Dynamic Models in Biology
Lab 1 Report
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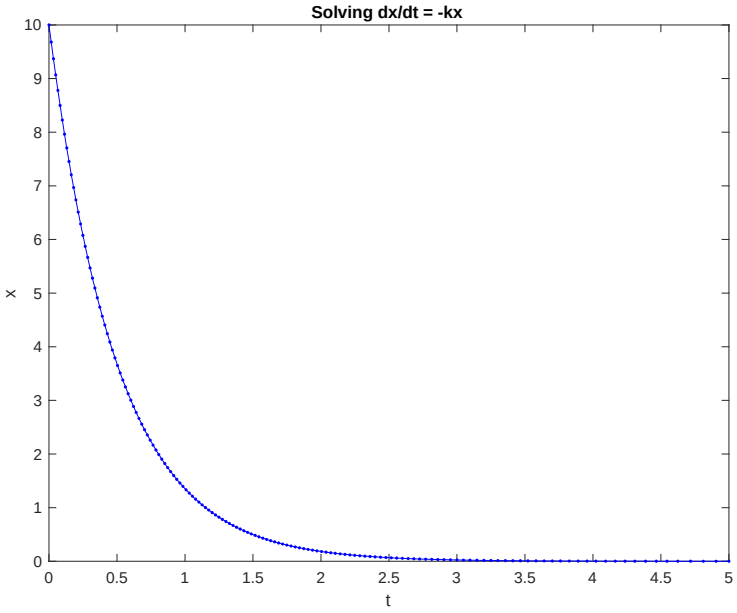
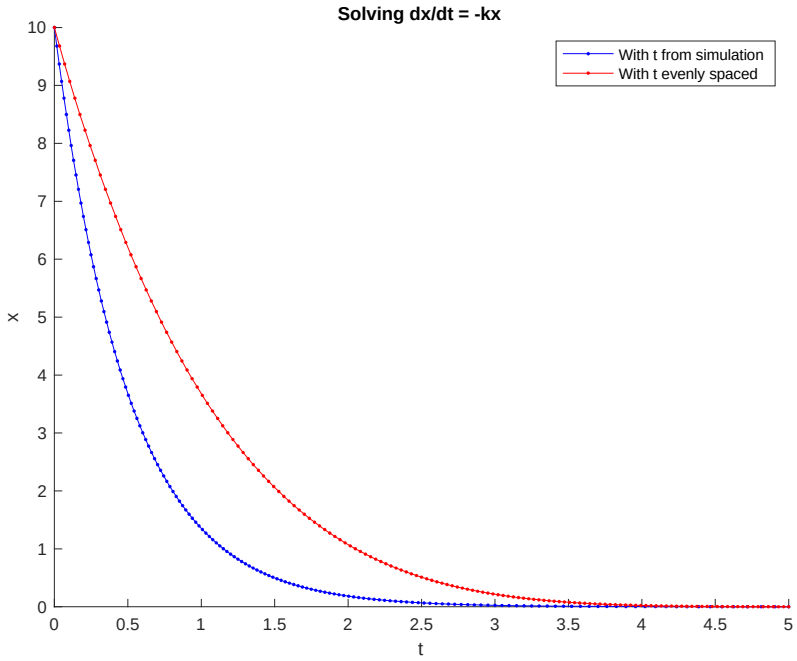
Fall 2023

Part 1 Simulating exponential decay

Decay with k=2

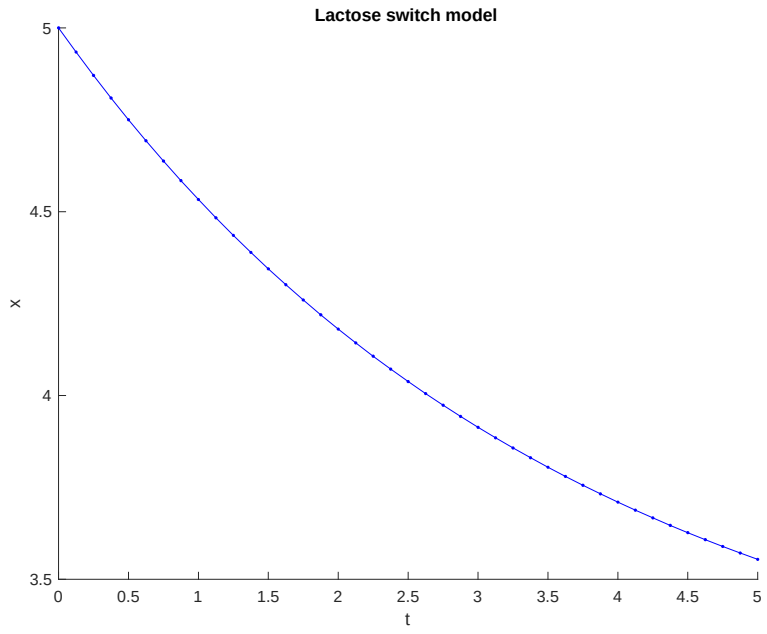


Using the incorrect t values changes the solution:

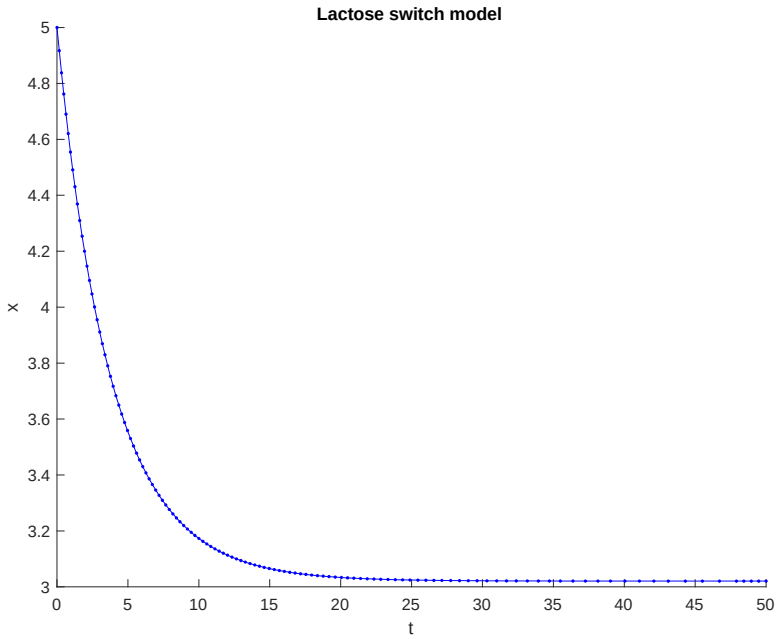


Part 2 Simulating the lactose switch model

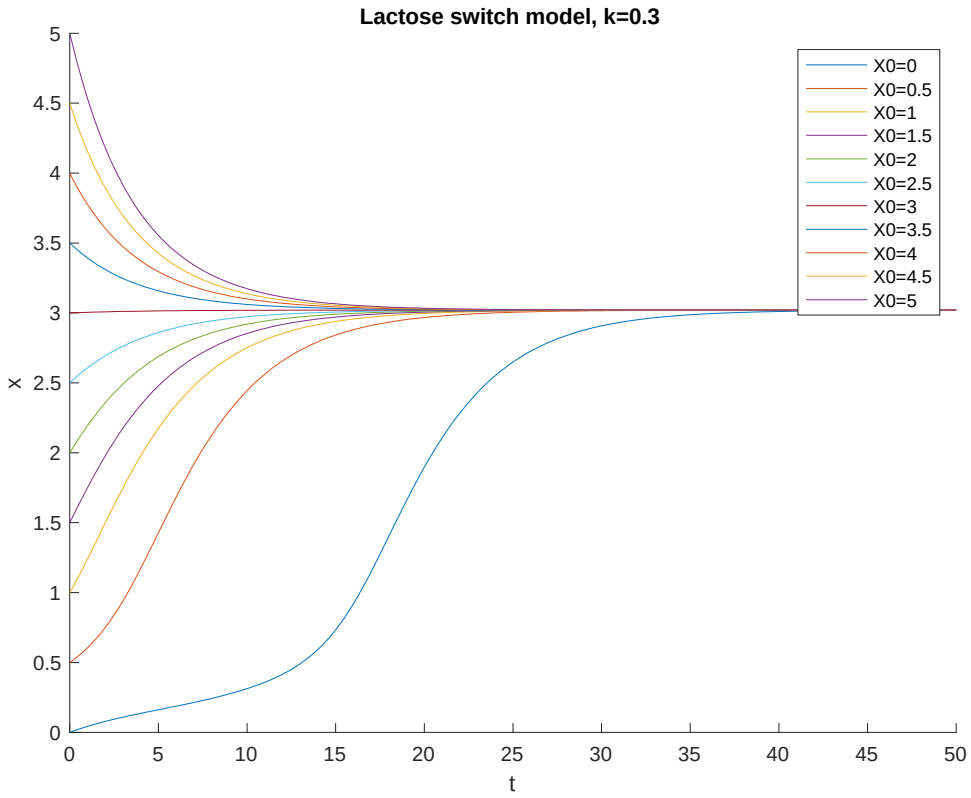
If t only goes until 5, then it does not reach steady-state (a=0.05, k=0.3, and an initial condition of x0=5, t 0:5)



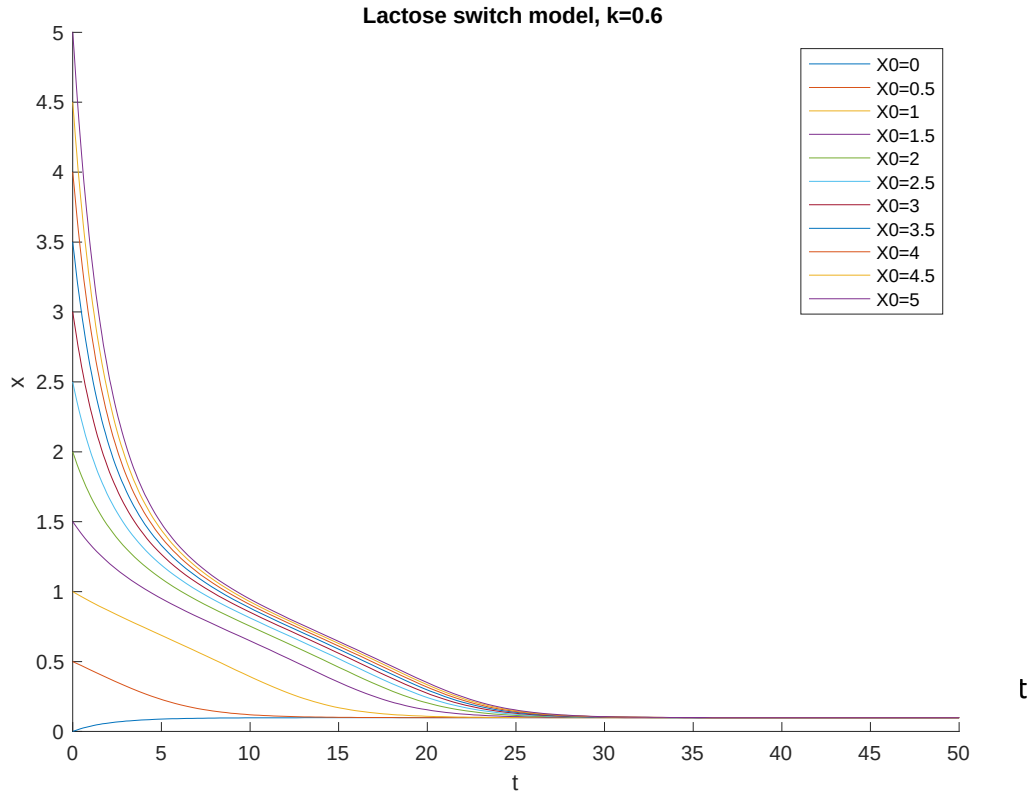
Increasing t will allow it to reach steady-state (a=0.05, k=0.3, and an initial condition of x0=5, t 0:50)



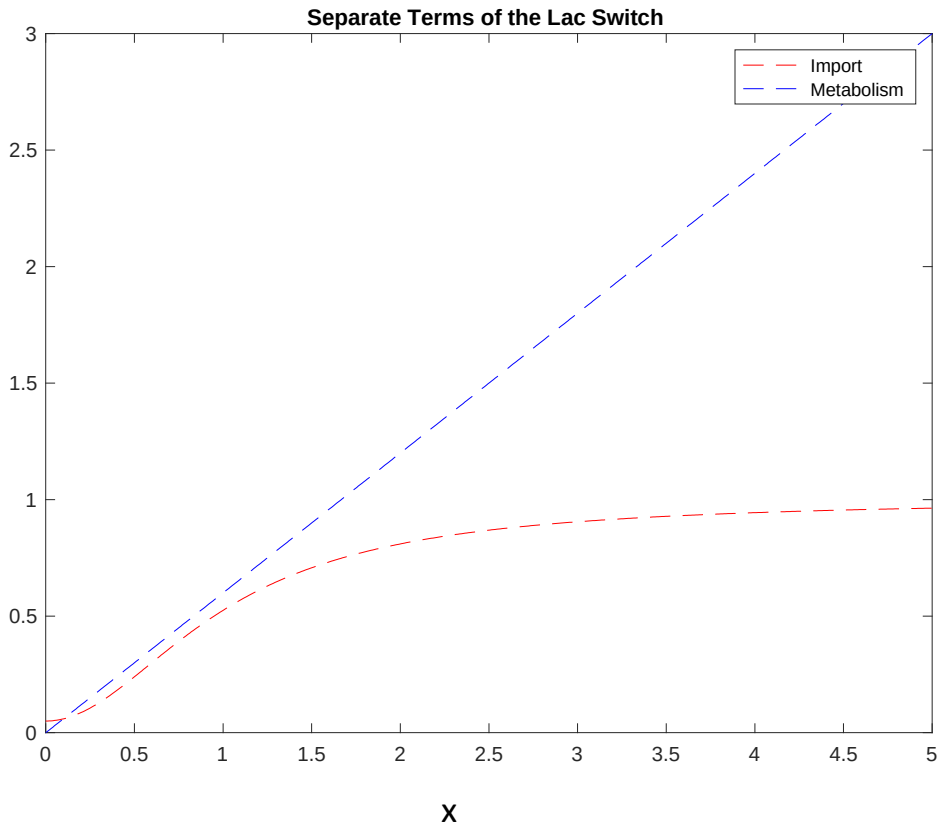
point at 3



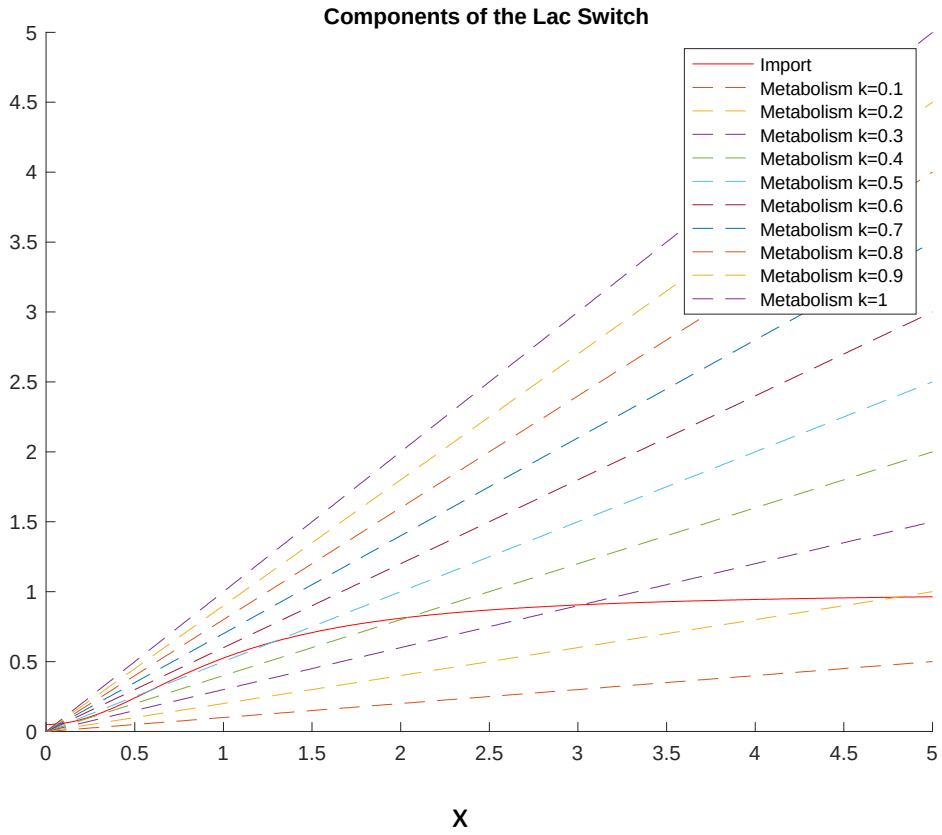
Now with k at 0.6, the steady-state approaches a different fixed point (around 0.1)



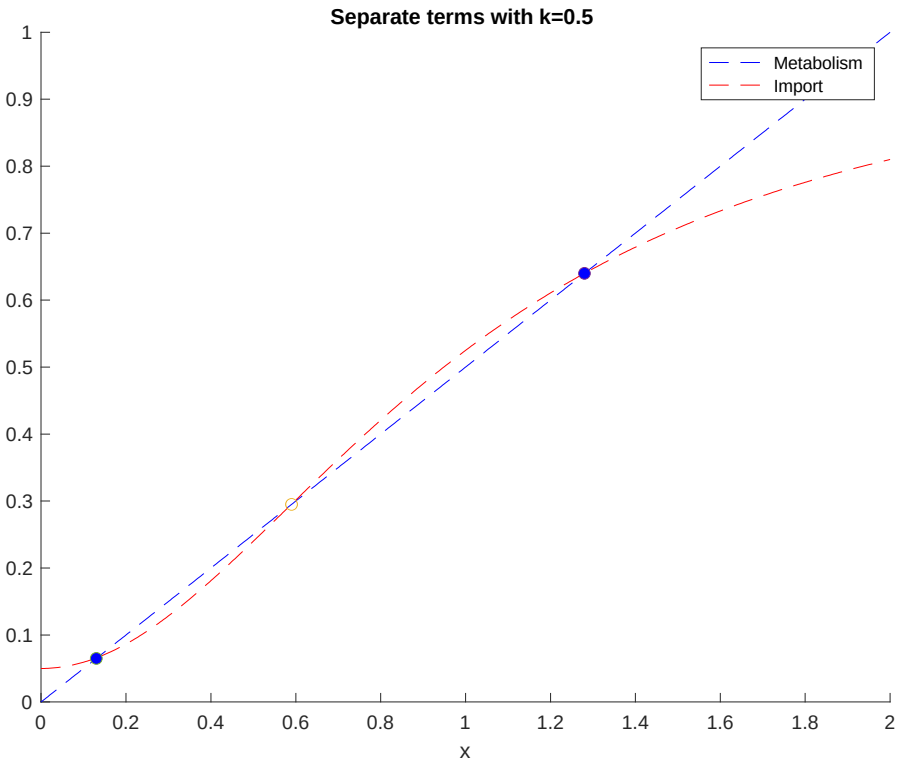
t



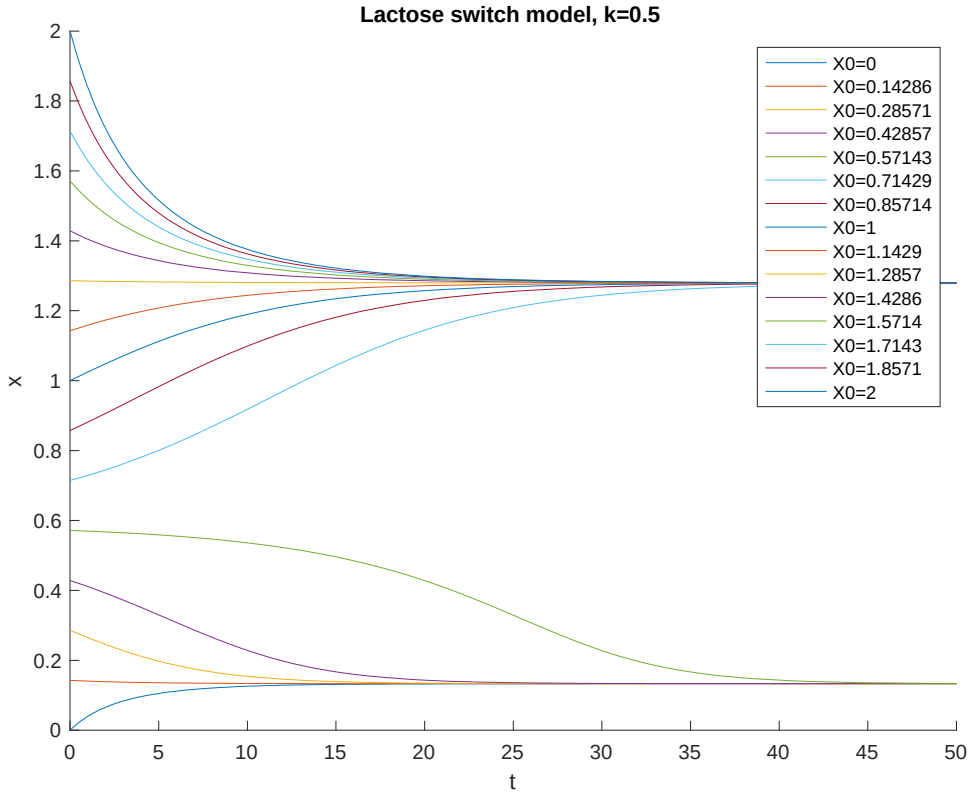
With that value of k, we only get one fixed point. If we want to find values of k for which there exist more fixed points, we vary k and re-run:



The light blue curve (k=0.5) looks like a good candidate. Plotting that one and zooming in a bit more, we do see there are 3 fixed points for the system with k=0.5. If we solve the equations, we can get the exact fixed points, $x^* \approx \{0.13, 0.59, 1.28\}$

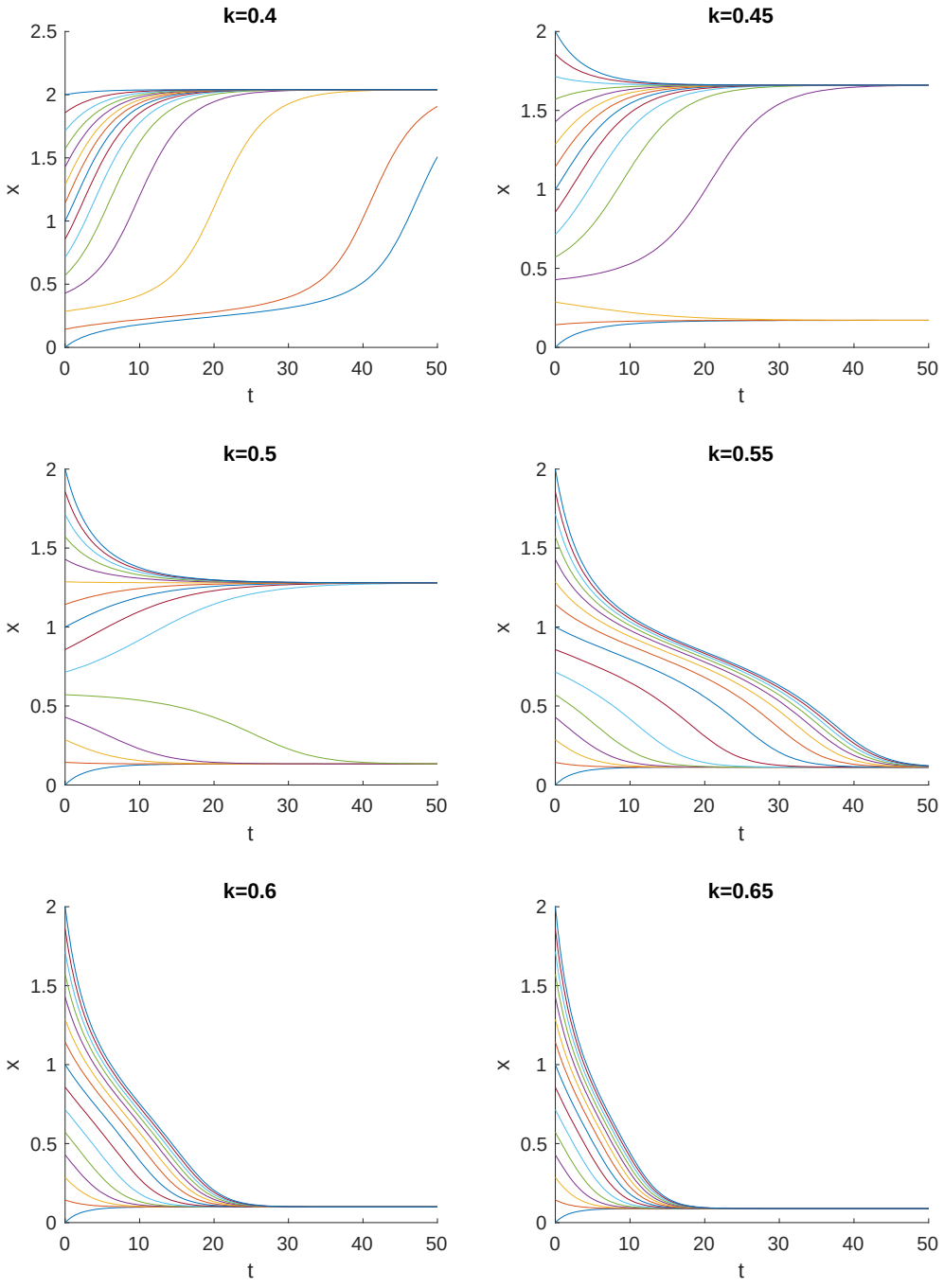


Running the simulation for k=0.5, we can see there are two basins of attraction, depending on the initial condition x0. In this figure, the basin of attraction changes around x0 = 0.6 which corresponds to the unstable fixed point where the red and blue curve meet in the figure before this one (unfilled orange circle)



The basin of attraction for the k values in the top half is convergent on the fixed point at x ≈ 1.28 while the basin of attraction for the k values in the bottom half goes to the stable fixed point at x ≈ 0.13.

We can now vary the parameter k, and see for which values of k there exists a bifurcation with 2 basins based on initial conditions:



Here we can see that only k values of 0.45 and 0.5 lead to bifurcation based on initial conditions.

If we want to zoom in with a bit more granularity, this becomes 0.42 < k < 0.54. (Obviously you can find more granularity by simulating more precise k values in the range around those edges)