Computing and Numerical Methods Part II Report:

Using C++ to code a simulation, and provide a convergence study of a Vessel System's Dynamics

Q6)(a)

Case	System Parameters	Vessel Parameters					
		m	A	K	y_0	$\dot{y}_0$	h_0
Single Vessel, no drag	$T = 1,$ $C_D = 0.0$	1.0	0.1	0.0	-0.1	0.0	0.0
Single Vessel, low drag	$T = 1,$ $C_D = 0.1$	5.0	0.5	0.0	0.1	-0.5	0.0
Sinking Vessel	$T = 2,$ $C_D = 0.0$	100.0	0.1	1000.0	0.0	0.0	0.0
Three Vessel	$T = 10,$ $C_D = 0.01$	1 10.0 50.0	0.1 0.5 10.0	20 10.0 1.0	-0.1 -0.1 -0.1	0.0 0.0 0.0	0.0 0.0 0.0

i) Identify and state the maximum time-step for a converged solution for FE and RK4.

Running test cases for the first test-case (Single Vessel, no drag).

The baseline solution is defined as the solution given by the numerical method using a sensible base time step, as stated below.

The maximum time step is defined as the largest time step falling within the 10% deviation of the baseline solution.

Case 1

The procedure is outlined below, using a leapfrog method:

ii) State, in table form, the final displacements, velocities, and water levels of the vessels.

Case	Method	Vessel	Max Step Size (m)	Final Displacement (m)	Final Velocity (m/s)	Final Water Levels (m)
Single Vessel, no drag	RK4	1		-0.099986	-0.317409	0.000000
	FE	1		-0.099552	-0.316048	0.000000
Single Vessel, low drag	RK4	1		0.006299	-0.236070	0.000000
	FE	1		0.006300	-0.235292	0.000000
Sinking Vessel	RK4	1		15.933335	15.738578	14.439672
	FE	1		15.933921	15.738459	14.440190
Three Vessel	RK4	1		0.144690	-0.033585	0.063547
		2		0.059553	-0.179188	0.004433
		3		0.010222	0.038018	0.000005
	FE	1		0.144497	-0.033789	0.063540
		2		0.059154	-0.177866	0.004433
		3		0.010012	0.035148	0.000005

iii) Plot the displacement of the vessel base from the $\bar{y}$ as a function of time, for FE and RK4

iv) **Need to change plots to size 24 font**

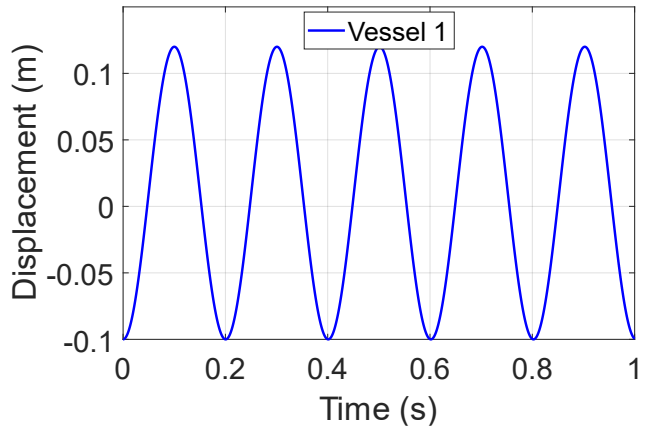

Figure 1: Case 1, RK4

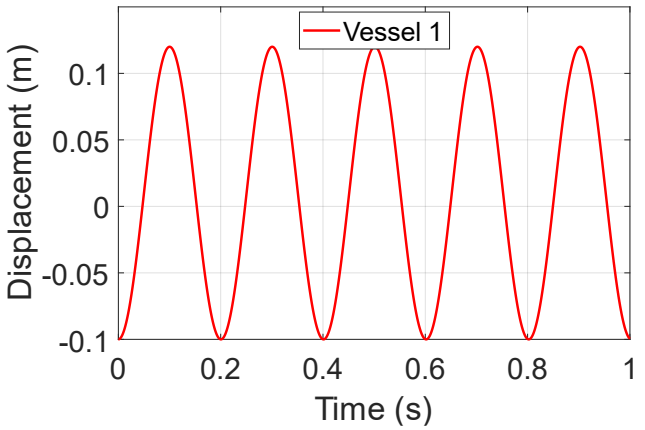

Figure 2: Case 1, FE

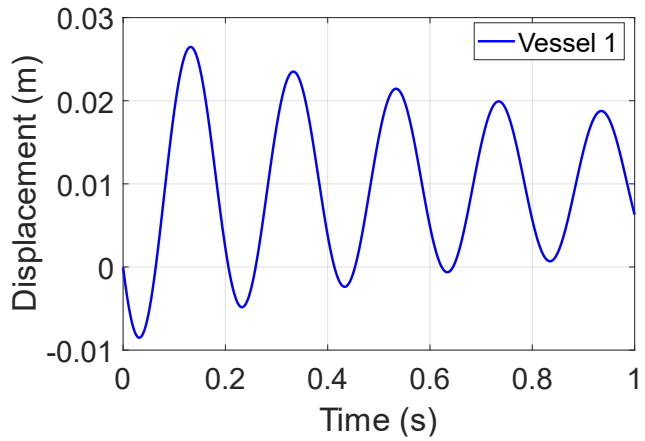

Figure 3: Case 2, RK4

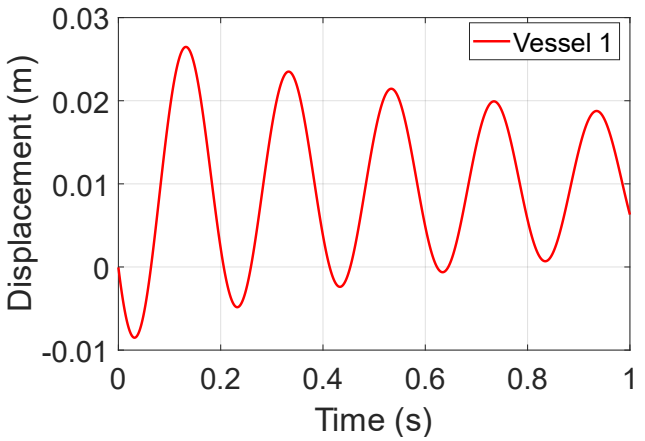

Figure 4: Case 2, FE

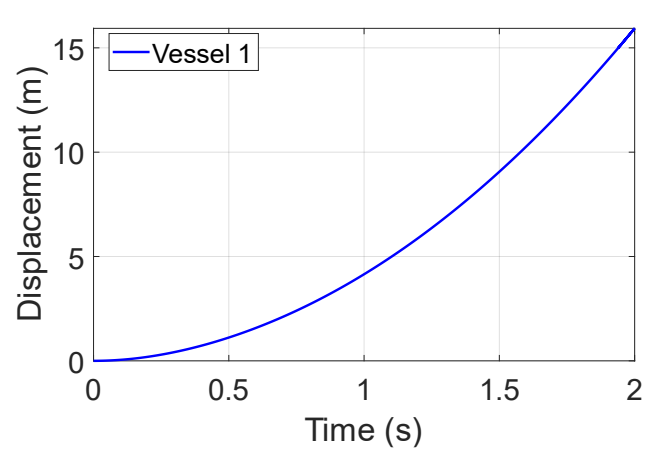

Figure 5: Case 3, RK4

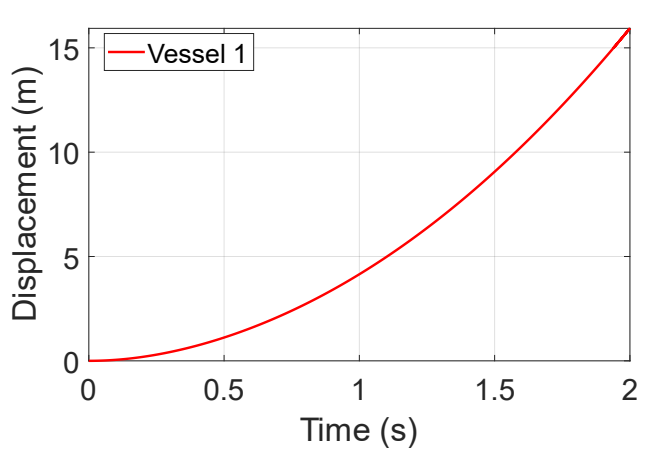

Figure 6: Case 3, FE

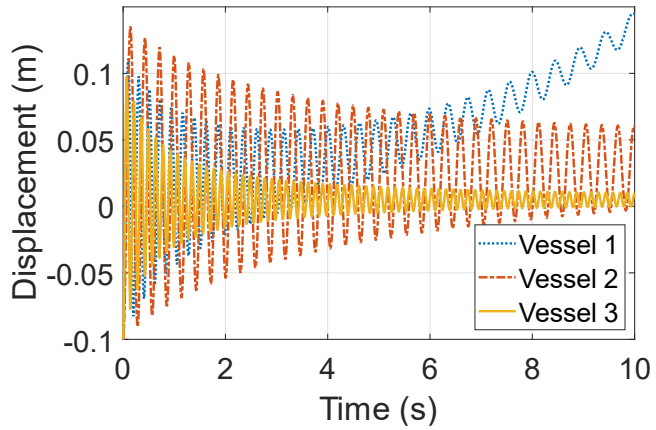

Figure 7: Case 4, RK4

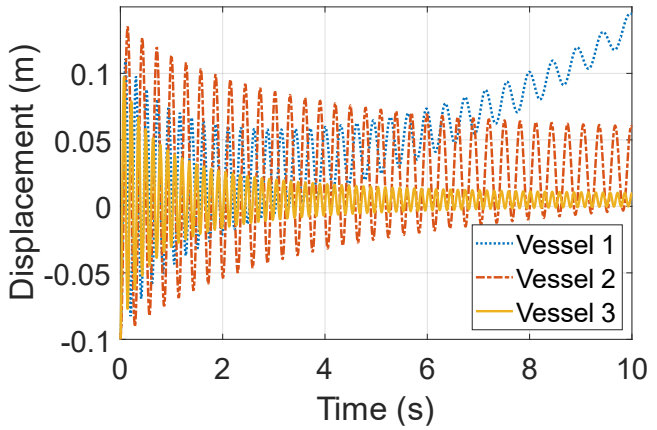

Figure 8: Case 4, FE

Q6(b)

i) Vary parameters then analyse the frequency response of the system and compare

Running the simulation for the single Test cases varying Vessel parameters using base test cases

Base Case	**Method**	**System Parameters**	**Vessel Parameters**					
			m	A	K	y_0	$\dot{y}_0$	h_0
Single Vessel, no drag	RK4	$T = 10,$ $C_d = 0.0$	1.0	0.1	0.0	-0.1	0.0	0.0

Add captions for images and explanation for part (b),i,ii

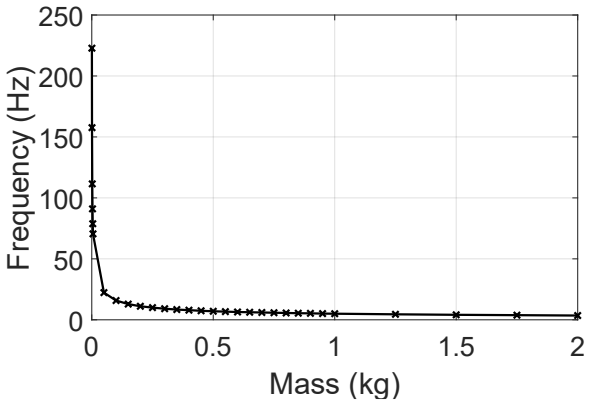

Figure 9: Study of Varying Mass

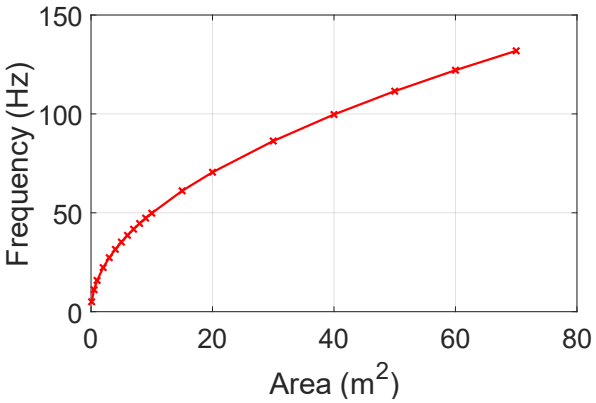

Figure 10: Study of Varying Area

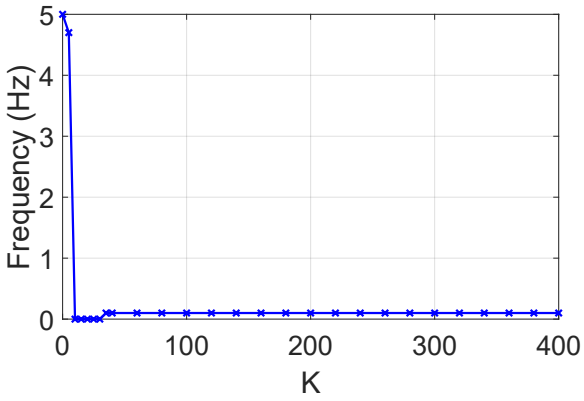

Figure 11: Study of Varying K

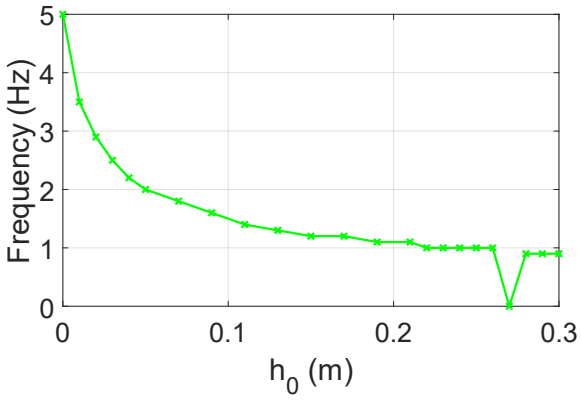

Figure 12: Study of Varying Initial Height

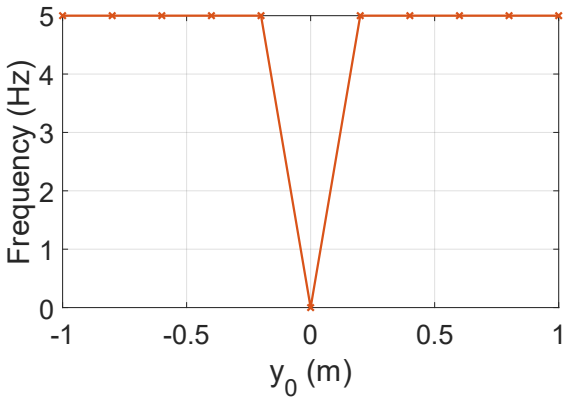

Figure 13: Study of Varying Initial Displacement

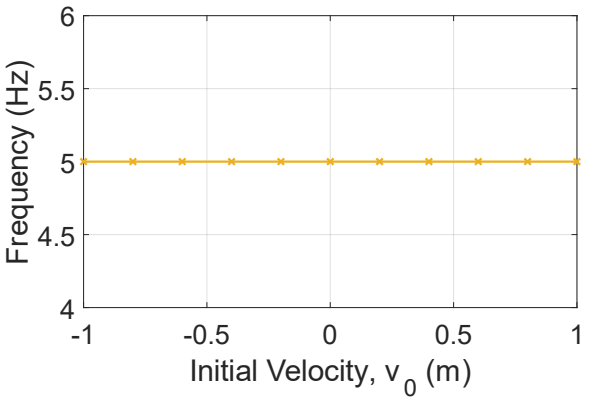

Figure 14: Study of Varying Initial Velocity

Q6(c)

Explain why it is advantageous to solve this problem, as well as more complex numerical problems, using C++ instead of an interpreted language

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Q6(d)

Describe your implementation approach: How did you use the STL and object-oriented programming paradigms? Which aspects of the problem did you encapsulate in using classes and why? How did you ensure your code was reasonably CPU- and memory-efficient?

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