AA 242A Midterm Exam

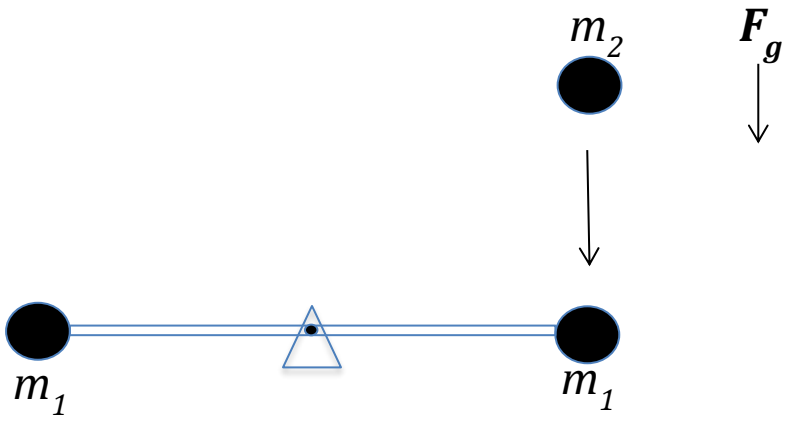
November 4, 2021

11:30 – 1:00 PM

- You may reference one page of equations (front and back) in addition to the Lagrange and conservation sheet given in class.
- There are two problems, each with multiple parts, and 80 possible points; the value of each problem is indicated. You are to work the problems individually.
- The completed exam is to be handed in at the end of class.
- Good luck!

To boldly go...

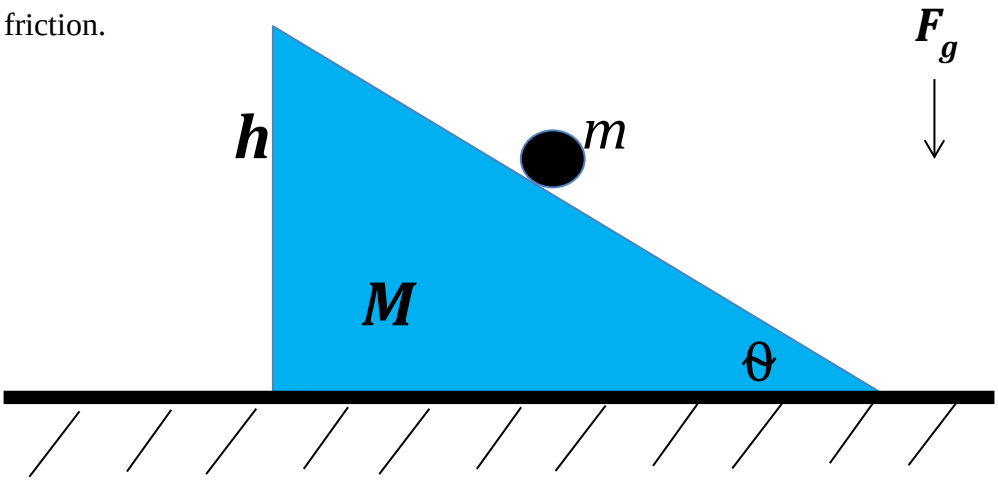
Problem 1 (40 points). Dr. Crusher and Data are trying to balance on a plank in the holodeck. Approximate the crew members as two point-masses, each with mass m_1, that are attached to the ends of a massless plank of length l. The plank is free to rotate in a vertical plane without friction about a fixed horizontal axis through its center. When the plank is initially horizontal and motionless, Spot jumps on Data and sticks to him. Approximate Spot as a point mass with mass m_2 and velocity v_2.



a. (12 points). What is and is not conserved in this system? Justify your answers.
b. (10 points). What is the angular velocity of the system immediately after mass m_2 impacts m_1?
c. (10 points). What is the ratio of the kinetic energy of the system after the collision to that of mass m_2 before the collision?
d. (8 points). Find the angle that the system will rotate to before it momentarily stops.

Problem 2 (40 points)

Worf (a point mass with mass *m*) is in combat on a wedge of mass *M* and height *h* that can move on a frictionless horizontal surface (i.e. both Worf and the wedge can move). Ignore friction.



a. (4 points) Draw a FBD for the system in the inertial frame.
b. (2 points) Write down the generalized coordinates.
c. (6 points) Write down the constraint(s).
d. (2 points) How many degrees of freedom are there?
e. (11 points) Find the EOM(s) using Lagrange's Equations with Lagrange multiplier(s). You do not have to solve for the constraint force(s).
f. (11 points) Find the EOM(s) using Force Balance.
g. (4 points) Write, but do not solve, a possible expression for Lagrange's equations that would include all friction. DO NOT SOLVE.

(+2) Bonus: What is the constraint force in Problem 2?