Physics 201 Fall 2023

Name (signature as on ID) ____________________ Name (printed) Key

Lab Section _________ Instructor (Ford, Holt, Kelly, Schuessler) ____________________

Exam 3 Chapters 9, 10, 11 in Young, Adams 11e

Multiple choice questions. Circle the correct answer. No work needs to be shown and no partial credit will be given.

(5 pts) 1. Two uniform solid cylinders are of the same size but different mass. They are released simultaneously at the same time at the top of an incline and ~~role~~ roll without slipping to the bottom of the incline. Which of the following statements is true.

b

(a) The heavier cylinder reaches the bottom of the incline ahead of the lighter one.
(b) Both cylinders reach the bottom of the incline at the same time.
(c) The lighter cylinder reaches the bottom of the incline before the heavier one.
(d) The lighter cylinder has greater translational speed at the bottom of the incline than the heavier one.

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

$\frac{1}{2}I\omega^2 = \frac{1}{2}\left(\frac{1}{2}mR^2\right)\left(\frac{V}{R}\right)^2 = \frac{1}{4}mv^2$

$mgh = \frac{3}{4}mv^2$

$v = \sqrt{\frac{4}{3}gh}$

The mass and radius divide out. The speed at the bottom depends only on the shape

(5 pts) 2. A uniform solid sphere is rolling without slipping on a horizontal surface. What fraction of its total kinetic energy is rotational?

d

(a) 1/2
(b) 1/3
(c) 2/5
(d) 2/7
(e) 2/3
(f) none of the above answers

$K_{tot} = K_{rot} + K_{trans}$

$K_{trans} = \frac{1}{2}mv^2$

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

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

$K_{rot} = \frac{1}{2}\left(\frac{2}{5}mR^2\right)\left(\frac{V}{R}\right)^2 = \frac{1}{5}mv^2$

$K_{tot} = \frac{1}{5}mv^2 + \frac{1}{2}mv^2 = \frac{7}{10}mv^2$

$\frac{K_{rot}}{K_{tot}} = \frac{\frac{1}{5}mv^2}{\frac{7}{10}mv^2} = \frac{1}{5}\left(\frac{10}{7}\right) = \frac{2}{7}$

(5 pts) 3. A uniform solid disk with mass 4.00 kg and radius $R = 0.500$ m is mounted on an axle at its center. It starts at rest and then starts to rotate with constant angular acceleration $\alpha = 2.00\ \text{rad/s}^2$ What is its rotational kinetic energy after it has turned through 16.0 rad ?

c

(a) 8.0 J
(b) 12.0 J
(c) 16.0 J
(d) 20.0 J
(e) 20.0 J
(f) none of the above answers

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

$I = \frac{1}{2}mR^2 = \frac{1}{2}(4.0\text{kg})(0.50\text{m})^2 = 0.50\ \text{kg}\cdot\text{m}^2$

$\alpha = 2\ \text{rad/s}^2$

$\theta - \theta_0 = 16\ \text{rad}$

$\omega_0 = 0$

$\omega = ?$

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

$\omega = \sqrt{2(2\text{rad/s}^2)(16\text{rad})} = 8\ \text{rad/s}$

$K = \frac{1}{2}(0.50\ \text{kg}\cdot\text{m}^2)(8\ \text{rad/s})^2 = 16\text{J}$

(5 pts) 4. A uniform disk with mass 4.00 kg and radius $R = 0.500$ m is mounted on a frictionless axle at its center. It starts from rest and starts to rotate with constant angular acceleration $\alpha = 3.00$ rad/s^2. After it has rotated for 4.00 s what is the translational speed of a point on the rim of the disk?

$V = R\omega$ $\qquad$ $V = (0.5\text{ m})(12\text{ rad/s}) = 6\text{ m/s}$

b

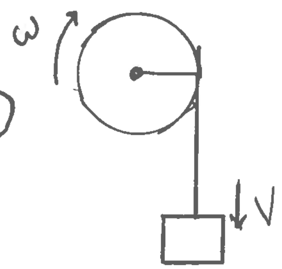
(a) 3.00 m/s
(b) 6.00 m/s
(c) 10.0 m/s
(d) 12.0 m/s
(e) 12.0 m/s
(f) none of the above answers

$t = 4$ s
$\alpha = 3$ rad/s^2
$\omega_0 = 0$
$\omega = \omega_0 + \alpha t = (3\text{ rad/s}^2)(4\text{ s}) = 12\text{ rad/s}$

(5 pts) 5. A light string is wrapped around the outer rim of a solid uniform cylinder that can rotate without friction about a fixed axle at its center. A block with mass 2.00 kg is suspended from the free end of the string as shown in the sketch. When the system is released from rest the block moves downward as the cylinder rotates. The block has speed 5.00 m/s after it has descended 2.00 m. If the cylinder has radius $R = 0.500$ m what is its moment of inertia for rotation about the axle?

b

(a) 0.250 kg•m^2
(b) 0.284 kg•m^2
(c) 0.500 kg•m^2
(d) 0.784 kg•m^2
(e) 1.12 kg•m^2
(f) none of the above answers



$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$
$mgh = (2\text{ kg})(9.8\text{ m/s}^2)(2\text{ m}) = 39.2\text{ J}$
$\frac{1}{2}mv^2 = \frac{1}{2}(2\text{ kg})(5\text{ m/s})^2 = 25.0\text{ J}$
$\frac{1}{2}I\omega^2 = 39.2\text{ J} - 25.0\text{ J} = 14.2\text{ J}$
$\omega = \frac{V}{R} = \frac{5.0\text{ m/s}}{0.5\text{ m}} = 10\text{ rad/s}$
$I = \frac{2(14.2\text{ J})}{(10\text{ rad/s})^2} = 0.284\text{ kg}\cdot\text{m}^2$

(5 pts) 6. A solid disk with radius 0.200 m is mounted on an axle through its center. It starts from rest and then rotates with constant angular acceleration $\alpha = 2.00$ rad/s^2. What is the radial component of the acceleration of a point on the rim of the disk after the disk has rotated for 4.00 s?

(a) 0.400 m/s^2
(b) 0.800 m/s^2
(c) 8.00 m/s^2
(d) 12.8 m/s^2
(e) 25.6 m/s^2
(f) none of the above answers

d

$a_{rad} = \frac{V^2}{R} = R\omega^2$
$\omega = \omega_0 + \alpha t = (2\text{ rad/s}^2)(4\text{ s}) = 8\text{ rad/s}$
$a_{rad} = (0.2\text{ m})(8\text{ rad/s})^2 = 12.8\text{ m/s}^2$

(5 pts) 7. A solid disk is mounted on an axle through its center. The disk is initially at rest and then starts to rotate with constant angular acceleration. If it turns through 20.0 rev in 10.0 s, what is its angular velocity at the instant when it has turned through 20.0 rev?

(a) 1.00 rev/s
(b) 2.00 rev/s
c (c) 4.00 rev/s
(d) 6.00 rev/s
(e) 8.00 rev/s
(f) none of the above answers

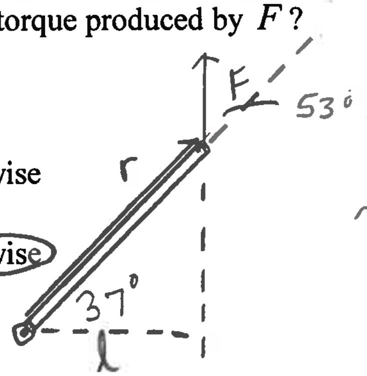
$\theta - \theta_0 = 20\text{ rev}$, $t = 10\text{ s}$, $\omega_0 = 0$, $\omega = ?$

$\theta - \theta_0 = \left(\frac{\omega_0 + \omega}{2}\right)t$

$\omega = \frac{2(\theta - \theta_0)}{t} = \frac{2(20\text{ rev})}{10\text{ s}} = 4\text{ rev/s}$

(5 pts) 8. A 2.00 m long bar is pivoted about an axis at its lower end. The bar makes a 37° angle with the horizontal. A vertical force $F = 5.00\text{ N}$ is applied to the upper end of the bar. What are the magnitude and direction of the torque produced by F?

(a) zero
(b) $6.00\text{ N}\bullet\text{m}$, clockwise
(c) $6.00\text{ N}\bullet\text{m}$, counterclockwise
(d) $8.00\text{ N}\bullet\text{m}$, clockwise
e (e) $8.00\text{ N}\bullet\text{m}$, counterclockwise
(f) none of the above answers



$\tau = Fl$

$l = (2\text{ m})\cos 37^\circ = 1.6\text{ m}$

$\tau = (5\text{ N})(1.6\text{ m}) = 8.0\text{ N}\cdot\text{m}$ ccw

(5 pts) 9. A uniform disk with radius $R = 0.400\text{ m}$ is mounted on a horizontal frictionless axle at its center. A light string is wrapped around the disk. The disk is initially at rest and then a constant force of 6.00 N is applied to the free end of the rope. After the force has been applied for 4.00 s the disk is rotating with angular velocity 12.0 rad/s. What is the mass of the disk?

(a) 2.0 kg
(b) 5.0 kg
c (c) 10.0 kg
(d) 15.0 kg
(e) 20.0 kg
(f) none of the above answers

$\tau = I\alpha$, $I = \frac{1}{2}mR^2$, $m = \frac{2I}{R^2} = \frac{2(0.8)}{(0.4)^2} = 10\text{ kg}$

$\omega_0 = 0$, $t = 4\text{ s}$, $\omega = 12\text{ rad/s}$, $\alpha = ?$

$\omega = \omega_0 + \alpha t$

$\alpha = \frac{\omega}{t} = \frac{12\text{ rad/s}}{4\text{ s}} = 3\text{ rad/s}^2$

$FR = I\alpha$

$I = \frac{(6\text{ N})(0.4\text{ m})}{3\text{ rad/s}^2} = 0.8\text{ kg}\cdot\text{m}^2$

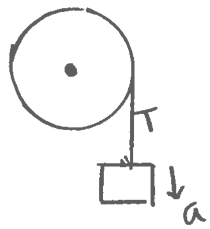
(5 pts) 10. A block is attached to a horizontal spring and moves in simple harmonic motion that has amplitude 0.300 m and frequency 5.00 Hz. For the same spring and block if the amplitude of the motion is changed to 0.150 m, what is then the frequency of the motion?

(a) 2.50 Hz
(b) 4.00 Hz
c (c) 5.00 Hz
(d) 10.0 Hz
(e) 15.0 Hz
(f) none of the above answers

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ does not depend on amplitude A

(5 pts) 11. A uniform disk with radius $R = 0.500$ m is mounted on a horizontal frictionless axle at its center. A light string is wrapped around the disk and a block is suspended from its free end as shown. The system is released from rest and the block moves downward with a constant acceleration of $4.00\ \text{m/s}^2$ as the disk rotates. While the block is descending the tension in the rope is 40.0 N. What is the moment of inertia of the disk for rotation about the axle?

(a) $2.0\ \text{kg}\cdot\text{m}^2$
b (b) $2.5\ \text{kg}\cdot\text{m}^2$
(c) $4.0\ \text{kg}\cdot\text{m}^2$
(d) $6.0\ \text{kg}\cdot\text{m}^2$
(e) $8.0\ \text{kg}\cdot\text{m}^2$
(f) none of the above answers 5.00 m/s



$\tau = I\alpha$

$I = \frac{TR}{\alpha}$

$\alpha = \frac{a}{R} = \frac{4\ \text{m/s}^2}{0.5\ \text{m}} = 8\ \text{rad/s}^2$

$I = \frac{(40\text{N})(0.5\text{m})}{8\ \text{rad/s}^2} = 2.5\ \text{kg}\cdot\text{m}^2$

(5 pts) 12. A block with mass 0.400 kg is attached to a horizontal spring that has force constant $k = 280$ N/m. The block is moving in simple harmonic motion on a frictionless surface. When the block is at $x = 0.200$ m it has speed 6.00 m/s. What is the amplitude of the motion of the block?

(a) 0.227 m
(b) 0.276 m
c (c) 0.302 m
(d) 0.356 m
(e) 0.406 m
(f) none of the above answers

$\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$

$\frac{1}{2}mv^2 = \frac{1}{2}(0.4\text{kg})(6\ \text{m/s})^2 = 7.2\text{J}$

$\frac{1}{2}kx^2 = \frac{1}{2}(280\ \text{N/m})(0.2\text{m})^2 = 5.6\text{J}$

$\frac{1}{2}kA^2 = 7.2\text{J} + 5.6\text{J} = 12.8\text{J}$

$A = \sqrt{\frac{2(12.8\text{J})}{280\ \text{N/m}}} = 0.302\text{m}$

(5 pts) 13. A block with mass 0.200 kg is attached to a horizontal spring that has force constant $k = 80.0$ N/m. The block is moving in simple harmonic motion on a horizontal frictionless surface. During its motion the maximum speed of the block is 5.00 m/s. During its motion what is the maximum magnitude of the force that the spring exerts on the block?

(a) 5 N
(b) 10 N
(c) 15 N
d (d) 20 N
(e) 30 N
(f) none of the above answers

(5 pts) 14. A light wire that has length 3.20 m and cross section area 2.00×10^{-6} m^2 is suspended from the ceiling. When a downward force of 500 N is applied to the lower end of the wire the length of the wire increases by 4.00×10^{-3} m . What is the value of Young's modulus for the material of the wire?

$Y = \frac{F/A}{\Delta l / l_0} = \frac{F l_0}{A \Delta l} = \frac{(500N)(3.2m)}{(2 \times 10^{-6} m^2)(4 \times 10^{-3} m)}$

$Y = 2 \times 10^{11}$ N/m^2

a
(a) 2.0×10^{11} N/m^2
(b) 3.0×10^{11} N/m^2
(c) 4.0×10^{11} N/m^2
(d) 5.0×10^{11} N/m^2
(e) 6.0×10^{11} N/m^2
(f) none of the above answers

(5 pts) 15. A block is attached to a horizontal spring and moves in simple harmonic motion on a frictionless horizontal surface. The amplitude of the motion is 0.040 m and the angular frequency is 10.0 rad/s. What is the maximum acceleration of the block during its motion?

$\omega = \sqrt{\frac{k}{m}} = 10$ rad/s

$a_{max} = \frac{kA}{m} = A\omega^2 = (0.04m)(10 rad/s)^2 = 4.0 m/s^2$

b
(a) 2.00 m/s^2
(b) 4.00 m/s^2
(c) 6.00 m/s^2
(d) 8.00 m/s^2
(e) 12.0 m/s^2
(f) none of the above answers

(5 pts) 16. On a planet other than the earth a simple pendulum with length 5.00 m has a frequency of $f = 0.200$ Hz. What is the value of g on this planet?

$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$

$g = (2\pi f)^2 l = (2\pi)^2 (0.2Hz)^2 (5.0m) = 7.9 m/s^2$

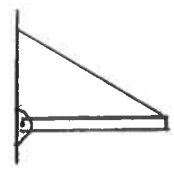
(a) 1.9 m/s^2
(b) 2.6 m/s^2
(c) 3.3 m/s^2
e
(d) 4.6 m/s^2
(e) 7.9 m/s^2
(f) none of the above answers

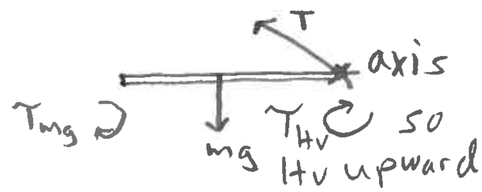
(5 pts) 17. A man is standing on a stool that rotates without friction. The man holds a dumbbell with mass 5.00 kg in each hand. With his arms outstretched the moment of inertia of the system (man, stool, dumbbells) is $12.0\ \text{kg}\bullet\text{m}^2$ and the system is rotating with an angular velocity of 2.00 rad/s. The man pulls his arms to his sides and the moment of inertia of the system becomes $8.00\ \text{kg}\bullet\text{m}^2$. What is the angular velocity of the rotating system after he has pulled in his arms?

c
(a) 1.20 rad/s
(b) 2.45 rad/s
(c) 3.00 rad/s
(d) 4.00 rad/s
(e) 4.50 rad/s
(f) none of the above answers

(5 pts) 18. A uniform bar is attached at one end to a vertical wall by a frictionless hinge. The bar is held in a horizontal position by a light rope that runs between the other end of the bar and the wall. What is the direction of the vertical component of the force that the hinge exerts on the bar, ~~or is the vertical component of the hinge force zero~~?

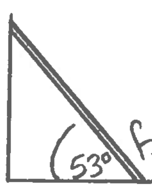
a
(a) upward
(b) downward
(c) the vertical component of the hinge force is zero

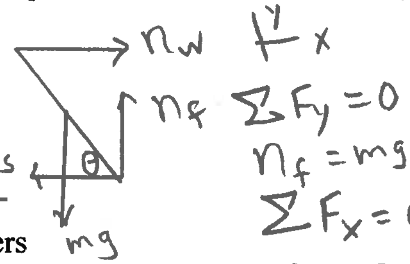




(5 pts) 19. A uniform ladder is leaning against a vertical wall. The wall is frictionless but there is friction at the floor. If the angle between the ladder and the floor is 53^o what minimum coefficient of static friction at the floor is required for the ladder not to slip?

a
(a) 0.377
(b) 0.664
(c) 0.753
(d) 0.866
(e) 1.33
(f) none of the above answers



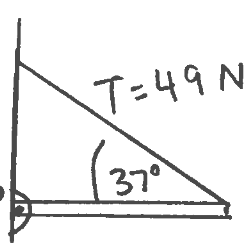


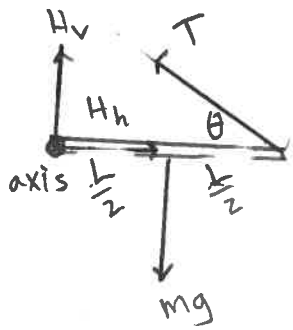
$\Sigma F_y = 0$
$n_f = mg$
$\Sigma F_x = 0$
$n_w = f_s$

Want min μ_s so $f_s = \mu_s n_f$ (max value)
$\Sigma \tau = 0$ axis at floor (+)
$mg\frac{l}{2}\cos\theta = n_w l \sin\theta$
$\frac{1}{2}mg = f_s \tan\theta$
$\frac{1}{2}mg = \mu_s mg \tan\theta$
$\mu_s = \frac{1}{2\tan\theta} = 0.377$

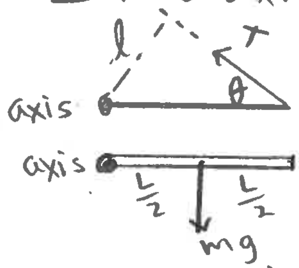
(5 pts) 20. A uniform bar is attached at one end to a vertical wall by a frictionless hinge. The bar is held in a horizontal position by a light rope that runs between the other end of the bar and the wall. The rope makes an angle of 37^o with the bar. If the tension in the rope is 49.0 N, what is the mass of the bar?

(a) 2.0 kg
(b) 3.0 kg
(c) 4.0 kg
d
(d) 6.0 kg
(e) 8.0 kg
(f) none of the above answers





$\Sigma \tau = 0$ axis at hinge (+)



moment arm $l = L\sin\theta$
$\tau_T = +TL\sin\theta$
$\tau_{mg} = -mg\left(\frac{L}{2}\right)$

$\Sigma \tau = 0$ $TL\sin\theta = \frac{1}{2}Lmg$
$m = \frac{2T\sin\theta}{g} = \frac{2(49N)(0.6)}{9.8} = 6.0$ kg

PHYS 201 Formula Sheet

Chapters 9—11 (Exam 3)

For constant α :

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

$$s = r\theta \qquad v = r\omega \qquad a_{\tan} = r\alpha \qquad a_{\text{rad}} = v^2 / r = r\omega^2$$

$$K = \tfrac{1}{2} I\omega^2 \qquad I = m_A r_A^2 + m_B r_B^2 + \ldots. \qquad U = Mgy_{\text{cm}} \qquad K_{\text{total}} = \tfrac{1}{2} Mv_{\text{cm}}^2 + \tfrac{1}{2} I_{\text{cm}}\omega^2$$

$$\tau = Fl \qquad \sum \tau = I\alpha \qquad \Delta W = \tau \Delta\theta \qquad P = \tau\omega \qquad L = I\omega \qquad \sum \tau = \frac{\Delta L}{\Delta t} \qquad L = mvl$$

first and second conditions for equilibrium:

$\sum F_x = 0$, $\sum F_y = 0$ and $\sum \tau = 0$ (any axis)

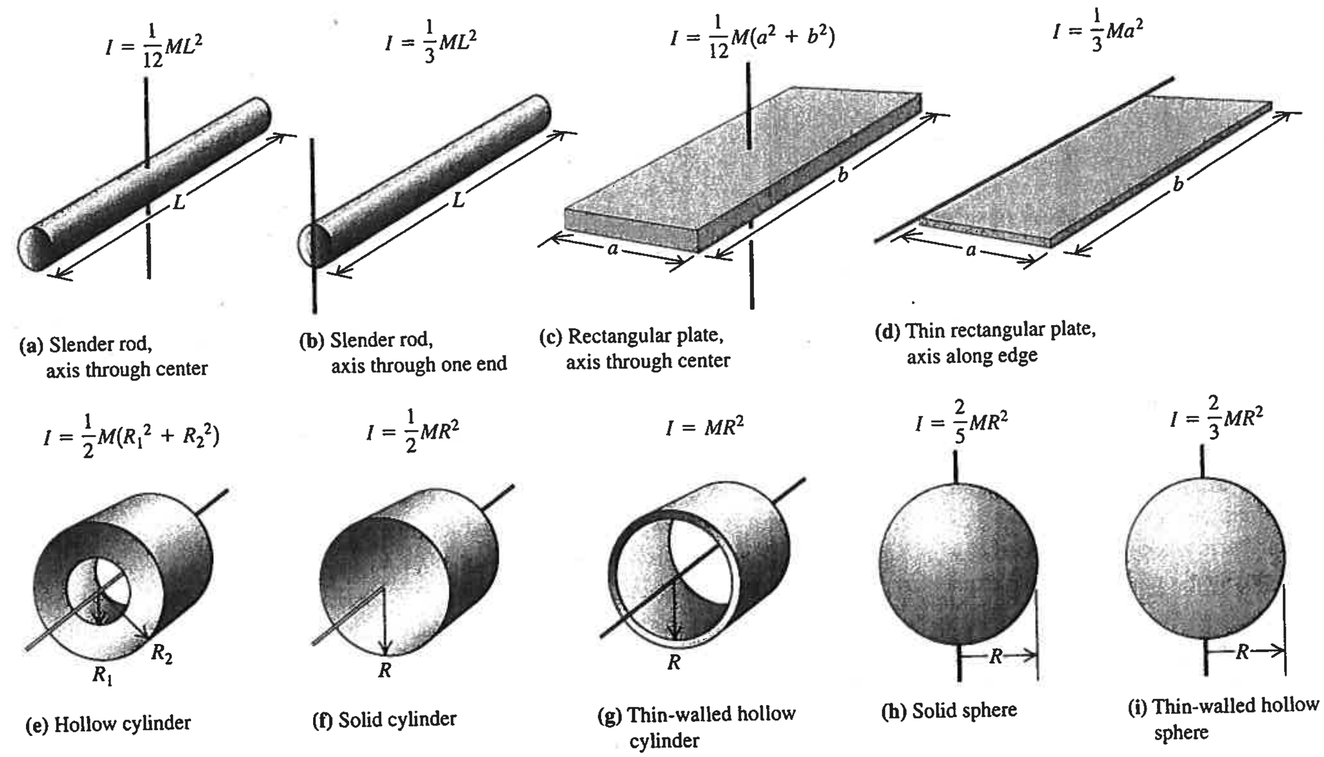
$$Y = \frac{F_\perp / A}{\Delta l / l_0} \qquad B = -\frac{\Delta p}{\Delta V / V_0} \qquad S = \frac{F_P / A}{x / h} = \frac{F_P / A}{\phi}$$

$$F_x = -kx \qquad a_x = -\frac{k}{m}x \qquad \omega = 2\pi f \qquad f = \frac{1}{T} \qquad U_{\text{el}} = \tfrac{1}{2}kx^2 \qquad K = \tfrac{1}{2}mv^2$$

$$x = A\cos\omega t \qquad v_x = -\omega A \sin\omega t \qquad \omega = \sqrt{\frac{k}{m}} \qquad f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad T = 2\pi\sqrt{\frac{m}{k}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}} \qquad T = 2\pi\sqrt{\frac{L}{g}}$$

TABLE 9.2 Moments of inertia for various bodies



(a) Slender rod, axis through center

(b) Slender rod, axis through one end

(c) Rectangular plate, axis through center

(d) Thin rectangular plate, axis along edge

(e) Hollow cylinder

(f) Solid cylinder

(g) Thin-walled hollow cylinder

(h) Solid sphere

(i) Thin-walled hollow sphere