- Previous Lecture:
  - Iteration using while

- Today's Lecture:
  - Nested loops
  - Developing algorithms

- Announcements:
  - Discussion this week in computer labs. Read Insight §3.2 before discussion section.
  - Project 2 due Monday at 11 pm
  - We do not use break in this course
  - Make use of Piazza, office hrs, and consulting hrs

### Common loop patterns

**Do something $n$ times**

```matlab
for k=1:n
    % Do something
end
```

**Do something an indefinite number of times**

```matlab
while (not stopping signal)
    % Do something
    % Update loop variables
end
```

### for-loop or while-loop: that is the question

- **for-loop**: loop body repeats a fixed (predetermined) number of times.

- **while-loop**: loop body repeats an indefinite number of times under the control of the "loop guard."

```matlab
x = 1;
disp(x)
y = x;
while y==x && x<=4 && y<=4
    x = 2*x;
disp(x)
end
```

What is the last line of output?

A: 1  B: 2  C: 4  D: 8

### What will be displayed when you run the following script?

```matlab
for k = 4:6
    disp(k)
k= 9;
disp(k)
end
```

4 9 4 4 4 9 4

A  B  C

### Review loops/conditionals using user-defined graphics function

Draw a black square;
then draw a magenta disk;
then draw a yellow star.
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\[
\begin{align*}
\text{DrawRect}(-1,-2,6,3,\text{,'y'})
\end{align*}
\]

\[
\begin{align*}
\text{x and y coordinates} & \quad \text{width} \quad \text{height} \\
\text{of lower left corner} & 
\end{align*}
\]

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\[
\begin{align*}
\text{DrawDisk}(1,3,4,\text{,'r'})
\end{align*}
\]

\[
\begin{align*}
\text{x and y coordinates} & \quad \text{radius} \\
\text{of the center} & 
\end{align*}
\]

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\[
\begin{align*}
\text{DrawStar}(1,3,4,\text{,'g'})
\end{align*}
\]

\[
\begin{align*}
\text{x and y coordinates} & \quad \text{"radius"} \\
\text{of the center} & 
\end{align*}
\]

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**Color Options**

- White \ (\text{,'w'})
- Black \ (\text{,'k'})
- Red \ (\text{,'r'})
- Blue \ (\text{,'b'})
- Green \ (\text{,'g'})
- Yellow \ (\text{,'y'})
- Magenta \ (\text{,'m'})
- Cyan \ (\text{,'c'}}

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A simple 3-line script

\[
\begin{align*}
\text{DrawRect}(\ldots) \\
\text{DrawDisk}(\ldots) \\
\text{DrawStar}(\ldots)
\end{align*}
\]

\vspace{1cm}

\[
\begin{align*}
\% \text{drawDemo} \\
\text{close all} \\
\text{figure} \\
\text{axis equal off} \\
\text{hold on} \\
\text{DrawRect}(0,0,2,2,\text{,'k'}) \\
\text{DrawDisk}(1,1,1,\text{,'m'}) \\
\text{DrawStar}(1,1,1,\text{,'y'}) \\
\text{hold off}
\end{align*}
\]
A general graphics framework

```matlab
% drawDemo
close all
figure
axis equal off
hold on
hold on
Code fragment to draw the objects (rectangle, disk, star)

Code fragment to draw the objects (rectangle, disk, star)

hold off
```

Example: Nested Stars

Knowing how to draw

How difficult is it to draw

Pattern for doing something \( n \) times

```matlab
n = _____
for k = 1:n
% code to do
% that something
end
```

Example: Are they prime?

Subproblem: Is it prime?

- Given integers \( a \) and \( b \), write a program that lists all the prime numbers in the range \([a, b]\).
- Assume \( a \geq 1 \), \( b \geq 1 \) and \( a < b \).
- Write a program fragment to determine whether a given integer \( n \) is prime, \( n > 1 \).
- Reminder: \( \text{rem}(x, y) \) returns the remainder of \( x \) divided by \( y \).
Example: Times Table

Write a script to print a times table for a specified range.

Row headings:

Column headings:

Developing the algorithm for the times table

Rational approximation of \( \pi \)

- \( \pi = 3.141592653589793\ldots \)
- Can be closely approximated by fractions, e.g., \( \pi \approx 22/7 \)
- Rational number: a quotient of two integers
- Approximate \( \pi \) as \( p/q \) where \( p \) and \( q \) are positive integers \( \leq M \)
- Start with a straightforward solution:
  - Get \( M \) from user
  - Calculate quotient \( p/q \) for all combinations of \( p \) and \( q \)
  - Pick best quotient \( \rightarrow \) smallest error

```matlab
% Rational approximation of pi
M = input('Enter M: ');

% Check all possible denominators
for q = 1:M
    % At this q, check all possible numerators
    for p = 1:M
        % Code to calculate p/q
    end
end
```