15. Strings

Operations
Subscripting
Concatenation
Search
Numeric-String Conversions

Built-Ins: `int2str`,`num2str`, `str2double`

Previous Dealings

```
N = input( 'Enter Degree:' )

title('The Sine Function')

disp( sprintf('N = %2d',N) )
```

A String is an Array of Characters

‘Aa7*>@ x!’

A	a	7	*	>	@		x	!

This string has length 9.

Why Important

1. Numerical Data often encoded as strings
2. Genomic calculation/search

Numerical Data is Often Encoded in Strings

For example, a file containing
Ithaca weather data begins with the string

W07629N4226

Longitude: 76° 29’ West
Latitude: 42° 26’ North

What We Would Like to Do

W07629N4226

Get hold of the substring ‘07629’

Convert it to floating format so that
it can be involved in numerical calculations.

Format Issues

9 as an IEEE floating point number:

0100000blablahblah01001111000100010010

9 as a character:

01000otherblabla

Different Representation

Genomic Computations

Looking for patterns in a DNA sequence:

```
'ATTCTGACCTCGATC'
      ACCT
```

Genomic Computations

Quantifying Differences:

```
ATTCTGACCTCGATC
ATTGCTGACCTCGAT
```

Remove?

Working With Strings

Strings Can Be Assigned to Variables

```
S = 'N = 2'
```

'N = 2'
S

```
N = 2;
S = sprintf('N = %1d',N)
```

sprintf produces a formatted string using fprintf rules

Strings Have a Length

```
s = 'abc';
n = length(s);  % n = 3

s = '';         % the empty string
n = length(s)   % n = 0

s = ' ';        % single blank
n = length(s)   % n = 1
```

Concatenation

This:

```
S = ‘abc’;
T = ‘xy’
R = [S T]
```

is the same as this:

```
R = ‘abcxy’
```

Repeated Concatenation

This:

```
s = ‘’;
for k=1:5
   s = [s ‘z’];
end
```

is the same as this:

```
z = ‘zzzzz’
```

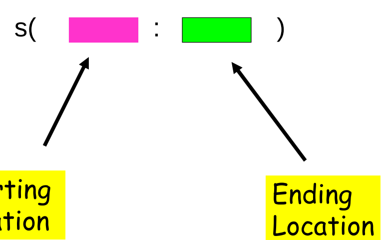
Replacing and Appending Characters

```
s = ‘abc’;
s(2) = ‘x’         %  s = ‘axc’

t = ‘abc’
t(4) = ‘d’        %  t = ‘abcd’

v = ‘’
v(5) = ‘x’        %  v = ‘    x’
```

Extracting Substrings

```
s = ‘abcdef’;

x  = s(3)          %   x = ‘c’
x  = s(2:4)        %   x = ‘bcd’
x  = s(length(s))  %   x = ‘f’
```

Colon Notation



Replacing Substrings

```
s = ‘abcde’;
s(2:4) = ‘xyz’   % s = ‘axyze’

s = ‘abcde’
s(2:4) = ‘wxyz’     % Error
```

Question Time

```
s = 'abcde';
for k=1:3
    s = [ s(4:5) s(1:3)];
end
```

What is the final value of s ?

A abcde   B. bcdea   C. eabcd   D. deabc

Problem: DNA Strand

x is a string made up of the characters 'A', 'C', 'T', and 'G'.

Construct a string Y obtained from x by replacinig each A by T, each T by A, each C by G, and each G by C

```
x: ACGTTGCAGTTCCATATG
y: TGCAACGTCAAGGTATAC
```

```
  function y = DNA(x)
% x is a string consisting of
% the characters A, C, T, and G.
% y is a string obtained by
% replacing A by T, T by A,
% C by G and G by C.
```

Comparing Strings

Built-in function **strcmp**

strcmp(s1,s2) is true if the strings **s1** and **s2** are identical.

How **y** is Built Up

```
x: ACGTTGCAGTTCCATATG
y: TGCAACGTCAAGGTATAC
```

Start:	**y: ''**
After 1 pass:	**y: T**
After 2 passes:	**y: TG**
After 3 passes:	**y: TGC**

```
for k=1:length(x)
   if strcmp(x(k),'A')
       y = [y 'T'];
   elseif strcmp(x(k),'T')
       y = [y 'A'];
   elseif strcmp(x(k),'C')
       y = [y 'G'];
   else
       y = [y 'C'];
   end
end
```

A DNA Search Problem

Suppose S and T are strings, e.g.,

```
S: 'ACCT'

T: 'ATGACCTGA'
```

We'd like to know if S is a substring of T and if so, where is the first occurrance?

```
  function k = FindCopy(S,T)
% S and T are strings.
% If S is not a substring of T,
%       then k=0.
% Otherwise, k is the smallest
% integer so that S is identical
% to T(k:k+length(S)-1).
```

A DNA Search Problem

```
S: 'ACCT'

T: 'ATGACCTGA'

strcmp(S,T(1:4))   False
```

A DNA Search Problem

```
S: 'ACCT'

T: 'ATGACCTGA'

strcmp(S,T(2:5))   False
```

A DNA Search Problem

```
S: 'ACCT'

T: 'ATGACCTGA'

strcmp(S,T(3:6))   False
```

A DNA Search Problem

```
S: 'ACCT'

T: 'ATGACCTGA'

strcmp(S,T(4:7)))   True
```

Pseudocode

```
First = 1; Last = length(S)
while S is not identical to T(First;Last)
    First = First + 1;
    Last  = Last + 1
end
```

Subscript Error

```
S: 'ACCT'

T: 'ATGACTGA'

strcmp(S,T(6:9))
```

There's a problem if S is not a substring of T.

Pseudocode

```
First = 1; Last = length(s)

while Last<=length(T) &&  …
       ~strcmp(S,T(First:Last))

    First = First + 1;
    Last  = Last + 1
end
```

Post-Loop Processing

Loop ends when this is false:

```
Last<=length(T) &&  …
       ~strcmp(S,T(First:Last))
```

Post-Loop Processing

```
if Last>length(T)
   % No Match found
   k=0;
else
   % There was a match
   k=First;
end
```

The loop ends for one of two reasons.

Numeric/String Conversion

String-to-Numeric Conversion

An example…

Convention:

`W07629N4226`

Longitude: **76º 29’** West
Latitude: **42º 26’** North

String-to-Numeric Conversion

```
S = ‘W07629N4226’
s1 = s(2:4);
x1 = str2double(s1);
s2 = s(5:6);
x2 = str2double(s2);
Longitude = x1 + x2/60
```

There are 60 minutes in a degree.

Numeric-to-String Conversion

```
x = 1234;
s = int2str(x);          % s = ‘1234’

x = pi;
s = num2str(x,’%5.3f’);   %s =‘3.142’
```

Problem

Given a date in the format

‘mm/dd’

specify the next day in the same format

`Y = Tomorrow(x)`

x	y
02/28	03/01
07/13	07/14
12/31	01/01

Get the Day and Month

```
month = str2double(x(1:2));
day   = str2double(x(4:5));
```

Thus, if x = ’02/28’ then month is assigned the numerical value of 2 and day is assigned the numerical value of 28.

```
L = [31 28 31 30 31 30 31 31 30 31 30 31];

if day+1<=L(month)
%   Tomorrow is in the same month
      newDay = day+1;
      newMonth = month;
```

```
L = [31 28 31 30 31 30 31 31 30 31 30 31];

else
%      Tomorrow is in the next month
       newDay = 1;
       if month <12
           newMonth = month+1;
       else
           newMonth = 1;
       end
```

The New Day String

Compute newDay (numerical) and convert…

```
d = int2str(newDay);
if length(d)==1
   d = ['0' d];
end
```

The New Month String

Compute newMonth (numerical) and convert…

```
m = int2str(newMonth);
if length(m)==1;
   m = ['0' m];
end
```

The Final Concatenation

```
y = [m '/' d];
```