Physics 120

Exam #3

March 6, 2026

Name___________________________________

Please read and follow these instructions carefully:

- Read all problems carefully before attempting to solve them.
- Your work must be legible, and the organization clear.
- You must show all work, including correct vector notation.
- You will not receive full credit for correct answers without adequate explanations.
- You will not receive full credit if incorrect work or explanations are mixed in with correct work. So, erase or cross out anything you don't want graded.
- Make explanations complete but brief. Do not write a lot of prose.
- Include diagrams.
- Show what goes into a calculation, not just the final number. For example, $|\vec{p}| \approx m|\vec{v}| = (5kg)\times\left(2\,\frac{m}{s}\right) = 10\,\frac{kg\cdot m}{s}$
- Give standard SI units with your results unless specifically asked for a certain unit.
- Unless specifically asked to derive a result, you may start with the formulas given on the formula sheet including equations corresponding to the fundamental concepts.
- Go for partial credit. If you cannot do some portion of a problem, invent a symbol and/or reasonable value for the quantity you cannot calculate (explain that you are doing this), and use it to do the rest of the problem.
- Each free-response part is worth 6 points

Problem #1	/18
Problem #2	/18
Problem #3	/18
Problem #4	/18
Total	/72

I affirm that I have carried out my academic endeavors with full academic honesty.

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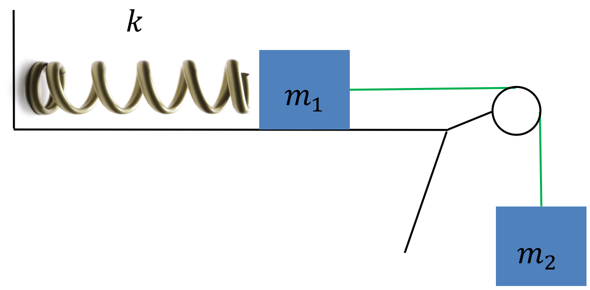
1. Suppose you have the setup shown on the right in which two masses $m_1 = 1kg$ and $m_2 = 3kg$ are connected by a light rope passed over a massless pulley. To the block of mass m_1, a spring of stiffness $k = 100\frac{N}{m}$ is attached.

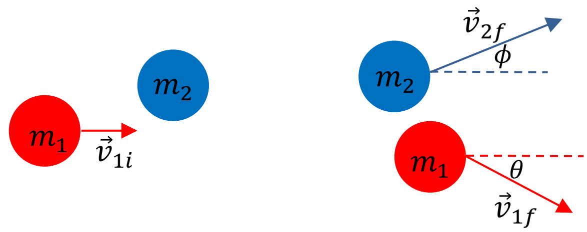


   a. Define your system and using energy ideas, what is the maximum extension y_{max} of the spring when mass m_2 is released from rest. Assume that the spring starts from its equilibrium position.

b. Define your system and using energy ideas, what are the speeds of the blocks when the spring has been stretched by an amount $y = 0.3y_{max}$ from equilibrium?

c. Suppose that the surface that the block of mass m_1 slides across were not frictionless, but that friction existed with coefficient of friction $\mu = 0.4$. In this case, what would be the maximum extension of the spring? How does this compare to the case without friction? Does the answer make sense? Explain why it does or does not.

2. Two balls of masses $m_1 = m$ and $m_2 = 3m$ shown below undergo a glancing collision in the plane of the page. Ball of mass m_1 has an initial velocity $\vec{v}_i = \langle 4,0,0 \rangle \frac{m}{s}$ and ball of mass m_2 is at rest. Because of the glancing collision the ball of mass m_2 is scattered through an angle $\phi = 21^0$ while the ball of mass m_1 is scattered through an angle $\theta = 38^0$.

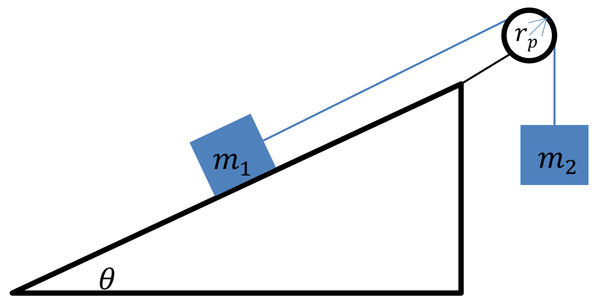


a. Starting with the *full vector equations* that govern the momenta of each ball before and after the collision, what is the ***velocity*** of the ball of mass m_2 after the collision?

b. Using the *full vector equations* that you wrote in part a, what is the ***velocity*** of the ball of mass m_1 after the collision?

c. Explain what it means for a collision to be elastic and inelastic and using your explanation, was the collision above elastic or inelastic? To answer the second part, you will need to perform a calculation and assume $m = 1kg$.

3. Consider the system of masses shown below where a block of mass m_1 is on a ramp inclined at angle θ measured with respect to the horizontal. Friction exists between this block and the ramp with coefficient of friction μ. To this mass, a block of mass m_2 is suspended by a light rope that passes over a pulley with mass m_p and radius r_p.



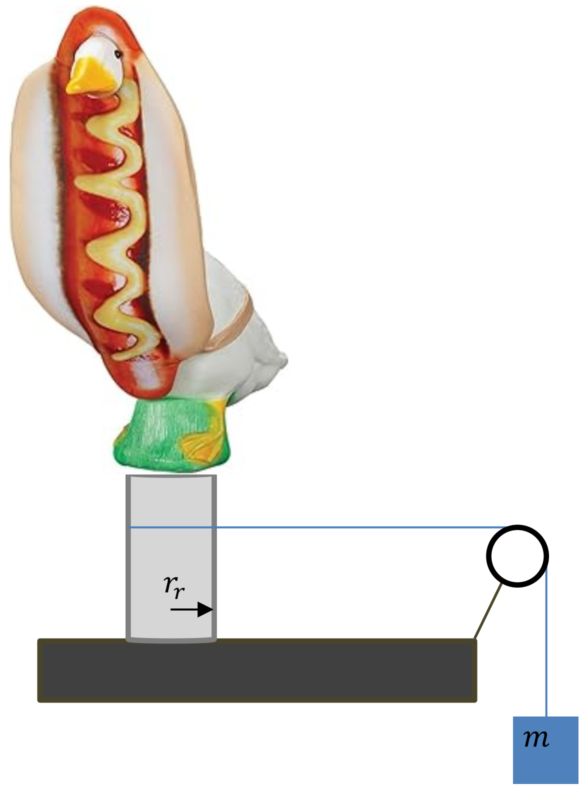
a. Starting from Newton's laws of motion in *full vector form for the forces and torques*, what is the magnitude of the acceleration of the system if the system is released from rest? Be sure to specify your coordinate system for each mass and for the directions for the torque.

b. Using the result from part a, if the block of mass m_1 slides a distance d up the incline, what are the final speeds of the blocks of mass m_1 and m_2?

c. Defining your system and using energy ideas, what is the final speed of the blocks of masses m_1 and m_2 if the block of mass m_1 slides a distance d up the ramp if the system is released from rest? What can you say about the speed of the block determined in part b and the speed determined here in part c? Are they the same? Should they be why or why not? Explain.

4. Consider the system shown below in which a priceless piece of art is attached to a rod of radius r_r. To the rod a light string is wound and the other end of the string passes over a light pulley and a mass m is connected as shown below.

   a. Starting with the full vector expression for the forces and torques, what is the expression for the moment of inertia of the piece of art in terms of the acceleration created by the falling mass m if the mass m is released from rest?



b. Using energy ideas, what is the what is the expression for the moment of inertia of the piece of art in terms of the speed of the falling mass m if the mass m is released from rest and falls through a height y?

c. You have two expressions for the moment of inertia that you derived in parts a and b. One was determined by looking at the forces and torques involved and the other by conservation of energy. Explain in full detail, which of the two methods, if either, would yield a better measurement of the moment of inertia for the piece of art? If both would yield an acceptable moment of inertia, explain why they both would.