Units

Goals: By the end of this class you should be able to:

- Use units to help you analyze problems and remember important concepts
- Improve your grades in ENGR 199 & PHYS 152!

Quantity	Definition or Equation
acceleration	
force	
work	
energy	
power	
pressure	

Quantity	Definition or Equation
acceleration	*Change in velocity per time* $= \frac{dv}{dt}$
force	*= ma*
work	*a force acting through a distance = Fd*
energy	*the ability to do work (same units as work)*
power	*(work or energy)/time*
pressure	*force/area*

Quantity	Dimensions	MKS basic units	MKS derived unit
frequency (f)	1/t	1/s	Hertz (Hz)
velocity (v)	L/t	m/s	
acceleration (a)	L/t^2	m/s^2	
force (F = ma)	$M\ L/t^2$	$kg\ m/s^2$	Newtons (N)

Quantity	Dimensions	MKS basic units	MKS derived unit
Energy or Work (E = FL)	$\frac{ML}{t^2}L = \frac{ML^2}{t^2}$	$kg\ m^2/s^2$	Joule (J) or N-m
pressure ($p = F/L^2$) or stress ($\sigma = F/L^2$)	$\frac{ML}{t^2}\frac{1}{L^2} = \frac{M}{Lt^2}$	$kg\ /m\ s^2$	Pascal or N/m^2
power (P=E/t)	$\frac{ML^2}{t^2}\frac{1}{t} = \frac{ML^2}{t^3}$	$kg\ m^2/s^3$	Watt (W) or J/s

Quantity	Dimensions	MKS basic units	MKS derived unit
Power (P=?)	$\frac{w}{t} = \frac{ML^2}{t^3}$	kg m^2/s^3 or VA	Watt (W)
voltage (V=E/q)	$\frac{ML^2}{t^2}\frac{1}{it} = \frac{ML^2}{it^3}$	kg m^2/ampere s^3 or W/A	Volt (V)
Resistance (R=V/i)	$\frac{ML^2}{it^3}\frac{1}{i} = \frac{ML^2}{i^2t^3}$	kg m^2/ampere^2 s^3 or V/A	Ohm (Ω)

Multiple	prefix	prefix symbol
10^{12}		
10^{9}		
10^{6}		
10^{3}		
10^{-2}		
10^{-3}		
10^{-6}		
10^{-9}		
10^{-12}		

Multiple	prefix	prefix symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

What is the name for one trillion (10^{12}) microphones?

What is the name for two thousand mocking birds?

What is name for one millionth of a fish?

Unit Conversions:

Complete these metric conversions:

- Simple: How many pF is 6.3 µF?
- Compound: Convert 10 kg m/s^2 to g cm/s^2

- ***Conversion:*** Complete these metric conversions:
- Simple: How many pF is 6.3 µF?
  6.3 µF (10^{-6} F/µF)(10^{12} pF/F) = 6.3 x 10^{6} pF or 6,300,000 pF
- Compound: Convert 10 kg m/s2 to g cm/s2.

10 kg m/s^2 (1000 g/kg)(100 cm/m) = 10^{6} or 1,000,000 g cm/s^2

10	kg	m	1000	g	100	cm
		s^2		kg		m

The group PV (pressure times volume) comes up frequently in thermodynamics:

What are the MKS basic units for this group?

The resulting units are equivalent to the units to

i. force ii energy iii acceleration
iv. power v. none of the above

In the group PV (pressure times volume) comes up frequently in thermodynamics:

What are the MKS basic units of this group?

The mks units for P are kg/(m s^2)
The mks units for V are m^3
PV [=] (kg/(m s^2))(m^3) = kg m^2/s^2

The resulting units are equivalent to the units for (circle one):

i. force ii energy iii acceleration
iv. power v. none of the above

Consider a mass sitting on a frictionless surface attached to a horizontal spring. If the spring is stretched and then let go, it will oscillate with a period Ts (units of time). This period is related to the mass on the spring (m) and the spring constant (k) which has units of force per length. The basic equation is of the form:

$$T_s = 2\pi \ g(m,k)$$

. (i.e., Ts = 2π times a function of m & k)
Using the MKS basic units, propose the form of the function *g(m, k)* that has proper units.

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m [=] kg, k [=] (kg m/s²) / (m) = kg/(s²)

1. the function must end up with units of time
2. therefore k must be in the denominator of a fraction inside a square root
3. the numerator must be mass to cancel out the kg

$$g(m,k) = \sqrt{\frac{m}{k}}$$

The frequency of a vibrating string (e.g. on a guitar) is given by:

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

where: f = the frequency (s-1)
L = the length of the string (m)
T = the tension on the string (units of force, kg m/s2)
μ = the linear mass of the string (kg/m)

Proportionality: Show two simple proportionalities derived from the above equation.

$$f \propto \frac{1}{L} \qquad f \propto \sqrt{T} \qquad f \propto \frac{1}{\sqrt{\mu}}$$

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

Lumped Parameters: Suppose you can experiment with a given string of fixed length.

Derive a lumped parameter model that relates the tension of that string to the frequency using a single parameter that can be determined experimentally.

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L, & μ are constant. The equation can be rearranged to:

$$f = \frac{1}{2L\sqrt{\mu}}\sqrt{T} \quad or \quad f = A\sqrt{T}$$

the variable A can be fitted with a simple experiment.