***Workshop 1 - MATLAB Lesson Plan for ECH 4605: Product & Process Systems Engineering***

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| ***Lesson Context*** | |
| ***Description of Instructional Setting*** | Whole-class lecture and discussion  Small group tutorial completion |
| ***Learner Objective(s)*** | Using MATLAB, students will be able to:   1. Create and utilize *function* files 2. Solve sets of multivariate, non-linear equations using **fsolve** 3. Evaluate and plot time-dependent differential equations using ODE solvers 4. Optimize constrained and unconstrained multivariate problems 5. Perform linear and nonlinear regression |

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| ***Summary of Lesson*** | |
| ***Lesson Summary*** | Introduce students to the course and go over workshop-related sections of the syllabus. Assign homework groups for the semester. Re-introduce students to MATLAB syntax, loops, and numerical solutions for engineering problems. Students will complete eleven (11) example problems in small groups. Group work will be turned in to the corresponding submission box in Canvas. |
| ***Rationale and***  ***Relevance*** | Students will use knowledge gained from this tutorial to complete assignments in this course and their other courses. Learning MATLAB will also prepare them for solving more complex problems which may arise in their careers. |

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| ***Planning for Addressing All Students’ Needs*** | |
| ***Differentiated Instruction*** | Students will be engaged during the workshop with whole-class topic discussions. Small (three-person) homework groups will ensure all students are working through example problems.  Students who complete the eleven (11) example problems will have the option to work on a GUI-related example problem. |

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| ***InstructionalProcedures/Practices*** | | | |
| *Activity* | *Description* | *Materials* | *Time* |
| ***Focus/Introduction*** | Welcome students to the class.   * Go over parts of the syllabus which relate to the workshops (e.g., cell phone policy, office hours, grading scale, late penalty, Canvas submissions) * Introduce students to the Canvas course setup (modules, assignments)   Have students form groups of three and sit together. Assign a number to each group. Open up self sign-up in Canvas:   * People * Homework * Edit (gear box) * Allow self sign-up   Close self sign-up.  Take first-day attendance. | Attendance Sheet  Syllabus  Computer  Projector | 7-10 min |
| ***Presenting the Content/Providing Instruction*** | Poll students to see who taught them for Numerical Methods and if they remember using MATLAB.  Re-introduce students to working with iteration (FOR, WHILE loops) and vector algebra (associative & commutative rules of addition; associative rule of multiplication). Explain the difference between scalars, vectors, and matrices/arrays.  Describe the difference between \* and .\* in MATLAB (matrix multiplication vs. pair-wise element multiplication)  Show how to convert a set of first-order multivariate equations into matrix form and solve using matrix inversion: | Whiteboard  Dry-erase Markers | 17-20 min |
| ***Assessment*** | What does the determinant of a square matrix tell you? (Matrix is invertible if, and only if, determinant is non-zero.) |  | 1-2 min |
| ***Transition*** | Have students open up MATLAB on their computers. Load MATLAB on the instructor computer. Access the corresponding workshop in Canvas.  If students are familiar with MATLAB, the introductory material (APPENDA.docx) may be skimmed over. | Computer  Projector  MATLAB | 1-2 min |
| ***Providing Practice/Scaffolding*** | **Small-group:**  Have students begin working through the first three examples (APPB13-1.docx).  **Whole class:**  After a few minutes of small group work, ask students how far they have gotten. Begin working through the example problems, explaining important steps or new features as you go (e.g., function files, optimset, vector indices [x1, x2]).  Discuss Example 3 and how it pertains to reaction engineering. | Computer  Projector  MATLAB | 20-23 min |
| ***Providing Practice*** | **Small-group:**  Allow students to start working on the second example set (APPB47-2.docx).  **Whole class:**  Make sure students pay special attention to the apostrophe at the ends of certain lines. The apostrophe takes the transpose of a vector or matrix; **fsolve** requires its inputs to be column vectors (as opposed to row vectors).  Discuss the difference between bound and unbound optimization (in terms of computing power and as a numerical method).  Explain that MATLAB optimization solvers only find minimum points. Thus, it is necessary to multiply through by (-1) in order to solve a maximization problem. | Computer  Projector  MATLAB | 23-25 min |
| ***Assessment*** | What does it mean for a variable to be “global” or have “global scope”?  (Usually, function variables are declared locally, meaning that the function will only see and be able to manipulate variables created within that function. Thus, a variable *length* in the MATLAB workspace will not change even if a function declares a variable called *length* and sets it to some arbitrary value. The new *length* variable is local to the function and will stop existing when the function finishes evaluating.  By declaring variables as **global** in both the workspace (or m-file) AND the function file, it forces the function to manipulate the same **variable object** [which, in computing terms, actually refers to the physical space in memory].) |  | 3-5 min |
| ***Providing Practice*** | **Small-group:**  Have students complete the third set of tutorial examples on linear and non-linear regression.  **Whole group:**  Note 1: there may be some syntax errors in the third example file (APPB11-3.docx) with the global declaration. Your global variables should be:  lnk  lnkcal  oneoverTe  Note 2: the variable “TeinF” for each example has an apostrophe at the end in order to convert it to a column vector. |  | 32-35 min |
| ***Assessment/Evaluation of understanding of objectives*** | Change the line colors of CA, CB, and CC in Example 3 to three colors of your choice (different from their original colors).  Change the plot title of Example 7 to:  *LastNameA, LastNameB, LastName C - Example 7*  Change the color and shape of the marker for lnk from Example 11.  Save the plots from examples 3, 7, and 11 as JPEG files:  *LastNameA\_W1\_Ex3\_F14.jpg*  *LastNameB\_W1\_Ex7\_F14.jpg*  *LastNameC\_W1\_Ex11\_F14.jpg*  Students will submit their MATLAB m-files in a ZIP folder named:  *LastNameA, LastNameB, LastNameC W1\_MATLAB\_F14.zip*  Submit all four (4) files to the corresponding Canvas link. The JPEG files will serve as a basis for grading. |  | 8-10 min |
| ***Lesson Extenders*** | If students are ahead of schedule or if time permits at the end of the lesson, students will begin working on the simple GUI tutorial (GUI\_tut.pdf).  Submit this file along with the other four files to Canvas. This example may be used to give credit if something is missing from another part of the workshop files or as extra credit (if permitted). | Computer  MATLAB | 18-25 min |
| ***Behavior Management*** | Students are responsible for knowing the contents of the syllabus. Pop-quizzes may be given if attendance is inadequate or a cell phone disturbs the recitation.  Potential quiz topics:   1. Calculate the (heat transfer area; inlet/outlet temperature of stream *N*; heat flow rate) of a counter-current heat exchanger given enough design parameters. 2. Find the inverse of a given 3x3 matrix (e.g., [1 2 3; 4 5 6; 7 8 8]) without MATLAB. 3. Write the general mass balance for a two-dimensional, rectangular control volume with reaction at non-steady state. | Paper  Pencil | 5-7 min |

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| ***Reflection*** |
| **⮚ What did you like or enjoy? What seemed to go well?**  **⮚ Good things I did that helped the students and showed good responses from the students**  **⮚ If you were to do this lesson again what changes would you make? Are there other ways you could do it, or something you would like to try? (Please add your reasoning for these ideas)**  **⮚What are the most valuable things you learned? In what ways did the students not respond as you hoped? What goals would you like to set for yourself for the next time you are working with these or other students?**  **⮚ What questions do you have? What caught your curiosity? What more knowledge/background would you like?**  **⮚ What do you feel were the most positive and valuable aspects of the lesson?** |