CSUC Spring Term 2020 Physics 204A Portfolio FINAL EXAM:

Due Friday, May 15, by Noon on our class Blackboard site: 202-PHYS204A-05-4569

Dear Class: This is the FINAL EXAM Portfolio Problem Set. I am looking for depth in your understanding. Use everything you know from this semester and show me your reasoning!
The reasoning "*is the answer*" in Physics and that is what I am principally looking for, and not just some final number (but which you will also need to produce).

This is an open book and unlimited time exercise. All problems are of equal value.

1.

An object at rest on a flat but **rough** horizontal surface explodes into two fragments, one of them *three times* as massive as the other. The heavier fragment slides 4 m before stopping. Assuming they both have the **same** coefficient of kinetic friction μ_k with the horizontal surface:

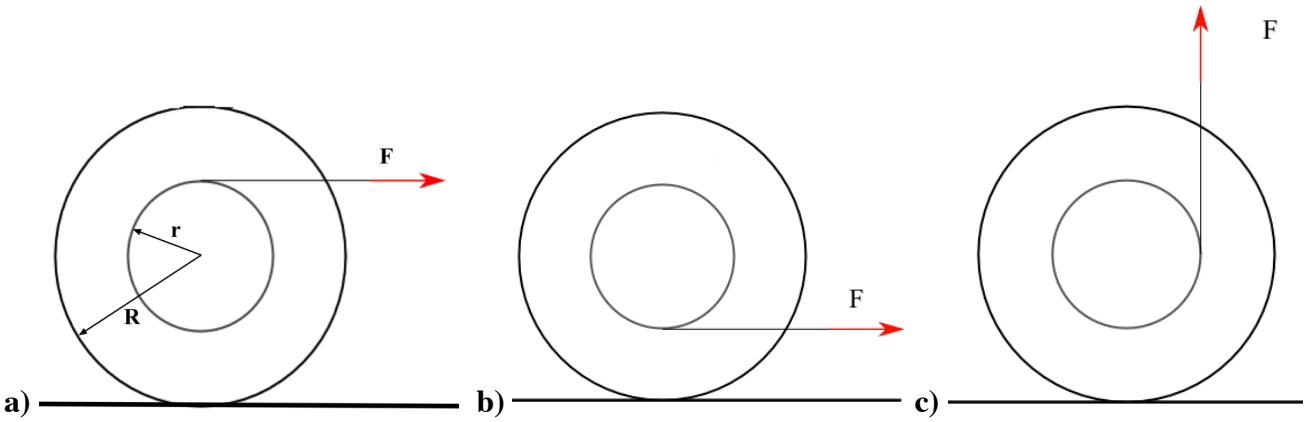
a) How far does the lighter fragment slide?
b) Did the position of the **Center of Mass** of the two-mass-system *move* between the beginning and end of the motion? **If not**, why not? **If yes**, how much did it move?
c) State the central theorems we know about center of mass motion and argue whether or not they apply to this situation.

2.

A circular "Yo-Yo" has an inner radius **r** = 3 cm and an outer radius **R** = 5 cm, and its mass is **M** = .2 kg . The mass of our "Yo-Yo" is distributed symmetrically about its center but not uniformly by radius so ***we don't know its Moment of Inertia***. It is now unwound by rolling it horizontally on the floor under the **same** constant force **F** applied to the unwinding thread in three different ways as shown. In each case the Yo-Yo rolls *without slipping*. You are to start by writing down the *universal equations of rigid body motion* and then apply them to the following settings:

➡**Now!** Suppose in the first example, case **a)** , we observe that its center accelerates at **a** = 3m/s² .
By comparing the equations of motion in each case, you should be able to find :

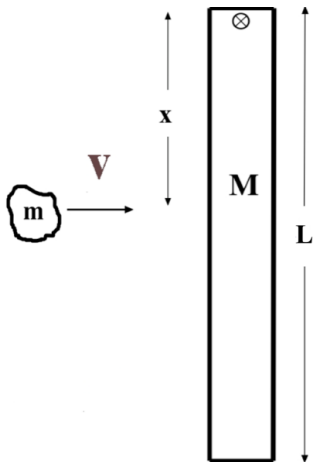
(1st) What will be the acceleration of the Yo-Yo in case **b)** ? (magnitude and direction!)
(2nd) What will be the acceleration of the Yo-Yo in case **c)** ? (magnitude and direction!)
(3rd) What will be the frictional force on the Yo-Yo in case **c)**? (magnitude and direction!)
(4th) Can we determine the moment of inertia from these numbers? **If not**, why not? **If yes**, what is it?



3.

A ballistic pendulum consists of a simple uniform rod of mass **M** = 1.2kg and length **L** = 1.5m hanging vertically at rest from a frictionless pivot at its top end. A blob of putty of mass **m** = .8kg is shot horizontally at speed **V** = 5 m/s so that it collides with and sticks to the rod a distance **x** = 1m below its pivot**. (see picture below)** Your algebraic answers to the questions below will involve ***only*** the symbols **{m, M, L, x and V}**! Then insert numerical values.

a) Find the vertical position of the Center of Mass of this system relative to the pivot.
b) Find the Angular Velocity of the pendulum-putty system immediately ***after*** the collision.
c) Find the Linear Velocity of the Center of Mass immediately ***after*** the collision.
d) Show whether or not Linear Momentum has entered at the pivot !



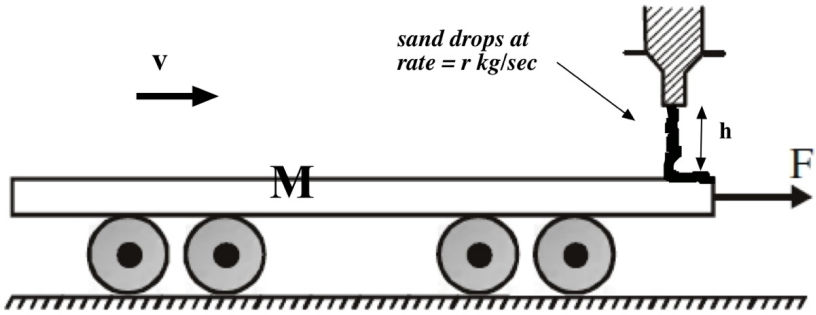
4.

A railway flatcar of mass **M** = 2000 kg moves to the right at constant velocity **v** =2 m/s and prepares to take on a load of sand. It passes under a stationary hopper dropping sand from a height **h** = 3m . The rate of sand loading is constant and equal to **r** = 25 kg/s . It is found necessary to apply an external horizontal force **F** in order to keep the flatcar moving at its constant speed **v**. Any friction involved is negligible.

The construction management team of *"Bill and Jill inc."* is assessing this situation.

Please *help them out* by computing the following!

a) ***Horizontal force***: **Find** the horizontal force **F** necessary to keep the flatcar at its constant velocity.
b) ***Vertical force***: It is found that the falling sand contributes a vertical force over and above the mere weight of the sand taken aboard. **Please find** this *extra* vertical force!
c) ***Power***: **What power** (i.e. rate of energy delivery) is the external force F supplying?
d) ***Kinetic Energy***: **At what rate** is the Kinetic Energy of the flatcar and its sand-load increasing?
e) Discuss how parts **c)** and **d)** relate!



5.

A block of mass **M** = 3kg is attached to a spring of constant k = 12N/m and oscillates with amplitude A_1 = 16 cm on a frictionless table.

a) What are the period T_1 , the maximum velocity v_1 , and the maximum acceleration of the motion ?

✶✶✶ ***We now perform an experiment*** ✶✶✶

We drop a blob of putty of mass **m** =1kg onto **M** at the *furthest extent* of its *original motion* as depicted in the picture :

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b) What are the period T_2, maximum velocity v_2 and amplitude A_2 of the resulting motion now ?

c) How would your answers be different if you had dropped the putty onto **M** *at the moment it was passing through its equilibrium position* ?