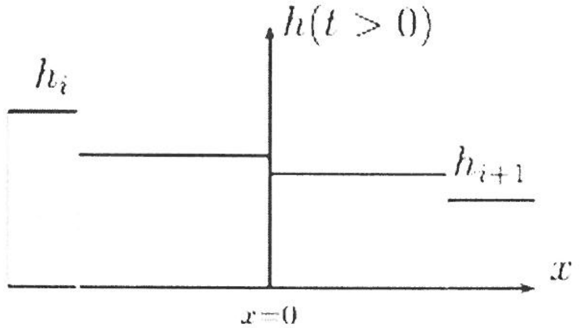
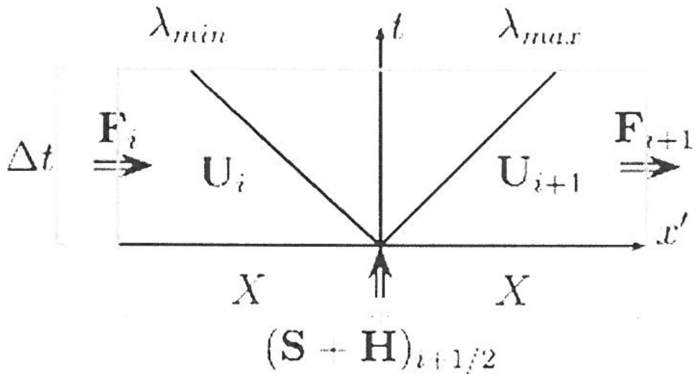
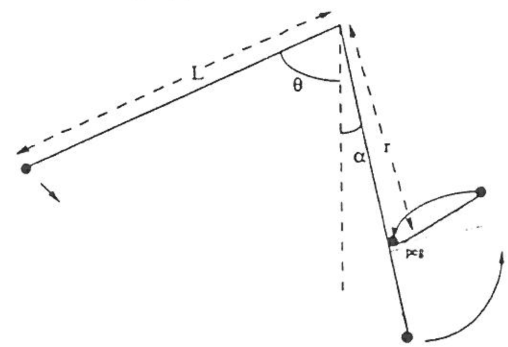
College Physics
Formula Sheets





Partial credit will not be given, so don't bother handing in unless it is correct. Show all your work clearly!!!!.

In the figure below a pendulum of mass "m" and length "L" is pulled back an angle "θ" and released. After the pendulum swings through its lowest point, it encounters a peg "α" degrees out and "r" meters from the top of the string. The mass swings up about the peg until the string becomes slack with the mass falling inward and hitting the peg.



Show for this condition:

$$\cos\theta = \frac{r}{L}\cos\alpha - \frac{\sqrt{3}}{2}\left(1-\frac{r}{L}\right)$$

Figure 1

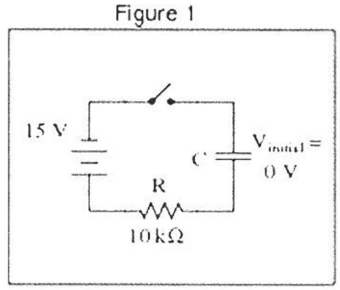


Figure 2

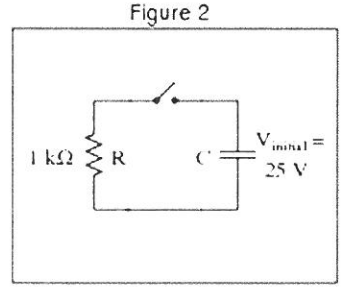


Figure 3

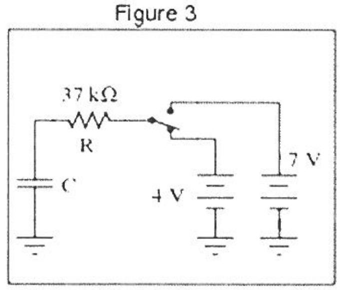
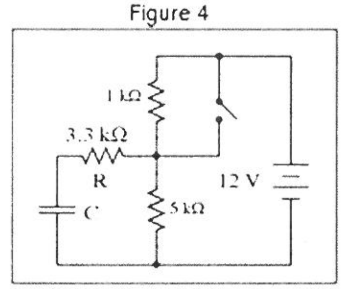


Figure 4



R·I·T

www.rit.edu/asc

College Physics I - 1

Kinematics	Linear	Rotational (Angular)	Tangential
Displacement:	$\Delta x = x_f - x_i$	$\Delta\theta = \theta_f - \theta_i$	$s = \theta r$
Velocity:	$v = \frac{\Delta x}{\Delta t}$	$\omega = \frac{\Delta\theta}{\Delta t}$	$v_T = \omega r$
Acceleration:	$a = \frac{\Delta v}{\Delta t}$	$\alpha = \frac{\Delta\omega}{\Delta t}$	$a_T = \alpha r$
Constant $\vec{a}$ formulas:	$v_f = v_i + a\Delta t$	$\omega_f = \omega_i + \alpha\Delta t$	
	$x_f = x_i + v_{avg}\Delta t$	$\theta_f = \theta_i + \omega_{avg}\Delta t$	
	$x_f = x_i + v_i\Delta t + \frac{1}{2}a\Delta t^2$	$\theta_f = \theta_i + \omega_i\Delta t + \frac{1}{2}\alpha\Delta t^2$	
	$v_f^2 = v_i^2 + 2a(x_f - x_i)$	$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$	

Uniform Circular Motion:

Centripetal $\vec{a}$:	$a_c = \frac{v^2}{r}$
Period:	$T = \frac{2\pi r}{v}$, in uniform circular motion
	$T = \frac{1}{f}$, where f is the frequency

Dynamics	Translational	Rotational (Angular)
Equilibrium:	$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \ldots + \vec{F}_n = 0$	$\tau_{net} = 0$
Torque:		$\tau = rF_\perp = rF\sin\phi$
Newton's 2^{nd} Law	$\vec{F}_{net} = m\vec{a}$	$\tau_{net} = I\alpha$
Momentum (single):	$\vec{p} = m\vec{v}$	$L = I\omega$
(system of particles):	$\sum\vec{p} = \vec{p}_1 + \vec{p}_2 + \ldots + \vec{p}_n$	$\sum L = L_1 + L_2 + \ldots + L_n$
Impulse:	$\vec{J} = \vec{F}_{avg}\Delta t = \Delta\vec{p}$	
Work:	$W = Fd\cos\theta$	
Kinetic Energy:	$K = \frac{1}{2}mv^2$	$K = \frac{1}{2}I\omega^2$
Work/Kinetic Energy:	$K_f = K_i + W$	
Potential Energy:	$U_g = mgy = mgh$	
	$U_{el} = \frac{1}{2}kx^2$	
Thermal Energy:	$\Delta E_{th} = f_k\Delta x$	
Mechanical Energy:	$E = K + U$	
Power:	$P = \frac{W}{\Delta t} = Fv\cos\theta$	

Forces:

Weight:	mg
Friction:	$f_s \le \mu_s n$
	$f_k = \mu_k n$
Spring:	$F_{sp} = -kx$
Gravitational:	$F = \frac{Gm_1m_2}{r^2}$

Constants:

Acc. of gravity:	$g = 9.80\ m/s^2$
Grav. const:	$G = 6.67\times10^{-11}\ Nm^2/kg^2$

Conservation Laws:

Momentum: $(p_{1x})_f + (p_{2x})_f + \cdots = (p_{1x})_i + (p_{2x})_i + \cdots$

$$(p_{1y})_f + (p_{2y})_f + \cdots = (p_{1y})_i + (p_{2y})_i + \cdots$$

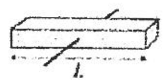
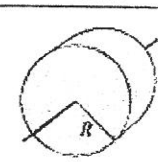
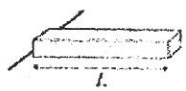
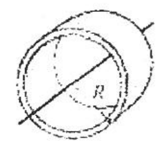
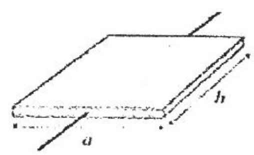
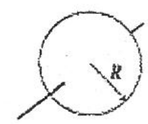
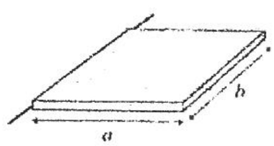
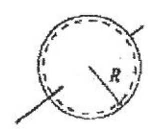
Energy: $K_i + K_{rot\,i} + U_{g\,i} + U_{el\,i} + W = K_f + K_{rot\,f} + U_{g\,f} + U_{el\,f} + \Delta E_{th}$

College Physics I - 2

Center of Mass & Moment of Inertia

$$x_{com} = \frac{x_1m_1 + x_2m_2 + \ldots + x_nm_n}{m_1 + m_2 + \ldots + m_n} \qquad y_{com} = \frac{y_1m_1 + y_2m_2 + \ldots + y_nm_n}{m_1 + m_2 + \ldots + m_n}$$

$$I = \sum m_i r_i^2$$

Object and axis	Picture	I	Object and axis	Picture	I
Thin rod, about center		$\frac{1}{12}ML^2$	Cylinder or disk, about center		$\frac{1}{2}MR^2$
Thin rod (of any cross section), about end		$\frac{1}{3}ML^2$	Cylindrical hoop, about center		MR^2
Plane or slab, about center		$\frac{1}{12}Ma^2$	Solid sphere, about diameter		$\frac{2}{5}MR^2$
Plane or slab, about edge		$\frac{1}{3}Ma^2$	Spherical shell, about diameter		$\frac{2}{3}MR^2$

Mathematics

Trigonometric formulas:	$\cos\theta = \frac{adj.}{hyp.}$; $\sin\theta = \frac{opp.}{hyp.}$; $\tan\theta = \frac{opp.}{adj.}$
Pythagorean theorem:	$a^2 + b^2 = c^2$
Quadratic equation:	$ax^2 + bx + c = 0$; Solution: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
Circumference of a circle:	$C = 2\pi r$
Area of a triangle:	$\frac{1}{2}bh$
Area of a rectangle:	lw

Experimental

Avg Deviation: $f = \frac{\sum |f_{av} - f|}{N} = \frac{|f_{av} - f_1| + |f_{av} - f_2| + \ldots}{N}$

Uncertainty: $\delta f = f_{max} - f$

Conversion Factors

$360° = 2\pi$ rad, 1 rev$= 2\pi$ rad,

1 km = 1000 m, 1 m = 100 cm, 1 m = 1000 mm, 1 kg = 1000 g,

$\mu = 10^{-6}$, $n = 10^{-9}$, $p = 10^{-12}$

COLLEGE PHYSICS II
FORMULA SHEET

$g = 9.80\,\frac{\text{m}}{\text{s}^2}$

$1.00\text{ atm} = 1.013 \times 10^5\text{ N/m}^2$

$\rho_{\text{water}} = 1000\,\frac{\text{kg}}{\text{m}^3}$

$2\pi\text{ rad} = 1\text{ rev} = 360^\circ$

$c = 3.00 \times 10^8\text{ m/s}$

$N_A = 6.022 \times 10^{23}$ particles/mole

$k_B = 1.381 \times 10^{-23}\,\frac{\text{J}}{\text{K (particle)}}$

$R = N_A \cdot k_B = 8.314\,\frac{\text{J}}{\text{mole K}}$

$\vec{F}_{net} = m\vec{a}$

If acceleration is constant then:

$$x_f = x_i + v_i t + \tfrac{1}{2}at^2$$

$$v_f = v_i + at$$

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$$\rho = \frac{m}{V}$$

$p = \frac{F}{A}$ gauge pressure $= p - p_{\text{atm}}$

$p = \rho g d + p_0$ $\qquad F_B = \rho_f V_f g$

$$Q = \frac{\Delta V}{\Delta t} = A_1 v_1 = A_2 v_2$$

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

$$\Delta p = 8\pi\eta \frac{L v_{avg}}{A}$$

$$Q = v_{avg} A = \frac{\pi R^4 \Delta p}{8\eta L}$$

$T_F = \tfrac{9}{5}T_C + 32$ $\qquad T = T_C + 273.15$

$\Delta V = \beta V_i \Delta T$ $\qquad \Delta L = \alpha L_i \Delta T$

$Q = Mc\Delta T$ $\qquad Q = nC_V \Delta T$ $\qquad Q = nC_P \Delta T$

$Q = ML_f$ (melting) $\qquad Q = ML_v$ (vaporization)

Radiation: $\frac{Q_{emitted}}{\Delta t} = e\sigma A T^4$ $\qquad \frac{Q_{net}}{\Delta t} = e\sigma A(T^4 - T_o^4)$ $\qquad \sigma = 5.67 \times 10^{-8}\text{ W/(m}^2\cdot\text{K}^4)$

$$\left.\frac{Q}{\Delta t}\right)_{conduction} = \left(\frac{kA}{L}\right)\Delta T$$

$n = \frac{N}{N_A}$ $\qquad n = \frac{M\text{ (in grams)}}{M_{mol}}$

$$v_{rms} = \sqrt{\left(v^2\right)_{avg}} = \sqrt{\frac{(v_1{}^2 + v_2{}^2 + v_3{}^2 + \cdots + v_N{}^2)}{N}}$$

IDEAL GAS:

$pV = Nk_BT = nRT$ $\qquad p = \frac{2}{3}\left(\frac{N}{V}\right) K_{avg}$

$K_{avg} = \frac{1}{2} m v_{rms}^2$ $\qquad K_{avg} = \frac{3}{2} k_B T$ (monatomic ideal gas)

$W = nRT \ \ln\left(\frac{V_f}{V_i}\right)$ (isothermal)

monatomic ideal gas $\quad E_{th} = N\,K_{avg} = \frac{3}{2} Nk_BT = \frac{3}{2} nRT = \frac{3}{2} pV$

$C_P = (5/2)R \qquad C_V = (3/2)R$

diatomic ideal gas $\quad C_P = (7/2)R \qquad C_V = (5/2)R$

$\Delta E_{th} = Q - W$

$W = p\,\Delta V$ (isobaric)

Heat engine: $W_{out} = Q_H - Q_C$ $\qquad e = \frac{W_{out}}{Q_H} = \frac{Q_H - Q_C}{Q_H}$ $\qquad e_{max} = 1 - \frac{T_C}{T_H}$

Heat pump: $Q_H = Q_C + W_{in}$ $\qquad \mathrm{COP} = \frac{Q_C}{W_{in}}$ $\qquad \mathrm{COP}_{max} = \frac{T_C}{T_H - T_C}$ (cooling)

$\mathrm{COP} = \frac{Q_H}{W_{in}}$ $\qquad \mathrm{COP}_{max} = \frac{T_H}{T_H - T_C}$ (heating)

SHM: $a = -\omega^2 x$

$x = A\cos\{\omega t\}$ $\quad$ *OR* $\quad x = A\sin\{\omega t\}$

$v = -\omega A \sin\{\omega t\}$ $\qquad v = \omega A \cos\{\omega t\}$

$a = -\omega^2 A\cos\{\omega t\}$ $\qquad a = -\omega^2 A \sin\{\omega t\}$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

mass/spring: $F_s = -k\,x$ $\qquad U_s = \frac{1}{2} k x^2$

$\omega^2 = \frac{k}{m}$ $\qquad T = 2\pi\sqrt{\frac{m}{k}}$

$E = K + U_{elastic}$ $\qquad \frac{1}{2} k A^2 = \frac{1}{2} m v^2 + \frac{1}{2} k x^2$

simple pendulum: $\omega^2 = \frac{g}{L}$ $\qquad T = 2\pi\sqrt{\frac{L}{g}}$

College Physics II – 3

WAVES: $I = \dfrac{\text{Power}}{\text{Area}}$ Intensity ~ (Amplitude)^2 Spherical waves: $I = \dfrac{P}{4\pi r^2}$

$$v = \frac{\lambda}{T} = \lambda f \qquad \omega = 2\pi f \qquad f = \frac{1}{T}$$

harmonic traveling waves: $y = A\cos\left[(2\pi f)t \pm \left(\dfrac{2\pi}{\lambda}\right)x\right]$

transverse waves : taut string $v = \sqrt{\dfrac{F_{tension}}{\mu}}$

interference: $\dfrac{\text{path difference}}{\lambda} = \dfrac{\text{phase difference}}{2\pi \text{ rad}}$

constructive: $|\text{path difference}| = m\lambda$ where $m = 0, 1, 2, \ldots$

destructive: $|\text{path difference}| = (m + \tfrac{1}{2})\lambda$ where $m = 0, 1, 2, \ldots$

STANDING WAVES :

General form (for one fixed end at $x = 0$): $y = 2A\cos(2\pi ft)\sin\left(\dfrac{2\pi}{\lambda}x\right)$

Taut string fixed at both ends, or sound wave in an open-open or closed-closed tube:

$\lambda_n = \dfrac{2L}{n}$ and $f_n = n f_1$ where $n = 1, 2, 3, 4, 5, \ldots$ and $f_1 = \dfrac{v}{2L}$

Sound wave in an open-closed tube (open on one end and closed on the other end):

$\lambda_n = \dfrac{4L}{n}$ and $f_n = n f_1$ where $n = 1, 3, 5, \ldots$ and $f_1 = \dfrac{v}{4L}$

SOUND:

$\beta = (10.0\,\text{dB})\log\left(\dfrac{I}{I_o}\right)$, $I_o = 10^{-12}\,\dfrac{\text{W}}{\text{m}^2}$ $I = I_o\, 10^{\left(\frac{\beta}{10\text{ dB}}\right)}$

$$\beta_2 - \beta_1 = (10.0 \text{ dB}) \log\left(\frac{I_2}{I_1}\right)$$

Doppler Effect using magnitudes (textbook's conventions): $f' = f\left(\dfrac{v \pm v_{observer}}{v \pm v_{source}}\right)$

Doppler Effect using velocity components (as in workshop): $f' = f\left(\dfrac{v_x - v_{Dx}}{v_x - v_{Sx}}\right)$

$$f_{beat} = |f_1 - f_2|$$

ELECTROMAGNETIC WAVES & OPTICS:

Refractive index: $n = \frac{c}{v}$ $\lambda_{material} = \frac{\lambda_{vacuum}}{n}$ $n_{air} = 1.00$

Law of Reflection: $\theta_r = \theta_i$

Law of Refraction (Snell's Law): $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Thin lens and magnification equations:

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \qquad m = \frac{h'}{h} = -\frac{s'}{s}$$

Double slit interference:

$$d\sin(\theta_m) = m\lambda \qquad y_m = \frac{m\lambda L}{d} \qquad m = 0, \pm 1, \pm 2, \ldots \qquad \text{maxima}$$

$$d\sin(\theta_m) = (m + \frac{1}{2})\lambda \qquad y_m = \frac{(m + \frac{1}{2})\lambda L}{d} \qquad m = 0, \pm 1, \pm 2, \ldots \qquad \text{minima}$$

Diffraction grating:

$$d \sin\theta_m = m\lambda \qquad m = 0, \pm 1, \pm 2, \ldots \qquad \text{diffraction peaks}$$

$$y_m = L \tan\theta_m$$

Single slit diffraction:

$$a\sin(\theta_m) = m\lambda \qquad y_m = \frac{m\lambda L}{a} \qquad m = \pm 1, \pm 2, \ldots \qquad \text{minima}$$

Thin film interference:

Constructive for 0 or 2 phase shifts; destructive for 1 phase shift:

$$2t = m\frac{\lambda}{n_{\text{film}}} \qquad m = 0, 1, 2, \ldots$$

Destructive for 0 or 2 phase shifts; constructive for 1 phase shift:

$$2t = (m + \frac{1}{2})\frac{\lambda}{n_{\text{film}}} \qquad m = 0, 1, 2, \ldots$$