Physics 110

Exam #2

October 19, 2026

Name_____

Please read and follow these instructions carefully:

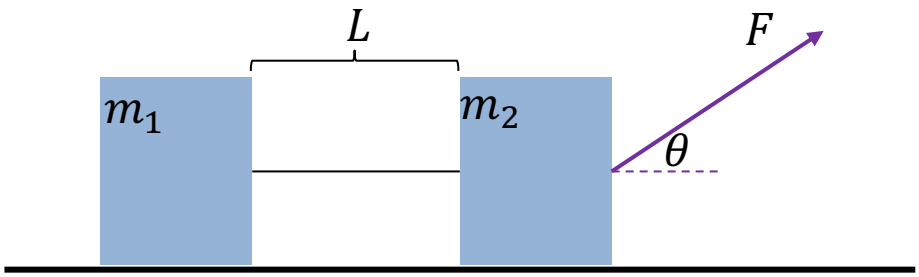
- Read all problems carefully before attempting to solve them.
- Your work must be legible, and the organization clear.
- You must show all work, including correct vector notation.
- You will not receive full credit for correct answers without adequate explanations.
- You will not receive full credit 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 4 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.

_____

1. Two blocks of masses $m_1 = 2kg$ and $m_2 = 5kg$ are being pulled by a force with magnitude $F = 50N$ oriented at an angle $\theta = 50^0$ measured with respect to the horizontal. The two masses are connected together by a massless rope of length $L = 50cm$. Friction exists between each block and the surface with coefficient of friction $\mu = 0.25$.



a. What are the reaction forces exerted on each block by the table?

b. What is the acceleration of the two-block system down the horizontal surface?

c. What are the magnitudes and directions of the tension force in the ends of the rope that are physically connected to each block? Do these forces obey Newton's 3rd law? Explain your answer.

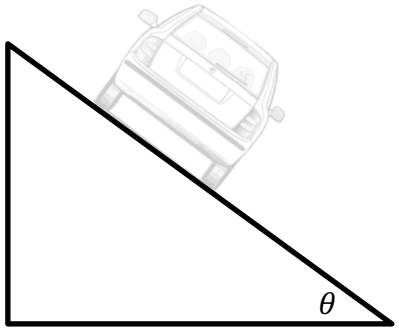
d. How much work was done on each block if the blocks are pulled from rest along the horizontal surface for a time $t = 4s$?

e. Using the work-kinetic energy theorem, what is the speed of the two-block system after being pulled along the horizontal surface for a time $t = 4s$?

f. Suppose that at a time $t = 4s$ you let go of the rope connected to the block of mass m_2. How far from where you let go of the rope will the blocks of masses m_1 and m_2 move before coming to rest?

2. A car of mass m is negotiating a corner in a road that has a radius of curvature R and is banked at an angle of θ measured with respect to the horizontal at a constant speed v as shown below.

a. From a carefully labeled free-body diagram, derive an expression for the magnitude of the reaction force of the roadway on the car? Your expression should depend on the bank angle θ. Does your expression make sense? That is, explain the limiting cases for θ, namely what do you get if $\theta = 0^0$ and $\theta = 90^0$. What do they mean and are these reasonable?



b. From your carefully labeled free-body diagram, derive an expression for the speed v at which the car can take the corner without having to rely on friction? This is called the design speed. Further, suppose that the car has a mass $m = 1200kg$, the road has a radius of curvature $R = 87m\ (\sim 270feet)$ and is banked at an angle of $\theta = 20^0$ measured with respect to the horizontal. What is the speed that the roadway is designed for? To earn full credit, you need to derive an expression for the speed v. Simply stating a formula or evaluating a formula with no derivation will earn minimal credit.

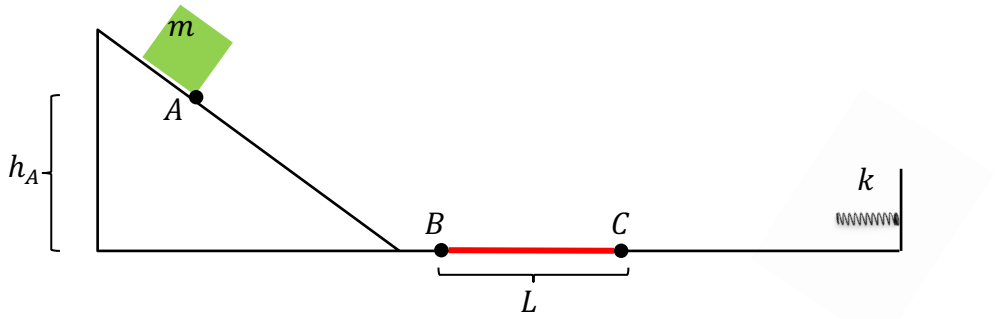
c. Suppose that you want to take the curve at a speed higher than the design speed, say perhaps $v = 55\frac{mi}{hr}\ (= 24\frac{m}{s})$. In this case you would have to rely on friction to help you take the corner. What coefficient of friction μ would be needed to safely take the corner at this speed using the numbers from part b?

d. A heavy semi-truck and a lightweight car approach the same banked curve with identical tire conditions, that is μ is the same for both the semi-truck and the car. Does one vehicle have a higher maximum safe speed before skidding, or can they both navigate the curve at the same maximum speed? Explain your answer in complete sentences using as much physics as possible.

e. Suppose the curve in the roadway approximated a semi-circle. How long would it take for a vehicle to negotiate the curve at the speed in part c?

f. As the vehicle negotiates the semi-circle around the corner at the design speed, how much work is done on the vehicle by all of the forces that act?

3. A block of mass $m = 3kg$ is released from rest at point A which is a height $h_A = 4m$ above the ground. The block slides down the ramp, assumed to be frictionless, to point B on the horizontal surface. The distance between points B and C is $L = 50cm$ long and over this region there is a rough patch where friction exists with a coefficient of friction $\mu = 0.8$. When the block exits point C it slides across a frictionless surface until it encounters a horizontal spring with stiffness $k = 600\frac{N}{m}$ that is attached to an immovable wall.



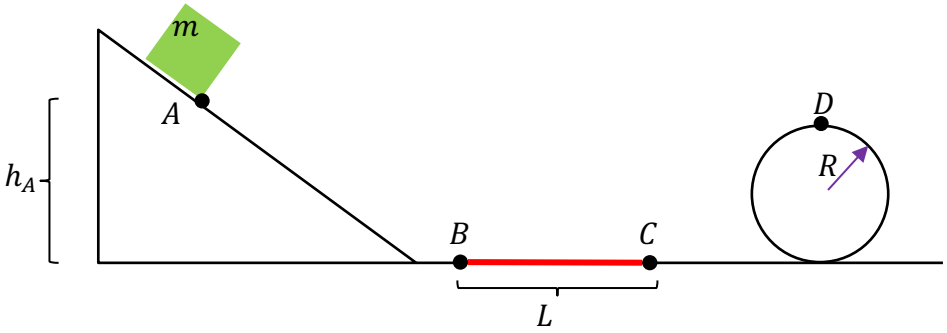
a. Using energy ideas, what is the speed of the block at point B?

b. How far is the spring compressed bring the bock momentarily to rest? Assume that the spring is initially at its equilibrium position when the block strikes it.

c. The spring will launch the block from rest back towards the ramp. On its first pass back across the rough patch what is the vertical displacement of the block back up the ramp? Use energy ideas.

d. How many times does the block cross the rough patch of ground between points B and C?

e. Suppose we remove the spring and replace it with a loop-the-loop track with radius $R = 1.5m$. The block is again released from rest at point A. Using energy ideas what will be the speed of the block at point D located at the top of the loop?



f. If the block slides around the inside of the loop, what is the magnitude of the reaction force of the track on the block when the block is at the top of the loop?