Name: ____________________________________

EXAM 1 - BIOE 391
Take Home – 2022

This portion of the exam is **open book/open notes**. Any other resources used must be acknowledged. Please **READ ALL INSTRUCTIONS**, manage your time effectively and answer the questions concisely but completely. Submit a zip file with all your documents. The recommended time investment in this take-home exam should be of no more than **5 hours**, although you are allowed to use more.

On my honor, I have neither given nor received any unauthorized aid on this exam.

Signature: ________________________

Read Carefully!

Please comment your code as much as possible. This will help us to grade and give YOU partial credit.

Problem 1 (24pt) You are hired as a consultant by a pharmaceutical company to investigate the clearance of a Mysterious New Drug (MND) by human liver. Your team has assumed that the steady-state degradation/clearance rate V obeys the following kinetic equation:

$$V = \frac{V_{max} m}{K + m + \dfrac{m^2}{K_0}} \qquad \text{[Eq.1]}$$

where m denotes the concentration of MND, V_{max} = 1.25/hr is the maximum degradation rate, K=1 μM is the Michaelis-Menten constant characterizing the saturation of the liver enzymes, and K_0 is a patient-specific substrate-inhibition constant characterizing the cytotoxicity of the drug to liver cells. Your goal is to develop a patient-specific treatment protocol that maximizes the drug clearance rate and investigate its dependence on various parameters.

a) Your task is to develop a MATLAB code that uses Eq.1 with input K_0 as a parameter to compute the value of $m=m^*$ corresponding to the maximum value of V and obtain $V^*=V(m^*)$, and outputs [m*, V*]. [**Hint**: use fminsearch MATLAB command]

b) Use your code to plot m*(K_0) for K_0 values of 10 to 150 μM.

c) Find the value of K_0 corresponding to V*= 1.0/hr using MATLAB fzero command.

Problem 2 (24pt) Develop a MATLAB code that computes the shear strain du/dx of blood flow for user-defined function u(x). The .m file should consider the function u(x), point x_0, initial step-size h (optional argument, default value = abs(x_0)/10 if abs(x_0)>0), desired accuracy ε_a (optional, default value 0.0001), and return a value of du/dx at x_0 with the following algorithm:

i. Use central divided difference (CDD) with h to compute the derivative du/dx;
ii. Replace h by h/2, recompute the derivative, compute the approximate relative error. If the error is below ε_a, stop, otherwise continue to halve the step-size until the specified tolerance is reached or the maximal number of iterations (50) is reached.

a) Test your code by computing the shear strain du/dx with

$$u(x) = x^2 \exp(-0.1x) \qquad \text{[Eq.2]}$$

for x = x_0 = 0:1:15 and compare the results with the true values computed analytically. Plot your results (both true relative error and du/dx) for each value of x_0.

b) With u(x) given in [Eq. 2], use MATLAB fzero command to find a value of x at which the shear strain du/dx equals zero.

c) Show how you can use the fminbnd command to find the maximum value of u(x) and compare the results with those in parts a) and b).