

Physics 1A, Section 6

November 20, 2008

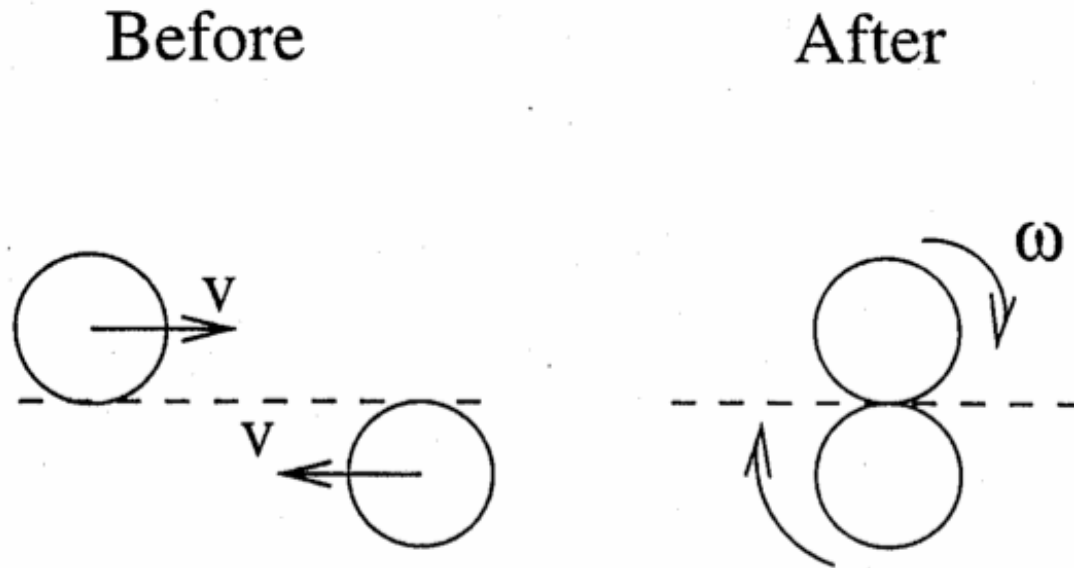
Section Business

- Homework #8 (fluid mechanics) is due Monday.
 - Web site has been updated.
- Extra T.A. office hour tomorrow or Monday?
- Quiz 4 covers:
 - material through T.M.U. chapter 14
 - New material includes:
 - rotational motion
 - oscillatory motion

Quiz

Problem 24

Two cylindrical pucks, each of mass M and radius R , slide towards each other on a smooth frictionless surface. Initially, each has speed v . They undergo a grazing collision, and stick together at their edge.

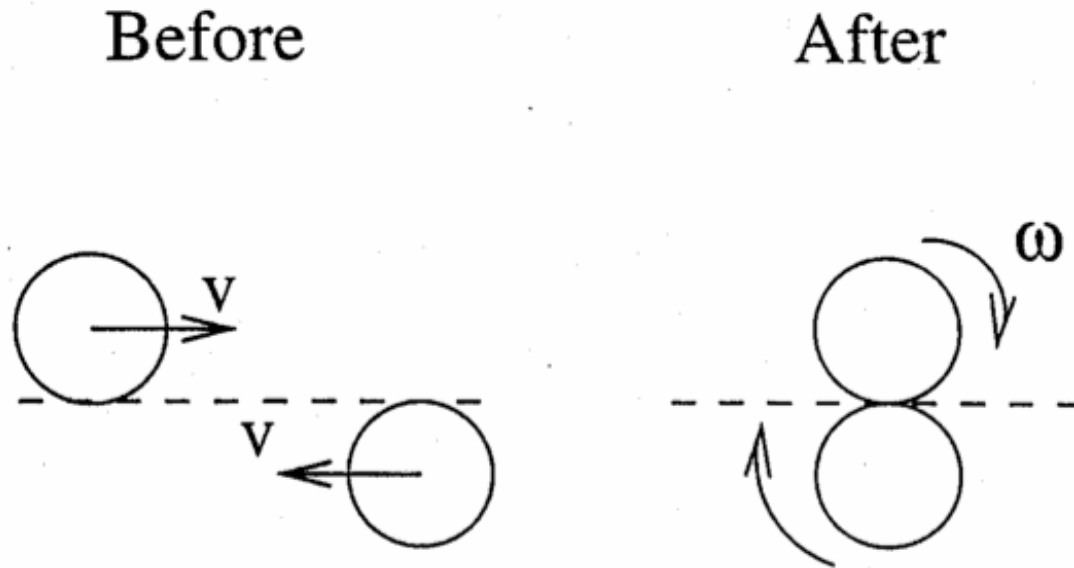


- (a) (1 point) What is the combined angular momentum of the two pucks about their mutual center of mass before the collision?
- (b) (1 point) What is the combined moment of inertia of the two pucks about their mutual center of mass after the collision?
- (c) (2 points) What is ω , the angular speed of the two pucks about their mutual center of mass after the collision?
- (d) (1 point) What fraction of the original energy is lost to heat during the collision?

Quiz

Problem 24

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- Answer:
- a) $L = 2MRv$
- b) $I = 3MR^2$
- c) $\omega = (2/3) v/R$
- d) 1/3 is lost

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Quiz

Problem 32 (modified)

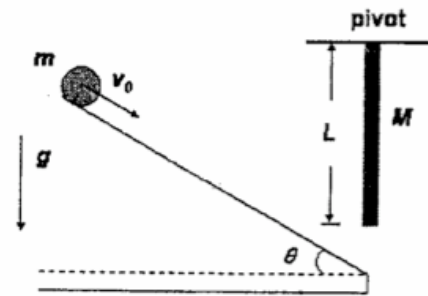


Figure 1A

rolls without slipping

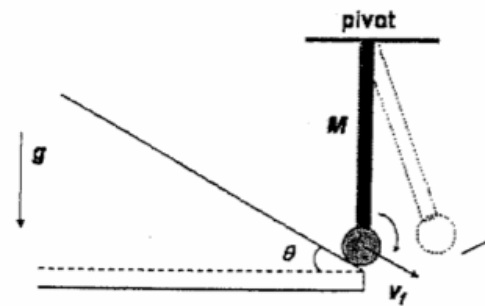


Figure 1B

- (c) (1 point) Find the moment of inertia I of the rod-disk assembly about the axis through the pivot.
- (d) (2 points) Find the angular momentum (both the magnitude and direction) of the rod-disk assembly about the axis through the pivot after the impact. Express your answers in terms of v_f , m , M , r and L . Discuss the condition required for the rod-disk assembly to swing to the right.
- e) Find the oscillation period of the rod-disk assembly.

Quiz

Problem 32 (modified)

• Answer:

c) $I = ML^2/3 + mr^2/2 + m(L+r)^2$

d) $L = mv_f[(L+r)\cos\theta - r/2]$
to the right if $\cos\theta > r/[2(L+r)]$

e) $\omega = \sqrt{DMg/I}$

$D = [ML/2 + m(L+R)]/(M+m)$

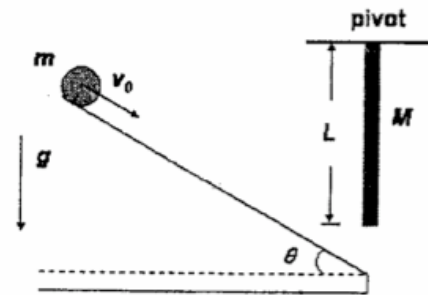


Figure 1A

rolls without slipping

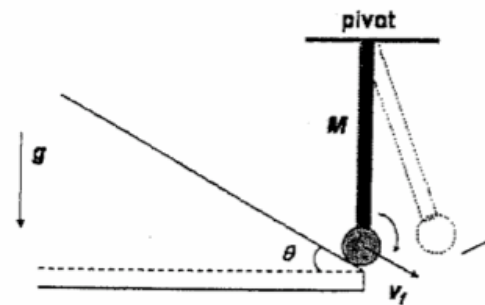


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Monday, November 24:

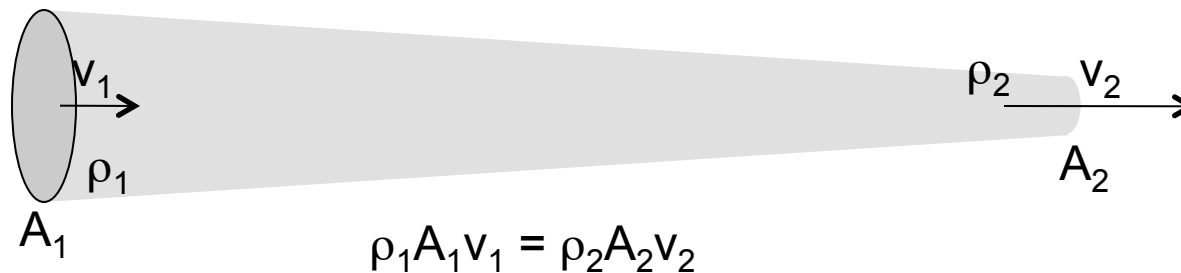
- fluid mechanics
- *Optional, but helpful, to look at these in advance.*

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Basics of Fluid Mechanics, 1

- Continuity Equation (mass conservation)
 - For fluid flow in a pipe, $\rho v A = \text{constant along pipe}$
 - ρ is the fluid density
 - v is the fluid speed (average)
 - A is the pipe cross-sectional area



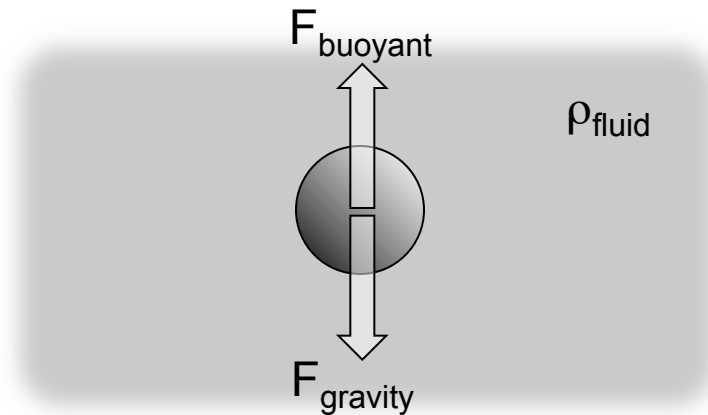
- The “pipe” could be virtual – for example, the boundary of a bundle of stream lines.
 - When the streamlines get closer together, the cross-sectional area decreases, so the speed increases.

Basics of Fluid Mechanics, 2

- Bernoulli's Equation (energy conservation)
 $\frac{1}{2} \rho v^2 + \rho g z + p = \text{constant along streamline}$
 - Applies to certain ideal flows, especially in an incompressible/low-viscosity fluid like water:
 - Density is approximately constant for water, nearly independent of pressure.

Basics of Fluid Mechanics, 3

- Archimedes' Principle (buoyant force)
 - For a solid in a fluid, the upward buoyant force on the solid is the weight of the displaced fluid.
 - Example:



- Two forces on solid are:
 - $F_{\text{gravity}} = mg$ downward, m = mass of solid
 - $F_{\text{buoyant}} = \rho_{\text{fluid}} Vg$ upward, V = volume of solid

Angular Momentum

- Angular momentum vector $\underline{\mathbf{L}}$ is constant, in the absence of outside torques.

If there are outside torques, $d\mathbf{L}/dt = \mathbf{\underline{\tau}}$

- Single particle: $\underline{\mathbf{L}} = \underline{\mathbf{r}} \times \underline{\mathbf{p}} = m \underline{\mathbf{r}} \times \underline{\mathbf{v}}$

$\mathbf{r}$ = distance (vector) from a fixed reference point

- System of particles: $\underline{\mathbf{L}} = \underbrace{M_{\text{tot}} \underline{\mathbf{r}}_{\text{cm}} \times \underline{\mathbf{v}}_{\text{cm}}}_{\text{orbital}} + \underbrace{\sum m_j \underline{\mathbf{r}}'_j \times \underline{\mathbf{v}}'_j}_{\text{spin (about c.m.)}}$

$\underline{\mathbf{r}}'_j, \underline{\mathbf{v}}'_j$ measured with respect to center of mass

- Rotating rigid body: $\underline{\underline{L}}_{\text{spin}} = \underline{\underline{I}}\underline{\underline{\omega}}$ (for principal axis)

$$I = \int R^2 dm = \text{moment of inertia}$$

R = distance from *rotation axis*

Moment of Inertia, Kinetic Energy

- Moments:

- 0th moment: $\int dm = \text{mass}$

- 1st moment: $\int \underline{\mathbf{r}} \, dm$

- $1/M \int \underline{\mathbf{r}} \, dm$ is the **center of mass**

- 2nd moment: $\int R^2 \, dm = \textit{moment of inertia}$

- Other ways to write the integral:

- $$\int dm = \int \rho \, dV = \iiint \rho \, dx \, dy \, dz$$

- Moment of inertia examples:

- T.M.U. Table 14.1, page 379

- Parallel axis theorem: $I = I_{\text{CM}} + Md^2$

- Kinetic energy: $K = \frac{1}{2} Mv_{\text{cm}}^2 + \frac{1}{2} I\omega^2$