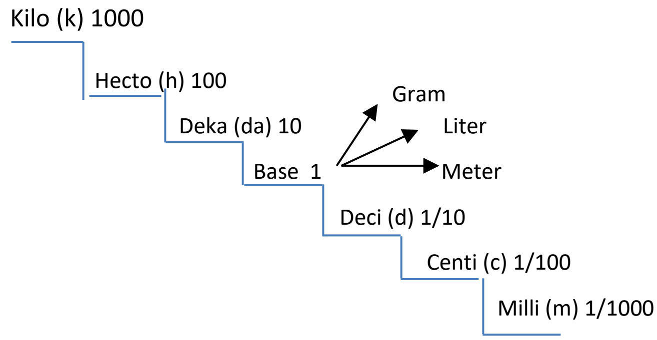
Physics Conversion Factors & Formulas:

Power of Ten	Prefix	Symbol	Power of Ten	Prefix	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	η
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y



One and Two Dimensional Motion:

$\overline{V} = s/t$ $\overline{V} = (V_f + V_o) / 2$ $V_f = V_o + at$ $\overline{a} = (V_f - V_o) / t$ $s = V_o t + 1/2\, at^2$ $V_f^2 = V_o^2 + 2as$

$F_{Net} = ma$ $Wt = mg$ $F_{app} = F_N + ma$ $F_{Fr} = \mu F_N$ Density = Mass / Volume

Algebraic, Geometric and Trigonometry Formula's and/or properties:

SOHCAHTOA
Sin = Opposite / Hypotenuse (SOH)
Cos = Adjacent/Hypotenuse (CAH)
Tan = Opposite / Adjacent (TOA)

Pythagorean's $c^2 = a^2 + b^2$

Spherical Volume $= 4/3\,\pi r^3$
Cylinder Volume $= \pi r^2 \times$ height
Circumference $= 2\pi r$ or πd
Circle surface area $= \pi r^2$
Surface area Sphere $= 4\pi r^2$

<u>Law of Cosines</u>

$c^2 = a^2 + b^2 - 2ab\cos C$

<u>Error</u>

Absolute: O - A
Relative: (O – A) / A

$$\%E = \frac{O - A}{A} \times 100\%$$

<u>Law of Sines</u>

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\%\,Diff = \frac{Difference}{Average} \times 100\%$$

<u>Quadratic Formula</u>

$x^2 + bx + c = 0$ (standard equation)

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

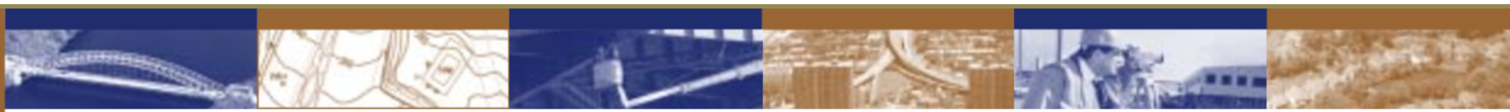
Densities of common substances

TABLE 1.4 Densities of some Selected Substances at 25°C

Substance	Density (g/cm^3)
Air	0.001
Balsa wood	0.16
Ethanol	0.79
Water	1.00
Ethylene glycol	1.09
Table sugar	1.59
Table salt	2.16
Iron	7.9
Gold	19.32

$$\rho = \frac{m}{V}$$

Substance	Density [$kg \cdot m^{-3}$]	Substance	Density [$kg \cdot m^{-3}$]
Benzine	750 (average)	Salt water	1,025 (average)
Ethanol	789	Milk	1,030 (average)
Aceton	790	Acetic acid	1,049
Methanol	790	Glycerine	1,260
Petroleum	800	Milk chocolate	1,280 (average)
Diesel	830	Honey	1,400 (average)
Crude oil	860 (average)	Nitric acid	1,512
Benzol	879	Sulfuric acid	1,834
Olive oil	910 (average)	Bromine	3,119
Pure water (4°C)	1,000	Mercury (0°C)	13,595



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SELLS METRIC CONVERSION TABLE

Additional trivia regarding this table can be obtained from our web site - www.chashsells.com

QUANTITY	ENGLISH UNIT	METRIC UNIT	ENGLISH TO METRIC	METRIC TO ENGLISH
Length	inch (in)	millimeter (mm)	1 in = 25.4 mm	1 mm = 0.03937 in
	foot (ft = 12 in)	meter (m = 10^3 mm)	1 ft = 0.3048 m	1 m = 3.2808 ft
	yard (yd = 3 ft)	meter (m)	1 yd = 0.9144 m	1 m = 1.0936 yd
	mile (mi = 5280 ft)	kilometer (km = 10^3 m)	1 mi = 1.6093 km	1 km = 0.62137 mi
Area	square inch (in^2)	square millimeter (mm^2)	1 in^2 = 645.16 mm^2	1 mm^2 = 1.550×10^{-3} in^2
	square foot (ft^2)	square meter (m^2)	1 ft^2 = 0.092903 m^2	1 m^2 = 10.764 ft^2
	square yard (yd^2)	square meter (m^2)	1 yd^2 = 0.83613 m^2	1 m^2 = 1.1960 yd^2
	square mile (mi^2)	square kilometer (km^2)	1 mi^2 = 2.590 km^2	1 km^2 = 0.38610 mi^2
	acre (acre = 43560 ft^2)	hectare (ha = 10^4 m^2)	1 acre = 0.40469 ha	1 ha = 2.4710 acre
Volume	cubic inch (in^3)	cubic millimeter (mm^3)	1 in^3 = 16387 mm^3	1 mm^3 = 6.1024×10^{-5} in^3
	cubic foot (ft^3)	cubic meter (m^3)	1 ft^3 = 0.028317 m^3	1 m^3 = 35.315 ft^3
	cubic yard (yd^3)	cubic meter (m^3)	1 yd^3 = 0.76455 m^3	1 m^3 = 1.3080 yd^3
	ounce-fluid (oz-fl)	milliliter (mL = 10^3 mm^3)	1 oz-fl = 29.574 mL	1 mL = 0.033814 oz-fl
	quart-liquid (qt = 32 oz-fl)	liter (L = 10^3 mL)	1 qt = 0.94635 L	1 L = 1.0567 qt
	gallon-liquid (gal = 4 qt)	liter (L)	1 gal = 3.7854 L	1 L = 0.26417 gal
Mass	ounce-mass (oz)	gram (g)	1 oz = 28.350 g	1 g = 0.035274 oz
	pound-mass (lb = 16 oz)	kilogram (kg = 10^3 g)	1 lb = 0.45359 kg	1 kg = 2.2046 lb
	slug (slug = 32.174 lb)	kilogram (kg)	1 slug = 14.594 kg	1 kg = 0.068522 slug
	ton-short (ton = 2000 lb)	metric tonne (tonne = 1000 kg)	1 ton = 0.90718 tonne	1 tonne = 1.1023 ton
Force	pound-force (lbf)	newton (N = kg·m/s^2)	1 lbf = 4.4482 N	1 N = 0.22481 lbf
	kilo-pound-force (kip = 10^3 lb)	kilo-newton (kN = 10^3 N)	1 kip = 4.4482 kN	1 kN = 0.22481 kip
	ton-force (tonf = 2000 lbf)	kilo-newton (kN)	1 tonf = 8.8964 kN	1 kN = 0.11240 tonf
	pound-force/foot (plf)	newton/meter (N/m)	1 plf = 14.594 N/m	1 N/m = 0.068522 plf
Stress	pound-force/square-foot (psf)	pascal (Pa = N/m^2)	1 psf = 47.880 Pa	1 Pa = 0.020885 psf
	kilo-pound-force/square-foot (ksf)	kilo-pascal (kPa = 10^3 Pa)	1 ksf = 47.880 kPa	1 kPa = 0.020885 ksf
	pound-force/square-inch (psi)	mega-pascal (MPa = 10^6 Pa)	1 psi = 6.8948×10^{-3} MPa	1 MPa = 145.04 psi
Density	pound-mass/cubic-foot (lb/ft^3)	kilogram/cubic-meter (kg/m^3)	1 lb/ft^3 = 16.018 kg/m^3	1 kg/m^3 = 0.062428 lb/ft^3
	pound-force/cubic-foot (pcf)	kilo-newton/cubic-meter (kN/m^3)	1 pcf = 0.15709 kN/m^3	1 kN/m^3 = 6.3659 pcf
Moment	pound-force-foot (lbf-ft)	newton-meter (N·m)	1 lbf-ft = 1.3558 N·m	1 N·m = 0.73756 lbf-ft
	kilo-pound-force-foot (kip-ft)	kilo-newton-meter (kN·m)	1 kip-ft = 1.3558 kN·m	1 kN·m = 0.73756 kip-ft
Inertia	$inch^4$ (in^4)	$millimeter^4$ (mm^4)	1 in^4 = 4.1623×10^5 mm^4	1 mm^4 = 2.4025×10^{-6} in^4
Velocity	foot/second (ft/sec)	meter/second (m/s)	1 ft/sec = 0.3048 m/s	1 m/s = 3.2808 ft/sec
	mile/hour (mph = 1.4667 ft/sec)	kilometer/hour (km/h = 0.2778 m/s)	1 mph = 1.6093 km/h	1 km/h = 0.62137 mph
Energy	pound-force-foot (lbf-ft)	joule (J = N.m)	1 lbf-ft = 1.3558 J	1 J = 0.73756 lbf-ft
	B. Thermal U. (BTU = 778.17 lbf-ft)	kilo-joule (kJ = 10^3 J)	1 BTU = 1.0551 kJ	1 kJ = 0.94782 BTU
Power	horse-power (hp = 550 lbf-ft/sec)	kilo-watt (kW = 10^3 W = kJ/s)	1 hp = 0.74570 kW	1 kW = 1.3410 hp
Temperature	degree Fahrenheit (°F)	degree Celcius (°C)	°F = 1.8(°C) + 32	°C = (°F - 32)/1.8

The above information is based on the following sources: ASTM *"E380 Standard Practice for the International System of Units (SI) (the Modernized Metric System)"*, AASHTO *"Guide to Metric Conversion"* , NYSDOT *"Interim Guide to Metric Design"*

Universal Law of Gravitation and Centripetal Motion:

$$F_{cp} = ma = \frac{mv^2}{r} = \frac{m[(2\pi r)/T]^2}{r} = \frac{m\,4\pi^2 r}{T^2} = G\frac{m_1 \cdot m_2}{r^2} = F_{Fr} = \mu \cdot F_N = m \cdot \omega^2 \cdot r$$

T = Time Period (sec/rev or time/oscillation) $T = 1/f$

f = Frequency (rev/sec or oscillation/time) $f = 1/T$

Gravitational Constant (G) = 6.67×10^{-11} N m^2 / kg^2

Kepler's Constant (K) = 3.35×10^{18} m^3 / s^2

Keplers 3rd Law

$$K = \frac{R^3}{T^2} \qquad \frac{R^3}{T^2} = \frac{R^3}{T^2}$$

Pendulum

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Earth Distance (mean) to Sun = 1.5×10^{11} meters (1 A.U.)

Earth Distance (mean) to Moon = 3.85×10^8 meters

Earth Time Period around the Sun = 365.25 days

Moon Time Period around the Earth = 27.3 days

Gravity = 9.81 m/s^2 or 32 ft/s^2

Light speed(c) = 3.0×10^8 m/s

Earth Mass = 5.98×10^{24} kg

Earth Radius = 6380 km

Earth Density = 5.513 g/cm^3 or 5520 kg/m^3 or 3.2 oz/in^3

Work and Energy:

$PE = mgh$ $KE = \frac{1}{2} mv^2$ $KE = \frac{1}{2} I\omega^2$ Work = $F \times D \cos\theta$ $E = P \cdot t$ $E = m \cdot c^2$

Kinetic Energy Theorem: $W = F \cdot D = \Delta KE = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2$

Conservative Force

Non-Conservative Force

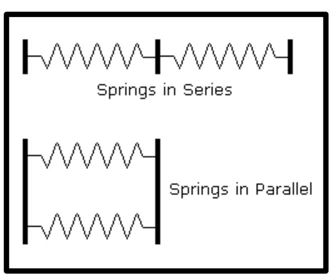
Conservation of Energy: $mgh_1 + \frac{1}{2} mv_1^2 + \frac{1}{2} I\omega_1^2 = mgh_2 + \frac{1}{2} mv_2^2 + \frac{1}{2} I\omega_2^2 + (F_{fr} \cdot D)$

$$\text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{F \cdot D}{\text{Time}} = F \cdot \bar{v}$$

$$\text{Horsepower (hp) (metric)} = \frac{\text{Power}}{746 \text{ Watts}} \quad \text{or} \quad \text{Horsepower (hp) (English)} = \frac{\text{Power}}{550 \text{ ft} \cdot \text{lb/sec}}$$

Hooke's Law $F = -kx$ Energy (U)= $\frac{1}{2} kx^2$

$$HP = \frac{\text{RPM} \times \text{Torque}}{5252}$$



Equivalent Spring Constant

Parallel: $K_{eq} = K_1 + K_2$

Series: $\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$

Momentum (Linear and Angular): Center of Mass:

$\Delta P = m \cdot \Delta v$ $P = m \cdot v$ $J = F \cdot t$ $\Delta P = F \cdot \Delta t$ $m \cdot \Delta v = F\ \Delta t$

$m_1 \cdot v_1 + m_2 \cdot v_2 = (m_1 + m_2)\, v'$ $m_1 \cdot v_1 = m_2 \cdot v_2$ $m_1 \cdot v_1 + m_2 \cdot v_2 = m_1 \cdot v_1' + m_2 \cdot v_2'$

Elastic Head on Collisions

$$v'_2 = \frac{2m_1}{m_1 + m_2} v_1 - \frac{m_1 - m_2}{m_1 + m_2} v_2$$

$$v'_1 = \frac{m_1 - m_2}{m_1 + m_2} v_1 + \frac{2m_2}{m_1 + m_2} v_2$$

Center of Mass

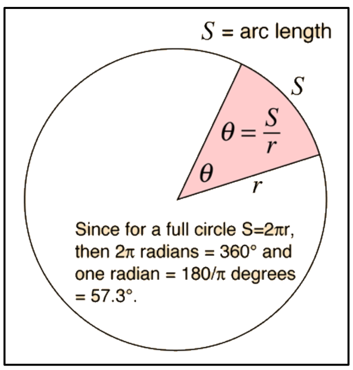
$$x_{CM} = \frac{m_1 x_1 + m_2 x_2 + \ldots}{m_1 + m_2 + \ldots}$$

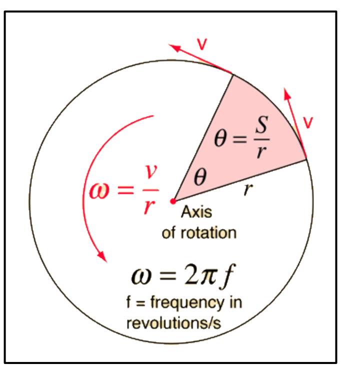
$$y_{CM} = \frac{m_1 y_1 + m_2 y_2 + \ldots}{m_1 + m_2 + \ldots}$$

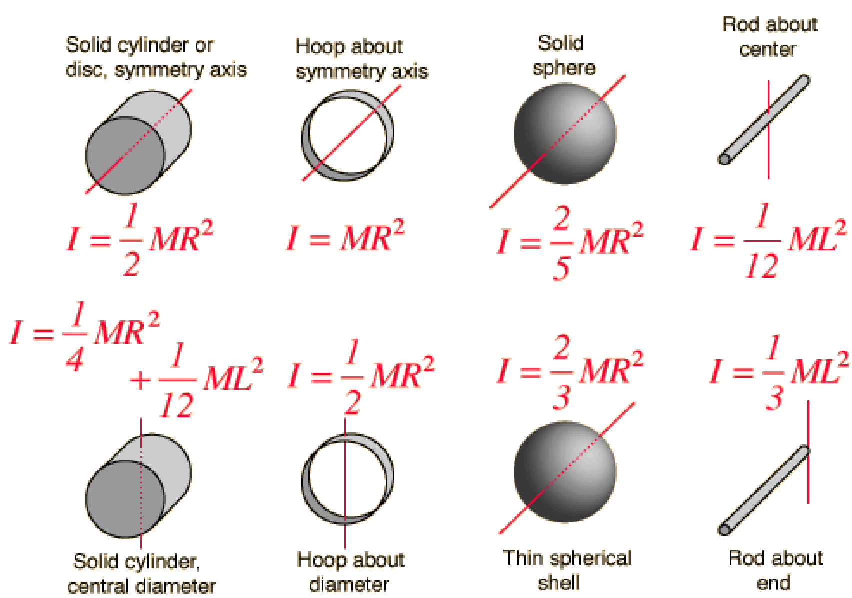
$\Sigma\ \tau_+ = \Sigma\, \tau_-$ $\theta = s / r$ $\overline{V} = s / t$ $\overline{V} = (\theta \cdot r) / t$ $\overline{V} = \overline{\omega} \cdot r$

$\tau = F \cdot L$ $\tau = I \cdot \alpha$ $L = \tau \cdot t$ $L = I \cdot \overline{\omega}$ $a_t = \Delta V / t = r \cdot \alpha$ $a_r = a_c = v^2 / r = \omega^2 \cdot r$

$\tau = NIA\, \beta \sin\theta$ $\tau = \mu\beta$ $\mu = I A$







Electrostatics, Electricity, & Electromagnetism:

$F = K [q_1 q_2] / r^2$ $E = [K q]/ r^2$ $E = F / q$ $E = 4 \pi kQ / A$ $P = VI$ $P = I^2 R$ $I = Q/t$

$V = Ed$ $Volts = [F d]/ q$ $V = IR$ $E = P t$ $E = I^2 R t$ $R = [\rho L]/A$

$\Delta U = q \Delta V$ $\Delta V = V_f - V_i$ $Work(energy) = -\Delta U = -q \Delta V = -q (V_f - V_i)$

$V = \frac{KQ}{r} = \frac{Q}{4 \pi \varepsilon_o r}$ $F = BIL \sin \theta$ $F = qvB$ $B = \frac{\mu_o I}{2 \pi r}$ $\varepsilon = -N \frac{\Delta \phi}{\Delta t} = -N \frac{\beta \Delta A}{\Delta t}$ ε = emf (voltage) $\varepsilon = BLv$

σ = charge density
$\varepsilon_o = 8.85 \times 10^{-12}$ F/m (permittivity of free space in parallel plate capacitor)
$\mu_o = 4 \pi \times 10^{-7}$ T m/A (permeability of free space – known as magnetic constant)
$K = 1 / [4 \pi \varepsilon_o] = 8.987552 \times 10^9 \ Nm^2 / C^2$ (Coulombs Constant)
β = Magnetic field (flux density –"T"esla)
ϕ = Magnetic Flux (Wb – weber)
1 electron/proton = 1.6×10^{-19} C
1 electron = 9.11×10^{-31} kg
1 proton = 1.672622×10^{-27} kg
1 neutron = 1.67493×10^{-27} kg
1 mole = 6.02×10^{23} molecules / atoms / anything!

Conductor Material	Resistivity (Ohm meters @ 20°C)
Silver	1.64×10^{-8}
Copper	1.72×10^{-8}
Aluminum	2.83×10^{-8}
Tungsten	5.50×10^{-8}
Nickel	7.80×10^{-8}
Iron	12.0×10^{-8}
Constantan	49.0×10^{-8}
Nichrome II	110×10^{-8}

Transformers:

$$a = \frac{n_1}{n_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

where:
- a = turns ratio of transformer
- n_1 = number of turns on primary
- n_2 = number of turns on secondary
- V_1 = primary voltage
- V_2 = secondary voltage
- I_1 = primary current
- I_2 = secondary current

Series

$R_T = R_1 + R_2 + R_3 + ...$
$V_T = V_1 + V_2 + V_3 + ...$
$I_T = I_1 = I_2 = I_3 = ...$
$1/ C_T = 1/ C_1 + 1/C_2 + 1/C_3 + ...$
$Q_T = Q_1 = Q_2 = Q_3 = ...$

Parallel

$1/ R_T = 1/ R_1 + 1/R_2 + 1/R_3 + ...$
$V_T = V_1 = V_2 = V_3 = ...$
$I_T = I_1 + I_2 + I_3 + ...$
$C_T = C_1 + C_2 + C_3 + ...$
$Q_T = Q_1 + Q_2 + Q_3 + ...$

RC – Circuits:

$V_{Battery} = V_R + V_C = IR + Q/C$
$\tau = RC$ Time Delay Equation
$I_{(t)} = I_{max} e^{-t/RC}$
Charging: $V_{(t)} = V_{max} (1 - e^{-t/\tau})$ Discharging: $V_{(t)} = V_{max} e^{-t/RC}$
Charging: $Q_{(t)} = Q_{max} (1- e^{-t/\tau})$ Discharging: $Q_{(t)} = Q_{max} e^{-t/RC}$

Capacitance of Parallel Plates

$U = ½[Q^2 /C] = ½ QV = ½ CV^2$
$E = \sigma / \varepsilon_o$ $\sigma = Q/A$
$E = F / Q$ $E = q V$
$C = Q / V$ $C = [k \varepsilon_o A]/d$

$R = R_{ref} [1 + \alpha(T - T_{ref})]$

Where,

- R = Conductor resistance at temperature "T"
- R_{ref} = Conductor resistance at reference temperature T_{ref}, usually 20° C, but sometimes 0° C.
- α = Temperature coefficient of resistance for the conductor material.
- T = Conductor temperature in degrees Celcius.
- T_{ref} = Reference temperature that α is specified at for the conductor material.

Dielectric Constants (k)

Material	Relative Permittivity
Vacuum	1.0000
Air	1.0006
PTFE, FEP (Teflon)	2.0
Polypropylene	2.20 to 2.28
Polystyrene	2.4 to 3.2
Wood (Oak)	3.3
Bakelite	3.5 to 6.0
Wood (Maple)	4.4
Glass	4.9 to 7.5
Wood (Birch)	5.2
Glass-Bonded Mica	6.3 to 9.3
Porcelain, Steatite	6.5

Optics: Mirrors / Lenses – Polarization and Snell's Law

Reflection / Refraction : Mirrors and Lenses:

$$\text{Magnification} = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad f = \frac{d_o\, d_i}{d_o + d_i} \qquad d_i = \frac{d_o\, f}{d_o - f} \qquad d_o = \frac{d_i\, f}{d_i - f}$$

Medium	Index of Refraction
vacuum	1.0000
air	1.0003
ice	1.31
water	1.33
ethanol	1.37
glycerin	1.47
quartz glass	1.47
crown glass	1.52
light flint glass	1.58
Lucite (Plexiglas)	1.52
ruby	1.54
zircon	1.92
diamond	2.42

f = focal length

d_o = object distance from mirror or lens

d_i = image distance from mirror or lens

h_i = height of image

h_o = height of object

n = index of refraction (optical density)

c = speed of light (3×10^8 m/s)

V = speed of light in substance

$$n_1 \sin\theta = n_2 \sin\theta \qquad n = \frac{c}{v}$$

Brewster's Angle

$$\tan\theta_B = n_1 / n_2 \qquad I = I_o \cos^2\theta$$

n_1 = index of refraction of substance light bounces off

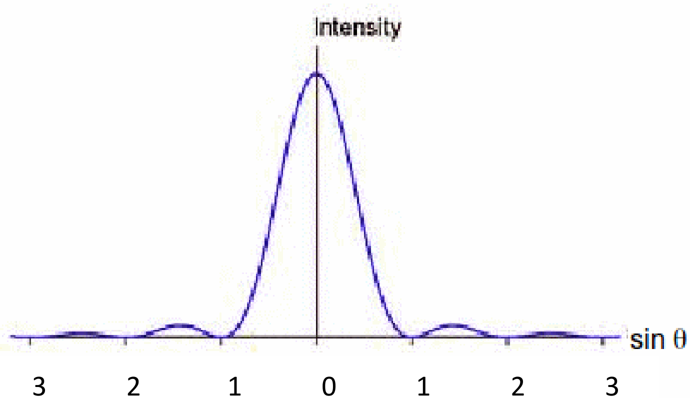
n_2 = index of refraction of substance before it reflects

Optics: Optical diffraction patterns – Single and Double Slit Apertures

Single-Slit Interference Patterns:

$d \sin\theta = (m+1/2)\lambda$ (Constructive Interference)

$d \sin\theta = m\lambda$ (Destructive Interference)

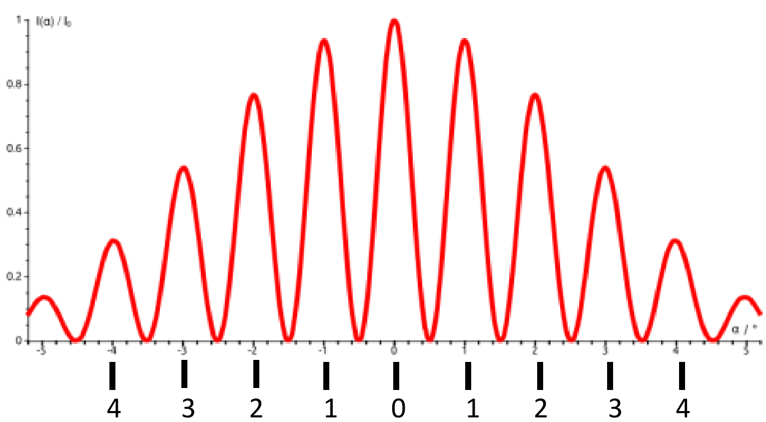


Double-Slit Interference Patterns:

$d \sin\theta = m\lambda$ (Constructive Interference)

$d \sin\theta = (m+1/2)\lambda$ (Destructive Interference)

$\lambda = xd / mL$ (small angles only)



Rayleigh's Criterion for resolution: Special case with <u>two</u> light emitting sources upon a single slit.

$$\theta = 1.22\, \lambda/D$$

Simple Harmonic Motion: SHM

Hooke's Law and Pendulums

$$V = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad \text{Energy (U)} = 1/2\, kx^2 \qquad T = 2\pi\sqrt{\frac{L}{g}} \qquad F = -kx$$

Wave Motion $\bar{v} = f \cdot \lambda$ $T = 1/f$ $f = 1/T$ $f_{beat} = |f_1 - f_2|$

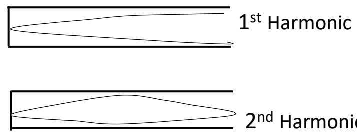
Strings and Open Tubes

1st Harmonic 2nd Harmonic

$$V = \sqrt{\frac{F_T}{m/L}} \qquad f = \frac{v}{\lambda} = \frac{v}{2L/n} \quad \text{or} \quad \sqrt{\frac{F_T}{4mL}}$$

$L = \ell + 0.4d$ (tubes) $\lambda = 2L/n$ (n=harmonic #)

Closed Tubes



$$f = \frac{v}{\lambda} = \frac{v}{4L/n}$$

$\lambda = 4L/n$ (n=harmonic #)

Speed of Sound

$$v = 331 m/s + (0.6 \tfrac{m/s}{^\circ C})T$$

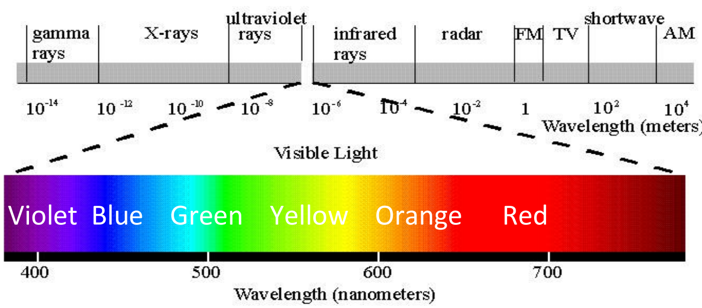
$v = \sqrt{\frac{B}{\rho}}$ Speed in Liquid $v = \sqrt{\frac{Y}{\rho}}$ Speed in Solid Rod $v = (331 m/s)\sqrt{\frac{T}{273K}}$ Speed in Air

B=Bulk Modulus ρ=Density
Y=Young's Modulus

Sound Intensity

$$d\beta = 10 \log \frac{I}{I_o} \qquad I = P / 4\pi r^2 \qquad \Delta d\beta = 10 \log \frac{I_2}{I_1}$$

$I_o = 1 \times 10^{-12}\ W/m^2$ (Threshold of hearing 0 dβ)



___ hz ⟵⟶ ___hz

$d \sin\theta = m\lambda$ m = Fringe number
$d \sin\theta = (m-1/2)\lambda$ d = slit separation

$$\left[\frac{(x_{m+1} - x_m)}{L}\right] = \left[\frac{\lambda}{d}\right]$$

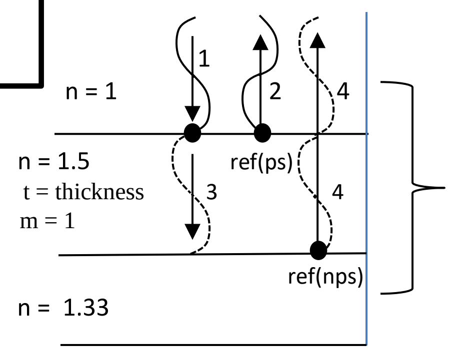
λ = wavelength
x = Fringe separation
L = Screen distance from Slits

$$\frac{x}{L} = \frac{m\lambda}{d}$$

Thin Film Interference

$\lambda_n = \lambda_{vac} / n$

1 pi shift(ps)		no (or 2) pi Shifts(nps)	
$2t = (m+1/2)\lambda_n$	Constructive	$2t = (m+1/2)\lambda_n$	Destructive
$2t = m\lambda_n$	Destructive	$2t = m\lambda_n$	Constructive



1. Incident ray
2. reflected ray (pi shift)
3. transmitted wave
4. reflected ray (no pi shift)

WAVE #2 AND #4 COMBINE <u>DESTRUCTIVELY</u>

$2t = m\lambda_n$

Hooke's Law and Pendulums

$$V = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad KE\ (U) = 1/2\ kx^2 \qquad T = 2\pi\sqrt{\frac{L}{g}}$$

Doppler Equations

f' = Observed Frequency (new)
f_o = Original Frequency (real)
V_{sd} = Velocity of sound (in medium)
V_{sc} = Velocity of sound Source
V_o = Velocity of observer

$$f' = f_o\left[\frac{V_{sd} \pm V_o}{V_{sd} \pm V_{sc}}\right]$$

$+V_o$ = Toward the source
$-V_o$ = Away from the source
$+V_{sc}$ = Away from Observer
$-V_{sc}$ = Toward the Observer

$$f' = f_o\left[1 \pm v/c\right]$$

f_o = Source emits EM wave with a frequency f_o
f' = Observed frequency (new frequency)
v = velocity between the source and the observer
c = speed of light

$$\frac{\Delta\lambda}{\lambda} = \frac{\lambda_1 - \lambda_2}{\lambda_1} = \frac{V}{C}$$

λ_1 = Unshifted Wavelength C = speed of light
λ_2 = Shifted Wavelength V = Velocity of the object emitting the light

Thermodynamics:

Substance	Specific Heat(J/kg. °C)
Specific Heat of Beryllium	1830
Specific Heat of Cadmium	230
Specific Heat of Copper	387
Specific Heat of Germanium	322
Specific Heat of Gold	129
Specific Heat of Iron	448
Specific Heat of Lead	128
Specific Heat of Silicon	703
Specific Heat of Silver	234
Specific Heat of Brass	380
Specific Heat of Glass	837
Specific Heat of Ice(-5°C)	2090
Specific Heat of Marble	860
Specific Heat of Wood	1700
Specific Heat of Alcohol(ethyl)	2400
Specific Heat of Mercury	140
Specific Heat of Water(15°C)	4186
Specific Heat of Steam(100°C)	2010
Specific Heat of Aluminium	900
Specific Heat of Tin	540
Specific Heat of Steel	120
Specific Heat of Sand	830
Specific Heat of Ethanol (Alcohol, ethyl 32°F)	2.3 K

TABLE 13–1 Coefficients of Expansion, near 20°C

Material	Coefficient of Linear Expansion, α $(C°)^{-1}$	Coefficient of Volume Expansion, β $(C°)^{-1}$
Solids		
Aluminum	25×10^{-6}	75×10^{-6}
Brass	19×10^{-6}	56×10^{-6}
Copper	17×10^{-6}	50×10^{-6}
Gold	14×10^{-6}	42×10^{-6}
Iron or steel	12×10^{-6}	35×10^{-6}
Lead	29×10^{-6}	87×10^{-6}
Glass (Pyrex®)	3×10^{-6}	9×10^{-6}
Glass (ordinary)	9×10^{-6}	27×10^{-6}
Quartz	0.4×10^{-6}	1×10^{-6}
Concrete and brick	$\approx 12 \times 10^{-6}$	$\approx 36 \times 10^{-6}$
Marble	$1.4–3.5 \times 10^{-6}$	$4–10 \times 10^{-6}$
Liquids		
Gasoline		950×10^{-6}
Mercury		180×10^{-6}
Ethyl alcohol		1100×10^{-6}
Glycerin		500×10^{-6}
Water		210×10^{-6}
Gases		
Air (and most other gases at atmospheric pressure)		3400×10^{-6}

TABLE 14–4 Thermal Conductivities

Substance	Thermal Conductivity, k: kcal/(s·m·C°)	Thermal Conductivity, k: J/(s·m·C°)
Silver	10×10^{-2}	420
Copper	9.2×10^{-2}	380
Aluminum	5.0×10^{-2}	200
Steel	1.1×10^{-2}	40
Ice	5×10^{-4}	2
Glass	2.0×10^{-4}	0.84
Brick	2.0×10^{-4}	0.84
Concrete	2.0×10^{-4}	0.84
Water	1.4×10^{-4}	0.56
Human tissue	0.5×10^{-4}	0.2
Wood	0.3×10^{-4}	0.1
Fiberglass	0.12×10^{-4}	0.048
Cork	0.1×10^{-4}	0.042
Wool	0.1×10^{-4}	0.040
Goose down	0.06×10^{-4}	0.025
Polyurethane	0.06×10^{-4}	0.024
Air	0.055×10^{-4}	0.023

R Values for Insulation

Material (per inch)	K Value	R Value
Wood	0.76	1.25
Aluminum	15.5	N/A
Vinyl	0.97	N/A
Fiberglass Batts	0.3	3..33
Rockwool	0.3	3.33
EPS	0.03	4.00
Air Space	0.7	1.43
Drywall (gypsum)	1	1.00
Cement board	1.92	.052
Sand and Gravel	1.7	0.59
Poured Concrete	3.9	0.08
CMU (hollow)	1	1
Common Brick	5	0.11
Ceramic Tile	12.5	0.08
Marble	11	0.09

The 1st law Thermodynamics is often formulated

$$\Delta U = Q - W$$

Δ Internal Energy = Heat added - Work done

$\Delta L = \alpha L_o \Delta T$ $\Delta V = \beta V_o \Delta T$

$Q = mc\Delta T$ $-Q = Q$

$Q = mL_f$ $Q = mL_v$

1 calorie = 4.186 J

1 Calorie = 1000 kcal

1 BTU = 252 cal = 1.055 kJ

TABLE 20.2 Latent Heats of Fusion and Vaporization

Substance	Melting Point (°C)	Latent Heat of Fusion (J/kg)	Boiling Point (°C)	Latent Heat of Vaporization (J/kg)
Helium	−269.65	5.23×10^{3}	−268.93	2.09×10^{4}
Nitrogen	−209.97	2.55×10^{4}	−195.81	2.01×10^{5}
Oxygen	−218.79	1.38×10^{4}	−182.97	2.13×10^{5}
Ethyl alcohol	−114	1.04×10^{5}	78	8.54×10^{5}
Water	0.00	3.33×10^{5}	100.00	2.26×10^{6}
Sulfur	119	3.81×10^{4}	444.60	3.26×10^{5}
Lead	327.3	2.45×10^{4}	1 750	8.70×10^{5}
Aluminum	660	3.97×10^{5}	2 450	1.14×10^{7}
Silver	960.80	8.82×10^{4}	2 193	2.33×10^{6}
Gold	1 063.00	6.44×10^{4}	2 660	1.58×10^{6}
Copper	1 083	1.34×10^{5}	1 187	5.06×10^{6}

HEAT TRANSFER:

$H_{(\text{Heat Flow})}$ = Power

$$H_{(\text{Heat Flow})} = P = \frac{Q}{t} = \frac{-kA\Delta T}{L} = \frac{-A\Delta T}{L/k} = \frac{-A\Delta T}{R}$$

$$R = \frac{L}{K} = \frac{-A \bullet \Delta T \bullet t}{K} = \frac{-A \bullet \Delta T}{P}$$

$$\Delta S = \frac{Q}{T} \qquad \Delta S = S_H - S_C$$

$R = \dfrac{L}{K}$

L = Thickness

R = Insulation Value = [$ft^2 \cdot F^0 \cdot hr$/ Btu] or [$K \cdot m^2$ / W] **(1 $K \cdot m^2/W$ = 5.678263 $hr \cdot ft^2 \cdot {}^\circ F/Btu$)**

K = Thermal Conductivity

$T_F = (9/5\,{}^0F/{}^0C)T_C + 32^0F$ $\qquad T_C = (5/9\,{}^0C/{}^0F)(T_F - 32^0F)$ $\qquad$ Kelvin = $T_C + 273.15$

Gas Laws:

Ideal Gas Law:

PV = nRT — n= # of moles; R= 8.31 J /(mol K)

PV=NkT — N= molecules / mole; k = 1.38 x 10^{-23} J/K

Table 1.

Values of the Universal Gas Constant R

$$\begin{aligned} R &= 0.08205\ (l \cdot atm)/(mole \cdot K) \\ &= 8.205 \times 10^{-5}\ (m^3 \cdot atm)/(mole \cdot K) \\ &= 82.05\ (cm^3 \cdot atm)/(mole \cdot K) \\ &= 1.99 \times 10^{-3} kcal/(mole \cdot K) \\ &= 8.314\ (J)/(mole \cdot K) \\ &= 1.987\ (cal)/(mole \cdot K) \\ &= 62{,}358\ (cm^3 \cdot torr)/(mole \cdot K) \\ &= 62{,}358\ (cm^3 \cdot mm\ Hg)/(mole \cdot K) \end{aligned}$$

Bernoulli's Principle:

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

Continuity of Fluids:

$$A_1 v_1 = A_2 v_2$$

$$P_{gauge} = \rho g h$$

$$P_{absolute} = P_0 + P_{gauge} = P_0 + \rho g h$$

P_O = Atmosphere Pressure

Pascal's Principle:

Pressure $= \dfrac{F}{\text{Area}}$ = N/m^2 (SI Unit)

1 Pascal (Pa) = 1 N/m^2 (SI unit)

1 ATM = 760 torr
= 760 mm Hg
= 101.33 kPa
= 14.7 psi

Archimedes Principle:

$$F_B = \rho_{fluid} V g$$

F_B = Buoyant Force
ρ = density of fluid
V = Volume of fluid
g = gravity

$$\rho = \frac{m}{V}$$

Quantum / Nuclear Physics:

$E = mc^2$ — E = Energy

$E = hf = pc$ — h = plank's constant (6.63×10^{-34} J s)

$E = hc / \lambda$ — f = frequency

$\lambda = h / p$ — m = mass

c = speed of light (3×10^8 m/s)

p = momentum

1 eV = 1.6×10^{-19} J

:

$$E = -13.6\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \text{eV}$$

Heisenberg Uncertainty Principle

$\Delta x\, \Delta p > h/4\pi = h / 2$

Special Theory of Relativity

$$t' = t\sqrt{1 - V^2/c^2}$$

Where: t' = dilated time
t = stationary time
V = velocity
c = speed of light

$$l = l_o\sqrt{1 - \frac{v^2}{c^2}}$$

where

l_o = length of object in rest
l = length of object in motion

$$U = \frac{V + U'}{(1 + (vu'/c^2))}$$

V = Relative Velocity between observers

u = Velocity of an object relative to stationary observer

u' = Is the velocity relative to moving observer

Nuclear Physics:

Carbon Dating: Carbon 14

$$t = \left[\frac{\ln \frac{N}{N_o}}{(-0.693)}\right] \bullet t_{1/2}$$

$t_{1/2}$ = half-life carbon-14 = 5730 years

t = age or death rate

N/N_o = Percentage C-14 remaining compared to living sample

In = Natural Log

SI Units, Base and Derived

SI Fundamental Base Units			Named units derived from SI base units				
Length	m (meter)		Name	Symbol	Quantity	Equivalents	SI base unit Equivalents
Mass	kg (kilogram)		hertz	Hz	frequency	1/s	s−1
Time	s (second)		radian	rad	angle	m/m	dimensionless
Electric Current	A (Ampere)		steradian	sr	solid angle	m2/m2	dimensionless
Thermodynamic Temperature	K (Kelvin		newton	N	force, weight	kg·m/s2	kg·m·s−2
Substance Amount	mol (mole)		pascal	Pa	pressure, stress	N/m2	kg·m−1·s−2
Luminous Intensity	cd (Candela)		joule	J	energy, work, heat	N·m C·V W·s	kg·m2·s−2
			watt	W	power, radiant flux	J/s V·A	kg·m2·s−3
			coulomb	C	electric charge or quantity of electricity	s·A	s·A
			volt	V	voltage, electrical potential difference, electromotive force	W/A J/C	kg·m2·s−3·A−1
			farad	F	electrical capacitance	C/V s/Ω	kg−1·m−2·s4·A2
			ohm	Ω	electrical resistance, impedance, reactance	V/A	kg·m2·s−3·A−2
			siemens	S	electrical conductance	1/Ω A/V	kg−1·m−2·s3·A2
			weber	Wb	magnetic flux	J/A	kg·m2·s−2·A−1
			tesla	T	magnetic field strength, magnetic flux density	V·s/m2 Wb/m2 N/(A·m)	kg·s−2·A−1
			henry	H	inductance	V·s/A Ω·s Wb/A	kg·m2·s−2·A−2
			degree Celsius	°C	temperature relative to 273.15 K	K - 273.15	K - 273.15
			lumen	lm	luminous flux	cd·sr	cd
			lux	lx	illuminance	lm/m2	m−2·cd
			becquerel	Bq	radioactivity (decays per unit time)	1/s	s−1
			gray	Gy	absorbed dose (of ionizing radiation)	J/kg	m2·s−2
			sievert	Sv	equivalent dose (of ionizing radiation)	J/kg	m2·s−2
			katal	kat	catalytic activity	mol/s	s−1·mol

Some Additional SI derived units				***Some Additional SI derived units***			
Name	Symbol	Quantity	Expression in SI base units	Name	Symbol	Quantity	Expression in SI base units
square metre	m2	area	m2	cubic metre per kilogram	m3/kg	specific volume	m3·kg−1
cubic metre	m3	volume	m3	newton per metre	N/m = J/m2	surface tension, stiffness	kg·s−2
metre per second	m/s	speed, velocity	m·s−1	watt per metre kelvin	W/(m·K)	thermal conductivity	m·kg·s−3·K−1
cubic metre per second	m3/s	volumetric flow	m3·s−1	coulomb per cubic metre	C/m3	electric charge density	m−3·s·A
metre per second squared	m/s2	acceleration	m·s−2	ampere per square metre	A/m2	electric current density	A·m−2
metre per second cubed	m/s3	jerk, jolt	m·s−3	farad per metre	F/m	permittivity	m−3·kg−1·s4·A 2
radian per second	rad/s	angular velocity	s−1	henry per metre	H/m	permeability	m·kg·s−2·A−2
newton second	N·s	momentum, impulse	m·kg·s−1	volt per metre	V/m	electric field strength	m·kg·s−3·A−1
newton metre second	N·m·s	angular momentum	m2·kg·s−1	ampere per metre	A/m	magnetic field strength	A·m−1
newton metre	N·m = J/rad	torque, moment of force	m2·kg·s−2	candela per square metre	cd/m2	luminance	cd·m−2
newton per second	N/s	yank	m·kg·s−3	lumen second	lm·s	luminous energy	cd·sr·s
kilogram per square metre	kg/m2	area density	m−2·kg	ohm metre	Ω·m	resistivity	m3·kg·s−3·A−2

Some other units such as the hour, litre, tonne, and electron volt are not SI units, but are widely used in conjunction with SI units