FORMULAS – Final Exam

Conversion Factors: 1 inch = 2.54 cm; 1 mi =1609.3 m; 1 cm=10^{-2}; 1 mm= 10^{-3} m; 1 g=10^{-3} kg;

Physical constants: $g = 9.8\ \text{m/s}^2$; $G = 6.674\times10^{-11}\ \text{N m}^2/\text{kg}^2$; $M_{Earth} = 5.97\times10^{24}$ kg ; $R_{Earth} = 6.37\times10^6$ m

Math: 360° = 2π radians = 1 revolution. Arc length $s = r\theta$; $V_{sphere} = 4\pi R^3/3$; $A_{sphere} = 4\pi R^2$; $A_{circle} = \pi R^2$

quadratic formula to solve $ax^2 + bx + c = 0$: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors: $\vec{A} = A_x\hat{i} + A_y\hat{j}$; $A_x = |\vec{A}|\cos(\theta)$; $A_y = |\vec{A}|\sin(\theta)$; $|\vec{A}| = \sqrt{A_x^{\,2} + A_y^{\,2}}$; $\tan\theta = \dfrac{A_y}{A_x}$

$\vec{C} = \vec{A} + \vec{B}$ implies $C_x = A_x + B_x$; $C_y = A_y + B_y$

$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos(\theta) = A_xB_x + A_yB_y + A_zB_z$; $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k} = 1$; $\hat{\imath}\cdot\hat{\jmath} = \hat{\imath}\cdot\hat{k} = \hat{\jmath}\cdot\hat{k} = 0$

$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$; $\vec{A}\times\vec{B} = \hat{i}(A_yB_z - A_zB_y) + \hat{j}(A_zB_x - A_xB_z) + \hat{k}(A_xB_y - A_yB_x)$

$\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = 0$; $\hat{i}\times\hat{j} = \hat{k}$; $\hat{j}\times\hat{k} = \hat{i}$; $\hat{k}\times\hat{i} = \hat{j}$

1D and 2D motion:

$\vec{v}_{avg} = \dfrac{\Delta\vec{r}}{\Delta t}$; $\vec{a}_{avg} = \dfrac{\Delta\vec{v}}{\Delta t}$; $\vec{v} = \dfrac{d\vec{x}}{dt}$; $\vec{a} = \dfrac{d\vec{v}}{dt} = \dfrac{d^2\vec{r}}{dt^2}$

$x = x_i + v_i t + \dfrac{1}{2}at^2$; $v = v_i + at$; $v^2 = v_i^2 + 2a(x - x_i)$; $\vec{r} = \vec{r}_i + \vec{v}_i t + \dfrac{1}{2}\vec{a}t^2$; $\vec{v} = \vec{v}_i + \vec{a}t$

Circular motion: $T = 2\pi R/v$; $T = 2\pi/\omega$; $a_c = v^2/R$

Newtons Laws: $\sum\vec{F} = m\vec{a}$; $\vec{F}_{12} = -\vec{F}_{21}$

Friction: $f_s \le \mu_s N$; $f_k = \mu_k N$

Energies: $K = \frac{1}{2}mv^2$; $U_g = mgy$; $U_s = \frac{1}{2}kx^2$; $W = -\int\vec{F}\cdot d\vec{r} = -\vec{F}\cdot\Delta\vec{r}$

$E_{total} = K + U_g + U_S$; $\Delta E_{mech} = \Delta K + \Delta U_g + \Delta U_s = -f_s d$; $\text{P} = \dfrac{\text{dW}}{\text{dt}} = \vec{\text{F}}\cdot\vec{\text{v}}$; $\Delta K = W$

Momentum and Impulse: $\vec{p} = m\vec{v}$; $\vec{I} = \int\vec{F}dt = \Delta\vec{p}$

Center of mass: $\vec{r}_{cm} = \sum_i m_i\vec{r}_i / \sum_i m_i$; $\vec{v}_{cm} = \sum_i m_i\vec{v}_i / \sum_i m_i$

Collisions: $\vec{p}$ = const and E≠ const (inelastic) or $\vec{p}$ = const and E= const (elastic)

Rotational motion: $\omega = 2\pi/T$; $\omega = d\theta/dt$; $\alpha = d\omega/dt$; $v_t = r\omega$; $a_t = r\alpha$ $a_c = a_r = v_t^2/r = \omega^2 r$

$a_{tot}^2 = a_r^2 + a_t^2$; $v_{cm} = r\omega$ (rolling, no slipping) ; $a_{cm} = r\alpha$

$\omega = \omega_o + \alpha t$; $\theta_f = \theta_i + \omega_o t + \alpha t^2/2$; $\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$

$I_{point} = MR^2$; $I_{hoop} = MR^2$; $I_{disk} = MR^2/2$; $I_{sphere} = 2MR^2/5$; $I_{shell} = 2MR^2/3$; $I_{rod\,(center)} = ML^2/12$

$I_{rod\,(end)} = ML^2/3$; $I = \sum_i m_i r_i^2$; $I = I_{cm} + Mh^2$; $\vec{\tau} = \vec{r}\times\vec{F}$; $\sum\tau = I\alpha$; $\vec{L} = \vec{r}\times\vec{p}$; $\vec{L} = I\vec{\omega}$

Energy: $K_{rot} = I\omega^2/2$; $K = K_{rot} + K_{cm}$; $\Delta K + \Delta U = 0$; $W = \tau\,\Delta\theta$; $P_{inst} = \tau\omega$

Fluid: $\rho = \frac{\text{M}}{\text{V}}$; $\text{P} = \text{P}_\text{o} + \rho\text{gh}$; $\text{A}_1\text{v}_1 = \text{A}_2\text{v}_2$; $\text{P}_1 + \rho\text{gy}_1 + \frac{1}{2}\rho\text{v}_1^2 = \text{P}_2 + \rho\text{gy}_2 + \frac{1}{2}\rho\text{v}_2^2$

Gravitation: $\vec{F}_g = -\dfrac{Gm_1m_2}{r^2}\hat{r}_{12}$; $g(r) = GM/r^2$; $U = -Gm_1m_2/r$; $T^2 = \dfrac{4\pi^2}{GM}a^3$

Oscillatory motion: $= \frac{1}{2\pi}\sqrt{\frac{k}{M}}$; $f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$; $\text{x(t)} = \text{A}\cos(\omega\text{t} + \varphi)$; $\text{v(t)} = \frac{\text{dx}}{\text{dt}}$; $\text{a(t)} = \frac{\text{dv}}{\text{dt}}$; $\text{E} = \frac{1}{2}\text{kA}^2$