MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01X Fall Term 2001

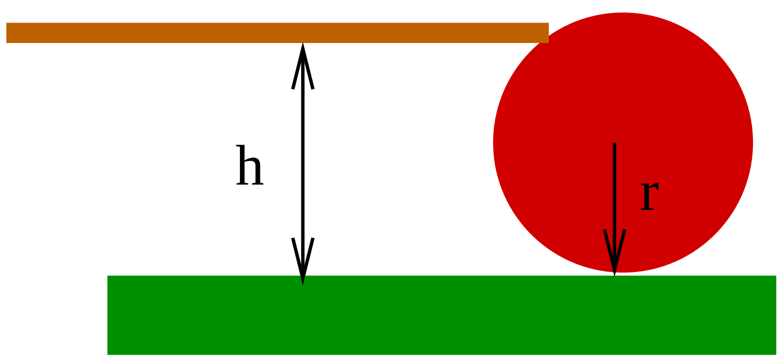
PROBLEM SET 11

Handed out: November 16
Due: November 30 at 5 pm in 4-339B.

Please write your name, subject, **recitation number**, and the name of the recitation instructor on the top right corner of the first page of your homework solutions. The solutions should be placed in the appropriate box in room 4-339B.

Problem 1:

A cue ball of radius r is initially at rest on a horizontal pool table. It is struck by a horizontal cue stick which delivers an impulse of magnitude $J_0 = F_{\text{ave}}\Delta t$. (We use J_0 for the impulse rather than I_0 to avoid confusion with moment of inertia.) The stick strikes the ball at point h above the point of contact on the table.



a. Find the initial angular velocity ω_0 in terms of v_0 (the initial linear velocity of the CM), h, and r.

b. Where should you strike the cue ball if you want it to begin rolling without slipping immediately after it is struck?

Problem 2:

Some Greek gods are hanging around Mount Olympus feeling bored, so they decide to stage a contest. They get Hephaestus to forge them some objects out of a homogeneous material, and then set out to roll them down an incline to see which object gets to the bottom first. They promise not to use any of their godly powers to influence the results. Athena gets a hoop, Apollo gets a disk, and Atlas gets a sphere. The objects all have the same radius (10 cm) and mass (3 kg). The objects are released from rest at the top of a $30°$ incline and roll down without slipping through a vertical distance of 2 m.

a. What are the speeds of the objects at the bottom of the incline?

b. Find the frictional force f in each case.

c. If they start together at $t = 0$, at what time does each reach the bottom? (Who will win the contest?)

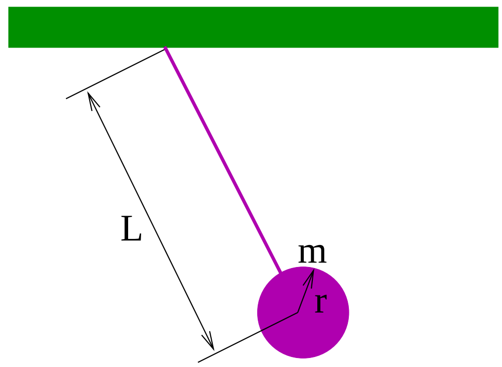
Problem 3:

A rocket of mass m drifts in a circle at constant speed v_0 around the planet Venus, which has mass M.

a. How far from the center of Venus is the rocket?

b. An explosion in the engine chamber suddenly increases the rocket's speed by 25% along its direction of motion. Make a rough sketch of the rocket's new orbit, being sure to indicate on the drawing where the explosion occurred.

c. In the new orbit, what is the maximum distance the rocket reaches from the center of the planet, in terms of M, v_0 and g? For this part, it's okay to just set up the equations and skip doing the algebra, so long as you make clear that it's possible to solve for r_{max} in terms of the other quantities.



Problem 4:

A physical pendulum consists of a spherical bob of radius r and mass m suspended from a string of length $L = r$ (the distance from the center of the sphere to the point of support is L.) When r is much less than L, the situation is often treated as a simple pendulum of length L.

a. Show that the period can be written

$$T = 2\pi\sqrt{\frac{L}{g}}\sqrt{1 + \frac{2r^2}{5L^2}} = T_0\sqrt{1 + \frac{2r^2}{5L^2}},$$

where $T_0 = 2\pi\sqrt{L/g}$ is the period of a simple pendulum of length L.

b. If L is 1 m and r is 2 cm, find the error made in using the approximation $T \sim T_0$ for this pendulum.

c. What must be the radius of the bob for the error to be 1 percent?