Physics 110

Exam #3

November 9, 2026

Name_____

Please read and follow these instructions carefully:

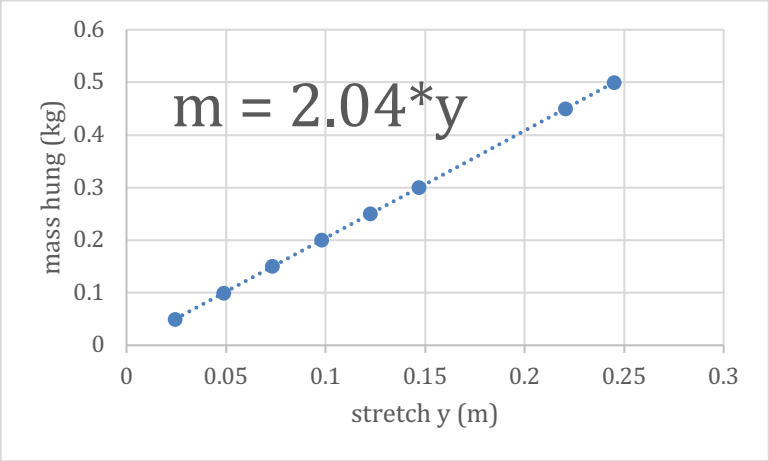
- Read all problems carefully before attempting to solve them.
- Your work must be legible, and the organization clear.
- You must show all work, including correct vector notation.
- You will not receive full credit for correct answers without adequate explanations.
- You will not receive full credit if incorrect work or explanations are mixed in with correct work. 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 to derive a result, you may start with the formulas given on the formula sheet including equations corresponding to the fundamental concepts.
- Formulas or constants not explicitly given on the formula sheet need to be derived before they can be used or full credit will not be given even if the formula or answer is correct.
- Go for partial credit. If you cannot do some portion of a problem, invent a symbol and/or value for the quantity you can't calculate (explain that you are doing this), and use it to do the rest of the problem.
- Each free-response part is worth 5 points.

Problem #1	/25
Problem #2	/25
Problem #3	/25
Total	/75

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

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1. A spring of stiffness k is suspended from the ceiling. Various masses m (in kilograms) are hung from the end of the spring and the stretch y (in meters) of the spring from equilibrium is measured. A plot of the mass hung from the end of the spring versus the stretch of the spring is constructed and shown on the right. A best fit line to the data is also provided.

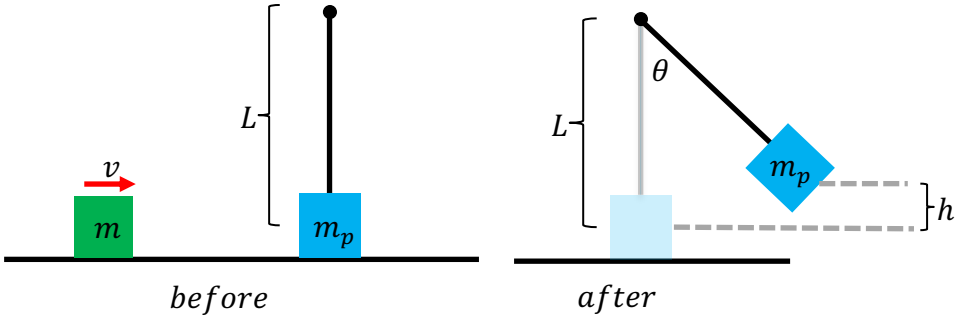


a. From the plot and a carefully labeled free-body diagram, what is the stiffness k of the spring? If you cannot determine a value for the stiffness, use $k = 10\frac{N}{m}$ in any calculations below.

b. The spring is removed from the ceiling and laid horizontally with the left end connected to a wall and the right end to a block of mass $m = 500g$ as shown on the right. The block of mass m is compressed against the spring by an amount $x = 75cm$ measured from the spring's equilibrium position taken to be zero. The block of mass m is launched from rest and when the spring reaches its equilibrium position the mass leaves the end of the spring. What is the launch speed of the mass m spring if the horizontal surface is frictionless?



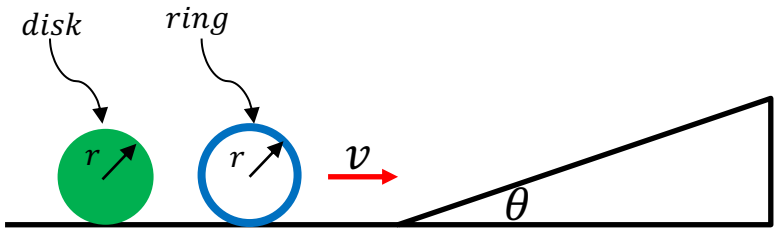
c. The block of mass m slides across the horizontal frictionless surface and collides with a stationary pendulum of mass $m_p = 1.5kg$ and length $L = 30cm$. After the collision *the pendulum* rises through a height h by sweeping out an angle $\theta = 37^0$ measured with respect to the vertical. The mass and the pendulum do not stick together after the collision. What was the speed of *the pendulum arm* immediately after the collision?



d. What is the magnitude of and the direction for the velocity of the *block of mass m* immediately after the collision?

e. Was the collision between the block and the pendulum arm elastic? You need to do a calculation to answer this and be sure to explain the result you get in terms of whether the collision is elastic or not.

2. A uniform disk and ring each of mass m and radius r roll without slipping along a horizontal surface each with a constant speed v as shown below. They both then encounter a ramp inclined at angle θ measured with respect to the horizontal and continue to roll without slipping up the ramp until they momentarily come to rest before rolling back down the ramp.



a. Explain how the angular acceleration vector $\vec{\alpha}$ points with respect to the angular velocity vector $\vec{\omega}$ as either object rolls up the incline. Be sure to clearly explain how the vectors must point relative to each other and be sure to use standard directions for vectors for rotating quantities.

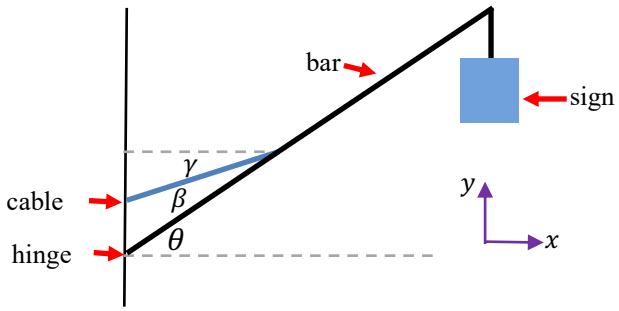
b. As either object rolls up the incline without slipping explain which way static friction between the object and the incline must point and why for the objects to slow down and come to rest momentarily.

c. From a carefully labeled free-body diagram what is the expression for the magnitude of the static frictional force expressed in terms of m, r, I, θ, and any constants you may need? Do not enter any expressions for the moment of inertia for either the disk or ring. Leave their moments of inertia as I in the expression for the static frictional force as the expression for the static frictional force is the same for both the disk and ring.

d. What is the magnitude of the translational acceleration of either object up the incline expressed in terms of m, r, I, θ, and any constants you may need? Again, leave their moments of inertia as I as the expression for the translational acceleration is the same for both the disk and ring.

e. Which object, the disk or ring, goes the farthest up the ramp before coming to rest? You will need to do a calculation to answer this and be sure to explain your result. That is, determine the expression for the displacement Δx along the ramp for both the disk and ring and see which is greater. Simply saying disk or ring will earn no credit.

3. A uniform bar of weight $F_{WB} = 500N$ and length $L = 5m$ is connected to a wall by a hinge on its left end and on its right end has a sign of weight $F_{Ws} = 110N$ suspended. To keep the system from rotating, a cable is attached to the wall on its left end and on its right end to the bar at a point 40% of the length of the bar measured from the hinge. The cable makes an angle $\beta = 15^0$ between it and the bar and an angle γ measured with respect to the horizontal as shown below. The bar is angled at an angle $\theta = 55^0$measured with respect to the horizontal.



a. Using the coordinate system shown in the figure, and from a carefully labeled free-body diagram what are the expressions for the sum of the forces in the x- and y-directions? Your expressions should contain no numbers (except constants like $\frac{1}{2}$ or 90^0, etc.), just symbols at this point. Express your answers in terms of the angle γ.

b. From a carefully labeled free-body diagram, what is the expression for the sum of the torques about the hinge and from this expression, what is the magnitude of the tension force in the cable? Your expression for the sum of the torques should also contain no numbers (except constants like $\frac{1}{2}$ or 90^0, etc.), just symbols at this point. Your answer for the magnitude of the tension force will be a number.

c. What is the magnitude of and the direction for the reaction force in the hinge, measured with respect to the horizontal?

d. Suppose the bar was lowered so that $\theta = 30^0$ measured with respect to the horizontal. For this situation, explain how the tension force in the cable changes. That is does it increase, decrease, or remain the same. Assume that the angle β between the bar and the cable does not change and simply stating the tension increases, decreases or remains the same with no explanation will earn minimal credit.

e. Suppose we return to the original setup shown in part a. If the cable were cut, what would be the initial magnitude of and direction for the angular acceleration of the bar about the hinge?