Name ____________________

FORMULAS

Date ____________ Period _____

Metric Prefixes

10^{3}	10^{2}	10^{1}	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}
k	–	–	none	d	c	m	–	–	μ	–	–	n	–	–	p

Motion

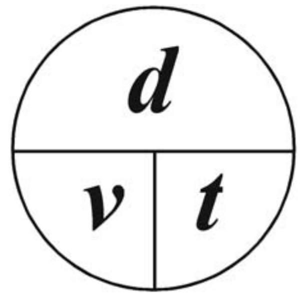
<u>Speed</u>:

speed: $v = \dfrac{d}{t}$

distance: $d = vt$

time: $t = \dfrac{d}{v}$

- v = speed
- d = distance
- t = time



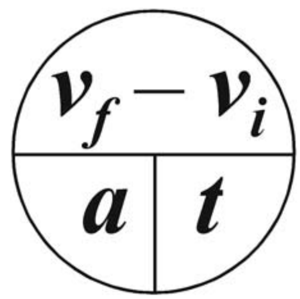
<u>Acceleration</u>:

acceleration: $a = \dfrac{\Delta v}{t} = \dfrac{v_f - v_i}{t}$

time: $t = \dfrac{v_f - v_i}{a}$

final velocity: $v_f = v_i + at$

- a = *acceleration*
- Δv = *change in velocity*
  - v_f = *final velocity*
  - v_i = *initial velocity*



<u>Free Fall</u>: (objects accelerating because of gravity)

final speed: $v_f = gt + v_i$

distance: $d = \frac{1}{2}at^2 + v_i t$

$v_{avg} = \dfrac{v_f + v_i}{2}$

- $g = a = 9.8\ ^{m}/_{s^2}$ = *acceleration of gravity*
- d = *distance*
- t = *time*
- v_i = *initial speed*
- v_f = *final speed*
- v_{avg} = *average speed*

<u>Units</u>:

distance: *m* = meters; *km* = kilometers; *cm* = centimeters

time: *h* = hours; *s* = seconds

mass: *g* = grams; *kg* = kilograms

Energy

<u>Gravitational Energy</u>

PE = mgh

- The height from which the object falls (*h*)
- The mass of the object (*m*)
- The acceleration of gravity (*g*)

KE = ½mv²

- The mass of the object (*m*)
- The speed (*v*)

Force

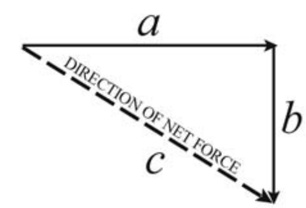
Net Force:

- **Forces in the same direction**
  $F_{net} = F_1 + F_2 + \ldots + F_n$
  - F_{net} = *net force*
  - $F_1 + F_2 + \ldots + F_n$ = *add all the forces*

- **Forces in opposite directions**
  $F_{net} = F_L - F_S$
  - F_L = *larger force*
  - F_S = *smaller force*
  - $F_L - F_S$ = *subtract the forces*

  *THE **NET FORCE** IS IN THE DIRECTION OF THE LARGER FORCE*

- **Forces at right angles**
  <u>*Pythagorean theorem*</u>
  $a^2 + b^2 = c^2$
  $c = \sqrt{c^2}$
  - a = *one of the forces at right angles*
  - b = *one of the forces at right angles*
  - c = *the net force*

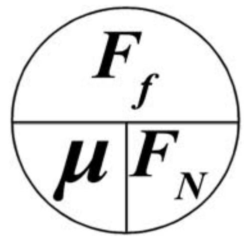


- **Multiple forces**
  Always add all the forces acting in the same direction before subtracting or applying the Pythagorean theorem

<u>Coefficient of Friction</u>

$F_f = F_N \times \mu$

- F_f = *force of friction*
- F_N = *normal force*
- μ = *coefficient of friction*



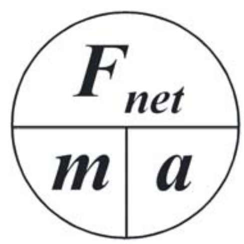
Newton's Second Law of Motion:

accleration: $a = \dfrac{F}{m}$

force: $F = ma \quad (F = m \times a)$

mass: $m = \dfrac{F}{a}$

- a = *acceleration*
- F = *force*
- m = *mass*



Air Resistance:

$F_{net} = F_{weight} - F_{air\ resistance}$

$F_{weight} = mg$

- F_{net} = *net force*
- F_{weight} = *weight*
- $F_{air\ resistance}$ = *air resistance*
- m = *mass*
- g = *acceleration of gravity* ($9.8\,{}^{m}/_{s^2}$)

Units:

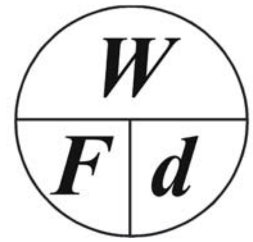
distance: m = meters; km = kilometers; cm = centimeters
time: h = hours; s = seconds
mass: g = grams; kg = kilograms
force: N = newtons; $1N = 1\dfrac{kg \bullet m}{s^2}$

Machines

Work:

$$\mathbf{W} = \boldsymbol{F} \times \boldsymbol{d}$$

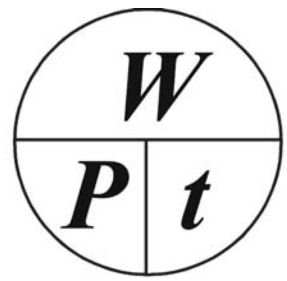
- W = work (J)
- F = force (N)
- d = distance (m)



Power:

$$Power = \frac{Work}{time}$$

$$P = \frac{W}{t}$$



Mechanical Advantage:

$$\begin{matrix}mechanical \\ advantage\end{matrix} = \frac{output\ \ force}{input\ \ force}$$

$$MA = \frac{F_{out}}{F_{in}}$$

Efficiency:

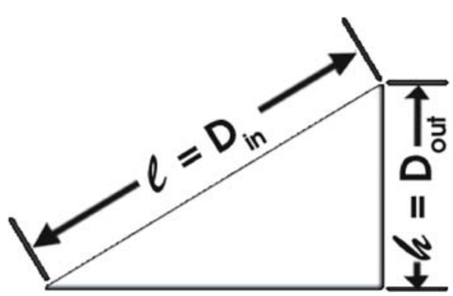
$$efficiency = \frac{work\ \ output}{work\ \ input} \times 100\%$$

$$eff = \frac{W_{out}}{W_{in}} \times 100\%$$

(*NOTE*: Express efficiency as a decimal to calculate W_{out} or W_{in}.)

Inclined Plane:

$\mathbf{W_{out} = F_{out} \times D_{out}}$
$\mathbf{W_{in} = F_{in} \times D_{in}}$
$\mathbf{W_f = W_{in} - W_{out}}$
$\mathbf{AMA = F_{out}/F_{in}}$
$\mathbf{IMA = D_{in}/D_{out}}$
$\mathbf{Eff = (W_{out}/W_{in}) \times 100}$
$\mathbf{Eff = (AMA/IMA) \times 100}$



Machines (Continued)

Levers:

$$IMA = \frac{A_E}{A_R}$$

$$M = F \times A$$

$$M = M_1 + M_2 + \ldots$$

$$\underline{Balanced\ levers}$$

$$M_E = M_R$$

- $IMA = ideal\ mechanical\ advantage$
- $A_E = effort\ arm$
- $A_R = resistance\ arm$
- $M_E = effort\ moment$
- $M_R = resistance\ moment$

Wheel and Axle:

$$IMA = \frac{input\ radius}{output\ radius}$$

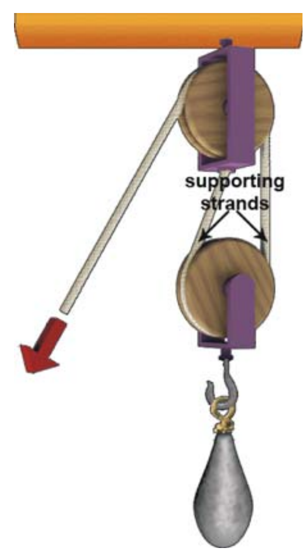
$$IMA = \frac{R_{in}}{R_{out}}$$

Pulleys:

IMA = # *of supporting strands*

IMA (*fixed pulley*) = 1

IMA (*movable pulley*) = 2



Units:

work:	*J* = joules	(also units for *energy*)
power:	*W* = watts	1 *W* = 1 $^J/_s$
MA:	no units	

Momentum

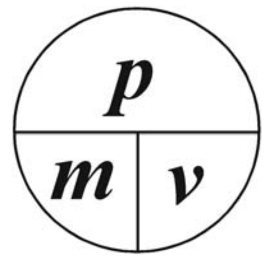
Momentum:

$p = mv$

- p = momentum ($kg \cdot m/s$)
- m = mass (kg)
- v = velocity (m/s)

- p_{TOTAL} = total momentum
- p_1, p_2, p_n = momentums of the objects in a system

$p_{TOTAL} = p_1 + p_2 + \ldots + p_n$



Change of Momentum and Force:

Definitions

- $F = ma$
- $a = \dfrac{\Delta v}{t}$
- $\Delta p = m\Delta v$

Substitutions

$F = \dfrac{m\Delta v}{t}$

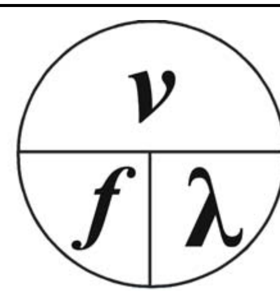
$F = \dfrac{\Delta p}{t}$

Waves

Speed:

$v = f\lambda$

- v = speed (m/s)
- f = frequency ($1/s$ *or* Hz)
- λ = wavelength (m)

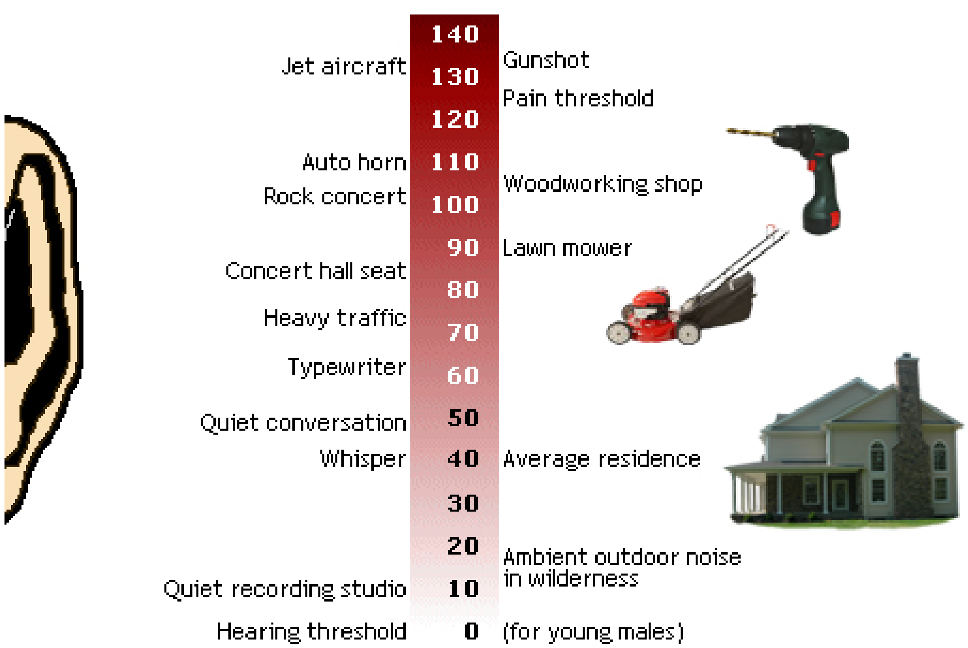


Sound

$$M = \frac{v}{v_{sound}}$$

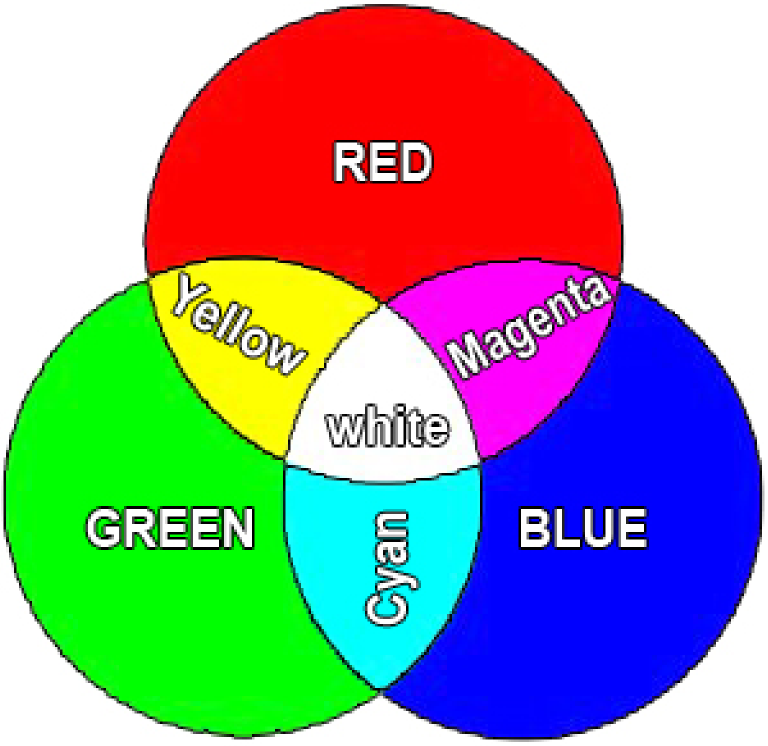
- M = mach number
- v = speed relative to the medium
- v_{sound} = speed of sound in the medium

Speed of Sound Through Different Materials	
Material	Speed (m/s)
Air	343
Water	1,483
Steel	5,940
Glass	5,640



Light

Primary Colors



Speed in a vacuum

Speed in a vacuum = $3.0 \times 10^8\ ^m/_s$

Heat

Temperature:

$K = C + 273$ • K = *Kelvins*

$C = K - 273$ • C = *Celsius* (°C)

Heat:

$q = mC\Delta T$ • q = *heat (joules)* • T_f = *final temperature*

• C = *specific heat* $\left(\frac{J}{g^\circ C} \text{ or } \frac{J}{gK}\right)$ • T_i = *initial temperature*

$\Delta T = T_f - T_i$ • ΔT = *temperature change*

Specific Heats of Common Substances:

Material	Specific Heat (J/g°C)
water	4.18
aluminum	0.897
copper	0.385
lead	0.129
nickel	0.444
zinc	0.388

Units:

heat J = joules

temperature $^\circ C$ = degrees Celsius; K = Kelvins

specific heat $\frac{J}{g^\circ C}$ *or* $\frac{J}{gK}$ = joules per gram degree Celsius *or* joules per gram Kelvin

Pressure and Fluids

Pressure:

pressure: $P = \frac{F}{A}$

force: $F = PA \left(F = P \times A\right)$

area: $A = \frac{F}{P}$

- $P = pressure$
- $F = force$
- $A = area$

Archimedes' Principle:

density: $D = \frac{m}{V}$

mass: $m = D \times V$

volume: $V = \frac{m}{D}$

$V = L \times W \times H$

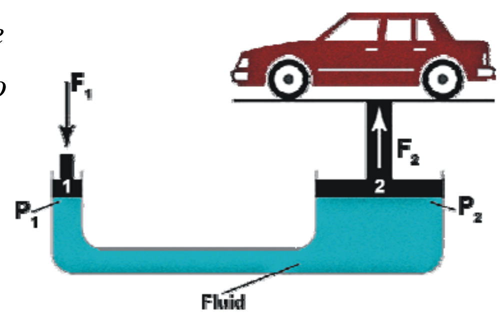
- $D = density$
- $m = mass$
- $V = volume$
- $L = length$
- $W = width$
- $H = height$

(*NOTE:* Density of water – $1\ {}^{g}/_{mL}$ or $1\ {}^{kg}/_{L}$)

Pascal's Principle:

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

- F_1 = *force applied on surface one*
- F_2 = *force applied on surface two*
- A_1 = *area of surface one*
- A_2 = *area of surface two*



Units:

force: N = newtons; $1N = 1\frac{kg \bullet m}{s^2}$

pressure: Pa = pascals

area: m^2 = meters squared

volume: m^3 = meters cubed; cm^3 = centimeters cubed (*note:* $1\ mL = 1\ cm^3$); L = liters

Physical Constants

Name	Symbol	Value
Universal gravitational constant	G	6.67×10^{-11} N•m^2/kg^2
Acceleration due to gravity	g	9.81 m/s^2
Speed of light in a vacuum	c	3.00×10^{8} m/s
Speed of sound in air at STP		3.31×10^{2} m/s
Mass of Earth		5.98×10^{24} kg
Mass of the Moon		7.35×10^{22} kg
Mean radius of Earth		6.37×10^{6} m
Mean radius of the Moon		1.74×10^{6} m
Mean distance—Earth to the Moon		3.84×10^{8} m
Mean distance—Earth to the Sun		1.50×10^{11} m
Electrostatic constant	k	8.99×10^{9} N•m^2/C^2
1 elementary charge	e	1.60×10^{-19} C
1 coulomb (C)		6.25×10^{18} elementary charges
1 electronvolt (eV)		1.60×10^{-19} J
Planck's constant	h	6.63×10^{-34} J•s
1 universal mass unit (u)		9.31×10^{2} MeV
Rest mass of the electron	m_e	9.11×10^{-31} kg
Rest mass of the proton	m_p	1.67×10^{-27} kg
Rest mass of the neutron	m_n	1.67×10^{-27} kg

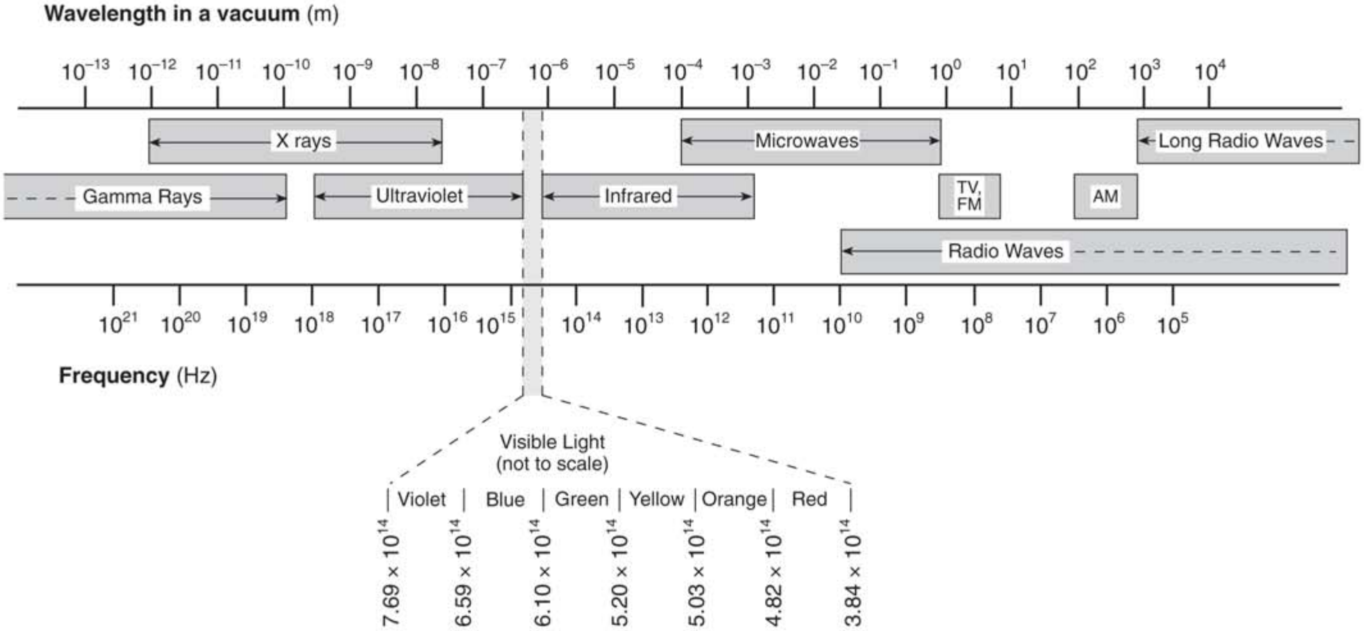
Prefixes for Powers of 10

Prefix	Symbol	Notation
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Approximate Coefficients of Friction

	Kinetic	Static
Rubber on concrete (dry)	0.68	0.90
Rubber on concrete (wet)	0.58	
Rubber on asphalt (dry)	0.67	0.85
Rubber on asphalt (wet)	0.53	
Rubber on ice	0.15	
Waxed ski on snow	0.05	0.14
Wood on wood	0.30	0.42
Steel on steel	0.57	0.74
Copper on steel	0.36	0.53
Teflon on Teflon	0.04	

The Electromagnetic Spectrum



Absolute Indices of Refraction ($f = 5.09 \times 10^{14}$ Hz)	
Air	1.00
Corn oil	1.47
Diamond	2.42
Ethyl alcohol	1.36
Glass, crown	1.52
Glass, flint	1.66
Glycerol	1.47
Lucite	1.50
Quartz, fused	1.46
Sodium chloride	1.54
Water	1.33
Zircon	1.92

Waves

$v = f\lambda$

$T = \dfrac{1}{f}$

$\theta_i = \theta_r$

$n = \dfrac{c}{v}$

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$\dfrac{n_2}{n_1} = \dfrac{v_1}{v_2} = \dfrac{\lambda_1}{\lambda_2}$

c = speed of light in a vacuum
f = frequency
n = absolute index of refraction
T = period
v = velocity or speed
λ = wavelength
θ = angle
θ_i = angle of incidence
θ_r = angle of reflection

Modern Physics

$E_{photon} = hf = \dfrac{hc}{\lambda}$

$E_{photon} = E_i - E_f$

$E = mc^2$

c = speed of light in a vacuum
E = energy
f = frequency
h = Planck's constant
m = mass
λ = wavelength

Geometry and Trigonometry

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$
$C = 2\pi r$

Right Triangle

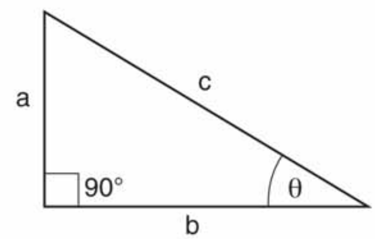
$c^2 = a^2 + b^2$

$\sin \theta = \dfrac{a}{c}$

$\cos \theta = \dfrac{b}{c}$

$\tan \theta = \dfrac{a}{b}$

A = area
b = base
C = circumference
h = height
r = radius



Mechanics

$\bar{v} = \frac{d}{t}$

$a = \frac{\Delta v}{t}$

$v_f = v_i + at$

$d = v_i t + \frac{1}{2}at^2$

$v_f^2 = v_i^2 + 2ad$

$A_y = A \sin\theta$

$A_x = A \cos\theta$

$a = \frac{F_{net}}{m}$

$F_f = \mu F_N$

$F_g = \frac{Gm_1m_2}{r^2}$

$g = \frac{F_g}{m}$

$p = mv$

$p_{before} = p_{after}$

$J = F_{net}t = \Delta p$

$F_s = kx$

$PE_s = \frac{1}{2}kx^2$

$F_c = ma_c$

$a_c = \frac{v^2}{r}$

$\Delta PE = mg\Delta h$

$KE = \frac{1}{2}mv^2$

$W = Fd = \Delta E_T$

$E_T = PE + KE + Q$

$P = \frac{W}{t} = \frac{Fd}{t} = F\bar{v}$

a = acceleration
a_c = centripetal acceleration
A = any vector quantity
d = displacement or distance
E_T = total energy
F = force
F_c = centripetal force
F_f = force of friction
F_g = weight or force due to gravity
F_N = normal force
F_{net} = net force
F_s = force on a spring
g = acceleration due to gravity or gravitational field strength
G = universal gravitational constant
h = height
J = impulse
k = spring constant
KE = kinetic energy
m = mass
p = momentum
P = power
PE = potential energy
PE_s = potential energy stored in a spring
Q = internal energy
r = radius or distance between centers
t = time interval
v = velocity or speed
$\bar{v}$ = average velocity or average speed
W = work
x = change in spring length from the equilibrium position
Δ = change
θ = angle
μ = coefficient of friction

Standard Temperature and Pressure

Name	Value	Unit
Standard Pressure	101.3 kPa 1 atm	kilopascal atmosphere
Standard Temperature	273 K 0°C	kelvin degree Celsius

Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of $H_2O(\ell)$	4.18 J/g•K

Selected Units

Symbol	Name	Quantity
m	meter	length
g	gram	mass
Pa	pascal	pressure
K	kelvin	temperature
mol	mole	amount of substance
J	joule	energy, work, quantity of heat
s	second	time
min	minute	time
h	hour	time
d	day	time
y	year	time
L	liter	volume
ppm	parts per million	concentration
M	molarity	solution **concentration**
u	**atomic mass unit**	**atomic mass**