Qdrag

January 15, 2023

[1]:

```python
import math

class QSim:
    """Simulation of 2-D drag for a projectile."""
    mass = 100.0
    trueAirspeed = 150.0
    angleOfAttack = math.radians( 45.0 )
    diameter = 1.0
    dt = 0.1

    x = 0.0
    y = 0.0

    # compute the body velocities
    u = trueAirspeed * math.cos( angleOfAttack )
    v = trueAirspeed * math.sin( angleOfAttack )

    # The state equations in the form Xdot = X
    X = [u, v]
    Xdot = []

    time  = 0.0
    drag = 0
    g = 9.81
    Cd = 0.5
    rho = 1.225
    S = 0.25 * math.pi * diameter**2

    # variable to hold output data
    data = []

    # The force system of equations in x and y
    def uDot(self, arg):
        """The force equation in the x direction."""
        return (-self.drag*math.cos(self.angleOfAttack)/self.mass)
    def vDot(self, arg):
        """The force equation in the y direction. """
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```
        return (-self.drag*math.sin(self.angleOfAttack)/self.mass - self.g)

    # Integrator for a system of first order differential equations
    def RungeKutta4(self, h, Fdot, arg):
        """A fourth order Runge-Kutta implementation for a system of
        first order differential equations.

        h - time step
        Fdot - array containing first order differential functions
        arg - array of output states
        """
        k1 = []
        arg1 = []
        for (a, f) in zip(arg, Fdot):
            k = h*f(arg)
            k1.append(k)
            arg1.append(a + 0.5*k)

        k2 = []
        arg2 = []
        for (a, f) in zip(arg, Fdot):
            k = h*f(arg1)
            k2.append(k)
            arg2.append(a + 0.5*k)

        k3 = []
        arg3 = []
        for (a, f) in zip(arg, Fdot):
            k = h*f(arg2)
            k3.append(k)
            arg3.append(a + k)

        k4 = []
        for f in Fdot:
            k4.append( h*f(arg3))

        result = []
        for (a, kc1, kc2, kc3, kc4) in zip(arg, k1, k2, k3, k4):
            result.append(a + (kc1 + 2.0*kc2 + 2.0*kc3 + kc4) / 6.0)

        return result

    def Reset(self):
        """Reset the simulation and set the state equations."""
        self.data.clear()
        self.Xdot = [self.uDot, self.vDot]
```

```python
    def Operate(self):
        """Run a time step of the simulation."""
        # save data
        angle = math.degrees( self.angleOfAttack )
        self.data.append( ([round(self.time, 2),
                            round(self.x, 2),
                            round(self.y, 2),
                            round(angle, 2),
                            round(self.X[0],2),
                            round(self.X[1],2)]) )

        # calculate the total drag force
        q = 0.5 * self.rho * (self.trueAirspeed)**2
        self.drag = q * self.S * self.Cd

        # integrate the equations
        self.X = self.RungeKutta4(self.dt, self.Xdot, self.X)

        # get the new position from the new u (X[0]) and v (X[1])
        self.x = self.x + self.X[0] * self.dt
        self.y = self.y + self.X[1] * self.dt

        # advance time
        self.time = self.time + self.dt

        # calculate new true airspeed
        self.trueAirspeed = math.sqrt(self.X[0]**2 + self.X[1]**2)
        self.angleOfAttack = math.atan2(self.X[1], self.X[0])

    def Run(self):
        """"Run the simulation until the projectile returns to earth."""
        while self.y >= 0.0:
            self.Operate()
        print("======done=======")
```

[2]:
```python
%%time
sim = QSim()
sim.Reset()
sim.Run()
```

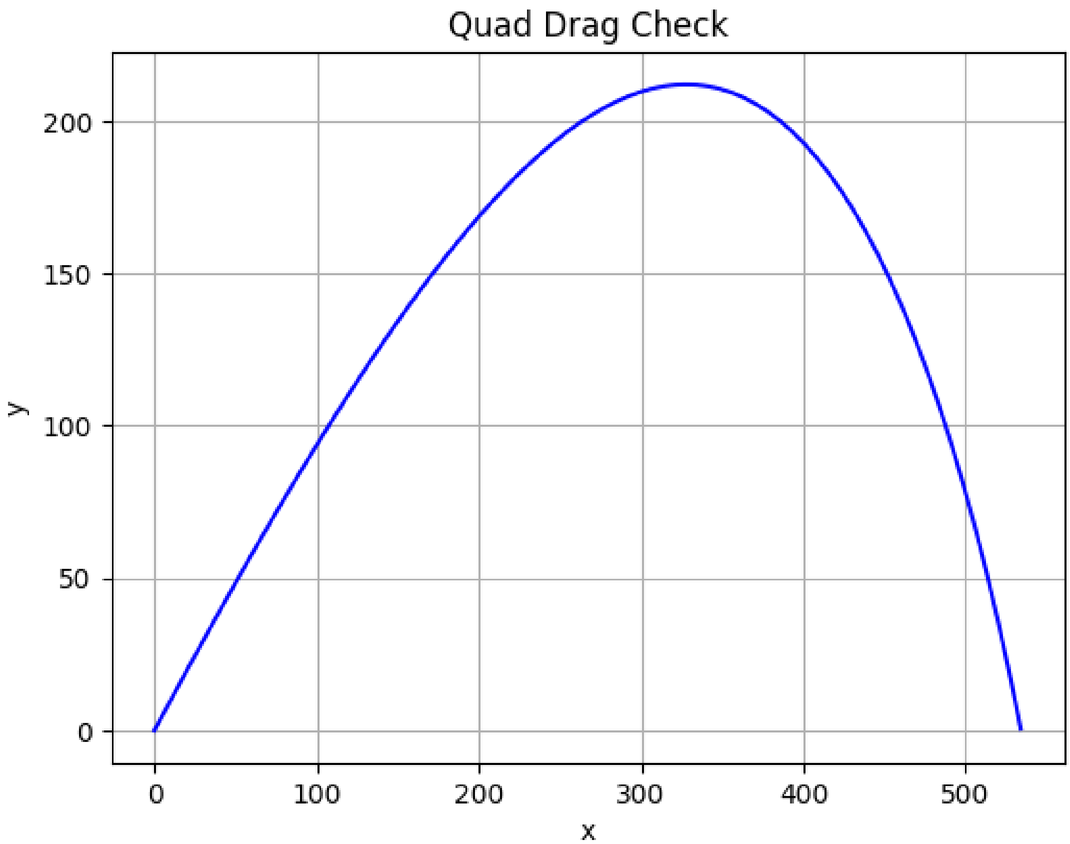
```
======done=======
CPU times: user 2.12 ms, sys: 702 µs, total: 2.83 ms
Wall time: 3.03 ms
```

[3]:
```python
import matplotlib.pyplot as plt

def MakePlot(inData):
```

```
    fig1 = plt.figure()
    ax1 = fig1.add_subplot(1, 1, 1)
    x = [ row[1] for row in inData ]
    y = [ row[2] for row in inData ]
    ax1.plot(x, y,'b')
    ax1.set(xlabel='x', ylabel='y', title='Quad Drag Check')
    ax1.grid()

MakePlot(sim.data)
```



[4]:
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sim.data
```

[4]:
```
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