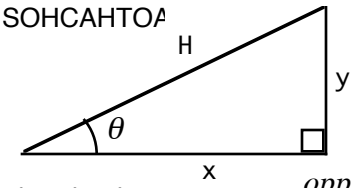
## RIGHT TRIANGLE TRIG

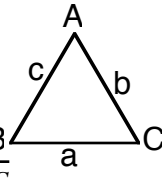
SOHCAHTOA




$H^2 = x^2 + y^2$ $\quad \sin\theta = \frac{opp}{hyp} = \frac{y}{H}$

$\cos\theta = \frac{adj}{hyp} = \frac{x}{H}$ $\quad \tan\theta = \frac{opp}{adj} = \frac{y}{x}$

## ANY TRIANGLE TRIG

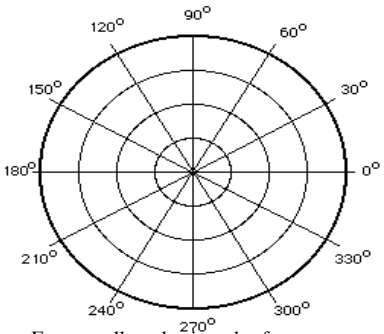



$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

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

## VECTOR ADDITION (2)

**Add Forces A and B acting at origin .**




Express all angles in polar form.

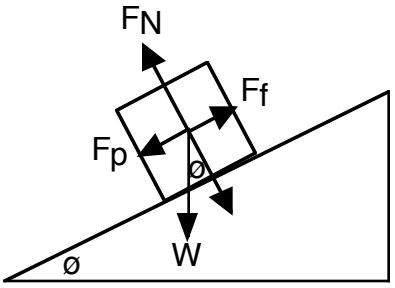
$\Sigma F_x = (\cos 30°)(A) + (\cos 240°)(B)$

$\Sigma F_y = (\sin 30°)(A) + (\sin 240°)(B)$

$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$

$\theta_{resultant} = \arctan \frac{\Sigma F_y}{\Sigma F_x}$

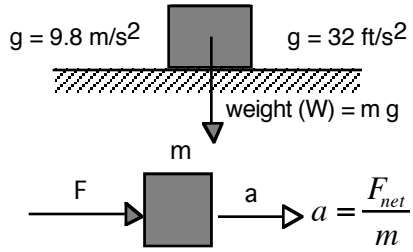
## FORCES: INCLINED PLANE




W = Weight of Block
$F_N$ = Normal Force
$F_p$ = Force parallel to plane
$F_f$ = Force of friction

$F_f = \mu F_N$ $\quad F_p = mg\sin\theta$

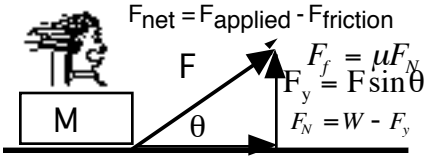
## WEIGHT & 2nd LAW




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

*Get Your Mass Moving*

$F_{net} = F_{applied} - F_{friction}$




$F_f = \mu F_N$

$F_y = F\sin\theta$

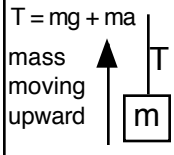
$F_N = W - F_y$

$F_x = F\cos\theta$

## TENSIONS

$T = mg + ma$

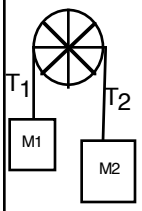
mass moving upward

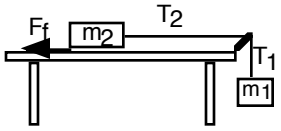



$T = mg - ma$

mass moving downward




If $m_2 > m_1$

$T_1 = m_1 g + m_1 a$

$T_2 = m_2 g - m_2 a$

$a = \frac{m_2 g - m_1 g}{m_1 + m_2}$

$T_1 = m_1 g - m_1 a$

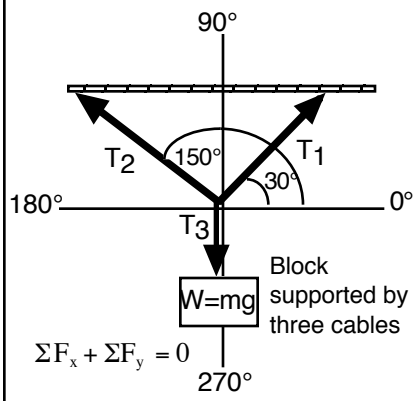
$T_2 = m_2 a +$

$F_f = \mu_k F_N$

$F_N = m_2 g$

$a = \frac{m_1 g - F_f}{m_1 + m_2}$

## COMPUTING TENSIONS




$\Sigma F_x + \Sigma F_y = 0$

Place a free body diagram on a coordinate system and express all angles in polar form.

$\Sigma F_x = (\cos 30°)(T_1) + (\cos 150°)(T_2) + (\cos 270°)(T_3) = 0$

$\Sigma F_y = (\sin 30°)(T_1) + (\sin 150°)(T_2) + (\sin 270°)(T_3) = 0$

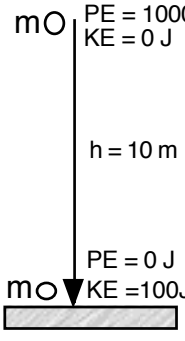
## ENERGY

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

$E_p = mgh$

$W = Fd$

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




$KE_i + PE_i = KE_f + PE_f$

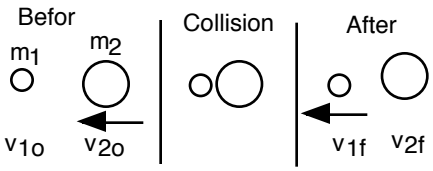
$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$

First Law of Bicycling: No matter which way you ride, it's always uphill and against the wind.

## IMPULSE & MOMENTUM

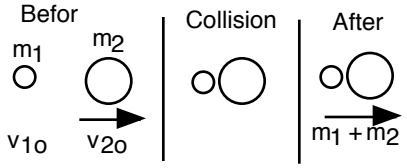
**Totally Elastic Collision**

$m_1v_{1o} + m_2v_{2o} = m_1v_{1f} + m_2v_{2f}$




**Totally Inelastic Collision**

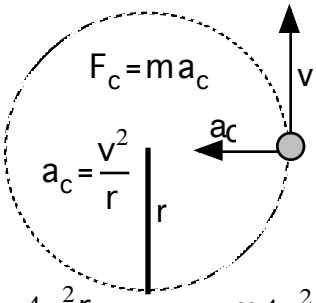
$m_1v_{1o} + m_2v_{2o} = v_f\,(m_1 + m_2)$




$\Delta p = m\Delta v$ $\quad J = F\Delta t$ $\quad F\Delta t = m\Delta v$

## CIRCULAR MOTION

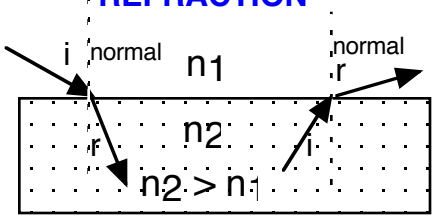
$T = \frac{1}{f}$ $\quad v = \frac{2\pi r}{T}$ $\quad f = \frac{1}{T}$ $\quad T = \frac{2\pi r}{v}$



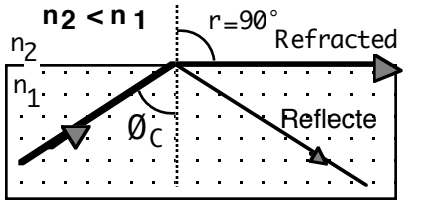

$a_c = \frac{4\pi^2 r}{T^2}$ $\quad F_c = \frac{m4\pi^2 r}{T^2}$

$F_c = \frac{mv^2}{r}$

## REFRACTION




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




$$\sin\theta_c = \frac{n_2}{n_1} \qquad \theta_c = \text{critical angle}$$

## MEASUREMENT

| | |
|---|---|
| mega (M) | $10^6$ |
| ---------- | $10^5$ |
| ---------- | $10^4$ |
| kilo (k) | $10^3$ |
| hecto (h) | $10^2$ |
| deka (da) | $10^1$ |
| Base Unit | $10^0$ |
| deci (d) | $10^{-1}$ |
| centi (c) | $10^{-2}$ |
| milli (m) | $10^{-3}$ |
| ---------- | $10^{-4}$ |
| ---------- | $10^{-5}$ |
| micro ($\mu$) | $10^{-6}$ |

$K = C + 273$

$F = 1.8\,C + 32$

$C = \frac{F - 32}{1.8}$

$C = K - 273$

$D = \frac{m}{v}$

■ not accurate or precise

● precise and accurate

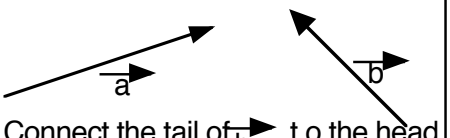
◀ precise not accurate

Error = accepted value - experimental value

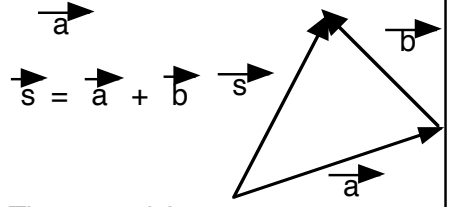
$$\%Error = \frac{|Error|}{accepted\ value} \times 100\%$$

## Vector Addition

Consider $\vec{a} + \vec{b}$

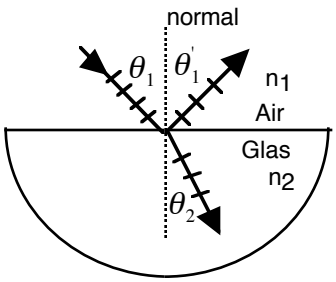



Connect the tail of $\vec{b}$ t o the head




The sum of the vectors points from the tail of $\vec{a}$ to the head of $\vec{b}$.

## REFLECTION & REFRACTION




$\theta_1$ = the angle of incidence

$\theta_2$ = the angle of refraction

$\theta_1$ = the angle of reflection

n = c/v where v is the speedof light in the medium.

Law of reflection: $\theta_1 = \theta_1'$

Law of refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ Snell's

n = index of refraction of the medium

## KINEMATICS VARIABLES

Uniformly Accelerated Motion

| x Component | Variable | y Component |
|---|---|---|
| x | Displacement | y |
| $a_x$ | Acceleration | $a_y$ |
| $v_x$ | Final Velocity | $v_y$ |
| $v_{ix}$ | Initial Velocity | $v_{iy}$ |
| t | Elapsed Time | t |

186,000 mi/s is not only a good idea, it's the law.

## KINEMATICS EQUATIONS

Uniformly Accelerated Motion

$$v_x = v_{ix} + a_x t \qquad x = \frac{1}{2}(v_{ix} + v_x)t$$

$$x = v_{ix}t + \frac{1}{2}a_x t^2 \qquad v_x^2 = v_{ix}^2 + 2a_x x$$

$$v_y = v_{iy} + a_y t \qquad y = \frac{1}{2}(v_{iy} + v_y)t$$

$$y = v_{iy}t + \frac{1}{2}a_y t^2 \qquad v_y^2 = v_{iy}^2 + 2a_y y$$

$$g = -9.8\frac{m}{s^2} \qquad g = -32\frac{ft}{s^2}$$

## ROTATIONAL MECHANICS

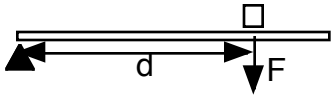
**Moment of Inertia**

$I_{sphere} = \frac{2}{5}mr^2$ $I_{cyl} = \frac{1}{2}mr^2$ $I_{hoop} = mr^2$

$I_{hoop} = \frac{1}{2}mr^2$ $I_{rodcg} = \frac{1}{12}mL^2$ $I_{rodend} = \frac{1}{3}mL^2$

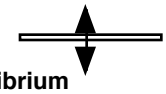
**Torque**

$\tau = F\,d$



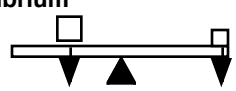

**Translational Equilibrium**

$F_{up} = F_{down}$



**Rotational Equilibrium**

$\tau_{cw} = \tau_{ccw}$



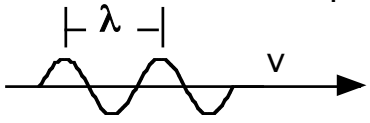
**Angular Momentum**

$L = mvr$ $L = I\omega$

$I_1\omega_1 = I_2\omega_2$ conservation

## WAVES AND VIBRATIONS

$v = f\lambda$ $T = \frac{1}{f}$ $f = \frac{1}{T}$




$$f = f_o \frac{(v + v_o)}{(v - v_s)}$$

v = speed of sound

$v_o$ = vel. of observer

$v_s$ = velocity of source

$f_o$ = actual frequency

f = perceived

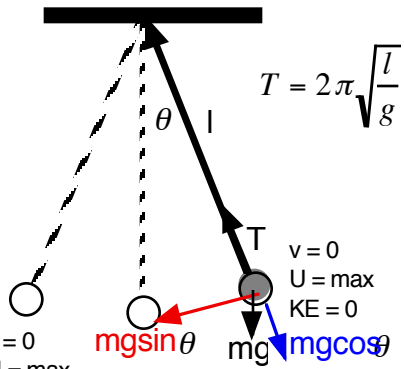
**$v_o$ is (+) if observer moves toward source**

**$v_o$ is (-) if observer moves away from source**

**$v_s$ is (+) if source moves toward observer**

**$v_s$ is (-) if source moves away from observer**

## SIMPLE HARMONIC MOTION




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

v = 0
U = max
KE = 0

v = 0
U = max
KE = 0

v = max
U = min
KE = max
equilibrium position

## Mechanics

1. Weight (force of gravity) decreases as you move away from the earth by distance squared.
2. Mass and inertia are the same thing.
3. Constant velocity and zero velocity means the net force is zero and acceleration is zero.
4. Weight (in newtons) is mass x acceleration (w = mg).
Mass is not weight!
5.Velocity, displacement [s], momentum, force and acceleration are vectors.
6. Speed, distance [d], time, and energy (joules) are scalar quantities.
7. The slope of the velocity-time graph is acceleration.
8. At zero (0) degrees two vectors have a resultant equal to their sum. At 180 degrees two vectors have a resultant equal to their difference. From the difference to the sum is the total range of possible resultants.
9. Centripetal force and centripetal acceleration vectors are toward the center of the circle- while the velocity vector is tangent to the circle.
10. An unbalanced force (object not in equilibrium) must produce acceleration.
11. The slope of the distance-tine graph is velocity.
12. The equilibrant force is equal in magnitude but opposite in direction to the resultant vector.
13. Momentum is conserved in all collision systems.
14. Magnitude is a term use to state how large a vector quantity is.

## Energy

1. Mechanical energy is the sum of the potential and kinetic energy.

2 .Units:

a = [m/sec $^2$]

F = [kg•m/sec $^2$] (newton)

work = pe= ke = [kg•m $^2$/sec$^2$] (joule)

3. An ev is an energy unit equal to 1.6 x 10 $^{-19}$ joules

4. Gravitational potential energy increases as height increases.

5. Kinetic energy changes only if velocity changes.

6. Mechanical energy (pe + ke) does not change for a free falling mass or a swinging pendulum. *(when ignoring air friction)*

7. The units for power are [joules/sec] or the rate of change of energy.

Checkout's Axiom:The other line will always move faster.

## Electricity

1. A coulomb is charge, an amp is current [coulomb/sec] and a volt is potential difference [joule/coulomb].
2. Short fat cold wires make the best conductors.
3. Electrons and protons have equal amounts of charge (1.6 x 10-19 coulombs each).
4. Adding a resistor in parallel decreases the total resistance of a circuit.
5. Adding a resistor in series increases the total resistance of a circuit.
6. All resistors in series have equal current (I).
7. All resistors in parallel have equal voltage (V).
8. If two charged spheres touch each other add the charges and divide by two to find the final charge on each sphere.
9. Insulators contain no free electrons.
10. Ionized gases conduct electric current using positive ions, negative ions and electrons.
11. Electric fields all point in the direction of the force on a positive test charge.
12. Electric fields between two parallel plates are uniform in strength except at the edges.
13. Millikan determined the charge on a single electron using his famous oil-drop experiment.
14. All charge changes result from the movement of electrons not protons (an object becomes positive by losing electrons)

Interchangeable parts ...won't.

## Magnetism

1. The direction of a magnetic field is defined by the direction a compass needle points.

2. Magnetic fields point from the north to the south outside the magnet and south to north inside the magnet.

3. Magnetic flux is measured in webers.

4. Left hands are for negative charges and right hands are for positive charges.

5. The first hand rule deals with the B-field around a current bearing wire, the third hand rule looks at the force on charges moving in a B-field, and the second hand rule is redundant.

6. Solenoids are stronger with more current or more wire turns or adding a soft iron core.

By making things absolutely clear, people will become confused.

## Wave Phenomena

1. Sound waves are longitudinal and mechanical.

2. Light slows down, bends toward the normal and has a shorter wavelength when it enters a higher (n) value medium.

3. All angles in wave theory problems are measured to the normal.

4. Blue light has more energy. A shorter wavelength and a higher frequency than red light (remember- ROYGBIV).

5. The electromagnetic spectrum (radio, infrared, visible. Ultraviolet x-ray and gamma) are listed lowest energy to highest.

6. A prism produces a rainbow from white light by dispersion (red bends the least because it slows the least).

7. Light wave are transverse (they can be polarized).

8. The speed of all types of electromagnetic waves is 3.0 x 10$^8$ m/sec in a vacuum.

9. The amplitude of a sound wave determines its energy.

10. Constructive interference occurs when two waves are zero (0) degrees out of phase or a whole number of wavelengths (360 degrees.) out of phase.

11. At the critical angle a wave will be refracted to 90 degrees.

## Wave Phenomena con't:

12. According to the Doppler effect a wave source moving toward you will generate waves with a shorter wavelength and higher frequency.

13. Double slit diffraction works because of diffraction and interference.

14. Single slit diffraction produces a much wider central maximum than double slit.

15. Diffuse reflection occurs from dull surfaces while regular reflection occurs from mirror type surfaces.

16. As the frequency of a wave increases its energy increases and its wavelength decreases.

17. Transverse wave particles vibrate back and forth perpendicular to the wave direction.

18. Wave behavior is proven by diffraction, interference and the polarization of light.

19. Shorter waves with higher frequencies have shorter periods.

20. Radiowaves are electromagnetic and travel at the speed of light (c).

21. Monochromatic light has one frequency.

22. Coherent light waves are all in phase.

## Geometric Optics

1. Real images are always inverted.

2. Virtual images are always upright.

3. Diverging lens (concave) produce only small virtual images.

4. Light rays bend away from the normal as they gain speed and a longer wavelength by entering a slower (n) medium *{frequency remains constant}*.

5. The focal length of a converging lens (convex) is shorter with a higher (n) value lens or if blue light replaces red.

2nd Law of Location: You always find something in the last place you look.

## Modern Physics

1. The particle behavior of light is proven by the photoelectric effect.

2. A photon is a particle of light *{wave packet}*.

3. Large objects have very short wavelengths when moving and thus can not be observed behaving as a wave. *(DeBroglie Waves)*

4. All electromagnetic waves originate from accelerating charged particles.

5. The frequency of a light wave determines its energy (E = hf).

6. The lowest energy state of a atom is called the ground state.

7. Increasing light frequency increases the kinetic energy of the emitted photo-electrons.

8. As the threshold frequency increase for a photo-cell (photo emissive material) the work function also increases.

9. Increasing light intensity increases the number of emitted photo-electrons but not their KE.

## Nuclear Physics

1. Alpha particles are the same as helium nuclei and have the symbol . $\alpha$

2. The atomic number is equal to the number of protons (2 for alpha)

3. Deuterium is an isotope of hydrogen

4. The number of nucleons is equal to protons + neutrons (4 for alpha)

5. Only charged particles can be accelerated in a particle accelerator such as a cyclotron or Van Der Graaf generator.

6. Natural radiation is alpha, beta, and gamma (high energy x-rays)

7. A loss of a beta particle results in an increase in atomic number.

8. All nuclei weigh less than their parts. This mass defect is converted into binding energy. (E=mc$^2$)

## MIRROR SIGN CONVENTIONS

**Focal Length (f)**

f is + for a concave mirror
f is - for a convex mirror

**Object Distance ($d_o$)**

$d_o$ is + if the object is in front of the mirror (real object)
$d_o$ is - if the object is behind the mirror (virtual object)

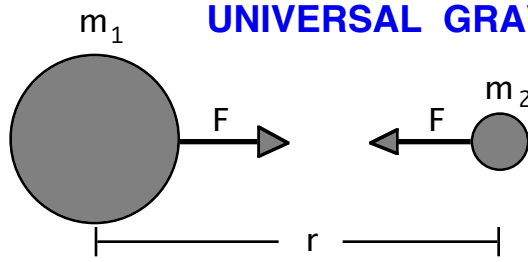
**Image Distance ($d_i$)**

$d_i$ is + if the image is in front of the mirror (real image)
$d_i$ is - if the image is behind the mirror (virtual image)

**Magnification (m)**

m is + for an image that is upright with respect to the object
m is - for an image that is inverted with respect to the object

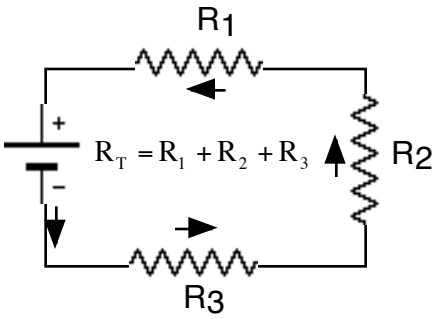
## UNIVERSAL GRAVITATION




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

This is Newton's Law of Gravity (or more formaly Newton's Law of Universal Gravitation). It was discovered by Newton in 1665 (327 before 1992) when he was only 23 years old. It states that any two point masses attract one another with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. This equation is exact only for point masses or sperical masses of uniform density. It's also exact for spherical masses of non-uniform density if the density of the spherical mass varies as a function of radius only. If the density of the spherical mass varies as a function of lattitude or longitude (or both) then this equation does not apply exactly. The constant of proportionality, G, which is called the Universal Gravitational Constant, was found by experiment to be equal to 6.6732E-11 NT-M2/KG2. The determination of this constant, first done by the English physicist Henry Cavendish in 1797, is known as "the Cavendish experiment" and is also called "weighing the Earth".

## SERIES CIRCUIT



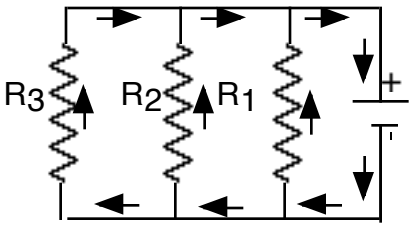

$$R_T = R_1 + R_2 + R_3$$

Adding a resistor in series increases the total resistance of a circuit.

All resistors in series have equal current (I).

$$i_t = \frac{V}{R_T}$$

## PARALLEL CIRCUIT

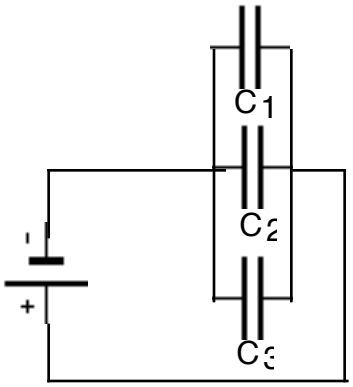



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Adding a resistor in parallel decreases the total resistance of a circuit.

All resistors in parallel have equal voltage (V).

## PARALLEL CAPACITORS




$$C_T = C_1 + C_2 + C_3 + \ldots$$

## Nuclear Physics cont:

9. Isotopes have different neutron numbers and atomic masses but the same number of protons (atomic numbers).

10. Geiger counters, photographic plates, cloud and bubble chambers are all used to detect or observe radiation.

11. Rutherford discovered the positive nucleus using his famous gold-foil experiment.

12. Fusion requires that hydrogen be combined to make helium.

13. Fission requires that a neutron causes uranium to be split into middle size atoms and produce extra neutrons.

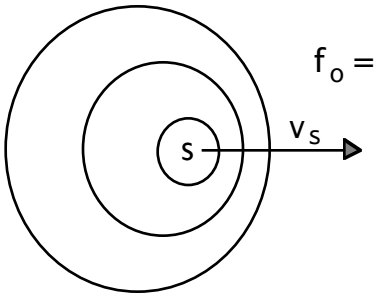
14. Radioactive half-lives can not be changed by heat or pressure.

15. One AMU of mass is equal to 931 meV of energy ($E = mc^2$).

16. Nuclear forces are strong and short ranged.

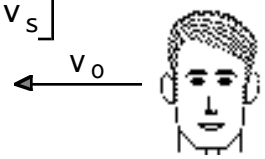
## DOPPLER EFFECT [SOUND]

Source




$$f_o = f_s\left[\frac{v + v_o}{v - v_s}\right]$$

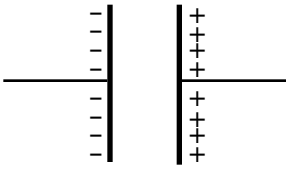
Observer




$f_o$ = frequency heard by observer
f = frequency of wave generated by source
v = speed of sound in medium
$v_o$ = velocity of observer (+ if moving toward source) ( - if moving away from source)

$v_s$ = velocity of source (+ if moving toward observer ( - if moving away from observer)

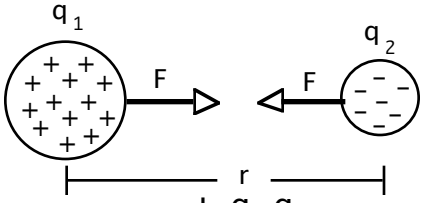
## CAPACITANCE



$$C = \frac{q}{V}$$

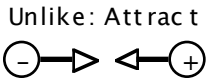
The capacitance of a capacitor is defined as the amount of charge on either of its two plates divided by the magnitude of the potential difference (voltage between the two plates. The SI unit of capacitance is the coulomb/volt. It has been given the name farad, in honor of Michael Faraday, the 19th century English experimentalist.

## COULOMB'S LAW



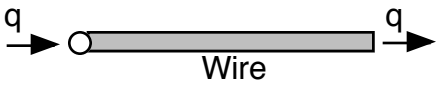

$$F = \frac{k\, q_1 q_2}{r^2}$$

$k = 9 \times 10^9\ Nm^2/C$





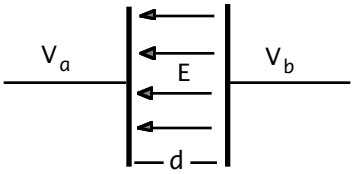
## CURRENT




$$i = \frac{q}{t}$$

Electric current is the flow of charge through a solid, liquid, gas, or vacuum. It is the amount of charge passing a certain cross section divided by the time it takes to pass. The SI unit of current is the Ampere. An ampere is the rate of charge flow equal to one coulomb per second.

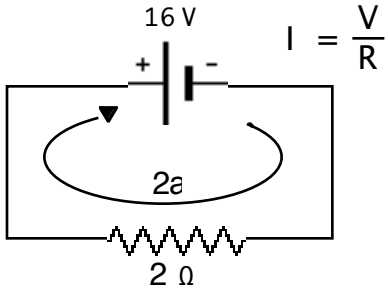
## ELECTRIC FIELD STRENGTH




$$E = \frac{F}{q}$$

The strength of an electric force field is determined by measuring the force on a test charge placed in the field. The quantity 'Electric Field Strength' is thus 'Force/Charge'. The unit of measurement is the Newton/Coulomb in the MKS system of units.

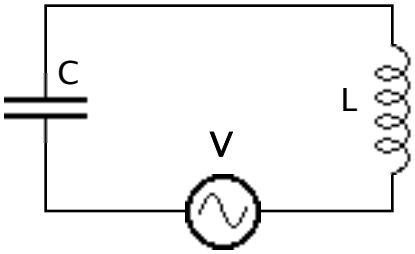
## OHM'S LAW




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

Ohm discovered that the electric current through a wire (the rate of charge flow) is directly proportional to the difference in electric potential between the ends of the wire and inversely proportional to the resistance of the wire through which the charge flows. The electrical resistance of a wire depends on its length, cross-sectional area, and the type of material (usually metal) of which it is made.

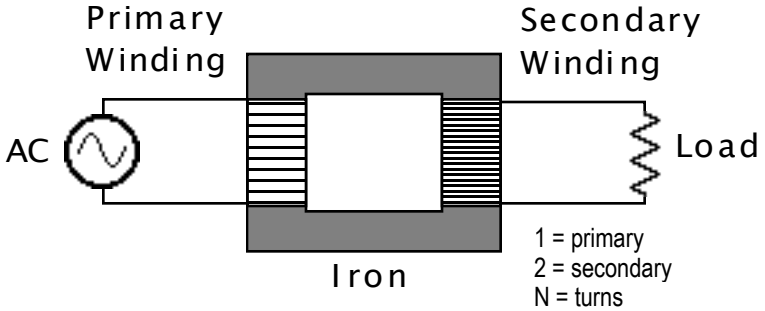
## RESONANCE




$$f = \frac{1}{2\pi\sqrt{LC}}$$

This formula gives the resonace frequency of an LC circuit

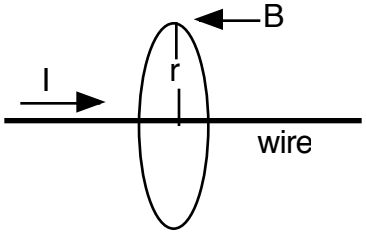
## TRANSFORMER




1 = primary
2 = secondary
N = turns
I = current
V = voltage

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \qquad V_1 I_1 = V_2 I_2 \qquad \frac{I_1}{I_2} = \frac{N_2}{N_1}$$

## B NEAR A STRAIGHT WIRE

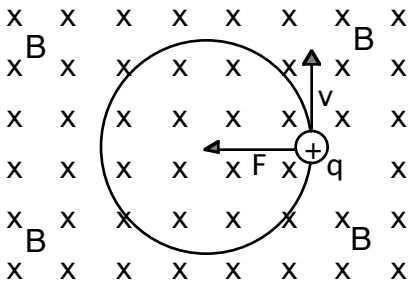



$$B = \frac{\mu_0 I}{2\pi r} \qquad \mu_0 = 4\pi \times 10^{-7}\ \frac{Tm}{A}$$

$\mu_0$ = permeability of free space

This equation gives the magnitude of the magnetic field at a distance r from a straight wire.

## ORBITAL RADIUS OF A CHARGED PARTICLE IN A MAGNETIC FIELD

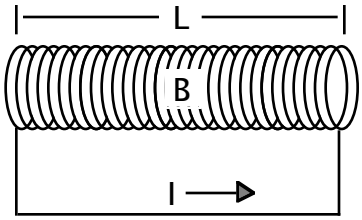



B is into the page

$$r = \frac{mv}{qB}$$

F would point to the right for a negative charge

## SOLENOID B

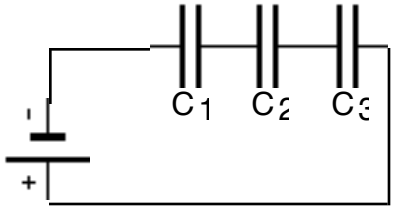



$$B = \mu_0 \frac{N}{L} I$$

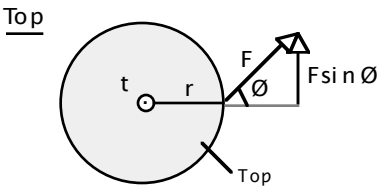
This equation gives the magnetic field strength at the center of a long solenoid.

## SERIES CAPACITORS

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + .....$$

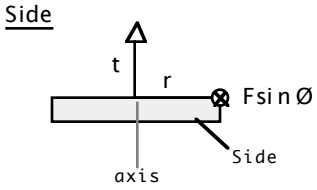



## TORQUE

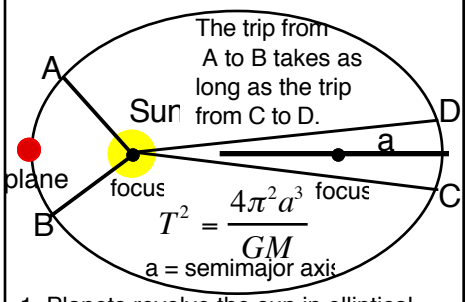



Torque (t)is the product of the length of the lever arm and the component of the force causing the torque that is perpendicular to the lever arm.

$$t = r F \sin Ø$$




## KEPLER"S LAWS




$$T^2 = \frac{4\pi^2 a^3}{GM}$$

a = semimajor axis

1. Planets revolve the sun in elliptical orbits
2. The segment joining the planet and the Sun sweeps out equal areas in equal time intervals

$M$ = mass of Sun

$G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$

## ROTATIONAL KINEMATICS

$$\omega = \omega_i + \alpha t \qquad \theta = \frac{1}{2}(\omega_i + \omega)t$$

$$\theta = \omega_i t + \frac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_i^2 + 2\alpha\theta$$

$\theta$ = Displacement

$\omega$ = final velocity

$\alpha$ = acceleration

$t$ = time

$\omega_i$ = initial velocity

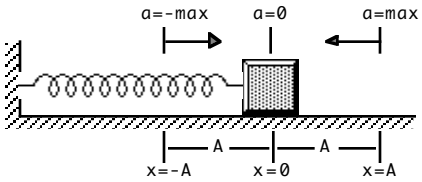
### UNITS

$\omega = \frac{\text{radians}}{\text{s}}$ $\alpha = \frac{\text{radians}}{\text{s}^2}$

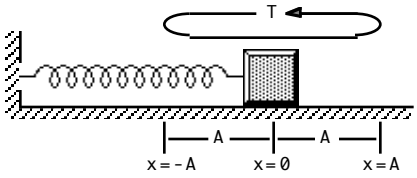
$\theta$ = radians $t = s$

1 rev = 2π radian

## SIMPLE HARMONIC MOTION

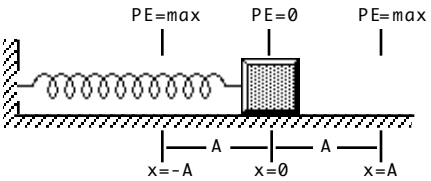



SHM-Acc. (a $a = -\frac{k}{m}x$

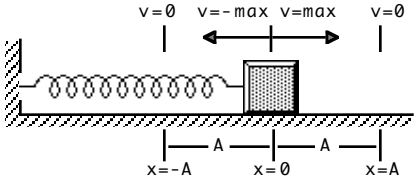



SHM-Per. (T $T = 2\pi\sqrt{\frac{m}{k}}$

## SIMPLE HARMONIC MOTION

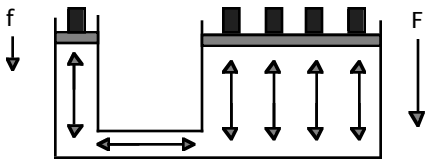



SHM-PE $PE = \frac{1}{2}kx^2$



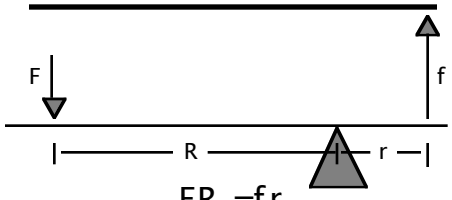

SHM-Velocity $v = \sqrt{\frac{k}{m}(A^2 - x^2)}$

## SIMPLE MACHINES




Hydraulic Press

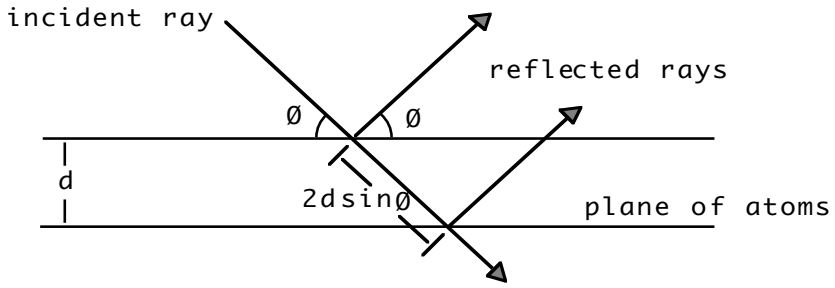
$$\frac{f}{a} = \frac{F}{A}$$



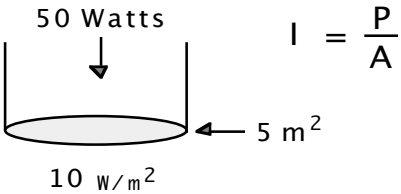

FR =fr

FORCE on a

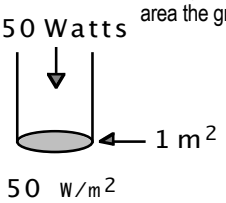
## BRAGG EQUATION



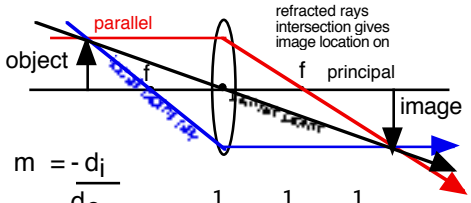

## IRRADIANCE




Irradiance is power per unit area. Irradiance is also called radiant flux density. The more power per unit area the greater the irradiance.




## CONVEX LENSES

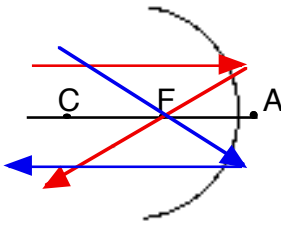



$m = -\frac{d_i}{d_o}$ $\quad m = \frac{h_i}{h_o}$ $\quad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

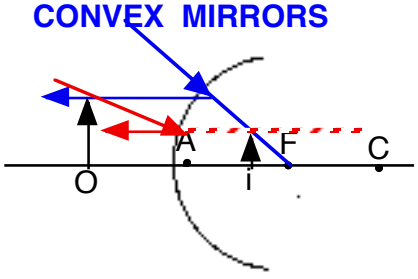
$d_o$ is + if the object is in front of the lens
$d_o$ is - if the object is in back of the lens
$d_i$ is + if the image is in back of the lens
$d_i$ is - if the image is in front of the lens
f is + for a converging lens
(sometimes called a convex or positive lens)
f is - for a diverging lens
(sometimes called a concave or negative lens)

| | Case# | Object Position | Image Position | Image Type | Size of Image Relative to Object Size | Image Orientation Relative to Object |
|---|---|---|---|---|---|---|
| Converging Lenses | I | Infinite Beyond 2F' | At F | Real | Reduced | Inverted |
| | II | Finite Beyond 2F' | Between F & 2F | Real | Reduced | Inverted |
| | III | At 2F' | At 2F | Real | Same size as object | Inverted |
| | IV | Between 2F' & F' | Beyond 2F | Real | Enlarged | Inverted |
| | V | At F' | No Image | No Image | No Image | No Image |
| | VI | Between F' & O | Same side as object | Virtual | Enlarged | Erect |
| Diverging Lenses | All | Anywhere in Front | Same side as object | Virtual | Reduced | Erect |

## CONCAVE MIRRORS

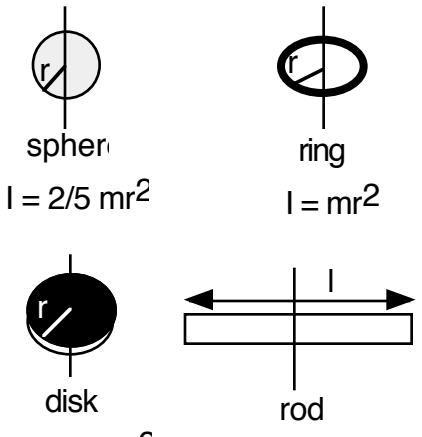



## CONVEX MIRRORS




| | Case# | Object Position | Image Position | Image Type | Size of Image Relative to Object Size | Image Orientation Relative to Object |
|---|---|---|---|---|---|---|
| Concave Mirrors | I | Infinite Beyond C | At F | Real | Reduced to a point at F | Inverted |
| | II | Finite Beyond C | Between C & F | Real | Reduced | Inverted |
| | III | At C | At C | Real | Same size as object | Inverted |
| | IV | Between C & F | Beyond C | Real | Enlarged | Inverted |
| | V | At F | No Image | No Image | No Image | No Image |
| | VI | Between F & A | Behind Mirror | Virtual | Enlarged | Erect |
| Convex Mirrors | All | Anywhere in Front | Behind Mirror | Virtual | Reduced | Erect |

## ROTATIONAL DYNAMICS




## GAS LAWS

**Charles Law (constant volume)**

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

**Boyle's Law (constant temperature)**

$$P_1V_1 = P_2V_2$$

**Ideal Gas Law**

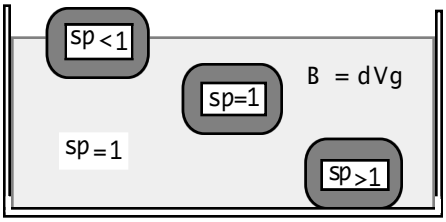
$$PV = nRT$$

Combined Gas Law

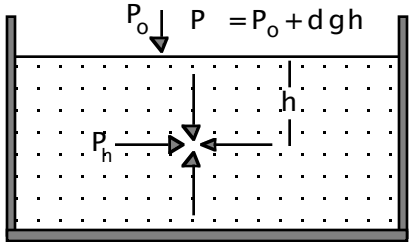
$$P1V1T2 =$$

T is in Kelvins  1 = old, 2 = new

## ARCHIMEDES PRINCIPLE (BUOYANT FORCE)

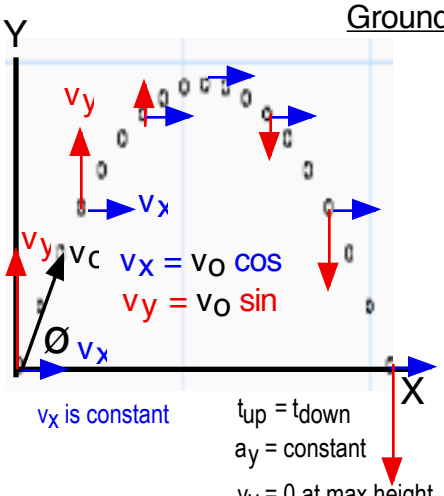



## PRESSURE in a LIQUID




## PROJECTILE MOTION

Ground to Groun




$$H = \frac{[v_o \sin\theta]^2}{2g}$$

$$T = \frac{2v_o \sin\theta}{g}$$

$$R = \frac{v_o^2 \sin[2\theta]}{g}$$

g = -32 ft/s²  g = -9.8 m/s²

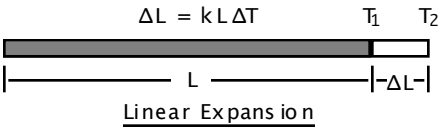
**Physics Price List**

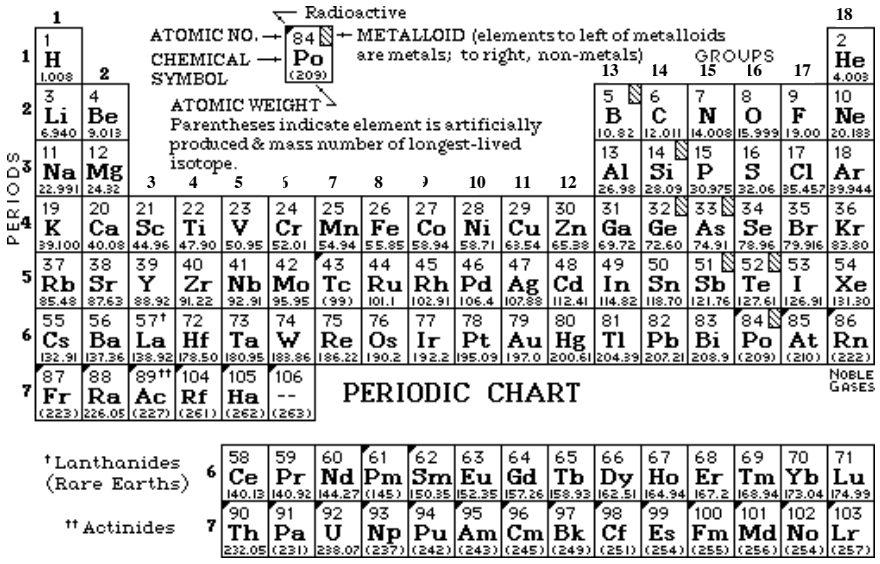
Answers to Physics Problems.....$1.00
Answers requiring thought..... $3.00
Answers, correct.....$5.00
Words of wisdom..... .....Free
Absolute Truths.....not available
Dumb looks.....Still Free

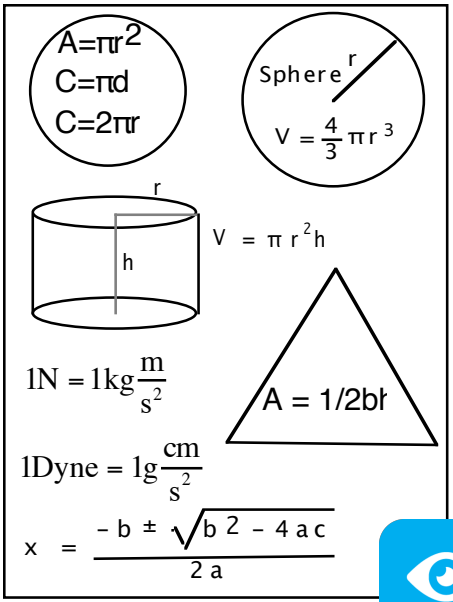
π's r round

**Conservation of Filth:**

Inorder for something to become clean, something else must become dirty.




**Mechanics**

**Symbols**

$v_{(avg)} = s/t$

$v_f = v_i + at$

a = acceleration
r = dist. between centers

$s = 1/2 ( v_o + v_f) t$
$s = v_o t + 1/2 at^2$
$v_f^2 = v_i^2 + 2as$
$F = ma$
$w = mg$
$F = (Gm_1m_2)/r^2$
$p = mv$
$J = Ft$
$Ft = mv$
$T=mg \pm ma$
$Fk = \mu_k F_N$
$Fs = \mu_s F_N$
$F_{net} = F_{applied} - F_{friction}$

F = force
g = accelertion due to gravity
G = universal gravitation constant
J = impulse
m = mass
p = momentum
s = displacement
t = time
v = velocity
T = tension
w = weight
h = height
$F_c$ = centripetal force
$F_N$ = normal force
$F_k$ = force of kinetic friction
$F_s$ = force of static friction
$\mu_k$ = coefficient of kinetic friction
$\mu_s$ = coefficient of static friction
k = spring constant
PE = potential energy
KE = kinetic energy
P = power
PEs = PE stored in spring
W = work
x = change in spring length
c = specific heat
$H_f$ = heat of fusion
$H_v$ = heat of vaporization
Q = amount of heat
$\Delta T$ = change in temperature

## Energy

$W = Fscos\theta$
$P = W/t = Fs/t = Fv$
$PE = mgh$
$KE = 1/2 mv^2$
$F = kx$
$PEs = 1/2 kx^2$

## Internal Energy

$Q = mc\Delta T$
$Q_f = mH_f$
$Q_v = mH_v$

## Solids, Liquids, Gases

$D = m/v$
$P = F/A$
$stress = F/A$
$strain = \Delta L/L$
$Y = FL/A\Delta L$
$P_h = Dgh$
$F_b = DgV$
$F_1/A_1 = F_2/A_2$
$P_1V_1T_2 = P_2V_2T_1$
$\Delta L = \alpha L \Delta T$
$\Delta V = \beta V \Delta T$
$PV = nRT$

D = density
P = pressure F = force
A = cross sectional area
$\Delta L$ = change in length
L = original length
Y = Young's modulus
$P_h$ = hydrostatic pressure
$F_b$ = buoyant force
V = volume
T = temperature
$\Delta V$ = change in volume
$\alpha$ = coefficient of linear expansion
$\beta$ = coefficient of volume expansion
R = gas constant

## Waves and Optics

$T = 1/f$
$v = f\lambda$
$n = c/v$
$\sin\theta_c = 1/n$
$n_1 \sin\theta_1 = n_2 \sin\theta_2$
$n_1v_1 = n_2v_2$
$\lambda/d = x/L$
$1/d_o + 1/d_i = 1/f$
$M = h_i/h_o = - d_i/d_o$

c = speed of light in a vacuum
d = distance between slits
f = frequency
L = distance from slit to screen
n = index of refraction
T = period
v = speed
x = distance from center to 1st max
$\lambda$ = wavelength of light
$d_i$ = image distance
$d_o$ = object distance
f = focal length
M = magnification
$h_i$ = image height
$h_o$ = object height
$\theta_c$ = critical angle

## Electricity & Magnetism

$F = kq_1q_2/r^2$
$E = F/q$
$V = W/q$
$E = V/d$
$I = q/t$
$V = IR$
$P = VI = I^2R = V^2/R$
$W = Pt = VIt = I^2Rt$
$F = qVB$
$V = Blv$
$F = BIl$

## Symbols

B = flux density
F = force
k = electrostatic constant
V = electric potential difference
E = electric field
q = charge
v = velocity
l - length of conductor

## Series Circuits

$It = I_1 = I_2 = I_3 = .....$
$V^t = V_1 + V_2 + V_3 + .....$
$R_t = R_1 + R_2 + R_3 + .....$

I = current
R = resistance
V = electric potential difference

## Parallel Circuits

$I_t = I_1 + I_2 + I_3 + .....$
$V_t = V_1 = V_2 = V_3 = ....$
$1/R_t = 1/R_1 + 1/R_2 + 1/R_3 + ....$

## Transformers

$N_p/N_s = V_p/V_s$
$V_pI_p = V_sI_s$

$I_p$ = current in primary coil
$I_s$ = current in secondary coil
$N_p$ = # of turns of primary coil
$N_s$ = # of turns of secondary coil
$V_p$ = voltage of primary
$V_s$ = voltage of secondary

## Modern Physics

$W_o = hf_o$
$E_{photon} = hf$
$KE_{max} = hf - Wo$
$p = h/\lambda$
$E_{photon} = E_i - E_f$

$W_o$ = work function
c = speed of light in vacuum
f = frequency
$f_o$ = threshold frequency
h = Planck's constant
p = momentum
$\lambda$ = wavelength
KE = kinetic energy

$T_{1/2} = 0.693/\lambda$
$N = N_o e^{-\lambda t}$

N = atoms remaining after time t
$N_o$ = original number of atoms
$\lambda$ = decay constant
t = time

## Nuclear Energy

$E = mc^2$

m = mass
E = energy

## Circular/Periodic Motion

$a_c = v^2/r$
$F_c = mv^2/r$
$v = 2\pi r/T$
$T = 2\pi (l/g)1/2$ [pendulum]
$g = GM/d2$
$v_{escape} = [2GM_E/r_e]1/2$
$T_{satellite} = 2\pi[(r^3/GM_E)]1/2$

r = radius
Fc = centripetal force
v = velocity
ac = centripetal acceleration
T = period
$M_E$ = mass of Earth
$r_E$ = radius of earth

## Fundamental Constants

| Quantity | Symbol | Value |
|---|---|---|
| Avogadro's number | NA | $6.02 \times 10^{23}$ |

| | | |
|---|---|---|
| Electron Charge | e | $1.6 \times 10^{-19}$ |
| Planck's Constant | h | $6.63 \times 10^{-34}$ J s |
| Mass of electron | me | $9.1 \times 10^{-31}$ kg |
| Mass of neutron | mn | $1.67 \times 10^{-27}$ kg |
| Mass of proton | mp | $1.67 \times 10^{-27}$ kg |
| Speed of light (vacuum) | c | $3 \times 10^{8}$ m/s |
| Universal Gravitational | G | $6.67 \times 10^{-11}$ N $m^2/kg^2$ |
| Universal Gas Constant | R | 8.314 J/mol K |
| Electrostatic Constant | k | $9.0 \times 10^{9}$ N $m^2/C^2$ |

## Some Useful Conversion Factors

### Length

1 in = 2.54 cm
1 ft = 0.3048 m
1 mi = 5280 ft = 1.609 km
1 m = 3.281 ft
1 km = 0.6214 mi
1 angstrom = 1 x 10-10 m

### Work and Energy

1 J = 0.7376 ft lb = 107 ergs
1 kcal = 4186 J
1 Btu = 1055 J
1 kWh = $3.60 \times 10^{6}$ J
1 ev = $1.602 \times 10^{-19}$ J

### Mass

1 slug = 14.59 kg
1 kg = 1000 g = $6.852 \times 10^{-2}$ slug
1 amu (u) = $1.66 \times 10^{-27}$ kg
1 kg = 2.205 lb

### Power

1 hp = 550 ft lb/s = 745.7 W
1 W = 1 J/s = 0.7376 ft lb/s

### Time

1 day = 24 h = 1440 min = $8.64 \times 10^{4}$ s
1 yr = 365.24 days =$3.156 \times 10^{7}$ s

### Pressure

1 atm = $1.013 \times 10^{5}$ Pa = 1.013 bar = 14.7 $lb/in^2$ = 760 Torr = 760 mm Hg

### Speed

1 mi/hr = 1.609 km/hr = 1.476 ft/s = 0.4470 m/s

1 km/hr = 0.6214 mi/hr = 0.2778 m/s = 0.9113 ft/s

### Volume

1 L = $10^{-3}$ $m^3$ = 1000 $cm^3$ = 0.0353 $ft^3$
1 ft3 = 0.02832 $m^3$ = 7.481 US gal

1 US gal = $3.785 \times 10^{-3}$ $m^3$ = 0.1337 $ft^3$

### Force

1 lb = 4.448 N
1 N = $10^5$ dynes = 0.2248 lb

### Angle

1 radian = 57.30°
1° = 0.01745 radian

## Prefixes Denoting Multiples of Ten

| Prefix | Symbol | Factor |
|---|---|---|
| Tera | T | $10^{12}$ |
| Giga | G | $10^{9}$ |
| Mega | M | $10^{6}$ |
| Kilo | k | $10^{3}$ |
| Hecto | h | $10^{2}$ |
| Deka | da | $10^{1}$ |
| Deci | d | $10^{-1}$ |
| Centi | c | $10^{-2}$ |
| Milli | m | $10^{-3}$ |
| Micro | $\mu$ | $10^{-6}$ |
| Nano | n | $10^{-9}$ |
| Pico | p | $10^{-12}$ |

## Useful Physical Data

| | |
|---|---|
| Earth Gravity | 9.8 $m/s^2$ or 32.2 $ft/s^2$ |
| Atm. Pres (sea level) | $1.013 \times 10^{5}$ Pa = 14.70 $lb/in^2$ |
| Density of air (STP) | 1.29 $kg/m^3$ |
| Speed of sound in air (20°C) | 343 m/s |

| | | |
|---|---|---|
| Water | | |
| | Density (4°C) | $1.000 \times 10^{3}$ $kg/m3$ |
| | Hf | $3.35 \times 10^{5}$ J/kg |
| | Hv | $2.26 \times 10^{6}$ J/kg |
| | c | 4186 J/kg °C |
| Earth | | |
| | Mass | $5.98 \times 10^{24}$ kg |
| | Radius (eq) | $6.38 \times 10^{6}$ m |
| | Earth-Sun Dist | $1.50 \times 10^{11}$ m |
| Moon | | |
| | Mass | $7.35 \times 10^{22}$ kg |
| | Radius | $1.74 \times 10^{6}$ m |
| | Earth-Moon Dist | $3.85 \times 10^{8}$ m |
| Sun | | |
| | Mass | $1.99 \times 10^{30}$ kg |
| | Radius | $6.96 \times 10^{8}$ m |

## Basic Mathematical Formulae

Area of circle = $\pi r^2$
Area of rectangle =l x w
Circumference of circle = $2\pi r = \pi d$
Surface area of a sphere = $4\pi r2$
Volume of a sphere = $4/3\ \pi r^3$
Pythagorean Theorem: $h^2 = ho^2 + ha^2$
Sine of an angle: sin ø = ho/h
Cosine of an angle: cos ø = ha/h
Tangent of an angle: tan ø = ho/ha
Law of cosines: $c^2 = a^2 + b^2$ - 2ab cos ø
Law of sines: a/sin A =b/sin B = c/sin C

Quadratic Formula:
If $ax^2 + bx + c = 0$, then *

## Vectors Components

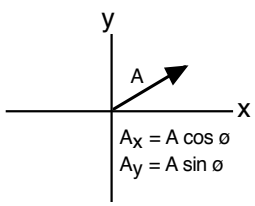
Vectorx = (Vector) cos ø
Vectory = (Vector) sin ø

ø = angle between vector an x-axis

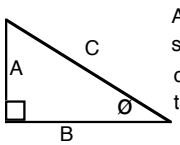
## SI Base Units

| Quantity | Unit | Abbr. | Apparatus |
|---|---|---|---|
| length | meter | m | ruler |
| mass | kilogram | kg | balance |
| time | second | s | stopwatch |
| amount of substance | mole | mol | ..... |
| temperature | kelvin | K | thermometer |
| electric current | ampere | A | ammeter |
| luminous intensity | candela | cd | light meter |

Vector Resolution




Rt. Triangle Trig.




$A^2 + B^2 = C^2$
sin ø = A/C
cos ø B/C
tan ø = A/B