General Physics I **Exam 3 - Chs. 7,8,9 - Momentum, Rotation, Equilibrium** **Nov. 3, 2010**

Name Rec. Instr. Rec. Time

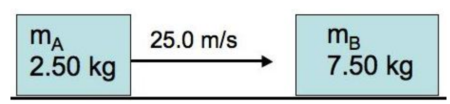
For full credit, make your work clear to the grader. Show formulas used, essential steps, and results with correct units and significant figures. Partial credit is available if your work is clear. Points shown in parenthesis. For TF and MC, choose the *best* answer.

1. (10) In an experiment, physics students push a 1.80×10^3-kg car for 12.0 s on a level road. There is no friction. The car starts at rest and reaches a final speed of 6.00 m/s after the 12.0 s.

a) (5) How large is the magnitude of the impulse imparted to the car by the students?

b) (5) What average force magnitude was applied by the students working together?

2. (12) Mass $m_A = 2.50$ kg travelling at 25.0 m/s crashes head-on into mass $m_B = 7.50$ kg which is originally at rest. The masses can slide without friction on the level surface. After the collision, m_A reverses direction, recoiling with a speed of 5.00 m/s in the opposite direction.



a) (6) Find the velocity of m_B after the collision.

b) (6) Determine whether the collision is **elastic** or **inelastic**.

3. (2) **T F** When a basketball bounces off the floor, its momentum is conserved.

4. (2) **T F** In a collision of two rocks in outer space, the momentum lost by one is gained by the other.

5. (2) **T F** When a 12-kg rock collides with a 6.0-kg rock, the 6.0-kg experiences the larger magnitude impulse.

6. (2) **T F** If the time duration of a collision can be reduced, the average force involved is also reduced.

7. (2) **T F** A 60-kg person running 10 m/s east has the same momentum as a 1200-kg car going 0.5 m/s north.

8. (2) A car traveling at a constant speed along a curve changes the direction of its velocity from north to south. In what direction was the momentum change of the car?

a. north b. south c. east d. west.

9. (2) A car traveling at a constant speed changes the direction of its velocity from north to east. In what direction was the average net force on the car?

a. northeast b. southeast c. southwest d. northwest.

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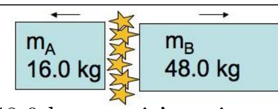
10. (16) A 64.0-kg mass initially at rest breaks into pieces of 16.0 kg and 48.0 kg, due to an explosion that produces 2.40 kJ of total kinetic energy in the pieces.



a) (2) Which piece acquires the larger magnitude momentum? a. 16.0 kg b. 48.0 kg c. it's a tie.

b) (2) Which piece acquires the larger kinetic energy? a. 16.0 kg b. 48.0 kg c. it's a tie.

c) (6) Calculate the KE of the 48.0-kg piece after the explosion.

d) (6) After the 48.0-kg piece has traveled 1.00 meter away from its original position, how far has the 16.0-kg piece traveled?

11. (12) A centrifuge accelerates uniformly from rest to its top speed in 6.00 s, while rotating through 2440 revolutions. Its outer radius is 2.50 cm.

a) (6) How large was its angular acceleration, in rad/s^2?

b) (6) Once running at its top speed, what is the centripetal acceleration of a point at its outer radius, measured in g's ?

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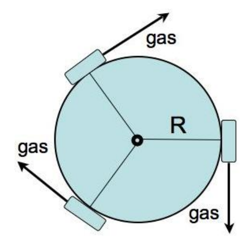
12. (16) A 975-kg satellite is a uniform solid cylinder of radius $R = 2.50$ m. It has three tangential rockets mounted on the edge, whose thrust can change its rotation rate. Each rocket provides a tangential thrust force of 175 N when activated.

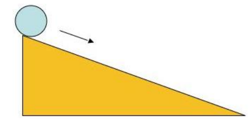


a) (6) When all three rockets are turned on, what total amount of torque do they apply to the satellite around its central axis?

b) (6) What angular acceleration does the satellite have (in rad/s^2) with all three rockets turned on?

c) (4) If the rockets are turned on for 5.00 minutes, what is the magnitude of the change in angular momentum of the satellite?

13. (9) A solid sphere ($I = \frac{2}{5}mR^2$), a solid cylinder ($I = \frac{1}{2}mR^2$), and a hoop ($I = mR^2$) have identical masses and radii. They are released together at the top of an incline, rolling without slipping to the bottom.



a) (3) Which one arrives at the bottom with the greatest total kinetic energy?

a. sphere b. cylinder c. hoop d. all total KE's are equal.

b) (3) Which one has the greatest rotational kinetic energy at the bottom?

a. sphere b. cylinder c. hoop d. all rotational KE's are equal.

c) (3) Which one arrives at the bottom first?

a. sphere b. cylinder c. hoop d. it's a 3-way tie.

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14. (2) **T F** All points on a spinning wheel have the same angular acceleration.

15. (2) **T F** All points on a spinning wheel have the same centripetal acceleration.

16. (2) **T F** The speed of a point on a spinning wheel is proportional to its radius.

17. (2) **T F** The larger the wheels on a car, the slower they rotate for a given car speed.

18. (2) **T F** If the net torque on an object is zero about any axis, the object is in static equilibrium.

19. (2) **T F** The torque due to some particular force depends on the choice of axis.

20. (2) **T F** When a force passes through the axis of rotation, it produces no torque about that axis.

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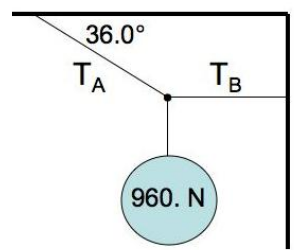
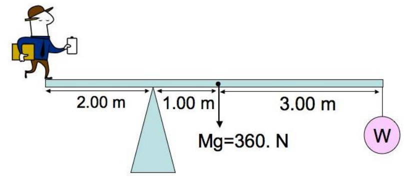
21. (10) A 960.-newton mass is hanging from two cords, one connected horizontally to the wall, and one making a 36.0°-angle to the point where it connects to the ceiling.



a) (5) Find the tension T_A in the cord connected to the ceiling.

b) (5) Find the tension T_B in the cord connected to the wall.

22. (12) A worker of mass 80.0 kg stands on the end of a beam weighing 360. N, supported on a pivot. The beam's center of mass is at its center. W is the weight of a counterweight needed to hold the beam in equilibrium.



a) (8) By finding the net torque on the beam, with the pivot point as the axis, determine the counterweight needed, in newtons.

b) (4) What vertical force must the pivot point make on the beam?

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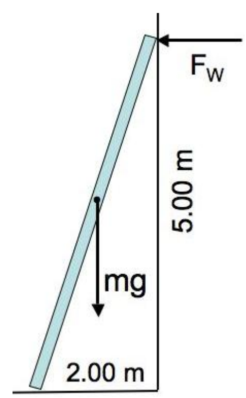
23. (8) A ladder weighing 2.00×10^2 N is set against the wall and does not slip. There is friction between the ladder and the floor, but no friction between the ladder and the wall. What horizontal force F_W due to the wall is needed to hold the ladder stable?



Score = ___________/133.

Prefixes

a=10^{-18}, 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}

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$c = 299792458$ m/s (speed of light)
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (Gravitational constant)
$R_E = 6380$ km (mean radius of Earth)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units and Conversions

1 inch = 1 in = 2.54 cm (exactly)
1 mile = 5280 ft
1 m/s = 3.6 km/hour
1 acre = 43560 ft^2 = (1 mile)^2/640
1 foot = 1 ft = 12 in = 30.48 cm (exactly)
1 mile = 1609.344 m = 1.609344 km
1 ft/s = 0.6818 mile/hour
1 hectare = 10^4 m^2

Trig summary

$\sin\theta = \frac{(\text{opp})}{(\text{hyp})}$, $\quad \cos\theta = \frac{(\text{adj})}{(\text{hyp})}$, $\quad \tan\theta = \frac{(\text{opp})}{(\text{adj})}$, $\quad (\text{opp})^2 + (\text{adj})^2 = (\text{hyp})^2$.
$\sin\theta = \sin(180^\circ - \theta)$, $\quad \cos\theta = \cos(-\theta)$, $\quad \tan\theta = \tan(180^\circ + \theta)$, $\quad \sin^2\theta + \cos^2\theta = 1$.

Acceleration Equations

$\bar{v} = \frac{\Delta x}{\Delta t}$, $\quad \Delta x = x - x_0$, $\quad$ slope of $x(t)$ curve $= v(t)$.
$\bar{a} = \frac{\Delta v}{\Delta t}$, $\quad \Delta v = v - v_0$, $\quad$ slope of $v(t)$ curve $= a(t)$.

For constant acceleration in one-dimension:
$\bar{v} = \frac{1}{2}(v_0 + v)$, $\quad v = v_0 + at$, $\quad x = x_0 + v_0 t + \frac{1}{2}at^2$, $\quad v^2 = v_0^2 + 2a(x - x_0)$.

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude=V, direction=θ or by components (V_x, V_y).
$V_x = V\cos\theta$, $\quad V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\quad \tan\theta = \frac{V_y}{V_x}$. $\quad$ θ is the angle from $\vec{V}$ to x-axis.
Addition: $\mathbf{A} + \mathbf{B}$, head to tail. $\quad$ Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $\quad -\mathbf{B}$ is $\mathbf{B}$ reversed.

Chapter 4 Equations

Newton's Second Law:
$\vec{F}_{\text{net}} = m\vec{a}$, means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$. $\quad$ $\vec{F}_{\text{net}} = \sum \vec{F}_i$, sum over all forces on a mass.

Friction (magnitude):
$f_s \le \mu_s N$ or $F_{\text{fr}} \le \mu_s F_N$ (static friction). $\quad$ $f_k = \mu_k N$ or $F_{\text{fr}} = \mu_k F_N$. (kinetic or sliding friction)

Gravitational force near Earth:
$F_G = mg$, downward.

Chapter 5 Equations

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

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

Gravitation:
$F = G\frac{m_1 m_2}{r^2}$; $\quad g = \frac{GM}{r^2}$, $\quad$ where $G = 6.67 \times 10^{-11}$ Nm^2/kg^2;

Orbits:
$\frac{v^2}{r} = g = \frac{GM}{r^2}$; $\quad v = \sqrt{\frac{GM}{r}}$. $\quad$ centripetal acceleration = free fall acceleration.

Chapter 6 Equations

Work & Kinetic & Potential Energies:

$W = Fd\cos\theta$, KE $= \frac{1}{2}mv^2$, $\text{PE}_{\text{gravity}} = mgy$, $\text{PE}_{\text{spring}} = \frac{1}{2}kx^2$. θ = angle btwn $\vec{F}$ and $\vec{d}$.

Conservation or Transformation of Energy:

Work-KE theorem:

$\Delta\text{KE} = W_{\text{net}}$ = work of all forces.

General energy-conservation law:

$\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}$ = work of non-conservative forces.

Power:

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

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:

$\frac{1}{2}m_Av_A^2 + \frac{1}{2}m_Bv_B^2 = \frac{1}{2}m_Av_A^{'2} + \frac{1}{2}m_Bv_B^{'2}$, or $v_A - v_B = -(v'_A - v'_B)$.

Center of Mass:

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

Chapter 8 Equations

Rotational coordinates:

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

Linear coordinates vs. rotation coordinates and radius:

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

Constant angular acceleration:

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

Torque & Dynamics:

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

Rotational Inertias about centers:

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

Chapter 9 Equations

Static Equilibrium:

$\Sigma F_x = \Sigma F_y = \Sigma F_z = 0$, $\Sigma\tau = 0$, $\tau = rFsin\theta$.