FORMULA LIST FOR PHYSICS

#3 Components of a Vector

if Vel = 34 m/sec ∠**48°**

then

$\mathbf{V_i = 34}$ m/sec **(cos 48°) and** $\mathbf{V_j = 34}$ m/sec **(sin 48°)**

#4 Weight = m g

g = 9.81m/sec² near the surface of the Earth

Density = mass / volume

$$\rho = \frac{m}{V}\left(unit : kg/m^3\right)$$

#7 Ave speed = distance / time = v = d/t

Ave velocity = displacement / time = v = d/t

Ave acceleration = change in velocity / time

#8 Friction Force

$\mathbf{F_F} = \mu\ F_N$

If the object is not moving, you are dealing with static friction and it can have any value from zero up to $\mu_s F_N$

If the object is sliding, then you are dealing with kinetic friction and it will be constant and equal to $\mu_K F_N$

#9 Torque

$\tau = F\ L \sin\theta$

Where θ is the angle between F and L; unit: Nm

#11 Newton's Second Law

$F_{net} = \Sigma F_{Ext} = m\ a$

#12 Work = F D cosθ

Where D is the distance moved and θ is the angle between **F** and the direction of motion:

unit : J

#16 Power = rate of work done

$$Power = \frac{Work}{time}$$

unit : watt

Efficiency = Work$_{out}$ / Energy put in

Mechanical Advantage = force out / force in

M.A. = F_{out} / F_{in}

#19 Constant-Acceleration Linear Motion

$v = v_o + a\ t$	x
$(x-x_o) = v_o\ t + ½\ a\ t^2$	v
$v^2 = v_o^2 + 2a\ (x - x_o)$	t
$(x-x_o) = ½(\ v_o + v)t$	a
$(x-x_o) = vt - ½\ a\ t^2$	v_o

#20 Heating a Solid, Liquid or Gas

$Q = m\ c\ \Delta\ T$

Q = the heat added

c = specific heat.

#23 Center of Mass – point masses on a line

$x_{cm} = \Sigma(mx) / M_{total}$

#25 Angular Speed vs. Linear Speed

Linear speed = v = rω = r x angular speed

#26 Pressure under Water

$P = \rho gh$

h = depth of water

ρ = density of water

#28 Universal Gravitation

$$F = G\frac{m_1 m_2}{r^2}$$

G = 6.67 E-11 N m² / kg²

#29 Mechanical Energy

$PE_{Grav} = P = mgh$

$KE_{Linear} = K = ½\ mv^2$

#30 Impulse = Change in Momentum

$F\Delta t = \Delta(mv)$

#31 Snell's Law

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

Index of Refraction

$n = c / v$

c = speed of light = 3 E8 m/s

#32 Ideal Gas Law

$P\ V = n\ R\ T$

n = # of moles of gas

R = gas law constant = 8.31 J / K mole.

#34 Periodic Waves

$v = f\lambda$

$f = 1 / T$

T = period of wave

#35 Constant-Acceleration Circular Motion

$\omega = \omega_o + \alpha\ t$	θ
$\theta-\theta_o = \omega_o t + ½\ \alpha\ t^2$	ω
$\omega^2 = \omega_o^2 + 2\alpha(\theta-\theta_o)$	t
$\theta-\theta_o = ½(\omega_o + \omega)\ t$	α
$\theta-\theta_o = \omega\ t - ½\ \alpha\ t^2$	ω_o

#36 Buoyant Force - Buoyancy

$F_B = \rho V g = m_{displaced\ fluid}\, g$ = weight of fluid

ρ = density of the fluid

V = volume of fluid displaced

#37 Ohm's Law

$V = I R$

V = voltage applied

I = current

R = resistance

Resistance of a Wire

$R = \rho L / A_x$

ρ = resistivity of wire material

L = length of the wire

A_x = cross-sectional area of the wire

#39 Heat of a Phase Change

$Q = m L$

L = Latent Heat of phase change

#41 Hooke's Law

$F = kx$

Potential Energy of a spring

$W = \frac{1}{2} k x^2$ = Work done on spring

#42 Electric Power

$P = I^2 R$

$P = V^2 / R$

$P = I V$

#44 Speed of a Wave on a String

$$T = \frac{mv^2}{L}$$

T = tension in string

m = mass of string

L = length of string

#45 Projectile Motion

Horizontal: $x - x_o = v_o t + 0$

Vertical: $y - y_o = v_o t + \frac{1}{2} a t^2$

#46 Centripetal Force

$$F = \frac{mv^2}{r} = m\omega^2 r$$

#51 Minimum Speed for the top of a Vertical Circle

$$v = \sqrt{rg}$$

#53 Resistor Combinations

SERIES

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

PARALLEL

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n} = \sum_{i=1}^{n} \frac{1}{R_i}$$

#54 Newton's Second Law and Rotational Inertia

$\tau_{orque} = I \alpha$

$I = m r^2$ (for a point mass)

#55 Circular Unbanked Tracks

$$\frac{mv^2}{r} = \mu mg$$

#56 Continuity of Fluid Flow

$A_{in}\, v_{in} = A_{out}\, v_{out}$

A= Area

v = velocity

#58 Moment of Inertia - I

cylindrical hoop	$m r^2$
solid cylinder or disk	$(1/2)\, m r^2$
solid sphere	$(2/5)\, m r^2$
hollow sphere	$(2/3)\, m r^2$
thin rod (center)	$(1/12)\, m L^2$
thin rod (end)	$(1/3)\, m L^2$

#59 Capacitors

$Q = C V$

Q = maximum charge on capacitor

C = capacitance of the capacitor

V = voltage applied to the capacitor

RC Circuits (Discharging)

$V = V_o e^{-t/RC}$

$V_c - I R = 0$

#60 Thermal Expansion

Linear: $\Delta L = L_o \alpha \Delta T$

Volume: $\Delta V = V_o \beta \Delta T$

#61 Bernoulli's Equation

$P + \rho g h + \frac{1}{2} \rho v^2 = \text{Constant}$

$Q_{ConstantFlow} = A_1 v_1 = A_2 v_2$

#62 Rotational Kinetic Energy

$KE_{rotational} = \frac{1}{2} I \omega^2 = \frac{1}{2} I (v / r)^2$

Angular Momentum = L $= I \omega = m v r \sin\theta$

Angular Impulse equals CHANGE IN Angular Momentum

$\Delta L = \tau_{orque} \Delta t = \Delta (I \omega)$

#63 Period of Simple Harmonic Motion

$$T = 2\pi\sqrt{\frac{m}{k}}$$ where k = spring constant

$$f = 1 / T$$

#66 First Law of Thermodynamics

$$\Delta U = Q - W$$

Change in Energy = +Heat added – Work done

Flow of Heat through a Solid

$$\Delta Q / \Delta t = kA\,\Delta T / L$$

k = thermal conductivity
A = area of solid
L = thickness of solid

#68 Potential Energy of a Capacitor

$$P = \tfrac{1}{2}CV^2$$

RC Circuit formula (Charging)

$$V_c = V_{cell}\,(1 - e^{-t / RC})$$

RC = one time constant

$$V_{cell} - V_{capacitor} - I R = 0$$

#71 Simple Pendulum

$$T = 2\pi\sqrt{\frac{L}{g}} \quad \text{and} \quad f = 1/ T$$

#72 Sinusoidal motion

$$x = A\cos(\omega t) = A\cos(2\pi f t)$$

ω = angular frequency
f = frequency

#73 Doppler Effect

$$f' = f\,\frac{330 \pm v_o}{330 \pm v_s}$$

v_o = velocity of observer: v_s = velocity of source

$-$ ⇐ Observer ⇒ $+$ $\quad$ $-$ ⇐ Source ⇒ $+$

#74 Maximum Efficiency of a Heat Engine (Carnot Cycle)

$$Eff = (1 - \frac{T_c}{T_h}) \cdot 100\%$$

#75 Thin Lens Equation

$$\frac{1}{f} = \frac{1}{D_o} + \frac{1}{D_i} = \frac{1}{o} + \frac{1}{i}$$

f = focal length

Magnification

$$M = -D_i / D_o = - i / o = H_i / H_o$$

Helpful reminders for mirrors and lenses

Focal Length of:	positive	negative
mirror	concave	convex
lens	converging	diverging
Object distance = o	all objects	
Object height = H_o	all objects	
Image distance = i	real	virtual
Image height = H_i	virtual, upright	real, inverted
Magnification	virtual, upright	real, inverted

#76 Coulomb's Law

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

$$k = \frac{1}{4\pi\varepsilon_o} = 9E9\,\frac{N \cdot m^2}{C^2}$$

#77 Capacitor Combinations

PARALLEL

$$C_{eq} = C_1 + C_2 + C_3$$

SERIES

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n} = \sum_{i=1}^{n}\frac{1}{C_i}$$

#78 Work done on a gas or by a gas

$$W = P\Delta V$$

#80 Electric Field around a point charge

$$E = k\,\frac{q}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_o} = 9E9\,\frac{N \cdot m^2}{C^2}$$

#82 Magnetic Field around a wire

$$B = \frac{\mu_o I}{2\pi r}$$

Magnetic Flux

$$\Phi = B\,A\cos\theta$$

Force caused by a magnetic field on a moving charge

$$F = q\,v\,B\sin\theta$$

#83 Entropy change at constant T

$$\Delta S = Q / T$$

#84 Capacitance of a Capacitor

$$C = \kappa\varepsilon_o A / d$$

κ = dielectric constant
A = area of plates
d = distance between plates
ε_o = 8.85 E(-12) F/m

#85 Induced Voltage

$$Emf = N\frac{\Delta\Phi}{\Delta t}$$

N = number of loops or turns

#86 Inductors during an increase in current

$$V_L = V_{cell}\, e^{-t\,R/L}$$

$$I = V_{cell}/R\ (1 - e^{-t\,R/L})$$

L / R = time constant

#88 Transformers

$$N_1 / N_2 = V_1 / V_2$$

$$I_1 V_1 = I_2 V_2$$

#89 Decibel Scale

$B_{\text{(Decibel level of sound)}} = 10 \log (I / I_o)$

I = intensity of sound

I_o = intensity of softest audible sound

#92 Poiseuille's Law

$\Delta P = 8\eta LQ/\pi r^4$

η = coefficient of viscosity

L = length of pipe

r = radius of pipe

Q = flow rate of fluid

Stress and Strain

Y or **S** or **B = stress / strain**

stress = F/A

Three kinds of strain: unit-less ratios

I. Linear: strain = $\Delta L / L$

II. Shear: strain = $\Delta x / L$

III. Volume: strain = $\Delta V / V$

#93 Postulates of Special Relativity

1. Absolute, uniform motion cannot be detected.

2. No energy or mass transfer can occur at a speed faster than the speed of light.

#94 Lorentz Transformation Factor

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

#95 Relativistic Time Dilation

$\Delta t = \Delta t_o / \beta$

#96 Relativistic Length Contraction

$\Delta x = \beta\, \Delta x_o$

Relativistic Mass Increase

$m = m_o / \beta$

#97 Energy of a Photon or a Particle

$E = h f = m c^2$

h = Planck's constant = 6.63 E(-34) J sec

f = frequency of the photon

#98 Radioactive Decay Rate Law

$A = A_o e^{-kt} = (1/2^n)\, A_o$

Where k = ln 2 / half-life

#99 Blackbody Radiation and the Photoelectric Effect

$E = n h f$ where h = Planck's constant

#100 Early Quantum Physics

Rutherford-Bohr Hydrogen-like Atoms

$$\frac{1}{\lambda} = R \cdot \left(\frac{1}{n_s^2} - \frac{1}{n^2} \right) meters^{-1}$$

or

$$f = \frac{c}{\lambda} = cR\left(\frac{1}{n_s^2} - \frac{1}{n^2} \right) Hz$$

R = Rydberg's Constant

= 1.097373143 E7 m^{-1}

n_s = series integer (2 = Balmer)

n = an integer > n_s

Mass-Energy Equivalence

$m_v = m_o / \beta$

Total Energy = KE + $m_o c^2 = m_o c^2 / \beta$

Usually written as $E = m c^2$

de Broglie Matter Waves

For light: $E_p = h f = h c / \lambda = p c$

Therefore: $p = h / \lambda$

Similarly for particles, $p = mv = h/\lambda$, so the matter wave's wavelength must be

$\lambda = h / m v$

Energy Released by Nuclear Fission and Fusion

$E = \Delta m_o c^2$

MISCELLANEOUS FORMULAS

Quadratic Formula

if $a x^2 + b x + c = 0$

then

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

Trigonometric Definitions

$\sin \theta$ = opposite / hypotenuse
$\cos \theta$ = adjacent / hypotenuse
$\tan \theta$ = opposite / adjacent

$\sec \theta = 1 / \cos \theta$ = hyp / adj
$\csc \theta = 1 / \sin \theta$ = hyp / opp
$\cot \theta = 1 / \tan \theta$ = adj / opp

Inverse Trigonometric Definitions

$\theta = \sin^{-1}$ (opp / hyp)
$\theta = \cos^{-1}$ (adj / hyp)
$\theta = \tan^{-1}$ (opp / adj)

Law of Sines

$a / \sin A = b / \sin B = c / \sin C$
or
$\sin A / a = \sin B / b = \sin C / c$

Law of Cosines

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

T-Pots

For the functional form

$$\frac{1}{A} = \frac{1}{B} + \frac{1}{C}$$

You may use "The Product over the Sum"

$$A = \frac{B \cdot C}{B + C}$$

For the Alternate Functional form

$$\frac{1}{A} = \frac{1}{B} - \frac{1}{C}$$

You may substitute T-Pot-d

$$A = \frac{B \cdot C}{C - B} = -\frac{B \cdot C}{B - C}$$

Fundamental SI Units

Unit	Base Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Luminous Intensity	candela	cd
Quantity of Substance	moles	mol
Plane Angle	radian	rad
Solid Angle	steradian	sr or str

Some Derived SI Units

Symbol/Unit	Quantity	Base Units
C coulomb	Electric Charge	A s
F farad	Capacitance	$A^2 s^4/(kg\ m^2)$
H henry	Inductance	$kg\ m^2/(A^2\ s^2)$
Hz hertz	Frequency	s^{-1}
J joule	Energy & Work	$kg\ m^2/s^2 = Nm$
N newton	Force	$kg\ m/s^2$
Ω ohm	Elec Resistance	$kg\ m^2/(A^2\ s^2)$
Pa pascal	Pressure	$kg/(m\ s^2)$
T tesla	Magnetic Field	$kg/(A\ s^2)$
V volt	Elec Potential	$kg\ m^2/(A\ s^2)$
W watt	Power	$kg\ m^2/s^3$

Non-SI Units

^oC	deg Celsius	Temperature
eV	elec-volt	Energy, Work

FORMULA LIST FOR PHYSICS

Aa acceleration, Area, A_x=Cross-sectional Area, Amperes, Amplitude of a Wave, Angle,
Bb Magnetic Field, Decibel Level of Sound, Angle,
Cc specific heat, speed of light, Capacitance, Angle, Coulombs, ^{o}Celsius, Celcius Degrees, candela,
Dd displacement, differential change in a variable, Distance, Distance Moved, distance,
Ee base of the natural logarithms, charge on the electron, Energy,
Ff Force, *frequency of a wave or periodic motion*, Farads,
Gg Universal Gravitational Constant, acceleration due to gravity, Gauss, grams, Giga-,
Hh depth of a fluid, height, vertical distance, Henrys, Hz=Hertz,
Ii Current, Moment of Inertia, image distance, Intensity of Sound,
Jj Joules,
Kk K or KE = Kinetic Energy, force constant of a spring, thermal conductivity, coulomb's law constant, kg=kilograms, Kelvins, kilo-, rate constant for Radioactive decay =1/τ=ln2 / half-life,
Ll Length, Length of a wire, Latent Heat of Fusion or Vaporization, Angular Momentum, Thickness, Inductance,
Mm mass, Total Mass, meters, milli-, Mega-, m_o=rest mass, mol=moles,
Nn index of refraction, moles of a gas, Newtons, Number of Loops, nano-,
Oo
Pp Power, Pressure of a Gas or Fluid, Potential Energy, momentum, Power, Pa=Pascal,
Qq Heat gained or lost, Maximum Charge on a Capacitor, object distance, Flow Rate,
Rr radius, Ideal Gas Law Constant, Resistance, magnitude or length of a vector, rad=radians
Ss speed, seconds, Entropy, length along an arc,
Tt time, Temperature, Period of a Wave, Tension, Teslas, $t_{1/2}$=half-life,
Uu Potential Energy, Internal Energy,
Vv velocity, Velocity, Volume of a Gas, velocity of wave, Volume of Fluid Displaced, Voltage, Volts,
Ww weight, Work, Watts, Wb=Weber,
Xx distance, horizontal distance, x-coordinate east-and-west coordinate,
Yy vertical distance, y-coordinate, north-and-south coordinate,
Zz z-coordinate, up-and-down coordinate,

Αα Alpha angular acceleration, coefficient of linear expansion,
Ββ Beta coefficient of volume expansion, lorentz transformation factor,
Χχ Chi

Δδ Delta Δ=change in a variable,

Εε Epsilon ε_o = permittivity of free space,

Φϕ Phi Magnetic Flux, angle,

Γγ Gamma surface tension = F / L,
1 / γ = lorentz transformation factor,
Ηη Eta

Ιι Iota

ϑφ Theta and **Phi** lower case alternates.
Κκ Kappa dielectric constant,

Λλ Lambda wavelength of a wave, rate constant for Radioactive decay =1/τ=ln2/half-life,

Μμ Mu friction, μ_o = permeability of free space, micro-,
Νν Nu alternate symbol for frequency,

Οο Omicron
Ππ Pi 3.1425926536,

Θθ Theta angle between two vectors,

Ρρ Rho density of a solid or liquid, resistivity,

Σσ Sigma Summation, standard deviation,
Ττ Tau torque, time constant for any exponential process; eg **τ**=RC or **τ**=L/R or **τ**=1/k=1/λ,
Υυ Upsilon
ςϖ Zeta and **Omega** lower case alternates
Ωω Omega angular speed or angular velocity, Ohms
Ξξ Xi

Ψψ Psi

Ζζ Zeta

Values of Trigonometric Functions for 1st Quadrant Angles

(simple mostly-rational approximations)

θ	sin θ	cos θ	tan θ
0^o	**0**	**1**	**0**
10^o	*1/6*	*65/66*	*11/65*
15^o	*1/4*	*28/29*	*29/108*
20^o	*1/3*	*16/17*	*17/47*
29^o	*$15^{1/2}/8$*	*7/8*	*$15^{1/2}/7$*
30^o	**1/2**	**$3^{1/2}/2$**	**$1/3^{1/2}$**
37^o	**3/5**	**4/5**	**3/4**
42^o	*2/3*	*3/4*	*8/9*
45^o	**$2^{1/2}/2$**	**$2^{1/2}/2$**	**1**
49^o	*3/4*	*2/3*	*9/8*
53^o	**4/5**	**3/5**	**4/3**
60	**$3^{1/2}/2$**	**1/2**	**$3^{1/2}$**
61^o	*7/8*	*$15^{1/2}/8$*	*$7/15^{1/2}$*
70^o	*16/17*	*1/3*	*47/17*
75^o	*28/29*	*1/4*	*108/29*
80^o	*65/66*	*1/6*	*65/11*
90^o	**1**	**0**	∞

(Memorize the **Bold** *rows for future reference.)*

Prefixes

Factor	Prefix	Symbol	Example
10^{18}	exa-	E	38 Es (Age of the Universe in Seconds)
10^{15}	peta-	P	
10^{12}	tera-	T	0.3 TW (Peak power of a 1 ps pulse from a typical Nd-glass laser)
10^{9}	giga-	G	22 G$ (Size of the Bill Gates Charitable Trust)
10^{6}	mega-	M	6.37 Mm (The radius of the Earth)
10^{3}	kilo-	k	1 kg (SI unit of mass)
10^{-1}	deci-	d	
10^{-2}	centi-	c	2.54 cm (=1 in)
10^{-3}	milli-	m	1 mm (The smallest division on a meter stick)
10^{-6}	micro-	μ	
10^{-9}	nano-	n	510 nm (Wavelength of green light)
10^{-12}	pico-	p	1 pg (Typical mass of a DNA sample used in genome studies)
10^{-15}	femto-	f	
10^{-18}	atto-	a	600 as (Time duration of the shortest laser pulses ever generated.)