Physics 115 Formulae

$F = \frac{Gm_1m_2}{r^2}$, $W = mg$, $f_s \le f_{s,max} = \mu_s N$, $f_k = \mu_k N$, $\sum \vec{F} = m\vec{a}$, $\Delta v_x = v_{fx} - v_{ix} = a_x \Delta t$,

$\Delta x = \frac{1}{2}(v_{fx} + v_{ix})\Delta t$, $\Delta x = v_{ix}\Delta t + \frac{1}{2}a_x(\Delta t)^2$, $v_{fx}^2 - v_{ix}^2 = 2a_x\Delta x$, $\omega_{av} = \frac{\Delta\theta}{\Delta t}$, $\theta = \frac{s}{r}$, $v = r|\omega|$,

$v = \frac{2\pi r}{T} = 2\pi rf$, $a_r = \frac{v^2}{r} = \omega^2 r$, $W = F\,\Delta r\cos\theta$, $K_{tr} = \frac{1}{2}mv^2$, $W_{total} = \Delta K$, $\Delta U_{grav} = -W_{grav} = mg\Delta y$,

$(K_i + U_i) + W_{nc} = (K_f + U_f)$, $U = -\frac{Gm_1m_2}{r}$, $F_x = -kx$, $U_{elastic} = \frac{1}{2}kx^2$, $P_{av} = \frac{\Delta E}{\Delta t}$, $P = Fv\cos\theta$,

$\vec{p} = m\vec{v}$, $\Delta\vec{p} = \sum \vec{F}\Delta t$, $F = k\frac{|q_1||q_2|}{r^2}$, $\vec{E} = \frac{\vec{F}_E}{q}$, $E = \frac{k|Q|}{r^2}$, $U_E = \frac{kq_1q_2}{r}$, $V = \frac{U_E}{q}$, $\Delta U_E = q\Delta V$,

$V = \frac{kQ}{r}$, $\Delta V = \frac{\Delta U_E}{q} = -Ed$, $Q = C\,\Delta V = \frac{\varepsilon_o A}{d}\Delta V$, $I = \frac{\Delta q}{\Delta t}$, $R = \frac{\Delta V}{I}$, $R = \rho\frac{L}{A}$, $\rho = \rho_0(1 + \alpha\,\Delta T)$,

$R_{eq} = \Sigma R_i = R_1 + R_2 + \cdots + R_N$, $\frac{1}{R_{eq}} = \sum \frac{1}{R_i} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}$, $P = I\Delta V = I^2R = \frac{V^2}{R}$, $\vec{F}_B = q\vec{v}\times\vec{B}$,

$F_B = qvB\sin\theta$, $B = \frac{\mu_o I}{2\pi r}$, $E = hf = \frac{hc}{\lambda}$, $K_{max} = hf - \phi$, $hf_{max} = K$, $p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$,

$\lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta)$, $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$, $r_n = \frac{n^2}{Z}a_o$, $E_n = -\frac{Z^2}{n^2} \times 13.6\text{ eV}$

Physics 115 Constants

$G = 6.674 \times 10^{-11}$ N·m^2/kg^2, $R_E = 6.38 \times 10^6$ m, $M_E = 5.98 \times 10^{24}$ kg, $g = 9.80$ N/kg, $e = 1.602 \times 10^{-19}$ C,
$k = 8.99 \times 10^9$ N·m^2/C^2, $\varepsilon_o = 8.85 \times 10^{-12}$ C^2/ N·m^2, $\mu_o = 4\pi \times 10^{-7}$ T·m/A, $h = 6.626 \times 10^{-34}$ J·s,
$h = 4.136 \times 10^{-15}$ eV·s, $c = 2.998 \times 10^8$ m/s, $R = 1.097 \times 10^7$ m^{-1}, $a_o = 5.29 \times 10^{-11}$ m, $m_e = 9.109 \times 10^{-31}$ kg

Standard Prefixes Used to Denote 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	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}
Femto	f	10^{-15}

Basic Mathematical Formulae

Area of a circle = πr^2

Circumference of a circle = $2\pi r$

Surface area of a sphere = $4\pi r^2$

Volume of a sphere = $\frac{4}{3}\pi r^3$

Pythagorean theorem:
$c^2 = a^2 + b^2$

Trigonometric relations:

$\sin\theta = a/c$

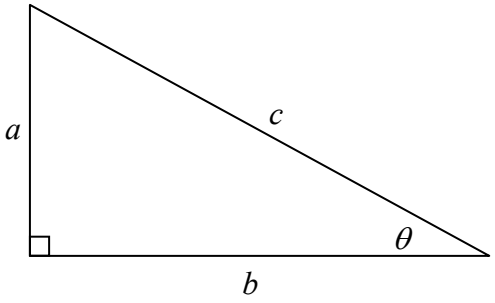
$\cos\theta = b/c$

$\tan\theta = \frac{a}{b} = \frac{\sin\theta}{\cos\theta}$

Quadratic formula:

If $ax^2 + bx + c = 0$, then

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



revised 1 September 2009

Physics 117 Formulae

$K_{\text{rot}} = \frac{1}{2} I\omega^2,\ \tau = \pm rF_\perp = \pm r_\perp F,\ W = \tau\,\Delta\theta,\ P = \tau\,\omega,\ \sum\tau = I\alpha,\ L = I\omega,\ P_{\text{av}} = \frac{F}{A},\ \rho = \frac{m}{V},\ P_2 = P_1 + \rho g d,$

$P_{\text{gauge}} = P_{\text{abs}} - P_{\text{atm}},\quad F_{\text{B}} = \rho_{\text{f}} g V_{\text{f}},\quad \frac{\Delta m}{\Delta t} = \rho A v,\quad \frac{\Delta V}{\Delta t} = Av,\quad A_1 v_1 = A_2 v_2,\ P + \rho g y + \frac{1}{2}\rho v^2 = \text{constant},$

$\frac{\Delta V}{\Delta t} = \frac{\pi}{8}\frac{\Delta P/L}{\eta} r^4,\quad F_{\text{D}} = 6\pi\eta r v,\quad \frac{F}{A} = Y\frac{\Delta L}{L},\quad \frac{F}{A} = S\frac{\Delta x}{L},\quad \Delta P = -B\frac{\Delta V}{V},\quad E_{\text{total}} = \frac{1}{2}kA^2,\quad v_{\text{m}} = \sqrt{\frac{k}{m}}A,$

$a_x(t) = -\frac{k}{m}x(t),\quad \omega = 2\pi f = \frac{2\pi}{T},\quad \omega = \sqrt{\frac{k}{m}},\quad \omega = \sqrt{\frac{mgd}{I}},\quad \omega = \sqrt{\frac{g}{L}},\quad a_x(t) = -\omega^2 x(t),\quad x(t) = A\cos(\omega t),$

$v_x(t) = -\omega A\sin(\omega t),\ a_x(t) = -\omega^2 A\cos(\omega t),\ I = \frac{\text{power}}{\text{area}} = \frac{P}{4\pi r^2},\ v = \sqrt{\frac{F}{\mu}},\ v = \frac{\lambda}{T} = f\lambda,\ \frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2},\ k = \frac{2\pi}{\lambda},$

$y(x,\,t) = A\cos(\omega t - kx),\ \text{phase difference} = k(d_2 - d_1),\ \beta = (10\text{ dB})\log_{10}\frac{I}{I_0},\quad f_{\text{o}} = \left(\frac{v - v_{\text{o}}}{v - v_{\text{s}}}\right) f_{\text{s}},\ T = T_{\text{C}} + 273.15,$

$\frac{\Delta L}{L_{\text{o}}} = \alpha\Delta T,\ \frac{\Delta A}{A_{\text{o}}} = 2\alpha\Delta T,\ \frac{\Delta V}{V_{\text{o}}} = \beta\Delta T,\ PV = NkT = nRT,\ \left\langle K_{\text{tr}}\right\rangle = \frac{3}{2}kT = \frac{1}{2}mv_{\text{rms}}^2,\ Q = mc\Delta T,\ \mathscr{P} = \kappa A\frac{\Delta T}{d},$

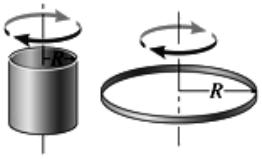
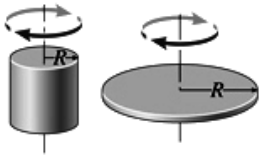
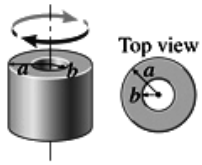
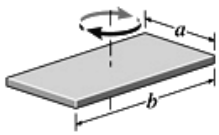
$\mathscr{P} = hA\Delta T,\ \mathscr{P} = e\sigma A T^4,\ n = \frac{c}{v},\ n_{\text{i}}\sin\theta_{\text{i}} = n_{\text{t}}\sin\theta_{\text{t}},\ m = \frac{h'}{h} = -\frac{q}{p},\ \frac{1}{p} + \frac{1}{q} = \frac{1}{f},\ M = \frac{N}{p},\ d\sin\theta = m\lambda,$

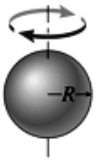
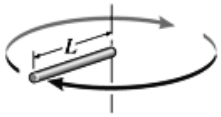
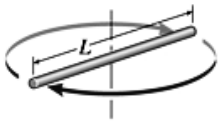
$M_{\text{total}} = m_{\text{o}} M_{\text{e}} = -\frac{L}{f_{\text{o}}}\times\frac{N}{f_{\text{e}}},\ a\sin\Delta\theta \geq 1.22\,\lambda_{\text{o}},\quad \lambda = \frac{h}{p},\quad r = r_0 A^{1/3},\quad E_{\text{B}} = (\Delta m)c^2,\quad R = \lambda N,\quad \tau = \frac{1}{\lambda},$

$N(t) = N_0 e^{-t/\tau},\quad T_{1/2} = 0.693\,\tau$

Physics 117 Constants

$\rho_{\text{water}} = 1.00\times10^3\text{ kg/m}^3$, $P_{\text{atm}} = 101.3\text{ kPa}$, $v_{\text{sound}} = 343\text{ m/s}$, $I_0 = 1.00\times10^{-12}\text{ W/m}^2$, $N_{\text{A}} = 6.022\times10^{23}\text{ mol}^{-1}$,
$\sigma = 5.670\times10^{-8}\text{ W/(m}^2\cdot\text{K}^4)$, $k = 1.381\times10^{-23}\text{ J/K}$, $R = 8.314\text{ J/K}\cdot\text{mol}$, $1\text{ kcal} = 4186\text{ J}$, $r_0 = 1.2\times10^{-15}\text{ m}$,
$m_{\text{e}} = 0.000548580\text{ u}$, $m_{\text{p}} = 1.673\times10^{-27}\text{ kg} = 1.0072765\text{ u}$, $m_{\text{n}} = 1.675\times10^{-27}\text{ kg} = 1.0086649\text{ u}$,
$c^2 = 931.494\text{ MeV/u}$

Shape	Axis of Rotation	Rotational Inertia
Thin hollow cylindrical shell (or hoop) 	Central axis of cylinder *of radius R*	MR^2
Solid cylinder (or disk) 	Central axis of cylinder *of radius R*	$\frac{1}{2}MR^2$
Hollow cylindrical shell or disk 	Central axis of cylinder *of outer radius a and inner radius b*	$\frac{1}{2}M(a^2 + b^2)$
Rectangular plate 	Perpendicular to plate through center	$\frac{1}{12}M(a^2 + b^2)$

Shape	Axis of Rotation	Rotational Inertia
Solid sphere *of radius R* 	Through center	$\frac{2}{5}MR^2$
Thin hollow spherical shell *of radius R* 	Through center	$\frac{2}{3}MR^2$
Thin rod 	Perpendicular to rod through end	$\frac{1}{3}ML^2$
Thin rod 	Perpendicular to rod through center	$\frac{1}{12}ML^2$