Name:

Make your work clear to the grader. Show formulas used. Give correct units and significant figures. Partial credit is available if your work is clear. Point values are given in parenthesis. Exact conversions: 1 inch = 2.54 cm, 1 ft = 12 in., 1 mile = 5280 ft. Prefixes: f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^{3}, M=10^{6}, G=10^{9}, T=10^{12}, P=10^{15}. Use g=9.80 m/s^2.

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1. (2) **T F** When a mass changes its momentum, a net force must have acted on it.

2. (2) **T F** When two nonequal masses collide, they cause equal but opposite impulses on each other.

3. (2) In which type of collision is kinetic energy conserved?

   a. elastic b. ineleastic c. completely inelastic d. 1-dimensional e. 2-dimensional

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4. (2) For a collision of two masses, the law of conservation of momentum says that

   a. the two masses experience equal momentum changes.
   b. the two masses experience equal and opposite momentum changes.
   c. each mass preserves its momentum during the collision.
   d. the larger mass will experience the larger change in momentum.

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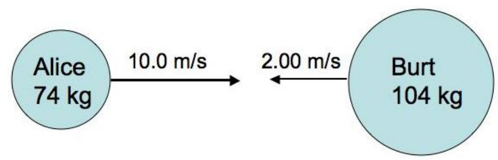
5. (16) Alice and Burt are riding in two different bumper cars at the festival. The combined mass of Alice and her car is 74 kg; Burt's is 104 kg. The cars make an elastic collision: Alice's car, travelling at 10.0 m/s, crashes head-on into Burt's car, travelling the opposite direction at 2.00 m/s.



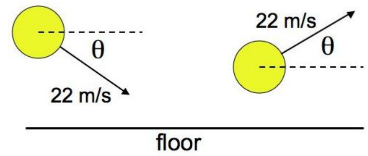
a) (4) What is the initial relative velocity (in m/s) of Alice's car compared to Burt's?

b) (4) Write the equation to express the conservation of momentum for the collision.

c) (4) Write the equation relating their relative velocity after the collision to their relative velocity before the collision.

d) (4) Use your equations to find the velocity of Alice's car after the collision (give magnitude and direction).

6. (6) A tennis ball bounces as shown off the floor.



a) (2) **T F** The ball experiences no change in momentum.

b) (2) In which direction was the average force of the floor acting on the ball?

a. up. b. down. to the left. d. to the right.

c) (2) **T F** The magnitude of the force due to the floor is proportional to the impact time.

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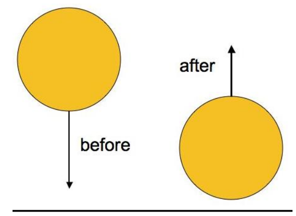
7. (12) A 420-gram basketball is thrown downward and just before it hits the floor, its speed is 28 m/s. Then it bounces back off the floor, upwards at 22 m/s.



a) (6) Calculate the ball's change in momentum. Give its magnitude and direction.

b) (4) The ball contacted the floor for 65 ms. How large was the *average net force* on the ball during impact?

c) (2) How does the magnitude of the average *normal force* (N) of the floor on the ball compare with the average *net force* (F_{net}) you found in (b)?

a. $N = F_{\text{net}}$. b. $N < F_{\text{net}}$. c. $N > F_{\text{net}}$.

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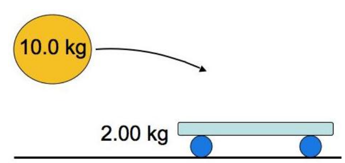
8. (12) Some physics students are checking the laws of momentum and collisions. They throw a 10.0-kg medicine ball with an initial horizontal momentum of 50.0 kg m/s onto a 2.00-kg skate board that is initially at rest. The ball lands and sticks on the skateboard, and they roll away together.



a) (6) What's the speed of the skateboard after the medicine ball lands on it?

b) (4) What's the final combined momentum of the skateboard and the ball?

c) (2) **T F** Kinetic energy was conserved when the ball landed on the skateboard.

Name:

1. (2) **T F** All points on a spinning wheel have the same *angular speed*.
2. (2) **T F** All points on a spinning wheel have the same *angular acceleration*.
3. (2) **T F** The tangential velocity of a point on a spinning wheel is proportional to its radius.

4. (10) A wheel on a truck has a radius of 48 cm (from axis to edge of the rubber tire). When the truck is travelling at 32 m/s, the kinetic energy of rotation of the wheel is 8.0 kJ.

a) (4) What's the angular speed of the wheel, in radians per second?

b) (6) Calculate the rotational inertia of the wheel, in kg·m^2.

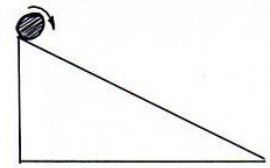
5. (12) A centrifuge has a motor that produces a constant angular acceleration of 1.20×10^2 rad/s^2. The normal operating speed of the centrifuge is 12.0×10^3 rpm.

a) (4) What's the operating angular speed in rad/s?

b) (4) Starting from rest, how long does it take to reach the operating speed?

c) (4) Once running at the operating speed, how many g's of centripetal acceleration are produced for a sample at a radius of 5.00 cm from the rotation axis?

6. (6) A solid cylinder and a hoop of the same mass are released from rest at the top of an incline and roll down without slipping. The hoop's radius is double the cylinder's radius.



a) (2) Which one has the larger rotational inertia?
 a. The solid cylinder. b. The hoop. c. It's a tie.

b) (2) Which one has the larger kinetic energy when reaching the bottom of the incline?
 a. The solid cylinder. b. The hoop. c. It's a tie.

c) (2) At the bottom, which one has the larger fraction of its KE as due to translation?
 a. The solid cylinder. b. The hoop. c. It's a tie.

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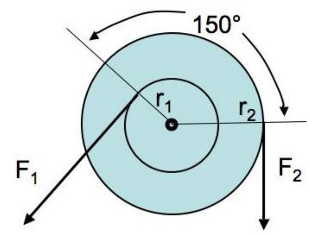
7. (6) A wheel mounted to spin around its center has two belts exerting forces on it, $F_1 = 64$ N at radius $r_1 = 24$ cm, and $F_2 = 27$ N at radius $r_2 = 48$ cm, as shown. Find the magnitude of the net torque on the wheel. Is it clockwise or counterclockwise?



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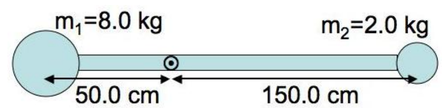
8. (6) Masses $m_1 = 8.0$ kg and $m_2 = 2.0$ kg are attached at the ends of a massless rod 2.00 meters long, mounted to spin around a point 50.0 cm from one end. Calculate the rotational inertia around the mount point.



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9. (8) A grinding wheel with rotational inertia $I = 1.80$ kg·m^2 slows from a top speed of 2.50×10^3 rpm (262 rad/s) to rest in 15.0 seconds when the motor is turned off. What average torque magnitude caused the wheel to stop?

Chapter 8 Equations

Rotational coordinates:

$1 \text{ rev} = 2\pi \text{ radians} = 360°, \qquad \omega = 2\pi f, \quad f = \frac{1}{T}, \qquad \bar{\omega} = \frac{\Delta\theta}{\Delta t}, \qquad \bar{\alpha} = \frac{\Delta\omega}{\Delta t}, \qquad \Delta\theta = \bar{\omega}\Delta t.$

Linear coordinates vs. rotation coordinates and radius:

$l = \theta r, \qquad v = \omega r, \qquad a_{\tan} = \alpha r, \qquad a_R = \omega^2 r,$ (must use radians in these).

Constant angular acceleration:

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

Torque & Dynamics:

$\tau = rf\sin\theta, \qquad I = \Sigma mr^2, \qquad \tau_{\text{net}} = I\alpha, \qquad L = I\omega, \qquad \Delta L = \tau_{\text{net}}\Delta t, \qquad \text{KE}_{\text{rot}} = \frac{1}{2}I\omega^2.$

Rotational Inertias:

$I = MR^2$,	$I = \frac{1}{2}MR^2$,	$I = \frac{2}{5}MR^2$,	$I = \frac{1}{12}ML^2$.
hoop	solid cylinder	sphere	thin rod

Chapter 7 Equations

Momentum & Impulse:

momentum $\vec{p} = m\vec{v}$, impulse $\Delta\vec{p} = \vec{F}_{\text{ave}}\ \Delta t$.

Conservation of Momentum:

(2-body collision) $m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v'}_A + m_B\vec{v'}_B$.

1D elastic collision–conservation of energy:

$\frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 = \frac{1}{2}m_A v_A'^2 + \frac{1}{2}m_B v_B'^2,$ or $v_A - v_B = -(v_A' - v_B').$

Center of Mass:

$x_{\text{cm}} = \frac{m_1x_1 + m_2x_2 + \ldots}{m_1 + m_2 + \ldots}, \qquad v_{\text{cm}} = \frac{m_1v_1 + m_2v_2 + \ldots}{m_1 + m_2 + \ldots}.$

Chapter 6 Equations

Work & Kinetic & Potential Energies:

$W = Fd\cos\theta, \qquad \text{KE} = \frac{1}{2}mv^2, \qquad \text{PE}_{\text{gravity}} = mgy, \qquad \text{PE}_{\text{spring}} = \frac{1}{2}kx^2.$

Conservation or Transformation of Energy:

"work-KE theorem" $\Delta\text{KE} = W_{\text{net}}$, **or use conservation law** $\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}$.

Power:

$P_{\text{ave}} = \frac{W}{t}$, or use $P_{\text{ave}} = \frac{\text{energy}}{\text{time}}$.

Chapter 5 Equations

Centripetal Acceleration:

$a_R = \frac{v^2}{r}$, towards the center of the circle.

Circular motion:

speed $v = \frac{2\pi r}{T} = 2\pi rf$, frequency $f = \frac{1}{T}$, where T is the period of one revolution.

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude$=V$, direction$=\theta$ or by components $(V_x,\, V_y)$.

$V_x = V\cos\theta, \quad V_y = V\sin\theta,$

$V = \sqrt{V_x^2 + V_y^2}, \quad \tan\theta = \frac{V_y}{V_x}.$ $\qquad$ θ is the angle from $\vec{V}$ to $+x$-axis.

Addition: $\mathbf{A}+\mathbf{B}$, head to tail. $\qquad$ Subtraction: $\mathbf{A}-\mathbf{B}$ is $\mathbf{A}+(-\mathbf{B})$, $\quad -\mathbf{B}$ is $\mathbf{B}$ reversed.

Trig summary

$\sin\theta = \frac{(\mathrm{opp})}{(\mathrm{hyp})}, \qquad \cos\theta = \frac{(\mathrm{adj})}{(\mathrm{hyp})}, \qquad \tan\theta = \frac{(\mathrm{opp})}{(\mathrm{adj})}, \qquad (\mathrm{hyp})^2 = (\mathrm{opp})^2 + (\mathrm{adj})^2.$