CDS-130/004 SPRING 2016: HOMEWORK 8 (version 1)
ASSIGNED 4 APRIL 2016, DUE 11 APRIL 2016 AT THE END OF CLASS

MATLAB PROGRAMMING EXERCISE

THIS IS A MATLAB PROGRAMMING EXERCISE: YOU MUST WRITE MATLAB CODE AND THEN EXECUTE YOUR CODE TO PRODUCE OUTPUT THAT SOLVES THIS PROBLEM. YOU MUST SHOW BOTH YOUR PROGRAM AND YOUR PROGRAM OUTPUT - IN HARDCOPY SCREENSHOT - TO RECEIVE FULL CREDIT FOR THIS EXERCISE. PLEASE NOTE THAT NO HANDWRITTEN MATLAB PROGRAMS, OR HAND-DRAWN DEPICTIONS OF OUTPUT, WILL BE ACCEPTED!

EXERCISE 1 (4 pts)

You open a bank account at the beginning of year 1 with an initial deposit of $7,250. The account pays 1.5% interest per year, and at the end of every year after the first year (that is, beginning at the end of year 2), you withdraw $475 to pay an accumulated credit card balance. What is your bank account balance at the beginning of the 10th year, after making your last $475 withdrawal?

NOTE:

Do not “floor” dollars in this exercise.

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EXERCISE 2 “BACTERIA IN A PETRI DISH” (6 pts)

INTRODUCTION:

Streak-plating of bacteria on an agar-filled petri dish is a common laboratory activity in microbiology. In this exercise we’ll explore unrestricted bacterial generation and the effect of growth inhibitors and promoters.

PROBLEM STATEMENT:

A student has an agar-filled petri dish that is initially streak-scored with 500 “bacteria M” cells at the beginning of hour 1. The generation time for bacteria M is 1 hour: bacteria M’s population doubles in size every 1 hour, i.e., bacteria M’s growth rate is 100%. At the end of hour 9, the agar plate is inadvertently exposed to UV light, which immediately kills 90% of the existing bacteria, and also reduces their growth rate from 100% to 15%. However, at the end of hour 15 the student returns to the lab, discovers the mistake, and adds a small amount of growth promoter to the bacterial colony on the plate. The growth promoter instantly raises the bacteria’s growth rate from 15% to 55%. How many live bacteria exist on the agar plate at the end of hour 20? Provide a plot of the size of the bacteria’s population over time, through the end of hour 20.

NOTE:

Do not “floor” the bacteria in this exercise.

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EXERCISE 3: "WOLF PACK IN YELLOWSTONE NATIONAL PARK" (6 pts)

INTRODUCTION:

Population biologists study animal populations "in the wild" by collecting population data, demographics and variation over time. These data enable them to construct models of target populations, and to study the effect of various beneficial and detrimental events on these populations. In the problem that follows, construct Matlab models of each population scenario using the "compute/correct" method discussed in class to apply necessary population corrections when needed.

PROBLEM STATEMENT:

A wolf pack in Yellowstone National Park numbers 65 total wolves. The pack's natural birth rate is 6.5%; their natural death rate is 3.2%. At the end of every even numbered year after year 1, a deadly bacterial infection strikes the pack and instantly reduces its population by 75%. Luckily, at the end of every odd numbered year after year 1, 22 wolves from neighboring Idaho wander into Yellowstone National Park. Upon arriving, they permanently join the existing Yellowstone pack.

1. How many total wolves comprise the Yellowstone wolf pack at the beginning of year 22? (NOTE: WHOLE WOLVES, NOT FRACTIONAL WOLVES!)
2. Construct a plot of the size of the Yellowstone wolf pack over time (i.e., plot the population vs. time, for years 1—22).
3. What do you notice about the Yellowstone wolf pack's size as a function of time? Is it growing, decaying or doing something else?
4. Reformulate the model so that the deadly bacterial infection strikes the wolf pack only at the end of every sixth year.
5. Construct a second plot of the pack's size vs. time for this new, reformulated model.
6. Compare this second plot with the first plot and discuss the difference(s) between them.

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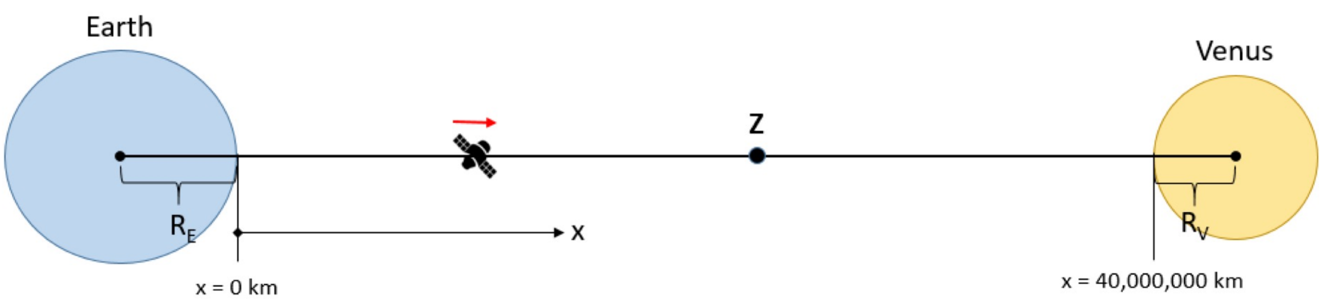
EXERCISE 4: "FLYING TO VENUS" (6 PTS.)

INTRODUCTION:

Venus is approximately 40,000,000 kilometers (km) from Earth at its closest approach. NASA wishes to launch a satellite from the surface of the Earth, as shown in the below diagram, and have it fly toward Venus when Venus is closest to Earth.



A satellite flies between the Earth and Venus, as shown, in the direction of the red arrow. It begins on the Earth's surface, at x = 0, and flies along the line connecting the center of the planets. At some point along the path, labeled $x = Z$ in the above diagram, the gravitational pull on the satellite from Earth exactly balances the gravitational pull on the satellite from Venus. We are interested in the location of $x = Z$, measured in kilometers from the surface of the Earth.

To find Z, we use Newton's Law of Gravitation and write the expression for the forces of gravity exerted on the satellite by the Earth and by Venus. When we write the appropriate force balance, we arrive at the following equation to solve for Z:

$$\frac{M_v}{(R_V + 40000000 - Z)^2} - \frac{M_E}{(R_E + Z)^2} = 0$$

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DATA:

$M_E = 5.972 \times 10^{24}$ kg
$M_V = 4.687 \times 10^{24}$ kg
$R_E = 6371$ km
$R_V = 6052$ km

PROBLEM:

Find the distance Z from the surface of the Earth, where the gravitational pull on the satellite from the Earth is exactly balanced by the gravitational pull on the satellite from Venus.

NOTE:

To solve this problem, construct a FOR loop that increases the value x from 0 to 30,000,000 in steps of 0.5 . Write only the left hand side of the equation inside the FOR loop, and use x instead of Z when writing the left hand side of the equation. Then, use an IF statement (also inside the FOR loop) to test the left hand side of the equation for each value of x that is substituted into it. The idea is to discover the value of x that causes the left hand side of the equation to be less than 500. That value for x, the value that causes the left hand side of the equation to be less than 500, is the value corresponding to the distance Z that you are looking for, and thus, is the solution to this problem.