CDS-130/004 SPRING 2016: HOMEWORK 7 (version 1)
ASSIGNED 28 MARCH 2016, DUE 4 APRIL 2016 AT THE END OF CLASS

MATLAB SYNTAX EXERCISES

In the below exercises, **predict the output from each of the following Matlab programs**. If the program results in an infinite loop, then write **"INFINITE LOOP"** as your answer, and explain why. If there is no output because an error results, write **"ERROR"** and then explain why the error occurs. You will need to show your work, meaning, demonstrate how you arrived at what you claim is the output from these programs.
Do not run these programs in Matlab to obtain your answers. Instead, you may sketch out on paper the matrices/arrays/variable assignments that result from executing the code, as well as keep track of intermediate computational results: It's important that you develop the ability to understand how WHILE loops work, and how to avoid errors using them.

Exercise 1 (1 pt):

```
counter = 10;
A = 1:10;
while (counter >= 5)
   counter = counter - 1;
   A(counter-1) = counter^2;
end
A
```

Exercise 2 (1 pt):

```
counter = 5;
A = 1:5;
while (counter <= 5)
   counter = counter - 1;
   A(counter-1) = counter^2;
end
A
```

Exercise 3 (1 pt):

```
counter = 1;
A(1) = 0;
while (counter <= 5)
   A(counter+1) = counter^2;
   counter = counter + 1;
end
A
```

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Exercise 4 (2 pt):

```
x = 1;
y = 5;
A(1) = 0;
B = 1:5;
while (x <= 5 && y >= 1)
   A(x) = y^2;
   B(y) = x^2;
   x = x + 1;
   y = y - 1;
end
A
B
```

Exercise 5 (2 pt):

```
x = 1;
y = 5;
A(1) = 0;
B = 1:5;
C(1) = 0;
while (x <= 5 && y >= 1)
   A(x) = y;
   B(y) = x^2;
   C(x) = A(x) - B(y);
   x = x + 1;
   y = y - 1;
end
C
```

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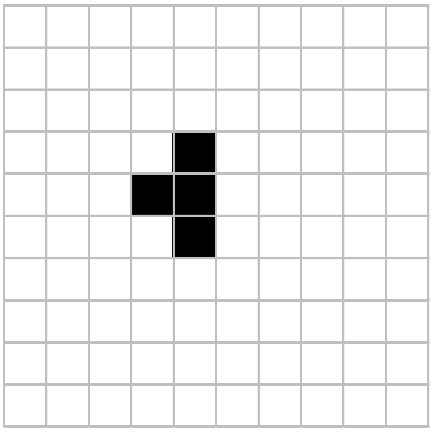
EXERCISE 7 (5 pts.)



Above is shown an example of a 10 × 10 image of matrix "A". Matrix A contains only two numerical values: 0 and 1. The value 0 corresponds to "white" and 1 corresponds to "black". Matrix A also contains a "bent T pixel pattern" consisting of four black colored pixels, **ORIENTED AS SHOWN.**

Write an image processing algorithm, similar to those algorithms that appear in the presentation entitled "Image Processing and Pattern Recognition", that can detect the four pixel "bent T pixel pattern" shown above, AND ORIENTED THE SAME WAY.

Your algorithm must be able to process a 10 × 10 image matrix A, and count all occurrences of bent T patterns occurring in it, oriented as shown. To test your algorithm, input into your algorithm the following image matrix A :

```
A =  [0,   1,   0,   0,   0,   0,   0,   0,   0,   1;
      1,   1,   0,   0,   0,   0,   0,   0,   1,   1;
      0,   1,   0,   0,   0,   0,   0,   0,   0,   1;
      0,   0,   0,   0,   1,   0,   0,   0,   0,   0;
      0,   0,   0,   1,   1,   0,   0,   0,   0,   0;
      0,   0,   0,   0,   1,   0,   0,   0,   0,   0;
      0,   0,   0,   0,   0,   0,   0,   1,   0,   0;
      0,   0,   1,   0,   0,   0,   1,   1,   0,   0;
      0,   1,   1,   0,   0,   0,   0,   1,   0,   0;
      0,   0,   1,   0,   0,   0,   0,   0,   0,   0]
```

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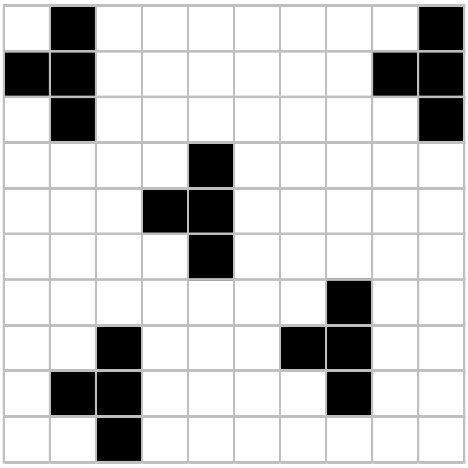
Which corresponds to the following image:



If your algorithm is working properly, then it should output a count of 5 bent pixel patterns shown when given this image matrix A as input.

If you're confident that you have a good algorithm, then try inputting the following image matrix A into your algorithm:

```
A = [1,   0,   0,   0,   1,   1,   1,   0,   1,   0;
     1,   1,   0,   0,   1,   0,   1,   1,   1,   0;
     0,   0,   0,   0,   1,   0,   0,   1,   1,   1;
     0,   1,   1,   0,   1,   1,   1,   1,   1,   1;
     1,   0,   0,   0,   1,   0,   0,   1,   0,   1;
     0,   1,   0,   0,   0,   0,   1,   0,   1,   1;
     1,   1,   1,   0,   1,   0,   0,   1,   1,   1;
     1,   1,   1,   1,   1,   0,   1,   0,   1,   1;
     0,   1,   0,   1,   0,   1,   1,   1,   0,   1;
     1,   1,   1,   0,   0,   0,   0,   0,   1,   1]
```

If your algorithm is working properly, then this particular A matrix should output a count of 10 for "bent T" pixel patterns, which is the number of "bent T" pixel patterns that the above matrix A contains.

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And now, how many four pixel "bent T" patterns does your algorithm discover in the following image matrix A? Here is A:

```
A = [1,   0,   0,   1,   0,   1,   1,   1,   0,   1;
     1,   0,   0,   0,   1,   1,   1,   1,   0,   0;
     0,   1,   0,   0,   1,   1,   1,   0,   0,   1;
     1,   1,   1,   1,   1,   1,   1,   0,   1,   1;
     1,   1,   1,   1,   1,   1,   1,   1,   1,   1;
     1,   1,   1,   0,   1,   1,   1,   1,   1,   1;
     1,   1,   1,   0,   0,   1,   0,   1,   0,   0;
     1,   1,   0,   0,   0,   1,   0,   1,   1,   1;
     0,   1,   1,   0,   0,   1,   0,   1,   0,   0;
     1,   1,   1,   1,   1,   0,   1,   1,   1,   1];
```

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EXERCISE 6 (5 pts.)

INTRODUCTION: Gravity on Earth varies with height above the Earth's surface. This is because the higher one gets, the further one travels away from the Earth's center. Gravity varies with height according to the following equation:

$$g_h = g_0 \left(\frac{r_e}{r_e + h} \right)^2$$

Where:

- g_h is the value of gravity at height h above the Earth's surface (in meters)
- r_e is the mean radius of the Earth (assumed equal to 6,371,000 meters)
- h is the height above the Earth's surface (in meters)
- g_0 is the value of gravity at the Earth's surface (equals 9.81 meters/s^2)

PROBLEM: At h = 0.0 meters, the value of g_h will be equal to g_0, that is, at h = 0.0 meters, g_h = 9.81 meters/s^2. At what height h above the Earth's surface will g_h be equal to 2.53 meters/s^2? (Note that 2.53 meters/s^2 is 68% of the value of acceleration due to gravity on the surface of Mars)

NOTE: You are required to solve this problem using an IF statement inside a FOR loop. Using h as the FOR loop index variable, begin h at a value of 3750000 meters and increase h in steps of 0.01 meters, to 7000000 meters. Use the IF statement to detect the first instance when abs(2.53 – g_h) ≤ 0.0001 (this will be the IF statement's test). The corresponding value of h represents the correct height and thus the correct answer to this exercise. When the IF statement detects the first instance, as above, then assign the appropriate value of h to a variable called `correct_answer` and then output the value of `correct_answer` upon exit from the FOR loop. Your screenshot must show your program AND the outputted value for the variable `correct_answer` in the command line window.

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EXERCISE 7 (5 pts.) INTRODUCTION: The year-to-year growth of money in a bank savings account can be modeled with the following MATLAB vector assignment statement:

```
B(t + 1) = (1 + r) * B(t)
```

Where: `B(t + 1)` is the bank account balance at the beginning of year `t + 1`;
`B(t)` is the bank account balance at the beginning of year `t`; and
`r` is the annual interest rate, expressed as a decimal fraction
(i.e., 4.5% is 0.045 and NOT 4.5!)

PROBLEM: What is the balance in a bank savings account at the beginning of year 25 if the account received an initial deposit of $10,000 at the beginning of year 1, grew at an annual rate of 3.75%, and experienced withdrawals and deposits according to the following schedule:

$1,500 deposited to the account **at the beginning of year 5**;
$2,375 withdrawn from the account **at the beginning of year 8**;
$8,000 deposited to the account **at the beginning of year 13**; and
$14,653 withdrawn from the account **at the beginning of year 19**.

NOTE 1: Model the growth of the bank account by placing the above vector assignment statement inside a FOR loop that is indexed with the variable t. Begin t at the value 1, and increase t in steps of 1, up to 24. Print out **B(25)** upon exit from the FOR loop; this value will be the solution for this exercise, and represents the dollar balance in the bank account at the beginning of year 25. **PRIOR TO ENTERING THE FOR LOOP, MAKE SURE THAT YOU WRITE THE FOLLOWING ASSIGNMENT STATEMENT:**

```
B(1) = 10000;
```

NOTE 2: Each of the four deposit/withdrawal situations above must be represented by its own IF statement INSIDE THE FOR LOOP. In each IF statement, test the value of `t+1` to see if `t+1` equals the appropriate year. When it does, reassign the value of `B(t+1)` to be its value computed by the vector assignment statement (which represents the account growth due to interest) plus or minus the appropriate dollar amount (plus for a deposit, minus for a withdrawal). For example, the first deposit's IF statement would be written in MATLAB as follows:

```
if (t+1) == 5
   B(t+1) = B(t+1) + 1500;
end
```