# A08 · Selection and Repetition Structures (WHILE Loops)

## Introduction

### Assignment Goals

This assignment focuses on two different types of non-sequential structures: selection structures and indefinite (while) loops. For each topic, you will gain programming experience coding a structure and then you will apply those skills to an engineering context. You will also learn to differentiate structure types in flowcharts.

### Successful Completion

This assignment has four (**4**) problems. Problems 1 and 3 go with Class A; Problems 2 and 4 go with Class B. Problems 3 and 4 have a team component.

1. Read *Notes Before You Start*, on **Page 1**.
2. Read each problem carefully. You are responsible for following all instructions within each problem.
    a. Problems 1 and 3 require selection structures. Problems 2 and 4 require repetition structures.
    b. The deliverables list within each problem contains everything you are expected to submit.
    c. You will need the problem generator **A08_skills.p** for Problem 1. See this link to view instructions.
3. Complete the problems using the problem-specific m-file templates when a template is provided in the assignment download.
4. For any file, replace *template* or *login* in the filename with your Purdue Career Account login.

    ***Example***: `A05Prob1_context_template.m` will be renamed `A05Prob1_context_pboilerm.m` for a student whose Career Account login is pboilerm.
5. Review your work using the learning objective evidences.
6. When your work is complete, confirm your deliverables are submitted to Gradescope.
    a. Note the three different assignments in Gradescope. See *Notes Before You Start*.
        i. Submit Problems 1 and 2 to **A08 – Skills Problems**.
        ii. Submit *individual* work for Problems 3 and 4 to **A08 – Context Problems**.
        iii. Submit *team plan* for Problems 3 and 4 to **A08 – Team Planning**.
    b. You can resubmit to Gradescope as many times as you need. Only your final submission is graded.
    c. Do **NOT** upload any document not listed in the deliverables. Do not upload temporary versions of m-files (*.m~ or *.asv).
7. Late submissions will be accepted up to 24 hours after the due date and will result in a 25% penalty.

### Learning Objectives & Grading

This course uses learning objectives (LOs) to assess your work. You can find a full list of the course LOs here. Review the grading outline at the end of each problem in this assignment to see each problem's LOs.

## Notes Before You Start

### Helpful MATLAB Commands

Learn about the following built-in MATLAB commands, which might be useful in your solutions:

`if, elseif, else, end, error, input, acos, while, disp, sqrt`

## Coding Long Expressions

Coding large expressions or commands in one line is difficult. For example, you need to code one solution to a quadratic equation using the formula

$$x = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

with the assigned variables a, b, and c. You have two options to manage statement length.

### Build from smaller terms

Calculate smaller terms that you assign to MATLAB variables; then build the expression from the assigned variables and any remaining terms.

```
% CALCULATIONS
discrim = sqrt(b^2 - 4*a*c);
denom = 2*a;
x = (-b + discrim)/denom;
```

### MATLAB ellipsis

Use MATLAB's ellipsis (`...`) to break up long lines of code for readability. Read this MATLAB documentation for more guidance on using the ellipsis: Continue Long Statements on Multiple Lines

*Example*: Code $x = \frac{-b+\sqrt{b^2-4ac}}{2a}$ using assigned scalar variables a, b, and c

```
% CALCULATIONS
x = (-b + sqrt(b^2 - 4*a*c))...
    /(2*a);
```

## Intervals and Ranges

A range of numbers can be defined as an interval. If a boundary value is included within the range, then we say the range is "inclusive" of the number. If a boundary value is not included in the range, then the range is "exclusive" (or not inclusive) of that number. See examples below for the range of number 5 to 10.

| Relational notation | Interval notation | Explanation |
|---|---|---|
| $5 \leq x \leq 10$ | $[5, 10]$ | The numbers between 5 and 10, inclusive of both 5 and 10 |
| $5 \leq x < 10$ | $[5, 10)$ | The numbers between 5 and 10, inclusive of only 5 (exclusive of 10) |
| $5 < x \leq 10$ | $(5, 10]$ | The numbers between 5 and 10, inclusive of only 10 (exclusive of 5) |
| $5 \leq x \leq 10$ | $(5, 10)$ | The numbers between 5 and 10, exclusive of both 5 and 10 |

## Gradescope

You will submit all your deliverables to Gradescope. This homework has **two** Gradescope submission assignments for the individual submissions, plus a **third** assignment for the team planning component:

- **A08 – Skills Problems**: submit your deliverables for Problems 1 and 2. Help link.
- **A08 – Context Problems**: submit your deliverables for Problems 3 and 4. Help link.
- **A08 – Team Planning**: submit your team plans for Problems 3 and 4 as a group. Help link.

# Problem 1: MATLAB Skills – Selection Structures

## Introduction

This problem allows you to practice writing a selection structure. You will submit your answers to an online assignment on Gradescope.

### Problem Generator Information

If you have questions about how to use the problem generator, review this link that shows step-by-step instructions.

| File Name | PUID | Problem Number |
|---|---|---|
| A08_skills | Your 8-digit PUID | 1 |

### Submission

| Gradescope Assignment | A08 – Skills Problems | Assignment Type | Individual |
|---|---|---|---|
| Deliverables | ☐ Requested information and A08Prob1_selection_*login*.m | | |

## Problem

1. Enter the problem generator function call into the MATLAB Command Window prompt.
2. Read the written instruction text that appears in the Command Window. Write a script to complete the task.
    - Use the included template to write the requested code.
    - Keep the conditions in the order they are presented in the instruction text.
    - It is possible that your instruction text may require a path that is never used. If this happens, code the conditions as given in the instruction text.
    - Test your structure with any integer for A. Good testing will attempt every path in the structure.
    - Programming standards will not be assessed in this problem. Do not include comments in your solutions. Properly name the file.
3. Submit your instruction text with run receipt and m-file into Gradescope.
4. Save your answers in Gradescope. See this video for help (this is an untimed assignment).

## Grading

LOs: PC05, MAT03, MAT06

Point value: 6 points. The partial credit may be more specific than what is in the course LOs and is based on evidence MAT03 (5) and MAT06. If you do not meet the PC05 expectations, you will lose additional credit.

| Evidence | Penalty |
|---|---|
| PC05 (1) | Lose full credit on problem |
| PC05 (2) | Lose 25% of full credit on problem |
| PC05 (3) | Lose 25% of full credit on problem |
| PC05 (4) | Lose 15% of full credit on problem |

# Problem 2: MATLAB Skills – While Loop

## Introduction

This problem allows you to practice writing a while loop repetition structure. You will submit your answers to an online assignment on Gradescope.

### Problem Generator Information

If you have questions about how to use the problem generator, review this link that shows step-by-step instructions.

| File Name | PUID | Problem Number |
|---|---|---|
| A08_skills | Your 8-digit PUID | 2 |

### Submission

| Gradescope Assignment | A08 – Skills Problems | Assignment Type | Individual |
|---|---|---|---|
| Deliverables | ☐ Requested information, solutions, and A08Prob2_while_*login*.m | | |

## Problem

1. Enter the problem generator function call into the MATLAB Command Window prompt.
2. Read the written instruction text that appears in the Command Window. Write a script to complete the task.
    - Use the included template to write the requested code.
    - Run your script to test your loop and generate the requested information.
    - Programming standards will not be assessed in this problem. Do not include comments in your solutions. Properly name the file.
3. Submit your instruction text with run receipt, solutions, and m-file into Gradescope.
4. Save your answers in Gradescope. See this video for help (this is an untimed assignment).

## Grading

LOs: PC05, MAT06

Point value: 6 points. The partial credit may be more specific than what is in the course LOs and is based on evidence in MAT06. If you do not meet the PC05 expectations, you will lose additional credit.

| Evidence | Penalty |
|---|---|
| PC05 (1) | Lose full credit on problem |
| PC05 (2) | Lose 25% of full credit on problem |
| PC05 (3) | Lose 25% of full credit on problem |
| PC05 (4) | Lose 15% of full credit on problem |

# Problem 3: Airline seat assignment

## Introduction

This problem focuses on your ability to translate an engineering-context flowchart, which has a selection structure, into a MATLAB script, and then use the script to test the selection structure. Follow good programming standards.

### Submission

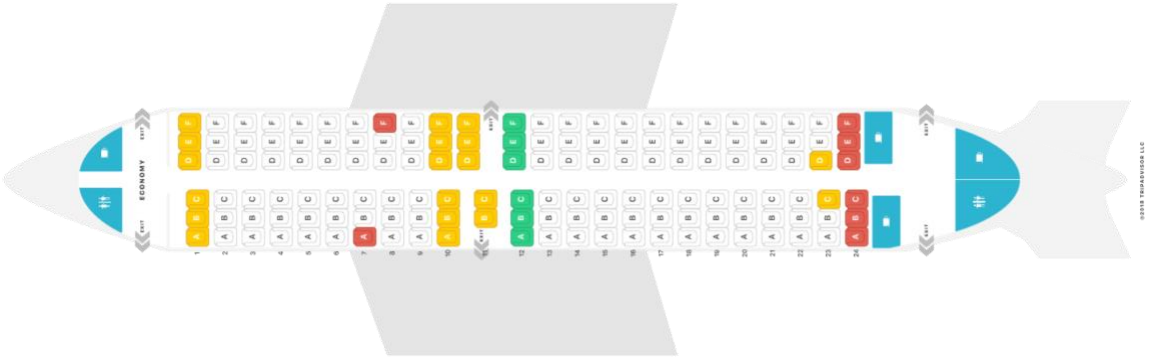
*Individual*

| Gradescope Assignment | A08 – Context Problems | Assignment Type | Individual |
|---|---|---|---|
| Deliverables | ☐ A08Prob3_seating_*login*.m<br>☐ Supporting files: Data_booking_numbers.txt | | |

*Team Plan*

| Gradescope Assignment | A08 – Team Planning | Assignment Type | Team |
|---|---|---|---|
| Deliverables | ☐ Requested information | | |

## Problem

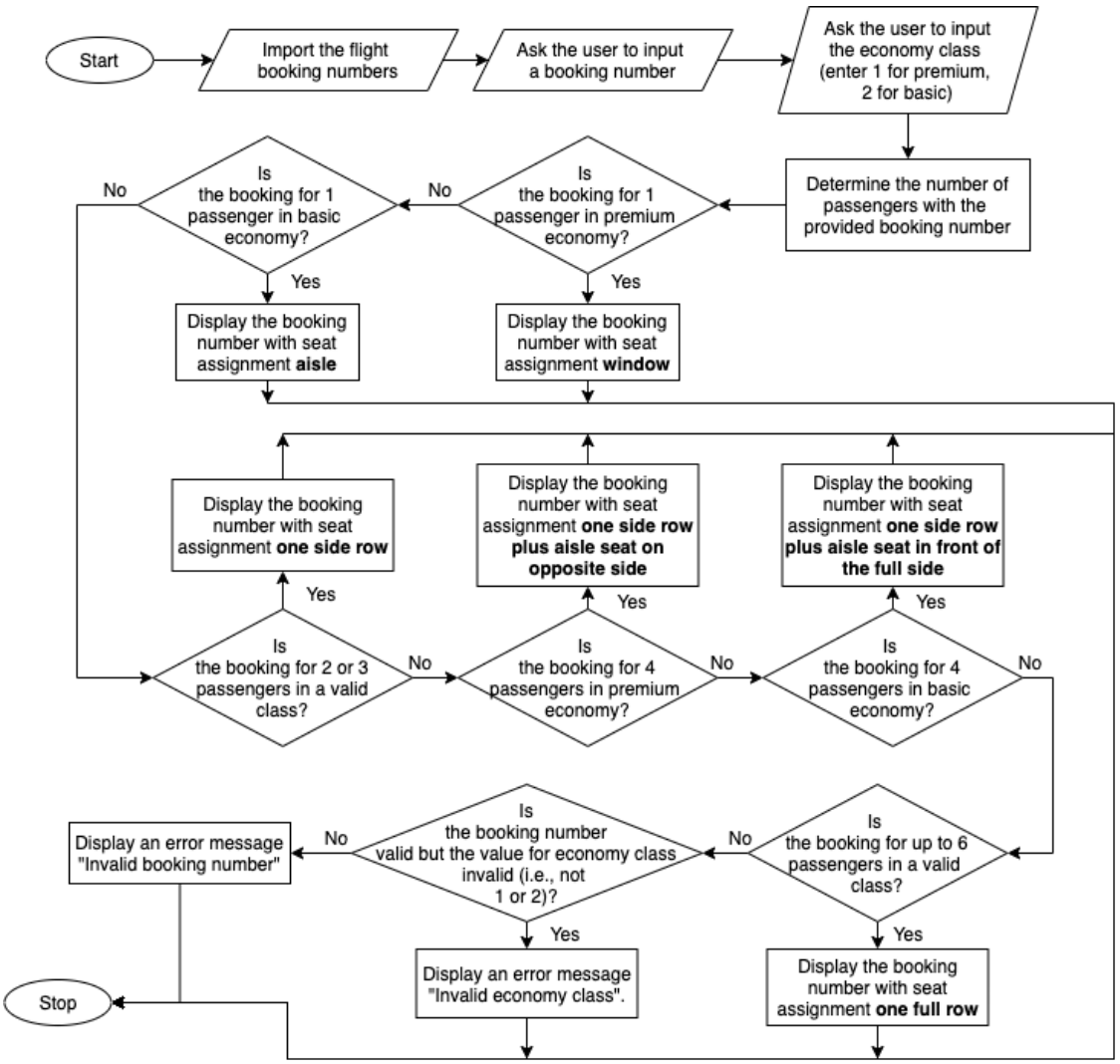


Airlines have a system that assigns seats to passengers in a flight. An airline has set new health requirements to ensure socially distant seating for passengers from different households. The airline wants you to help them write code to assign seat locations based on the number of passengers in one booking and their booking class (premium economy or basic economy).

The aircraft seats 6 people in one row, with 3 on one side of the aisle and 3 on the other. The airline has set these options for assigning seats: window, aisle, one side row, one side row plus aisle seat on opposite side, one side row plus aisle seat in front of the full side, or full row (all six seats, across the aisle). The seat location may depend on the number of passengers per booking number and the booking class (see the flowchart below).

You can assume that passengers with the same booking number are from the same household and can sit next to each other. The airline allows a maximum of 6 people per booking. Note: the airline does not want you to assign a seat number, only determine the corresponding seat option according to the flowchart.

You have been provided a data file, named **Data_booking_numbers.txt**, that contains the booking numbers for all passengers on an upcoming flight. The booking could be in premium economy class or basic economy class. For this code, assume the user knows the class and can enter it when requested. The flowchart below shows how the airline wants you to assign seats to the passengers. Translate the flowchart to a script.




Once you have your code written, run it with the following test cases:

| Test Case | Booking Number | Economy Class Number |
|---|---|---|
| 1 | 16209315 | 2 |
| 2 | 15088033 | 1 |
| 3 | 15529040 | 2 |
| 4 | 14238657 | 1 |
| 5 | 17221902 | 1 |
| 6 | 20333663 | 1 |
| 7 | 11976972 | 2 |
| 8 | 14313145 | 2 |

For each test case, paste your printed display into the `RESULTS` section of your script as comments.

After you finish your test cases, answer this question in the `ANALYSIS` section of your script. Write your answer as MATLAB comments.

Q1. Does each condition in the flowchart get tested at least one time with the test cases listed above? If no, then list all conditions that are **not** tested. Format your answer following the guidelines in EPS01.

**Instructions**

1. Read through the entire problem statement.
2. **With your teammates**: develop and document a plan to solve this problem.
    a. Understand the expectations of the problem.
    b. Discuss strategies for solving the problem. This can include citing examples from class notes, drawing pictures, outlining a plan using text or pseudocode, etc. **DO NOT SHARE CODING SOLUTIONS.**
    c. Submit your plan to the team assignment in Gradescope
        1. Open the Gradescope assignment for this assignment's team plan (see the submission list at the beginning of this problem).
        2. In the area for this problem:
            a. Enter the names of your teammates who participated in the planning.
            b. Enter a brief description of your team's plan to solve the problem. The plan should be connected to the problem and have at least 2-3 steps. It should not be a detailed explanation of every step necessary to solve the problem.
            c. If you have image files, etc., that you would prefer to share, then you may add them in the *Optional* file submission area.
        3. Save your results.
    d. Add your teammates to the submission. Select 1 team member to submit the plan. **Work together** to make sure it is done correctly.
        1. Click **Submit & View Submission** at the bottom of the assignment
        2. Add all teammates to the group (Gradescope instruction link)
        3. All teammates confirm that you get a submission email and verify that you can see the submission in your Gradescope.
        4. You only need to add teammates one time (regardless of the number of problems in the assignment or the number of resubmissions your team makes).
3. **Individually**:
    a. Complete your script, run it for each test case to get your results, and paste those results as comments into the script. Answer the analysis question.
        - The team plan is an initial start on the problem. It may not be completely correct, and you may find flaws in the plan once you start coding. You should make any individual changes that are necessary to obtain the best solution. You will be assessed on your individual solution to the problem.
    b. Cite any peers you worked with in your script header if their help changed how you decided to solve the problem.
        1. Make sure you also completed the rest of the script header.
    c. Submit your properly named m-file and data file to the appropriate problem in the individual Gradescope assignment (see the submission list at the beginning of this problem).
        - Submit your deliverables once all your context problems are complete. Click here for help.
        - Do not submit any other files.

## Grading

LOs: PC05, MAT01, EPS01, MAT07, MAT09

Team plan: 1 point

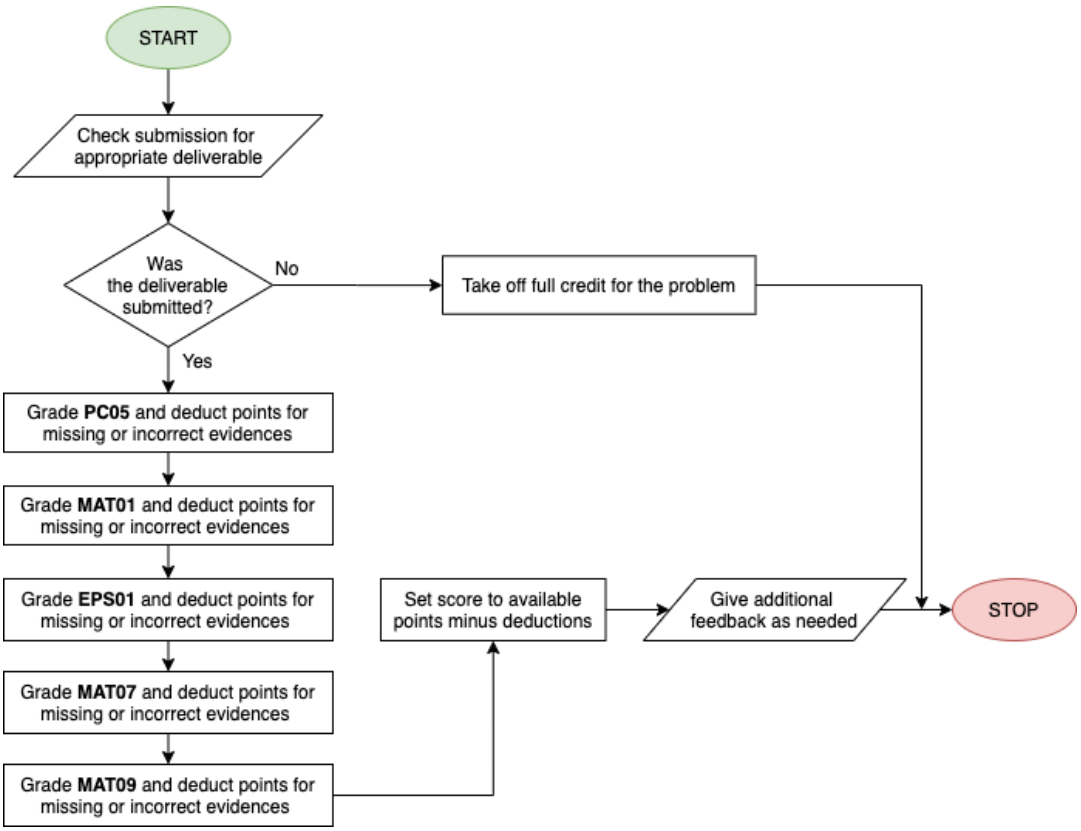
Individual assignment point value: 9 points. Partial credit is possible; see the LO table below for details. You must meet the PC05 expectations. If you do not meet these, you will lose additional credit.

**LO Table**

| | PC05 | MAT01 | EPS01 | MAT07 | MAT09 |
|---|---|---|---|---|---|
| (1) | -100% | 0.4 | 0 | 0.6 | 0.6 |
| (2) | -25% | 0.1 | 0 | 0.6 | 1.2 |
| (3) | -10% | 0.1 | 0 | 0.6 | 1.2 |
| (4) | -15% | 0.4 | 0 | 0.6 | 0 |
| (5) | 0 | 0.3 | 0.5 | 0.6 | 0 |
| (6) | 0 | 0.2 | 0 | 0.6 | 0 |
| (7) | 0 | 0.2 | 0 | 0 | 0 |
| (8) | 0 | 0.2 | 0 | 0 | 0 |

**Grading Process**

This flowchart outlines how the grader will assess your work for this problem.



# Problem 4: Tank Volume

## Introduction

This problem focuses on your ability to translate a flowchart into a MATLAB script that uses a while loop to answer engineering-based questions. Be sure to follow good programming standards in your script.

### Submission

*Individual*

| Gradescope Assignment | A08 – Context Problems | Assignment Type | Individual |
|---|---|---|---|
| Deliverables | ☐ A08Prob4_tankVol_*login*.m<br>☐ Supporting file: A08Prob4_image_*login*.png | | |

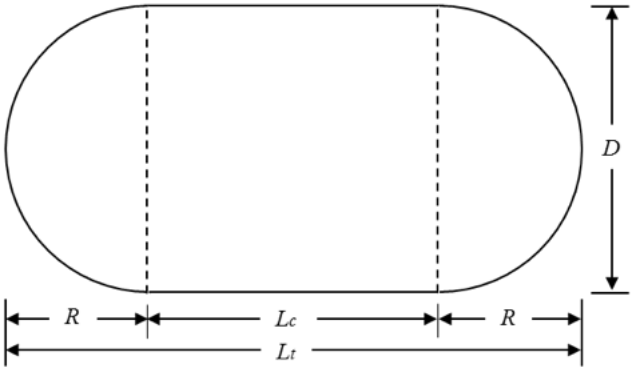
*Team Plan*

| Gradescope Assignment | A08 – Team Planning | Assignment Type | Team |
|---|---|---|---|
| Deliverables | ☐ Requested information | | |

## Problem

Cylindrical steel tanks have many outdoor uses. They are used in oil and gas refining, food production, farming, liquified gas storage, and more. Cylindrical tanks can have flat end caps, elliptical end caps, or spherical end caps.

Your company uses cylindrical tanks with spherical end caps. You are working on a design for a tank fill measurement system that can be used in tanks that are installed horizontally. A probe will measure the height of the fluid in the tank, and that fluid height will be used to determine the volume of the liquid in the tank.




The tanks have the geometry shown in the figure. The two hemispherical end caps are equivalent to one sphere. The end caps and the cylindrical center section have the same radius, $R$. The tank length, $L_t$, is the sum of the tank diameter, $D$, and the length of the cylindrical center, $L_c$. All lengths are interior measurements. The tank wall thickness is not required for this application.

When a tank is installed horizontally, the fluid volume at any fluid height within the tank can be calculated using the function

$$V_f(h) = \frac{\pi h^2(3R - h)}{3} + L_c\left(R^2 \cos^{-1}\left(\frac{R-h}{R}\right) - (R-h)\sqrt{2Rh - h^2}\right)$$

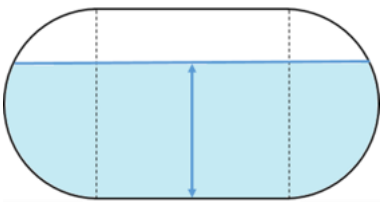
Where

$V_f$ = fluid volume

$h$ = fluid height (between 0 and the tank diameter, inclusive of both; measured from the tank bottom)

$R$ = tank radius

$L_c$ = length of cylindrical section of the tank



It is important to never overfill a tank. Liquid in outdoor industrial tanks can expand with ambient air temperature changes, so the tank must be empty enough to accommodate the expansion. Your measurement system must ensure that the fill process will shut down properly and not allow a tank to overfill. The first step to achieve this is to set a safety percent, which is the maximum percentage of the tank volume that can be filled.

The fluid height is not measured instantaneously in this system. Instead, the programmer sets an increment and the fluid height is measured in those increments. For example, if the increment is 0.5m and the tank is empty at the start of the fill, then the volume will be calculated at 0m, 0.5m, 1.0m, 1.5m, etc. until the tank is properly filled.

To ensure the tank does not overfill, you must stop the fill before the fluid volume passes the safety volume. You will keep the volume from exceeding the safety limit by setting a maximum tolerance. To find the maximum allowable tolerance, $V_{tol}$, you will calculate the difference in fluid volume at two different fluid heights, $R + 0.5\Delta h$ and $R - 0.5\Delta h$:

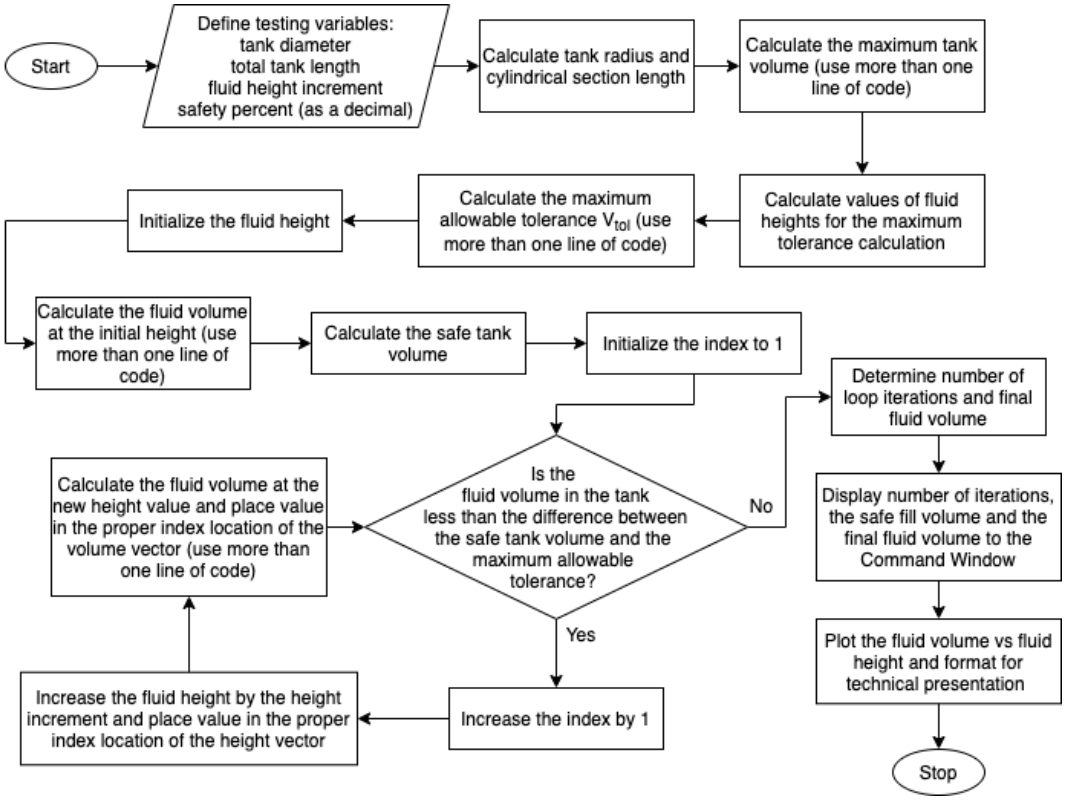
$$V_{tol} = V_f(R + 0.5\Delta h) - V_f(R - 0.5\Delta h)$$

Using the volume function $V_f$ above, where $\Delta h$ is the fluid height increment and $R$ is the tank radius.

For testing purposes, you will use your company's most popular tank size, which has a diameter of 3.35 meters and a total tank length of 14.5 meters. Assume a fluid height increment of 0.15 meters and that the tank can be safely filled to 80% capacity (0.8 as a decimal). Also assume that the tank is completely empty when filling begins.

To meet the safety needs of the system, you will write a script that translates the flowchart below. Your script will

- Define the testing values as variables,
- Calculate the requested values,
- Create a vector of fluid height values and another vector of corresponding volumes using a while loop,
- Stop adding elements to the vector as close as possible to the fill capacity without exceeding that value,
- Plot the resulting vectors as fluid volume versus fluid height. Format for technical presentation.



In the `RESULTS` section of your script, copy and paste as comments the information displayed to the Command Window. When you are finished with your script, run it and save a *.png file of your figure window (see help if needed).

**Instructions**

1. Read through the entire problem statement.
2. **With your teammates**: develop and document a plan to solve this problem.
    a. Understand the expectations of the problem.
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        4. You only need to add teammates one time (regardless of the number of problems in the assignment or the number of resubmissions your team makes).
3. **Individually**:
    a. Complete your script, run to get your results, and paste those results as comments into the script. Save the plot figure as a PNG image.
        - The team plan is an initial start on the problem. It may not be completely correct, and you may find flaws in the plan once you start coding. You should make any individual changes that are necessary to obtain the best solution. You will be assessed on your individual solution to the problem.
    b. Cite any peers you worked with in your script header if their help changed how you decided to solve the problem. Make sure you also completed the rest of the script header.
    c. Submit your properly named m-file and image file to the appropriate problem in the individual Gradescope assignment (see the submission list at the beginning of this problem).
        - Submit your deliverables once all your context problems are complete. Click here for help.
        - Do not submit any other files.

## Grading

LOs: PC05, MAT01, MAT07, MAT08, EPS01, EPS02

Team plan: 1 point

Individual assignment point value: 9 points. Partial credit is possible; see the LO table below for details. You must meet the PC05 expectations. If you do not meet these, you will lose additional credit.

**LO Table**

| | PC05 | MAT01 | MAT07 | MAT08 | EPS01 | EPS02 |
|---|---|---|---|---|---|---|
| (1) | -100% | 0.3 | 0.8 | 0 | 0 | 0 |
| (2) | -25% | 0 | 0.8 | 0.9 | 0 | 0.4 |
| (3) | -10% | 0 | 0.8 | 0.6 | 0.3 | 0.4 |
| (4) | -15% | 0 | 0.8 | 0 | 0.3 | 0 |
| (5) | 0 | 0.3 | 0.8 | 0 | 0 | 0 |
| (6) | 0 | 0 | 0.8 | 0 | 0 | 0 |
| (7) | 0 | 0.3 | 0 | 0 | 0 | 0.4 |
| (8) | 0 | 0 | 0 | 0 | 0 | 0 |

**Grading Process**