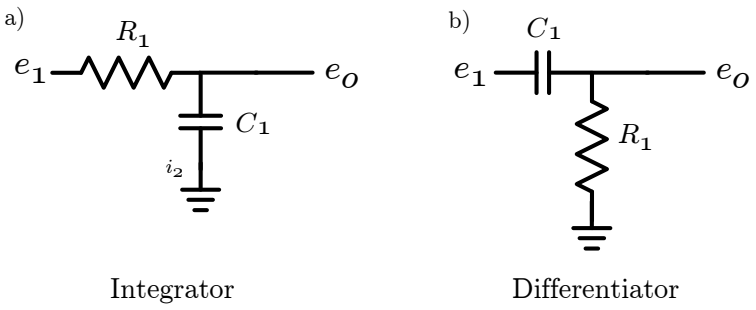
336: Systems and Control
Week 1 and 2: Take Home Assignments



Integrator Differentiator

Figure 1: Integrator and differentiator circuits

Assignment 1

See videos for proofs that the circuits shown in Figure **??** do the operations they claim to do. Graded in the next speed quiz.

Assignment 2

Watch the YouTube video: Op Amp Circuit Analysis: Non-Inverting Amplifier by Darry Morrell. Graded in the next speed quiz

---

Assignment 3

Watch the additional YouTube videos on (See web site for links):

1. Moniac Water Model
2. Antikythera Mechanism
2. Electrical Models

Graded in the next speed quiz

Assignment 4

Draw a block diagram of the following system of two differential equations.

$$\frac{dS_1}{dt} = -k_1 S_1$$

$$\frac{dS_2}{dt} = k_1 S_1 - S_2$$

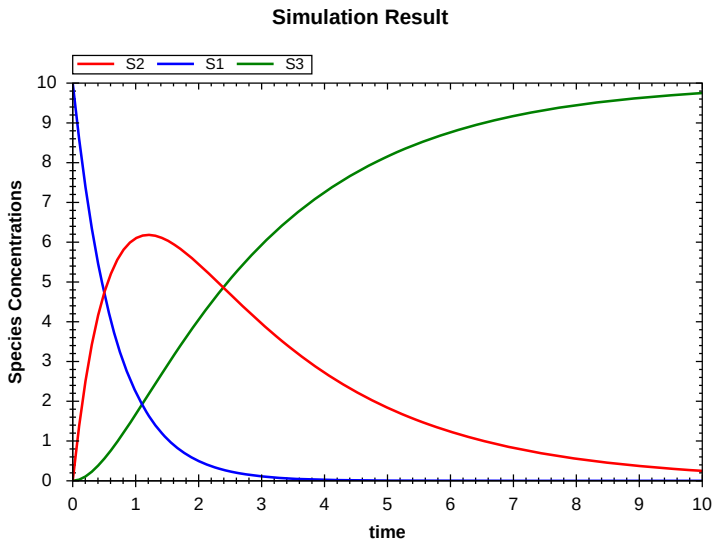


Figure 2: Computer Simulation of two Consecutive Chemical Reactions. $S_1(0) = 10, k_1 = 1.5; k_2 = 0.4$

Assignment 5

The following describes two consecutive chemical reactions involving three chemical species, S_1, S_2 and S_3.

$$S_1 \xrightarrow{v_1} S_2 \xrightarrow{v_2} S_3$$

We assume that each chemical reaction is governed by simple mass action kinetics so that the reaction rates, v_1 and v_2 are given by:

$$v_1 = k_1 S_1 \quad v_2 = k_2 S_2$$

We can write down a simple mathematical model that describes the time evolution of the three species by invoking the conservation of mass. That is:

$$\frac{dS_1}{dt} = -k_1 S_1$$

$$\frac{dS_2}{dt} = k_1 S_1 - k_2 S_2$$

$$\frac{dS_3}{dt} = k_2 S_2$$

Solve the above equations using Matlab or some other suitable computer software. Use the rate constant values and initial conditions shown in Figure **??**

Assignment 6

Identify the state variables and parameters in the following systems:

a) A projectile fired from a cannon (Figure **??**)

b) An RC circuit (Figure **??**)

c) A water tank with a continuous flow of water into the tank and a narrow opening at the bottom of the tank (Figure **??**).

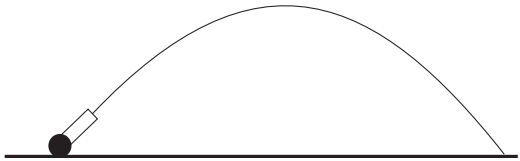


Figure 3: Projectile fired from a cannon

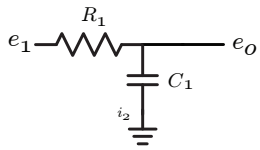


Figure 4: RC Circuit

d) An ecosystem comprising of a population of rabbits and foxes (Figure **??**) where the model is based on the Lotka-Volterra system of equations.

e) A chemical system based on the Brusselator model (Read Wikipedia entry)

Assignment 7

Show whether the following relationships are linear or nonlinear:

a) $y = x^2$

b) $y = \frac{dx}{dt}$

c) $\frac{dy}{dt} = ay + x$

d) $y = mx + b$

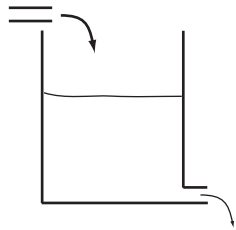


Figure 5: Water Tank Model

Assignment 8

Linearize the following equations:

a) $y = \sqrt{x}$ at $x = 4$

b) $y = \sqrt[3]{x}$ at $x = 8$

c) $y = 2\ln(x)$ at $a = 1$

d) $f(x, y) = y^2 e^{x+y}$

Assignment 9

Investigate the physiology and molecular biology literature and name two other systems where negative feedback is used to achieve some kind of objective.

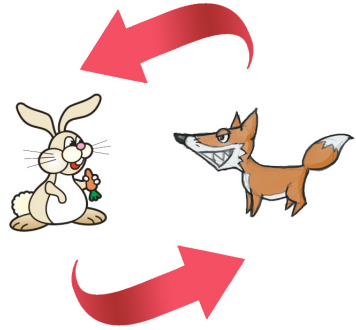


Figure 6: Foxes and Rabbits