INDIAN INSTITUTE OF TECHNOLOGY MADRAS
Department of Chemical Engineering

CH 2082
Assignment 3 (20/03/2014)

1. Attempt all problems on your own.
2. You may discuss with the TAs for assistance.
3. All variables should be declared or initialized within your program
4. **Comment all your files**
5. Name each program using the following convention using a combination of your roll number, assignment number and question number. i.e., if your roll number is CH12B001, name the program in the first question of the first assignment as follows:
CH12B001_A1_Q1.m
6. Submit a single zipped folder containing .m files for each of the questions and a single pdf file that is published. The zip file should be named as follows: if your roll number is CH12B001, then the zip file name would be CH12B001_A1

Note: All submissions are to be made by 5pm on the same day.

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1. The rate of an enzymatic reaction is given by the following expression:

$$r = \frac{k[S]}{K_m + [S]}$$

The problem of estimating k and k_m can be converted to linear regression by inverting the above expression and defining:

$$x = \frac{1}{[S]}, \qquad y = \frac{1}{r}$$

The following data was obtained in the lab:

$[S]$	1.233	0.540	0.442	0.258	0.198	0.162	0.130	0.128
r	5.970	3.319	2.253	2.547	1.493	1.182	1.095	0.869

1. Obtain $y = a_0 + a_1x$ and hence find the values of k and k_m
2. Now, take x as the dependent variable and obtain $x = b_0 + b_1y$ and hence find the values of k and k_m
3. Compare the two values and explain your results.

2. Consider the following two equations in two unknowns

$$x^2 - xy = 4$$
$$y^3 + y\sqrt{x} = -12$$

Use [x y]' = [1 1]' as the starting point. Use fsolve to solve.

3. The friction factor f depends on the Reynolds number for turbulent flow in a smooth pipe according to the following relationship:

$$\frac{1}{\sqrt{f}} = -0.4 + \sqrt{3}\ln\left(\mathrm{Re}\sqrt{f}\right)$$

The above equation may be rearranged to be written in the standard forms:
f = G(f) or F(f) = 0

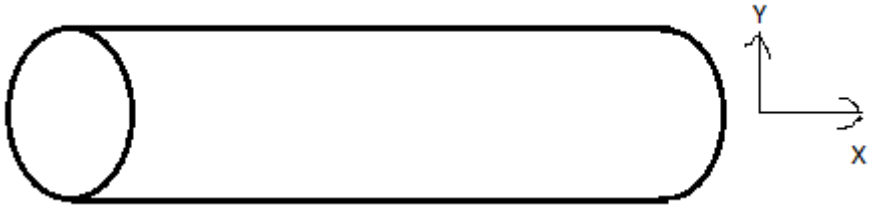
With $f^{initial}$ = 0.01, find the friction factor for Re = 10^5 as follows:

1. Use an iterative procedure
2. Use the Matlab subroutine fsolve
3. Repeat step 3 (i.e., solving using fsolve) for 10 different values of Reynolds number starting from 4000 to 10^6. Plot friction factor vs. Reynolds number on a log-log scale.

4. Consider a liquid flowing through a 20 cm long cylindrical pipe of diameter 5cm. Obtain the steady state fully developed flow profile for the liquid. The pressure drop across the tube is 100 mPa. (μ = 0.001 kg/m.s)

You may derive the necessary expressions from Navier Stokes momentum balance equation.

1. Calculate the maximum velocity
2. Plot the velocity profile of the liquid.



$$\rho\left(\frac{\partial v_z}{\partial t} + v_r\frac{\partial v_z}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta} + v_z\frac{\partial v_z}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2} + \frac{\partial^2 v_z}{\partial z^2}\right] + \rho g_z$$