Physics UN2801 Professor Christ
Midterm Examination (Practice) 10/26/2020

Answer each 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 taken without searching for the solutions on the web. The problems on the actual midterm will be chosen to be more difficult to find in a web search than some of those below.)

1. Short problems:

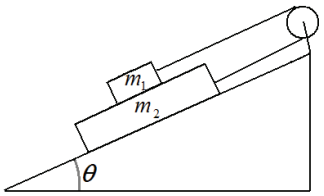
   (a) A cork is fixed to the bottom, inside an upright, freely-falling bucket filled with water. If the cork is released at $t = 0$, find the distance between the cork and the bottom of the bucket as a function of time. [9 points]

   (b) At what rate is work done by a 50Kg boy walking up a down escalator at such a rate that he stays in the same place? Assume the escalator stairs move downward with a speed of 10 cm/sec at an inclination of 30° from the horizontal. [9 points]

   (c) Neglecting the influence of visual stimulae, what causes a person traveling in a car to become motion sick: The car's velocity? The car's acceleration? or Changes in the car's acceleration? Explain your reasoning. [8 points]

   (d) A child is riding in a school bus holding a helium-filled balloon floating above her head and tethered to a string. If the bus driver suddenly brakes, does the balloon move toward the rear or the front of the bus? Explain. [8 points]

2. A block of mass m_1 slides on top of a block of mass m_2 which, in turn, slides on an 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.) [33 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 $0 \leq t \leq T$.

   (a) What is the total mass, $M(t)$, of the moving car and sand? [4 points]

   (b) Determines the car's velocity $v(t)$ at the time t. [12 points]

   (c) What is the position of the front edge of the car, $x(t)$? [12 points]

   (d) Find the time T in terms of L, M, v_0, and λ. [5 points]