Exam 4 formulas

To be given on exam

Continued from exams 1-3

$g = 9.80\ m/s^2$

If $ax^2 + bx + c = 0, \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

For constant a:

$$x = x_o + v_o t + \frac{1}{2}at^2$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

gravity: $w = mg$, $PE_g = mgy$

friction: $f = \mu N$ (or $f \leq \mu N$, for static friction)

springs: $F = -kx$, $PE_s = ½\ kx^2$

$P = F_{//} v = Fv\cos\theta$

arc length: $s = r\theta$

$v = r\omega$

$a_{tan} = r\alpha$

$a_c = v^2/r$

gravity: $F = \frac{GMm}{r^2}$, $PE_g = -\frac{GMm}{r}$

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

$R_{earth} = 6.38 \times 10^6\ m$

$M_{earth} = 5.98 \times 10^{24}\ kg$

$M_{sun} = 1.99 \times 10^{30}\ kg$

$I_{sphere} = (2/5)\ MR^2$

$I_{hoop} = MR^2$

$I_{disk} = ½\ MR^2$

$I_{rod\ (center)} = (1/12)\ ML^2$

$I_{rod\ (end)} = (1/3)\ ML^2$

New for exam 4

Constants

$\rho_{water} = 1000\ kg/m^3$

$k_B = 1.381 \times 10^{-23}\ J/K$

$N_A = 6.022 \times 10^{23}$

$R = \underline{k_B} \cdot N_A = 8.314\ J/mol{\cdot}K = 0.08206\ liter{\cdot}atm/mol{\cdot}K$

$\sigma = 5.67 \times 10^{-8}\ W/m^2{\cdot}K^4$

Conversion factors:

1 atm = 1.013×10^5 Pa = 14.7 psi

$$T_F = \frac{9}{5}T_C + 32$$
$$T_K = T_C + 273.15$$
1 cal = 4.186 J
1 m^3 = 1000 L

stress = F/A; strain = $\Delta L/L$

$$P = P_0 + \rho g h$$
$$A_1 v_1 = A_2 v_2$$
$$P_1 + \frac{1}{2}\rho v_1{}^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2{}^2 + \rho g y_2$$
$$\Delta L = \alpha L_0 \Delta T$$
$$\Delta V = 3\alpha V_0 \Delta T$$
$$KE_{ave} = \frac{1}{2} m v_{ave}{}^2 = \frac{3}{2} k_B T$$
$$\frac{\Delta Q}{\Delta t} = kA\frac{T_2 - T_1}{L}$$

$$P = e\sigma A T^4$$
$W_{on\ gas} = -P\Delta V$ (constant pressure)

$U = \frac{3}{2} nRT = \frac{3}{2} Nk_B T$ (monatomic ideal gas)

Definition: $e = \frac{|W_{net}|}{Q_h} = 1 - \frac{Q_c}{Q_h}$

Carnot Theorem: $e_{\max} = e_c = 1 - \frac{T_c}{T_h}$

To be memorized

Continued from exams 1-3

Definition: $v_{ave} = < v > = \frac{\Delta x}{\Delta t}$

Definition: $a_{ave} = < a > = \frac{\Delta v}{\Delta t}$

For constant a:

$$v = v_o + at$$
$$v_{ave} = < v > = \frac{v_i + v_f}{2}$$

Newton's 2nd Law: $\sum \vec{F} = m\vec{a}$

Newton's 3rd Law: $\vec{F}_{12} = -\vec{F}_{21}$

Definition: $W = F_{//}\,\Delta x = F\cos\theta\,\Delta x$
Definition: $KE = ½\, m\, v^2$
<u>Colton conservation of energy</u>: $E_{before} + W_{net} = E_{after}$
<u>Hess conservation of energy</u>: $KE_i + PE_i + W_{in} = KE_f + PE_f + W_{out}$
Definition: $P = \Delta E/\Delta t$
Definition of momentum: $p = mv$
Conservation of momentum: $\sum p_{before} = \sum p_{after}$ (if no outside force)
Angular kinematics: replace x with θ, v with ω, and a with α in all the kinematics formulas
Quick derivation of satellite velocity: $\frac{GMm}{r^2} = m\frac{v^2}{r}$
Period: $T = 2\pi r/v$
Definition of torque: $\tau = r_\perp F = rF_\perp = rF\sin\theta$
Moment of inertia for point mass: $I = mr^2$
$I_{tot} = I_1 + I_2 + \ldots$
Angular KE: $KE = ½\, I\, \omega^2$
Newton's 2nd Law for torques: $\sum \tau = I\alpha$
Definition of angular momentum: $L = r_\perp p = rp_\perp = rp\sin\theta$, also $L = I\omega$

New for exam 4

Definition: $\rho = \frac{m}{V}$
Definition: $P = \frac{F}{A}$
Archimedes' Principle: $F_B = w_{displaced\,fluid} = m_{displaced\,fluid} \times g = \rho_{fluid} V_{displaced}\, g$

Ideal Gas Law $PV = nRT = Nk_BT$
Calorimetry: $Q = mc\Delta T$; $Q = mL$
P-V diagram: $W_{on\ system}$ = area under the curve, positive if decreasing volume
First Law of Thermodynamics: $\Delta U = Q_{added} + W_{on\ system}$
Definition: isothermal = no temperature change
Definition: adiabatic = no heat exchanged
Cycles: $\Delta U = 0$; $|W_{net}| = Q_{added} - Q_{exhausted} = Q_h - Q_c$