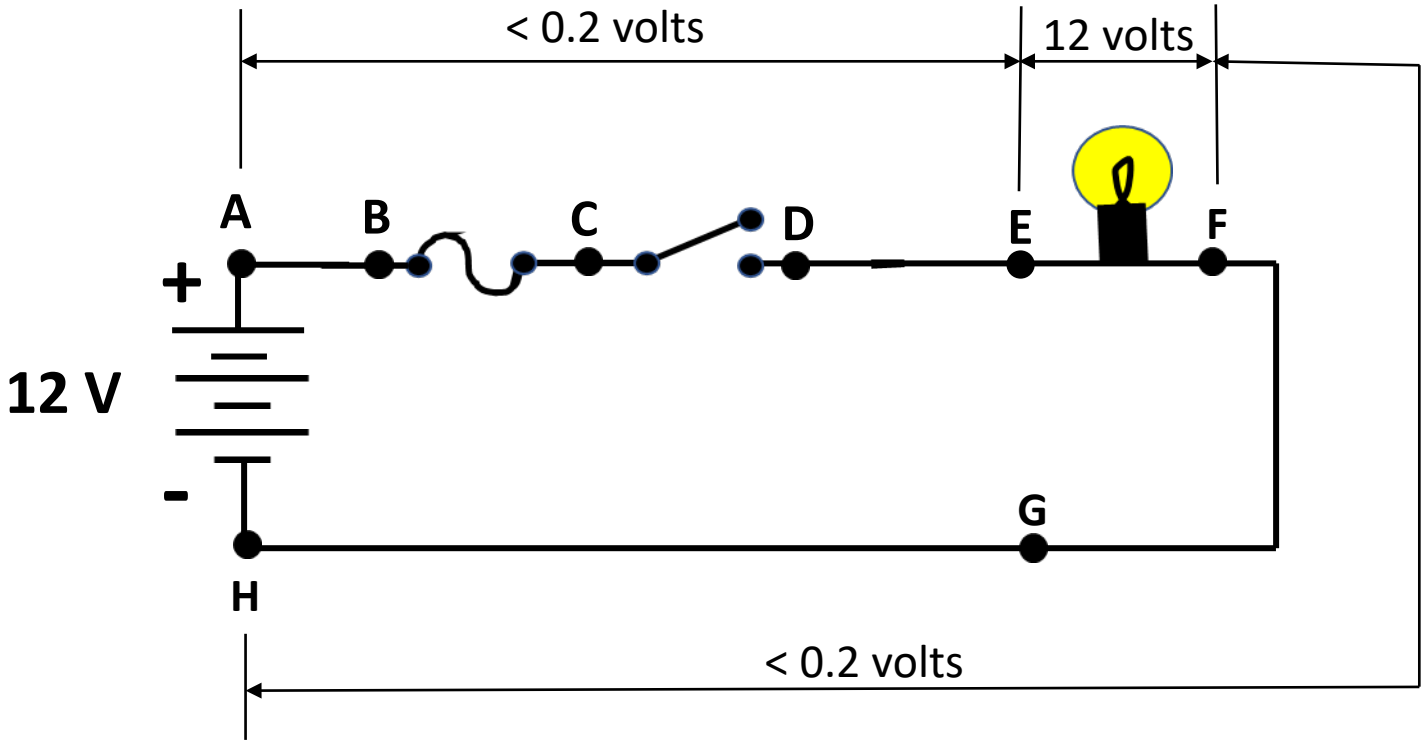
Unexpected resistance in a circuit is equivalent to adding additional loads, which could effect electrical performance.



Need to take voltage measurements along the entire circuit to find location of unexpected "high" voltage drops.

All connections and wire will have some resistance, and could indicate some voltage drop.

Acceptable voltage drop is usually 0.2 per each side, or 0.4 - 0.5 volts total in the circuit.



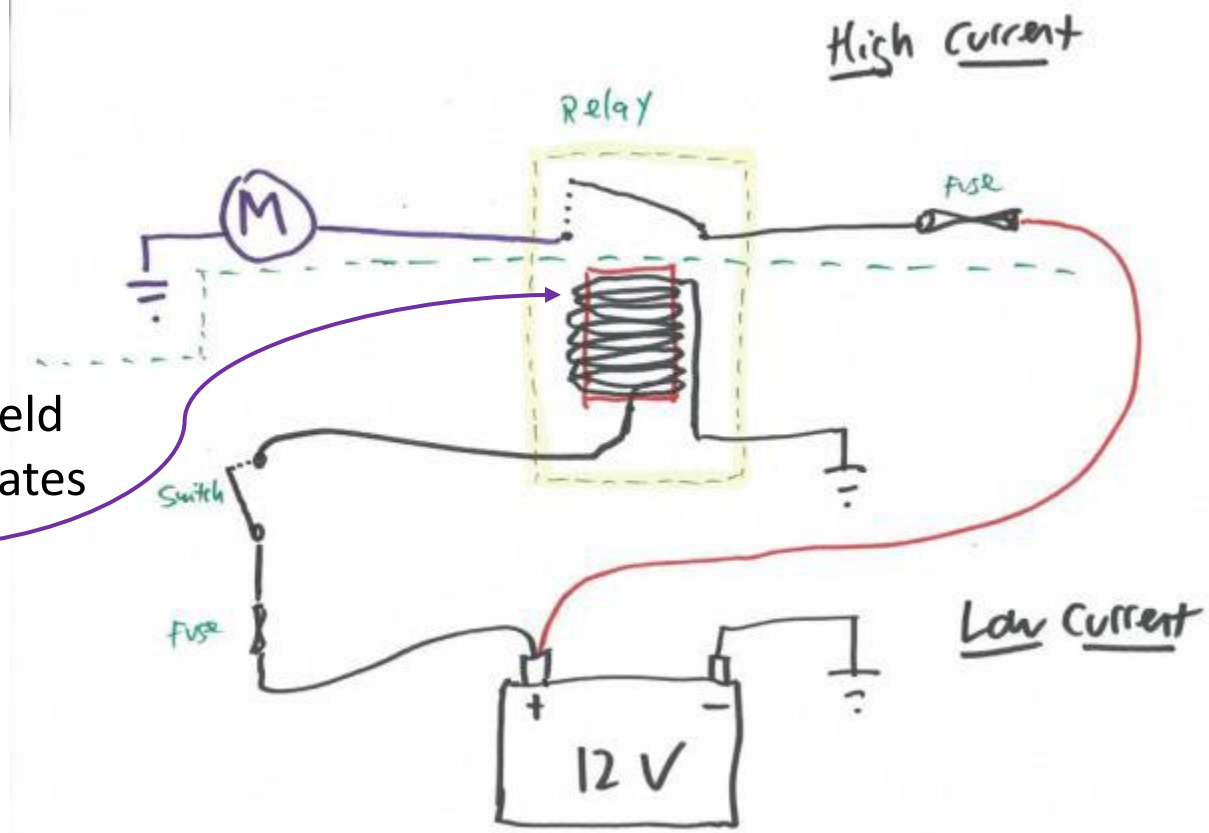
Relays

Relays use a low amperage circuit to control a large amp circuit. This allows smaller (lower capacity) wires and switches in the passenger compartment. Safer and saves weight.

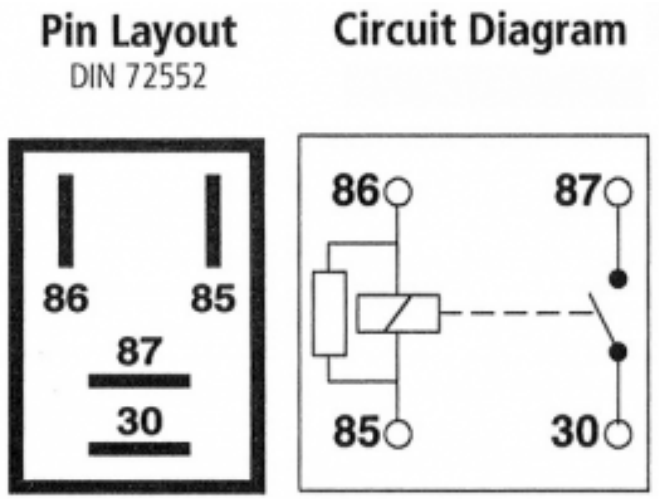
Commonly used for air conditioning circuits, headlights, starters (solenoid), and cooling fans.

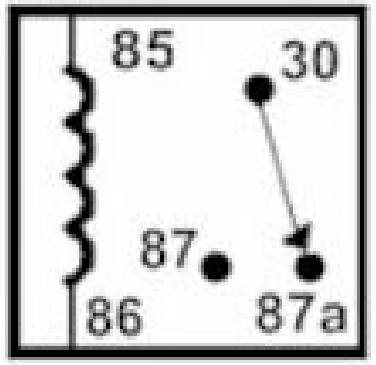
Relays are the interaction of two separate circuits,

- Load side
- Control side.

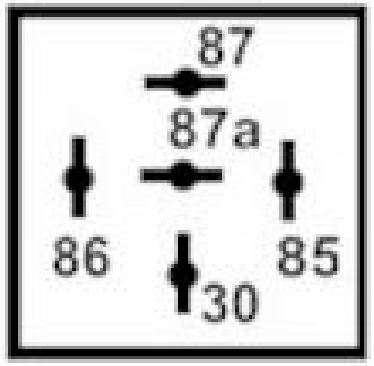


Magnetic field at coil activates switch





Schematic



5 Pin View

Troubleshooting
Need to determine which side of the circuit is the problem

Can remove the relay and use a jumper wire across load terminals to see if the system operates. Can use voltmeter to see if getting power to terminals for #85 and #30, and ohmmeter to check continuity to ground for terminals #86 and (w/ control) #87 (and 87A w/o control)

With the relay removed, can measure the resistance across the control coil. Should read 60 – 100 ohms (Usually 75 ohms).

Pulse Width Modulation (PWM)

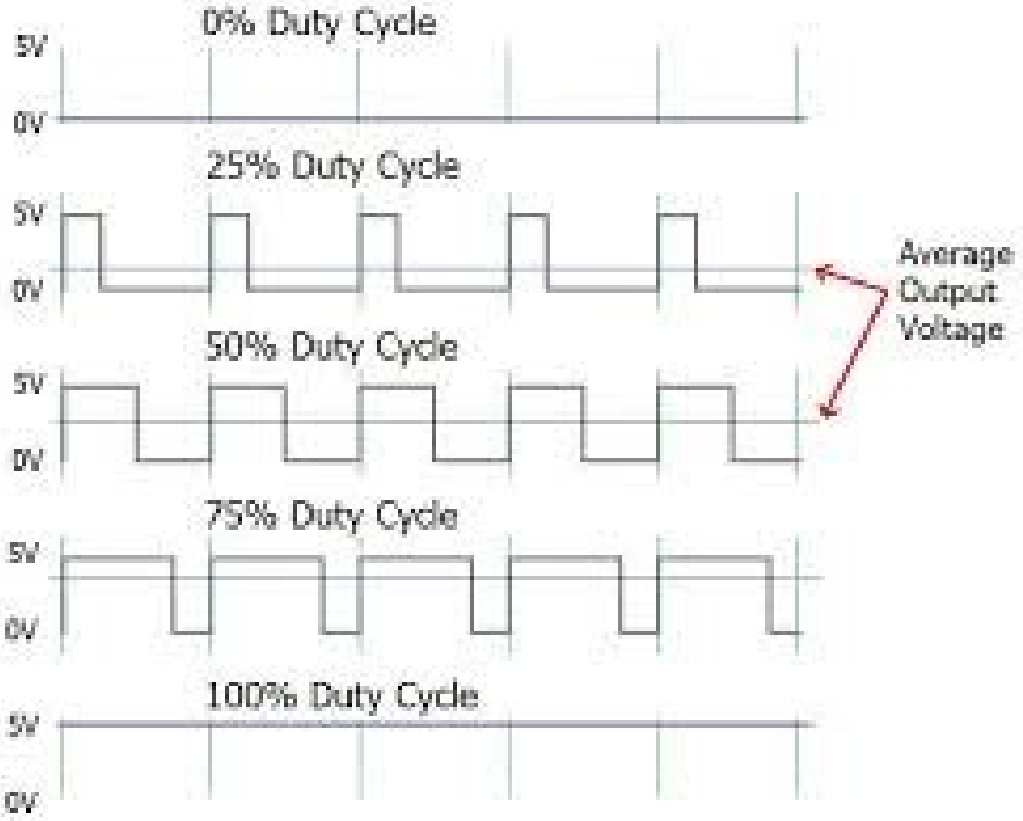
In modern cars, used to vary the output of a digital signal.

Cycling at a fixed frequency, the signal is rapidly turn on and off several times a second.

Used to control the output or speed of alternators, cooling fans, fuel pumps, interior lights, and others.

Duty Cycle – ratio of “on” time during a cycle
Pulse width – length of actual “on” time in milliseconds

Voltmeter will read average output voltage.



Battery – State of Charge Test

“Open Circuit Battery Voltage”

1. Engine off, all electrical accessories are off

2. Put test leads on battery posts (DC Volts setting)

12.6 volts	100% charged
12.4 volts	75% charged
12.2 volts	50% charged
12.0 volts	25% charged
< 11.9 volts	discharged

When > 12.6 volts, and if recently driven or charged, the battery plates have a surface charge.

To remove surface charge, wait a few minutes, or turn on headlights for a minute and then wait a couple of minutes.

Alternator Function Test

Charging Voltage Test

1. Battery must be at least 75% charged
2. Put voltmeter leads on battery posts (DC volts)

Should see voltage between 13.5 to 15 volts (Fiero 16 volts?)

If voltage is too high, check the alternator
If voltage is too low, check the alternator and cables

Resources

Using Multimeters

Wonder Spawn – How to use a Multimeter- Beginners Crash Course (19:21)
(didn't explain disconnecting cable for parasitic draw test)
DieselWorld - Beginners Guide on Using Electrical Multimeters for Auto (19:05)
Dial2Fast - How to Use a Multimeter – Video 1, 2, and 3 (15:54, 8:24, 8:09)

Voltage Drop

Schrodingers Box - Diagnosing and Understanding Voltage Drops (33:15)
MattsMotorz - What is Voltage Drop Test (2:40)
Daniel Sullivan - What is Voltage Drop (14:53)
Eric the Car Guy – Ground Side vs. Power Side Switching (20:02)
The Trainer - #74 How to Verify the Integrity of Power and Ground (25:13)
#47 What Measuring on the Ground Side Means (9:37)

Relays

Schrodingers Box – Understanding, Diagnosing, and Testing Relays (28:54)