Instructor(s): *Profs. Acosta, Hamlin, Muttalib*

PHYSICS DEPARTMENT

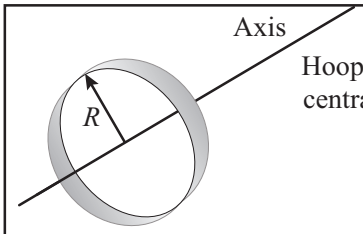
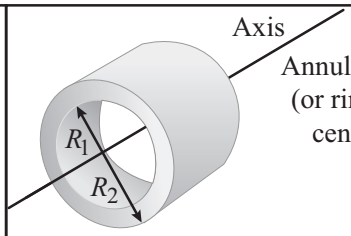
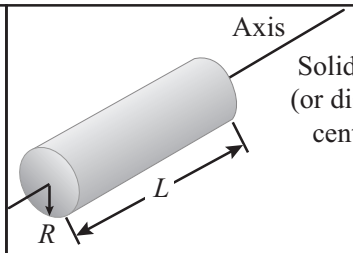
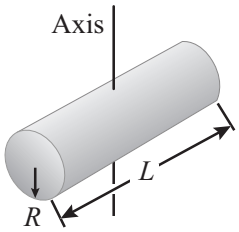
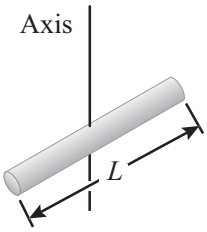
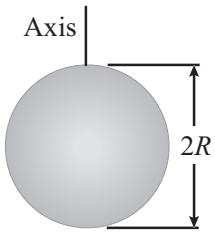
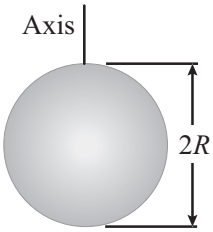
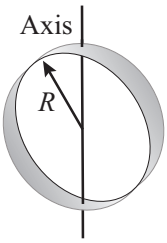
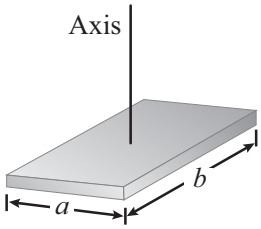
PHY 2048 Exam 2 March 24, 2017

Name (print, last first): _____ Signature: _____

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

(1) **Code your test number on your answer sheet (use lines 76–80 on the answer sheet for the 5-digit number)**. Code your name on your answer sheet. **DARKEN CIRCLES COMPLETELY**. Code your UFID number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch work anywhere on this exam that you like. **Circle your answers on the test form.** At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout.
(4) **Blacken the circle of your intended answer completely, using a #2 pencil or <u>blue</u> or <u>black</u> ink**. Do not make any stray marks or some answers may be counted as incorrect.
(5) **The answers are rounded off. Choose the closest to exact. There is no penalty for guessing. If you believe that no listed answer is correct, leave the form blank.**
(6) Hand in the answer sheet separately.

 Hoop about central axis $I = MR^2$	 Annular cylinder (or ring) about central axis $I = \frac{1}{2}\ M(R_1^2 + R_2^2)$	 Solid cylinder (or disk) about central axis $I = \frac{1}{2} MR^2$
 Solid cylinder (or disk) about central diameter $I = \frac{1}{4} MR^2 + \frac{1}{12} ML^2$	 Thin rod about axis through center perpendicular to length $I = \frac{1}{12}\ ML^2$	 Solid sphere about any diameter $I = \frac{2}{5} MR^2$
 Thin spherical shell about any diameter $I = \frac{2}{3} MR^2$	 Hoop about any diameter $I = \frac{1}{2}\ MR^2$	 Slab about perpendicular axis through center $I = \frac{1}{12} M(a^2 + b^2)$

Formula-sheet: Exam 1

- *For constant acceleration $\vec{a}$:*

$$\vec{v} = \vec{v}_0 + \vec{a}t \qquad v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$
$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2 \qquad v_y^2 = v_{y0}^2 + 2a_y(y - y_0)$$

  Acceleration due to gravity: $g = 9.8\ \mathrm{m/s^2} = 32\ \mathrm{ft/s^2}$ vertically down.

- *For force acting on a body of mass m:* $\vec{F} = m\vec{a}$
- Frictional forces: $f_{s,max} = \mu_s N$; $f_k = \mu_k N$. N : normal force.
- *For uniform circular motion:* centripetal acceleration is $a_c = \dfrac{v^2}{r}$
- Kinetic energy: $K = \dfrac{1}{2}mv^2$
- Work done by a constant force: $W = \vec{F} \cdot \vec{d} = Fd \cos$ (angle between $\vec{F}$ and $\vec{d}$)
- Work-kinetic energy theorem: $W = K_f - K_i$
- Vectors (2d): $\vec{A} = \hat{\imath}A_x + \hat{\jmath}A_y$; $A = \sqrt{A_x^2 + A_y^2}$;

  $A_x = A\cos$(angle between $\vec{A}$ and $\hat{\imath}$); $A_y = A\sin$(angle between $\vec{A}$ and $\hat{\imath}$)

Formula-sheet: Exam 2

- Potential Energy: $\Delta U = -W = -\displaystyle\int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r}$ $\quad F_x = -\dfrac{dU}{dx}$

  Gravitational (y=up): $F_y = -mg$ $\quad U(y) = mgy$

  Elastic (x from spring equilibrium): $F_x = -kx$ $\quad U(x) = \dfrac{1}{2}kx^2$
- Mechanical Energy: $E_{\mathrm{mec}} = K + U$
  E_{mec} = constant for an isolated system with conservative forces
- Work-Energy: $W(\text{external}) = \Delta K + \Delta U + \Delta E(\text{thermal})$
- Center of Mass: $\vec{r}_{\mathrm{com}} = \dfrac{1}{M_{\mathrm{tot}}}\displaystyle\sum_{i=1}^{N} m_i\vec{r}_i$ $\quad M_{\mathrm{tot}} = \displaystyle\sum_{i=1}^{N} m_i$
- Linear Momentum: $\vec{p} = m\vec{v}$ $\quad$ Impulse: $\vec{J} = \Delta\vec{p} = \displaystyle\int_{t_i}^{t_f} \vec{F}(t)dt = \vec{F}_{\mathrm{av}}\Delta t$

  $\vec{F} = \dfrac{d\vec{p}}{dt}$ $\quad$ If $\vec{F} = \dfrac{d\vec{p}}{dt} = 0$ then $\vec{p} =$ constant and $\vec{p}_f = \vec{p}_i$

  $\vec{P}_{\mathrm{tot}} = M_{\mathrm{tot}}\,\vec{v}_{\mathrm{com}} = \displaystyle\sum_{i=1}^{N} \vec{p}_i$ $\qquad \vec{F}_{\mathrm{net}} = \dfrac{d\vec{P}_{\mathrm{tot}}}{dt} = M_{\mathrm{tot}}\,\vec{a}_{\mathrm{com}}$

- Elastic Collisions of Two Bodies, 1D

  $v_{1f} = \dfrac{m_1 - m_2}{m_1 + m_2} v_{1i} + \dfrac{2m_2}{m_1 + m_2} v_{2i}$ $\qquad$ $v_{2f} = \dfrac{2m_1}{m_1 + m_2} v_{1i} + \dfrac{m_2 - m_1}{m_1 + m_2} v_{2i}$

- Rockets: Thrust $= Ma = v_{\text{rel}} \dfrac{dM}{dt}$ $\qquad$ $\Delta v = v_{\text{rel}} \ln\left(\dfrac{M_i}{M_f}\right)$

- Rotational Variables

  angular position: $\theta(t)$ $\qquad$ angular velocity: $\omega(t) = \dfrac{d\theta(t)}{dt}$

  angular acceleration: $\alpha(t) = \dfrac{d\omega(t)}{dt} = \dfrac{d^2\theta(t)}{dt^2}$

- *For constant angular acceleration α:*

$$\omega = \omega_0 + \alpha t \qquad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \qquad \theta = \theta_0 + \frac{1}{2}(\omega + \omega_0)t$$

- Angular to linear relationships for circular motion
  arc length: $s = r\theta$ $\qquad$ velocity: $v = r\omega$
  tangential acceleration: $a_{\text{T}} = r\alpha$ $\qquad$ centripetal acceleration: $a_{\text{c}} = r\omega^2$

- Rotational Inertia: $I = \sum_{i=1}^{N} m_i r_i^2$ (discrete)

  $I = \int r^2\, dm$ (uniform)
  Parallel Axis: $I = I_{\text{com}} + M_{\text{tot}} d^2$ (d is displacement from com)

- Rotational, Rolling Kinetic Energy: $K_{\text{rot}} = \dfrac{1}{2} I\omega^2$ $\quad$ $K_{\text{roll}} = \dfrac{1}{2} M v_{\text{com}}^2 + \dfrac{1}{2} I_{\text{com}} \omega^2$

  Rolling without slipping: $x_{\text{com}} = r\theta$ $\quad$ $v_{\text{com}} = r\omega$ $\quad$ $a_{\text{com}} = r\alpha$

- Torque: $\vec{\tau} = \vec{r} \times \vec{F}$ $\qquad$ (where $\hat{k} = \hat{\imath} \times \hat{\jmath}$ gives directions for cross product)

  $\tau = rF$ sin (angle between $\vec{r}$ and $\vec{F}$) $= rF_{\perp}$

- Angular Momentum: $\vec{L} = \vec{r} \times \vec{p}$ $\qquad$ $\vec{\tau} = \dfrac{d\vec{L}}{dt}$

  $L = rp$ sin (angle between $\vec{r}$ and $\vec{p}$) $= rp_{\perp}$

  If $\vec{\tau}_{\text{net}} = \dfrac{d\vec{L}}{dt} = 0$ then $\vec{L} =$ constant and $\vec{L}_f = \vec{L}_i$

- Work done by a constant torque: $W = \tau\Delta\theta = \Delta K_{\text{rot}} = \dfrac{1}{2} I\omega_2^2 - \dfrac{1}{2} I\omega_1^2$
- Power done by a constant torque: $P = \tau\omega$
- *For torque acting on a body with rotational inertia I: $\vec{\tau} = I\vec{\alpha}$*
- Stress and Strain (Y = Young's modulus, B = bulk modulus)

  Linear: $\dfrac{F}{A} = Y \dfrac{\Delta L}{L}$

  Volume: $P = \dfrac{F}{A} = -B \dfrac{\Delta V}{V}$

- *For torque acting on a body with rotational inertia I: $\vec{\tau} = I\vec{\alpha}$*