Physics 110

Exam #2

May 19, 2023

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	/24
Problem #2	/24
Problem #3	/24
Total	/72

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

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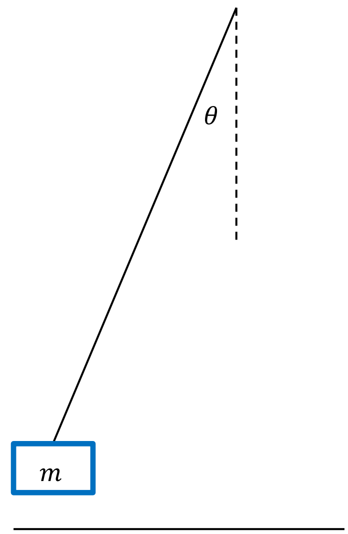
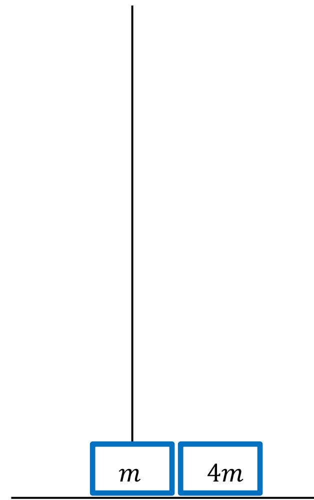
1. A block of mass $m = 0.5kg$ is attached to a string of length $l = 0.5m$. The block is pulled back from the vertical (taken to be $\theta = 0^0$) and is released from rest when the string makes an angle $\theta = 35^0$, as shown below.



   a. What is the speed of the mass when it passes through $\theta = 0^0$?

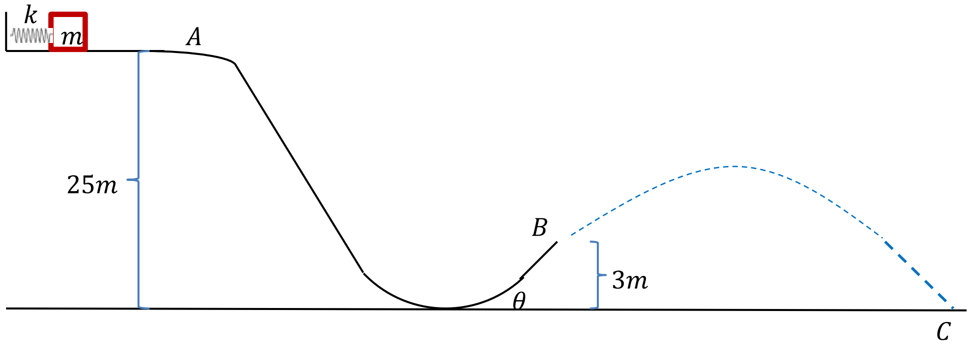
   b. What is the magnitude and direction of the tension force in the string when the block passes trough $\theta = 0^0$?

c. As soon as the block of mass m passes through $\theta = 0^0$, it makes a head on collision with a second block of mass $4m$, initially at rest. After the collision it is found that the block of mass $4m$ moves to the right with a velocity $v_{f,4m} = 0.25\frac{m}{s}$. If the blocks do not stick together after the collision, what is the velocity of the block of mass m after the collision, $v_{f,m}$?



d. Is the collision of the two blocks elastic or inelastic? You will earn no credit for simply saying elastic or inelastic. You need to show that the collision is elastic or inelastic.

2. A $m = 70kg$ mass is launched from rest by a $x = 2m$ compressed spring of stiffness $k = 630\frac{N}{m}$. The mass m moves across the horizontal surface and then down the $25m$ tall hill and is launched from end of the $3m$ tall ramp on the right inclined at $\theta = 30^0$ measured with respect to the horizontal. All surfaces the mass moves on are frictionless.



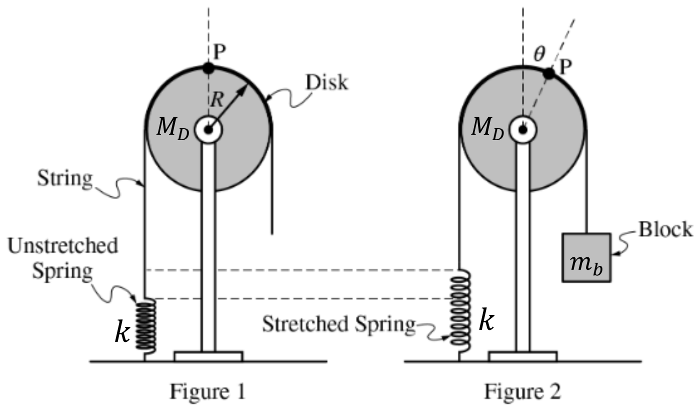
a. Using the work-kinetic energy theorem, what is the speed of the mass at point A, just before the mass goes down the hill?

b. Using energy ideas between points A and B, what is the launch speed of the mass from the end of the ramp?

c. The mass eventually lands at point C. How far horizontally is point C from point B?

d. How much work was done by gravity between points B and C?

3. A solid disk of mass M_D and radius R is supported by a vertical stand. The disk can rotate about an axis through its center without friction. The rotational inertia of the disk is $I_D = \frac{1}{2}M_D R^2$ and there is a light string draped over the disk. The left end of the string is attached to a spring of stiffness k and the right end to a block of mass m_b. The mass m_b is slowly lowered until the spring/disk/block system comes into equilibrium. In equilibrium the disk has rotated through an angle θ measured with respect to the vertical and the spring has stretched by y from its unstretched length.



a. Derive an expression for the mass of the block m_b, in terms of M_D, R, k, θ, and any constants you need.

b. At a time $t = 0$, the string on the right is cut and the mass m_b falls to the ground. As soon as the string is cut, the disk accelerates about the axis through its center. What is the expression for the initial maximum angular acceleration α about the axis through the center of the disk?

c. When the spring returns to its unstretched length, the disk reaches its maximum rotational speed. What is the maximum rotational speed ω of the disk?

d. Suppose that the system is adjusted so that the axis the disk rotates on does NOT pass through the center of the disk but is offset by an amount r. The block is again hung from the right side of the string and lowered until the spring/disk/block system are again in equilibrium. For each of the forces shown below, does the torque about the axis through the disk increase, decrease or remain the same due to each of these forces compared to those same forces from part a?

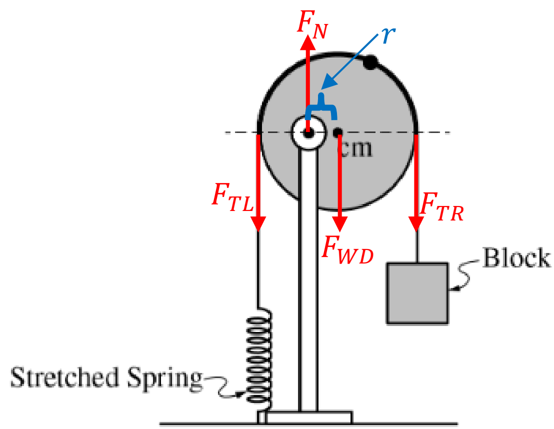


Figure 3

F_{WD}:

F_N:

F_{TR}:

F_{TL}: