A GUIDE FOR TEACHING MATLAB FOR ENGINEERS (ME 1311) AND ENGINEERING COMPUTATION USING MATLAB (MET 2501)

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KENNESAW STATE UNIVERSITY

HISTORY

Introduction of the Course:

- **Engineering Computation using MATLAB** was first introduced by Simin Nasseri in the MET department in 2008, as a major elective for juniors/seniors.
- The course was well received by students. Many students were able to use MATLAB in other courses and after graduation.
- The course soon became a required course for sophomore/junior students (First MET 3501 and then MET 2501), in place of C++ course, because students were not able to easily use C++. Furthermore, MATLAB language is user-friendly, applied and more suitable for undergraduate students.
- Simin Nasseri offered the course for the ME department in Spring 2015. The course is allocated mainly for sophomore students (**MATLAB for Engineers with Application,** ME 1311).

COURSE DESCRIPTION

ME 1311 - MATLAB for Engineers with Applications

- This course will provide an introduction to fundamental computing principles and programming concepts. Students will use the high-level programming language, MATLAB to develop and implement programs to solve engineering problems. Basic programming concepts covered include: algorithm design, data types, flow control, functions, sorting, plotting, simulation, and numerical methods.

Please check the latest prerequisite allocated for each course.

COURSE DESCRIPTION

MET 2501:Engineering Computation using MATLAB

- This course provides an introduction to computation in the context of engineering problem solving. In this course, the fundamental tenets of computer programming will be placed into the context of MATLAB, a user-friendly language for engineers. It employs hands on exercises, examples from the world of engineering, and a variety core tools to increase general proficiency and capability in the computer programming, preparing students to fluidly adapt learned programming concepts to other languages. After teaching the linear, algebra, an introduction to computer programming with MATLAB, including flow charts, loops, condition statements, and functions, is given. Basic numerical methods, including numerical integration, differentiation, and root finding are also covered. Emphasis is placed on using MATLAB to solve engineering problems, and using user-defined functions and toolboxes within MATLAB to create computer programs and GUI's.

COURSE OUTCOMES

For both courses:

By the end of this course, students will be able to:

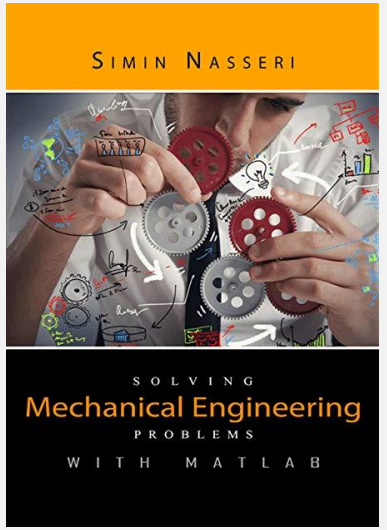
- Introduce vectors and matrices in MATLAB,
- Apply basic concepts of Linear Algebra for vector and matrix operations,
- Perform 2D and 3D plotting,
- Formulate and solve systems of linear equations by Gaussian elimination, and matrix inversion,
- Write conditional statements and loops,
- Write scripts and functions in MATLAB,
- Solve some engineering problems using MATLAB,
- Apply the fundamental knowledge of mathematics, science & engineering, to solve the real mechanical engineering problems (through case studies).

COURSE CONTENT:

Topic coverage:

- MATLAB environment and important commands
- Linear Algebra and matrix operations
- Fundamental engineering computing and statistics
- Save, load, display and fprintf and other similar commands
- Communication with Excel
- 2D (normal, logarithmic and subplots) and 3D plotting
- Solutions to systems of linear equations
- Conditional statements (if statements, also any, all, find and other commands)
- Loops (for and while loops)
- MATLAB scripts and functions
- Polynomials, including numerical and symbolic differentiation and integration (trapz, quadl, integral, int, diff and other commands)
- Using MATLAB for simple and complicated engineering problems (applying Matlab to solve problems related to mechanical engineering problems; thermal/fluid and solid mechanics).

COURSE TEXT (REQUIRED):



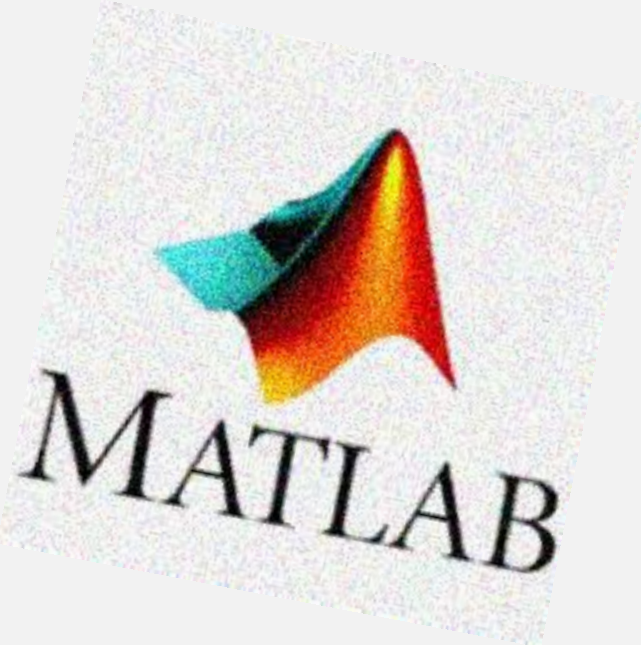
Solving Mechanical Engineering Problems with MATLAB" written by Simin Nasseri, Linus Learning Publications *(click to see the website)*

- The textbook was first published in 2015 and the revised edition was sent out in 2016.
- The textbook **was specifically written for the course** to ensure that all outcomes would be achieved.
- Initially, the textbook was optional for students to purchase, however, through a careful review and also a survey, it was noted that students earned much higher grades when they had purchased a textbook. Hence, professors are advised to encourage the students to purchase the textbook (even directly from the publisher).
- Second edition of the textbook is gradually being prepared, which incorporates the new MATLAB commands.
- For KSU bookstore inventory purposes, Faculty members are required to make sure that this textbook is selected for their course before each semester starts.

COURSE SOFTWARE (REQUIRED):

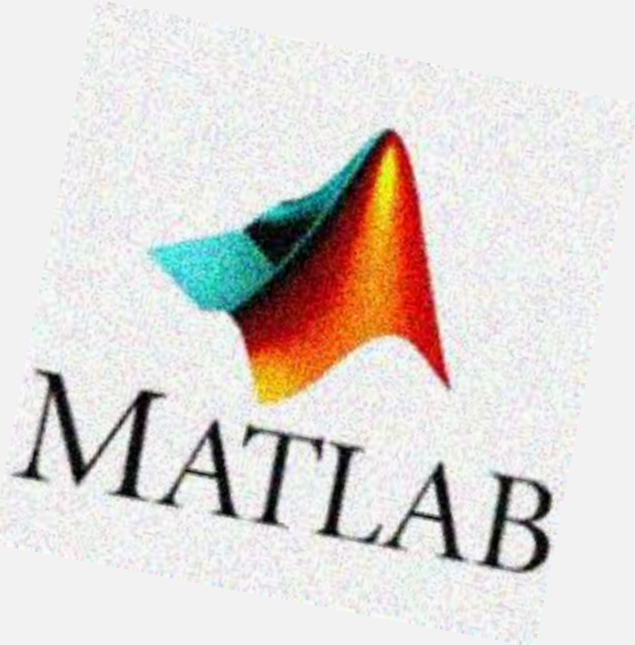
Instructions for Accessing and Downloading MATLAB at KSU

1. Go to apps.kennesaw.edu
2. Sign--in with your KSU NetID and NetID password
3. Click **KSU Software Downloads** under *Public Applications*.
4. Click **View Files** next to *MATLAB Account Activation*
5. Copy the 25--digit **Activation Key** under *Description*.
6. Create a MathWorks Account using your KSU email address here:
   - *mathworks.com/accesslogin/createProfile.do.*
7. Go to the License Center: *mathworks.com/licensecenter*.
8. Click **Associate License** in the upper right hand corner.
9. When prompted to do so, paste the **Activation Key** copied from Step 5.



MATLAB is installed on all computers in the labs.

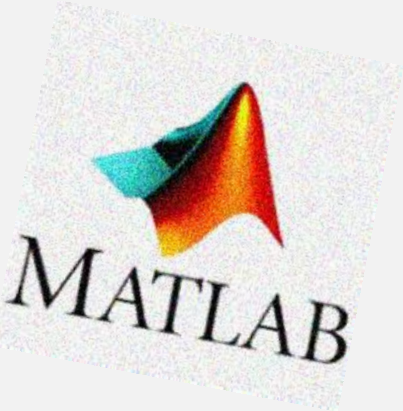
COURSE SOFTWARE (REQUIRED):



Instructions for Accessing and Downloading MATLAB at KSU

10. Go to: *mathworks.com/downloads/web_downloads/select_release*.
11. Click the **Download** button for the current release.
12. Click the **Installer** button to download the installer.
13. Locate the install file in a file browser.
14. Start the installer:
    - **Windows**: Double--click the installer file you downloaded in the previous step. The Windows Self-- Extractor runs, and then the installer starts.
    - **Mac OS X**: Double--click the installer file you downloaded in the previous step. This action extracts the files and creates another folder called **matlab_<release>_maci64**, where <release> represents the release number. Inside this folder, double--click **InstallForMacOSX** to start the installer.

COURSE SOFTWARE (REQUIRED):



Instructions for Accessing and Downloading MATLAB at KSU

15. In the MathWorks installer, select **Log in with a MathWorks Account** and follow the online instructions.
16. When prompted to do so, select the license you want to use.
17. Select the products you want to download and install.
18. After downloading and installing your products, keep the **Activate MATLAB** checkbox selected and click **Next**.

- For additional help or installation issues, please contact:

KSU Service Desk for Faculty & Staff, 470--578--6999, service@kennesaw.edu

Website: http://uits.kennesaw.edu/faculty--staff/

KSU Student Help Desk, 470--578--3555, studenthelpdesk@kennesaw.edu

Website: http://uits.kennesaw.edu/

CLASSROOM CAPACITY:

In Q building:

- MET computer labs (Q 218, Q 219 and Q 222) hold maximum 20 students each, whereas there are 23 computer stations for students in Q 303 computer lab. However, more students can be added, provided that they use their own laptops (Max 25 students).
- Professors can allow the maximum number of students as mentioned above. However, students should be advised that if they use their own laptops, there are some limitations, such as not being able to use the classroom printer directly. They should use the ksuprint:
  - https://ksuprint.kennesaw.edu/MyPrintCenter/
- For many assessments, students need to have money on their cards to be able to print in computer labs.

COMPONENTS/ASSESSMENTS

KENNESAW STATE
UNIVERSITY

COURSE GRADE DETERMINATION:

The Original Grade Policy:

- There are many assessments to ensure that all the outcomes in this course are achieved.
- Professors are advised to follow the suggested assessments and their formats.
- There are **lab assignments** (in-class assignments or quizzes), **tests** and **case study** or project (which includes the presentation).
- Faculty members can allocate some **online quizzes**, specially for the linear algebra section (Chapters 2 and 3).
- **Case studies are considered rather than final exams**. The main emphasis of the course is on gaining practical skills and to be able to solve Mechanical engineering problems.
- Students should be advised not to miss any lab sessions. Attendance is mandatory and points should be taken off for unexcused absence.

COURSE GRADE DETERMINATION:

A Typical Grading Policy:

Attendance	5%
Lab assignments	30%
Tests	40%
Case Study	25%
Total	100%

COURSE GRADE DETERMINATION:

Tentative Assessment Schedule:

Lab Assignment /Quiz/Test	Chapters of the book
Online Quiz 1	Chapters 1 and 2
Lab 1	Chapter 2
Online Quiz 2	Chapters 2 and 3
Lab 2	Chapter 4
Test 1	Chapters 2, 3 and 4
Lab 3	Chapter 5 (and previous ones)
Lab 4 (Homework assignment)	Chapters 5, and 7 (and previous ones)
Test 2	Chapters 2 to 7 (mainly 5 and 7)
Case study (Instead of final exam)	All
Test 3	Chapters 9 and 10

LAB ASSIGNMENT EXAMPLES:

Some of the Questions from Chapter 2 for Lab 1 or Test 1:

- Introduce these vectors, using the colon operator:

H= [1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16]

L = [15 12 9 6 3 0 -3 -6 -9 -12 -15]

- List all the odd elements of the vector H and store them in a vector H1.

- Change the third element of vector *b* to 7 (you should not type the whole vector again).

LAB ASSIGNMENT/TEST EXAMPLES:

A Question from Chapter 4 for Lab 2:

3- For all the x and y values between *0* and *10* (with the increment of *0.5*) perform the following operations:

a. $$z = \frac{\left(9 + 5y - x^2\right) e^{\sin(x)}}{\left(\sqrt{x} + y + 1\right)}$$

b. Type *clf* to clear the last figure or create a new one.
c. Plot the surface of *z*.
d. Choose your name as the title of the figure *(e.g.: Taylor Smith)*
e. Copy and paste this Fig. into the Word document you have (you will have 4 figures altogether). Add the related MATLAB commands/statements. Resize/crop the figures, so the figures would be placed on just 2 pages.
f. Save the file as *yourname-lab2.doc* and print it out (make sure to write down your name on the assignment sheet that you submit).

LAB ASSIGNMENT/TEST EXAMPLES:

A Test 2 Question:

- Select any problem related to Math, Physics, Solid Mechanics, Thermal/Fluid Science, etc.
- Some students have not even taken Statics, however, they can still work on problems related to Engineering Mechanics and others that they have taken in their Physics classes.
- For test 2, they need to write a **MATLAB Function**, preferably for an engineering problem. Otherwise, it can be related to anything that is practical and useful.

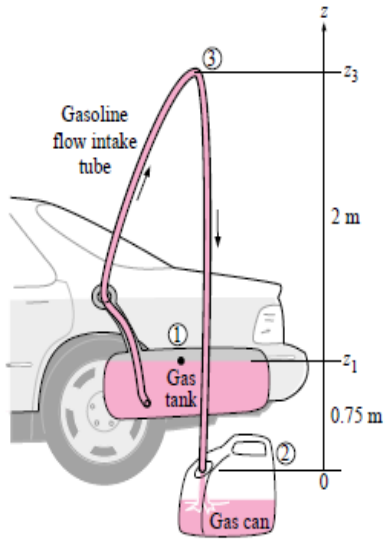


FIGURE 12–26
Schematic for Example 12–5.

EXAMPLE 12–5 **Siphoning out Gasoline from a Fuel Tank**

During a trip to the beach (P_{atm} = 1 atm = 101.3 kPa), a car runs out of gasoline, and it becomes necessary to siphon gas out of the car of a good Samaritan (Fig. 12–26). The siphon is a small-diameter hose, and to start the siphon it is necessary to insert one siphon end in the full gas tank, fill the hose with gasoline via suction, and then place the other end in a gas can below the level of the gas tank. The difference in pressure between point 1 (at the free surface of the gasoline in the tank) and point 2 (at the outlet of the tube) will cause the liquid to flow from the higher to the lower elevation. Point 2 is located 0.75 m below point 1 in this case, and point 3 is located 2 m above point 1. The siphon diameter is 4 mm, and frictional losses in the siphon are to be disregarded. Determine (*a*) the minimum time to withdraw 4 L of gasoline from the tank to the can and (*b*) the pressure at point 3. The density of gasoline is 750 kg/m³.

SOLUTION Gasoline is to be siphoned from a tank. The time it takes to withdraw 4 L of gasoline and the pressure at the highest point in the system are to be determined.

Assumptions **1** The flow is steady and incompressible. **2** Even though the Bernoulli equation is not valid through the pipe because of frictional losses, we employ the Bernoulli equation anyway in order to obtain a *best-case estimate*. **3** The change in the gasoline surface level inside the tank is negligible compared to elevations z_1 and z_2 during the siphoning period.

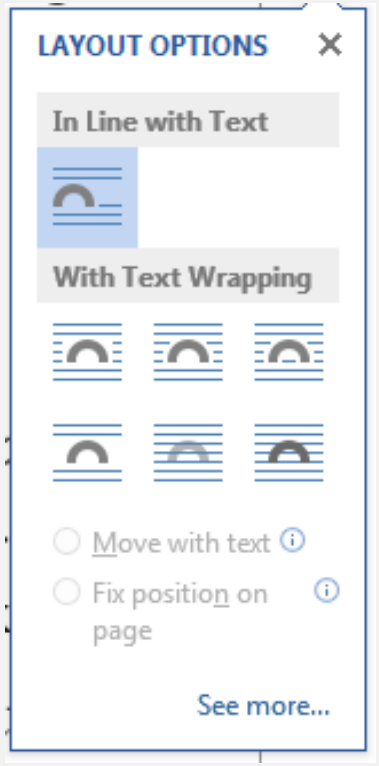
Properties The density of gasoline is given to be 750 kg/m³.

Analysis (*a*) We take point 1 to be at the free surface of gasoline in the tank so that $P_1 = P_{atm}$ (open to the atmosphere), $\mathcal{V}_1 \cong 0$ (the tank is large relative to the tube diameter), and $z_2 = 0$ (point 2 is taken as the reference level). Also, $P_2 = P_{atm}$ (gasoline discharges into the atmosphere). Then the Bernoulli equation simplifies to

TEACHING MS WORD©

What Students Need to Know:

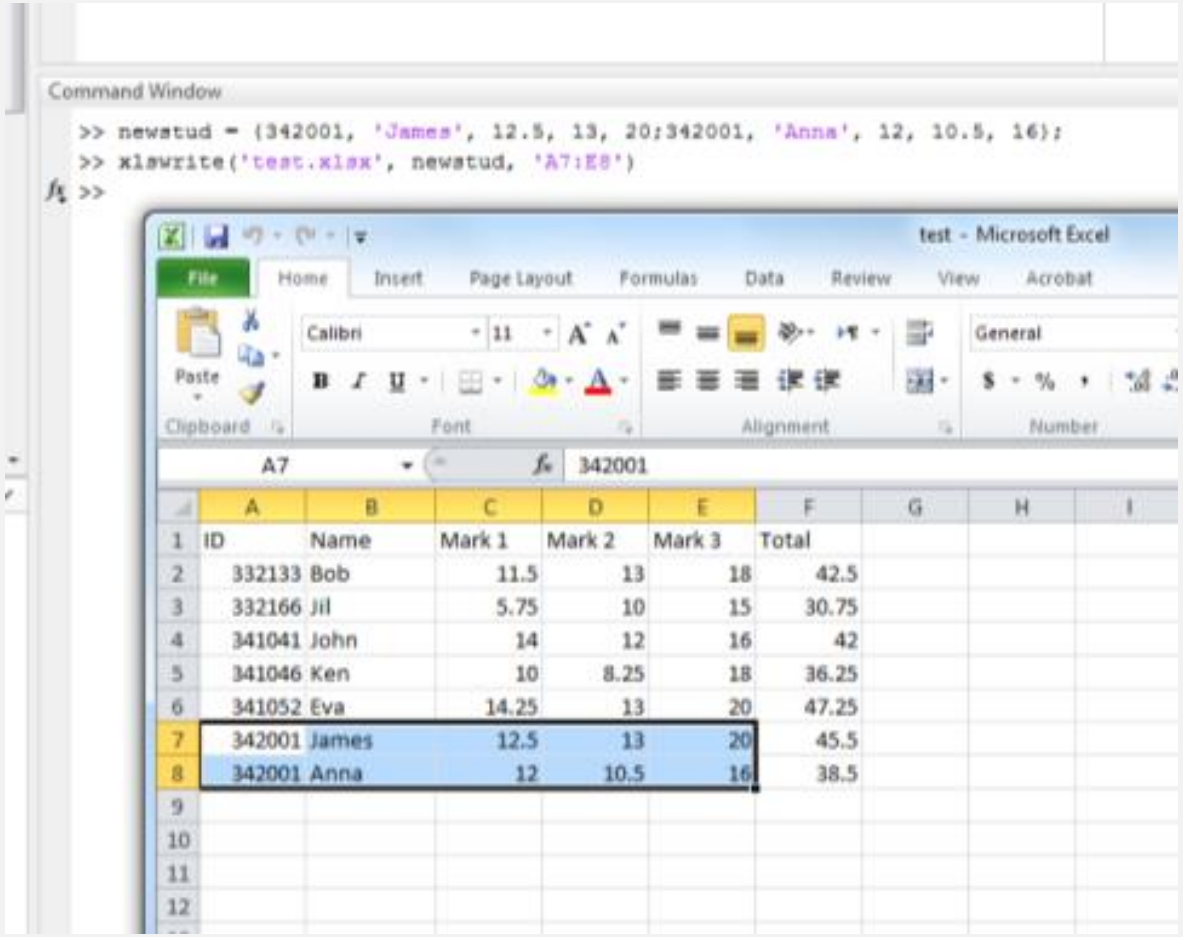
- They need to know how to insert an image from MATLAB to an MS Word Document, resize it, crop it if needed and select the appropriate Layout options (in line with text, in front of text, etc.).
- They need to prepare a professional document for their plotting lab assignment (Ch. 4), inserting the MATLAB commands and the Figures they produce and place them side by side.
- This is beneficial for creating reports for other classes and labs.



TEACHING EXCEL©

What Students Need to Know:

- Chapter 3 teaches them how MATLAB communicates with Excel.
- This section is important and should be emphasized more.
- For many Engineering jobs, knowledge of MATLAB combined with MS Word/Excel© is required.



CASE STUDIES OR PROJECTS

The Most Important Part of the Course:

- Case study or project **weighs 25%** of students' total grade, replacing the final exam.
- Case studies can either be related to **engineering** (e.g. Bernoulli's Equation and Pump Performance Charts, etc.), **Math** or **Physics** problems or anything else related to their jobs.
- Students **select their own** case studies, but they get **approval** from their professors first.
- **First Draft** contains only the solved engineering problem and the code. It is due about 2 weeks before the last day of class. Professors should give feedback extensively, so students can improve their programs.
- **Final case study** is due the last day of class and it contains the complete report, and the code.
- Case studies **are presented** in class on the last day of the semester.

CASE STUDY REPORT

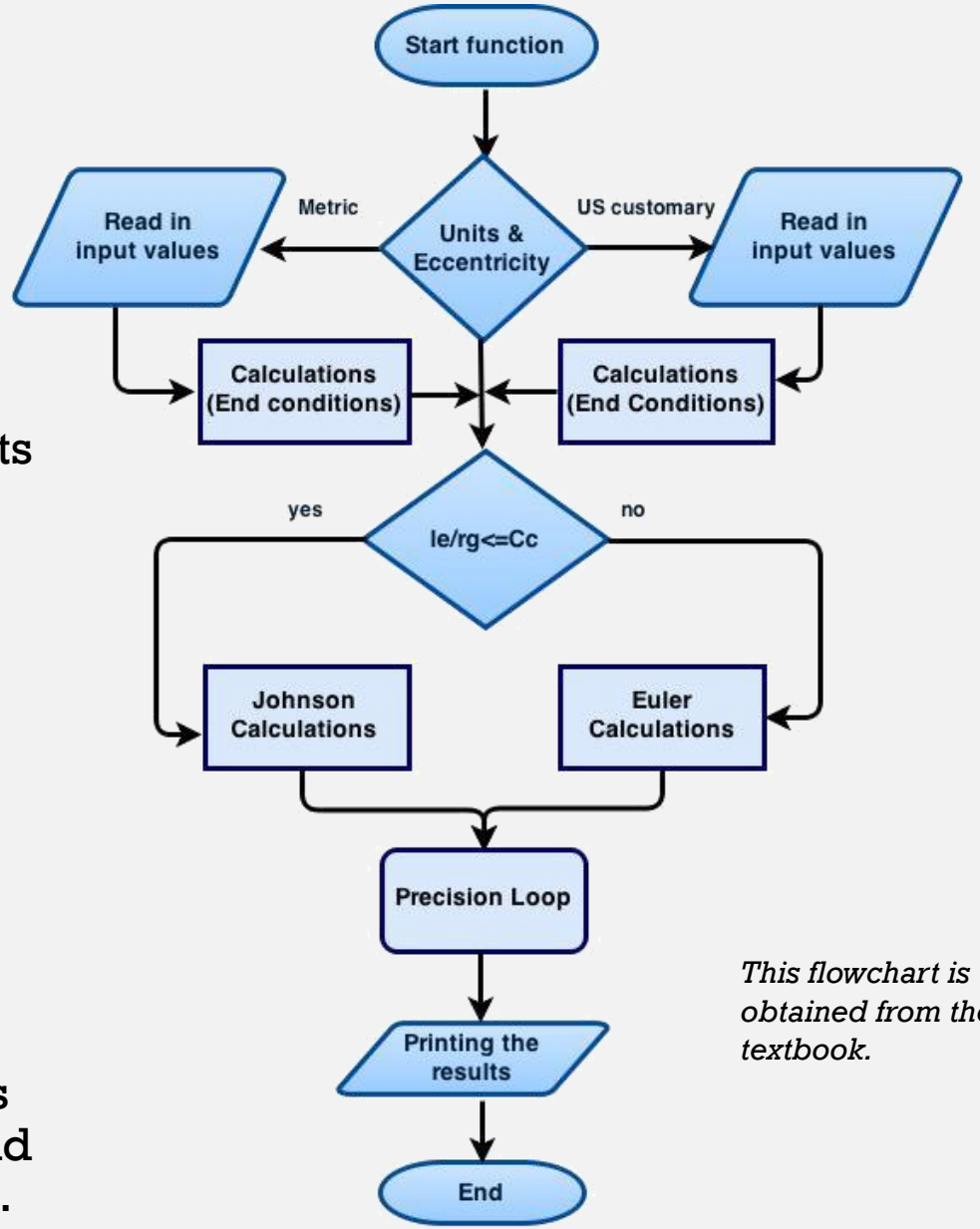
Components of the Report:

- The first page of your report, contains the title of the case study, student's name, Professor's name, class, date, etc.
- Engineering problem is then stated which is supported by figures/tables if needed.
- Equations are typed neatly (by equation editor in MS Word©). If necessary, professors should teach them how to type the equations.
- Student should indicate the inputs and outputs and what exactly the function does. The function is copied from MATLAB editor and pasted into the report.
- A flowchart should be added.
- All the output results are included: the output data and figures that are obtained after running the function (The screen shots of MATLAB when the program is run).
- Review chapters 11 to 14 for students' case studies. However, these are at a more advanced level since in most cases the author helped the students with their projects.

CASE STUDY REPORT

Functions and Flowcharts:

- Professors are advised to encourage the students to write FUNCTIONS, not just Scripts.
- The code should contain FOOL-PROOFING statements (for meaningless user's inputs) and other conditional statements for which students use the if-statements or the while loops.
- They can consider two different units of Metric and US Customary.
- To produce flowcharts, students can use www.draw.io for free.
- The standard flowchart only contains the shapes shown here. All arrows should get connected and they should only be either vertical or horizontal.

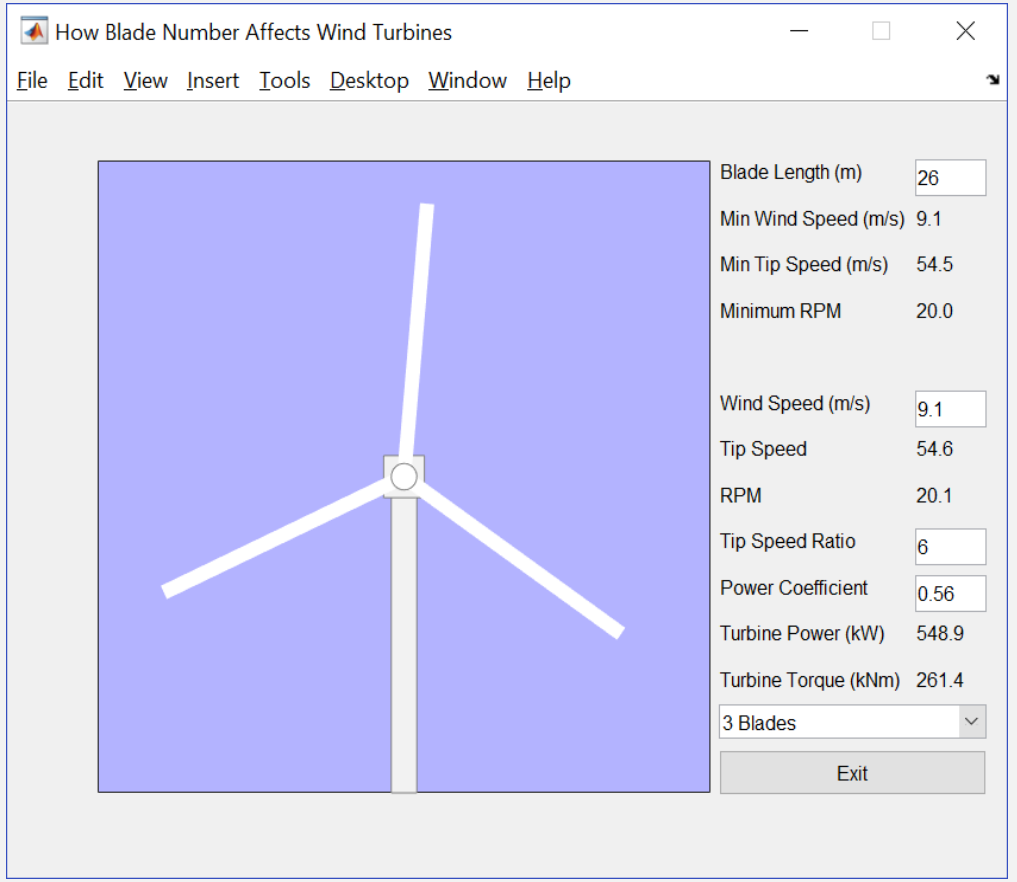


This flowchart is obtained from the textbook.

CASE STUDY REPORT

A Graphical User Interface (GUI):

- Creating a GUI is **OPTIONAL**.
- Professors can place the GUI manuals or links to tutorial videos on D2L.
- It is advised to encourage a couple of students to create GUIs.
- In case the case study is very simple, students can create a GUI and add to their reports. However, troubleshooting a GUI is time-consuming and requires lots of patience!



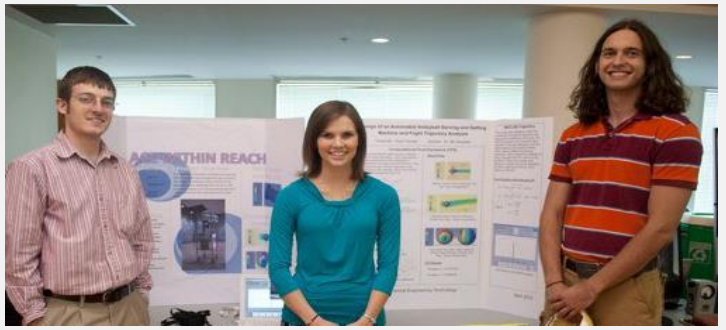
By: Corey Lockridge,
MET 2501, Nasseri, Fall 2016

CASE STUDY REPORT

Summary:

- Title page,
- Stating the engineering problem with equations,
- MATLAB Function's inputs, outputs and how it works,
- Flowchart,
- MATLAB Code (and/or GUI),
- Function run (screen shot of MATLAB outputs),
- References.

CASE STUDY PRESENTATION



How it works:

- Students should work in groups of two. Three students can work in a group provided that the project is very difficult.
- This encourages students to do better and they learn the teamwork required later on for their engineering positions. It is better to pair students who are at the same level academically.
- On the last day of class, the teams who already have all the files ready on their flash-drives present their works.
- They should be advised to speak only for 5 minutes. Both students should present almost equally.
- They show the report and explain what the engineering problem is. Then they show all the components, such as the flowchart, *etc.* one by one.
- They run their code and show the results.
- They are advised to have eye contact, a good hand gesture, vocal variety, *etc.* This is a training for some of the soft skills that they require for their engineering positions.