Chris Paul Final Exam Word Document

Part 2.2

A screenshot of a computer

Description automatically generated

Part 2.6:

import numpy as np

import massParam as P

**class** massDynamics:

**def** \_\_init\_\_(self, alpha=0.0):

        self.state = np.array([

            [0.0],  *# initial position*

            [0.0]  *# initial velocity*

        ])

        self.g = P.g

        self.theta = 45 \* np.pi / 180 \* (1.+alpha\*(2.\*np.random.rand()-1.))

        self.m = P.m \* (1.+alpha\*(2.\*np.random.rand()-1.))

        self.Fmax = P.F\_max

        self.k1 = P.k1\* (1.+alpha\*(2.\*np.random.rand()-1.))

        self.k2 = P.k2 \* (1.+alpha\*(2.\*np.random.rand()-1.))

        self.b = P.b \* (1.+alpha\*(2.\*np.random.rand()-1.))

        self.Ts = P.Ts

        self.force\_limit = P.F\_max

**def** update(self, u):

        u = self.saturate(u, self.force\_limit)

        self.rk4\_step(u)

        y = self.h()

        return y

**def** f(self, state, F):

*# Return xdot = f(x,u), the system state update equations*

*# re-label states for readability*

        z = state.item(0)

        zdot = state.item(1)

        xdot = np.array([

            [zdot],

            [1/self.m \* (F - self.b\*zdot - self.k1\*z - self.k2\*z\*\*3 + self.m\*self.g/np.sqrt(2.0))]

        ])

        return xdot

**def** h(self):

*# return the output equations*

*# could also use input u if needed*

        z = self.state.item(0)

        y = np.array([

            [z],

        ])

        return y

**def** rk4\_step(self, u):

*# Integrate ODE using Runge-Kutta RK4 algorithm*

        F1 = self.f(self.state, u)

        F2 = self.f(self.state + self.Ts / 2 \* F1, u)

        F3 = self.f(self.state + self.Ts / 2 \* F2, u)

        F4 = self.f(self.state + self.Ts \* F3, u)

        self.state += self.Ts / 6 \* (F1 + 2 \* F2 + 2 \* F3 + F4)

**def** saturate(self, u, limit):

        if abs(u) > limit:

            u = limit \* np.sign(u)

        return u

A screenshot of a computer

Description automatically generated Part 3.5