How to do unit conversions

- This is not hard if you take your time, are careful, and use a calculator
  1. Need a conversion factor (e.g. 1 meter = 3.28 ft, or 1 gallon of gas = 36.6kWh)
  2. Only convert between same things (e.g. distance to distance, or energy to energy, or power to power, but NOT energy to power, and NOT distance to speed)
- Example 1: Convert 1500 meters to feet
  - 1500 meters (3.28 ft/1 meter) = (1500)(3.28) (meters ft/meters) = 4290 ft
- Example 2: Convert 1.5 km to miles
  - Need three conversion factors! 1 km = 1000 m, 1 mile = 5280 ft, 1 m = 3.28 ft
  - 1.5 km (1000m/1km)(3.28ft/1m)(1mi/5280ft) = (1.5)(1000)(3.28)/5280 mi = .93 miles
- Example 3: Convert 100 kilowatt hours of electricity into gallons of gas
  - Check: BOTH kWh and gallons of gas are ENERGY so conversion can be done
  - 100 kWh (1 gal gas/36.6 kWh) = 2.7 gallons of gas
- Example 4: Convert 1000 Watts to gallons of gas
  - Check: Watt is power and kWh is energy; conversion CANNOT BE DONE
- Convert 3.2km to miles per hour
  - Check: km is distance and miles per hour is speed; conversion CANNOT BE DONE

ENERGY CONVERSION FACTORS

- 1kWh = 862 Cal = 3413 Btu = 3.6 MJ
- 1 Cal = .0016 kWh = 3.97 Btu = 4184 J
- 1 Btu = .252 Cal = .000293 kWh = 1055 J
- 1 ft-lb = 1.36 J
- 1 gal gasoline = 31000 Cal = 36.6 kWh =125000 Btu = 132 MJ
- 1 bbl oil = 1.5M Cal = 5.8 M Btu = 1700 kWh =6.1 GJ
- 1000 cf nat gas = 260,000 Cal = 1M Btu = 300 kWh= 1GJ = 10 therm
- 1 ton coal = 6.7M Cal = 27 M Btu = 7800 kWh = 28GJ
- 1 Qbtu = 300 G kWh = .17 G boe
- POWER = ENERGY/TIME CONVERSIONS:
- 100 Qbtu/yr = 3.35 TW = 172. G boe/year
- 1 Cal/hr = 1.16 W = 3.97 Btu/hr
- 1 horsepower = 746W = 550 ft-lb/sec
- boe = barrel of oil equivalent, Cal = kcal = 1000 cal, J=Joule (metric), kWh = kilo Watt hr, W = Watt (metric)
- k=kilo, M=Mega=10^6, G=Giga=10^9, T=Tera=10^{12}, P=Peta=Q=Quadrillion=10^{15}

The Physics of Energy Formula List

- Lots of forms of energy coming fast and furious, but to put it in perspective, here's a list of formulas:

Energy Form	**Energy Formula**
Work	$W = F \cdot d$ *(Force times distance)*
Kinetic Energy	K.E. = $\frac{1}{2}mv^2$ (mass times velocity squared)
(Grav.) Potential Energy	$E = mgh$ *(mass times height times* $10 m/s^2$*)*
Heat Energy	$\Delta E = c_p m \Delta T$ *(mass times change in temperature times heat capacity)*
Mass energy	$E = mc^2$ (mass times speed of light squared)
Radiative energy flux	$F = \sigma T^4$ (temperature to the fourth power times a constant)
Power (rate of energy use)	$P = \Delta E / \Delta t$

A note on arithmetic of units

- The proper way is to carry units in your calculations and multiply and divide them as if they were numbers. An alternative is to switch everything to metric units; then the answer is in the metric unit of energy (or power or whatever))
  - Metric units: Distance in meters (m), mass in kilograms (kg), time in seconds (s), Energy in Joules (J), Power in Watts (W), Force in Newtons (N), speed in meters/sec (m/s)
  - k= kilo=10^3=1000, M=Mega=10^6 =million, G=giga=10^9=billion, T=tera=10^{12}=trillion
- Example: the force of air drag is given by:
- $F_{drag} = \frac{1}{2} c_D \rho A v^2$
- c_D is a dimensionless drag coefficient
- ρ is the density of air, 1.3 kg/m^3
- A is the cross-sectional area of the body in m^2
- v is the velocity in m/s
- units: $(kg/m^3)\cdot(m^2)\cdot(m/s)^2 = (kg\cdot m^2/m^3)\cdot(m^2/s^2) =$

$$\frac{kg\cdot m^2\cdot m^2}{m^3\cdot s^2} = \frac{kg\cdot m^4}{m^3\cdot s^2} = kg\cdot m/s^2 = \text{Newtons}$$