FALL 2015 EXAM I FOR ME 104

INSTRUCTIONS:

- NO electronic devices, notes, etc., are allowed.
- NEATNESS COUNTS. DRAW VERY PRECISE DIAGRAMS FOR EACH PROBLEM.
- Write on only the sheets provided to you.
- Make sure that your full name (not nickname) is on each sheet.
- Make sure that all of your sheets are stapled together.
- Box your answers. Be as concise as possible.
- Optimize your time and first set up all the problems.

The only "nonstandard" equations that you may need are

$$\mathbf{r} = r\mathbf{e}_r$$

$$\mathbf{v} = \dot{r}\mathbf{e}_r + r\dot{\theta}\mathbf{e}_\theta$$

$$\mathbf{a} = (\ddot{r} - r\dot{\theta}^2)\mathbf{e}_r + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\mathbf{e}_\theta.$$

$$\mathbf{a} = \dot{v}\mathbf{e}_t + \frac{v^2}{\rho}\mathbf{e}_n$$

- PROBLEM 1: 25
- PROBLEM 2: 25
- PROBLEM 3: 20
- PROBLEM 4: 15
- PROBLEM 5: 15

PROBLEM 1 (25 POINTS)

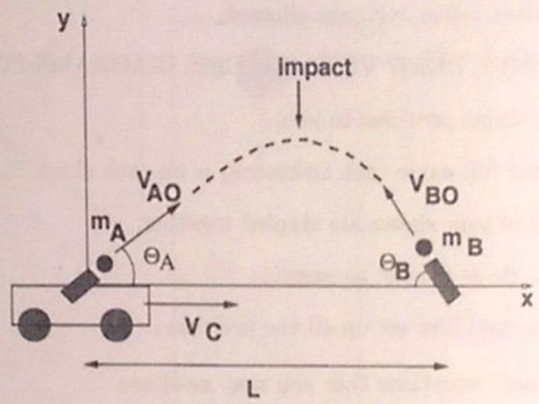


Figure 1: For parts a, b and c.

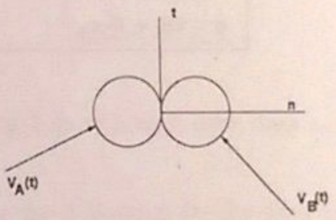
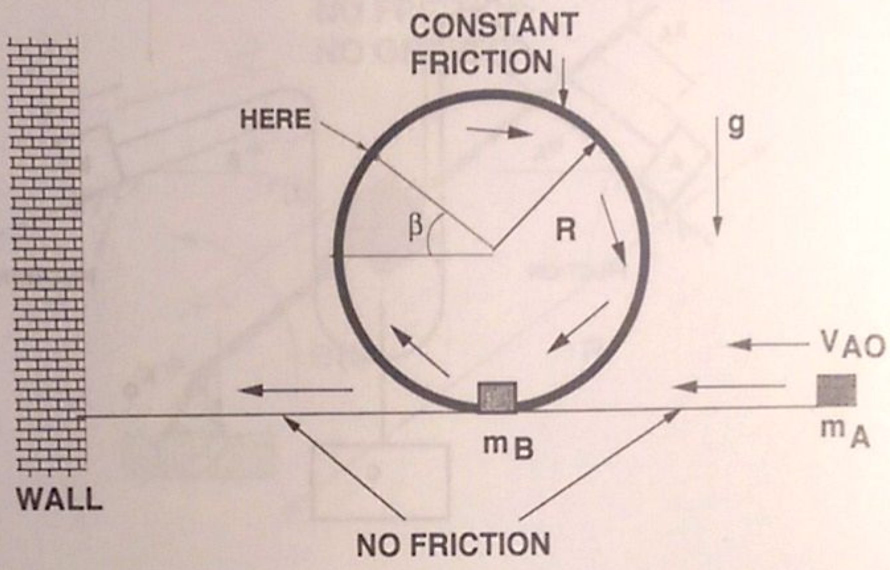


Figure 2: For parts d, e, f and g.

A moving vehicle (with velocity v_C) carrying a launcher releases a projectile (m_A) with exit velocity v_{A0} (relative to the vehicle) in the configuration shown. It moves only under the influence of gravity (no drag). Simultaneously, another projectile (m_B) is launched in the configuration shown (from a stationary site) with a velocity v_{B0}.

- (a) Draw a neat freebody diagram and effective force diagram for each projectile.
- (b) Derive the acceleration, velocity and position vectors of A and B as a function of time?
- (c) Compute the relative acceleration, velocity and position vectors of B with respect to A as a function of time.
- (d) Solve for the time for when the will the two paths intersect.
- (e) What are the velocity vectors when they intersec?
- (f) Assuming that when the paths intersect, the projectiles are in the configuration shown, what are the velocities immediately after impact (no friction). Assume that $e = 0.5$. You need to use the velocities from part (d) as the pre-impact velocities.
- (g) What is the magnitude and direction of the impact impulse, $\int F\,dt$?
- **Hint**: Compute the complete trajectory expressions, then equate them.

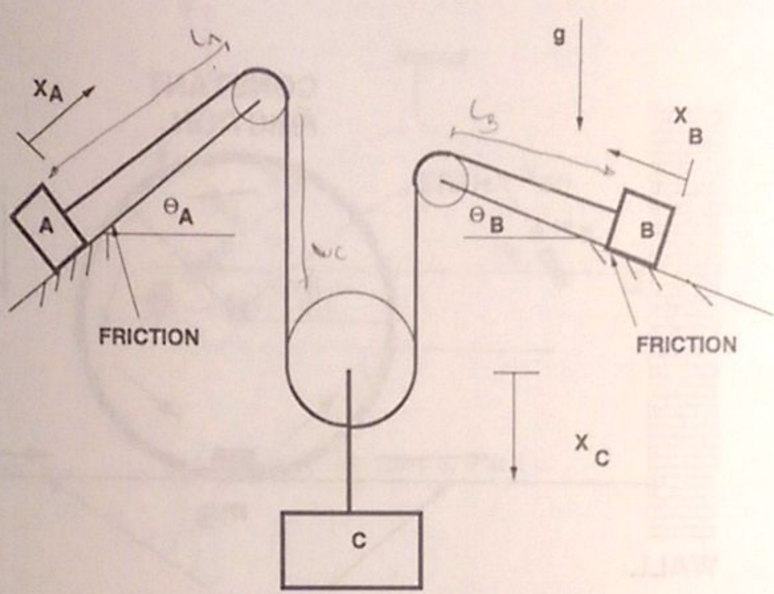
PROBLEM 2 (25 POINTS)



An object is pushed with a velocity of initial v_{AO}. It hits a second object before it goes around the loop and then sticks to it ($e = 0$). They go around the loop together, which has a simple constant friction $F = C$ (on the loop) only. You may assume that the objects always stay in contact with the loop. The objects then slide down the loop and hit the wall with $e = 0.5$.

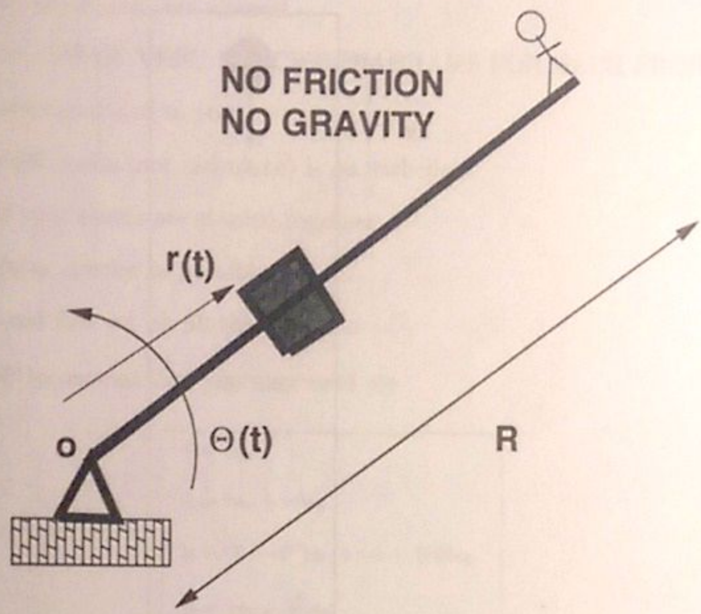
- (a) Draw a neat freebody and effective force diagram for the stuck-together body where it says "HERE" in the diagram.
- (b) Where it says "HERE" what are the normal and tangential accelerations?
- (c) What is the velocity of the stuck pair when it hits the wall?
- (d) How big is the impact impulse $\int F\,dt$? when it hits the wall?

PROBLEM 3 (20 POINTS)



- (a) Draw the freebody and effective force diagram for every body in the system (assume A and B are sliding with friction $F = \mu_D N$)
- (b) Write down, but do not solve, the equations that results from the freebody and effective force diagrams.
- (c) Determine the kinematic relationship between the objects.
- (d) List all of the unknowns. Put a box around each equation that needs to be solved.
- **Hint**: Just like the problem on HW SHEET.

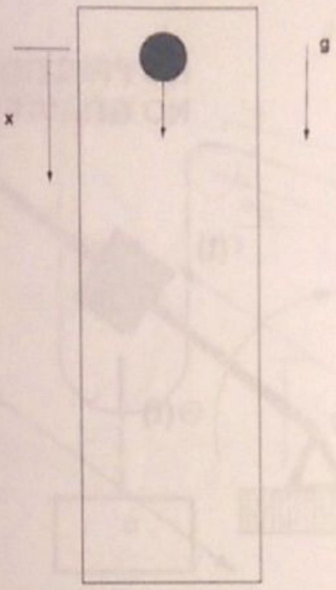
PROBLEM 4 (15 POINTS)



A frictionless slot slides up a rod whose rotation is controlled: $\theta(t), \dot{\theta}(t)$ and $\ddot{\theta}(t)$ are all given.

- (a) Draw the freebody and effective force diagram
- (b) Write down, but do not solve, the equations that results from the FBD/EFD.
- (c) What is the relative position, velocity and acceleration of the slot, with respect to the observer at the end of the rod?

PROBLEM 5 (15 POINTS)



An object placed in a viscous surrounding fluid in a very, very, deep container (zero strarting velocity). The drag is given by $F = -cv$

- (a) Draw a neat freebody and effective force diagram for the body (ignore buoyancy).
- (b) Analytically solve the governing differential equation for the velocity only (not the position).
- (c) Eventually (after a long time), the velocity will become constant. What is that velocity (hint, look at the differential equation solution and the FBD)?
- (d) Set up the numerical scheme to solve this differential equation for both the velocity and position.
- **Hint**: Just like project 1-but simpler!