**Modelling with MATLAB: Assignment 1, 2016.**

This assessment is “formative”; a mark will be provided and feedback will be given, but nothing will count towards your final assessment for this module. Assignments 2-5 will be summative and will be combined to provide the full mark for this module. Their format will be similar to Assignment 1, but the material will be more challenging. In all cases, you will need to spend your own time in researching the concepts as well as in coding and documenting your solutions.

There are two questions, and each question carries equal marks.

1. Consider the simple nonlinear dynamical system (the **“Lotka-Volterra predator-prey system”**)

x’ = ax – bxy

y’ = cxy - dy

where x and y are the population densities of predators and prey respectively, a, b, c and d are strictly positive constants, and the ’ denotes a derivative with respect to time.

a) Define a MATLAB function lvderivs to evaluate the time derivatives for this dynamical system, taking care to define any parameters as global if necessary. Verify that the origin (0, 0) is a trivial fixed point of the dynamical system by evaluating lvderivs at this point.

b) Write a MATLAB script which uses fsolve with your lvderivs function and a range of random (physically reasonable) initial guesses to show that the system has a strictly positive fixed point. Find the eigenvalues of the system’s Jacobian matrix at this strictly positive fixed point.

c) Use ode45 to integrate the system forward in time, using a range of initial values with x-coordinate on the non-trivial y null cline

x = d / c

and using a time interval appropriate to reveal the system’s dynamics.

d) Write your own MATLAB script (not a pre-defined function) which uses lvderivs to produce approximate solutions to the dynamical system using an explicit Euler method with a fixed time step, showing outputs for at least two different (fixed) time steps. Explain why these solutions differ to those of part c).

**Note: This simple (and probably rather unrealistic) dynamical system is an instructive building block and will be relevant later in the module e.g. when we look at complex networks of interactions and/or stochastic differential equations.**

2. The Lotka-Volterra model in question 1 has been criticised because it does not have a linearly stable strictly positive equilibrium.

a) Modify the model so that, at least for some set of biologically meaningful parameter values, it has a linearly stable strictly positive equilibrium. Explain what the modification represents biologically.

b) Show either algebraically or numerically that there is a linearly stable strictly positive equilibrium in your revised model.

c) Using a numerical method, calculate the elasticity of the linearly stable strictly positive equilibrium point, for some chosen set of parameter values. If possible, confirm your result numerically.