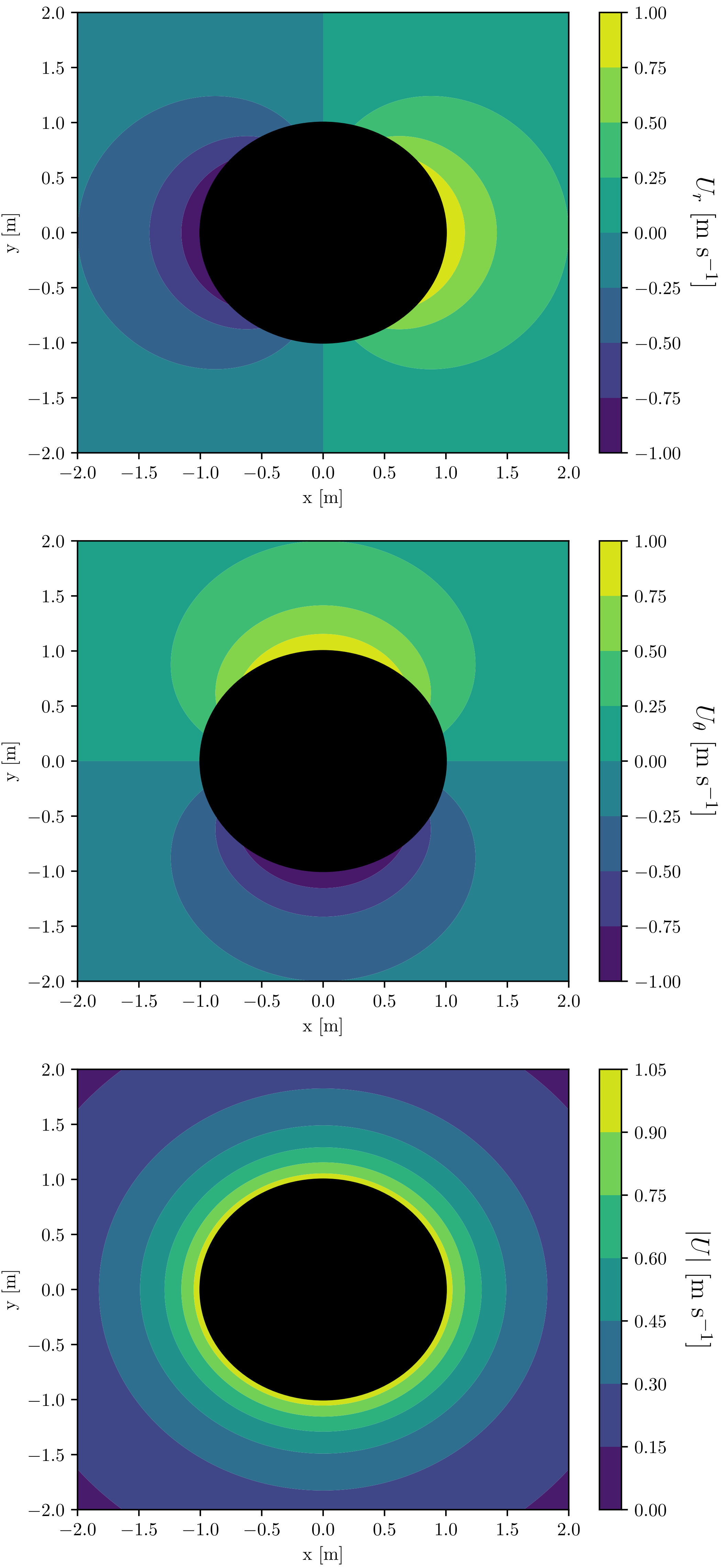
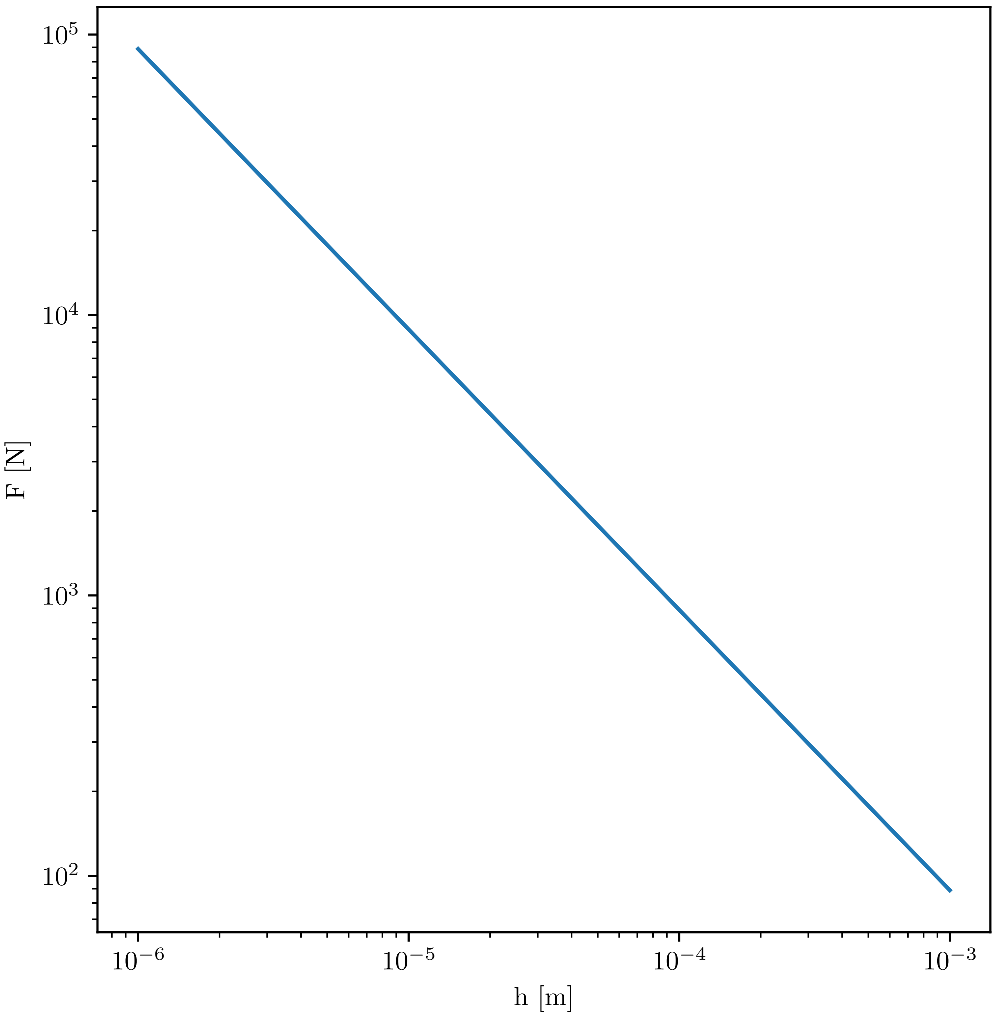
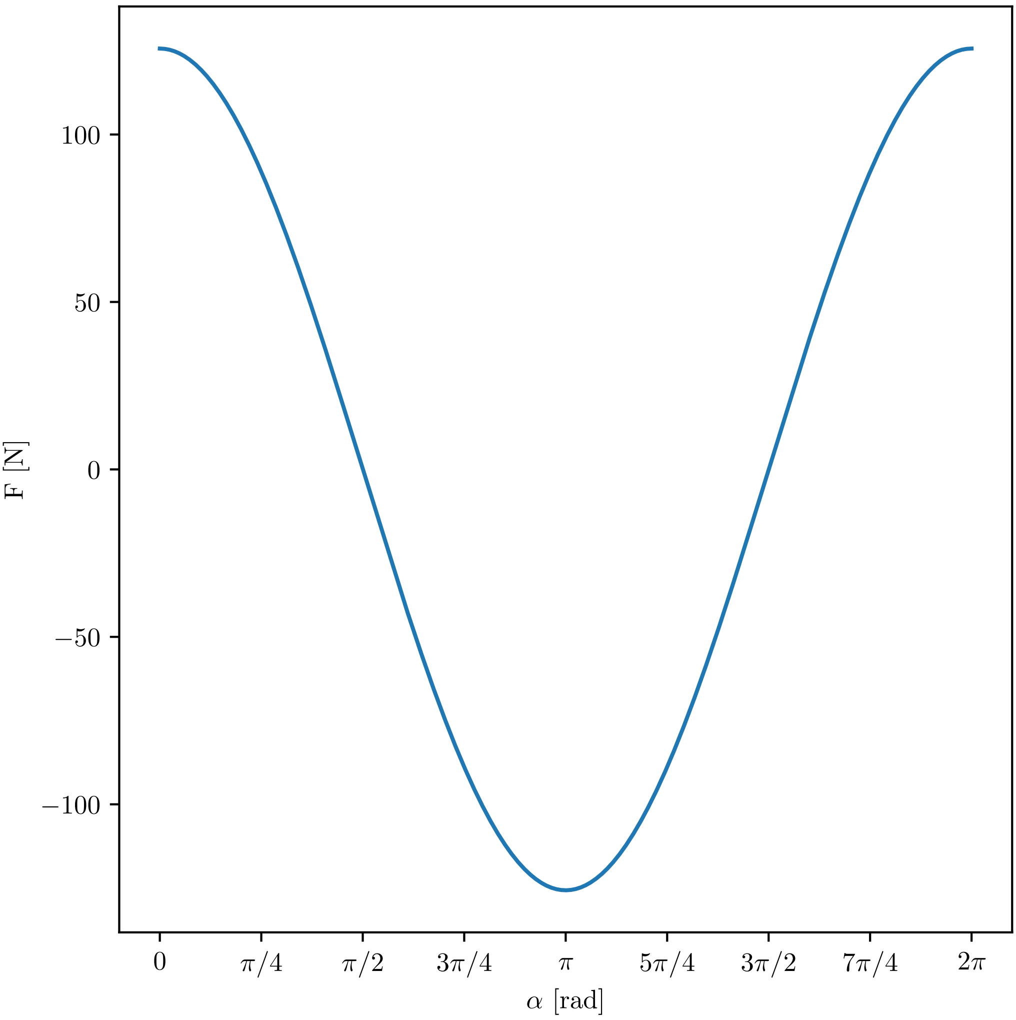
Assignment 1



Assignment 2

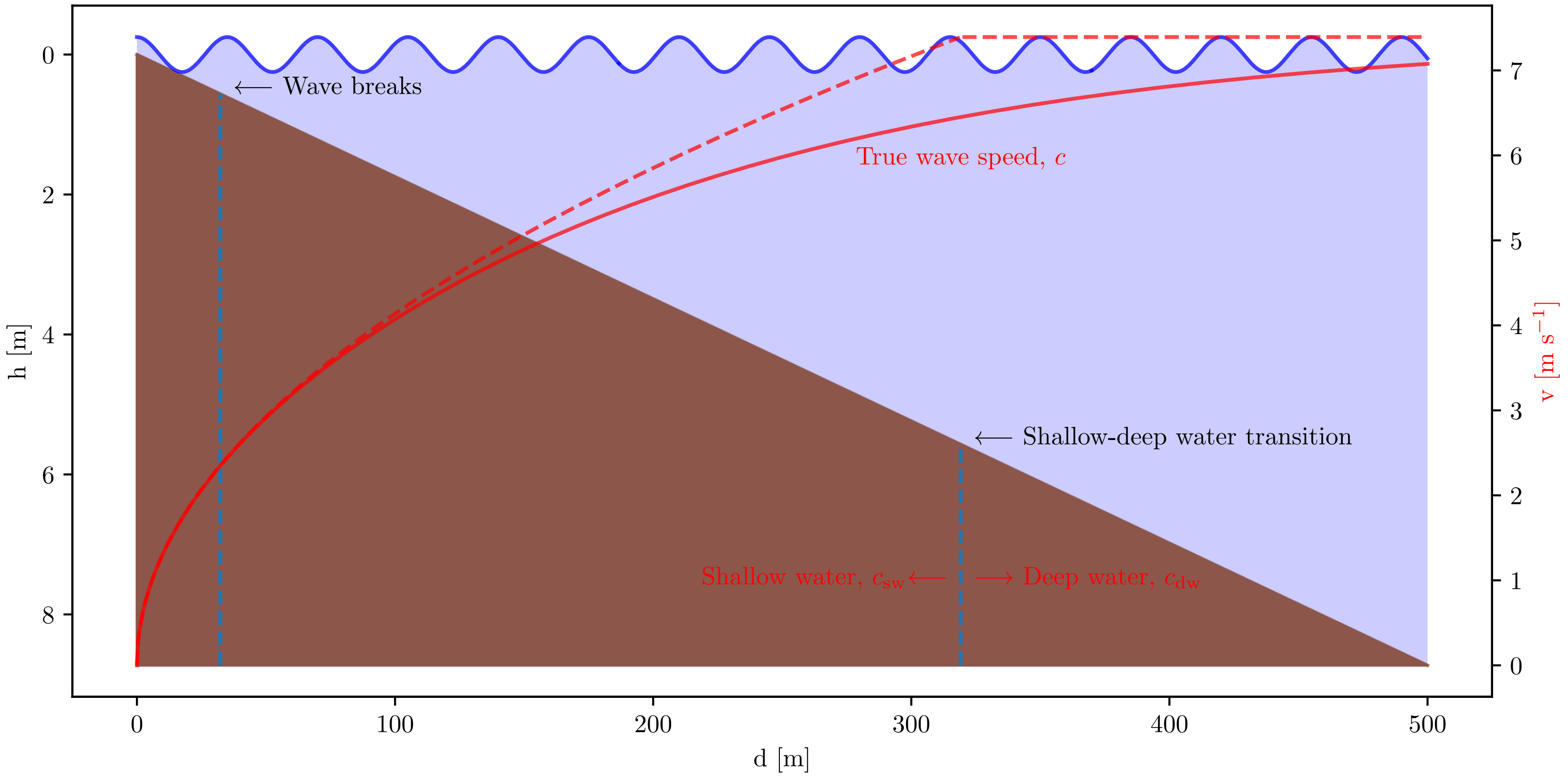


The apparent power-law behavior leads to very high forces required at microscopic liquid heights.



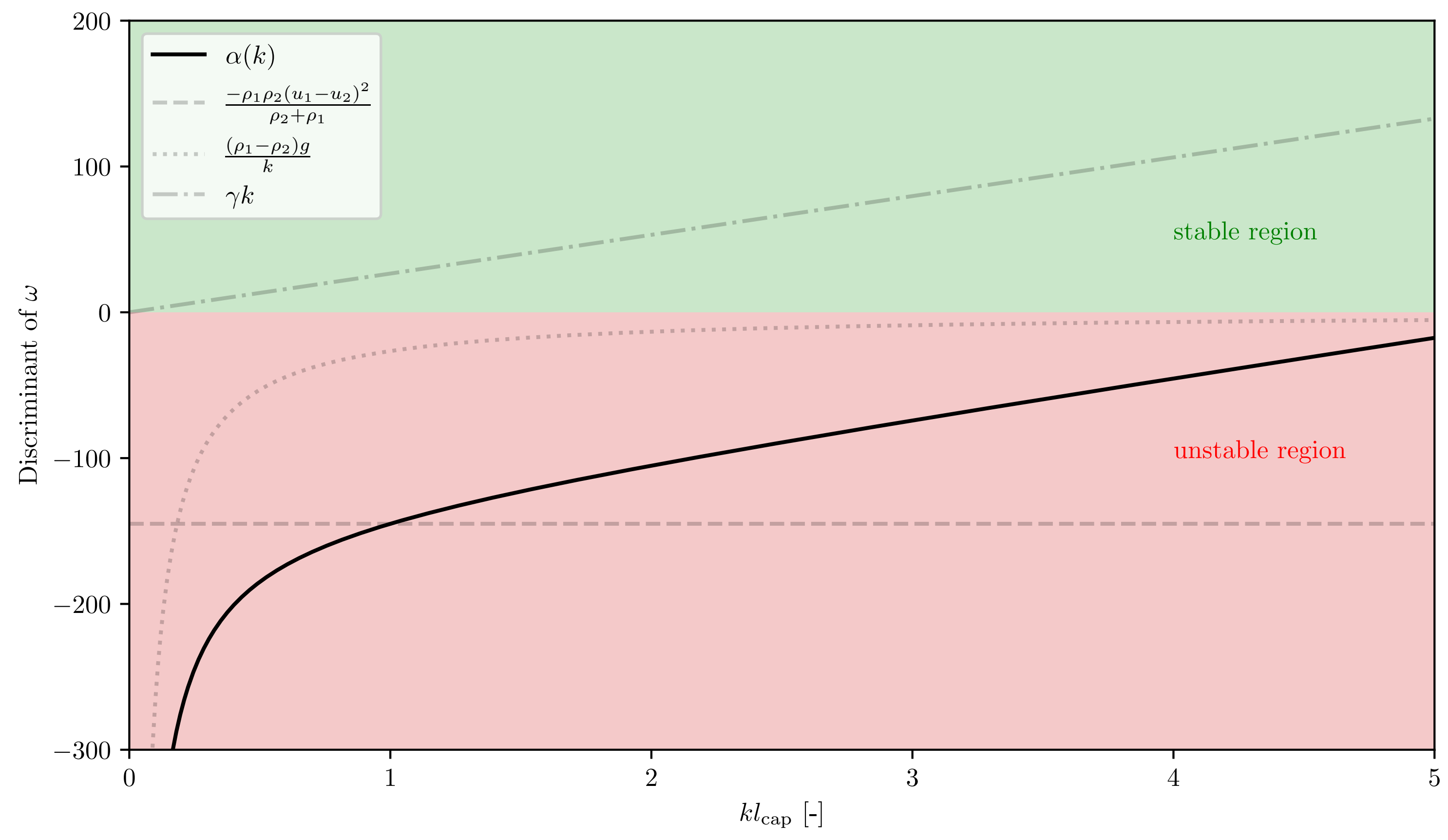
Wetting liquids (i.e. $\alpha < \pi/2$): the plates need to be pushed together (positive force)
Non-wetting liquids (i.e. $\alpha > \pi/2$): the plates stick together (negative force).

Assignment 3

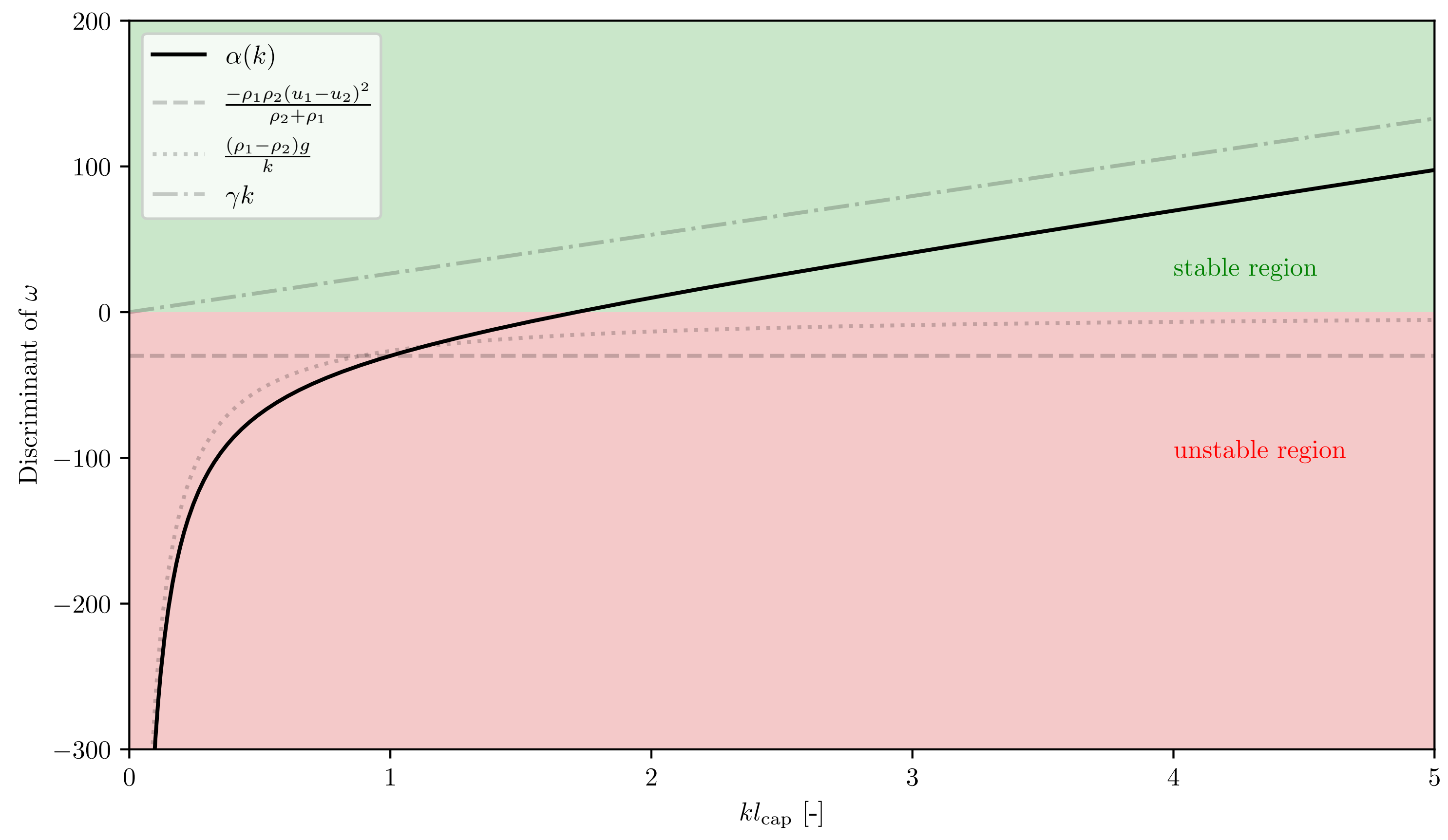


Assignment 4

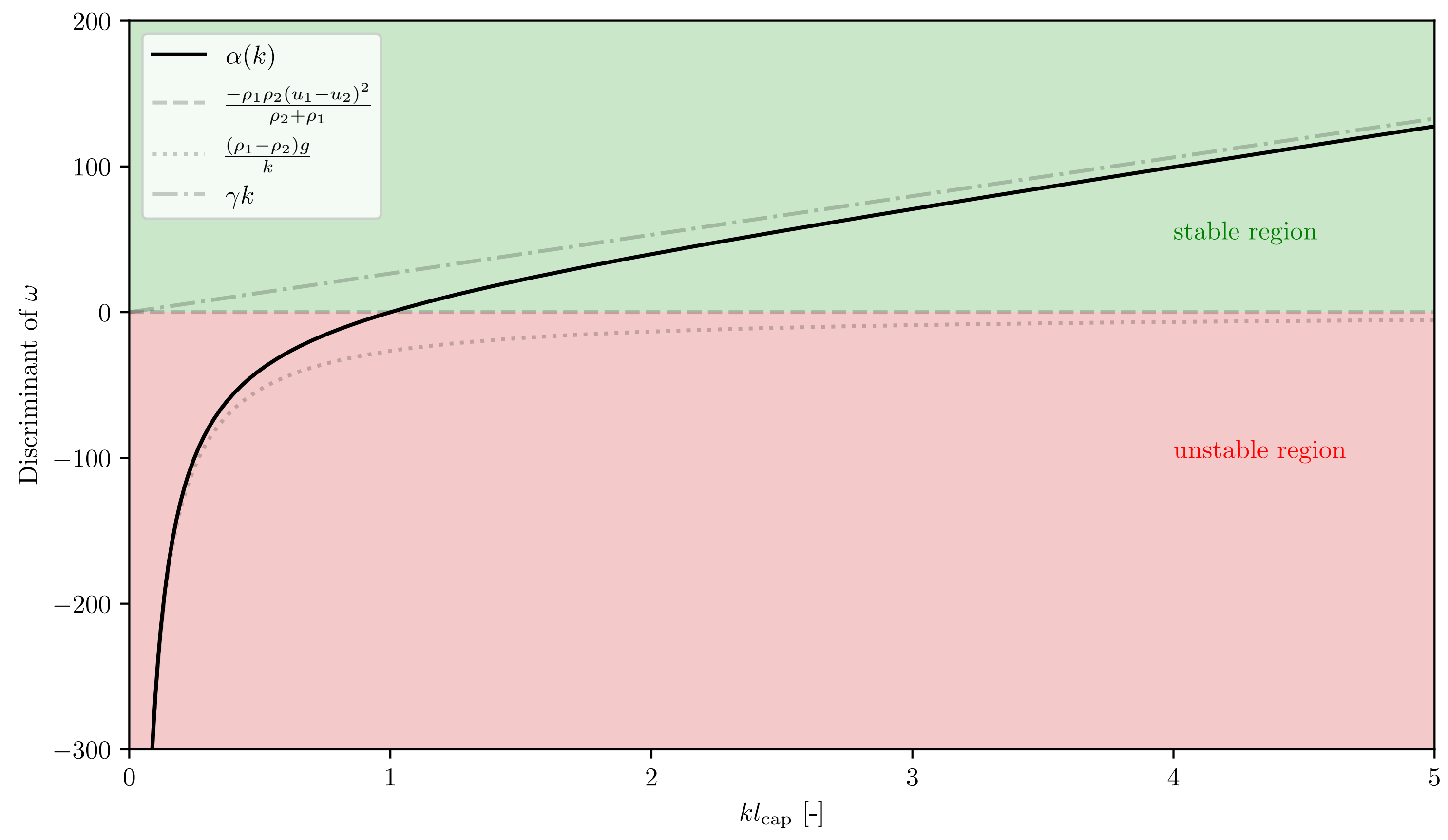
Task 1a: $|u_1 - u_2| = 11$ m/s, stable for $\lambda < 3$ mm
gravity and velocity terms (dotted, dashed) destabilize, capillarity term stabilizes (dash-dotted)



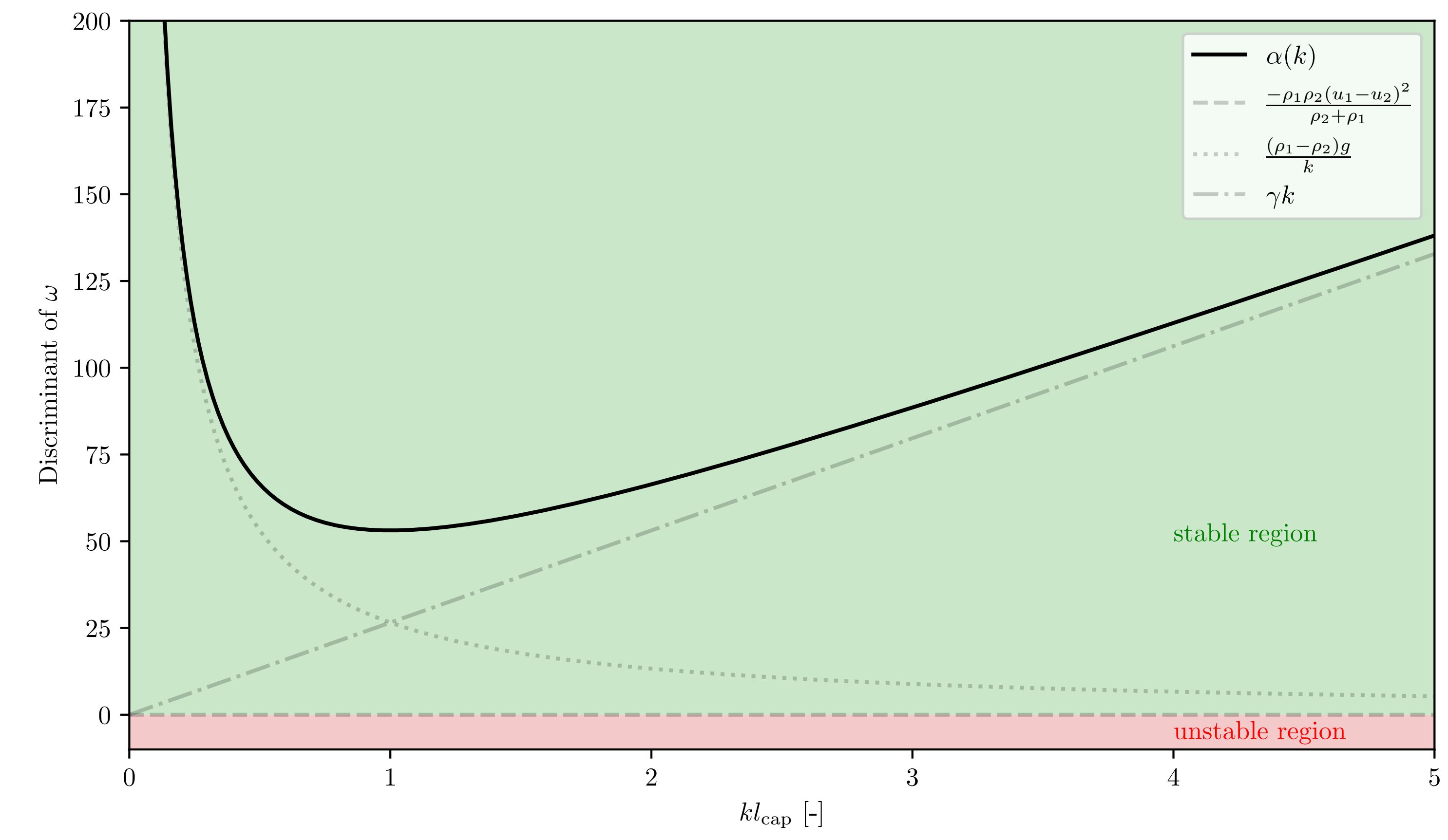
Task 1b: $|u_1 - u_2| = 5$ m/s, stable for $\lambda < 10$ mm
gravity and velocity terms (dotted, dashed) destabilize, capillarity term stabilizes (dash-dotted)



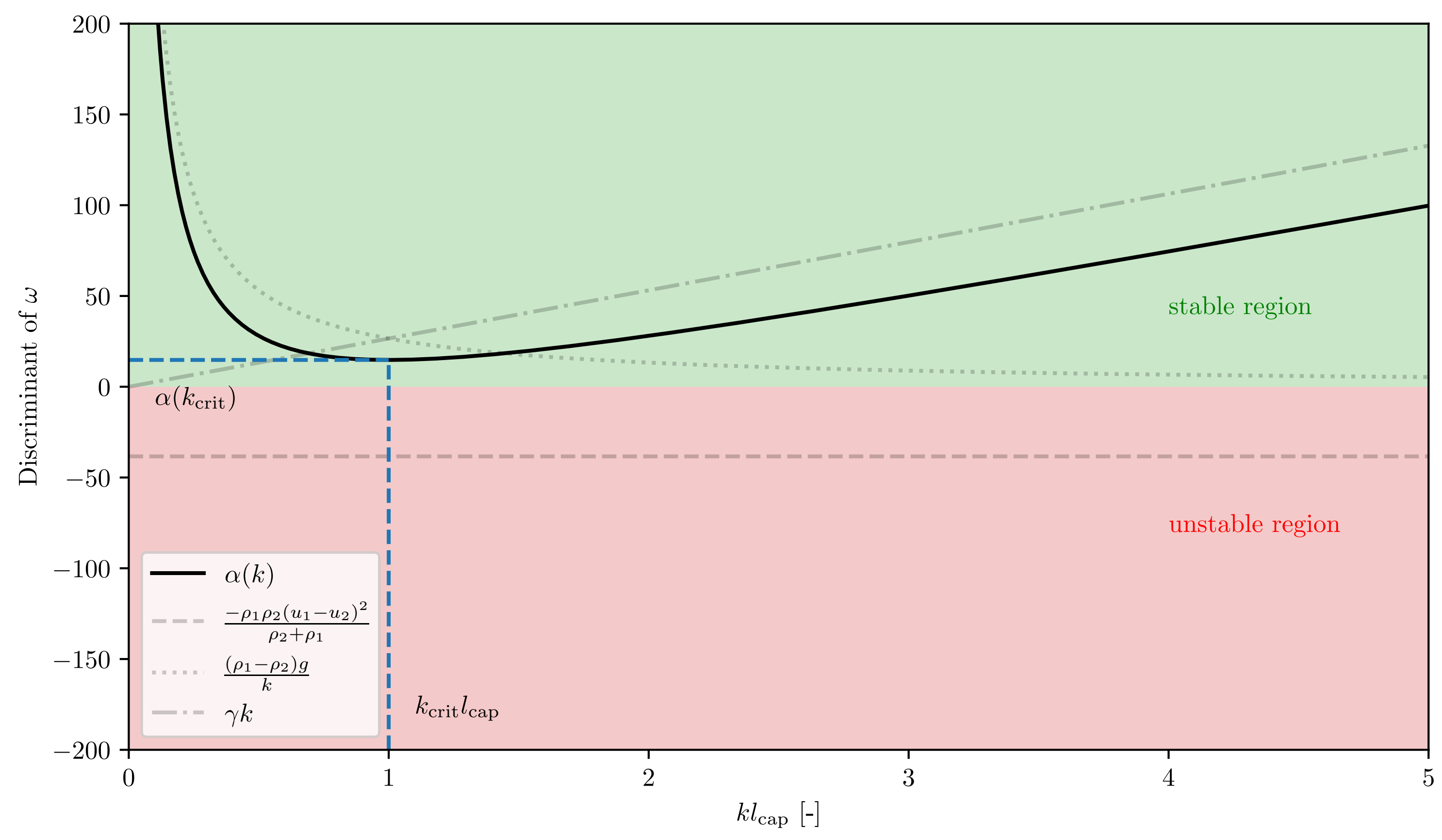
Task 2: $u_1 = u_2 = 0$, stable for $\lambda < 17$ mm
gravity term (dotted) destabilizes, capillarity term stabilizes (dash-dotted)



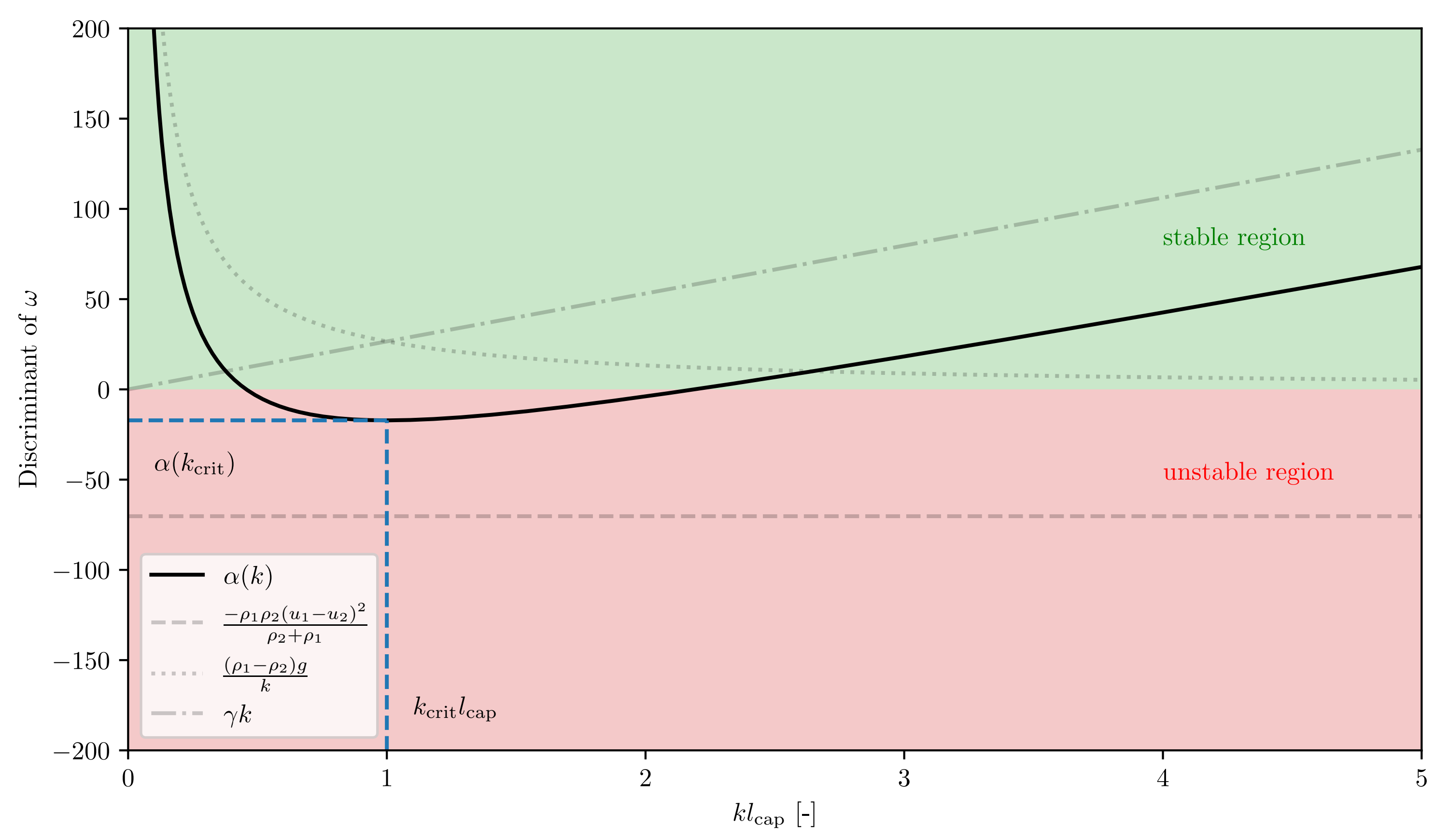
Task 3a: $|u_1 - u_2| = 0$, long λ stabilized by gravity term (dotted),
short λ stabilized by capillarity term (dash-dotted)



Task 3b, Part 1: $|u_1 - u_2| < |u_1 - u_2|_{\mathrm{crit}}$ (e.g. $|u_1 - u_2|_{\mathrm{crit}} - 1$ m/s)

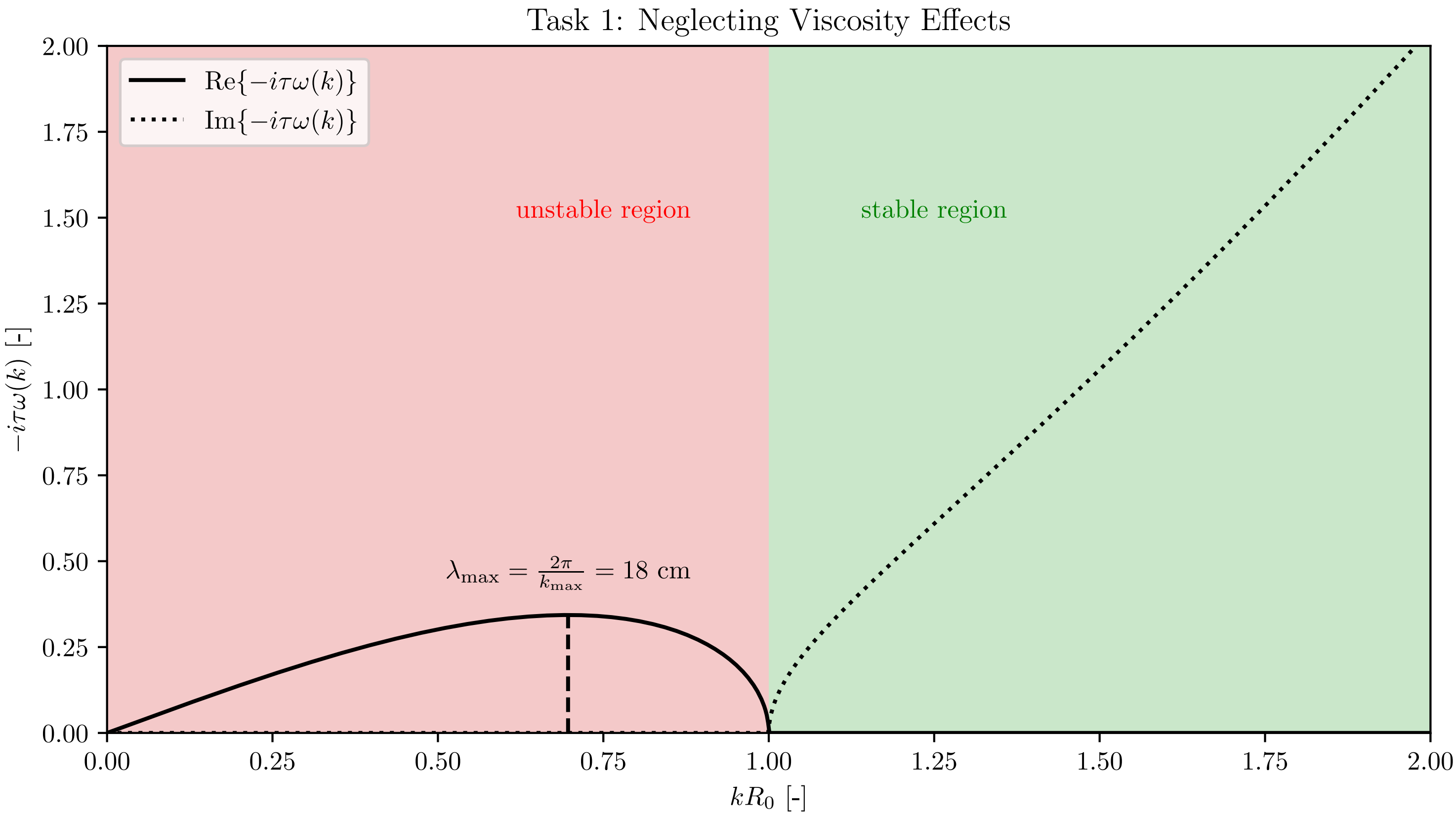


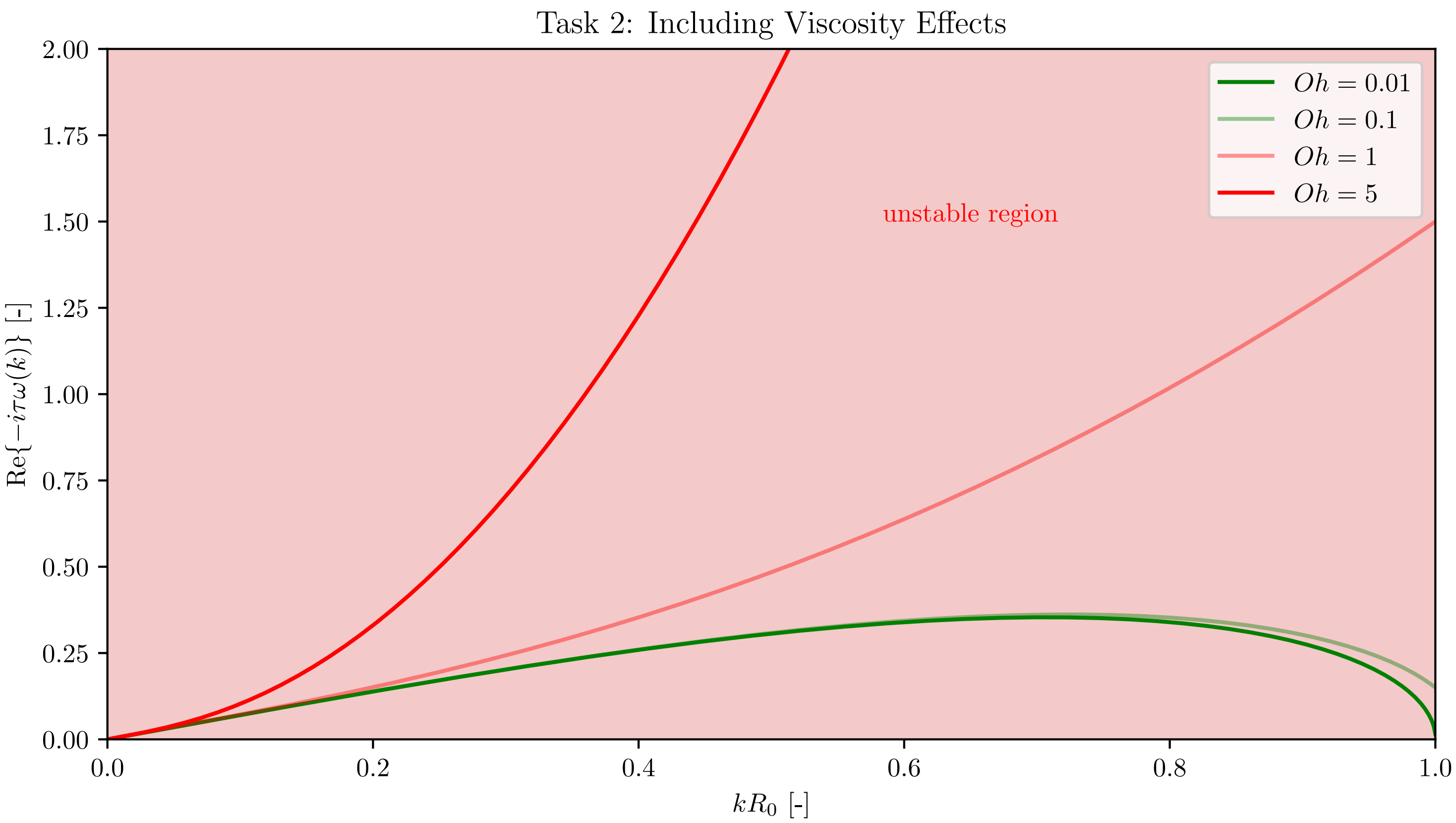
Task 3b, Part 2: $|u_1 - u_2| > |u_1 - u_2|_{\mathrm{crit}}$ (e.g. $|u_1 - u_2|_{\mathrm{crit}} + 1$ m/s)



Expressions for $(u_1 - u_2)_{\mathrm{crit}}$ and λ_{crit} can be found in a markdown cell above in the jupyter notebook!

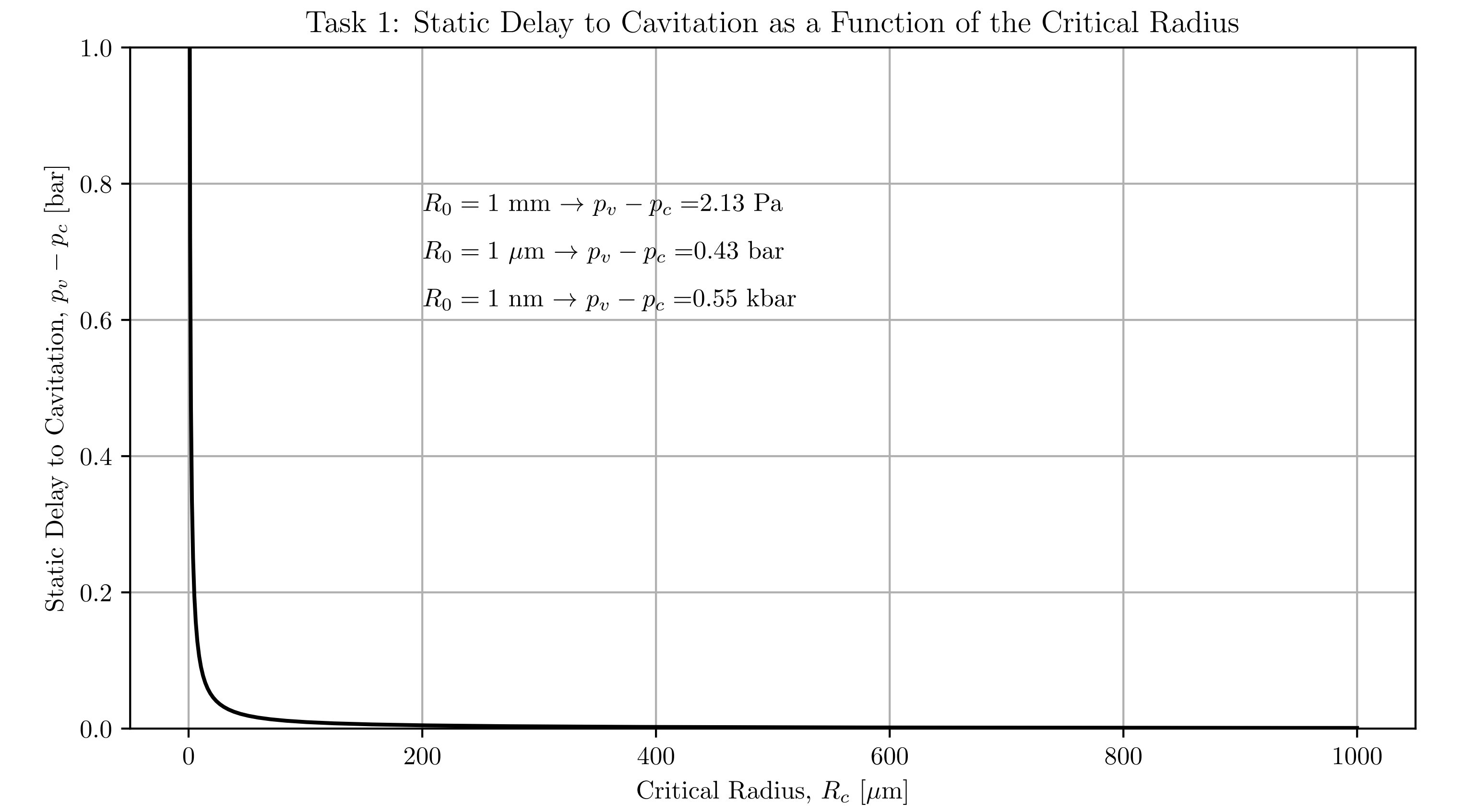
Assignment 5

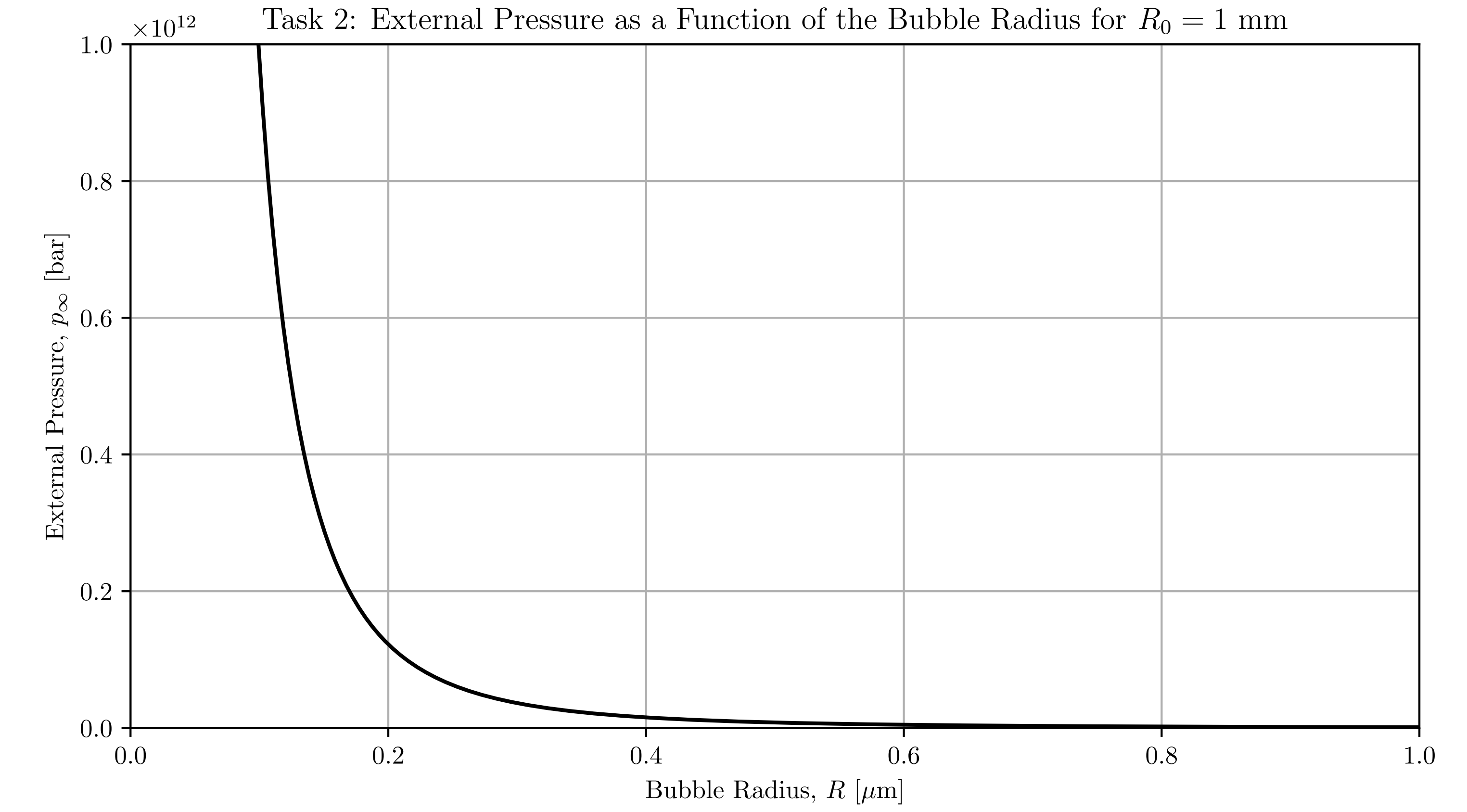


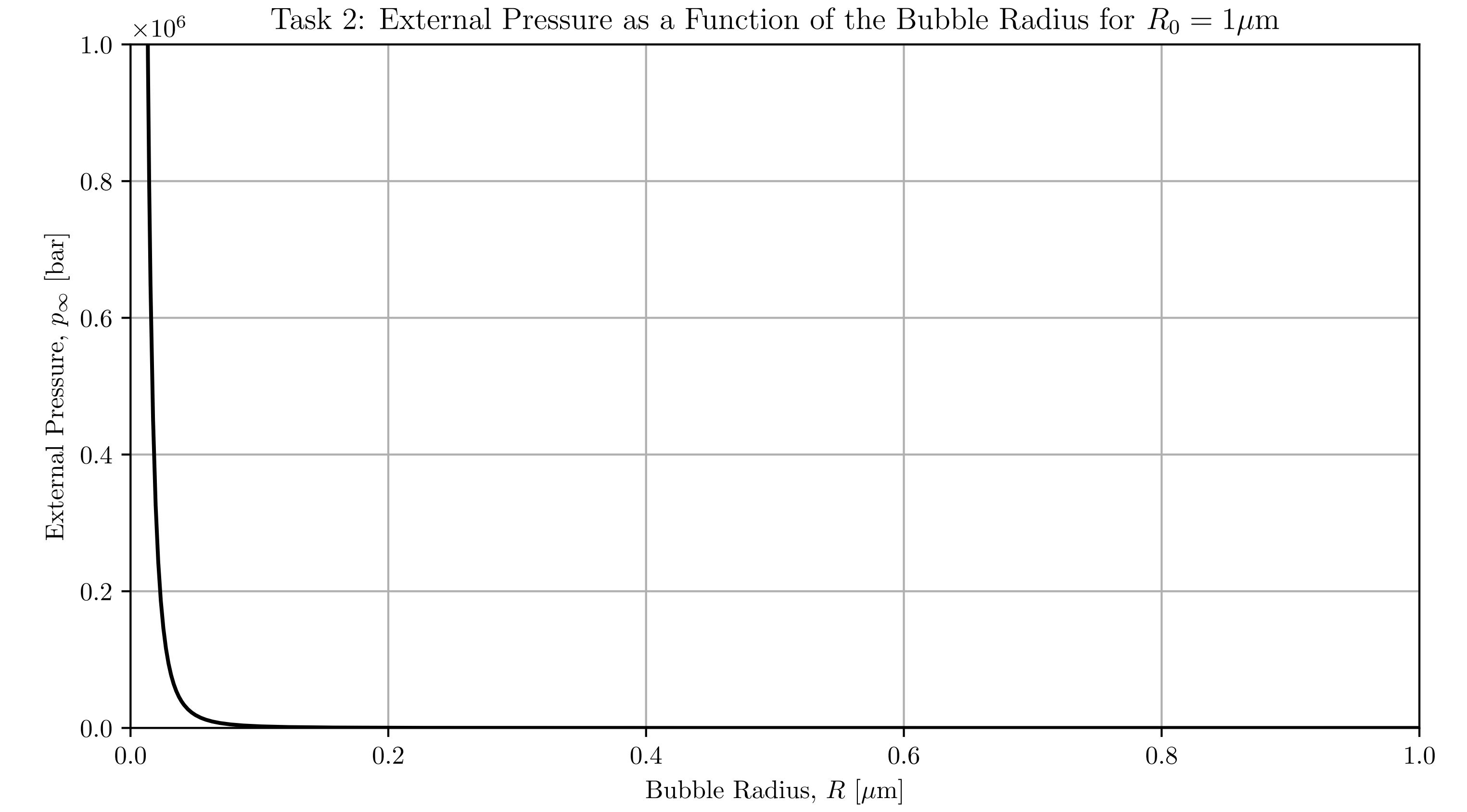


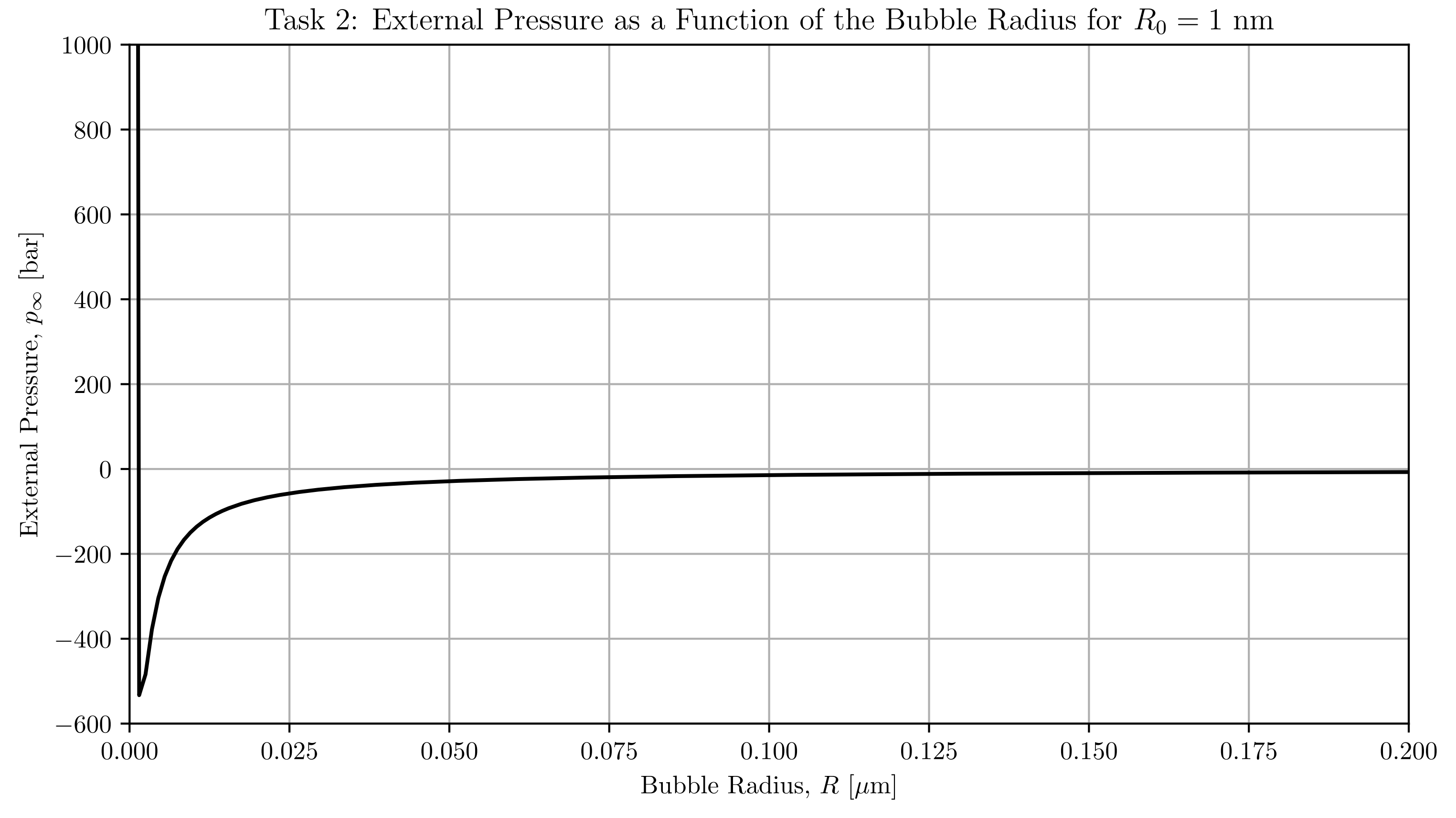
In the limit of low Oh numbers (where capillarity effects dominate and viscosity is negligible), we see that the real part of the plotted expression converges to the one of the previous task, as it is expected. Furthermore, the higher the Oh number (i.e. high viscosity fluids), the stronger the destabilization rate, which also agrees with experimental evidence. Moreover, the curve changes from a concave (with a maximum) to a convex (unlimited growth) curvature with increasing Oh numbers and thus at high Oh numbers, no stable flow can establish!

Assignment 6

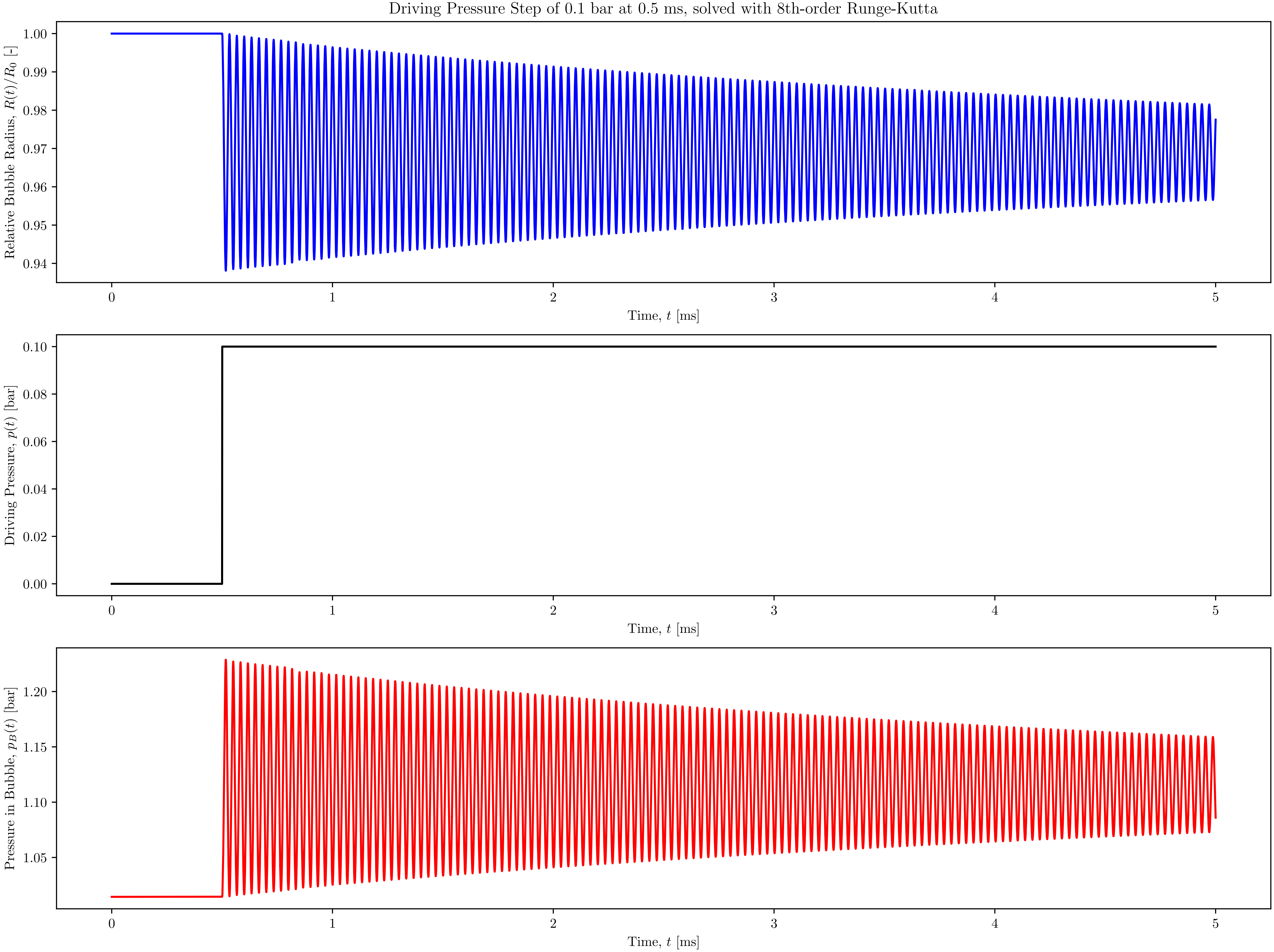


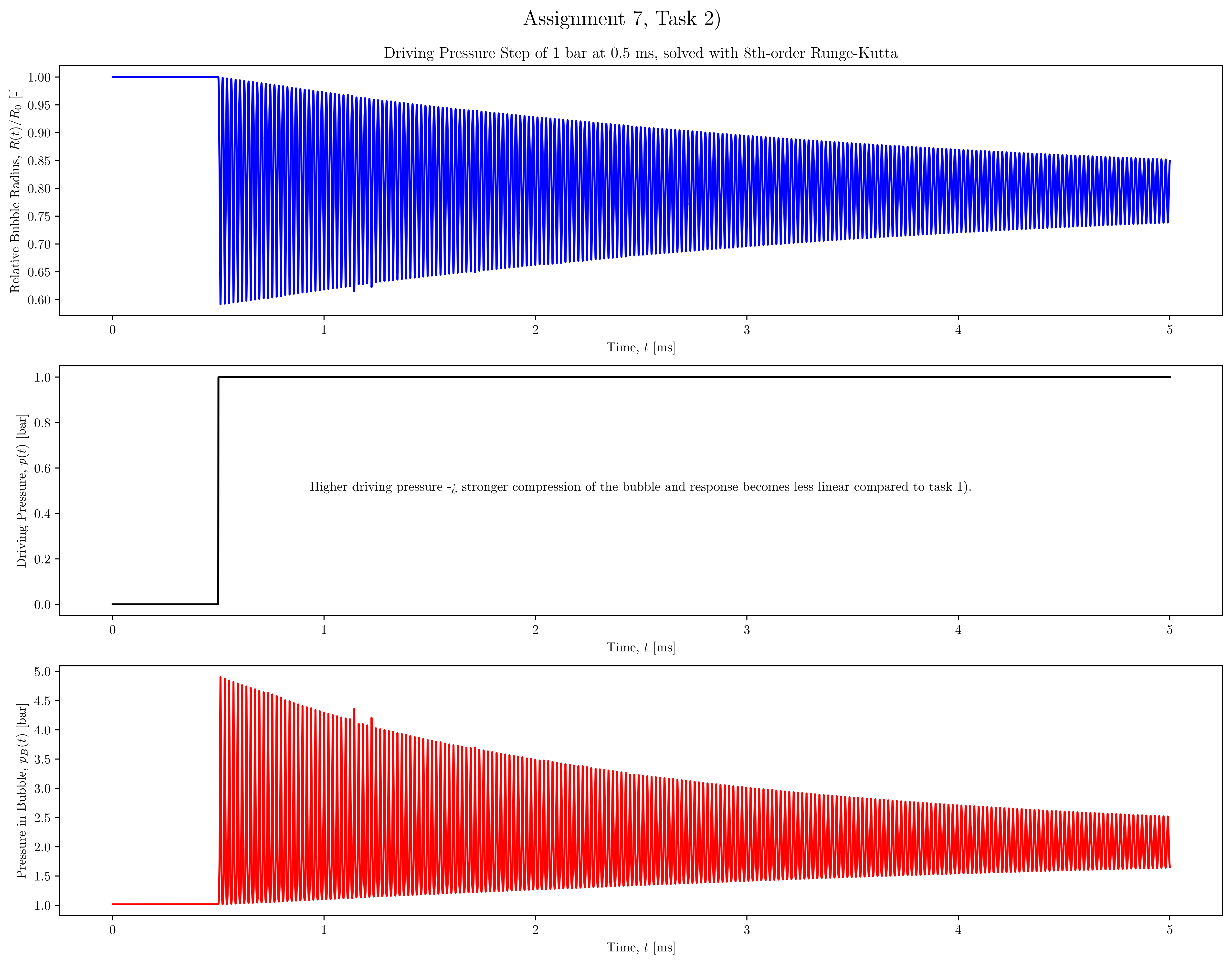




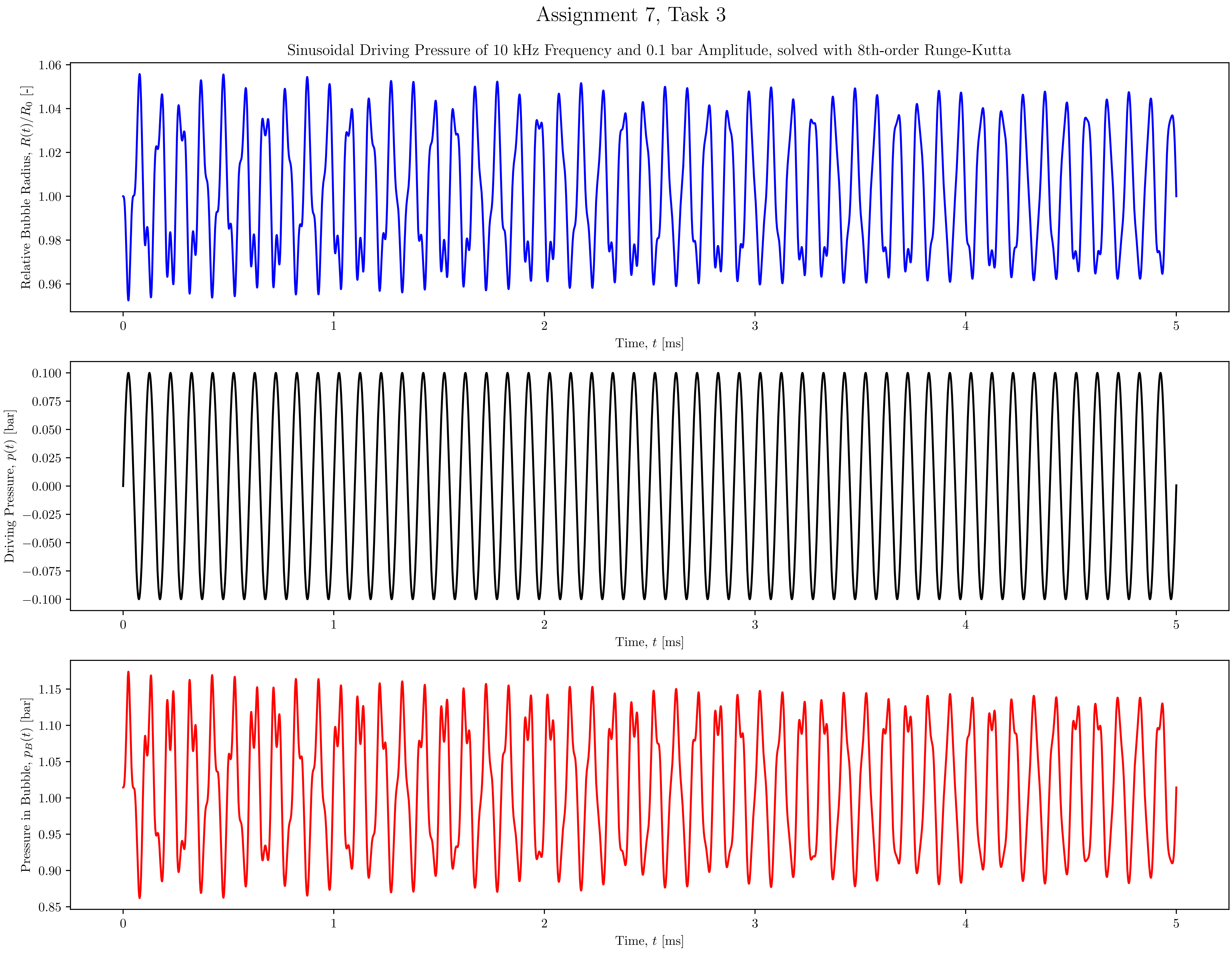


Assignment 7, Task 1



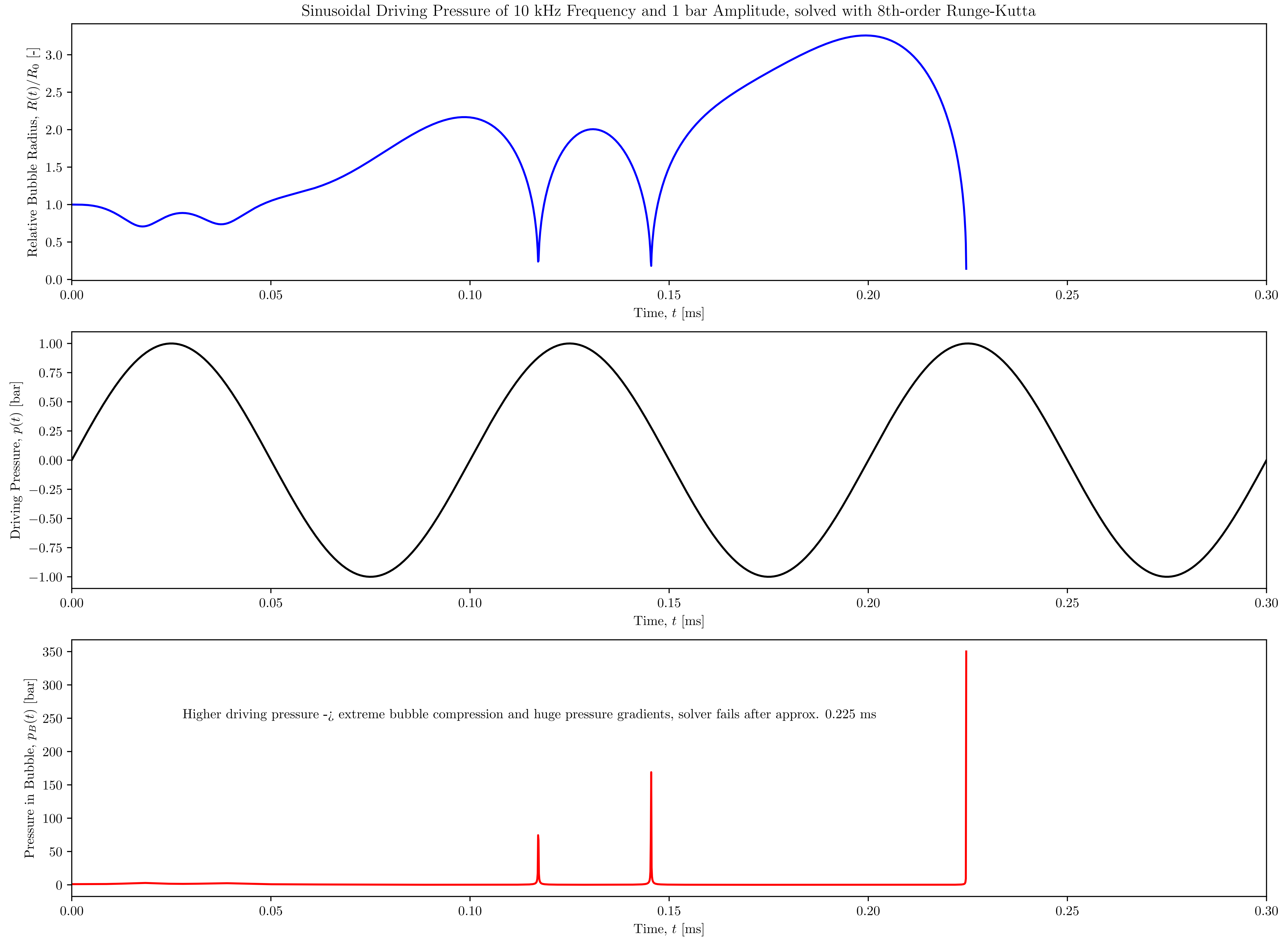


Assignment 7, Task 2)
Driving Pressure Step of 1 bar at 0.5 ms, solved with 8th-order Runge-Kutta
Relative Bubble Radius, $R(t)/R_0$ [-]
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
Time, t [ms]
0
1
2
3
4
5
Driving Pressure, $p(t)$ [bar]
1.0
0.8
0.6
0.4
0.2
0.0
Higher driving pressure -¿ stronger compression of the bubble and response becomes less linear compared to task 1).
Time, t [ms]
0
1
2
3
4
5
Pressure in Bubble, $p_B(t)$ [bar]
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Time, t [ms]
0
1
2
3
4
5

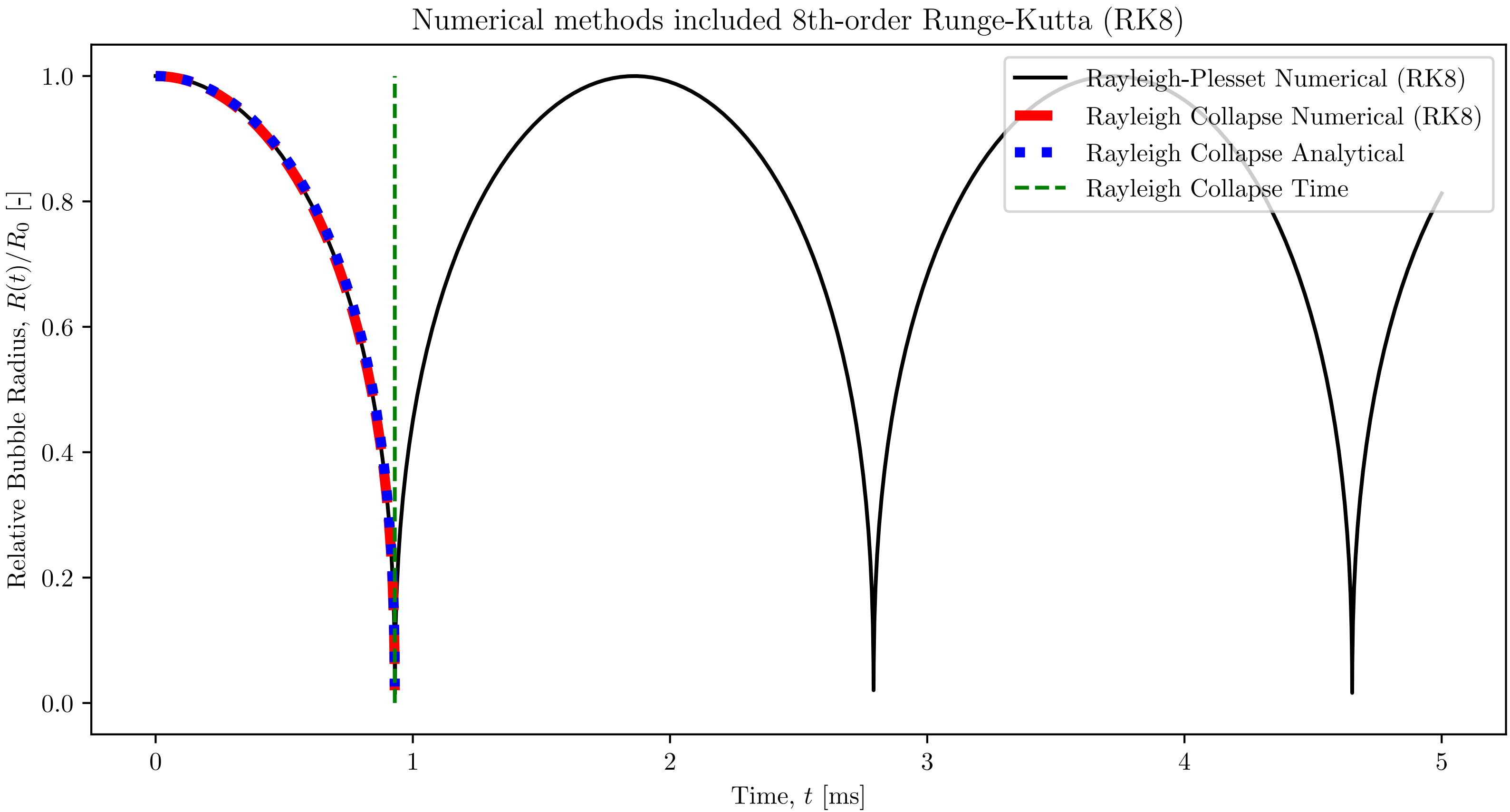


Assignment 7, Task 3
Sinusoidal Driving Pressure of 10 kHz Frequency and 0.1 bar Amplitude, solved with 8th-order Runge-Kutta
Relative Bubble Radius, $R(t)/R_0$ [-]
Time, t [ms]
Driving Pressure, $p(t)$ [bar]
Time, t [ms]
Pressure in Bubble, $p_B(t)$ [bar]
Time, t [ms]

Assignment 7, Task 4



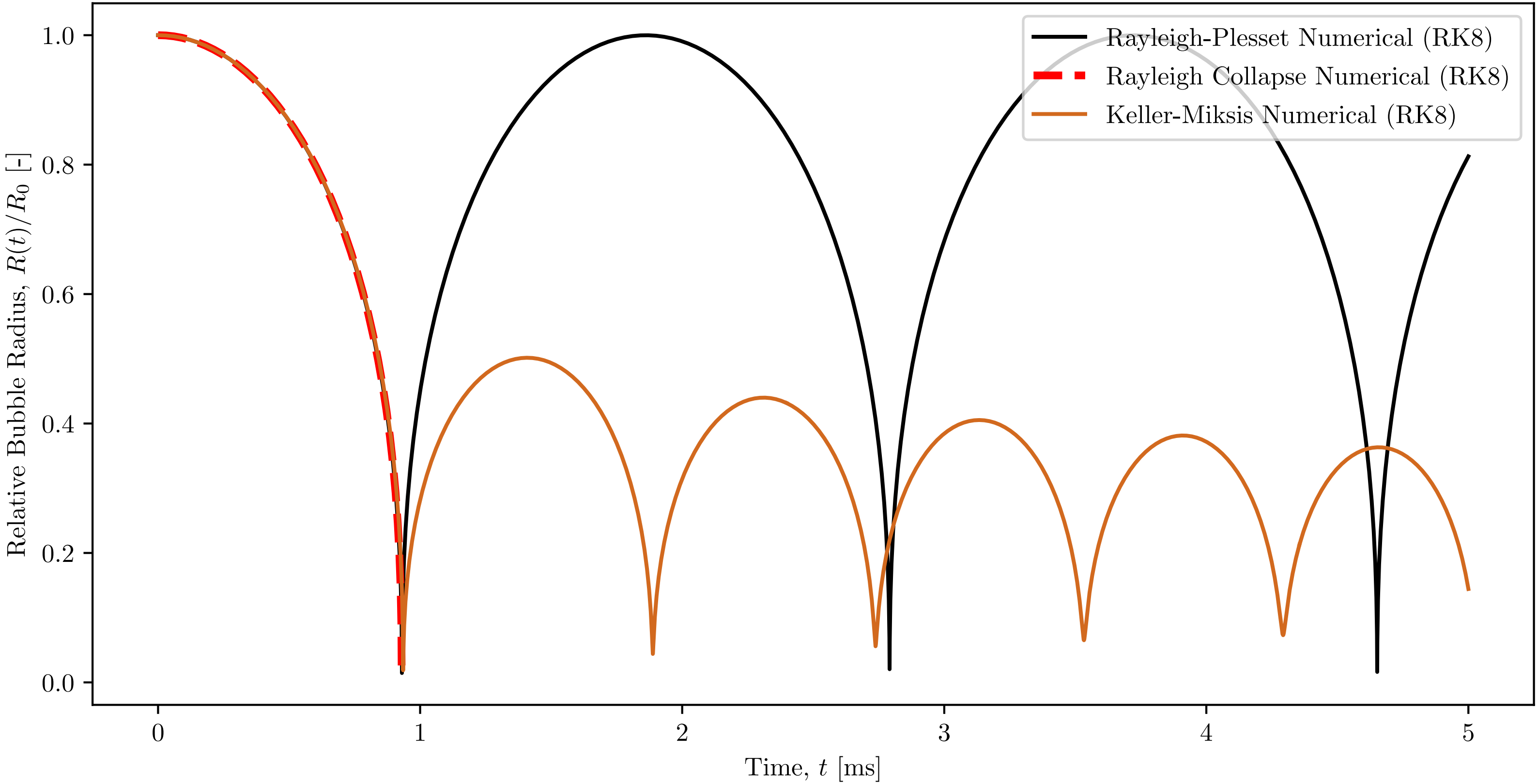
Assignment 8, Tasks 1-2



The Rayleigh collapse equation (colored lines) neglects the gas pressure term, p_g, which means that only the constant (!) vapor pressure of the surrounding liquid opposes the bubble collapse and a bubble rebound cannot happen.

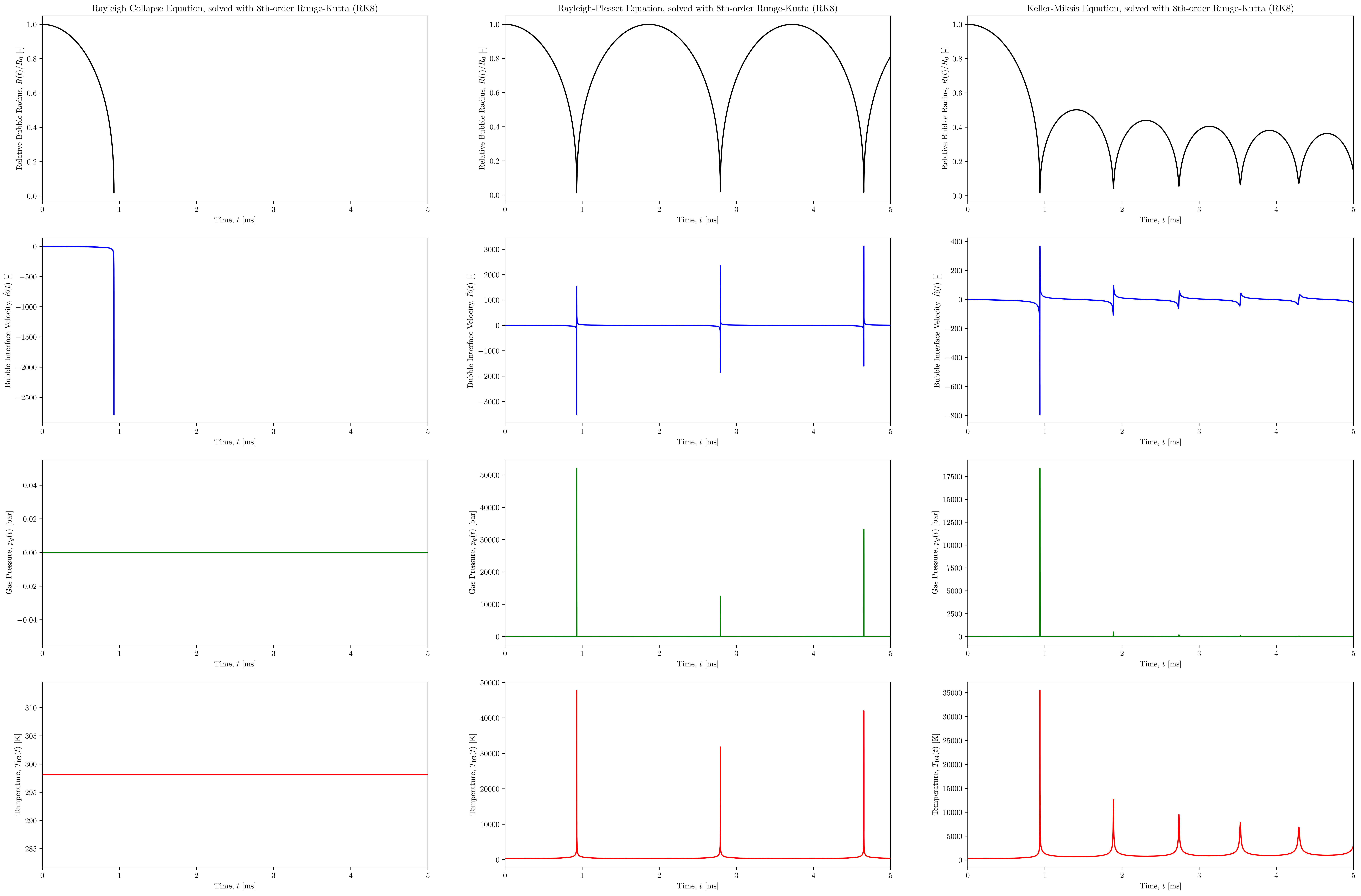
Assignment 8, Task 3

Numerical methods included 8th-order Runge-Kutta (RK8)

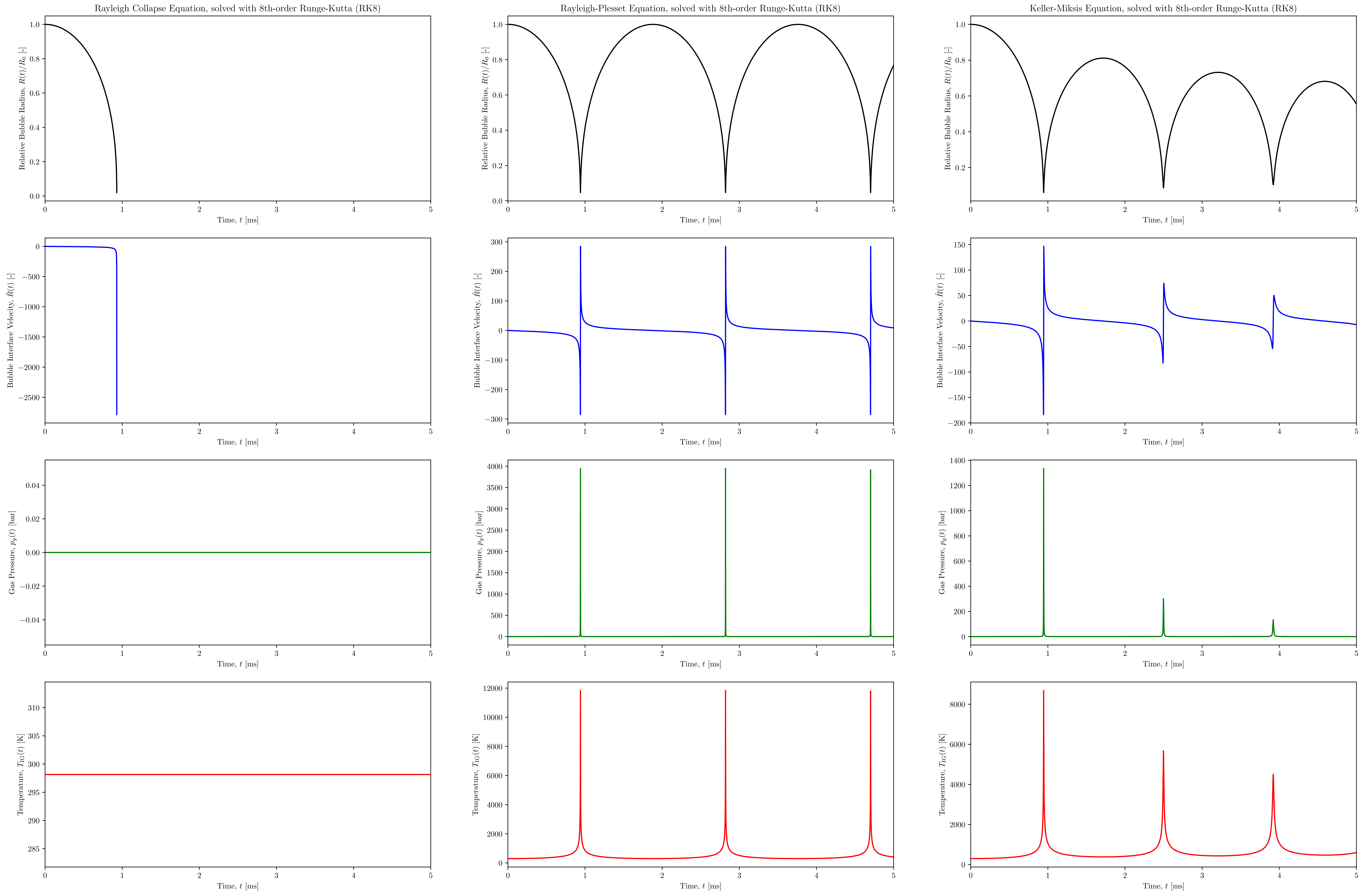


When considering compressibility effects (Keller-Miksis), the first bubble oscillation remains very similar, however, the rebounds are significantly reduced due to shockwave emissions.

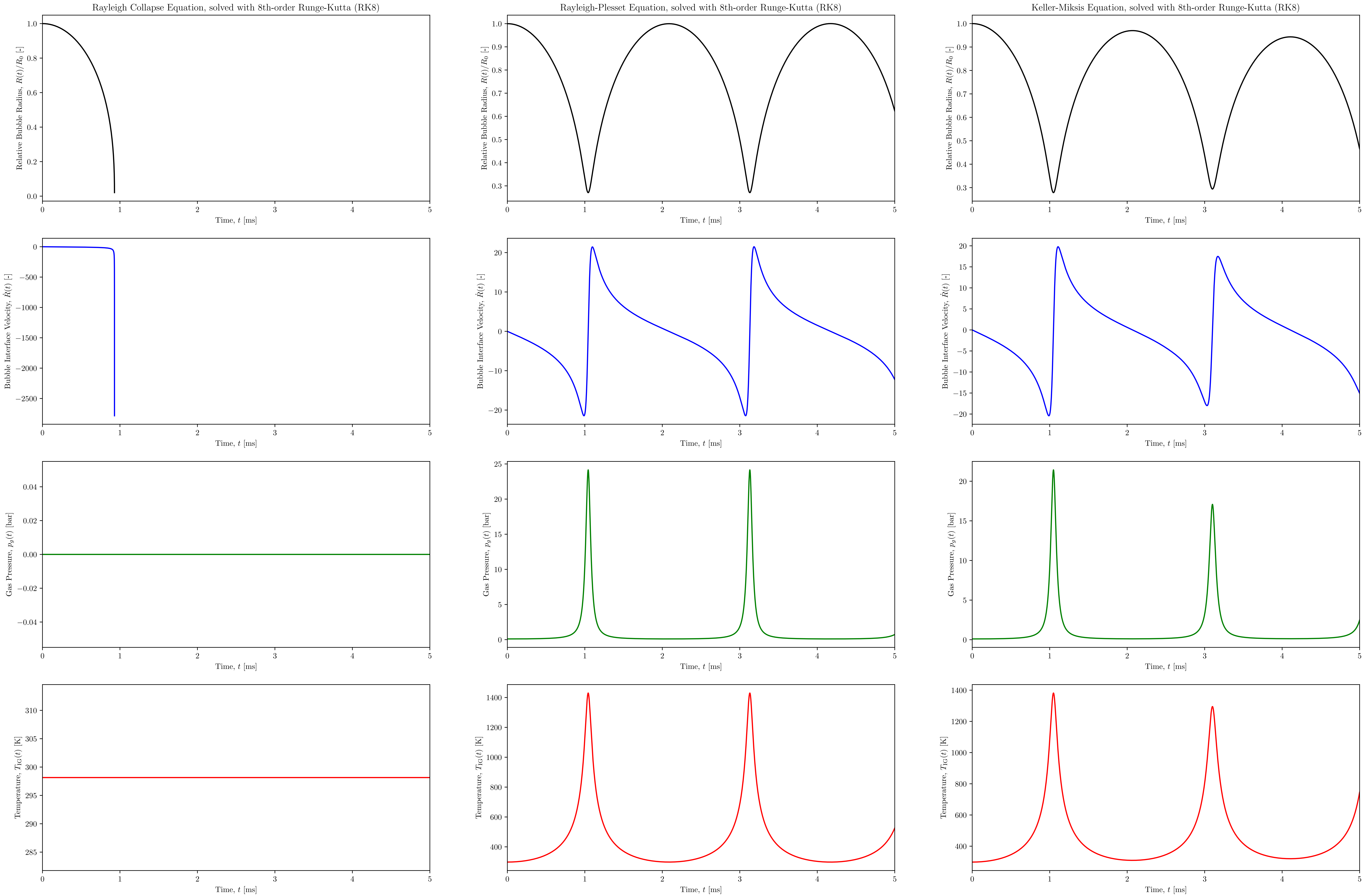
Assignment 8, Task 4 ($p_{g0} = 0.1$ kPa)



Assignment 8, Task 5 ($p_{g0} = 1$ kPa)



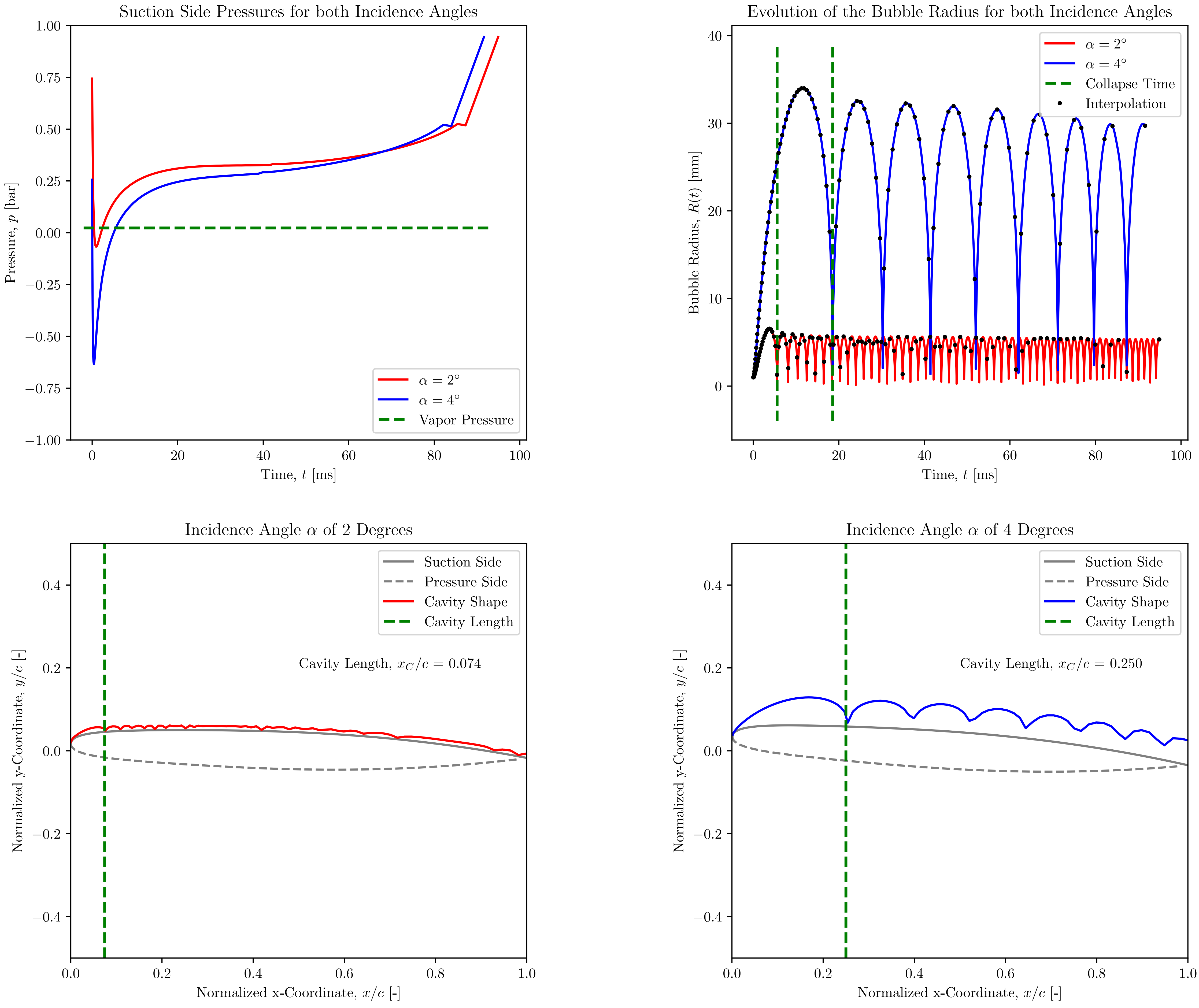
Assignment 8, Task 6 ($p_{g0} = 10$ kPa)



At higher gas pressures inside the bubble, the force resisting the bubble collapse becomes larger, which decreases the maximal interface velocity as well as the resulting max. pressures and temperatures inside the bubble significantly. In addition, the deviation from the Rayleigh collapse equation (which assumes no gas pressure) becomes larger.

Assignment 9

Rayleigh-Pesset Eq. solved with 8th-order Runge-Kutta



Assignment 9 - Additional Plots