Physics 160-01 Exam #3 Name:__________________

A bullet of mass 5.0 g is fired horizontally into a 2.0 kg wooden block at rest on a horizontal surface. The coefficient of kinetic friction between block and surface is 0.25. The bullet stops in the block, which slides straight ahead for 2.5 m (without rotation).

1) What is the speed of the block immediately after the bullet stops in it?

A) 2.94m/s
B) 3.70m/s
C) 2.54m/s
D) 3.30m/s
E) 3.50m/s
F) 1.85m/s
G) 2.17m/s
H) 0.43m/s
I) 2.70m/s
J) 3.12m/s

Friction does work on the block to stop it. The magnitude of the frictional force is (eq. 3) F_f = 0.25*(2.005kg*9.8m/s^2)=4.91N and acts on the block for 2.5m, so from eq.2, W=Fd=-4.91N*2.5m=-12.3J. This will represent a change in the kinetic energy (eqs. 7 & 8). So v = sqrt(2*12.3Nm/2.005kg) = 3.50m/s.

2) At what speed is the bullet fired?

A) 600m/s
B) 700m/s
C) 800m/s
D) 900m/s
E) 1000m/s
F) 1100m/s
G) 1200m/s
H) 1300m/s
I) 1400m/s
J) 1500m/s

Momentum is conserved in the collision, so mv_{before} = mv_{after} or 0.005kg*v=(2.0kg+0.005kg)*3.50m/s so v = 1400m/s.

A constant horizontal force of 20 N is applied to a wheel of mass 6 kg and radius 0.60 m as shown in Fig. 12-31. The wheel rolls without slipping on the horizontal surface, and the acceleration of its center of mass is 1.00 m/s^2.

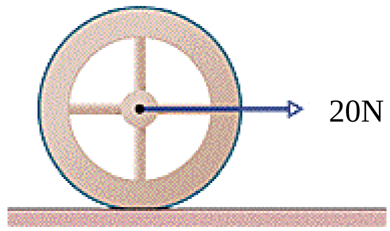

Figure 12-31

3) What are the magnitude and direction of the frictional force on the wheel?

A) 6N to the right
B) 6N to the left
C) 14N to the left
D) 14N to the right
E) 4N to the left
F) 26N to the right
G) 26N to the left
H) 10N to the right
I) 10N to the left
J) Cannot determine

Newton's second law (eq. 4) states that the sum of all the forces will give the mass an acceleration. 20N + F_f = 6kg*1.00m/s^2 so F_f = -14N or 14N to the left.

4) What is the rotational inertia of the wheel about an axis through its center of mass and perpendicular to the plane of the wheel? Note that not enough information is given to calculate the moment of inertia using the geometry.

A) 5.0 kgm^2
B) 5.5 kgm^2
C) 6.0 kgm^2
D) 6.5 kgm^2
E) 7.0 kgm^2
F) 7.5 kgm^2
G) 8.0 kgm^2
H) 8.5 kgm^2
I) 9.0 kgm^2
J) 9.5 kgm^2

Newton's second law for rotation (eq. 10) states that the sum of all the torques will give the rotational inertia an angular acceleration. From the definition of torque (eq. 9) and the relation between the linear acceleration and the angular acceleration for rolling (eq. 11), F_f*0.6m = I*(1.00m/s^2)/(0.6m) so with F_f=14N, I = 5.04kgm^2.

A diver of weight 750 N stands at the end of a 4.0 m diving board of negligible mass. (Fig. 13-24.) The board is attached to two pedestals 1.0 m apart (circled below).

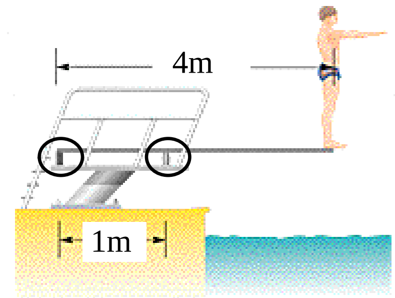

Figure 13-24

5) What are the magnitude and direction of the force on the board from the left pedestal?

A) 2250N downward
B) 2250N upward
C) 3000N downward
D) 3000N upward
E) 1125N downward
F) 1125N upward
G) 750N downward
H) 750N upward
I) 4250N downward
J) 4250N upward

Newton's second law for rotation (eq. 10) states that the sum of all the torques will be zero for a static equilibrium situation. Setting the pivot point at the right support, we have F_l *1m– 750N*3m = 0 or F_l = 2250N downward.

6) What are the magnitude and direction of the force on the board from the right pedestal?

A) 2250N downward
B) 2250N upward
C) 3000N downward
D) 3000N upward
E) 1125N downward
F) 1125N upward
G) 750N downward
H) 750N upward
I) 4250N downward
J) 4250N upward

Newton's second law for a static equilibrium situation says that the sum of all forces must be zero or -750N – 2250N + F_r = 0 or F_r = 3000N upward.

7) A merry-go-round with a radius of 2m and a moment of inertia 200kgm^2 is rotating at 0.2 revolutions per second. A child of mass 50kg runs at the merry-go-round in a line tangent to its edge, and grabs onto it. After the child is on board, it rotates at 0.3 revolutions per second. How fast was the child running?

A) 1.0m/s
B) 1.5m/s
C) 2.0m/s
D) 2.5m/s
E) 3.0m/s
F) 3.5m/s
G) 4.0m/s
H) 4.5m/s
I) 5.0m/s
J) 5.5m/s

This involves conservation of angular momentum, $L_i = L_f$.

$$L_i = (I\omega_i)_{merry-go-round} + (\vec{r}\times\vec{p})_{child}$$

$$= (200kgm^2)\left(0.2\frac{rev}{s}\right)\left(\frac{2\pi rad}{rev}\right) + (2m)(50kg)v$$

$$L_f = \left[I_{merry-go-round} + I_{child}\right]\omega_f$$

$$= \left[(200kgm^2) + (50kg)(2m)^2\right]\left(0.3\frac{rev}{s}\right)\left(\frac{2\pi rad}{rev}\right)$$

Solving for v, we get v=5.0m/s

8) Now, the child jumps off so that when they hit the ground, there is no horizontal component to their velocity (they are standing still relative to the ground right before they hit the ground). What is the new rate of rotation of the merry-go-round?

A) 0.1 revolutions per second
B) 0.2 revolutions per second
C) 0.3 revolutions per second
D) 0.4 revolutions per second
E) 0.5 revolutions per second
F) 0.6 revolutions per second
G) 0.7 revolutions per second
H) 0.8 revolutions per second
I) 0.9 revolutions per second
J) 1.0 revolutions per second

This involves conservation of angular momentum, $L_i = L_f$.

$$L_i = \left[I_{merry-go-round} + I_{child}\right]\omega_i$$

$$= \left[(200kgm^2) + (50kg)(2m)^2\right]\left(0.3\frac{rev}{s}\right)\left(\frac{2\pi rad}{rev}\right)$$

$$L_f = (I\omega_f)_{merry-go-round} + (\vec{r}\times\vec{p})_{child}$$

$$= (200kgm^2)\left(x\frac{rev}{s}\right)\left(\frac{2\pi rad}{rev}\right) + 0$$

Now we want to solve for x, and we get x=0.6 rev/sec.

9) A rocket is fired straight upward on a windless day. At the peak of its trajectory, it explodes into two parts, one with three times the mass as the other. Both pieces strike the ground at the same time. You find the heavy piece 10m to the East of the launch site. Where should you look for the lighter piece? Assume no air resistance.

A) 3m to the West of the launch site.
B) 6m to the West of the launch site.
C) 10m to the West of the launch site.
D) 15m to the West of the launch site.
E) 20m to the West of the launch site.
F) 25m to the West of the launch site.
G) 30m to the West of the launch site.
H) 33m to the West of the launch site.
I) 60m to the West of the launch site.
J) It depends upon the energy released in the explosion.

Since the center of mass wouldn't move (no outside forces in the horizontal direction) the center of mass would remain at the launch site. The center of mass is closer to the heavier object, so the lighter object is farther from the launch site. If we put x=0 at the launch site, then we have

$$x_{CM} = 0 = 10 \times 3m - x_{light} \times m \Rightarrow$$

$$x_{light} = 30m$$