PHYS 615 – Quiz 1: Forces, Newton's Laws

Name: _____

Instructions: You have 40 minutes to work on this quiz. If possible, upload your work to grade-scope when you are done – alternatively, just hand it in on paper.
Possibly useful equations:

$$\vec{F}_{net} = m\vec{a} \qquad F_{fk} = \mu_k F_N \qquad F_{fs} \le \mu_s F_N \qquad F_G = mg \qquad \vec{F}_{kind,A\,on\,B} = -\vec{F}_{kind,B\,on\,A}$$

1. (50 points)

   A person in an elevator is holding a book vertically by pressing it against the wall of the elevator; their push is exactly horizontal. There is static friction between the book and the person, the book and the wall, and the person and the floor; to keep things simple, we'll take the coefficients of static friction to be all the same μ_s. The mass of the book is m_B, the mass of the person m_P. The elevator is accelerating upward with acceleration a.

   (a) (10 points) Draw separate free body diagrams for the book and the person. Label the forces with the kind of force, as well as what is acting on what. (use "E": Earth, "W": wall of elevator, "F": floor of elevator, "B": book, "P": person)

   (b) (10 points) Assume the person is pushing just hard enough so that the book doesn't start sliding relative to the wall. Write out Newton's 2nd Law for both the book and the person, in both directions.

   (c) (10 points) Find the expressions for all the normal forces and frictional forces in this problem in terms of a, g, μ_s, m_P, m_B.

   (d) (10 points) Does your answer make sense as μ_s gets very small?

   (e) (10 points) If the person now pushes with twice the normal force as before, do the frictional forces double? (Be specific about which frictional forces you are talking about.)

2. (50 points)

   Here is a modified Atwood machine with an inclined plane:
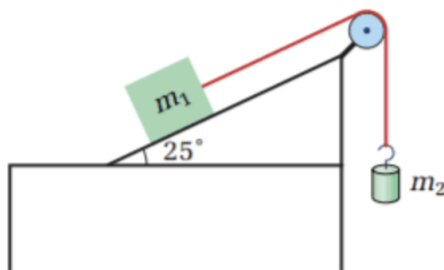
   Given the angle of the plane θ (= 25°, but please just use θ), and the masses of the two blocks m_1, m_2, what is the minimum coefficient of static friction μ_s between block 1 and the inclined plane, such that the blocks stay at rest?