

Physics 2300: Problem Set #8

These problems are due before class on Wednesday, October 24. Remember to write a concise problem statement, and to give just a word or two as to where your equations are coming from.

1. Three center of mass integrals.
 - (a) In an hourglass, sand flows at a rate σ ($[\sigma] = M/T$), and falls a distance h from the upper chamber to the lower. What is the distance from the CM of the falling column to the ground? (Suggestion: break the column up in to elements described as “that sand which started falling between t and $t + dt$ ”.)
 - (b) Use polar coordinates to find the CM of a slice of uniform pizza of angular size θ and radius R . To be precise, what is the distance from the apex to the CM?
 - (c) Use spherical coordinates to find the CM of a solid hemisphere of uniform density. To precise, in terms of the radius R , what is the distance from the CM to the plane which defines one boundary.
2. Generalization of Morin 5.15 (Propelling a car): find $v(t)$ including a friction force $-\mu Mg$. As Mathematica will tell you, the form $v(t) = u_0 - A \tanh(\gamma t + \phi)$ is a good ansatz. Find the constants A , γ and ϕ in terms of the inputs M , u_0 , σ and μg . What is the limiting velocity as $t \rightarrow \infty$? (On the Mathematica homework we ask you to DSolve and Plot your $v(t)$.)
3. Morin 5.51 (Beads on a hoop) Closely connected question: what is the maximum vertical component of normal force as one bead slides around?
4. Morin 5.58 (Sphere and cones)
5. Morin 5.70 (Snow on a sled, quantitative) For each case find and solve the appropriate differential equation for $v(t)$. On the Mathematica homework we ask you to DSolve and Plot these 3 cases together.
6. Morin 5.76 (Seven pool balls)
7. Morin 5.83 (Maximum v_y)
8. Morin 5.91 (Falling chain) Use the “ Δt ” movie method to disentangle the “impulsive” from the “deadweight” contributions, and then check your answer by doing this the quick way using the momentum of the entire system.

9. (BONUS) Morin 5.94 (Downhill dustpan)