Grade 11 Physics Study Guide SPH3U1

Unit 1: Kinematics + Intro

How to count significant figures:

-Embedded 0's count (i.e. 101 has 3 sig figs)

-Any numbers that aren't zeros count (i.e. 5263 has 4 sig figs)

-0's after the decimal place count (i.e. 1.00 has 3 sig figs)

-Trailing 0's (i.e. 2000 has 4 sig figs)

-Numbers after the first non-zero (i.e. 0.0002102 has 4 sig figs)

How to add and subtract numbers with proper sig figs:

The result will have the least amount of numbers after the decimal place.

(i.e. 1.23 + 1.3 + 10.004 = 12.5)

How to multiply and divide numbers with proper sig figs:

The result will have the least number of sig figs

(i.e. 3.0 x 12.60 = 38)

Big 5

v2= v1+ aΔt

Δd=0.5v2+v1Δt

Δd=v1Δt+ 12aΔt2

Δd= v2Δt-12aΔt2

v22=v12+2aΔd

Δd = *Area under a velocity-time graph*

a = *Slope of a velocity-time graph*

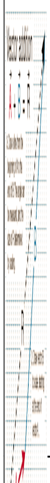
v = *slope of a distance-time graph*

Vector Addition(tip to tail)

Vector = both magnitude and direction Scalar = only magnitude, no direction

Ex. Time = scalar, displacement = vector

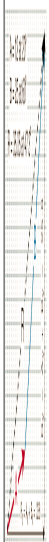
Graphical Vector Addition



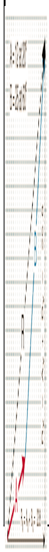
Example of Vector Components

Finding the components of vectors for vector addition involves forming a right triangle from each vector and using the standard triangle trigonometry.

Polar Form Example



Combining Vector Components



After finding the components for the vectors A and B, these components may be just simply added to find the components of the resultant vector R.

Air Navigation Problems (Tail to tail)

This sort of problem is when you have one full vector and 2 partial vectors.

Steps:

1- Draw the full vector

2- Pick the partial vector of which you know the direction. Draw it tail to tail (or tip to tip) with the full vector
3- Draw the other partial vector TIP to TAIL

River Crossing Problems (Tip to Tail)

This sort of problem is when you have 2 full vectors and you are missing a partial vector.

Steps:

1- Draw both full vectors
2- Use the vector component, Pythagorean theorem method

Vector Acceleraton

To determine vector acceleration we must use vector subtraction first to solve for v2 - v1 first as in a= v2-v1t

Now technically v2 - v1 is the same as adding the negative vector of v1 to v2.

i.e. x + (-y) = x - y

Basically, to subtract 2 vectors you need to add the opposite vector.

** this only affects the directions not whether the magnitude itself is positive or negative

i.e. to make 12m/s [N] negative, it becomes 12 m/s [S]

i.e. to make 30m/s [S10W] negative, it becomes 30m/s [N10E]

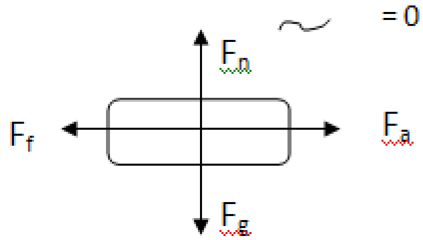
Then, you need only draw out the diagram and do vector addition as usual.

Unit 2: Forces and Motion

Newton's Laws of Motion

1- Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.
2- The relationship between an object's mass *m*, its acceleration a, and the applied force *F* is *F* = *ma*. Acceleration and force are vectors (as indicated by their symbols being displayed in slant bold font); in this law the direction of the force vector is the same as the direction of the acceleration vector.
3- For every action there is an equal and opposite reaction.

Free body Diagrams



F_g = mg

$F_g = F_n$ when a = 0 on the vertical plane

F_n = mg

~ Means acceleration

Force, Friction, Motion, General Notes

Force = a push or pull in a given direction

Friction = force that resists motion between objects whose surfaces are in contact due to microscopic welds

Uniform Motion = motion in a straight line at a constant speed

Net force = Mass times Acceleration

Coefficients of Friction

The greek letter **μ (**pronounced mew) represents the coefficient of friction

Kinetic Friction: Friction that occurs when object is moving μ_k

Static Friction: Friction that occurs when the object is not moving but a force is still being applied to it μ_s

Formula for friction: $F_f = \mu_k F_n$

The coefficient of friction has no units because when rearranged, it's newtons over newtons which cancel out.

When speed is constant, acceleration = 0 and therefore, net force = 0 based on the Fnet = ma formula

Universal Gravitation

G = Universal Gravitational Constant

G = 6.67 x 10^{-11} (measured in Nm2kg2)

It is used in the formula Fg= Gm1m2r2

Where r is the distance between the centres of the 2 objects

Also, g= Gm1r2

For the Earth, g = 9.8m/s^2

Units

Mass: kg

Time: s

Distance: m

Speed: m/s

Forces: N (newtons)

Acceleration: N/kg or m/s^2

Unit 3: Energy

Work

A force through a distance

Work = applied force times displacement

W= FΔd

**Force and displacement have to be in the same direction

Work is measured in Joules (J)

A joule is equal to a Newton times a metre (J = Nm)

In some situations, there may be force and motion but no work is done

1- No applied force; no force required to keep object moving
2- No displacement; unable to move object though a force is exerted
3- Force and displacement are in different directions

Gravitational Potential Energy and Kinetic Energy

GPE is the energy stored in an object due to its distance above the Earth (measured in Joules)

Symbol = E_p or E_g

formula = E_p= mgh

m = mass

$g = 9.8$

h = height

(mg as in $F_g = mg$ and h as derived from $W = Fd$, but the d is h)

Kinetic Energy is the energy of a moving object

Also measured in joules

Symbol = E_k

Formula = $E_k = mv^2$

Conservation of Energy

In any transfer of energy, the total amount of energy remains constant.

$E_T = E_k = E_P$

E_T = Total Energy

$E_{T1} = E_{T2}$

Efficiency and Power

When energy is transferred from one form to another, some energy is transformed to a form that is not useful (though no energy is actually lost)

Efficiency = (useful output enery/total input energy)x100

Power = rate at which work is done

Measured in Watts

Power = work/time

Heat Capacity

The amount of heat that can be added to a sample of matter is dependant on the heat capacity.

~= the amount of heat required to raise the temp of an object by 1 degree Celsius

Specific heat capacity = the amount of heat that must be added to raise the temp of 1kg of a substance by 1 degree Celsius (Joules/kilogram times degree Celsius)

Formula: $Q = mc\Delta T$

Q = amount of heat energy gained/lost in joules

m = mass in kg

c = specific heat capacity in Joules/kg degree Celsius

ΔT = change in temperature

Heat Transfer

When two substances at different temperatures are mixed together, the amount of heat lost (transferred) from the hot substance equals the amount of heat gained (transferred) to the cold substance.

$Q_{gained} = -Q_{lost}$

Unit 4: Electricity and Magnetism

Electricity - Current, Potential Difference, Resistance, Power

	Location	Charge	Mass
Electron	Electron cloud	Negative	1/2000 amu (atomic mass units)
Proton	Nucleus	Positive	1 amu
Neutron	Nucleus	Neutral	1 amu

*Charged objects attract neutral objects

There are 3 methods of charging: Contact, Induction, and Charging by Grounding

	Symbol	Measured in	Which equals	Other info
Current	I (or A for amperes)	Amperes (amount of charge/second)	1 A = 1 coulomb/second	1 A = 6.24×10^{18} electrons/second (1 coulomb = 6.24×10^{18} electrons)
Potential Difference/ Voltage	V	Volts	Joules/coulomb	Amount of energy each electron is given from the source
Resistance	Ω	Ohms	Volts/ Amperes	Opposition to charge flow

Power ← measured in Watts

Power = IV (current times voltage) = the rate at which electric energy is passed

Ohm's Law: V =IR

** Conventional current flow is from positive to negative while in reality current flows from negative to positive (think poles of a battery)

Series vs. Parallel

The following rules apply to a **series circuit**:

1. The sum of the potential drops equals the potential rise of the source.
$$V_T = V_{R1} + V_{R2} + V_{R3} \cdots$$
2. The current is the same everywhere in the series circuit.
$$I_T = I_1 = I_2 = I_3 = \ldots$$
3. The total resistance of the circuit (also called **effective resistance**) is equal to the sum of the individual resistances.
$$R_T = R_1 + R_2 + R_3 \ldots$$

The following rules apply to a **parallel circuit**:

1. The potential drops of each branch equals the potential rise of the source.
$$V_T = V_1 = V_2 = V_3 = \ldots$$
2. The total current is equal to the sum of the currents in the branches.
$$I_T = I_1 + I_2 + I_3 + \ldots$$
3. The inverse of the total resistance of the circuit (also called **effective resistance**) is equal to the sum of the inverses of the individual resistances.

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

Mixed Circuits

-Separate circuits into parts (the parallel circuit that's connected to the series one or vice versa) and calculate things separately for each and then bring it all together

Laws of Magnetism

-magnets are made out of ferromagnetic substances

-Like poles repel

-Unlike poles attract

N-pole = north-seeking pole (not just North pole)

S-pole = south-seeking pole (not just South pole)

-if you break a magnet, it'll break into more magnets

SIN and NOS

South→(Inside)→North North → (Outside)→ South

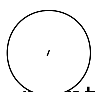
Inside a magnet, the field lines go from south-seeking to north-seeking poles. Outside a magnet, field lines go from north to south.

Earth's magnetism: The earth is a giant magnet. Geographic north is the earth's south-seeking pole while geographic south is the north-seeking pole.

-A compass will always point in the direction of the field lines

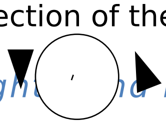
Right Hand Rules (RHRs)-Straight Conductors

into the page out of the page



For straight conductors, point the thumb of your right hand in the direction that the symbol tells you to (into or out of the page). The wrapped fingers point in the direction of the field lines around the conductor.

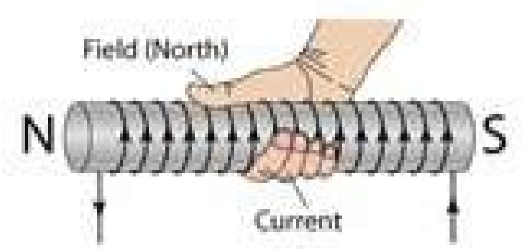
I.e.



Right Hand Rules (RHRs)-Coiled Conductors

-Wrap your fingers (right hand) around the coil (fingers into the page where it says so and wrapped around back out of the page where it says so)

-Your thumb will point to the N-seeking pole



I.e.

Electromagnetism

-magnetic forces produced by an electric current

Motor Principle

To make an electromagnetic field stronger:

1- Add more loops
2- Higher current
3- A smaller cross-sectional core,

Faraday’s Motor Principle: when a current-carrying conductor is located in an external magnetic field perpendicular to the conductor, the conductor experiences a force perpendicular to itself and to the external magnetic field.

The right-hand rule for force on a conductor can be used to determine the direction of the force experienced on the conductor: if the right thumb points in the direction of the current in the conductor and the fingers of the right hand point in the direction of the external magnetic field, then the force on the conductor is directed outward from the palm of the right hand.

An external field is a **permanent magnet’s field

Electromagnetic Induction

~ = using magnets to generate electrical energy

-Galvanometers detect current

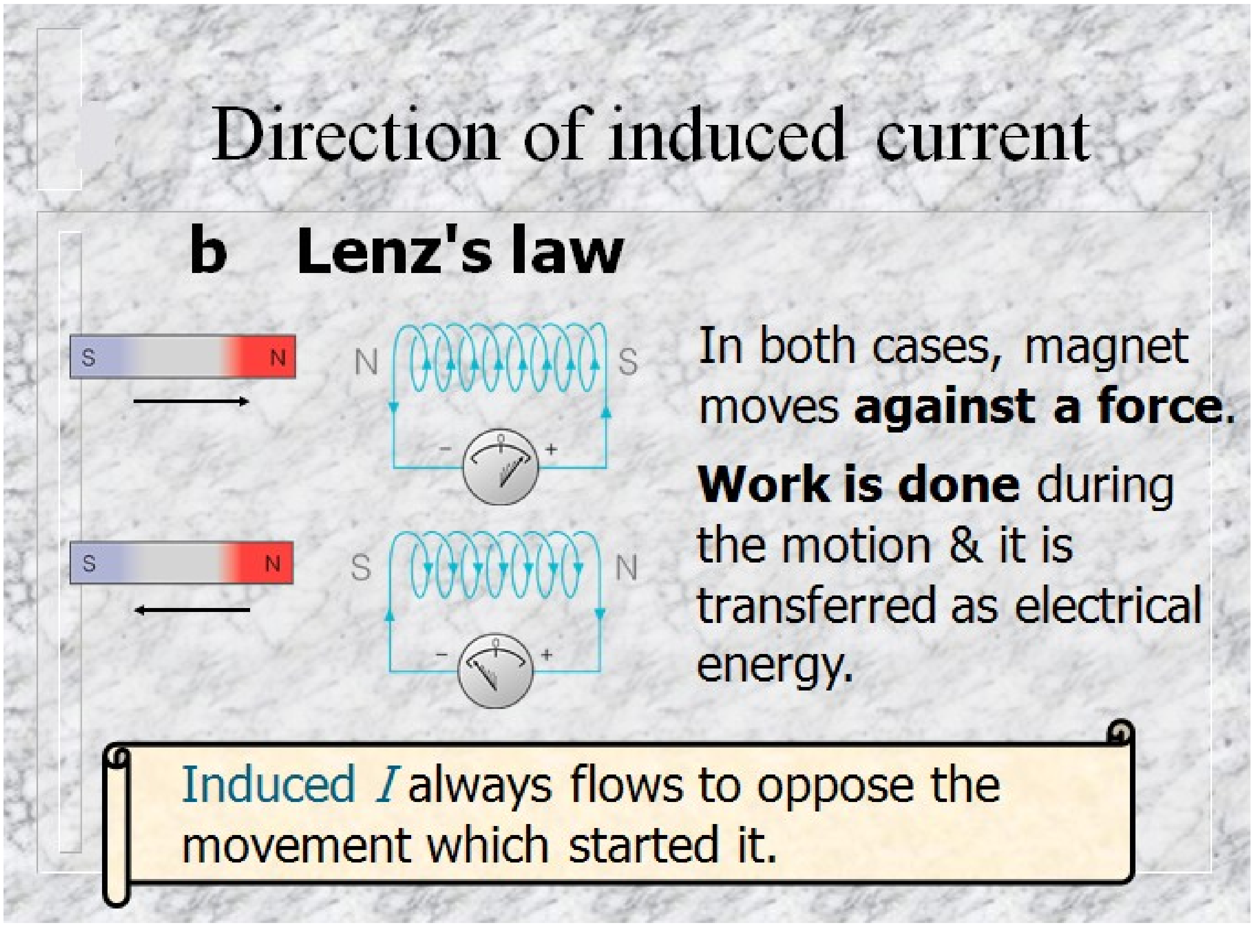
-Faraday’s law: whenever the magnetic field in the region of a conductor changes, electric current is induced in the conductor.

Lenz’s Law

-For a current induced in a conductor by a changing magnetic field, the current is in such a direction that its own field opposes the change that was produced in it.

OR

“An induced current is always in such a direction as to oppose the motion or change causing it"



Transformers

~ use mutual induction to change electricity at one voltage and electricity at another voltage

To do this, the primary circuit of the transformer must have a different number of windings (loops) than the secondary circuit.

Step-Up Transformer = the number of windings **increases** for the secondary circuit

Step-Down Transformer = the number of windings **decreases** for the secondary circuit

P = Power, V = Voltage, I = Current, N = number of windings

$P_{primary} = P_{secondary}$

$P = IV$

$I_pV_p = I_sV_s$

$V_p/V_s = I_s/I_p = N_p/N_s$ ← Main formula to memorize

** = The purpose of transformers are to prevent machinery from "Frying"

Generators

-made of a magnet and a coil

-turns rotational mechanical energy into electrical energy (AC)

-in order to generate DC, a split-ring commutator would be used

-Generators use <u>slip rings</u>

-Generators are difficult to spin so poles of a magnet are the opposite of what you would normally think in relation to the rotational direction (as in Lenz's Law). It is because of the difficulty to spin it that electrical energy is created.

This website explains things really well:
http://www.animations.physics.unsw.edu.au//jw/electricmotors.html#mandg

Motors

-Motors use slip rings to make DC

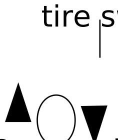
-turns electrical energy into mechanical rotational energy

-opposite of a generator (even in diagrams; inner magnets' poles are opposite. The magnet rotates because each time it is either repelled or attracted by the permanent magnet and has to move that way.)

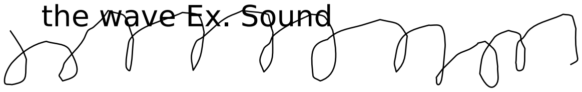
Unit 5: Waves and Sound

3 types of Vibrations

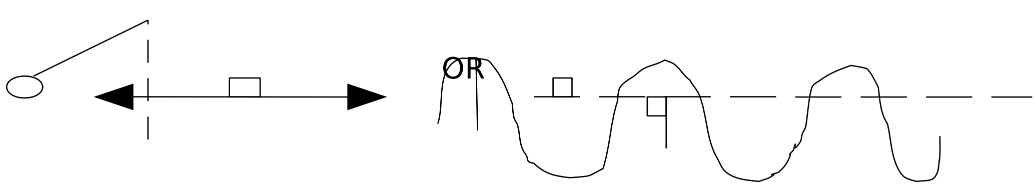
1- Torsional: an object twists around its axis at the rest position Ex. A twisted tire swing



2- Longitudinal: the particles vibrate parallel to the direction of the motion of the wave Ex. Sound



3- Traverse: when an object vibrates perpendicular to its axis at the rest position Ex. A pendulum OR the particles in the medium vibrate at right angles to the direction that the wave travels in Ex. Waves of a musical instruments' strings, like guitar strings.

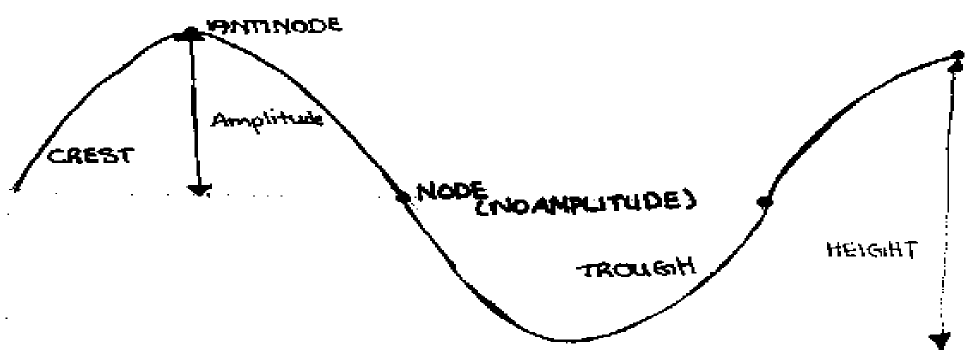


Relationships between Frequency, Amplitude, Length, and Period

Wave = transfer of energy without the movement of matter
Amplitude = maximum displacement from rest (A)
Period = time for one cycle (T) measured in seconds
Frequency = # of cycles per second (F) measured in Hertz
Wave Length = distance between any 2 consecutive points on a wave (the wave must be in phase) (λ; the greek symbol that is pronounced lambda)

Trough- the bottom curve of the wave
Crest- the top curve of the wave
Node- place of no amplitude=equilibrium (i.e. on the rest line/ no amplitude line)
Antinode- place of most disturbance
Height- double the amplitude or from crest to trough
Compression- size of wavelength decreases
Interference- two waves meet and get in each other's way
Longitudinal wave- 3-D wave that travels up/down, left/right, and forward simultaneously
Transverse wave- 2-D waves that move perpendicular to each other

WAVE PARTS



-mass and amplitude have no affect on frequency or period

<u>Formulas and Relationships</u>

T = t/N Period = time/Number of cycles

F = N/t Frequency = Number of cycles/time

$F = 1/\lambda$ Frequency = 1/wavelength

$T = 1/F$ Period = 1/frequency

$F = 1/T$

L = length

Length and period are proportional

Length and 1/F are proportional

Period and Wavelength are proportional

Universal Wave Equation

V = speed of wave/velocity

$V = F\lambda$ ←memorize this equation

d_n = internodal distance = the distance between 2 consecutive nodes

$d_n = 0.5\lambda$

internodal distance = half of wavelength

-Standing wave: waves that are in phase with one another and constant in their frequency, period, etc. They are characterized by points on their line of rest that do not vibrate called nodes

-interspersed between the nodes are antinodes that alternate between crest and trough

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Example Problem: A standing wave has a distance of 45 cm between 4 consecutive nodes. What is the wavelength? What is the speed of the wave in the medium if the frequency is 30 Hz (hertz)?

Given: L (length/distance) = 45 cm F = 30 Hz n = 4 nodes number of dn's = 3 dn = 15 cm λ = ? v = ?

L = 3dn dn = 0.5λ L = $3(0.5\lambda)$ 45 = 1.5λ

λ = 30 cm

$V = f\lambda$

V = (30hz)(30cm)

= 900 cm/s

*** = A Hz is equal to one over a second (1/s). that’s why the units of the final answer are in cm/s

Principle of Super-Position

When 2 or more waves act simultaneously, the resultant displacement is the sum of displacements of simultaneous waves individually. There can be a supertrough if 2 troughs meet or a supercrest if 2 crests meet. Or, if a crest and trough meet, they can cancel each other out.

If a supercrest or supertrough forms, it’s called **constructive Interference**

If cancellation occurs, it’s called **destructive interference**

Speed of Sound in Air

-In the context of sound waves, frequency refers to the pitch of the sound (NOT THE VOLUME)

-Sound waves are technically longitudinal but they are often drawn as traverse

-Sound travels at different speeds through different mediums depending on temperature and air pressure

-air pressure is normally 332

-therefore, the formula for the speed of sound in air is

Speed of sound in air = (332 + 0.6T)m/s

*= T refers to the temperature in degrees Celsius

Mach #

Mach # = speed of object/speed of sound

A Mach # greater than 1 is considered supersonic and one that is less than 1 is considered subsonic

Doppler Effect

~ = The sound heard anytime 2 objects pass each other with **different** velocities while emitting sounds

If the object is moving toward you, the formula you use is:
f2= f1vsvs-vo

If the object is moving away from you, the formula you use is:

f2= f1vsvs+vo

A simple way to remember this is the formula with **A**ddition in it is for when the object is moving **A**way

In these formulas, f_2 refers to the sound that you hear

f_1 refers to the sound emitted by the source

v_s is the speed of sound

v_o is the speed of the object

Mechanical Resonance

~ is the vibrating response of an object to a periodic force from a source that has the same frequency as the natural frequency of the object Ex. The Tacoma bridge

Beat Frequency

~ is when two notes of slightly different frequencies sound together causing a pulsating sound

$f = f_1 - f_2$ (** , the answer needs to be in absolute numbers meaning it must ALWAYS be a positive value)

Sound Intensity

Intenisty = Power/Area

I = P/A

Where area is measured in W/m^2

Another important formula related to intensity is:

$I_1/I_2 = (r_2)^2/(r_1)^2$

Decibel System

$\beta = 10\log(I_2/I_1)$

β represents number of decibels

The constant for the threshold of human hearing is 1.0×10^{-12} W/m^2

Unit 6: Light and Optics

Reflection

Laws of reflection:

1- The angle of incidence equals the angle of reflection
2- The incident ray, the normal and the reflection ray will be in the same plane (i.e. 2D, 3D)

Normal = the imaginary line that is perpendicular to the plane of the mirror

Total Internal Reflection

-when light travels from a **more** optically dense medium to a **less** optically dense one and the refracted angle is 90 degrees, the incident ray is reflected back into the more optically dense medium

Critical Angle = the angle of incidence that causes the refracted angle to be 90 degrees

Formula is:

$\Theta_c = \sin^{-1}(n_2/n_1)$

Where Θ_c is the critical angle, and n represents the optical density of the medium.

Refraction

~ = the bending of a ray of light

-apparent when light moves from one substance to another

-reason = light's speed changes as it enters one object from another

Less dense to more dense means the ray will bend towards the normal

More dense to less dense means the ray will bend away from the normal

Snell's Law

-shows the relationship between the angle of incidence and the angle of refraction

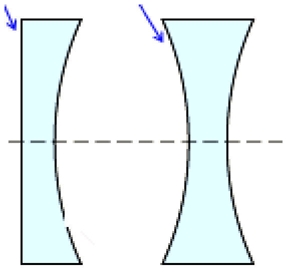
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Types of Lenses

2 types: Converging which bend rays IN and diverging which bend rays OUT

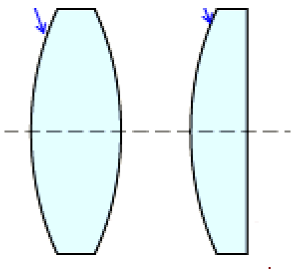
Diverging←People with myopia, nearsighted people, require diverging lenses

Concave, Biconcave



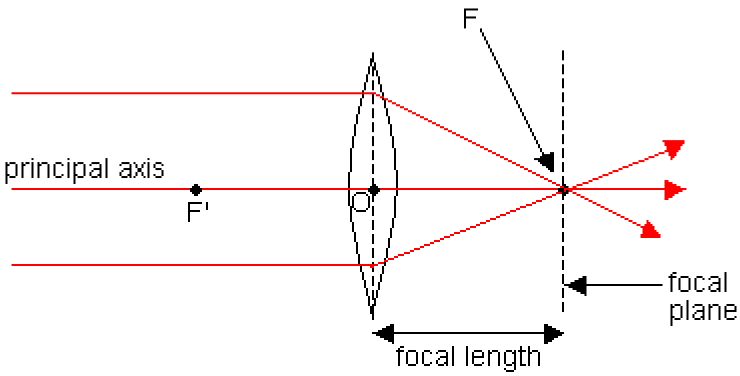
Converging←people with hyperopia, farsighted people, require converging lenses

Biconvex, Convex



*= People with astigmatism see asymmetrically and require cylindrical lenses

**=People with Presbyopia see badly due to old age and need bifocal lenses



Index of Refraction

~ = the ration of the speed of light to the speed of light in a given material

C = speed of light = 3.00 x 10^8m/s

n=C/v

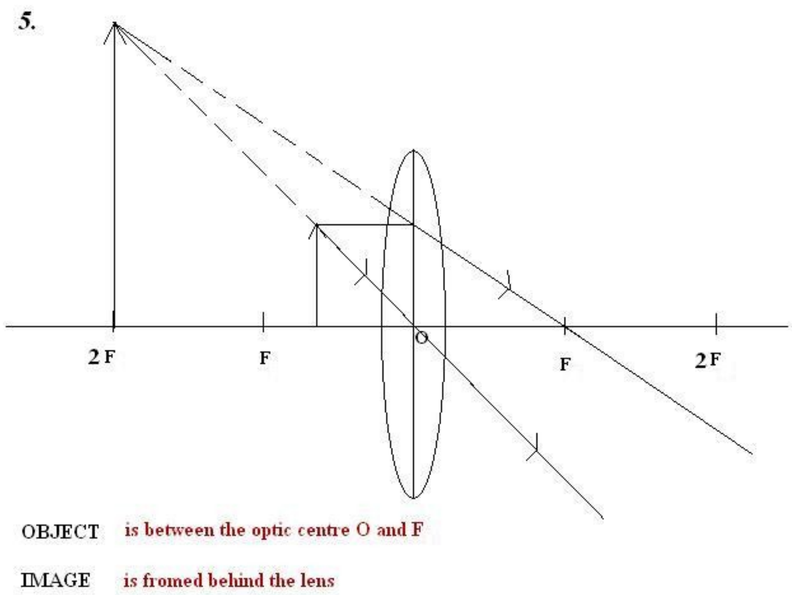
where n = index

c = speed of light

v = speed of light in the medium

Rules for drawing lens diagrams

1- A ray that is parallel to the PA (principal axis) is refracted through the PF (principal focus)
2- A ray that passes through F’ or 2F’ is refracted parallel to the PA
3- A ray that passes through the optical centre goes straight through without bending Any of the 2 rays may be used to locate the tip of the image



If the image is…

Behind 2F = smaller, inverted, real

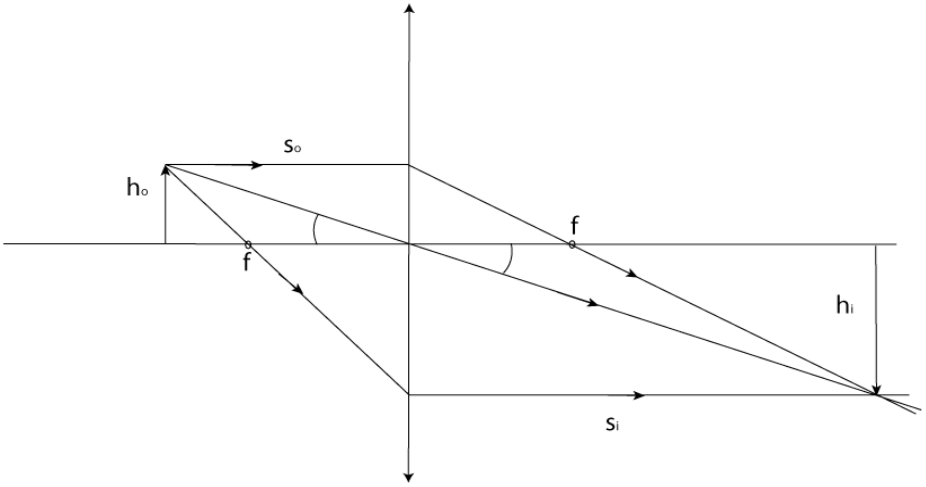
At 2F = same size, inverted, real

Between 2F and F = larger, inverted, real

At F = parallel = No image

In front of F = larger, virtual, upright

Thin Lens Equation



Equation:

$1/d_o = 1/d_i = 1/f$

Sign Convention

1- All distances are measured from the optical centre of the lens
2- Distances of real objects and images are positive
3- Distances of virtual objects and images are negative
4- Object heights and image heights are positive when measured upward and negative when measured downward from the principal axis

Magnification

$M = h_i/h_o = -d_i/d_o$

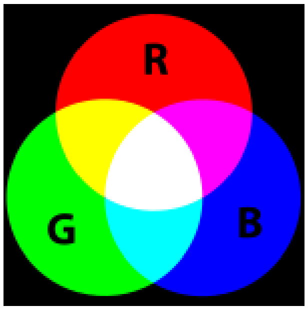
M = magnifaction

i=image o=object

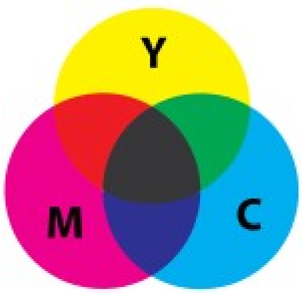
h=height   d=distance

if Magnification is positive, the image is upright and if it’s negative, it’s inverted

Additive Colour Theory



Subtractive Colour Theory



Electromagnetic Spectrum

-the whole range of wavelengths, from longest to shortest

Lasers

Laser = Light Amplification through the Stimulated Emission of Radiation

-when electrons drop from one orbit to another, they lose energy which is given off as a burst of light called a photon

-There are two types of these emissions

1-Spontaneous:

-electrons don't like to stay in their excited state so when they fall, a photon is emitted

-occurs in light bulbs

2-Stimulated:

-when a photon comes near an excited electron which has the same energy as it would lose in falling to the ground state, it will drop to the ground state and produce a 2nd photon.

-lasers work like this

Lasers are special because:

1- They have only one colour/wavelength
2- Their beam is entirely straight
3- Waves are in phase
4- Can produce tremendously powerful short bursts of light