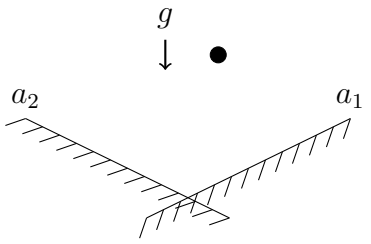
Homework 12: Time-stepping

24-760 Robot Dynamics & Analysis
Fall 2022

Name: _____

Problem 1) Falling Ball



Consider a point particle that can make plastic frictionless impact with several constraints. Assume the particle is mass 1 and gravity is 9.8. Let the constraints be $a_1(x, y) = 2y - x$ and $a_2(x, y) = 2y + x$.

1.1) Simulate the system with an event-based simulation in Matlab using `ode45` and an event function. You are encouraged to reuse any code that you would like from past homeworks.

1.2) Run a simulation from initial condition $(0.2, 1)$ for 3 seconds. What contact mode transitions occur and at what times? Discuss any problems that arise.

1.3) Now simulate the same system with a time-stepping simulation in Matlab using `solve`. At each timestep, pass the full system of equations (including the difference equations for $\dot{q}$ and q as well as all inequality and complementarity constraints) to `solve` in order to find the next $q, \dot{q}$, and λ. The following Matlab resources may help:
https://www.mathworks.com/help/symbolic/solve.html
https://www.mathworks.com/help/symbolic/solve-a-system-of-algebraic-equations.html

1.4) Run a simulation from initial condition $(0.2, 1)$ for 3 seconds with time-step sizes h of $40, 20$, and 10 ms. What contact mode transitions occur and at what times? In time-stepping the "contact mode" can be interpreted as those constraints who provided a positive force or impulse over the time step (as we cannot differentiate between these), though the system may not meet all of the requirements for the domain D_I in the hybrid system sense. Discuss any differences between these and the event-based simulation.