DEPARTMENT OF MATHEMATICS, NORTHEASTERN UNIVERSITY

MTH G131: Introduction to mathematical methods and modeling.

Suggestions for course project

1) This project concerns determining the trajectory of a rocket. We started the analysis in one of the Problem sessions. The equation of motion is deduced using Newton's Law; assuming a constant rate of 'burn' for the fuel and a constant rate at which exhaust gases are emitted, you can compute the trajectory as a function of time. In this project you will include the effects of air resistance and decreasing gravity as the rocket ascends. So you will need to (a) get the equation of motion, (b) solve it for some special cases, (c) get a numerical solution for the general case, (d) use realistic numbers for the parameters, (e) output a nice graph showing altitude as a function of time.

2) The TCP protocol on the Internet can be modeled as a community of users all competing for a finite resource (in this case bandwidth). Each user probes the network for available bandwidth, and slowly increases its transmission rate. When the combined transmission rates exceed the capacity, the users are notified and immediately reduce their transmission rates by a multiplicative factor (in standard TCP by 50%). Users then again start to slowly increase their rates until capacity is again exceeded. In this project you will (a) set up equations for the transmission rates, (b) analyze standard TCP and show that the solutions converge to a fixed point, (c) analyze variants of TCP and determine whether solutions converge, (d) get a numerical solution, (e) include some stochastic elements (time and energy willing).

3) A more complicated predator-prey model was introduced by Odell (1980). It contains two parameters and as the parameters vary the model undergoes a bifurcation. We studied bifurcations for one-dimensional nonlinear ODE's, in this project you will perform a similar study of bifurcations for this two-dimensional nonlinear ODE. You will (a) set up and explain the equations, (b) find the critical points, (c) determine the nature of the bifurcation, (d) sketch phase plane diagrams (Matlab will be helpful here).