Physics 151 Roster No.:_____

Score: **22 pts. possible**

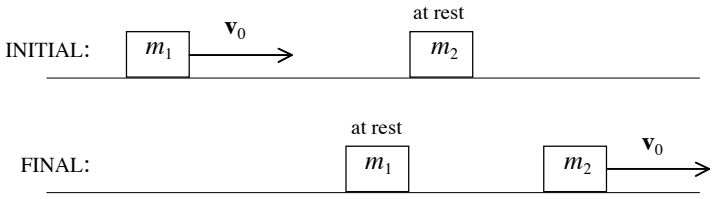
SPRING 2004 Midterm Exam #3, Part A

Exam time limit: 50 minutes. You may use calculators and both sides of 2 pages of notes, *handwritten only*. Closed book; no collaboration. For multiple choice questions, circle the one best answer or letter (unless more than one answer is asked for).

Some moments of inertia:

hoop or thin ring:	$I = M R^2$	thin rod, about center:	$I = (1/12)\, M L^2$
solid cylinder or disk:	$I = (1/2)\, M R^2$	thin rod, about end:	$I = (1/3)\, M L^2$
solid sphere:	$I = (2/5)\, M R^2$		

(1 pt. each, unless otherwise specified)



1. In the collision shown here, the outgoing m_2 leaves with the same speed v_0 as the incoming m_1. The surface is frictionless. Assess the truth of the following statements about this collision:

a. The **momentum** of m_1 before the collision is *equal to* the momentum of m_2 after the collision.

A. True B. False C. Cannot determine from the information given.

b. **Mass** m_1 is *equal to* mass m_2.

A. True B. False C. Cannot determine from the information given.

c. The collision is **elastic**.

A. True B. False C. Cannot determine from the information given.

d. The **impulsive force** of m_1 on m_2 during the collision is *greater than* the impulsive force of m_2 on m_1 during the collision.

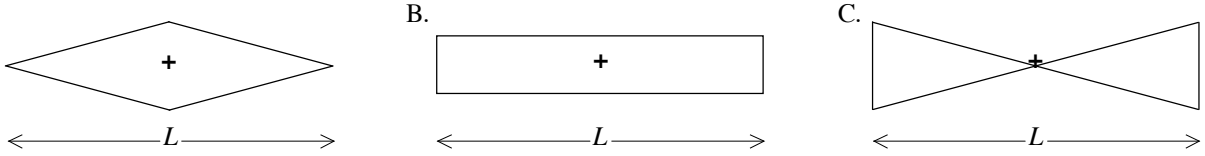
A. True B. False C. Cannot determine from the information given.

2. (2 pts.) You are stranded at rest in space near your spacecraft. To get back to it, you decide to throw your toolkit in a direction away from your spacecraft. If your toolkit has a **mass** 10 times smaller than you do, **then**…

A. your final speed will be 10 times the speed you throw the toolkit
B. your final speed will be $\sqrt{10}$ times the speed you throw the toolkit
C. your final speed will be equal to the speed you throw the toolkit
D. your final speed will be $1/\sqrt{10}$ times the speed you throw the toolkit
E. your final speed will be 1/10 times the speed you throw the toolkit

3. Each of the following shapes is cut from a 1-centimeter-thick sheet of wood. Each shape has the same mass M and same horizontal length L. If each shape lies in the plane of the page, and is rotated in the plane of the page about its center of mass (marked with a cross), which one will have the **SMALLEST moment of inertia**?

A. B. C.



4. The **units** of **angular momentum** are:

A. rad/s C. kg/s^2 E. $kg{\cdot}m/s^2$
B. rad/s^2 D. $kg{\cdot}m/s$ F. $kg{\cdot}m^2/s$

5. (2 pts.) Suppose that a rigid object (with unchanging moment of inertia) has a slowly **decreasing angular momentum**. Which ***TWO*** of the following statements about the object are **TRUE**?

A. Its period is decreasing.
B. Its angular velocity is decreasing.
C. Its angular acceleration is zero.
D. There is a non-zero net torque acting on the object.

6. a. Gyroscopes are only useful if they have very little or no precession. Besides balancing the gyroscope as carefully as possible at its center of mass, we can also minimize precession by making the gyroscope's **angular momentum** as **large** as possible. This can be accomplished by doing any one of the following **EXCEPT**:

A. Increasing the gyroscope's mass.
B. Spinning the gyroscope faster.
C. Decreasing the gyroscope's radius.

b. (2 pts.) An upcoming experiment to test Einstein's theory of general relativity will fly two gyroscopes in a spacecraft around the Earth. Both gyroscopes are spheres made of solid quartz crystal, the most perfect spheres ever manufactured for any purpose! If both spheres spin with the same angular speed, but one sphere has *twice the radius* of the other, then how much larger is its **rotational kinetic energy**? (*Hint:* Volume of sphere = $(4/3)\,\pi\,R^3$.)

A. same
B. 2 times
C. 4 times
D. 8 times
E. 16 times
F. 32 times

7. A room fan has three angular velocity settings: "LO" = ω_0, "MED" = $2\,\omega_0$, and "HI" = $3\,\omega_0$.

a. (2 pts.) The **period** of the fan blades on HI is _____ their period on LO.

A. 1/9 times
B. 1/3 times
C. $1/\sqrt{3}$ times
D. $\sqrt{3}$ times
E. 3 times
F. 9 times
G. the same as

b. (2 pts.) The **angular momentum** of the fan blades on HI is _____ their angular momentum on LO.

A. 1/9 times
B. 1/3 times
C. $1/\sqrt{3}$ times
D. $\sqrt{3}$ times
E. 3 times
F. 9 times
G. the same as

c. (2 pts.) The **rotational kinetic energy** of the fan blades on HI is _____ their rotational KE on LO.

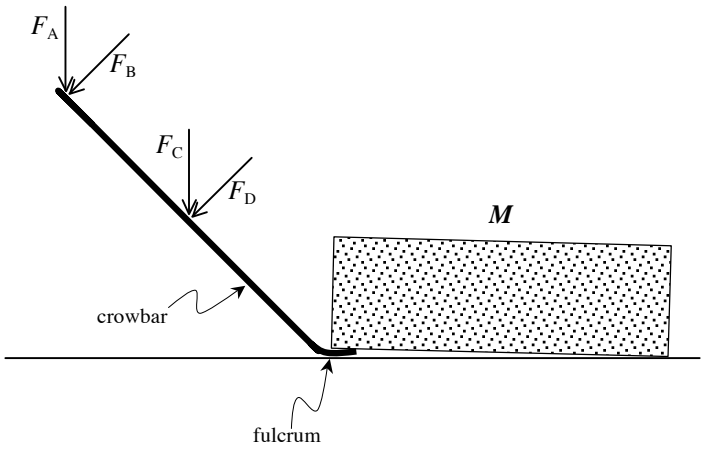
A. 1/9 times
B. 1/3 times
C. $1/\sqrt{3}$ times
D. $\sqrt{3}$ times
E. 3 times
F. 9 times
G. the same as

d. The **moment of inertia** of the fan blades on HI is _____ their moment of inertia on LO.

A. 1/9 times
B. 1/3 times
C. $1/\sqrt{3}$ times
D. $\sqrt{3}$ times
E. 3 times
F. 9 times
G. the same as

8. (2 pts.) You want to use a crowbar to pry up a huge stone block *M*, as shown at right. If each of the possible force vectors shown has the same magnitude, **which one of force vectors** should you choose to create the **greatest upward force on *M***? (*Hint:* Which choice creates the greatest torque about the fulcrum?)

A. *A*
B. *B*
C. *C*
D. *D*



Physics 151 Roster No.:_____

Score: **28 pts. possible**

SPRING 2004 Midterm Exam #3, Part B

Exam time limit: 50 minutes. You may use calculators and both sides of 2 pages of notes, *handwritten only*. Closed book; no collaboration. Show your work on free-response questions. Be sure to use **proper units** and **significant figures** in your final answers.

1. A sports utility vehicle (SUV) (m_s = 1800 kg) is traveling at speed v_s when it collides with a compact car (m_c = 1400 kg) which was initially at rest. The two cars stick together in the collision, continuing onward with a new speed v'. You are a police officer investigating the accident.

a. (6 pts.) Together, the joined vehicles slide a distance of 5.0 m along the street before coming to rest (which you determined by measuring the length of the skid marks left by the rubber tires). If $\mu_k = 0.75$ between the tires and the road, show that the **speed v'** of the two vehicles immediately after the collision was **8.6 m/s**. (Note: The vehicles' tires are locked in position and *slide* along the road; they do NOT roll.)

b. (6 pts.) Using all of the above information, determine the **speed v_s** of the SUV immediately before the collision. Since America is one of the last countries in the world that has not adopted the metric system, you will need to convert your final answer from [m/s] to **miles per hour (mph)** for your police report: 1.000 m/s = 2.237 mi/h.

2. (8 pts.) Two children, Alika (45 kg) and Bryce (35 kg), are sitting on opposite ends of a 3.8-meter-long seesaw (teeter-totter). The seesaw has a fulcrum located exactly beneath its center (i.e., 1.9 meters from either end), and the mass of the seesaw itself is negligible. **How far from the fulcrum** should Crystal (25 kg) sit so that the combination of all three children will be exactly *balanced*? On **which side** of the fulcrum should she sit, Alika's or Bryce's? Clearly explain your approach and show your work.

3. (8 pts.) A 65-kg diver is standing at the end of a 2.0-meter-long, 15-kg diving board. The other end of the board is fastened to a post at point *P*. A heavy spring pushes upward on the diving board at a distance of 0.50 meters from *P*. If the diving board is in static equilibrium and is exactly horizontal, find the **magnitude of the force $\mathbf{F_s}$** provided by the spring. (*Hint:* Sum the torques on the diving board about point *P*. You will not need to sum the *x*-forces or *y*-forces on the diving board.)