Physics 21 Practice Midterm - 50 minutes
2 Pages - turn over!!

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Tuesday, Feb. 1

Write your answers in a blue book. Calculators and one page of notes allowed. No textbooks or wireless communications allowed. Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**

1. A 40 kg person runs up the stairs of to the fifth Floor of Broida Hall, which is 10 meters from the ground. It takes them 30 seconds. What is the average power they exerted? Take the acceleration of gravity to be $g = 10 \, \text{m/s}^2$.

2. A mass $m = 1 \, \text{kg}$ is attached to a spring, which has spring constant $k = 4 \, \text{N/m}$. The mass is displaced from the spring's equilibrium by $2 \, \text{m}$, and released.

   (a) An instant before release, what is the potential energy?

   (b) What is the speed of the mass when it passes back through the spring's equilibrium?

   (c) The sequence is repeated, except an additional mass $M = 3 \, \text{kg}$ is now attached to the original mass m. What now are the answers to the previous two parts?
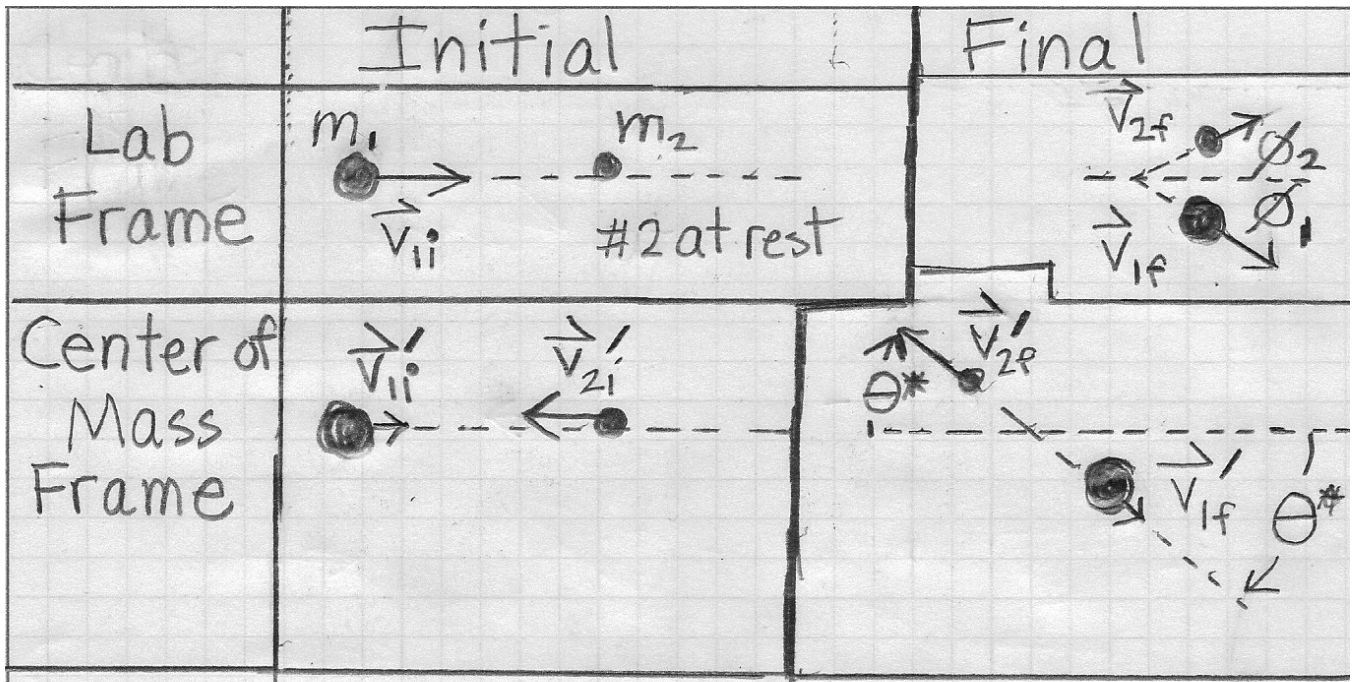
Figure 1: Problem 3.

3. In the 'Lab Frame,' a ball of mass $m_1 = 5\,\text{kg}$ has initial velocity of $v_{1i} = 3\,\text{m/s}$, and collides with a ball at rest, which has mass $m_2 = 1\,\text{kg}$. See Fig 1. After the collision, ball #2 proceeds at an angle $\phi_2 = 30°$ from ball #1's original direction. Find:

   (a) The scattering angle $\theta^\star$ in the 'Center of Mass Frame'. Note as shown in Fig. 1, $\theta^\star < 0$.

   (b) The final speed of ball #2, $|\vec{v}_{2f}|$, in the Lab Frame.

   (c) The angle, after the collision, that ball #1 makes with its original direction, ϕ_1, in the Lab Frame. Note as shown in Fig. 1, $\phi_1 < 0$.

   (d) The final speed of ball #1, $|\vec{v}_{1f}|$, in the Lab Frame.

4. Four bars, each of mass $M/4$ and length L, are assembled into a rigid square. The rotation axis is perpendicular to the plane of the square, and goes through a corner of the square. What is the rotational inertia of the square about that axis? You can use a table for basic rotational inertias.