Introduction to Simulink

Please complete the tutorial on Simulink found at

`http://www.mathworks.com/access/helpdesk/help/pdf_doc/simulink/sl_gs.pdf`

. This will familiarize you with the basic operation of Simulink.

1 Introduction

The field of systems engineering is undergoing continuous advancement in the direction of doing more at the systems engineering level. One popular trend is that of model based engineering, where rather than building the actual system, a computer model of the system is built instead and properties of this model are checked against the requirements.

Simulink is a model-based design tool dynamic systems. It provides an interactive graphical environment and a set of block libraries that let you design, simulate and implement a variety of systems. Tools like Simulink are used to verify and validate system properties and requirements from a model rather than the implementation.

In this exercise, we will be using Simulink to model a very simple predator prey system. By doing this, you will familiarize yourself with building and modifying hierarchical graphical models with Simulink.

2 Predator Prey Model

You are asked to build a Simulink model that captures predator prey dynamics. Let $x(t)$ represent the number of prey and $y(t)$ represent the number of predators at time t.

There are two factors that affect the prey population, their natural tendency to reproduce at a birthrate b

$$bx(t)$$

and the fact that predators eat them in proportion to the product of their populations parameterized by p, the rate of predation

$$-px(t)y(t).$$

This results in the following formula for prey dynamics

$$\dot{x}(t) = bx(t) - px(t)y(t) \tag{1}$$

Predators are subject to their own population dynamics. Unlike prey, their numbers naturally tend to decrease at decay rate d

$$-dy(t).$$

However, their numbers increase when feeding on prey, in proportion to the product of the populations with ratio r

$$rx(t)y(t).$$

Resulting in the following formula for predator dynamics

$$\dot{y}(t) = -dy(t) + rx(t)y(t). \tag{2}$$

3 Problems

1. Using Simulink, model the dynamics of these populations.

2. Using the scope tool, generate a plot of the populations over time.

3. Use the subsystem tool to create separate subsystems for the predator and prey populations.

4. A pendulum is described by the equations, where θ is the current angle,

$$\ddot{\theta} = -\frac{g \sin \theta}{l}.$$

   Which can also be written as

$$\begin{aligned} \dot{\theta} &= \omega \\ \dot{\omega} &= -\frac{g \sin \theta}{l}. \end{aligned}$$

   Create a Simulink to model of a pendulum. Use the scope tool to plot the angle and angular velocity of the pendulum as a function of time.

The following two problems are extra credit.

1. Extra Credit(a): Instead of Simulink, read the documentation on ode45 and figure out how to use the differential equations solver manually to model these same equations.

2. Extra Credit(b): If you completed the first extra credit, using the ode solver, it is possible to use ode45 to solve for zero crossings. For the pendulum, make a plot of the period as a function of the initial angle.