SIERRA COLLEGE

MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

Class 03
Electrical Units of Measure

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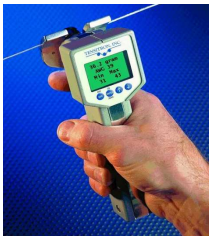
- Units of Measurement
  - Base Units

Quantity	SI Base Unit and Symbol	US Customary Unit and Symbol
Distance	meter (m)	feet (ft)
Mass	kilogram (kg)	pound-mass (lbm)
Time	second (s)	second (s)
Electric current	Ampere (A)	Ampere (A)
Temperature	Kelvin (K)	degree Fahrenheit (°F)
Luminous intensity	candela (cd)	candela (cd)
Amount of substance	mole (mol)	mole (mol)

  - Derived Units
    - Combinations of base units



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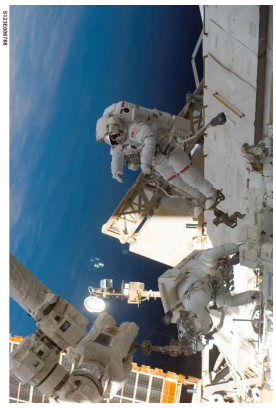
- Units of Measurement
  - Mass
    - A measure of an objects inertia
  - Newtons First Law
    - An object at rest will stay at rest unless acted upon by an external force
    - An object in motion will stay in motion (in a straight line) unless acted upon by an external force.
  - Base Units
    - Kilogram, slug / pound mass



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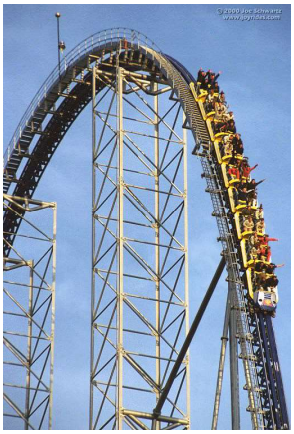
- Units of Measurement
  - Force
    - A push or pull experienced by objects with mass
  - Newtons Second Law
    - When a net force acts on a mass the acceleration is directly proportional to the force.
    - **Force = mass x acceleration**
  - Derived Units
    - Newton (kg m / sec^2)
    - Pound



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- Units of Measurement
  - Work / Energy
    - Force applied through a distance
    - W = F x d
  - Derived Units
    - Joule (Newton meter)
    - Pound foot

Energy Types
- Electric
- Thermal
- Nuclear
- Magnetic
- Gravitational
- Radiant

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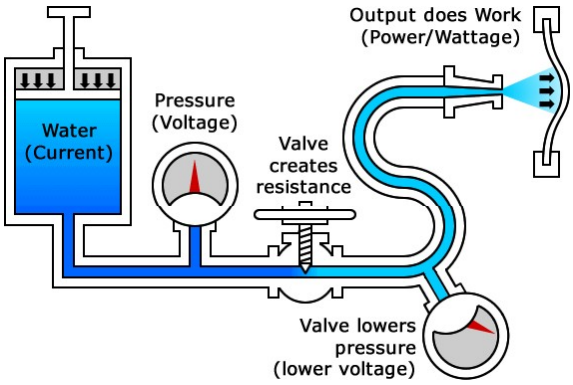
- Electricity
  - The Hydraulic Analogy



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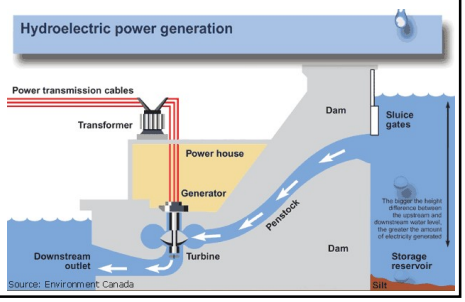
- Electrical Units of Measure
  - Gravitational Potential
    - The work done by mass in the presence of an gravitational field.
    - Derived Units – Joules per kilogram, J / kg
    - AKA gravitational force, pressure differential

Hydraulic Analogy

What happened to the pressure?



"A joule per kilogram is defined as a difference of energy causing one kilogram of mass to do one joule of work"

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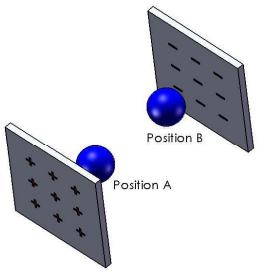
- Electrical Units of Measure
  - Electric Potential
    - The work done by a charged particle in the presence of an electrical field.
    - Derived Units – Volt (E,V) (Joules per Coulomb)
    - AKA electro-motive force, voltage, potential differential



Electric potential energy is the amount of work required to move a charged particle from position B to position A.

"A volt is defined as a difference of potential causing one coulomb of current to do one joule of work"

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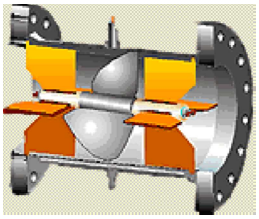
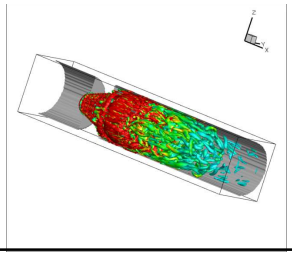
- Electrical Units of Measure
  - Hydraulic Flow
    - The mass per unit time that passes a point in a closed system
    - Requires pressure potential, free molecules & flow path
  - Derived Unit – kilogram per second

Hydraulic Analogy





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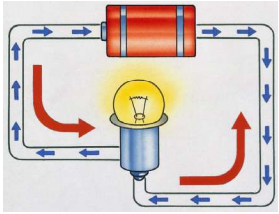
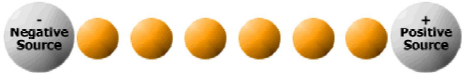
- Electrical Units of Measure
  - Electron Flow (current)
    - The charge per unit time that passes a point in a circuit
    - Requires electric potential, free electrons & current path
  - Derived Unit – Ampere (I) = 1 Coulomb per second (6.25 x 10^{18} electrons per second)





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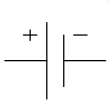
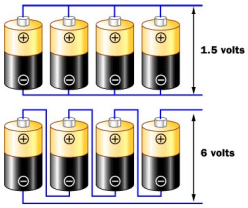
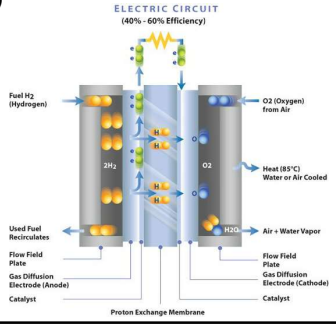
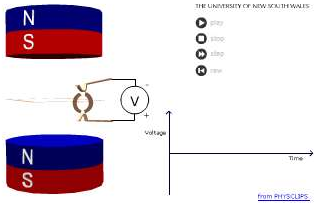


- Electrical Units of Measure
  - Direct Current
    - Electrical charges that flow in one direction
  - Derived Unit – Ampere (I) (Coulomb per second)







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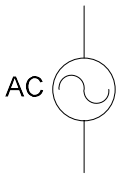
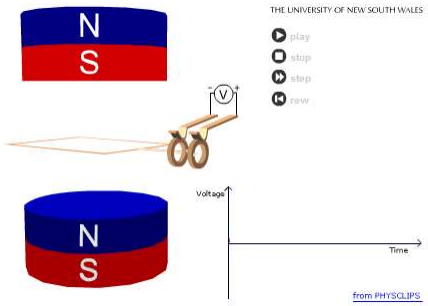
- Electrical Units of Measure
  - Alternating Current
    - Electrical charges that periodically reverse direction
  - Derived Unit – Ampere (I) (Coulomb per second)





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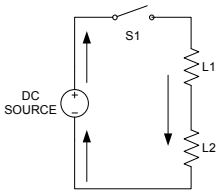
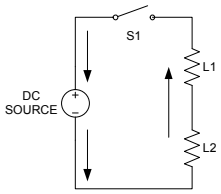
- Electrical Units of Measure
  - Electric Current
    - **Conventional Current** – Early concept, prior to electron theory, assumed current flowed from positive (surplus) to negative (deficit)
    - **Electron Flow** – negatively charged electrons flow from negative to positive



CONVENTIONAL CURRENT



ELECTRON CURRENT

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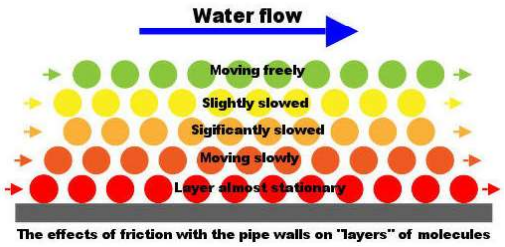
- Electrical Units of Measure
  - Losses
    - Opposition to hydraulic flow
  - Derived Unit – Head Feet (ft hd)

Hydraulic Analogy

Frictional Losses (Bad)



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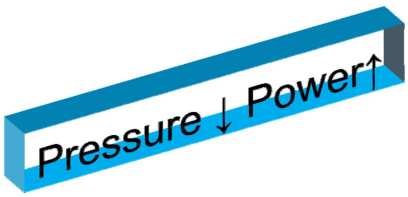
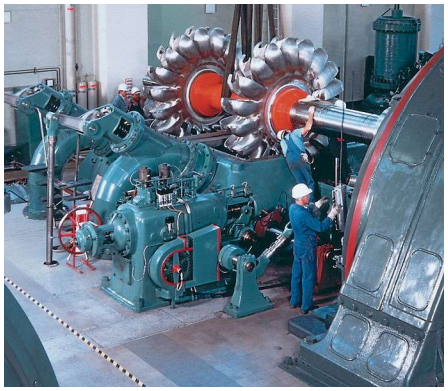
- Electrical Units of Measure
  - Losses
    - Opposition to hydraulic flow
  - Derived Unit – Head Feet (ft hd)



Hydraulic Analogy

Engineered Losses
(Good)



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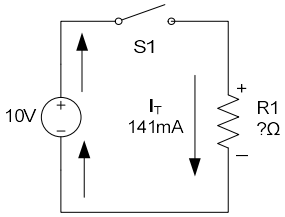
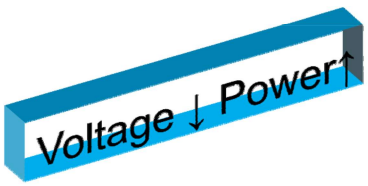
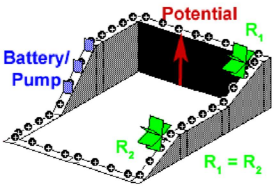
- Electrical Units of Measure
  - Resistance
    - Opposition to charge flow
    - From Ohm's Law V = I R
  - Derived Unit – Ohm Ω (R) Volt / Current

$$R = \frac{E}{I}$$







What happened to the potential?

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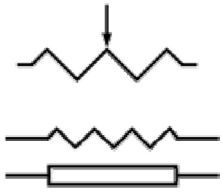
- Electrical Units of Measure
  - Resistance
    - Opposition to current flow
    - From Ohm's Law V = I R
  - Derived Unit – Ohm Ω (R) Volt / Current
  - Causes voltage drop across loads



$$R = \frac{E}{I}$$

"One ohm is defined as that amount of resistance that will limit the current in a conductor to one ampere when the potential difference (voltage) applied to the conductor is one volt."

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- Electrical Units of Measure
  - Conductance
    - Inverse of resistance
  - Derived Unit – 1/R, mho siemens (S)

$$G = \frac{1}{R} \qquad G = \frac{I}{E}$$

"One siemens is defined as that amount of conductance that will allow the current in a conductor to reach one ampere when the potential difference (voltage) applied to the conductor is one volt."

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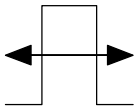
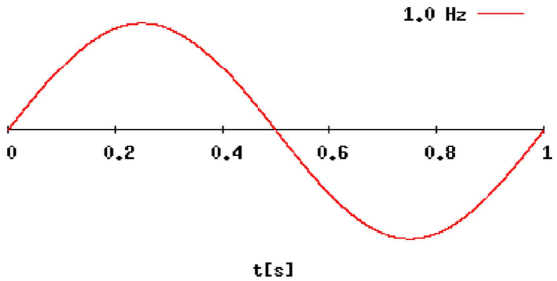
- Electrical Units of Measure
  - Frequency
    - The number of occurrences in a period of time
  - Derived Unit – Hertz = 1/t





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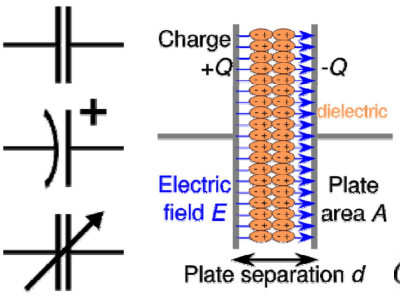
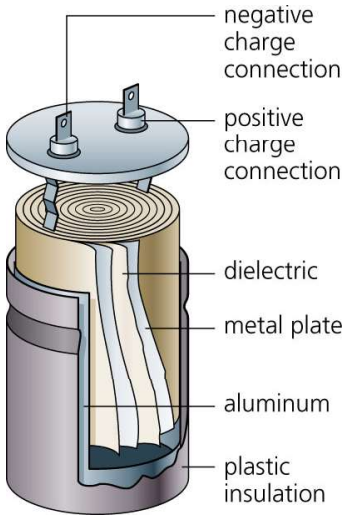
- Electrical Units
  - Capacitance
    - Stored charge per Volt
  - Derived Unit – Farad
    (Coulomb / Volt)



$$C = \epsilon_r \epsilon_0 \frac{A}{d}$$

$$W_{stored} = \frac{1}{2} C V^2$$



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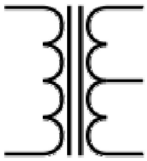
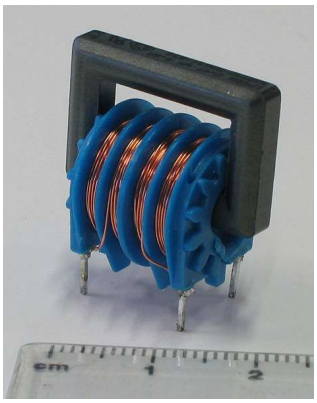
- Electrical Units
  - Inductance
    - Magnetic flux per unit current
  - Derived Unit – Henry (Φ / I)
    - Weber / Amp
    - Volt sec / Amp





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Fundamentals of Mechatronics

Mechatronics
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- Inductance – the opposition to ***change*** in current

$$E = L\left(\frac{di}{dt}\right)$$

If the rate of change of current in a circuit is one ampere per second and the resulting electromotive force is one volt, then the inductance of the circuit is ***one henry.***

Name	Unit symbol	Quantity	Symbol
inductance	H	Henry's	L[22]

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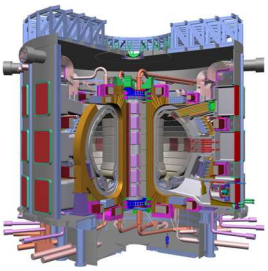
- Electrical Units
  - Power
    - The rate of doing work
    - Newton meters per second
  - Derived Unit – Watt
    - Joules per second



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MECH 10
Fundamentals of Electronics

Mechatronics
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- Powers of Ten & Engineering Notation
  - Expresses very large and very small numbers
    - 3,000,000,000 Watts = 3.00 x 10^{9} Watts (GW)
    - 0.000000003 Farads = 3.00 x 10^{-9} Farads (nF)

Number	Power of 10	Term	Sample Electronic Term
0.000000000001	1.E-12	pico	pA (1 x 10^{-12} ampere)
0.000000001	1.E-09	nano	ήA (1 x 10^{-9} ampere)
0.000001	1.E-06	micro	μA (1 x 10^{-6} ampere)
0.001	1.E-03	milli	mA (1 x 10^{-3} ampere)
1,000	1.E+03	kilo	kΩ (1 x 10^{3} Ohm)
1,000,000	1.E+06	mega	MΩ (1 x 10^{6} Ohm)
1,000,000,000	1.E+09	giga	GW (1 x 10^{9} Watt)
1,000,000,000,000	1.E+12	tera	TW (1 x 10^{12} Watt)

Powers of ten related to meteric & electronic terms

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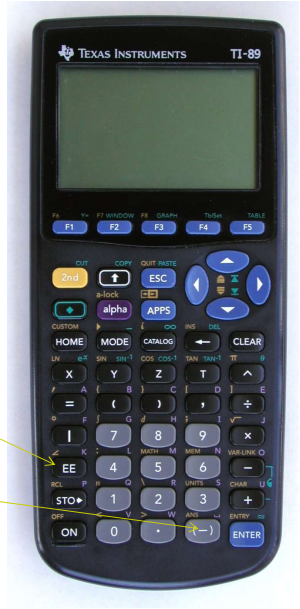
- Engineering Notation Mode
  - Display digits – 3 fixed
  - Exponential Format – Engineering
  - Exact / Approximate
- Input 5kΩ
  - Enter [5000] [ENT] = 5 EE 3
- Input 5kΩ x 24mA
  - Enter [5 EE 3] x [24 EE (-)3]



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- Significant Figures
  - The number of digits whose value is known with certainty.

Significant Digits	Example
Non zero digits	119 (3 sig figs)
Zeros between non-zero digits	109 (3 sig figs)
Trailing zeros after decimal point	12.20 (4 sig figs)

  - Use all precision available for calculations, round off final answers to least significant digit!

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- Non-Significant Figures
  - The number of digits whose value is not known with certainty.

Non-Significant Digits	Example
Leading zeros	0.0053 (2 sig figs)
Trailing zeros without decimal	1500 (2 sig figs)

  - Use all precision available for calculations, round off final answers to least significant digit!

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- Scatter Plots
  - Data visualization

Time (sec)	Distance (feet)	Distance (feet)	Distance (feet)
1	15.63	2.72	100.00
2	31.25	7.39	50.00
3	46.88	20.09	33.33
4	62.50	54.60	25.00
5	78.13	148.41	20.00
6	93.75	403.43	16.67
7	109.38	1096.63	14.29
8	125.00	2980.96	12.50

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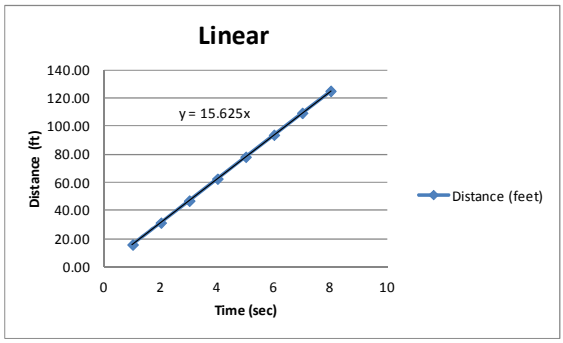
- Scatter Plots
  - Data visualization

Time (sec)	Distance (feet)
1	15.63
2	31.25
3	46.88
4	62.50
5	78.13
6	93.75
7	109.38
8	125.00



Linear Relationship

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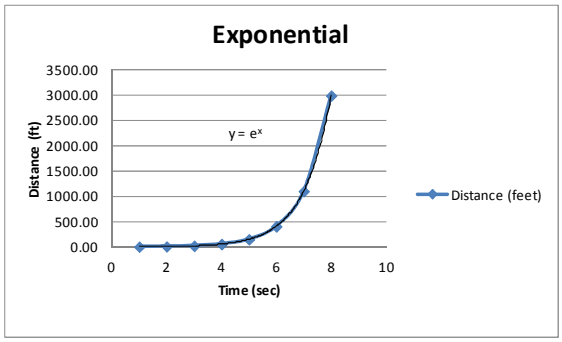
Real Skills Real Jobs

- Scatter Plots
  - Data visualization

Time (sec)	Distance (feet)
1	2.72
2	7.39
3	20.09
4	54.60
5	148.41
6	403.43
7	1096.63
8	2980.96



Exponential Relationship

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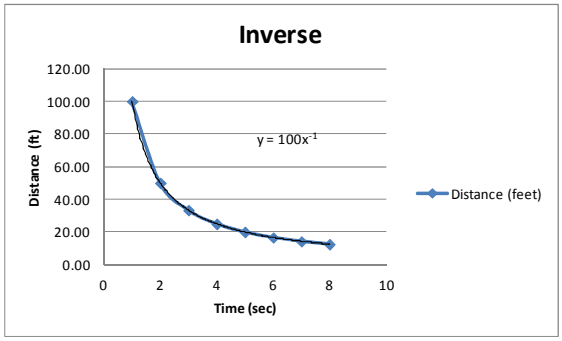
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

- Scatter Plots
  - Data visualization

Time (sec)	Distance (feet)
1	100.00
2	50.00
3	33.33
4	25.00
5	20.00
6	16.67
7	14.29
8	12.50



Inverse Relationship

SIERRA COLLEGE

MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

- Lab 03 – Basic Multimeter Function
  - Use a digital multimeter (DMM) to take voltage, resistance, current, frequency and capacitance readings.
  - Select the proper measurement ranges to provide the greatest measurement resolution.
  - Build a simple circuit using the Global Specialties Proto-Board.
  - Test the circuit with the multimeter and record the results.

		Points Possible
Documentation	Quality of documentation (research, neatness, clarity, spelling, complete sentences)	**10**
	Resistance measurements accurate and questions answered.	**5**
	DC voltage measurements accurate and questions answered.	**5**
	AC voltage measurements accurate and questions answered.	**5**
	AC current measurements accurate and questions answered.	**5**
	Diode test completed and questions answered.	**5**
	Audible continuity test completed with question answered	**5**
	Total	**40**