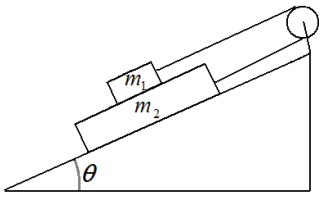
Physics UN2801 Professor Christ
Midterm Examination (Practice) 10/10/2022

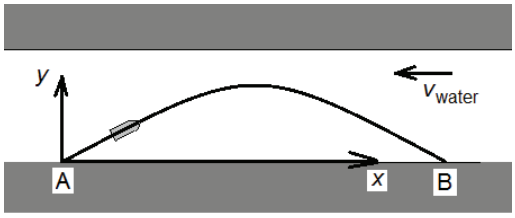
Answer **two (2)** of the following **three (3)** questions.

Please give a complete description of your method of solution since *partial credit* will be given. (This practice exam is best first attempted under realistic conditions, *ie.* on you own and consulting only material to which you would have access during the in-class midterm.)

1. A block of mass m_1 slides on top of a block of mass m_2 which, in turn, slides on a stationary inclined plane making an angle of θ with the horizontal. They are joined by a massless rope passing over a pulley as shown on the right. Each sliding surface experiences a frictional force with coefficient of friction μ. With what acceleration does m_2 slide down the inclined surface? (Assume that m_2 is sufficiently large compared to m_1 that m_2 does slide downward.) [50 points]



2. A boat travels from point A to point B on the same side of a river. The river water flows parallel to the banks but at a speed $v_{\text{water}} = ky$ where y is the distance from the river bank. The boat follows the path $y(x) = ax - bx^2$ where a and b are positive constants and x is the distance the boat moves upstream from the point A. The water exerts a force $\vec{F} = \sigma\vec{v}$ on the boat where $\vec{v}$ is the velocity of the water relative to the boat. You may assume that the boat's speed relative to the river bank is sufficiently small that it can be neglected when determining the force the water exerts on the boat.



   (a) What is the maximum distance the boat reaches from the river bank? [12 points]

   (b) Find the work done by the boat as it follows the path from A to B. [30 points]

   (c) Is the force acting on the boat conservative? Explain your conclusion. [8 points]

3. Sand falls at a constant rate λ (in units of mass per unit time) from a raised hopper, located at the position $x = 0$, onto railroad tracks. A flatcar of length L and mass M_0 moves without friction on those tracks with initial velocity v_0. At $t = 0$ the front edge of the car passes under the hopper so the sand begins to fall on the flatcar. At the time $t = T$ the flatcar passes beyond the hopper and the falling sand. Consider $0 \le t \le T$.

   (a) What is the total mass, $M(t)$, of the moving car and sand? [6 points]

   (b) Determine the car's velocity $v(t)$ at the time t. [18 points]

   (c) What is the position of the front edge of the car, $x(t)$? [18 points]

   (d) Find the time T in terms of L, M_0, v_0, and λ. [8 points]