Diagnostic 11 Solution

Modeling and Simulation
Fall 2017

This diagnostic covers material from Chapter 11 of *Modeling and Simulation in Python*.

Vocabulary

The rate of change in angular velocity is called ___angular acceleration_____ and typically denoted with the Greek letter __alpha_____.

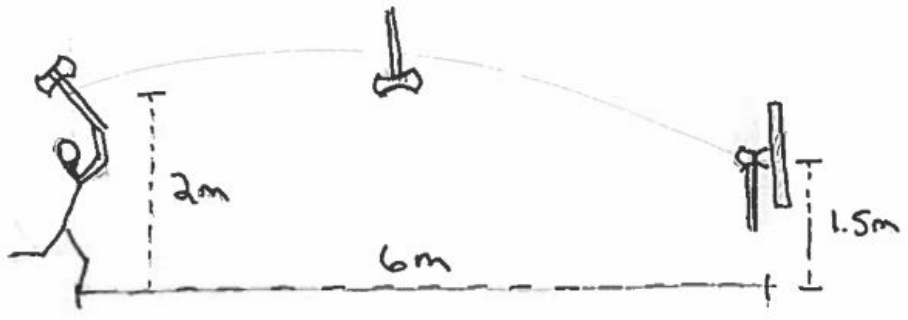
Given a force and a moment arm in the form of vectors, we can compute torque using the ___cross product_____ operation.

Mass is what makes an object hard to accelerate; ____moment of inertia_____ is what makes an object hard to rotate.

In SymPy, the function that solves systems of equations is ___solve_____.

Code

Our favorite event at Lumberjack Competitions is axe throwing. The axes used for this event typically weigh 1.5 to 2 kg, with handles roughly 0.7 m long. They are thrown overhead at a target typically 6 m away and 1.5 m off the ground. Normally, the axe makes one full rotation in the air to hit the target blade first, with the handle close to vertical.



Assume that we have written the following `make_system` function:

```
def make_system():
    P = Vector(0, 2)    # position in m
    V = Vector(8, 4)    # velocity in m/s

    duration = 1.0
    init = State(x=P.x, y=P.y, theta=2,
                 vx=V.x, vy=V.y, omega=-7)
    ts = linspace(0, duration, 101)

    return System(init=init, ts=ts,
                  g = 9.8,             # acceleration of gravity
                  mass = 1.5,          # mass in kg
                  length = 0.7)        # length in m
```

1) Write a slope function for this system (called slope_func, of course). As a simple starting place, you can ignore drag, so the only force on the axe is gravity.

```
def slope_func(state, t, system):
    x, y, theta, vx, vy, omega = state
    unpack(system)

    ax = 0
    ay = -g
    alpha = 0

    return vx, vy, omega, ax, ay, alpha
```

2) Write a line of code to call odeint with this system and slope function.

```
run_odeint(system, slope_func)
```

3) Write a few lines of code to extract the x and y positions of the axe's center of gravity as a function of time, and plot the results as a trajectory.

```
xs = system.results.x
ys = system.results.y
plot(xs, ys, label='trajectory')
```

If you'd like to see this simulation in action, pull from upstream, then run `throwingaxe.ipynb`. If you are so inclined, work on the exercises you find there (or look at `throwingaxesoln.ipynb`).