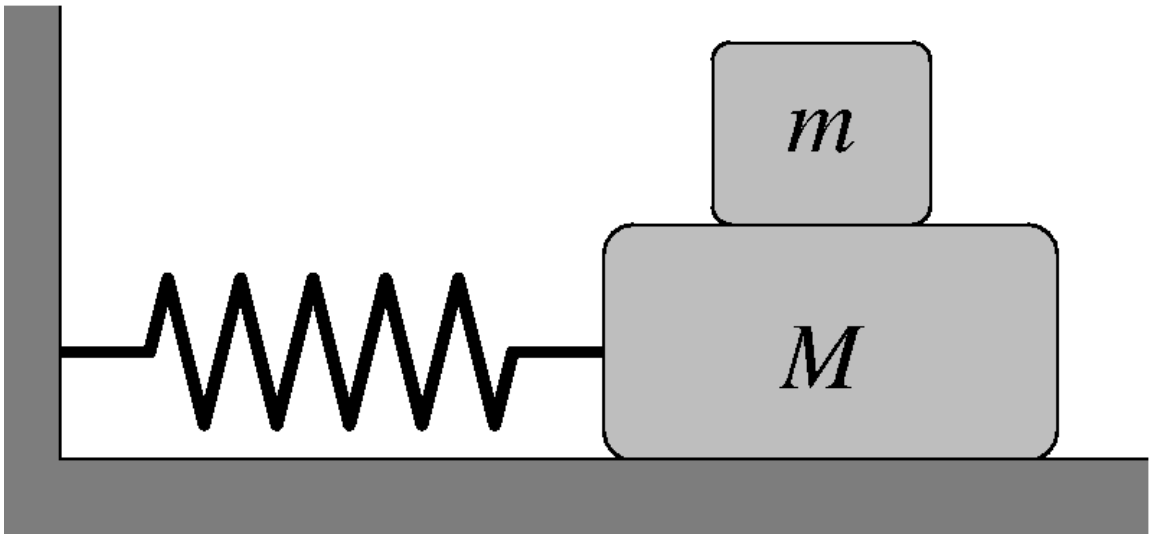
January 7, 2016
Prelim Exam – Day 1

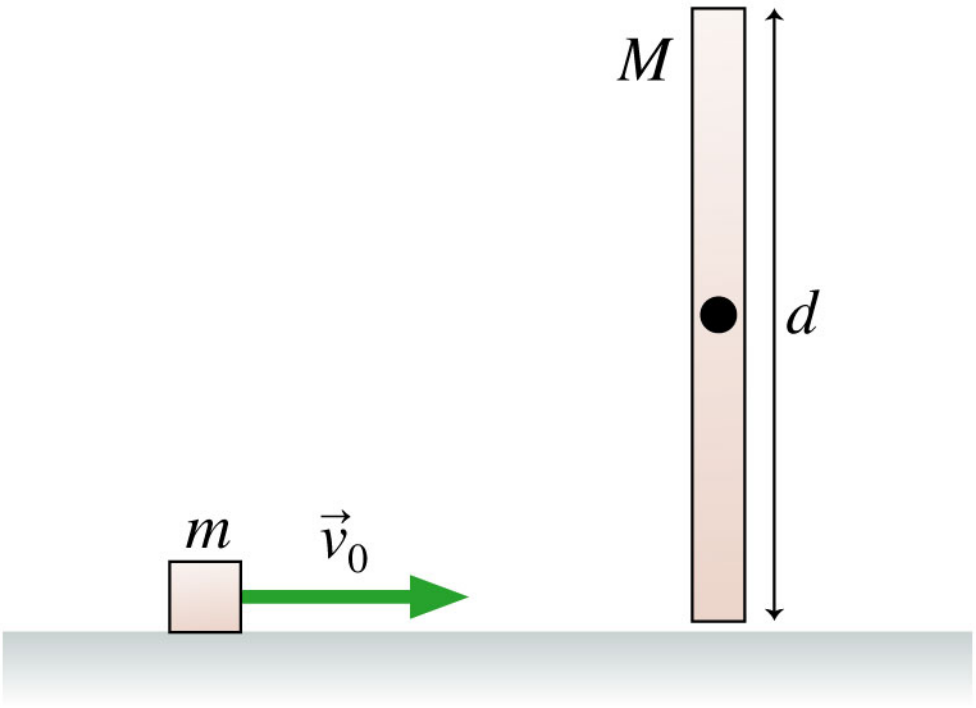
Begin each problem on a separate sheet of paper. Write your **Prelim ID #** in the top right-hand corner of each and every page you submit.

Problem 1:



A large block of mass M attached to a spring oscillates at frequency f as it slides across a frictionless table. A smaller block of mass m rests on the larger block, and the coefficient of static friction between the two is μ_s. What is the maximum amplitude of oscillation that the system can have if the upper block is not to slip?

Problem 2:



The figure above shows a cube of mass m sliding without friction at speed v_0. It undergoes a perfectly elastic collision with the bottom tip of a uniform rod of length d and mass $M = 2m$. The rod is pivoted about a frictionless axle through its center, and initially it hangs straight down and is at rest. What is the cube's velocity – both speed and direction – after the collision? (Hint: The moment of inertia of a rod of length d and mass M rotating about its center is $Md^2/12$.)

Problem 3:

The rotating loop in an AC generator is a square 10.0 cm on a side. It is rotated at 60 Hz in a uniform field of 0.8 T.

(a) Calculate the flux through the loop as a function of time.

(b) Calculate the emf induced in the loop.

(c) Calculate the current induced in the loop for a loop resistance of 1.00 Ω.

(d) Calculate the power delivered to the loop.

(e) Determine the torque that must be exerted to rotate the loop.

Problem 4:

Find the capacitance per unit length of two coaxial metal cylindrical tubes, of radii a and b.

Problem 5:

Fill in the table, each column of which refers to a spherical mirror and a real object. Distances are in centimeters; if a number in the table has no plus or minus sign in front of it, find the correct sign. You may want to check your results by graphical analysis.

	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
Type	Concave						Convex	
f	20		+20			20		
R					–40		40	
s′					–10		4	
s	+10	+10	+30	+60				+24
m		+1		–0.5		+0.10		0.50
Real image?		no						
Erect image?								no

s = object distance, *s′* = image distance