PROBLEM STATEMENT

You need to program a coupled trim solution for the helicopter for which the data is given below. All integrations are to be performed numerically using six-point Gaussian Quadrature. In the numerical integration, the blade must first be discretized into a series of small elements (10 to 20) of equal span. Flap response equation must be solved numerically using Newmark's algorithm. Use uniform inflow. This is followup from the previous assignment and in this we would complete the Jacobian based coupled trim analysis.
Relevant data pertaining to UH-60A Black Hawk helicopter are given below:

Density of air, ρ	1.225 kg/m^3
Number of blades, N_b	4
Blade radius, R	8.18 m
Blade chord, C	0.46 m
Profile Drag coefficient, C_{do}	0.01
Lift curve slope, C_{l_α}	5.73
Rotor angular speed, Ω	27 rad/sec
Blade flap frequency, ν_β	1.04 per rev
Lock number, γ	8.0
Weight of the aircraft	70000 N
Blade twist rate, θ_{tw}	0°

Vehicle paramters (symbols have their usual meaning)
h = 1.83 m, lT = 9.75 m, f = 1.85 m2, xcg = -0.6 m, ycg = 0, MxF = 0, MyF = 0, kh = 1.15, θtw = 0◦

Please do the following:

Q1. Using the numerical solution of blade flap equation from previous assignment, calculate and plot all the blade hub shear forces and moments in the rotating frame of reference as a function of azimuth ψ. Make two separate graphs, one with all three forces and one with all three moments. On a third plot, show the variation of non-dimensional rotating frame vertical shear force as a function of ψ for all four blades. On a fourth and a fifth plot show the graph of variation of forces and moments in fixed frame of reference as a function of ψ. Comment on the nature of the plots. Note: each of the intergration has to be done using time integration.

Q2. Starting with the initial guess of the following control inputs for hover with $\theta 0$ = 10.0◦, $\theta 1c$ = 1.5◦, $\theta 1s$ = -8◦, αs = -5◦ and ϕs = -3◦. Perform the free flight coupled trim analysis for μ varying from 0 to 0.45 for the given helicopter, plot and discuss the following:
(a) the variation of control angles, $\theta 0$, $\theta 1s$, $\theta 1s$ vs. μ in the same plot.
(b) the variation of vehicle shaft angles αs and ϕs vs. μ in the same plot.