

1) Write a program (less than 10 lines of code) that will crash your IDE/compiler/make your PC temporarily unstable; (infinite loops are not allowed). Explain why it crashed.

2) Write a routine to implement

- a. Rk4 integration
- b. Adaptive Rk4 integration

for a system where the second derivative,  $f''(t)$ , is a function of the first derivative  $f'(t)$ .

The aim is to get  $f(t)$  through both Rk4 and adaptive Rk4.

Choose a function in mechanics which follows the model above. (Could be any system that follows the conditions above)

Show the reduction in error of the position  $f(t)$  as the time step is reduced manually in Rk4 vs. automatically in adaptive Rk4. What do you recommend for use in a rocket trajectory simulation? Why?

3) Write down the equations of motion assuming gravity loss, drag, and engine thrust based accelerations on a single stage rocket from vertical launch to burnout. Assume a thrust of 100kN produced by the engine, thrust to weight ratio of 1.4

- a. Initiate a gravity turn at approximately 100 meters altitude and capture the dynamics of the rocket including the impact of the gravity turn.
- b. Plot the trajectory, dynamic pressure and other key variables.

4) Two point masses in outer space (not on planet), P1 and P2 of mass 10 kg and 20 kg are initially at position (0,0) and (0, 10) and velocity  $(10\mathbf{i} + 0\mathbf{j})$  and  $(-10\mathbf{i} + 0\mathbf{j})$  respectively.

All units are in SI.

- a. Make FBD
- b. Numerically evaluate trajectories of particles under gravitational interaction with fixed time step time marching scheme. (XY plot of positions)
- c. How will you make it a variable time step?