PHYSICS 1401

Avg speed = $\dfrac{\text{DISTANCE}}{\text{ELAPSED TIME}}$

$\vec{v}_{AVG} = \dfrac{\Delta \vec{x}}{\Delta t}$; $\vec{v}(t) = \lim_{\Delta t \to 0} \dfrac{\Delta \vec{x}}{\Delta t}$

$\vec{a}_{AVG} = \dfrac{\Delta \vec{v}}{\Delta t}$; $\vec{a}(t) = \lim_{\Delta t \to 0} \dfrac{\Delta \vec{v}}{\Delta t}$

$G = 6.673 \times 10^{-11} \dfrac{N\text{-}m^2}{kg^2}$

$g = 9.81\ m/s^2$

$M_e = 5.98 \times 10^{24}$ kg

$r_e = 6.38 \times 10^{6}$ m.

$M_J = 1.90 \times 10^{27}$ kg

$R_J = 6.91 \times 10^{7}$ m.

$v = v_0 + at$

$x = \frac{1}{2}(v_0 + v)t$ (const. accel.)

$x = v_0 t + \frac{1}{2}at^2$

$v^2 = v_0^2 + 2as$ (s = displacement)

Applies to x direction and y-direction

For gravity

$a_y = \pm g$

$a_x = 0$

In general

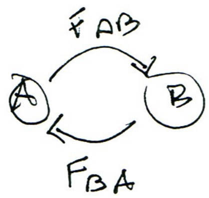
$a_x \neq 0$

$a_y \neq 0$

Newton's Laws

1. $\Delta \vec{v} = 0$ if net $\vec{F} = 0$
2. $\vec{F} = m\vec{a}$
3. Action-Reaction

$F_{AB} = -F_{BA}$



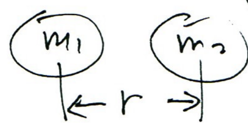
CENTRIPETAL FORCE

$F_c = ma_c = \dfrac{mv^2}{r}$

$\omega = 2\pi f = \dfrac{2\pi}{T}$

GRAVITATION

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



$F_c = \dfrac{G m M_E}{r^2} = \dfrac{mv^2}{r} \longrightarrow v = \sqrt{\dfrac{G M_E}{r}}$

$T = \dfrac{2\pi r^{3/2}}{\sqrt{G M_E}}$

FRICTION

$f_s^{MAX} = \mu_s F_N$ STATIC

$f_k = \mu_k F_N$ KINETIC

EXAM 2 — FORMULA SHEET

WORK: $W = (F\cos\theta)s$

KINETIC ENERGY $= KE = \frac{1}{2}mv^2$

WORK-ENERGY THEOREM

$$W = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

GRAVITATIONAL POTENTIAL ENERGY

$$PE = mgh$$

CONSERVATION OF MECHANICAL ENERGY

$$E = KE + PE$$

AVERAGE POWER

$$P_{AVG} = \frac{\text{WORK (J)}}{\text{TIME (s)}} \text{ ; } WATT = \frac{J}{s}$$

IMPULSE

$$J = F_{AVG} \cdot \Delta t \text{ (N·s)}$$

LINEAR		CIRCULAR
d	$=$	$r\theta$
v	$=$	$r\omega$
a	$=$	$r\alpha$

LINEAR MOMENTUM

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

IMPULSE-MOMENTUM THEOREM

$$(\Sigma \vec{F}_{AVG})\Delta t = m\vec{v}_f - m\vec{v}_i$$

CONSERVATION OF LINEAR MOMENTUM

IF $\Sigma \vec{F}_{AVG} = 0$ $\quad p_f = p_i$

CENTER OF MASS

$$x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$$

AVERAGE ANGULAR VELOCITY

$$\omega_{AVG} = \frac{\theta - \theta_0}{t - t_0} = \frac{\Delta\theta}{\Delta t} \left(\frac{rad}{s}\right)$$

AVERAGE ANGULAR ACCELERATION

$$\alpha_{AVG} = \frac{\omega - \omega_0}{t - t_0} = \frac{\Delta\omega}{\Delta t} \left(\frac{rad}{s^2}\right)$$

KINEMATIC EQUATIONS
(α = CONSTANT)

$$\omega = \omega_0 + \alpha t$$

$$\theta = \frac{1}{2}(\omega_0 + \omega)t$$

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

WORK $= \tau\theta$

KE $= \frac{1}{2}I\omega^2$

ANGULAR MOMENTUM

$$L = I\omega$$

CONSERVATION OF ANGULAR MOMENTUM

IF $\Sigma \tau_{EXT} = 0$
L = CONSTANT

TORQUE

$$\tau = F \cdot \ell \text{ (N·m)}$$

EQUILIBRIUM OF A RIGID BODY

$$\Sigma F_x = 0, \ \Sigma F_y = 0, \ \Sigma \tau = 0$$

ROTATIONAL 2ND LAW

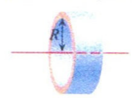
$\Sigma \tau = I\alpha$; I = MOMENT OF INERTIA

MOMENT OF INERTIA

$$I = \sum_{i=1}^{n} m_i r_i^2$$

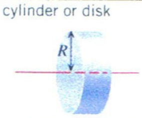
Table 9.1 *Moments of Inertia for Various Rigid Objects of Mass M*

Thin-walled hollow cylinder or hoop



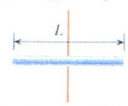
$I = MR^2$

Solid cylinder or disk



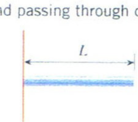
$I = \frac{1}{2}MR^2$

Thin rod, axis perpendicular to rod and passing through center



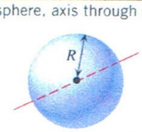
$I = \frac{1}{12}ML^2$

Thin rod, axis perpendicular to rod and passing through one end



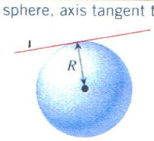
$I = \frac{1}{3}ML^2$

Solid sphere, axis through center



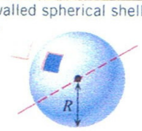
$I = \frac{2}{5}MR^2$

Solid sphere, axis tangent to surface



$I = \frac{7}{5}MR^2$

Thin-walled spherical shell, axis through center



$I = \frac{2}{3}MR^2$

EXAM 3 – FORMULA SHEET

SPRING

$F = -KX$ HOOKE'S LAW

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

(ω in radians)

A = amplitude of motion

$v_{max} = A\omega$ (rad/s)

$a_{max} = A\omega^2$ (rad/s²)

$\omega = \sqrt{\frac{k}{m}}$

POTENTIAL ENERGY

$PE_{elastic} = \frac{1}{2}kx^2$

$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + mgh + \frac{1}{2}kx^2$

PENDULUM

$\omega = 2\pi f = \sqrt{\frac{g}{L}}$

$T = 2\pi\sqrt{\frac{L}{g}}$

ELASTIC DEFORMATION

YOUNG'S MODULUS $F = Y\left(\frac{\Delta L}{L_0}\right)A$

SHEAR MODULUS $F = S\left(\frac{\Delta X}{L_0}\right)A$

PRESSURE $P = \frac{F}{A}$

BULK MODULUS $\Delta P = -B\left(\frac{\Delta V}{V_0}\right)$

MASS DENSITY

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

PRESSURE IN A STATIC FLUID

$P_2 = P_1 + \rho g h$

PASCAL'S PRINCIPLE

ANY CHANGE IN PRESSURE APPLIED TO A COMPLETELY ENCLOSED FLUID IS TRANSMITTED UNDIMINISHED TO ALL PARTS OF THE FLUID AND THE ENCLOSING WALLS.

ARCHIMEDES PRINCIPLE

BUOYANT FORCE = WEIGHT OF FLUID DISPLACED.

PERIODIC WAVES

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

WAVE ON A STRING

$v = \sqrt{\frac{F}{m/L}}$

$y = A \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) \rightarrow +x$

$y = A \sin 2\pi\left(\frac{t}{T} + \frac{x}{\lambda}\right) \leftarrow -x$

SOUND INTENSITY

$I\left(\frac{W}{m^2}\right) = \frac{\text{POWER}}{\text{AREA}}$

$I_0 = 1 \times 10^{-12}\,\frac{W}{m^2}$ (THRESHOLD OF HEARING)

$I = \frac{P}{4\pi R^2}$

DECIBELS

$\beta = (10\text{ dB})\log\left(\frac{I}{I_0}\right)$

PHASE	DESC.	PATH DIFFERENCE
0°	IN PHASE	$\Delta x = n\lambda$ CONSTRUCTIVE $\Delta x = \frac{m\lambda}{2}$ DESTRUCTIVE
180°	EXACTLY OUT OF PHASE	$\Delta x = \frac{m\lambda}{2}$ CONSTRUCTIVE $\Delta x = n\lambda$ DESTRUCTIVE

$n = 1, 2, 3, 4, \ldots$; $m = 1, 3, 5, 7, \ldots$

TRANSVERSE STANDING WAVES

$f_n = n\left(\frac{v}{2L}\right)$; $n = 1, 2, 3, 4, \ldots$ STRING FIXED AT BOTH ENDS. L = LENGTH.

LONGITUDINAL STANDING WAVES (PIPES)

OPEN BOTH ENDS

$f_n = n\left(\frac{v}{2L}\right)$

$n = 1, 2, 3, 4, \ldots$

CLOSED ONE END

$f_n = n\left(\frac{v}{4L}\right)$

$n = 1, 3, 5, 7, \ldots$

THERMAL EXPANSION

$\Delta l = l_0 \alpha \Delta T$; $\Delta V = V_0 3\alpha \Delta T$

$\Delta A = A_0 2\alpha \cdot \Delta T$

SPECIFIC HEAT

$\Delta Q = mc\Delta T$

CONDUCTION OF HEAT

$$\frac{\Delta Q}{\Delta t} = KA\frac{\Delta T}{\Delta l}$$

1ST LAW OF THERMODYNAMICS

$\Delta Q = \Delta U + W$; MONOATOMIC $\Delta U = \frac{3}{2} nR\Delta T$; DIATOMIC $\Delta U = \frac{5}{2} nR\Delta T$

2ND LAW OF THERMODYNAMICS

$\Delta S = \frac{\Delta Q}{T}$ (CHANGE IN ENTROPY AT CONSTANT T)

IDEAL GAS LAW

$PV = nRT$

STD PRESSURE = 1 ATM
$= 1.013 \times 10^5$ Pa

STD TEMP = $0°C$
$= 273.15$ K

AT STD T + STD P
1 mole of gas
occupies 22.4 Liters

HEAT OF FUSION

$Q = L_f m$

HEAT OF VAPORIZATION

$Q = L_v m$

RADIATION

$P_{net} = \sigma A e (T_s^4 - T^4)$

THEMAL VOL EXPAN

$\Delta V = \beta V_0 \Delta T$

WORK

ISOBARIC
$W = P\Delta V$

ISOTHERMIC
$W = nRT \ln\left(\frac{V_2}{V_1}\right)$

ADIABATIC
$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$

$\gamma = \frac{C_P}{C_V}$

σ: STEFAN BOLTZMAN CONSTANT
$= 5.67 \times 10^{-8}$ W/m$^2 \cdot$K^4

1 cal $= 4.186$ J

$k_B = 1.38 \times 10^{-23}$ J/K

$R = 8.31$ J/(mol$\cdot$K)

HEAT OF VAPORIZATION

(H_2O) $L_v = 540$ cal/g

HEAT OF FUSION

(H_2O) $L_f = 80$ cal/g

SPECIFIC HEAT

cal/g$\cdot$°C @ 20°C

ALUM.	0.214
COPPER	0.092
IRON	0.119
LEAD	0.0306
WATER	1.00
STEAM	0.48
ICE	0.50

AVAGADRO'S NO.
$N_A = 6.02 \times 10^{23}$ $\frac{\text{molecules}}{\text{mole}}$

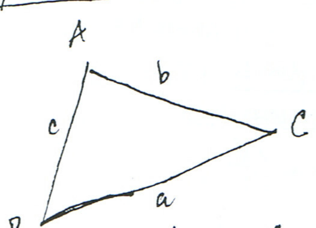
STD PRESSURE = 1 ATM
1.013×10^5 PA

STD TEMP $0°C = 273$K

VOL = 22.7 LITERS

then $n = 1$ MOLE

LAW OF SINES



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

LAW OF COSINES

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