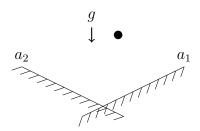
Homework 11: Time-stepping

24-760 Robot Dynamics & Analysis Fall 2021

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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.