Math 4600: Homework 1

Due: January 18th

Note: In these and subsequent homeworks, the tag **(computing)** means that the use of MATLAB is expected in this problem. Hand in your written conclusions and printed graphs from MATLAB, and upload your code to Canvas.

1. **(computing)** Go through the MATLAB primer. Try all of the examples for yourself. If you don't understand how any of the results come about, please ask. This exercise will not be graded, this is for your MATLAB training for the rest of the course.

Problems 2-5 refer to the model of periodic arterial pulse, from the class. You are very strongly encouraged to write a short MATLAB code to do graphs in problem 2, and then simply change parameters to do problems 3 and 4. This will allow you to practice MATLAB more, in addition to making your life easier. Define parameters in the beginning of your code, so that you can change their values easier.

Example: Plot $y = ax^b$ for x from 0 to 1, and $a = 2$, $b = 3$.

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MATLAB code:
a=2;
b=3;
xmin=0;
xmax=1;
dx=0.02;
x=[xmin:dx:xmax];
y=a*x.^b;
plot(x,y)
xlabel('x')
ylabel('y')
```

Make sure you understand every line and every dot in this example!

2. **(computing)**(1.19 from HP) Use the following parameter values for the model of the periodic arterial pulse that we considered in class: $R_s = 17.5$ mmHg/(liter/min), $C_{sa} = 0.00175$ liters/mmHg, $\Delta V_0 = 0.07$ liters, $T = (1/80)$ min. Answer the following questions:

   (a) Find the systolic pressure, the diastolic pressure, the pulse pressure (**Definition:** *pulse pressure* is difference between the maximum (systolic) and minimum (diastolic) pressures. In the standard 120/80 situation, the pulse pressure is equal to 40 mmHg).

   (b) Make a graph of the systemic arterial pressure as a function of time, include a few periods of heart beat.

   (c) If a person has all parameters exactly the same as above, except his heart pumps 1.5 times as much blood per beat, what blood pressure would that person have?

3. **(computing)** During exercise, the arterioles in an exercising muscle dilate, and the systemic resistance falls. Let us assume that it falls to half its value.

   (a) First, make an unrealistic assumption that the circulatory system does not compensate for this change, i.e. that all other parameters remain the same. Plot the new time course of systemic arterial pressure. What would happen to the systolic, diastolic and pulse pressure?

   (b) In reality, the fall in systemic resistance is compensated in multiple ways, most noticeably by the increase of heart rate, i.e. by decrease in T. Assume that T changes proportionally to R_s. Plot the new time course of systemic arterial pressure. What are the changes in the systolic, diastolic and pulse pressure?

4. **(computing)** Suppose there is a patient, whose heart does not respond properly to exercise, and the heart rate remains constant.

(a) The average value of a periodic function can be found by averaging over one period. Find a formula for average P_{sa} as a function of R_s, ΔV_0, and T. Suppose that the patient performs exercise (i.e. R_s falls). Using the formula you just found, how much does the stroke volume need to change to compensate for the fall in R_s to keep the mean pressure unchanged?

(b) If during exercise the stroke volume changes enough to keep the mean pressure unchanged, with these new parameter values plot the new time course of systemic arterial pressure. What are the changes in the systolic, diastolic and pulse pressure?

5. **(computing)** Suppose that the stroke volume and the heartbeat period randomly change from beat to beat by as much as 20%. Plot the resulting pulse time course for the first four beats and dexcribe how the pulse characteristics change between the shorter and the longer beats.