PS 161 Exam 4 Formulas

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$$s = r\theta \qquad v = r\omega \qquad a = r\alpha \tag{1}$$

$$\omega = \omega_0 + \alpha t \tag{2}$$

$$\theta = \omega_{\text{av}}t = \omega_0 t + \frac{\alpha}{2}t^2 \tag{3}$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta \tag{4}$$

$$a_{\text{rad}} = \frac{v^2}{r} = r\omega^2 \tag{5}$$

$$I = \sum_{i=1}^{N} m_i r_i^2 = \int r^2 \,\mathrm{d}m = \int r^2 \lambda(r)\,\mathrm{d}r \tag{6}$$

$$I = I_{\text{cm}} + md^2 \implies I_2 = I_1 + m\left(d_2^2 - d_1^2\right) \tag{7}$$

$$K_{\text{rot}} = \frac{1}{2}I\omega^2 \tag{8}$$

$$W = \Delta K_{\text{lin}} + \Delta K_{\text{rot}} \tag{9}$$

$$U_{\text{grav}} = mgy_{\text{cm}} \tag{10}$$

$$\tau = \vec{r} \times \vec{F} = F\ell = F_\perp r = rF\sin\theta = I\alpha = \dot{L} \tag{11}$$

$$x_{\text{cg}} = x_{\text{cm}} \quad \text{(usually)} \tag{12}$$

$$\text{statics} \implies \sum F = \sum \tau = 0 \tag{13}$$

$$\text{rolling without slipping} \implies v_{\text{cm}} = r\omega \quad \wedge \quad a_{\text{cm}} = r\alpha \tag{14}$$

$$P = \tau\omega \tag{15}$$

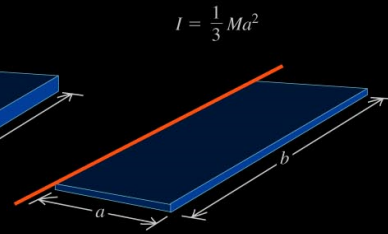**(a)** Slender rod,
axis through center

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

(b) Slender rod,
axis through one end

$I = \frac{1}{3}ML^2$
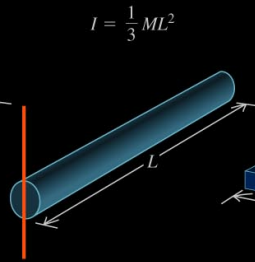
(c) Rectangular plate,
axis through center

$I = \frac{1}{12}M(a^2 + b^2)$
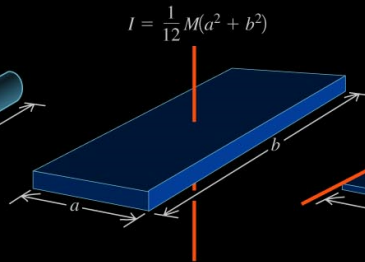
(d) Thin rectangular plate,
axis along edge

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

(e) Hollow cylinder

$I = \frac{1}{2}M(R_1^2 + R_2^2)$

(f) Solid cylinder

$I = \frac{1}{2}MR^2$
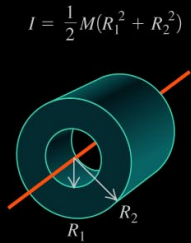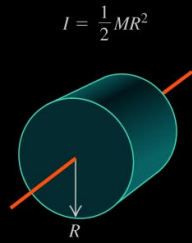
(g) Thin-walled hollow
cylinder

$I = MR^2$

(h) Solid sphere

$I = \frac{2}{5}MR^2$
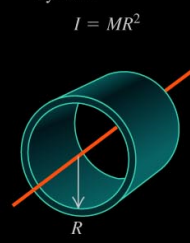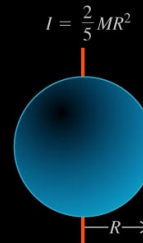
(i) Thin-walled hollow
sphere
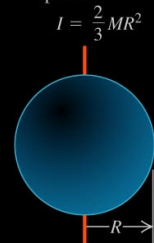
$I = \frac{2}{3}MR^2$

$$L = \vec{r} \times \vec{p} = mvr\sin\theta = mv\ell = I\omega \qquad (16)$$

$$L_0 = L_1 \quad \text{(assuming no external torque)} \qquad (17)$$