# Final Projects
# ChE 231
# Spring 2019

## Group and Report Requirements

Each group must complete one of the three projects listed below. Students must form four person groups. No larger groups will be allowed. Contact Professor Henson if you are having trouble finding a group.

Each group must submit a written report (hard copy) on the due date listed in the course schedule. The reports should be prepared in 12 point Times font with double spacing. The required report format is described below along with the suggested length of and points allocated to each section.

- Title page: title of project, list of group members, date (1 page, 5 points)
- Abstract: summary of problem addressed and results obtained (1 page, 15 points)
- Introduction: review of the relevant background and motivation for the proposed study (2 pages, 15 points)
- Methods technical description of the problem and the mathematical methods used for solution (3 pages, 15 points)
- Results and Discussion: presentation and description of representative results (5 pages, 25 points)
- Conclusions: summary of key results and suggested future work on the problem (1 page, 10 points)
- References: consistently formatted set of 5+ references cited in the main text of the report (1 page, 5 points)
- Appendix: copies of all Matlab codes along with any important results not included in the Results section (5 pages, 10 points)

## Project Topics

1. *Statistics Problem*: Consider the dataset collected for a chemical reactor that is posted as an Excel file on the course website. The first tab contains data for the results of a series of experiments in which five inputs ($u_1$ – feed flow rate, $u_2$ – catalyst concentration, $u_3$ – agitation rate, $u_4$ – reactor temperature, $u_5$ – reactant concentration) were varied according to a full factorial design with two levels. The reactant conversion ($y$) was measured for

each experiment. Perform statistical analyses of these data including the development of regression models.

2. *Nonlinear Algebraic System Problem*: Consider the pH neutralization system model described in the following paper posted on the course website: M. A. Henson, M. A. and D. E. Seborg, "Adaptive Input-Output Linearization of a pH Neutralization Process, *Int. J. Adapt. Control Signal Process.*, **11**, 171–200 (1997). Develop a MATLAB code for simultaneous solution of the nonlinear algebraic equations (9) and (10) with the steady-state versions of equations (11) and (12) using the parameter values in Table 1. Generate steady-state solutions for a range of volumetric flow rates $q_1$, $q_2$ and $q_3$. Plot the dependence of the pH on these flow rates and explain your results.

3. *Differential Equation System Problem*: Consider the fluidized bed chemical reactor model described in the following paper posted on the course website: Kurtz, M. J. and M. A. Henson, "State and Disturbance Estimation for Nonlinear Systems Affine in the Unmeasured Variables," *Computers and Chemical Engineering*, **22**, 1441–1459 (1998). Develop a MATLAB code for solution of the dimensionless nonlinear differential equations (5) with the parameter values in Table 1 and initial conditions in Table 2. Generate dynamic solutions for several combinations of the inlet benzene mole fraction $y_{bz0}$ and coolant flow rare $F_c$. Discuss the effects of $y_{bz0}$ and $F_c$ on the dynamic responses and the resulting steady states.