Logic and Loops

MATH-151: Mathematical Algorithms in Matlab

August 28, 2023

Formal Logic Statements

- In general, a **logical statement** is a declarative sentence to which one (and only one) of the terms "true" or "false" can be meaningfully applied
  - Air Bud is a dog that plays basketball. (True statement!)
  - $\pi = 3$ (False statement!)
  - This statement is false. (Neither! Can't meaningfully apply true or false)
  - Let's go Air Bud! (This isn't a statement, not declarative)

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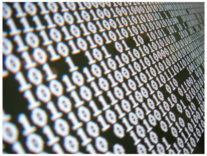
  - This statement is false. (Neither! Can't meaningfully apply true or false)
  - Let's go Air Bud! (This isn't a statement, not declarative)
- Because computers "think" in 1s and 0s, logical statements are very useful in computing.
  - 1 means true. 0 means false.
- Logical statements allows us to turn parts of our code "on" and "off" using control statements



Logical Statements in Code

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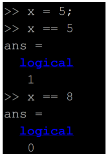
- Equality (==)
    - This returns true if the values on both sides of the == are the same, and false if not
    - Example: We can see if a value is even by seeing if dividing by two gives us an integer

      `x/2 == round(x/2)`



```
>> x = 5;
>> x == 5
ans =
  logical
   1
>> x == 8
ans =
  logical
   0
```

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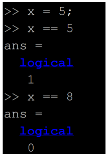
- Inequalities ($>$, $>$=, $<$, $<$=)
  - Checks how one value relates to another
  - Example: Check if grade is an A

    `score >= 93`



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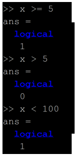

```
>> x >= 5
ans =
  logical
   1
>> x > 5
ans =
  logical
   0
>> x < 100
ans =
  logical
   1
```

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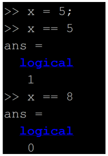
- Not equality ~=
  - This is the opposite of equality.
  - Example: Value is odd if dividing by two is not an integer

    `x/2 ~= round(x/2)`



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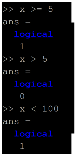

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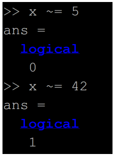

```
>> x ~= 5
ans =
  logical
   0
>> x ~= 42
ans =
  logical
   1
```

If ... Else .. Statements

- Sometimes in life we have contingencies
    - If it is raining, bring an umbrella. Else, don't bring an umbrella.

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  - If there is an odd number of data values, take the center value
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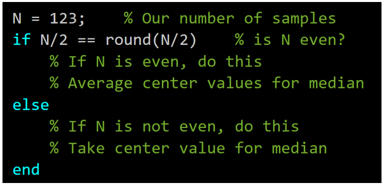
- `if ... else ...` statements in code allow us to do this. See our example for the median



```
N = 123;    % Our number of samples
if N/2 == round(N/2)    % is N even?
    % If N is even, do this
    % Average center values for median
else
    % If N is not even, do this
    % Take center value for median
end
```

Elseif Statements

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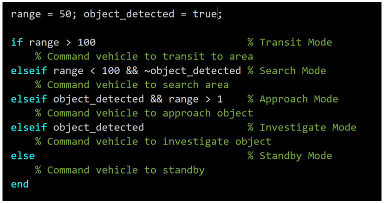
- We can add additional conditions between our `if` and `else` using `elseif`.
- For example my vehicle code controlled differently based on range from object, and whether or not it has detected the object yet



```
range = 50; object_detected = true;

if range > 100                           % Transit Mode
    % Command vehicle to transit to area
elseif range < 100 && ~object_detected % Search Mode
    % Command vehicle to search area
elseif object_detected && range > 1     % Approach Mode
    % Command vehicle to approach object
elseif object_detected                  % Investigate Mode
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else                                     % Standby Mode
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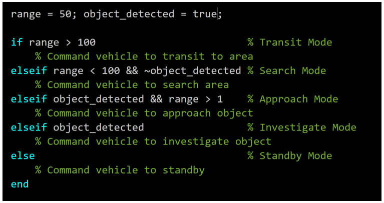

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- The computer starts at the `if` statement, and works its way down the `elseif` statements until one of them are true.

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`xor(p,q)`		`p`	
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- not (`~p`)

`p`	1	0
`~p`	0	1

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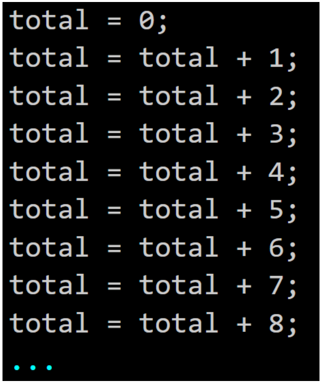

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- That is repetitive and annoying to read and type out. There has to be a better way.

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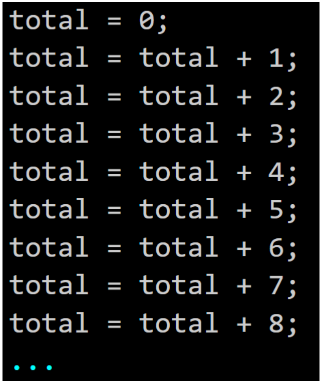

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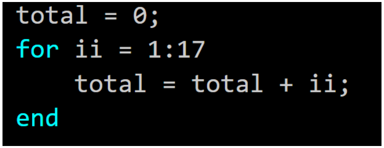
- This is where loops come into play, they allow us to tell the computer to repeat statements that follow a similar structure.

For Loops

- Let's look at that sum of the first 17 integers using a `for` loop



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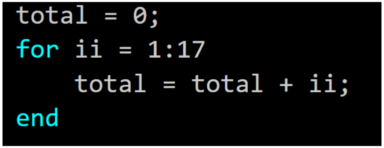

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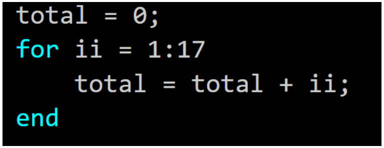

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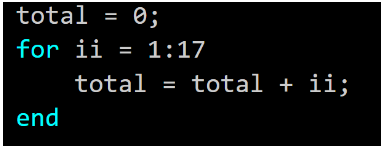

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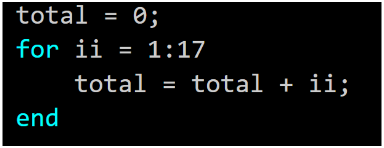

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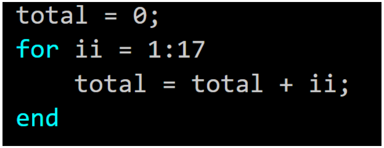

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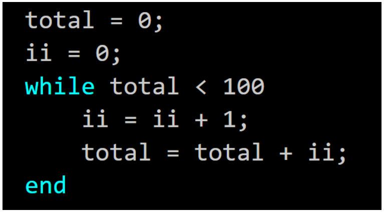
  - `total = total + ii;` takes our current value for `total` and add on our value of `ii` before stepping to our next **iteration**, or repeat of the code.
- Note that we indented the `total = total + ii;` line to indicate it is a line the loop is repeating.

While Loops

- Suppose instead we want to find how many numbers to add up before our sum gets greater than 100, this is a task better left for a `while` loop



```
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ii = 0;
while total < 100
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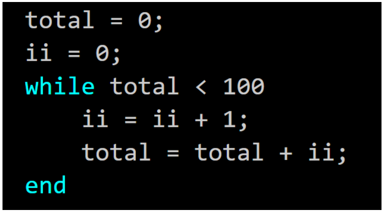

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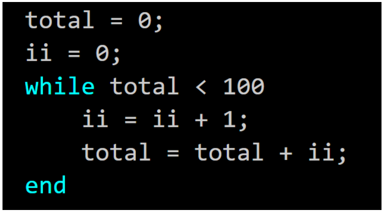

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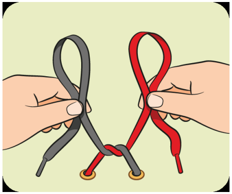
- `while total < 100` tells the computer to repeat the loop while the logical statement `total < 100` is true
- In this case we have to update our **counter** `ii` ourselves. It helps us count how many times the loop is repeated.

When to Use Each Loop

- In general, for any loop you need to perform, you could use either a `for` or `while` loop. But one is usually preferable based on the context
- The general rule of thumb is



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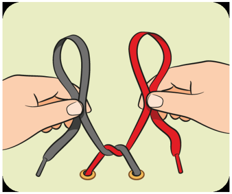

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  - Use a `while` loop when you are repeating the loop until some event occurs