King Saud University
College of Engineering
Chemical Engineering Department

CHE401: Final Exam **Time = 2 hrs**

Q1: The friction factor f for a turbulent flow of an incompressible fluid in a pipe is given by the following equation:

$$\sqrt{\frac{1}{f}} = -0.86 \ln\left(\frac{\varepsilon / D}{3.7} + \frac{2.51}{N_r \sqrt{f}}\right)$$

If the roughness ratio $\varepsilon/D = 1\text{x}10^{-4}$ and the Reynold number $N_r = 1\text{x}10^{5}$, find the friction factor value using the Bisection method. Take the solution to be in the interval [0.01, 0.03] and the termination criterion to be $|b - a| \le 0.005$. Show all calculations and **Tabulate your results**.

Q2: Acetone reaction takes place in a plug flow reactor and the percentage conversion is given by the following equation:

$$\frac{dX}{dV} = \frac{k}{v}\frac{1-X}{1+X}\frac{T_0}{T}$$

$$k = 3.58 \exp\left[34222\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]$$

Let the molar flow rate, v be 0.2 m^3/sec, the inlet temperature T_0 be 1035K and the reactor temperature T be 1050K. Using Euler explicit method, find the conversion when the reactor volume is 0.3 and 0.5 m^3. Show all calculation and **Tabulate your result**.

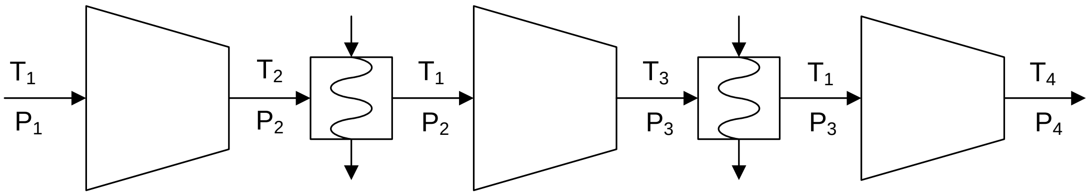
Q3: Show three steps of the Golden search method towards finding the optimum solution of the following function:

$$\min_{x} f(x) = \frac{x^3}{10} - 1400x \,; \qquad x \in [63, 255]$$

Show all calculations and **Tabulate your results**.

Q4: The work of adiabatic compression shown in Figure below is given by the following equation:

$$W = \frac{RT}{n}\left[\left(\frac{P_2}{P_1}\right)^n + \left(\frac{P_3}{P_2}\right)^n + \left(\frac{P_4}{P_3}\right)^n - 3\right]$$



(a) Assume R, T, n, P_1 and P_4 are constant. Using analytical (derivative) method, find the value of P_2 and P_3 that gives minimum work, W.

(b) Prove that the optimum values obtained in (a) is indeed a minimum by showing that the *determinant* of the Hessian is positive.