- Previous Lecture:
  - Working with images
- Today's Lecture:
  - Characters and strings
- Announcements:
  - Discussion this week in classrooms as listed on roster
  - Project 4 due Thurs 10/25 at 11pm
  - Prelim 2 on Nov 6th (Tues) at 7:30pm. Email Randy Hess (rbh27) ASAP about any conflict and include information on the conflicting event (course number, instructor name and email, etc.)

Single quotes enclose strings in Matlab

Anything enclosed in single quotes is a string (*even if it looks like something else*)

- `'100'` is a character array (string) of length 3
- `100` is a numeric value
- `'pi'` is a character array of length 2
- `pi` is the built-in constant 3.1416…
- `'x'` is a character (vector of length 1)
- `x` may be a variable name in your program

Characters & strings

- We have used strings already:
  - `n= input('Next number: ')`
  - `sprintf('Answer is %d', ans)`
- A string is made up of individual characters, so a string is a 1-d array of characters
- '`CS1112 rocks!`' is a character array of length 13; it has 7 letters, 4 digits, 1 space, and 1 symbol.

'C'	'S'	'1'	'1'	'1'	'2'	' '	'r'	'o'	'c'	'k'	's'	'!'

- Can have 2-d array of characters as well

'C'	'S'	'1'	'1'	'1'	'2'
'r'	'o'	'c'	'k'	's'	'!'

2×6 matrix

Strings are vectors

Vectors

- Assignment
  ```
  v= [7 0 5];
  ```
- Indexing
  ```
  x= v(3);     % x is 5
  v(1)= 1;     % v is [1 0 5]
  w= v(2:3);   % w is [0 5]
  ```
- : notation
  ```
  v= 2:5;      % v is [2 3 4 5]
  ```
- Appending
  ```
  v= [7 0 5];
  v(4)= 2;     % v is [7 0 5 2]
  ```
- Concatenation
  ```
  v= [v [4 6]];
                % v is [7 0 5 2 4 6]
  ```

Strings

- Assignment
  ```
  s= 'hello';
  ```
- Indexing
  ```
  c= s(2);     % c is 'e'
  s(1)= 'J';   % s is 'Jello'
  t= s(2:4);   % t is 'ell'
  ```
- : notation
  ```
  s= 'a':'g';  % s is 'abcdefg'
  ```
- Appending
  ```
  s= 'duck';
  s(5)= 's';   % s is 'ducks'
  ```
- Concatenation
  ```
  s= [s ' quack'];
                % s is 'ducks quack'
  ```


Matlab types: `char`, `double`, `uint8`, `logical`

There is not a type "string"! What we call a string is a *1-d array of chars*

`a` 'C' 'S' '1'	`a` is a 1-d array with type `char` components. We call `a` a "string" or "char array"
`b = [3 9]`	`b` is a 1-d array with type `double` components. `double` is the default type for numbers in Matlab. We call `b` a "numeric array"
`c = uint8(b)`	`c` is a 1-d array with type `uint8` components. We call `c` a "uint8 array"
`d = rand > .5`	`d` is a scalar of the type `logical`. We call `d` a "boolean value"

Some useful string functions

```
str= 'Cs 1112';

length(str)   % 7
isletter(str) % [1 1 0 0 0 0 0]
isspace(str)  % [0 0 1 0 0 0 0]
lower(str)    % 'cs 1112'
upper(str)    % 'CS 1112'

ischar(str)
  % Is str a char array? True (1)
strcmp(str(1:2),'cs')
  % Compare strings str(1:2) & 'cs'. False (0)
strcmp(str(1:3),'CS')
  % False (0)
```

Example: capitalize 1st letter

Write a function to capitalize the first letter of each word in a string. Assume that the string has lower case letters and blanks only. (OK to use built-in function **upper**)

```
function [str, nCaps] = caps(str)
% Post: Capitalize first letter of each word.
%    str = partially capitalized string
%    nCaps = no. of capital letters
% Pre: str = string with lower case letters & blanks only
```

```
look for   the  spaces
Look For   The  Spaces
```

See `caps.m`

Arithmetic and relational ops on characters

- `'c'-'a'` gives 2
- `'6'-'5'` gives 1
- `letter1='e'; letter2='f';`
- `letter1-letter2` gives -1

- `'c'>'a'` gives true
- `letter1==letter2` gives false

- `'A' + 2` gives 67
- `char('A'+2)` gives 'C'

ASCII characters

(American Standard Code for Information Interchange)

ascii code	*Character*	*ascii code*	*Character*
:	:	:	:
:	:	:	:
65	'A'	48	'0'
66	'B'	49	'1'
67	'C'	50	'2'
:	:	:	:
90	'Z'	57	'9'
:	:	:	:

What is in variable g (if it gets created)?

```
d1= 'Mar 3';  d2= 'Mar 9';
x1= d1(5);  x2= d2(5);
g= x2-x1;
```

A: the character '6'

B: the numeric value 6

C: Error in the subtraction operation

D: Error in assigning variables x1, x2

E: Some other value or error

Character vs ASCII code

```
str= 'Age 19'
    %a 1-d array of characters
code= double(str)
    %convert chars to ascii values
str1= char(code)
    %convert ascii values to chars
```


What is in variable g (if it gets created)?

```
d1= 'Mar 13';  d2= 'Mar 29';
x1= d1(5:6);  x2= d2(5:6);
g= x2-x1;
```

A: the string '16'

B: the numeric value 16

C: Error in the subtraction operation

D: Error in assigning variables x1, x2

E: Some other value or error

Example: toUpper

Write a function toUpper(cha) to convert character cha to upper case if cha is a lower case letter. Return the converted letter. If cha is not a lower case letter, simply return the character cha.

Hint: Think about the distance between a letter and the base letter 'a' (or 'A'). E.g.,

a b c d e f g h …

distance = 'g'-'a' = 6 = 'G'-'A'

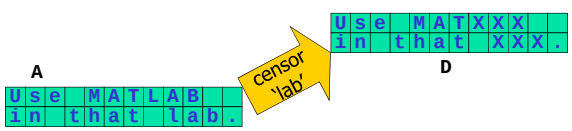
A B C D E F G H …

Of course, do not use Matlab function upper!


```
function up = toUpper(cha)
% up is the upper case of character cha.
% If cha is not a letter then up is just cha.
```


Example: censoring words

```
function D = censor(str, A)
% Replace all occurrences of string str in
% character matrix A with X's, regardless of
% case.
% Assume str is never split across two lines.
% D is A with X's replacing str.
```




```
function D = censor(str, A)
% Replace all occurrences of string str in character matrix A,
% regardless of case, with X's.
% A is a matrix of characters.
% str is a string.  Assume that str is never split across two lines.
% D is A with X's replacing the censored string str.

D= A;
B= lower(A);
s= lower(str);
ns= length(str);
[nr,nc]= size(A);

% Build a string of X's of the right length



% Traverse the matrix to censor string str
```


Example: removing all occurrences of a character

- From a genome bank we get a sequence
  ATTG CCG TA GCTA CGTACGC AACTGG AAATGGC CGTAT…
- First step is to "clean it up" by removing all the blanks. Write this function:

```
function s = removeChar(c, s)
% Return string s with all occurrences
% of character c removed
```


Example: removing all occurrences of a character

Can solve this problem using iteration—check one character (one component of the vector) at a time

```
function s = removeChar_loop(c, s)
% Return string s with all occurrences of
% character c removed.
```