

**Instructions:** A printed copy of your homework should be handed in at **the start of class** the day it is due. Any supplementary electronic files (e.g. R scripts or wxMaxima files) should be emailed to the instructor with file name format: **Lastname-hwX.ext**. Each part of each exercise is worth 10 points unless stated otherwise.

**Exercise 1:** Show the phase diagram for the following models (assume all parameters are strictly positive unless otherwise indicated) with labels indicating equilibrium points and their stability. Analytically find the equilibrium points as well.

a.  $\dot{x} = x \sin(x)$

b.  $\dot{x} = \frac{ax(\alpha-x)+gx}{k+x^2}$

c.  $\dot{x} = \exp(\cos(\pi x)) - \frac{1}{2}$

**Exercise 2:** Find (analytically) the stability of each equilibrium point  $x_* \in 2\mathbb{Z}$  for  $\dot{x} = \sin(\pi x) + 1 - \cos(\pi x)$ . Since  $\dot{x}$  is differentiable, what does this imply about the existence (or absence of) other equilibria?

**Exercise 3:** Use the `ode()` function in the package `deSolve` in R to generate a numerical solution of the above equation starting at  $x(0) = 1$ .