Physics 120

Exam #2

February 13, 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, $|\vec{p}| \approx m|\vec{v}| = (5kg) \times (2\frac{m}{s}) = 10\frac{kg \cdot m}{s}$
- 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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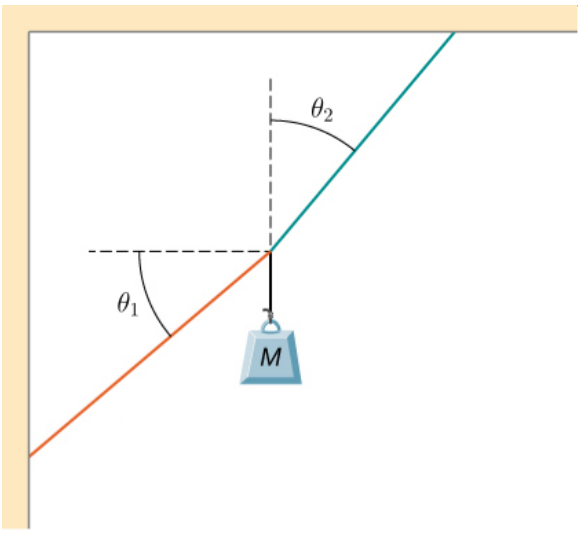
1. A $M = 6.75kg$ mass is suspended from the ceiling and the left wall by two light ropes that make angles $\theta_1 = 37^0$ and $\theta_2 = 21^0$as shown on the right. Let the tension in the upper rope be $F_{T,upper}$ and $F_{T,lower}$ the tension in the lower rope.

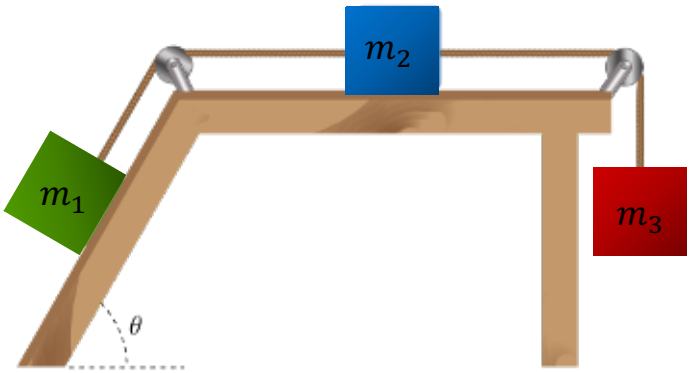


   a. Starting with the vector expression for Newton's Laws of motion, what is the magnitude of the tension force in the upper rope, $F_{T,upper}$? Be sure to specify to your choice of coordinate system for the problem.

b. Starting with the vector expression for Newton's Laws of motion or continuing with the results of part a, what is the magnitude of the tension force in the lower rope, $F_{T,lower}$?

c. Based on your results from parts a and b, which tension force $F_{T,upper}$ or $F_{T,lower}$ is larger and is this a reasonable result? To earn full credit, please be sure to fully explain your answer and why you think it is or is not reasonable.

2. Consider the arrangement of masses shown below, where a block of mass $m_2 = 3m$ is sitting on the horizontal surface. To this mass a block of mass $m_3 = 10m$ is connected on the right side of the $3m$ block and is suspended vertically from a massless pulley by a light string. To the left of the $3m$ block a block of mass $m_1 = 4m$ connected by a light string that passes over a massless pulley and is on an incline, inclined at angle $\theta = 45^0$measured with respect to the horizontal. You may assume that the surfaces are all frictionless and that all of the blocks start from rest.

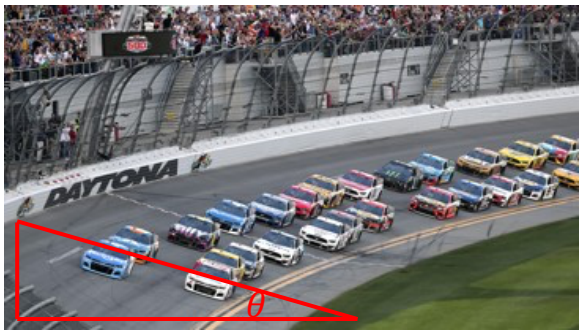


a. Starting from Newton's Laws of motion, write the *full vector equations* that govern each block. There should be three equations in total, one for each block and be sure to specify to your choice of coordinate system for each block.

b. If the block of mass $3m$ is released from rest, determine the expression for the magnitude of the acceleration of the system in terms of the acceleration due to gravity g. That is, your answer should be in of the form $a = C \cdot g$, where C is a number. Do not actually evaluate the actual acceleration at this moment.

c. What is the speed of the block of mass $3m$ if the block of mass $10m$ falls a distance $0.75m$ from rest?

3. We've said in class that roadways and racetracks are banked so that cars can negotiate the curves without having to rely on friction to take the turn, but instead rely on a component of the normal force from the track/roadway itself. Suppose that a racetrack, shown below, is banked at an angle $\theta = 31^0$. This racetrack is designed to allow the racecar to take the curve at a speed $v = 200\frac{mi}{hr} = 89\frac{m}{s}$.



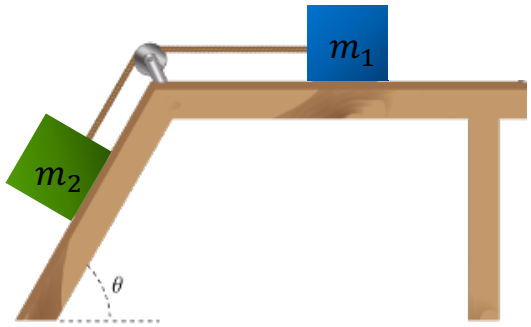
https://www.ajc.com/sports/racing/rains-delay-end-daytona-500-until-monday/Ctvg7ozshchtRxGVsfjpYK/

a. Starting from Newton's laws of motion in *full vector form*, what is the design radius of the track? That is, what is the radius of the horizontal circle that the racecar would travel in around the curve? Be sure to specify your coordinate system.

b. Suppose that the racecar driver wanted to take the curve at a higher speed than the track was designed. If the coefficient of friction between the tires and the track is $\mu = 0.4$, what is the racecar's allowable *maximum speed* in order to take the curve at the radius found in part a?

c. Suppose that the racecar driver wanted to take the curve at a lower speed than the track was designed. If the coefficient of friction between the tires and the track is $\mu = 0.4$, what is the racecar's allowable *minimum speed* in order to take the curve at the radius found in part a?

4. Consider the arrangement of masses shown below. A block of mass m_1 sits at rest on the horizontal surface while a block of mass m_2 sits at rest on the incline which is oriented at an angle θ measured with respect to the horizontal. Friction exists on all surfaces with coefficient of friction μ.



a. Starting from the general definition of work, what are the expressions for the work done on masses m_1 and m_2 if both masses are released from rest? There should be two expressions, one for mass m_1 and one for mass m_2.

b. Starting with the work-kinetic energy theorem and using your results from part a, what is the expression for the speed of the bock of mass m_1, if both blocks are released from rest?

c. How much work was done on the system of masses m_1 and m_2 by gravity and how does this relate to the change in gravitational potential energy? To earn full credit, either show how the change in gravitational potential energy is related to the work done using some mathematical equations, or fully explain the result.