

Homework 1

BEE 4750/5750

Due: Sep 15, 2022 by 9:00pm ET

1 Overview

1.1 Learning Objectives

Homework 1 is focused on assessing your ability to:

- derive and implement a descriptive simulations model; and
- to evaluate tradeoffs across multiple objectives.

2 Problems

2.1 Problem 1: Evaluating A Wastewater Treatment Plan

Cheap Plastic Products, Inc. is operating a plant that produces $100\text{m}^3/\text{day}$ of wastewater that is discharged into Pristine Brook. The wastewater contains $1\text{kg}/\text{m}^3$ of YUK, a toxic substance. The US Environmental Protection Agency has imposed an effluent standard on the plant prohibiting discharge of more than $20\text{kg}/\text{day}$ of YUK into Pristine Brook.

Cheap Plastic Products has analyzed two methods for reducing its discharges of YUK. Method 1 is land disposal, which costs $X_1^2/20$ dollars per day, where X_1 is the amount of wastewater disposed of on the land (m^3/day). With this method, 20% of the YUK applied to the land will eventually drain into the stream (*i.e.*, 80% of the YUK is removed by the soil).

Method 2 is a chemical treatment system which costs $\$1.50$ per m^3 of wastewater treated. The chemical treatment has an efficiency of $e = 1 - 0.005X_2$, where X_2 is the quantity of wastewater (m^3/day) treated. For example, if $X_2 = 50\text{m}^3/\text{day}$, then $e = 1 - 0.005(50) = 0.75$, so that 75% of the YUK is removed.

Your assignment is to evaluate treatment programs for the factory using a combination of these methods and direct discharge into Pristine Brook.

2.1.1 Problem 1.1

Draw a diagram of the system to show an overview of the system you are modeling. Include a description and any nomenclature necessary for understanding your summary or diagram in

text below the figure. To include a figure, you can modify the basic network graph provided in `solutions-template.jmd`, or use Markdown to include a figure you generate in another program, with the following syntax:

```
![Alternate Text](path/to/figure/)
```

2.1.2 Problem 1.2

Express the effluent standard as an equation based on the treatment levels X_1 and X_2 .

2.1.3 Problem 1.3

Show the process of formulating a mathematical model for your system, computing the concentration of YUK for a given treatment plan. This is best done with equations supported by some descriptions. To generate a math block (as opposed to inline math mixed with text), use [syntax similar to a Julia block, but with "math" as the language](#).

2.1.4 Problem 1.4

Implement your model as a Julia function which computes the resulting YUK concentration and cost for a particular treatment plan. You can return multiple values from a function with a [tuple](#), as in:

```
function multiple_return_values(x, y)
    return x+y, x*y
end
```

```
a, b = multiple_return_values(2, 5)
println(a)
println(b)
```

```
7
10
```

2.1.5 Problem 1.5

Evaluate your model over a variety of treatment plans by varying X_1 and X_2 . Plot the resulting tradeoffs between YUK concentrations and cost by using the [scatter\(\) function from Plots.jl](#) (make one axis cost, and the other concentrations). What do you notice? You can also add a line to the plot to represent the effluent standard (either [hline!\(\)](#) or [vline\(\)](#), depending on which axis is appropriate...notice the use of the version of the function with an ! at the end of the name to reflect that this function mutates an existing plot object).

2.1.6 Problem 1.6

Based on the plot from Problem 1.5, how would you select a treatment plan? How might this plan reflect the perspectives of various interested parties (factory owners, the public,

regulatory agencies, etc)? Did how you set up your numerical experiment in Problem 1.5 influence your conclusions? Might they have changed with a different experimental design?

2.1.7 Problem 1.7

What do you think should be investigated further to improve your model? What assumptions did the problem or you make that should be kept in mind when interpreting your results?

2.2 References

If you used any external resource in the process of solving this problem, provide a reference below. These could be other people, websites, datasets, or code examples.