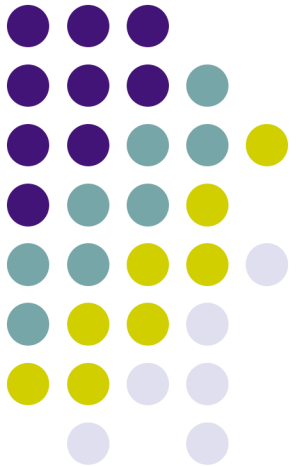
Principles of Computer Science I

Prof. Nadeem Abdul Hamid

CSC 120 – Fall 2006

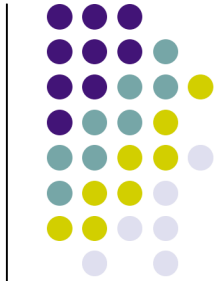
Lecture Unit 7 - Iteration



Lecture Outline

- Programming loops (iteration)
- Simple GUI animation
- Understand common loop errors
- Nested loops
- Processing input
- File input/output
- Random numbers and simulations

Cannonball



- Exercise P7.3
- Cannonball.java
- CannonTester.java

`while` Loop

- Looping = Iteration = Repetition

```
while ( condition )
   statement
```

- `while` statement repeatedly executes a block of code as long as condition is true

```
double curTime = 0.00;
while ( curTime <= 20.0 ) {
   ball.updatePosition( deltaT );
   curTime += deltaT;
}
```

Counting Program

```
int count, number, sum;

System.out.println( "Enter a number to count up to: " );
Scanner in = new Scanner( System.in );
number = in.nextInt();

count = 1;
sum = 0;
while ( count <= number ) {
   System.out.println( count );
   sum += count;
   count++;
}

System.out.println();
System.out.println( "The sum is: " + sum );
```

Counting Program

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Scanner in = new Scanner( System.in );
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count = 1;
sum = 0;
while ( count <= number ) {
   System.out.println( count );
   sum += count;
   count++;
}

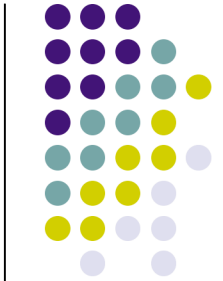
System.out.println();
System.out.println( "The sum is: " + sum );
```

Initialization

Termination test

Loop body

Side Topic: Simple GUI Animation



- Basic idea: Add a Timer object to your component class
  - Every time the timer goes off (e.g. 10 msec) update the display

- Imports needed

```
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;
import javax.swing.JComponent;
import javax.swing.Timer;
```

- CannonballComponent.java
- CannonballViewer.java

GUI Animation Skeleton

```
public class ComponentName
  extends JComponent
  implements ActionListener {
   . . .

   /**
    Starts the timer going by constructing a Timer object with the
    frequency (in milliseconds) of Timer activations and the object ('this')
    that will be handling the Timer events
    */
   public void animate() {
      timer = new Timer( (int)Math.round(deltaT * 1000), this );
      timer.start();
   }

   /**
    Processes a Timer activation event
    */
   public void actionPerformed( ActionEvent e ) {
      // Code to update the state of the object
      // should go here
      . . .

      repaint();     // repaint the component on the screen
   }

   Timer timer;             // timer instance variable
   . . . // other instance variables (fields)
}
```

Infinite Loops

Infinite Loops

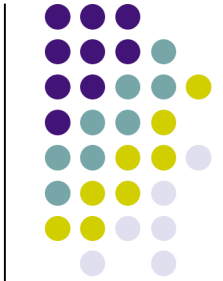
```
count = 1;
sum = 0;
while ( count <= number ) {
  System.out.println( count );
  sum += count;
}
```

Infinite Loops

```
count = 1;
sum = 0;
while ( count <= number ) {
  System.out.println( count );
  sum += count;
}
```

```
// (two errors in this code?)
count = number;  // count down from number
sum = 0;
while ( count <= number ) {
  System.out.println( count );
  sum += count;
  count++;
}
```

Infinite Loops



```
count = 1;
sum = 0;
while ( count <= number ) {
  System.out.println( count );
  sum += count;
}
```

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// (two errors in this code?)
count = number;  // count down from number
sum = 0;
while ( count <= number ) {
  System.out.println( count );
  sum += count;
  count++;
}
```
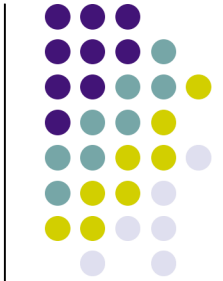

- Stop a running program using ‘Ctrl’+ ‘c’ keys

Off-by-One Errors



```
count = 1;
sum = 0;
while ( count < number ) {
   count++;
   System.out.println( count );
   sum += count;
}
```

- Common type of error when programming loops
- Work through simple test cases to avoid these errors
- Common issues:
  - Should variable start at 0 or 1 ?
  - Should test condition be < or <= ?
  - Where should the loop variable be updated?

- Note: when processing strings, loops often start at 0 and use <

do Loop

- Executes the loop body at least once

```
do
   statement
while ( condition );
```

- Common use: Validating input

```
double value;
do {
   System.out.print( "Please enter a positive number: " );
   value = in.nextDouble();
} while (value <= 0);
 . . .
```

Replacing do with while

- Introduce a boolean control variable

```
double value;

boolean done = false;
while ( !done ) {
    System.out.print( "Please enter a positive number: ” );
    value = in.nextDouble();

    if ( value > 0 ) done = true;
}
. . .
```

Replacing do with while

- Introduce a boolean control variable

```
double value;

boolean done = false;
while ( !done ) {
    System.out.print( "Please enter a positive number: " );
    value = in.nextDouble();

    if ( value > 0 ) done = true;
}
. . .
```

A Common Loop Idiom

```
i = start;
while ( i <= end ) {
    . . .
    i++;
}
```

- Special syntax supports this idiom

```
for ( i = start; i <= end; i++ ) {
    . . .
}
```

for Loop

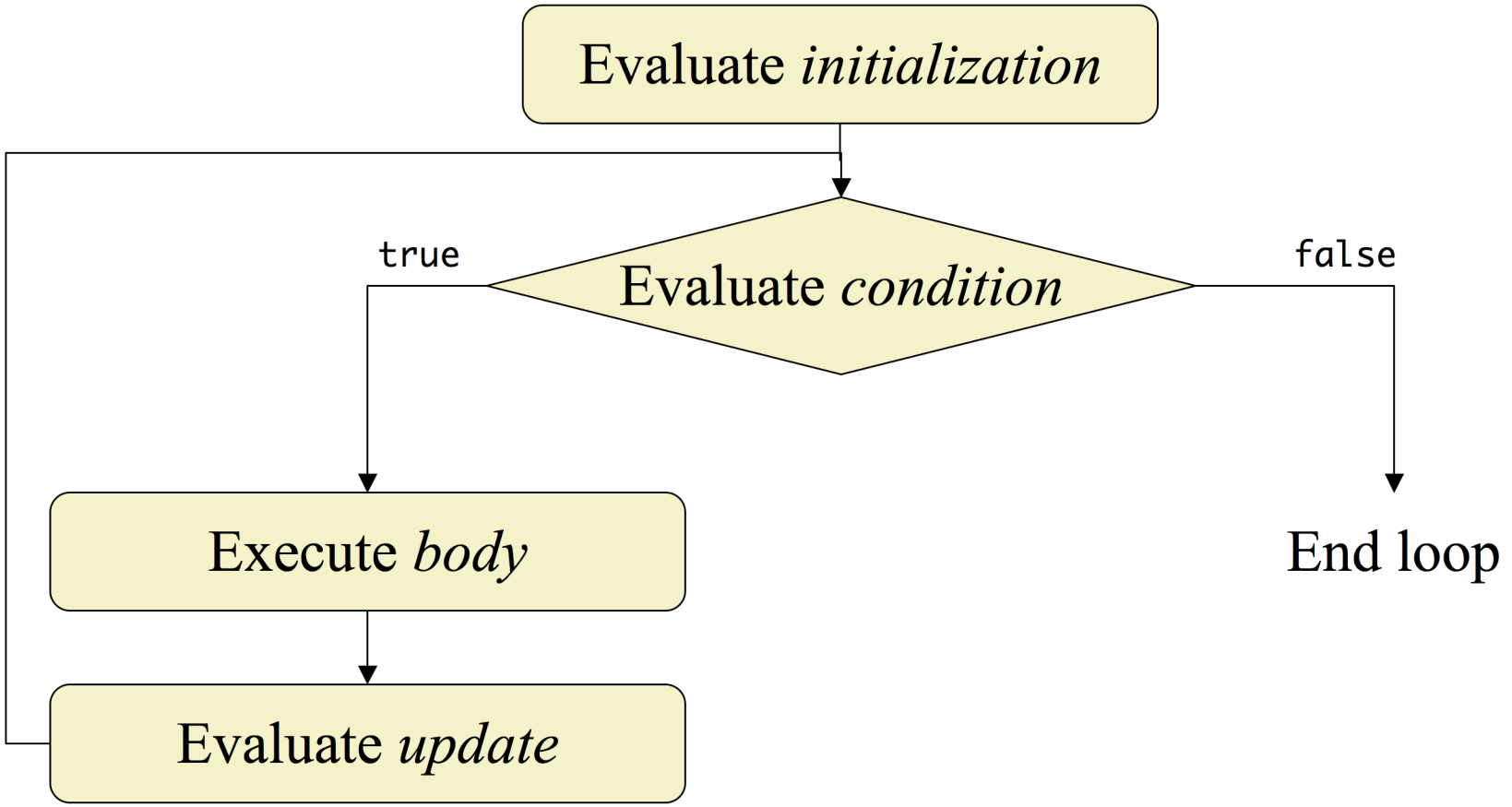
```
for ( initialization ; condition ; update )
   statement
```

- Use a `for` loop when a variable runs from a starting to end value with constant increment or decrement
- Easy to abuse `for` notation – any expressions can be put in the header

```
for ( rate = 5; years-- > 0;
                  System.out.print(balance) ) . . .
```

How for Loops Work

```
for ( initialization ; condition ; update )
   body
```



for Loops: Common Errors

- Extra semicolon

```
sum = 0;
for ( i = 1; i <= 10; i++ );
   sum = sum + i;
System.out.println(sum);
```

- Missing semicolon

```
for (years = 1; (balance = balance + balance *
                    rate / 100) < targetBalance; years++)
System.out.println(years);
```

- Using != condition instead of <=

```
for ( i = 1; i != 10; i+=2 ) . . .
```

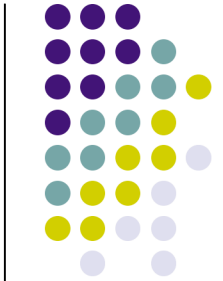
Variable Scope in `for` Loops

- Scope: the area of code in which an identifier (name) is defined/can be used

- Possible to declare a new variable in the header of a `for` loop - only has scope within the loop

```
for ( int i = 1; i <= n; i++ ) {
    . . .
}
// i is no longer defined here
```

Commas in for Statements



- Header of a `for` loop can contain multiple initializations/updates, separated by commas
- For example, this code:

```
product = 1;
for ( n = 1; n <= 10; n++ )
    product = product * n;
```

- Can be rewritten as:

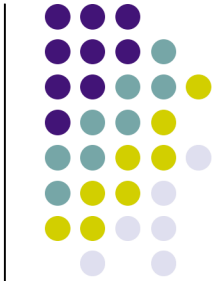
```
for ( n=1, product=1; n<=10; product=product*n, n++ )
    ;
```

- Considered 'clever' but not necessarily good coding practice

Fibonacci Numbers

- Write a program to compute the n’th Fibonacci number

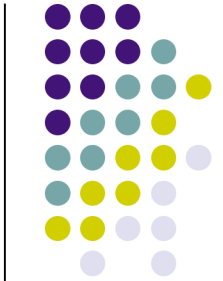
Fibonacci Numbers



- Write a program to compute the n'th Fibonacci number

```
f1 = 1;
f2 = 1;

cur = 3;
while ( cur <= n ) {
    long fnew = f1 + f2;
    f1 = f2;
    f2 = fnew;
    cur++;
}

System.out.println( n + "th Fibonnaci number is: " + f2 );
```

Fibonacci Numbers



- Write a program to compute the n'th Fibonacci number

```
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f2 = 1;

cur = 3;
while ( cur <= n ) {
    long fnew = f1 + f2;
    f1 = f2;
    f2 = fnew;
    cur++;
}
```
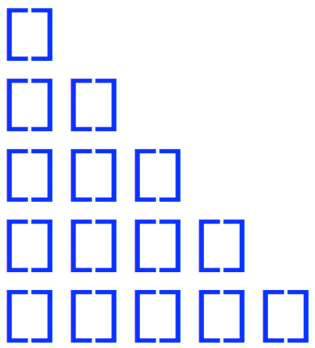

```
f1 = 1;
f2 = 1;

for ( cur = 3; cur <= n; cur++ ) {
    long fnew = f1 + f2;
    f1 = f2;
    f2 = fnew;
}
```

```
System.out.println( n + "th Fibonnaci number is: " + f2 );
```

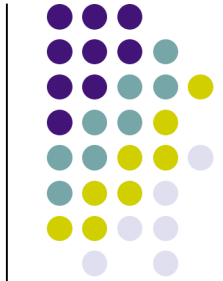
Nested Loops

- Often one loop may be *nested* (contained) in another
  - Typical example: Printing table of rows and columns

- Write a program to print out a triangular shape, given a maximum width (e.g. 5):

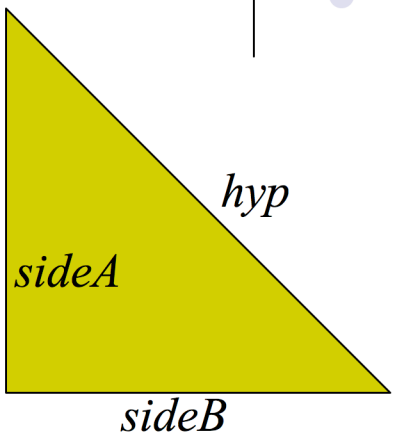


Nested Loops



- Pythagorean Triples
  - Set of integer values such that

$$sideA^2 + sideB^2 = hyp^2$$



- Write a program to find all such triples, where the side lengths are less than 100

- *PythagTriples.java*

Processing Sentinel Values

- Sentinel: value that is not valid input and indicates the end of input
  - `0` or `-1` are not always good sentinel values

```
Enter value, Q to quit: 1
Enter value, Q to quit: 2
Enter value, Q to quit: 3
Enter value, Q to quit: 4
Enter value, Q to quit: Q
Average = 2.5
Maximum = 4.0
```

- *DataSet.java*

Loop and a Half

- Sometimes the termination condition can only be checked in the middle of a loop
  - Then, introduce a boolean variable to control the loop

```
boolean done = false;
while ( !done ) {
   System.out.print( "Enter value, Q to quit: " );
   String input = in.next();
   if ( input.equalsIgnoreCase( "Q" ) )
      done = true;
   else {
      double x = Double.parseDouble( input );
      data.add(x);
   }
}

System.out.println("Average = " + data.getAverage());
System.out.println("Maximum = " + data.getMaximum());
```

`break` Statement

- Used to break out of a `switch` statement
- Also used to exit (immediately) a `while`, `for`, or `do` loop
  - See Advanced Topic 7.4 (pg 258-259)

```
while ( true ) {
   System.out.print( "Enter value, Q to quit: " );
   String input = in.next();
   if ( input.equalsIgnoreCase( "Q" ) )
      break;
   double x = Double.parseDouble( input );
   data.add(x);
}
```

File Input/Output

- (Section 16.1)

- Two ways of storing data in files
  - *Text* format – human readable sequence of characters
    - Convenient for humans
  - *Binary* format – bytes of data
    - More compact and efficient
- We will use
  - `Scanner` class to read input from text files
  - `PrintWriter` class to write output to text files

Reading Text File

- First construct `FileReader` object with the name of the input file
- Then use it to construct a `Scanner` object
- Use the `Scanner` object for input just as if it was keyboard input
  - Use `next`, `nextLine`, `nextInt`, `nextDouble` methods

```
FileReader reader = new FileReader( "input.txt" );
Scanner in = new Scanner( reader );
```

- After done reading input, call the `close` method on the `FileReader` object

Writing Text File

- Construct a `PrintWriter` object with the name of the output file
  - Use `print`, `println`, `printf` methods

```
PrintWriter out = new PrintWriter( "output.txt" );
```

- Close the file when done
  - Otherwise not all output may be written to the file

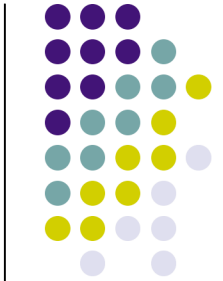
```
out.close();
```

Skeleton Code for File Input/Output

```
// import necessary classes
import java.io.IOException;
import java.io.PrintWriter;
import java.io.FileReader;
import java.util.Scanner;

public class . . . {

   public . . . { // method
      . . .
      try {
         // Do file input/output stuff here
         // . . .

      } catch ( IOException exc ) {
         System.out.println( "Error processing file: " + exc );
      }
      . . .
   }
}
```

LineNumberer.java

Random Numbers and Simulation



- In a simulation, you repeatedly generate random numbers and use them to simulate an activity

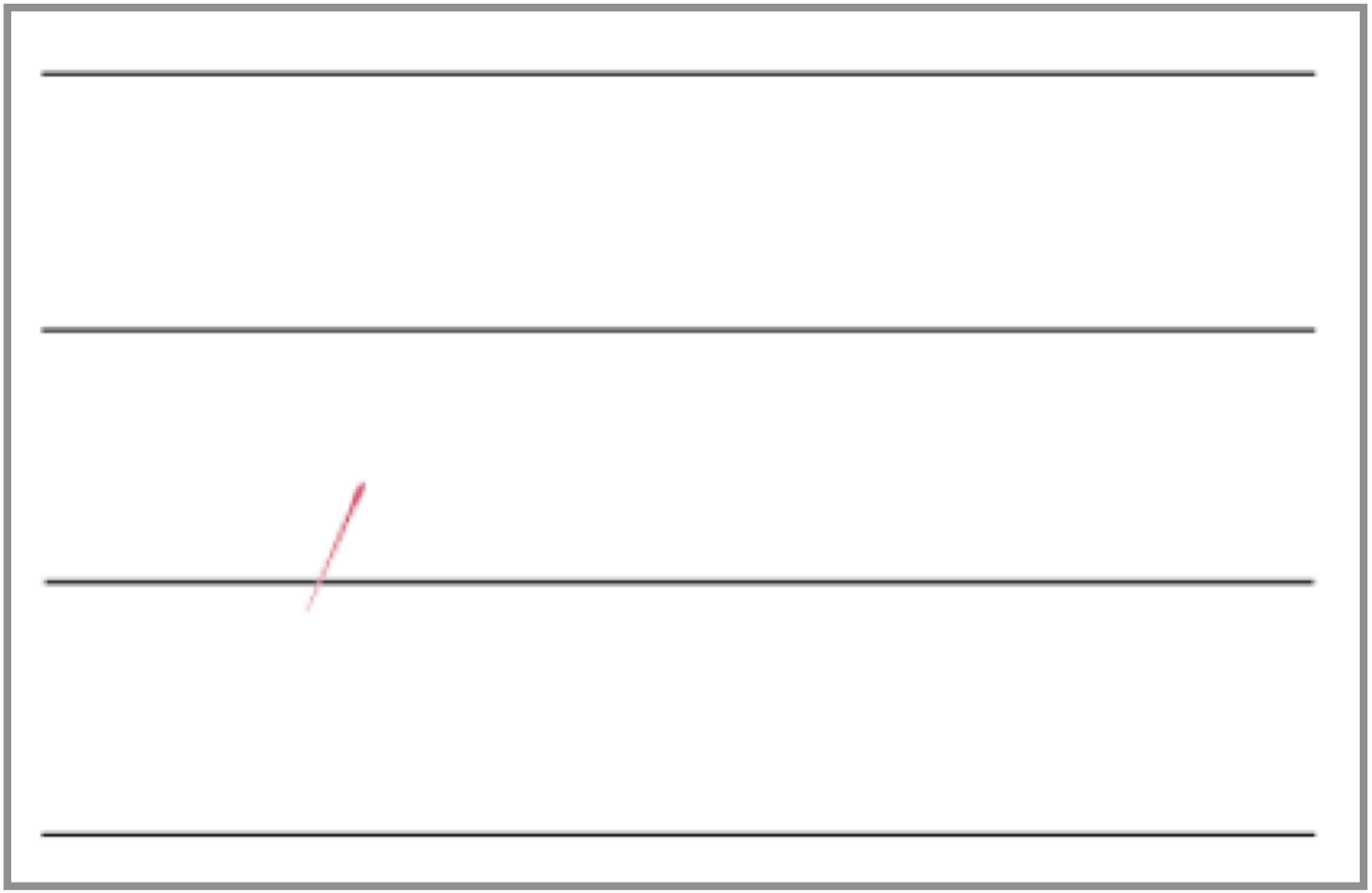
```
Random generator = new Random();
int n = generator.nextInt(a); // 0 <= n < a
double x = generator.nextDouble(); // 0 <= x < 1
```

Random Numbers

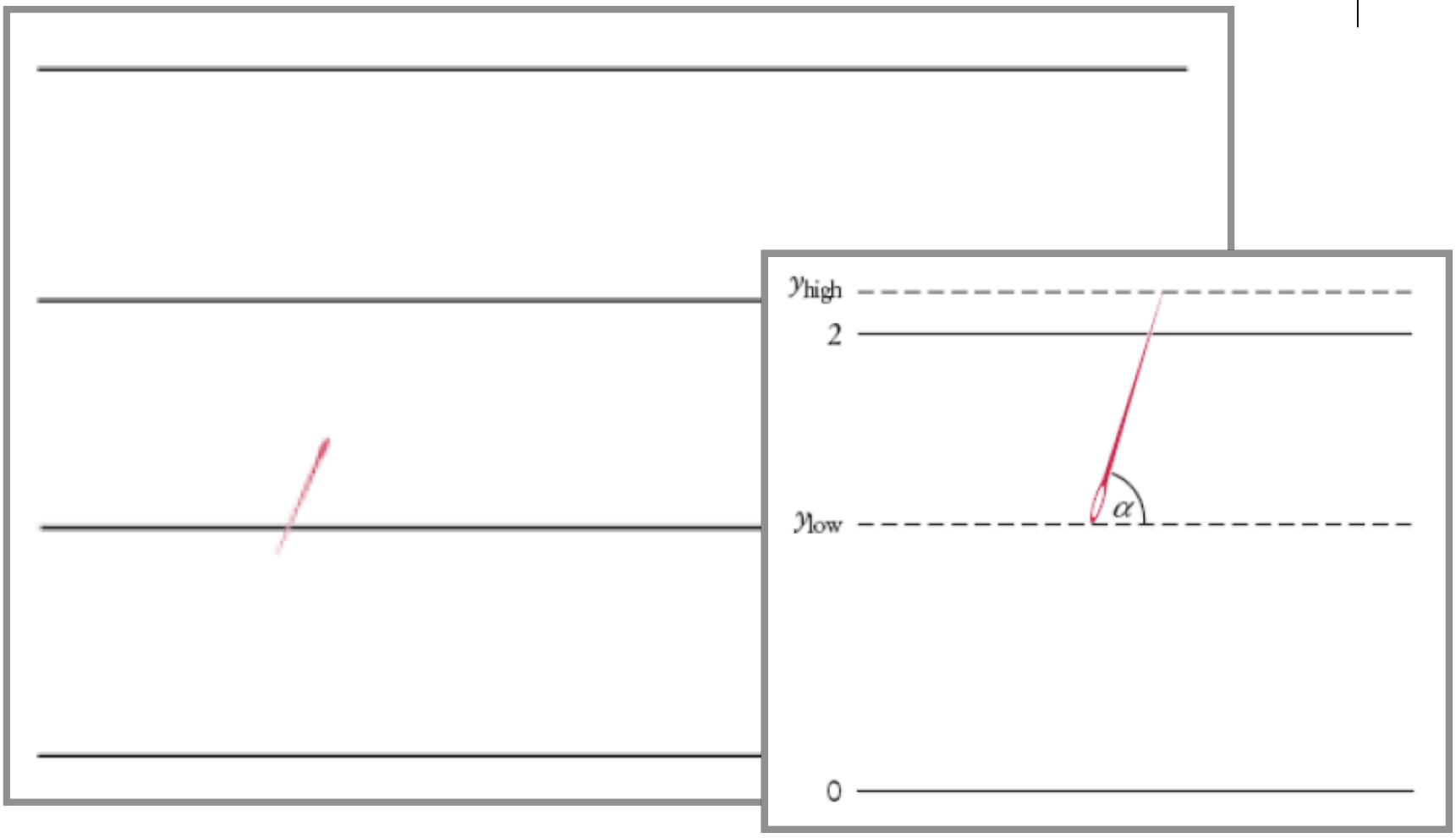
- `Random` class (`java.util` package) provides a (pseudo)random number generator
  - Produces long sequences of non-repeating numbers that behave like a random sequence
- Two useful methods
  - `nextInt(n)` – returns 'random' *integer* between `0` (inclusive) and `n` (exclusive)
  - `nextDouble()` – returns 'random' *floating-point* number between `0.0` (inclusive) and `1.0` (exclusive)

- *Die.java*
- *DieTester.java*

Buffon Needle Experiment



Buffon Needle Experiment



Needle Position

- When does a needle fall on a line?
  - Needle length = 1in, distance between lines = 2in

- Generate random y_{low} between 0 and 2
- Generate random angle α between 0 and 180 degrees
- $y_{high} = y_{low} + \sin(\alpha)$
- Hit if $y_{high} \geq 2$

Needle.java
NeedleTester.java