ME 6280: Design and Optimization of Energy Systems

Assignment I - March 2nd 2015

(1) The operating point of a centrifugal pump is to be determined. The pump performance curve and the system load characteristics are given as follows.

Pump: $\Delta P = 240 \times 10^3 - 43.8 \times 10^2 Q^2$
Load: $\Delta P = 40 \times 10^3 + 156.2 \times 10^3 Q^{1.8}$

Where ΔP is the static pressure rise in Pa and Q is the discharge in m^3/s.

(1) Using the successive substitution method for 2 unknowns, determine the operating point of the pump.

Start with an initial guess value of $Q = 0.4\ m^3/s$.
Decide on your own stopping criterion.

(2) At the operating point, if the pump efficiency is known to be 86%, what is the electrical power required for the pump?

(2) Solve problem #1, using the Newton-Raphson method for 2 unknowns. Decide on your own stopping criterion.

(3) An engineer requires 4800, 5810 and 5690 m^3 of sand, fine gravel and coarse gravel respectively for a building project. There are three pits from where these materials can be sourced. The composition of these pits is

	Sand, %	Fine gravel, %	Coarse gravel %
Pit 1	52	30	18
Pit 2	20	50	30
Pit 2	25	20	55

Determine how many m^3 must be hauled from each pit in order to meet the engineer's needs, using the Gauss Seidel method. For uniformity you may denote the quantity hauled from Pits 1, 2 and 3 as x, y and z. Start with an initial guess value of $x=y=z=2000\ m^3$. ***Perform at least 8 iterations*** and report the sum of the squares of the residues of the three variables at the end of very iteration. **Show the entire process on a Tabular column.**

(4) The thermal diffusivity of water in m^2/s varies with temperature (T) as shown in the Table given below

T, K	Thermal diffusivity, m^2/S
300	22.5×10^{-6}
350	29.9×10^{-6}
400	38.3×10^{-6}
450	47.2×10^{-6}

(a)Using ***Newton's divided difference method*** appropriate for 4 data points derive an exact fit to the thermal diffusivity as a function of temperature.

(b) Using the above fit, estimate the *diffusivity* at 382 K.

(c)Compare the result obtained in (b) with a ***quadratic interpolation***

(5) Using the data provided in Problem #4, evaluate the thermal diffusivity of water at 416 K by using a second order Lagrange polynomial and compare the result with that obtained from linear interpolation.