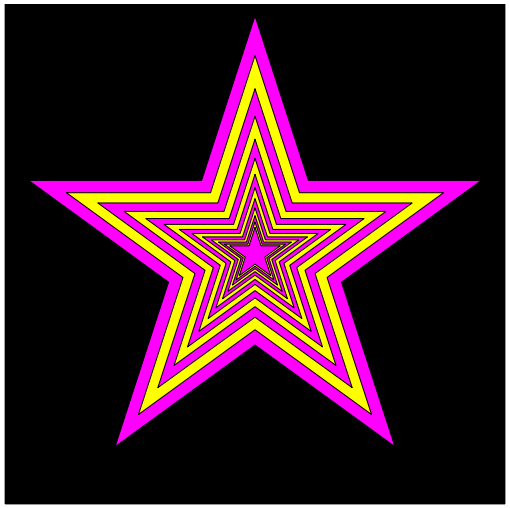
- Previous Lecture:
  - Iteration using `while`
- Today's Lecture:
  - Nested loops
  - Developing algorithms
- Announcements:
  - Read *Insight* §3.2 before discussion next week in the lab
  - Project 2 Parts A & B due Thurs 9/20 at 11pm
  - We do not use `break` in this course
  - Make use of Piazza, office hrs, and consulting hrs

# What is the last line of output?

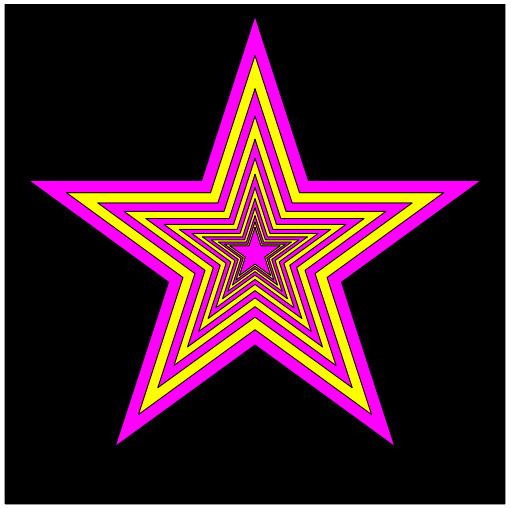
```
x = 1;
disp(x)
y = x;
while y==x && x<=4 && y<=4
    x = 2*x;
    disp(x)
end
```

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

# Example: Nested Stars



## Example: Nested Stars



Draw a black square

-Bigger than the biggest star (at least 2 times radius of star)

- Center at (0,0)

Draw a sequence of stars

-Stars alternate in color

-Stars get smaller

  - radius r=1 to start

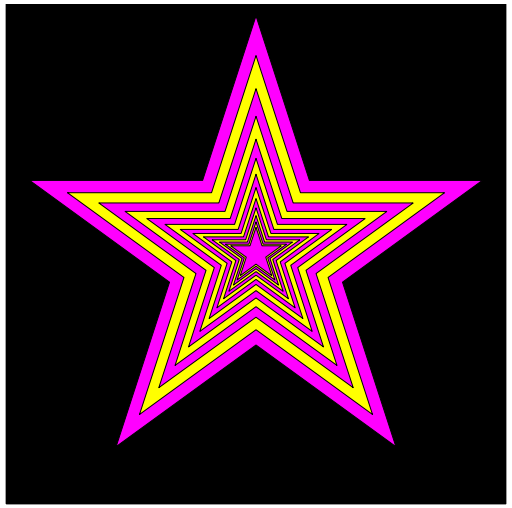
-1st star smaller than the sqr

-When to stop?

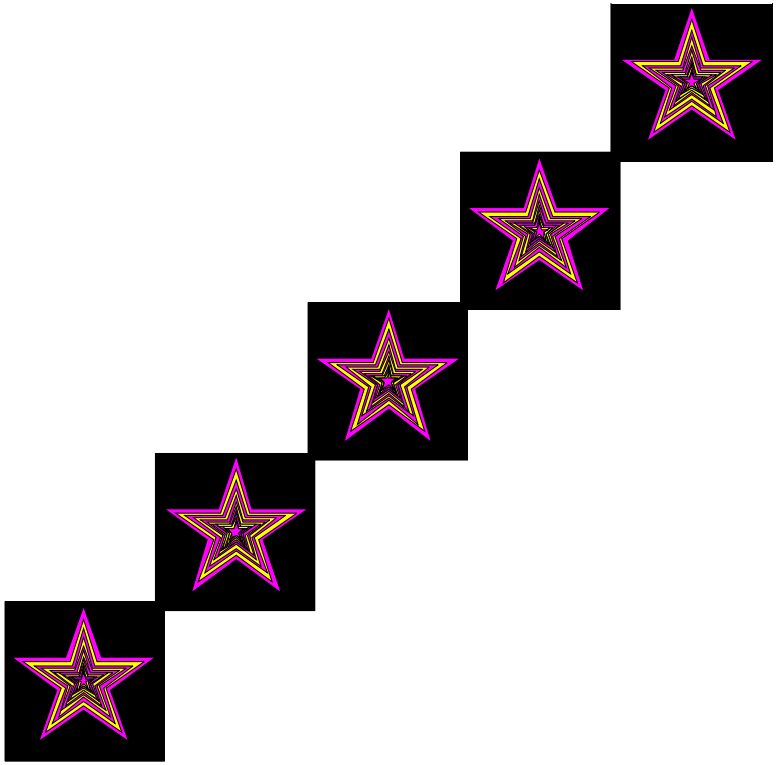
  - when r is small

# nestedStars.m

# Knowing how to draw



## How difficult is it to draw



# Pattern for doing something *n* times

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

```
x= 0; y= 0; % figure centered at (0,0)

s= 2.1;   % side length of square
DrawRect(x-s/2,y-s/2,s,s,'k')

r= 1;  k= 1;
while  r > 0.1   %r still big
   % draw a star
   if rem(k,2)==1  %odd number
      DrawStar(x,y,r,'m')  %magenta
   else
      DrawStar(x,y,r,'y')  %yellow
   end
   % reduce r
   r= r/1.2;
   k= k + 1;
end
```

```
for c = 0:2:8
    x= c; y= c; % figure centered at (c,c)
    s= 2.1;   % side length of square
    DrawRect(x-s/2,y-s/2,s,s,'k')

    r= 1;  k= 1;
    while  r > 0.1   %r still big
       % draw a star
       if rem(k,2)==1  %odd number
          DrawStar(x,y,r,'m')  %magenta
       else
          DrawStar(x,y,r,'y')  %yellow
       end
       % reduce r
       r= r/1.2;
       k= k + 1;
    end
end
```

# Pattern for doing something *n* times

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

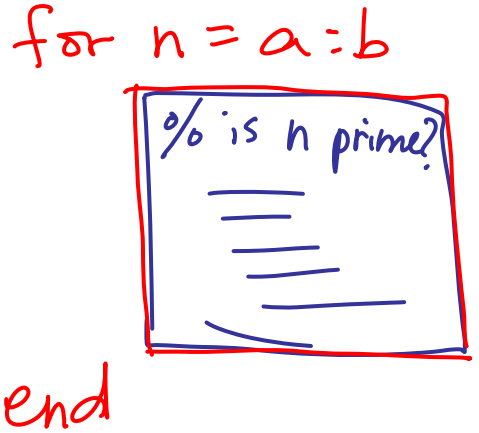
# Example: Are they prime?

- Given integers a and b, write a program that lists all the prime numbers in the range [a, b].
- Assume a>1, b>1 and a<b.

# 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>1, b>1 and a<b.
- Write a program fragment to determine whether a given integer n is prime, n>1.
- Reminder: rem(x,y) returns the remainder of x divided by y.

# 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>1, b>1 and a<b.
- Write a program fragment to determine whether a given integer n is prime, n>1.
- Reminder: rem(x,y) returns the remainder of x divided by y.

Start:

divisor = 2

Repeat:

rem(n, divisor)
divisor = divisor + 1

End:

rem(n, divisor) == 0

divisor ← n ?

```
divisor = 2;
while (rem(n,divisor) ~= 0)
    divisor = divisor + 1;
end
if (divisor == n)
    disp('prime')
else
    disp('composite')
end
```

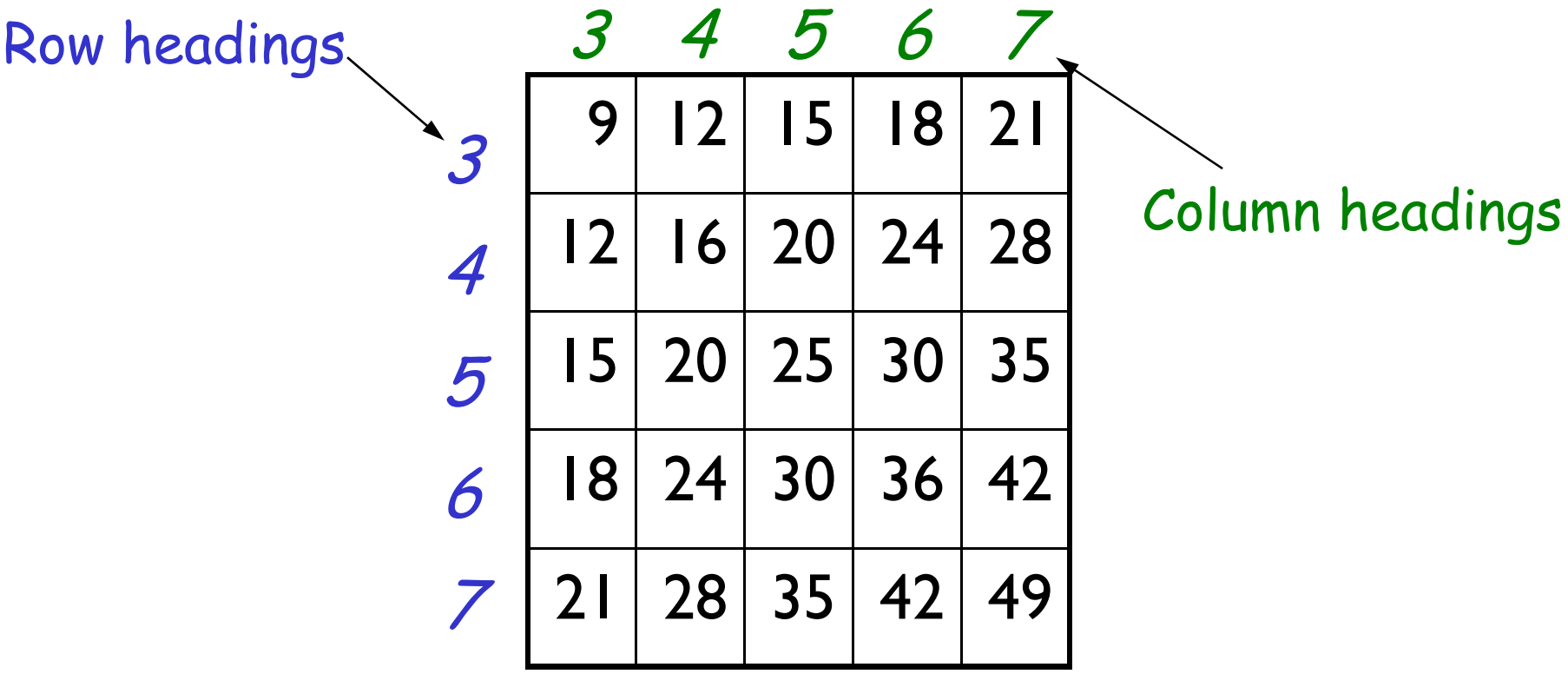
```
%Given n, display whether it is prime
divisor= 2;
while ( rem(n,divisor)~=0 )
     divisor= divisor + 1;
end
if (divisor==n)
     fprintf('%d is prime\n', n)
else
     fprintf('%d is composite\n', n)
end
```

```
for  n = a:b
    %Given n, display whether it is prime
    divisor= 2;
    while ( rem(n,divisor)~=0 )
        divisor= divisor + 1;
    end
    if (divisor==n)
        fprintf('%d is prime\n', n)
    else
        fprintf('%d is composite\n', n)
    end

end
```

# Example: Times Table

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



# Developing the algorithm for the times table

| | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| 3 | 9 | 12 | 15 | 18 | 21 |
| 4 | 12 | 16 | 20 | 24 | 28 |
| 5 | 15 | 20 | 25 | 30 | 35 |
| 6 | 18 | 24 | 30 | 36 | 42 |
| 7 | 21 | 28 | 35 | 42 | 49 |

# Developing the algorithm for the times table

| | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| 3 | 9 | 12 | 15 | 18 | 21 |
| 4 | 12 | 16 | 20 | 24 | 28 |
| 5 | 15 | 20 | 25 | 30 | 35 |
| 6 | 18 | 24 | 30 | 36 | 42 |
| 7 | 21 | 28 | 35 | 42 | 49 |

- Look for patterns
  - Each entry is row# × col#
  - Row#, col# increase regularly
- ⇒ Loop!!!
- What kind of loop?
  - for-loop—since the range of the headings will be specified and increment regularly
  - for each row#, get the products with all the col#s. Then go to next row# and get products with all col#s, …
  - ⇒ Nested loops!
- Details: what will be the print format? Don't forget to start new lines. Also need initial input to specify the range.

```
disp('Show the times table for specified range')
lo= input('What is the lower bound? ');
hi= input('What is the upper bound? ');
```

# Rational approximation of $\pi$

- $\pi$ = 3.141592653589793…
- 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 ≤M
- Start with a straight forward solution:
  - Get M from user
  - Calculate quotient p/q for all combinations of p and q
  - Pick best quotient → smallest error