

Things You Should Know About Regents Physics

Measurement and Mathematics

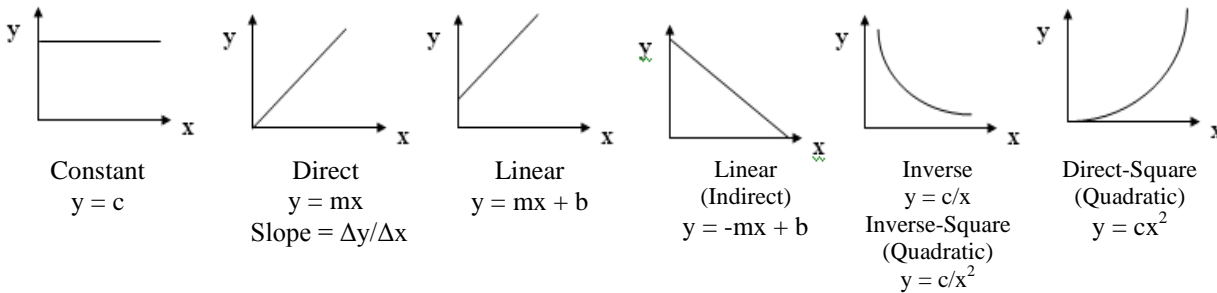
Estimation: 1 kg = 2.2 lbs 1 apple = 1 N 1 quarter = 5 g = 0.005 kg

Order of magnitude: power of ten (thickness of paper = 10^{-4} m)

Fundamental units

Quantity	Units	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A

General Relationships:



Scalars (magnitude only)	Vectors (magnitude and direction) – only 9!
Distance Speed	Displacement Velocity Acceleration
Anything else!	Force (weight, normal force, etc.) Momentum Impulse Fields (gravitational, electric, magnetic)

$$\sin \theta = \frac{opp}{hyp}$$

$$\cos \theta = \frac{adj}{hyp}$$

$$\tan \theta = \frac{opp}{adj}$$

Graphs of Motion

Slope = velocity
 Slope = acceleration
 Area = displacement

Two Types of Motion

Constant Velocity

Forces are balanced
 $F_{net} = 0, a = 0$
 In equilibrium
 Newton's first law

Distance v. time Speed v. time Acceleration v. time

Constant Acceleration

Forces are unbalanced
 $F_{net} \neq 0, a \neq 0$
 not in equilibrium
 Newton's second law

Distance v. time Speed v. time Acceleration v. time

Projectiles

Horizontal Launch

	x	Y
d		h
t	the same	
a	0	9.81
v_i	v_i	0
v_f	v_i	
v_{avg}	v_i	

Horizontal – constant speed
 Vertical – constant acceleration

Angle Launch

	x	Y
d		
t	whole	half
a	0	9.81
v_i	v_x	v_y
v_f	v_x	0 (top)
v_{avg}	v_x	

Things You Should Know About Regents Physics

Mechanics

Equilibrium: no net force, no acceleration, constant velocity or at rest, forces form a closed figure

Concurrent vectors: placed tail-to-tail

Component vectors: must be head-to-tail to find resultant

Resultant force = F_{net} : head-to-head and tail-to-tail with components

Range of possible resultants:

Maximum = sum of vectors Minimum = difference of vectors

Equilibrant: equal and opposite to resultant

Box on a Hill in Equilibrium: $mg\sin\theta = F_f$ or F_A or F_T and $mg\cos\theta = F_N$

Mass (m): = **inertia**, amount of matter, constant from place to place, units: kg

Weight (F_g): = force of gravity, changes from place to place, units: N

Formula: $F_g = mg$

Two names for little "g":

1) acceleration due to gravity, units: m/s^2 , formula: $g = GM/r^2$ 2) gravitational field strength, units: N/kg, formula: $g = F_g/m$

Vectors

Concurrent Resultant Equilibrant

Maximum $\theta = 0^\circ$ 2 5 7

Minimum $\theta = 180^\circ$ 2 5 3

Triangle rule \rightarrow sum of any 2 sides \geq third side for forces to be in equilibrium

Inclined Plane

F_A F_f F_T F_N $F_{\parallel} = m g \sin\theta$

F_g $F_{\perp} = m g \cos\theta$

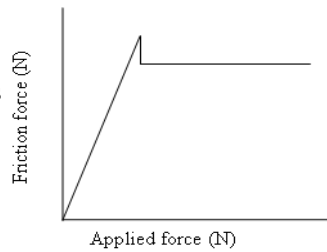
Friction

Static friction (at rest) = applied force until motion starts

Kinetic friction (in motion) is constant

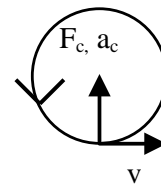
Maximum static friction is greater than kinetic friction

$$F_f = \mu F_N$$



Newton's Third Law: Whenever A exerts force on B, B exerts equal/opposite force on A. (Action/reaction pairs: bat and ball, Earth and Moon, hammer and nail)

Circular Motion



$$v = \frac{d}{t} = \frac{\text{circumference}}{\text{period}} = \frac{2\pi r}{T}$$

$$a_c = \frac{v^2}{r} \quad F_c = ma_c = \frac{mv^2}{r}$$

Forces are the same but the **effects** of the forces are not: $m\mathbf{a} = \mathbf{m}\mathbf{a}$

Newton's Law of Universal Gravitation

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

Conservation Laws: electric charge, momentum, mass and energy

Things You Should Know About Regents Physics

Energy

Work: force and displacement must be parallel

$$W = Fd$$

Mechanical Energy: $PE_g + PE_s + KE$

Total Energy: $PE_g + PE_s + KE + Q$

Internal Energy = Q : thermal energy, heat due to friction/air resistance

Power: rate of change of energy, rate of done work
(units: Watts (W) = J/s)

PE_g increases if height increases. KE increases if speed increases. PE_s increases if spring is stretched or compressed.

Formulas for springs: $PE_s = \frac{1}{2} kx^2$ $F_s = kx$

k = spring constant (units: N/m)

Conservation of Energy: $E_T = E_T$
 $PE_g + PE_s + KE + Q = PE_g + PE_s + KE + Q$

Work-Energy Theorem: $W = \Delta E_T$

Electricity

Conductors (metals) have free electrons, insulators do not.

Objects become charged by losing or gaining electrons (not protons).

Elementary Charge: proton or electron

1 Coulomb of charge = 6.25×10^{18} elementary charges

Charge of Electron: $q = -1e$ OR $q = -1.60 \times 10^{-19} \text{ C}$

Mass of Electron: $m = 9.11 \times 10^{-31} \text{ kg}$

Charge of Proton: $q = +1e$ OR $q = +1.60 \times 10^{-19} \text{ C}$

Mass of Proton: $m = 1.67 \times 10^{-27} \text{ kg}$

If two or more identical charged spheres touch, the final charge on each is the **average** charge (total charge/# of spheres). The total charge is conserved.

A neutral object will be attracted (never repelled) by any charged object. If two objects attract, they could have opposite charges or one could be neutral. If two objects repel, they must have the same type of charge.

Charging by conduction: direct contact - electroscope gets same charge as rod

Charging by induction: no direct contact - electroscope gets charge opposite of rod

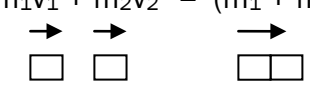
Collisions

Conservation of Momentum: $p_{\text{before}} = p_{\text{after}}$

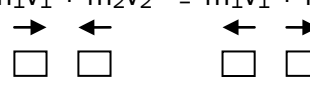
Isolated System: no external forces

Elastic Collision: total KE is conserved

Sticky
(inelastic) $m_1v_1 + m_2v_2 = (m_1 + m_2) \cdot v_f$

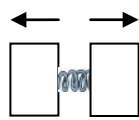


Bouncy
(elastic) $m_1v_1 + m_2v_2 = m_1v_1 + m_2v_2$



Remember - Moving to the left gets a NEGATIVE sign!

Explosion



Equal and opposite forces, impulses, changes in momentum, and contact times

Different speed based on mass

$$m\mathbf{a} = M\mathbf{a}$$

$$m\mathbf{V} = M\mathbf{V}$$

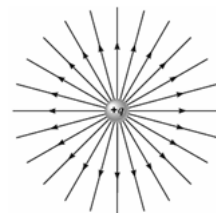
Coulomb's Law
(electric force,
electrostatic force)

$$F_e = \frac{kq_1q_2}{r^2}$$

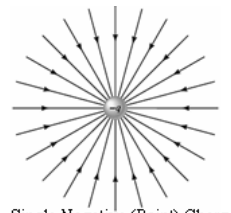
Electric Field
(units: N/C or V/m)

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

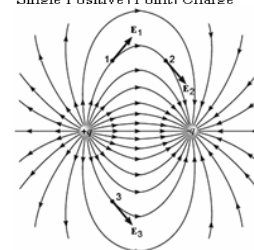
Lines go from + to -.
Lines never cross.
Lines show direction of force on small positive test charge.
Field is most intense where field lines are most dense.



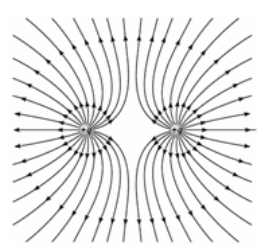
Single Positive (Point) Charge



Single Negative (Point) Charge



Two Unlike Equal Charges



Two Like Equal Charges

Things You Should Know About Regents Physics

Electric potential difference (voltage): work done per unit charge ($V = W/q$)

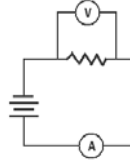
Resistance of a wire: $R = \rho L/A$ where $A = \pi r^2$

Least resistance (best conductor): short, fat, cold

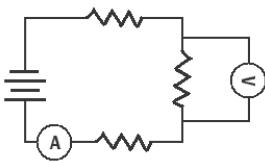
Most resistance (worst conductor): long, skinny, hot

Voltmeter: connect in parallel, infinite internal resistance

Ammeter: connect in series, zero internal resistance



Series Circuit



$$R_{eq} = R_1 + R_2 + R_3$$

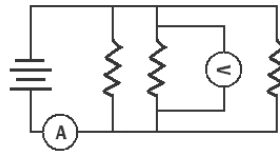
$$V_T = V_1 + V_2 + V_3$$

Control: current stays the same

Resistance adds up (greater than greatest)

Adding extra resistor increases total resistance and decreases total current.

Parallel Circuit



$$I_T = I_1 + I_2 + I_3$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Control: voltage stays the same

Resistance adds down (less than least)

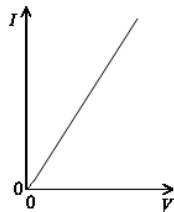
Adding extra resistor decreases total resistance and increases total current.

Potential difference	V	Volt	$V = J/C$
Current	I	Amps	$A = C/s$
Resistance	R	Ohms	$\Omega = V/A$
Power	P	Watts	$W = J/s$
Charge	q	Coulombs	C
Energy	W	Joules	$J = N \cdot m$

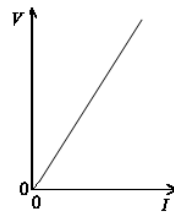
Resistance: $R = V/I$

Ohmic Device: follows Ohm's law ($V \propto I$ at constant T) = constant resistance

Non-Ohmic Device: resistance not constant (eg. filament lamp)



Slope = $1/R$



Slope = R

Mechanical Power: $P = W/t = Fd/t = Fv$

Electrical Power: $P = VI = I^2R = V^2/R$

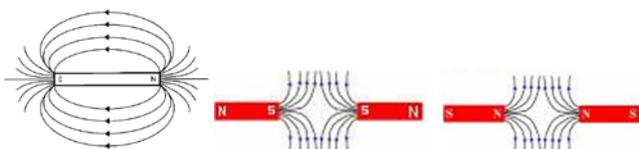
1 electronvolt (eV) = 1.60×10^{-19} J

1 kilowatt hour = $(1000 \text{ W})(1 \text{ hr}) = 3.6 \times 10^6$ J

Three units of energy: joules, electronvolts, kilowatt hours

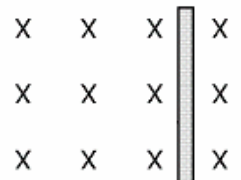
Magnetic Fields

From N to S, density = strength (intensity)
Direction of lines = direction of compass needle



Two Principles of Electromagnetism:

- 1) An electric current (or moving charged particle) generates a magnetic field.
- 2) A changing/moving magnetic field induces an electric current (electromagnetic induction).

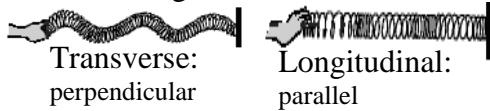


Things You Should Know About Regents Physics

Waves

Mechanical: needs medium

Electromagnetic: no medium



Transverse:
perpendicular

Longitudinal:
parallel

Radio Wave: electromagnetic wave – speed = 3.00×10^8 m/s

Period (T): seconds/cycle

Frequency (f): cycles/second

Wave equation: $v = f\lambda$

Sound

Longitudinal, mechanical

Speed = 331 m/s (STP) 340 m/s (room temp)

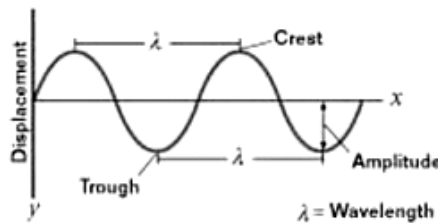
Amplitude = loudness (volume)

Frequency = pitch

Energy \propto amplitude

Speeds up when going from air to water

Can't be polarized



Light

Transverse, electromagnetic

Speed = $c = 3.00 \times 10^8$ m/s (vacuum)

Amplitude \propto brightness (intensity)

Frequency \propto energy ($E = hf$)

Slows down when going from air to water

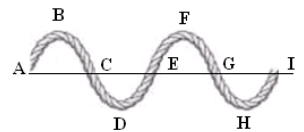
Can be polarized

Red: long wavelength, low frequency

Blue: short wavelength, high frequency

In Phase: A, E, I

Out of Phase by 180° or $\lambda/2$: A, C



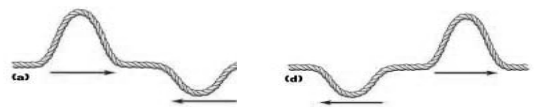
Hard reflection: out of phase



Soft reflection: in phase



Constructive interference: in phase

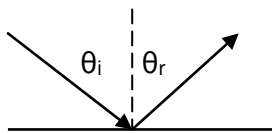


Destructive interference: out of phase

In one medium : $f \propto 1/\lambda$

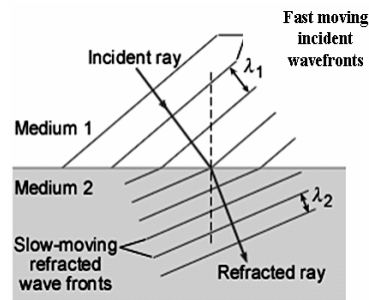
Control: speed - you can only change the speed of the wave by changing the properties of the medium)

Law of Reflection: $\theta_i = \theta_r$



Crossing a boundary: $v \propto \lambda$

Control: frequency stays the same, so does period and phase

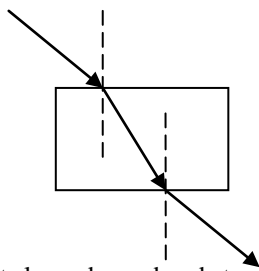


Refraction: changing direction when changing speed when crossing a boundary

FAST:

into fast, bend away from normal (high n to low n)

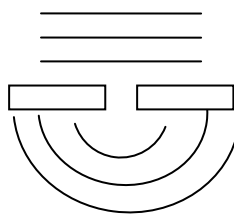
into slow, bend towards normal (low n to high n)



Light slows down, bends towards the normal, and has a shorter wavelength when it enters a medium with a higher index. The frequency stays the same.

Diffraction: bending around obstacle or spreading through opening

Noticeable diffraction: when size of opening approx. equal to size of wavelength – as opening gets smaller, more diffraction effects

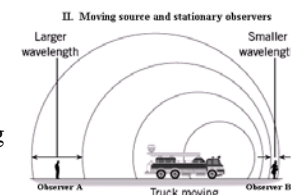


Resonance: energy is transferred to a system by making it vibrate at its natural frequency resulting in large amplitude standing waves

Examples: guitar strings, bridges, swings, wine glasses

Doppler Effect: apparent change in frequency due to relative motion

Constant low frequency, Decreasing amplitude



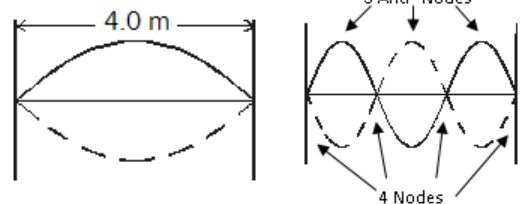
Constant high frequency, Increasing amplitude

Doppler Shift for Light:

“blue shift” = object moving towards

“red shift” = object moving away

Standing Wave: Two identical waves traveling in opposite directions in the same medium interfere



Fundamental Wave:

lowest frequency (f_1),

$\lambda_1 = 8.0$ m

Order of Electromagnetic Spectrum: Source – accelerating charged particles

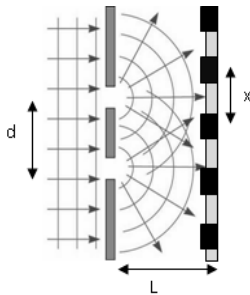
Radioactive Monkeys In Virginia Use X-ray Guns –

lowest to highest frequency and energy

Visible Light: 400 nm (violet) – 700 nm (red)

Things You Should Know About Regents Physics

Double Slit Diffraction and Interference: equally spaced bright and dark bands

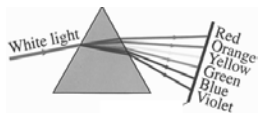


Red Spread

Single Slit Diffraction: wide and bright central maximum

Dispersion: spreading out of light into components due to refraction – each color has slightly different index and speed

Blue Bends Best - slowest
Red Resists Refraction - fastest



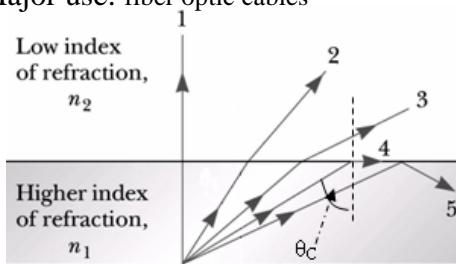
Total Internal Reflection

Critical Angle (θ_C): incident angle for which the refracted angle is 90°

Formula: $\sin \theta_C = n_2/n_1$

Total Internal Reflection: all light is reflected at surface, none is refracted – only occurs when light travels from high to low index and incident angle is greater than θ_C

Major use: fiber optic cables



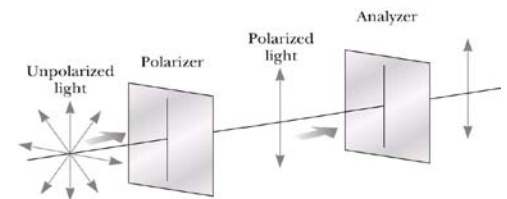
Polarization

Only transverse waves can be polarized
– light = yes, sound = no.

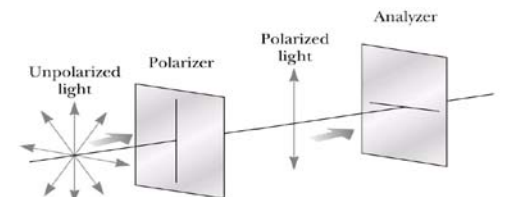
Polarized Light: vibrates in only one direction

Natural Polarization: light is partially polarized when it reflects off a surface

50% of unpolarized light transmits through a single polarizer.



Parallel polarizers: 50% passes through both



Perpendicular polarizers: 0% passes through second

Modern Physics

Wave-Particle Duality

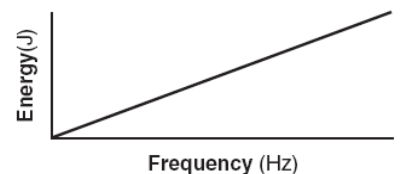
	Wave Nature	Particle Nature
Light (Energy)	- Diffraction - Interference - Doppler Effect	Photo-electric Effect
Matter	- Electron Diffraction - Matter Waves	Collisions (e.g. Alpha particle scattering)

Photon – quantum (particle) of light

Higher frequency = higher energy
($E = hf$)

Higher intensity = more photons

Energy vs. Frequency



Slope = Planck's constant (h)

Atomic Spectra

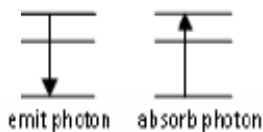
Ground state: lowest energy level

Excited state: higher energy level

Ionization: zero energy level

$$E_{\text{photon}} = |\Delta E_n|$$

$$(E_{\text{photon}} = E_i - E_f)$$



$$E = mc^2 \text{ (only use if } E \text{ is in Joules and } m \text{ is in kg)}$$

$$1 \text{ u} = 9.31 \times 10^2 \text{ MeV}$$

Hadrons made of quarks, leptons don't break down further...

Antimatter = same mass, opposite charge

Alpha particle = helium nucleus (2 protons and 2 neutrons)

Positron = anti-electron = positive electron

Proton = uud

Neutron = udd

Fundamental forces:

EM and gravity – long-range; Strong and weak – short-range