

MOTION EQUATIONS

$$\Delta s = s_f - s_i$$

$$\Delta v = v_f - v_i$$

$$\bar{v} \equiv \frac{\Delta s}{\Delta t}$$

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

$$\bar{v} = \frac{v_i + v_f}{2}$$

$$v_f = v_i + a\Delta t$$

$$\Delta s = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$v_f^2 = v_i^2 + 2a(\Delta s)$$

Really good motion chart:

v_i	v_f	\bar{v}	Δv	a	Δt	Δs

Acceleration due to gravity near various bodies

Body	accel. in m/s ²	accel. in g's
Earth	9.8	1
Moon	1.7	0.17
Mars	3.7	0.38
Jupiter	24.8	2.54
Pluto	0.49	0.05
Sun	270	28

SPECIAL RELATIVITY

KINEMATICS

"relativity factor": $\sqrt{1 - \frac{v^2}{c^2}}$

$$\Delta t_{\text{moving frame}} = \frac{\Delta t_{\text{rest frame}}}{\sqrt{1 - v^2/c^2}}$$

$$\Delta s_{\text{moving frame}} = \Delta s_{\text{rest frame}} \left(\sqrt{1 - v^2/c^2} \right)$$

DYNAMICS

$$p_{\text{moving object}} = \frac{mv}{\sqrt{1 - v^2/c^2}}$$

$$KE = \frac{mc^2}{\sqrt{1 - v^2/c^2}} - mc^2$$

$$E_0 = mc^2$$

$$c = 3.0 \times 10^8 \text{ m/s}$$

1 light year \equiv the distance traveled by light in one year

1 a.u. \equiv the distance between the earth and the sun = 93,000,000 miles

Binomial Approximation:
 $(1+a)^n \approx 1 + na$

Approximation at low velocities:
 $RF \approx 1 - \left(\frac{1}{2}\right)(v^2/c^2)$

Approximation at velocities very near c:
 $v/c \approx 1 - \left(\frac{1}{2}\right)(RF^2)$

MOMENTUM & ENERGY

$$\Sigma \text{Quantity}_{\text{initial}} = \Sigma \text{Quantity}_{\text{final}}$$

$$\vec{p} = m\vec{v}$$

$$\text{Impulse} = \vec{F}\Delta t = \Delta(mv)$$

$$\Sigma \vec{p}_i = \Sigma \vec{p}_f$$

$$\Sigma E_i = \Sigma E_f$$

$$KE = \frac{1}{2}mv^2 \text{ (low speeds)}$$

$$k = F/\Delta x$$

$$PE_{\text{el}} = \frac{1}{2}k(\Delta x)^2$$

$$PE_g = -G \frac{m_1 m_2}{r}$$

$$PE_g = m_1 g h$$

$$\text{Efficiency} = \frac{E_{\text{achieving goal}}}{E_{\text{initial}}}$$

$$G = 6.67 \times 10^{-11} \text{ N}\cdot(\text{m}/\text{kg}^2)$$

$$1 \text{ amu} = 1.66053886 \times 10^{-27} \text{ kg}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

$$\text{mass}_{\text{electron}} = 5.49 \times 10^{-4} \text{ amu}$$

$$\text{mass}_{\text{proton}} = 1.007276 \text{ amu}$$

$$\text{mass}_{\text{neutron}} = 1.008665 \text{ amu}$$

VECTORS

$$\cos(\theta) = \frac{a}{h}$$

$$\sin(\theta) = \frac{o}{h}$$

$$\tan(\theta) = \frac{o}{a}$$

$$|R| = \sqrt{\Sigma R_x^2 + \Sigma R_y^2}$$

$$R_x = |R| \cos(\theta^*)$$

$$R_y = |R| \sin(\theta^*)$$

* = θ measured by convention

Law of Sines:

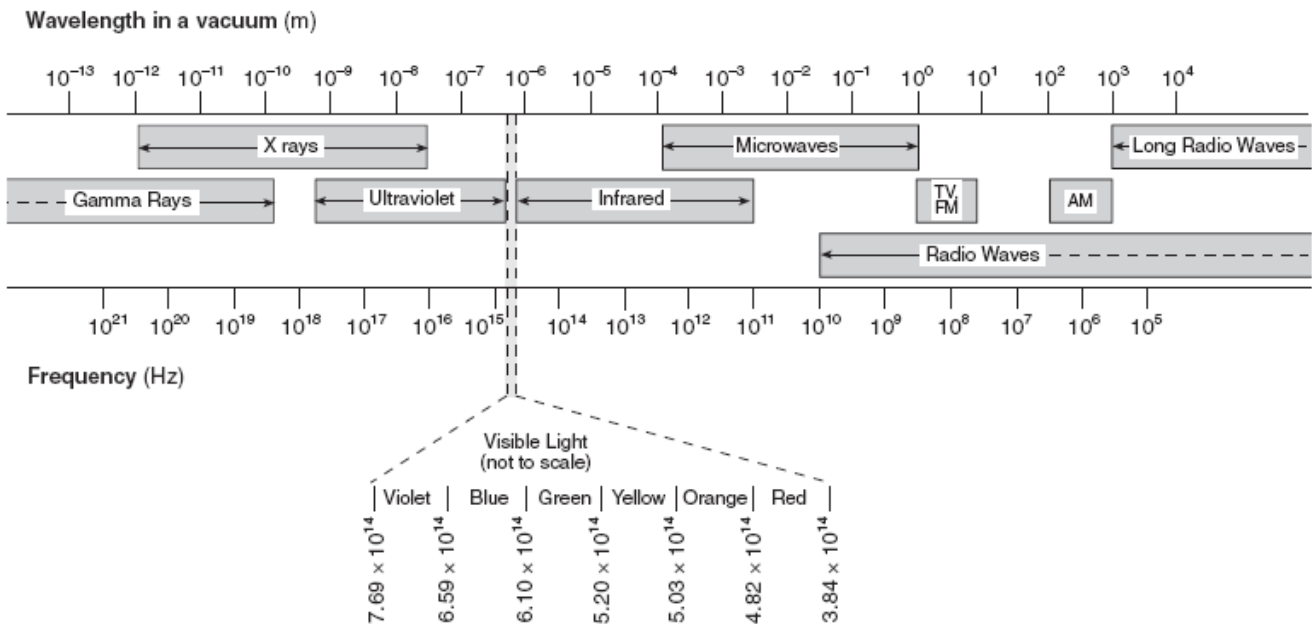
$$\frac{\sin(A)}{A} = \frac{\sin(B)}{B} = \frac{\sin(C)}{C}$$

Law of Cosines:

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

<h1>WAVES & QUANTUM PHYSICS</h1>	
<p>Speed of sound in air = 330 m/s Speed of light in air = 3×10^8 m/s</p> <p style="text-align: center;">$v = f * \lambda$</p> <p style="text-align: center;">$E_{total} \propto A^2$</p> <p>Double slit: $\Delta path = \Delta s (d \backslash L)$</p> <p>Planck's constant: $h = 6.63 \times 10^{-34}$ J*sec</p> <p style="text-align: center;">$E_{photon} = h * f$</p> <p>Uncertainty: $\Delta p * \Delta x \leq h/4\pi$</p>	<p>deBroglie wavelength: $\lambda = h / p$</p> <p>deBroglie frequency: $f = E_{tot}/h$</p>

ELECTROMAGNETIC SPECTRUM:



General Unit Conversions

Time:

- 24 hours = 1 day
- 365 days = 1 year
- 10 years = 1 decade
- 100 years = 1 century
- 2 weeks = 1 fortnight

Length:

- 1 inch = 2.54 centimeters
- 12 inches = 1 foot
- 3 feet = 1 yard
- 8 furlongs = 1 mile
- 5280 feet = 1 mile
- 100 cm = 1 meter
- 1609 meters = 1 mile
- 1 AU = 93,000,000 miles
- 1 light year = 9.461×10^{15} meters

Mass:

- 1000 grams = 1 kilogram
- 1 kilogram \approx 2.2 pounds
- 1 atomic mass unit = 1.7×10^{-27} kilograms
- 1 kilogram = 0.0685 slugs

Energy:

- 1 eV = 1.6×10^{-19} J

Other Quantities:

- 1 acre = 4047 meters²
- 1 gallon = 3.788 liters
- 1 liter = 1000 cm³
- 1 radian = 57.3°

<i>Metric Conversions</i>		
Power	Prefix	abbreviation
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exo	E

<u>Sub-Atomic Values:</u>	
mass of electron = 9.1×10^{-31} kg	
charge of electron = -1.6×10^{-19} C	
mass of proton = 1.6×10^{-27} kg	
charge of proton = 1.6×10^{-19} C	
mass of neutron = 1.7×10^{-27} kg	
charge of neutron = 0 C	

<u>Solar System Values:</u>	
Mass of Earth:	6×10^{24} kg
Radius of Earth:	6.4×10^6 m
Distance to Moon:	3.8×10^8 m
Mass of Moon:	7.4×10^{22} kg
Distance to Sun:	1.5×10^{11} m
Mass of Sun:	2×10^{30} kg

Matter										Antimatter									
I			II			III			I			II			III				
Quarks Up $+2/3$ r, g, b ~ 3 Down $-1/3$ r, g, b $\sim 6, 3$										Antiquarks Antiup $-2/3$ \bar{u} c, m, y ~ 3 Antidown $+1/3$ \bar{d} c, m, y $\sim 6, 3$									
Leptons Electron -1 e^- 0.511 Electron neutrino 0 ν_e < 0.000002										Antileptons Positron $+1$ e^+ 0.511 Electron antineutrino 0 $\bar{\nu}_e$ < 0.000002									
Muon -1 μ^- 106 Muon neutrino 0 ν_μ < 0.000002										Antimuon $+1$ $\bar{\mu}$ 106 Muon antineutrino 0 $\bar{\nu}_\mu$ < 0.000002									
Tau -1 τ^- $1,777$ Tau neutrino 0 ν_τ < 0.000002										Antitau $+1$ $\bar{\tau}$ $1,777$ Tau antineutrino 0 $\bar{\nu}_\tau$ < 0.000002									
Gauge Bosons Strong Gluons 0 0 0 Weak W^\pm Z^0 W 80.4 91.2 80.4 Electromagnetic Photons 0 Gravitational Gravitons 0										Legend Name \rightarrow Up $+2/3$ Charge r, g, b Color ~ 3 Symbol \rightarrow U \leftarrow Generation \leftarrow Rest Mass (MeV/c ²)									

QUARK PROPERTIES

Quark Flavor	Symbol	Charge	Mass (MeV/c ²)	Baryon Number	Strange-ness	Charm-ness	Bottom-ness	Top-ness
Up	u	+2/3	~3	+1/3	0	0	0	0
Down	d	-1/3	~6.5	+1/3	0	0	0	0
Strange	s	-1/3	~115	+1/3	-1	0	0	0
Charm	c	+2/3	~1,250	+1/3	0	1	0	0
Bottom	b	-1/3	~4,250	+1/3	0	0	-1	0
Top	t	+2/3	~175,000	+1/3	0	0	0	1
Antiup	\bar{u}	-2/3	~3	-1/3	0	0	0	0
Antidown	\bar{d}	+1/3	~6.5	-1/3	0	0	0	0
Antistrange	\bar{s}	+1/3	~115	-1/3	1	0	0	0
Anticharm	\bar{c}	-2/3	~1,250	-1/3	0	-1	0	0
Antibottom	\bar{b}	+1/3	~4,250	-1/3	0	0	1	0
Antitop	\bar{t}	-2/3	~175,000	-1/3	0	0	0	-1

LEPTON PROPERTIES

Lepton Flavor	Symbol	Charge	Mass (MeV/c ²)	Electron Number	Muon Number	Tau Number
Electron	e^-	-1	0.511	1	0	0
Muon	μ^-	-1	106	0	1	0
Tau	τ^-	-1	1,777	0	0	1
Electron neutrino	ν_e	0	$< 3 \times 10^{-6}$	1	0	0
Muon neutrino	ν_μ	0	< 0.2	0	1	0
Tau neutrino	ν_τ	0	< 20	0	0	1
Positron	e^+	+1	0.511	-1	0	0
Antimuon	$\bar{\mu}$	+1	106	0	-1	0
Antitau	$\bar{\tau}$	+1	1,777	0	0	-1
Electron antineutrino	$\bar{\nu}_e$	0	$< 3 \times 10^{-6}$	-1	0	0
Muon antineutrino	$\bar{\nu}_\mu$	0	< 0.2	0	-1	0
Tau antineutrino	$\bar{\nu}_\tau$	0	< 20	0	0	-1

Additional data may be found in *The Review of Particle Physics*, published by the Particle Data Group at Lawrence Berkeley Laboratory. *The Review of Particle Physics* is available online at: <http://pdg.lbl.gov/pdg.html>

BARYON PROPERTIES

Use the Quark Properties chart to determine the quark composition of the following baryons. A method for determining baryon composition is shown on the following page. Use your answers from this exercise to fill the appropriate circles on the Baryon Composition exercise that follows.

Baryon Name	Symbol	Charge	Mass (MeV/c ²)	Strange-ness	Charm-ness	Spin	Baryon Number
Proton	p	+1	938	0	0	1/2	+1
Antiproton	\bar{p}	-1	938	0	0	1/2	-1
Neutron	n	0	940	0	0	1/2	+1
Antineutron	\bar{n}	0	940	0	0	1/2	-1
Lambda	Λ^0	0	1116	-1	0	1/2	+1
Antilambda	$\bar{\Lambda}^0$	0	1116	+1	0	1/2	-1
Charmed lambda plus	Λ_c^+	+1	2285	0	1	1/2	+1
Sigma plus	Σ^+	+1	1189	-1	0	1/2	+1
Antisigma minus	$\bar{\Sigma}^-$	-1	1189	+1	0	1/2	-1
Sigma zero	Σ^0	0	1193	-1	0	1/2	+1
Antisigma zero	$\bar{\Sigma}^0$	0	1193	+1	0	1/2	-1
Sigma minus	Σ^-	-1	1197	-1	0	1/2	+1
Antisigma plus	$\bar{\Sigma}^+$	+1	1197	+1	0	1/2	-1
Xi zero	Ξ^0	0	1315	-2	0	1/2	+1
Antixi zero	$\bar{\Xi}^0$	0	1315	+2	0	1/2	-1
Xi minus	Ξ^-	-1	1321	-2	0	1/2	+1
Antixi plus	$\bar{\Xi}^+$	+1	1321	+2	0	1/2	-1
Omega minus	Ω^-	-1	1672	-3	0	3/2	+1
Antiomega plus	$\bar{\Omega}^+$	+1	1672	+3	0	3/2	-1
Delta zero	Δ^0	0	1234	0	0	3/2	+1
Antidelta zero	$\bar{\Delta}^0$	0	1234	0	0	3/2	-1
Delta minus	Δ^-	-1	1232	0	0	3/2	+1
Delta plus	Δ^+	+1	1233	0	0	3/2	+1
Delta two plus	Δ^{++}	+2	1231	0	0	3/2	+1
Sigma star plus	Σ^{*+}	+1	1383	-1	0	3/2	+1
Sigma star zero	Σ^{*0}	0	1384	-1	0	3/2	+1
Sigma star minus	Σ^{*-}	-1	1387	-1	0	3/2	+1
Xi star minus	Ξ^{*-}	-1	1535	-2	0	3/2	+1
Xi star zero	Ξ^{*0}	0	1532	-2	0	3/2	+1

MESON PROPERTIES

Use the Quark Properties chart to determine the quark composition of the following mesons. A method for determining meson composition is shown on the following page. Use your answers from this exercise to fill the appropriate circles on the “Meson Composition” exercise that follows.

Meson Name	Symbol	Charge	Mass (MeV/c ²)	Strange-ness	Charm-ness	Bottom-ness	Top-ness
Pi zero	π^0	0	135	0	0	0	0
Pi minus	π^-	-1	140	0	0	0	0
Pi plus	π^+	+1	140	0	0	0	0
Rho	ρ	0	775	0	0	0	0
Eta	η	0	548	0	0	0	0
K zero	K^0	0	498	+1	0	0	0
Anti K zero	\bar{K}^0	0	498	-1	0	0	0
K plus	K^+	+1	494	+1	0	0	0
K minus	K^-	-1	494	-1	0	0	0
D zero	D^0	0	1864	0	+1	0	0
Anti D zero	\bar{D}^0	0	1864	0	-1	0	0
D plus	D^+	+1	1869	0	+1	0	0
D minus	D^-	-1	1869	0	-1	0	0
D strange plus	D_s^+	+1	1969	+1	+1	0	0
D strange minus	D_s^-	-1	1969	-1	-1	0	0
J/Psi	J/Ψ	0	3097	0	0	0	0
B zero	B^0	0	5279	0	0	+1	0
Anti B zero	\bar{B}^0	0	5279	0	0	-1	0
B plus	B^+	+1	5279	0	0	+1	0
B minus	B^-	-1	5279	0	0	-1	0
Phi	ϕ	0	1019	0	0	0	0
Upsilon	Y	0	9460	0	0	0	0