Indicators
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Vectorization
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Functions
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CS368 MATLAB Programming
Lecture 5

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Based on lecture slides by Michael O'Neill and Beck Hasti

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Indicators
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Guess Two-Thirds of the Average Game

Quiz

Indicators
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Comment on Vectorization

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Boolean Variables
Math

- A Boolean variable, also called *logical* variable type in MATLAB, is a variable with two possible values *true* and *false* .

- A Boolean variable is stored as either 1 for *true* or 0 for *false* .

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Indicator Functions
Math

- Indicator functions, also called dummy variables, are functions that return 1 if a condition is satisfied and 0 if the condition is not satisfied.

1. $x == y$ is the indicator of $x = y$, meaning $\begin{cases} 1 & \text{if } x = y \\ 0 & \text{if } x \neq y \end{cases}$.

2. $x \ \tilde{} = y$ is the indicator of $x \neq y$, meaning $\begin{cases} 1 & \text{if } x \neq y \\ 0 & \text{if } x = y \end{cases}$,

   $x \ != y$ does not work in MATLAB.

3. $x > y$, $x >= y$ are indicators of $x > y$ and $x \geqslant y$.

4. $x < y$, $x <= y$ are indicators of $x < y$ and $x \leqslant y$.

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Other Logical Functions
Code

- ~ is not: *~0* is 1 and *~1* is 0.
- *&* is and: *0 & 0* is 0, *0 & 1* is 0, *1 & 0* is 0, *1 & 1* is 1.
- *|* is or: *0 | 0* is 0, *0 | 1* is 1, *1 | 0* is 1, *1 | 1* is 1.
- *==*, *~=*, *<*, *<=*, *>*, *>=*, *~*, *&*, *|* can be applied element-wise to a vector directly.

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Short Circuit Evaluation
Code

- $\&\&$ is and, but only works on scalars.

- $||$ is or, but only works on scalars.

- $\&\&$ and $||$ use short-circuit evaluation, for example, when evaluating $a \ \&\& \ b$, if a is false, then b will not be evaluated, and when evaluating $a \ || \ b$, if a is true, then b will not be evaluated.

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Vector Reduction Logical Functions

Code

- *any(x)* returns whether any of the elements in the matrix or vector *x* is non-zero.
- *all (x)* returns whether all of the elements in the matrix or vector *x* is non-zero.
- *find (x)* finds the index of all the non-zero elements in the vector *x*.
- *find (x, 1)* finds the index of the first non-zero element in the vector *x*.

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Other Reduction Functions
Code

- *sum(x)* and *prod(x)* compute the sum and product of the elements in a matrix or vector *x*.

- *sum(x, 1)* and *prod(x, 1)* compute the column sums and products of the elements in a matrix *x*, for example, *sum([1 2; 3 4], 1)* returns the column sums $\begin{bmatrix} 4 & 6 \end{bmatrix}$.

- *sum(x, 2)* and *prod(x, 2)* compute the row sums and products of the elements in a matrix *x*, for example, *sum([1 2; 3 4], 2)* returns the row sums $\begin{bmatrix} 3 \\ 7 \end{bmatrix}$.

- *mean(x)* computes the average of the numbers in a matrix or vector *x*.

- *max(x)* and *min(x)* compute the maximum and minimum of the elements in a matrix or vector *x*.

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Indicator, Quiz Grade

Quiz

Indicators
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Indicator, Grade Point Average

Quiz

Indicators
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Functions
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Indicator, Letter Grade

Quiz

Indicator, Letter Grades
Quiz

Functions
Math

- A function $y = f(x)$ is a mapping from a list of inputs x, also called arguments or parameters, to a list of outputs y.

- The previous lectures covered many built-in functions in MATLAB, for example, *log* has 1 input and 1 output, $+$ has 2 inputs and 1 output, and *size* has 1 input and 2 outputs.

- New functions can be defined in *.m* files and used in commands.

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Function Definition
Code

- A function with name *f* should be put in a file named *f.m*.
- The first line of the file is *function y = f(x)* or
  function [y1, y2, ...] = f(x1, x2, ...) , where *y* is the
  name or names of the variables to return, and *x* is the list of
  arguments of the function.
- The second line of the file is usually comments describing
  what the function does. Comments start with *%* the line after
  % is not executed by the program.
- The last line of the file should be *end*, but it can be omitted.

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Helper Functions
Code

- Multiple functions can be defined in the same file $f.m$, but only f can be used outside the file in commands.

- The functions in $f.m$ that is not f are helper functions.

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Function Example, Addition
Code

- The addition function $x + y$ is usually written in infix notation (argument 1, then function name, then argument 2).
- The following function is the addition function in prefix notation (function name, then argument 1, then argument 2).

1. *function z = add(x, y)*
2.   *z = x + y;*
3. *end*

- *add(1, 2)* returns **3** .

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Function Example, Linear Combination
Code

- The linear combination of x and y with coefficients u and v is $ux + vy$.
- Sometimes, u, v are not specified, so the default value $u = v = 1$ is used.

1. *function z = lincom(x, y, u, v)*
2.   *arguments*
3.   *x; y; u = 1; v = 1;*
4.   *end*
5.   *z = u ∗ x + v ∗ y;*
6. *end*

- *arguments* block is also used for input validation. More detail in a later lecture.

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Function Example, Linear Combination Too
Code

1. *function z = lincom(x, y, u, v)*

2.   *arguments*

3.   *x; y; u = 1; v = 1;*

4.   *end*

5.   *z = u * x + v * y;*

6. *end*

- *lincom(1, 2, 3, 4)* returns **11** .
- *lincom(1, 2, 3)* returns **5** .
- *lincom(1, 2)* returns **3** .

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Function Example, Max and Min
Code

- Multiple values can be returned from a function, $[y1,\ y2,\ ...,\ yn] = f(x)$ stores the value of i-th output in y_i for $i = 1, 2, ..., n$ and $f(x)$ only returns first output.

1. *function [mx, mn] = mxn(x)*
2. *mx = max(x);*
3. *mn = min(x);*
4. *end*

- *mxn([1, 2, 3])* returns **3**
- *[a b] = mxn([1, 2, 3])* sets *a* to **3** and *b* to **1** .

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Functions, Vector Output
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Functions, Multiple Outputs
Quiz

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