

CSC 321: Data Structures

Fall 2016

- Java review (or What I Expect You to Know from 222)
 - class, object, fields, methods, private vs. public, parameters
 - variables, primitive vs. objects, expressions, if, if-else, while, for
 - object-oriented design: cohesion, coupling
 - String, Math, arrays, ArrayList
 - searching and sorting, algorithm efficiency, recursion
 - interfaces, inheritance, polymorphism
 - GUI building

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Class structure

```
/**
 * This class models a simple die object,
 * which can have any number of sides.
 * @author Dave Reed
 * @version 8/15/16
 */
public class Die {

    private int numSides;
    private int numRolls;

    /**
     * Constructs a 6-sided die object
     */
    public Die() {
        this.numSides = 6;
        this.numRolls = 0;
    }

    /**
     * Constructs an arbitrary die object.
     * @param sides the number of sides on the die
     */
    public Die(int sides) {
        this.numSides = sides;
        this.numRolls = 0;
    }

    . . .
}
```

a *class* defines a new type of object

- *fields* are variables that belong to the object (and maintain its state)
- typically *private*, so can only be accessed from within the class
- note: "*this*." is optional, but instructive
- *methods* define the actions that can be performed on an object
- typically *public*, so can be called by client code
- note: "*this*." is optional, but instructive
- a *constructor* is a special method that automatically initializes the object when it is created
- can have more than one constructor

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Class structure (cont.)

```
...
/**
 * Gets the number of sides on the die object.
 * @return the number of sides (an N-sided die can roll 1 through N)
 */
public int getNumberOfSides() {
    return this.numSides;
}

/**
 * Gets the number of rolls by on the die object.
 * @return the number of times roll has been called
 */
public int getNumberOfRolls() {
    return this.numRolls;
}

/**
 * Simulates a random roll of the die.
 * @return the value of the roll (for an N-sided die,
 *         the roll is between 1 and N)
 */
public int roll() {
    this.numRolls++;
    return (int)(Math.random()*this.getNumberOfSides() + 1);
}
}
```

a *return statement* specifies the value returned by a call to the method

accessor method: provides access to a private field

mutator method: changes one or more fields

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public static void main

using the BlueJ IDE, we could

- create objects by right-clicking on the class icon
- call methods on an object by right-clicking on the object icon

the more general approach is to have a separate "driver" class

- if a class has a "public static void main" method, it will automatically be executed
- a *static* method belongs to the entire class, you don't have to create an object in order to call the method

```
public class DiceRoller {
    public static void main(String[] args) {
        Die d1 = new Die();
        Die d2 = new Die();

        int roll = d1.roll() + d2.roll();

        System.out.println("You rolled a " + roll);
    }
}
```

- you can have a *public static void main* method in any class – makes it executable (good for testing purposes)

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Java variables

variable names consist of letters, digits, and underscores

- must start with a letter (can use underscore, but don't)

naming conventions:

- class names start with a capital letter
 - e.g., Die, String
- methods, fields, parameters, and local variables start with a lowercase letter
 - e.g., roll, getNumberOfRolls, numRolls, numSides, sides, i
- constants (i.e., final values) are in all capitals
 - e.g., MAX_SCORE, DEFAULT_SIZE

primitive types are predefined in Java

```
int num;           double x = 5.8;       char ch = '?';
num = 0;           boolean flag = false;
```

object types are those defined by classes

```
Die d8 = new Die(8);       String str1 = "foo";
int result = d8.roll();    String str2 = new String("foo");
```

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Class composition

fields of a class can be instances of other classes

- consider a Dot class, to be used in dot race simulations

predefined mathematical ops:

+, -, *, /, %, ++, --

arithmetic assignments:

+=, -=, *=, /=, %=

when applied to Strings, '+' concatenates

```
public class Dot {
    private Die die;
    private String dotColor;
    private int dotPosition;

    public Dot(String color, int maxStep) {
        this.die = new Die(maxStep);
        this.dotColor = color;
        this.dotPosition = 0;
    }

    public int getPosition() {
        return this.dotPosition;
    }

    public void step() {
        this.dotPosition += this.die.roll();
    }

    public void reset() {
        this.dotPosition = 0;
    }

    public void showPosition() {
        System.out.println(this.dotColor + ": " +
            this.dotPosition);
    }
}
```

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DotRace class

`final` denotes a *constant* variable

- once assigned a value, it cannot be changed

`static` denotes a class variable

- belongs to the class, is shared by all instances

```
public class DotRace {
    public final static int GOAL = 20;
    public final static int MAX_STEP = 3;

    public static void main(String[] args) {
        Dot redDot = new Dot("RED", MAX_STEP);
        Dot blueDot = new Dot("BLUE", MAX_STEP);

        while (redDot.getPosition() < GOAL && blueDot.getPosition() < GOAL) {
            redDot.step();
            blueDot.step();

            redDot.showPosition();
            blueDot.showPosition();
        }

        if (redDot.getPosition() >= GOAL && blueDot.getPosition() >= GOAL) {
            System.out.println("It is a tie");
        }
        else if (redDot.getPosition() >= GOAL) {
            System.out.println("RED wins!");
        }
        else {
            System.out.println("BLUE wins!");
        }
    }
}
```

if statement (w/ optional else) defines conditional execution

while loop defines conditional repetition

- both driven by a boolean test
- can use relational ops: > >= < <= == !=
- can use logical connectives: && (and), || (or), ! (not)

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Example: VolleyballSimulator

consider a volleyball simulation in which each team's power ranking determines their likelihood of winning a point

```
public class VolleyballSimulator {
    private Die roller; // Die for simulating points
    private int ranking1; // power ranking of team 1
    private int ranking2; // power ranking of team 2

    /**
     * Constructs a volleyball game simulator.
     * @param team1Ranking the power ranking (0-100) of team 1, the team that serves first
     * @param team2Ranking the power ranking (0-100) of team 2, the receiving team
     */
    public VolleyBallSimulator(int team1Ranking, int team2Ranking) {
        this.roller = new Die(team1Ranking+team2Ranking);
        this.ranking1 = team1Ranking;
        this.ranking2 = team2Ranking;
    }

    /**
     * Simulates a single rally between the two teams.
     * @return the winner of the rally (either "team 1" or "team 2")
     */
    public String playRally() {
        if (this.roller.roll() <= this.ranking1) {
            return "team 1";
        }
        else {
            return "team 2";
        }
    }
    . . .
}
```

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Example: VolleyballSimulator (cont.)

```
...
/**
 * Simulates an entire game using the rally scoring system.
 * @param winningPoints the number of points needed to win the game (winningPoints > 0)
 * @return the winner of the game (either "team 1" or "team 2")
 */
public String playGame(int winningPoints) {
    int score1 = 0;
    int score2 = 0;
    String winner = "";

    while ((score1 < winningPoints && score2 < winningPoints)
        || (Math.abs(score1 - score2) <= 1)) {
        winner = this.playRally();
        if (winner.equals("team 1")) {
            score1++;
        }
        else {
            score2++;
        }

        System.out.println(winner + " wins the point (" + score1 + "-" + score2 + ")");
    }
    return winner;
}
}
```

java.lang.Math contains many useful static fields & methods

- Math.PI, Math.E
- Math.abs, Math.sqrt, Math.random

operators: && (and), || (or), ! (not)

short-circuit evaluation

note: always use equals to compare objects, not ==

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Example: Interactive VolleyballStats

```
import java.util.Scanner;
/**
 * Performs a large number of volleyball game simulations and displays statistics.
 * @author Dave Reed
 * @version 8/15/16
 */
public class VolleyballStats {

    public final static int WINNING_POINTS = 15;
    public final static int NUM_GAMES = 10000;

    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);

        System.out.print("What is the ranking for team 1? ");
        int ranking1 = input.nextInt();
        System.out.print("What is the ranking for team 2? ");
        int ranking2 = input.nextInt();

        VolleyballSimulator sim = new VolleyballSimulator(ranking1, ranking2);
        int teamWins = 0;
        for (int game = 0; game < NUM_GAMES; game++) {
            if (sim.playGame(WINNING_POINTS).equals("team 1")) {
                teamWins++;
            }
        }

        System.out.println("Out of " + NUM_GAMES + " games to " + WINNING_POINTS +
            ", team 1 (" + ranking1 + "-" + ranking2 + ") won: " +
            100.0*teamWins/NUM_GAMES + "%");
    }
}
```

the Scanner class contains methods for reading from the console or a file

- next, hasNext, nextLine, hasNextLine
- nextInt, hasNextInt, nextDouble, hasNextDouble

for loop: neater version of while, for count-driven loops

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Design issues

cohesion describes how well a unit of code maps to an entity or behavior

in a highly cohesive system:

- each class maps to a single, well-defined entity – encapsulating all of its internal state and external behaviors
- each method of the class maps to a single, well-defined behavior

- leads to code that is easier to read and reuse

coupling describes the interconnectedness of classes

in a loosely coupled system:

- each class is largely independent and communicates with other classes via a small, well-defined interface

- leads to code that is easier to develop and modify

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Java Strings

the `String` class includes many useful methods (in addition to '+')

<code>int length()</code>	returns number of chars in <code>String</code>
<code>char charAt(int index)</code>	returns the character at the specified index
<code>int indexOf(char ch)</code>	returns index where the specified char/substring
<code>int indexOf(String str)</code>	first occurs in the <code>String</code> (-1 if not found)
<code>String substring(int start, int end)</code>	returns the substring from indices start to (end-1)
<code>String toUpperCase()</code>	returns copy of <code>String</code> with all letters uppercase
<code>String toLowerCase()</code>	returns copy of <code>String</code> with all letters lowercase
<code>boolean equals(String other)</code>	returns true if other <code>String</code> has same value
<code>int compareTo(String other)</code>	returns <i>neg</i> if < other; 0 if = other; <i>pos</i> if > other

ALSO, from the `Character` class:

<code>char Character.toLowerCase(char ch)</code>	returns lowercase copy of <code>ch</code>
<code>char Character.toUpperCase(char ch)</code>	returns uppercase copy of <code>ch</code>
<code>boolean Character.isLetter(char ch)</code>	returns true if <code>ch</code> is a letter
<code>boolean Character.isLowerCase(char ch)</code>	returns true if lowercase letter
<code>boolean Character.isUpperCase(char ch)</code>	returns true if uppercase letter

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Example: Pig Latin

```
...
public String pigLatin(String word) {
    int firstVowel = this.findVowel(word);

    if (firstVowel <= 0) {
        return word+ "way";
    }
    else {
        return word.substring(firstVowel, word.length()) +
            word.substring(0, firstVowel) + "ay";
    }
}

private boolean isVowel(char ch) {
    String VOWELS = "aeiouAEIOU";
    return (VOWELS.indexOf(ch) != -1);
}

private int findVowel(String str) {
    for (int i = 0; i < str.length(); i++) {
        if (this.isVowel(str.charAt(i))) {
            return i;
        }
    }
    return -1;
}
}
```

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Java arrays

arrays are simple lists

- stored contiguously, with each item accessible via an index
- must specify content type when declare, size when create
- once created, the size cannot be changed (without copying entire contents)

```
public class DiceStats1 {
    public final static int DIE_SIDES = 6;
    public final static int NUM_ROLLS = 10000;

    public static void main(String[] args) {
        int[] counts = new int[2*DIE_SIDES+1];

        Die die = new Die(DIE_SIDES);
        for (int i = 0; i < NUM_ROLLS; i++) {
            counts[die.roll() + die.roll()]++;
        }

        for (int i = 2; i < counts.length; i++) {
            System.out.println(i + ": " + counts[i] + " ("
                + (100.0*counts[i]/NUM_ROLLS) + "%)");
        }
    }
}
```

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Java ArrayLists

an `ArrayList` is a more robust, general purpose list of objects

- must specify content type when declare, size is optional (default is 0)
- can be dynamically expanded/reduced; can easily add/remove from middle

common methods:

<code>T get(int index)</code>	returns object at specified index
<code>T add(Object obj)</code>	adds obj to the end of the list
<code>T add(int index, T obj)</code>	adds obj at index (shifts to right)
<code>T remove(int index)</code>	removes object at index (shifts to left)
<code>int size()</code>	removes number of entries in list
<code>boolean contains(T obj)</code>	returns true if obj is in the list

other useful methods:

<code>T set(int index, T obj)</code>	sets entry at index to be obj
<code>int indexOf(T obj)</code>	returns index of obj in the list (assumes obj has an <code>equals</code> method)
<code>String toString()</code>	returns a String representation of the list e.g., "[foo, bar, biz, baz]"

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Example: Dictionary

one constructor can call another via `this()`

a `Scanner` object can be used to read from a file

- must create a `File` object
- in case the file isn't there, the code is required to catch `FileNotFoundException`

```
try {
    // CODE TO TRY
}
catch (ExceptionType e) {
    // CODE IN CASE IT OCCURS
}
```

```
import java.util.ArrayList;
import java.util.Scanner;
import java.io.File;

public class Dictionary {
    private ArrayList<String> words;

    public Dictionary() {
        this.words = new ArrayList<String>();
    }

    public Dictionary(String filename) {
        this();

        try {
            Scanner infile = new Scanner(new File(filename));
            while (infile.hasNext()) {
                String nextWord = infile.next();
                this.add(nextWord);
            }
        }
        catch (java.io.FileNotFoundException e) {
            System.out.println("FILE NOT FOUND");
        }
    }

    public void add(String newWord) {
        this.words.add(newWord.toLowerCase());
    }

    public boolean remove(String oldWord) {
        return this.words.remove(oldWord.toLowerCase());
    }

    public boolean contains(String testWord) {
        return this.words.contains(testWord.toLowerCase());
    }
}
```

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ArrayLists & primitives

ArrayLists can only store objects, but Java will automatically box and unbox primitives into *wrapper classes* (Integer, Double, Character, ...)

```
import java.util.ArrayList;

public class DiceStats2 {
    public final static int DIE_SIDES = 6;
    public final static int NUM_ROLLS = 10000;

    public static void main(String[] args) {
        ArrayList<Integer> counts = new ArrayList<Integer>();
        for (int i = 0; i <= 2*DIE_SIDES; i++) {
            counts.add(0);
        }

        Die die = new Die(DIE_SIDES);
        for (int i = 0; i < NUM_ROLLS; i++) {
            int roll = die.roll() + die.roll();
            counts.set(roll, counts.get(roll)+1);
        }

        for (int i = 2; i < counts.size(); i++) {
            System.out.println(i + ": " + counts.get(i) + " (" +
                + (100.0*counts.get(i)/NUM_ROLLS) + "%)");
        }
    }
}
```

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List interface

an *interface* defines a generic template for a class

- specifies the methods that the class must implement
- but, does not specify fields nor method implementations

```
public interface List<T> {
    boolean add(T obj);
    boolean add(int index, T obj);
    void clear();
    boolean contains(Object obj);
    T get(int index);
    T remove(int index);
    boolean remove(T obj);
    T set(int index, T obj);
    int size();
    . . .
}
```

advantage: can define different implementations with different tradeoffs

```
public class ArrayList<T> implements List<T> { ... } // uses array, so direct access
// but must shift when add/remove

public class LinkedList<T> implements List<T> { ... } // uses doubly-linked list, so
// sequential access but easy
// add/remove
```

- so, can write generic code that works on a `List` → either implementation will work

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Example: Dictionary

polymorphism: the capability of objects to react differently to the same method call

here, can declare the field to be of type `List` (the more generic interface)

- if choose to instantiate with an `ArrayList`, its methods will be called
- if choose to instantiate with a `LinkedList`, its methods will be called

this style leads to more general-purpose code

```
import java.util.ArrayList;
import java.util.Scanner;
import java.io.File;

public class Dictionary {
    private List<String> words;

    public Dictionary() {
        this.words = new ArrayList<String>();
    }

    public Dictionary(String filename) {
        this();

        try {
            Scanner infile = new Scanner(new File(filename));
            while (infile.hasNext()) {
                String nextWord = infile.next();
                this.add(nextWord);
            }
        } catch (java.io.FileNotFoundException e) {
            System.out.println("FILE NOT FOUND");
        }
    }

    public void add(String newWord) {
        this.words.add(newWord.toLowerCase());
    }

    public boolean remove(String oldWord) {
        return this.words.remove(oldWord.toLowerCase());
    }

    public boolean contains(String testWord) {
        return this.words.contains(testWord.toLowerCase());
    }
}
```

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Collections class

`java.util.Collections` provides a variety of static methods on Lists

```
static int binarySearch(List<T> list, T key); // where T is Comparable
static T max(List<T> list); // where T is Comparable
static T min(List<T> list); // where T is Comparable
static void reverse(List<T> list);
static void shuffle(List<T> list);
static void sort(List<T> list); // where T is Comparable
```

since the `List` interface is specified, can make use of polymorphism

- these methods can be called on both `ArrayLists` and `LinkedLists`

```
ArrayList<String> words = new ArrayList<String>();
...
Collections.sort(words);

LinkedList<Integer> nums = new LinkedList<Integer>();
...
Collections.sort(nums);
```

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Searching an ArrayList

sequential search traverses the list from beginning to end

- check each entry in the list
- if matches the desired entry, then FOUND (return its index)
- if traverse entire list and no match, then NOT FOUND (return -1)

recall: the `ArrayList` class has `indexOf`, `contains` methods

```
public int indexOf(T desired) {
    for(int k=0; k < this.size(); k++) {
        if (desired.equals(this.get(k))) {
            return k;
        }
    }
    return -1;
}

public boolean contains(T desired) {
    return this.indexOf(desired) != -1;
}
```

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Sequential search: Big-Oh analysis

to represent an algorithms performance in relation to the size of the problem, computer scientists use *Big-Oh* notation

an algorithm is $O(N)$ if the number of operations required to solve a problem is proportional to the size of the problem

sequential search on a list of N items requires *roughly* N checks (ignoring constants)
→ $O(N)$

[we will revisit the technical definition of Big-Oh later in the course]

for an $O(N)$ algorithm, doubling the size of the problem requires double the amount of work (in the worst case)

- if it takes 1 second to search a list of 1,000 items, then
it takes 2 seconds to search a list of 2,000 items
it takes 4 seconds to search a list of 4,000 items
it takes 8 seconds to search a list of 8,000 items

...

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Binary search

the `Collections` utility class contains a `binarySearch` method

- `T extends Comparable<? super T>` is UGLY notation
refers to the fact that the class must implement the `Comparable` interface, or if a derived class then one of its parents must

```
public static <T extends Comparable<? super T>> int binarySearch(List<T> items, T desired) {
    int left = 0; // initialize range where desired could be
    int right = items.length-1;

    while (left <= right) {
        int mid = (left+right)/2; // get midpoint value and compare
        int comparison = desired.compareTo(items.get(mid));

        if (comparison == 0) { // if desired at midpoint, then DONE
            return mid;
        }
        else if (comparison < 0) { // if less than midpoint, focus on left half
            right = mid-1;
        }
        else { // otherwise, focus on right half
            left = mid + 1;
        }
    }
    return -left - 1; // if reduced to empty range, NOT FOUND
}
```

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Binary search: Big-Oh analysis

an algorithm is $O(\log N)$ if the number of operations required to solve a problem is proportional to the logarithm of the size of the problem

- binary search on a list of N items requires *roughly* $\log_2 N$ checks (ignoring constants)
→ $O(\log N)$

for an $O(\log N)$ algorithm, doubling the size of the problem adds only a constant amount of work

- if it takes 1 second to search a list of 1,000 items, then
searching a list of 2,000 items will take time to check midpoint + 1 second
searching a list of 4,000 items will take time for 2 checks + 1 second
searching a list of 8,000 items will take time for 3 checks + 1 second
...

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Comparison: searching a phone book

Number of entries in phone book	Number of checks performed by sequential search	Number of checks performed by binary search
100	100	7
200	200	8
400	400	9
800	800	10
1,600	1,600	11
...
10,000	10,000	14
20,000	20,000	15
40,000	40,000	16
...
1,000,000	1,000,000	20

to search a phone book of the United States (~321 million) using binary search?

to search a phone book of the world (7.3 billion) using binary search?

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$O(N^2)$ sorts

a variety of algorithms exist for sorting a list

- *insertion sort* takes one item at a time and inserts it into an auxiliary sorted list
- *selection sort* traverses to find the next smallest, then swaps it into place
- both are $O(N^2)$, so doubling the list size quadruples the amount of work

```
public static <T extends Comparable<? super T>>
    void selectionSort(ArrayList<T> items) {
    for (int i = 0; i < items.size()-1; i++) { // traverse the list to
        int indexOfMin = i; // find the index of the
        for (int j = i+1; j < items.size(); j++) { // next smallest item
            if (items.get(j).compareTo(items.get(indexOfMin)) < 0) {
                indexOfMin = j;
            }
        }

        T temp = items.get(i); // swap the next smallest
        items.set(i, items.get(indexOfMin)); // item into its correct
        items.set(indexOfMin, temp); // position
    }
}
```

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O(N log N) sorts

faster, but more complex sorts exist

- *quick sort* partitions the list around a pivot, then recursively sorts each partition
- *merge sort* recursively sorts each half of the list, then merges the sorted sublists
- both are O(N log N), so doubling the list size increases the work by a little more than double

```
public static <T extends Comparable<? super T>>
    void mergeSort(ArrayList<T> items) {
    mergeSort(items, 0, items.size()-1);
}

private static <T extends Comparable<? super T>>
    void mergeSort(ArrayList<T> items, int low, int high) {
    if (low < high) {
        int middle = (low + high)/2;
        mergeSort(items, low, middle);
        mergeSort(items, middle+1, high);
        merge(items, low, high);
    }
}
. . .
```

note: merging two lists of size N can be done in O(N) steps

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Recursion

recursion is useful when a task can be broken down into smaller, similar tasks

- functional recursion: a method directly or indirectly calls itself

```
private static <T extends Comparable<? super T>> void
    mergeSort(ArrayList<T> items, int low, int high) {
    if (low < high) {
        int middle = (low + high)/2;
        mergeSort(items, low, middle);
        mergeSort(items, middle+1, high);
        merge(items, low, high);
    }
}
```

key to understanding recursion:

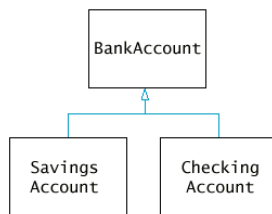
don't think too hard – only 1 level deep!

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Inheritance

inheritance is a mechanism for enhancing existing classes

- one of the most powerful techniques of object-oriented programming
- allows for large-scale code reuse



- here, a static field is used so that each account has a unique number

```
public class BankAccount {
    private double balance;
    private int accountNumber;
    private static int nextNumber = 1;

    public BankAccount() {
        this.balance = 0;
        this.accountNumber = this.nextNumber;
        this.nextNumber++;
    }

    public int getAccountNumber() {
        return this.accountNumber;
    }

    public double getBalance() {
        return this.balance;
    }

    public void deposit(double amount) {
        this.balance += amount;
    }

    public void withdraw(double amount) {
        if (amount >= this.balance) {
            this.balance -= amount;
        }
    }
}
```

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Derived classes

```
public class SavingsAccount extends BankAccount
{
    private double interestRate;

    public SavingsAccount(double rate)
    {
        this.interestRate = rate;
    }

    public void addInterest()
    {
        double interest =
            this.getBalance()*this.interestRate/100;
        this.deposit(interest);
    }
}
```

a derived class automatically inherits all fields and methods (but private fields are inaccessible)

- can override existing methods or add new fields/methods as needed

```
public class CheckingAccount extends BankAccount
{
    private int transCount;
    private static final int NUM_FREE = 3;
    private static final double TRANS_FEE = 2.0;

    public CheckingAccount()
    {
        this.transCount = 0;
    }

    public void deposit(double amount)
    {
        super.deposit(amount);
        this.transCount++;
    }

    public void withdraw(double amount)
    {
        super.withdraw(amount);
        this.transCount++;
    }

    public void deductFees()
    {
        if (this.transCount > NUM_FREE) {
            double fees =
                TRANS_FEE*(this.transCount - NUM_FREE);
            super.withdraw(fees);
        }
        this.transCount = 0;
    }
}
```

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Inheritance & polymorphism

polymorphism applies to classes in an inheritance hierarchy

- can pass a derived class wherever the parent class is expected
- the appropriate method for the class is called

```
public void showAccount(BankAccount acct) {
    System.out.println("Account " + acct.getAccountNumber() + ": $" +
        acct.getBalance());
}

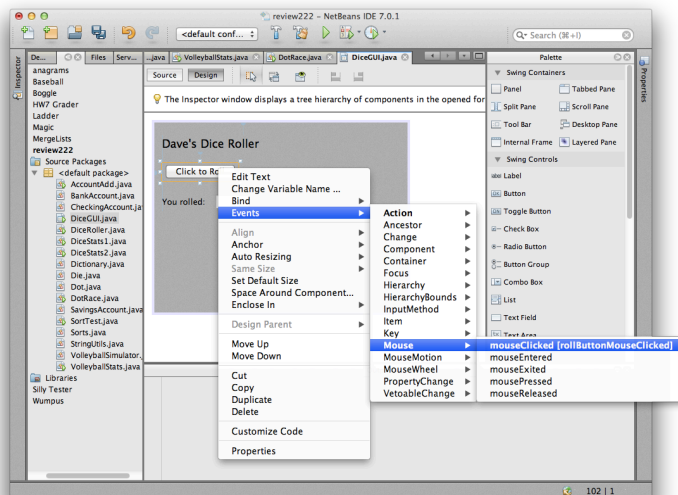
BankAccount acct1 = new BankAccount();
...
showAccount(acct1);

SavingsAccount acct2 = new SavingsAccount();
...
showAccount(acct2);

CheckingAccount acct3 = new CheckingAccount();
...
showAccount(acct3);
```

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NetBeans GUI builder



can easily create a GUI in NetBeans

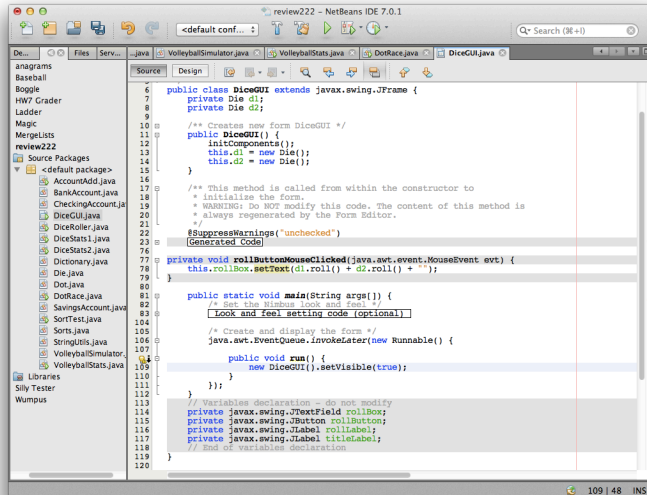
create a JFrame under Swing GUI Form

drag the elements from the Palette and position in the Design frame

you can change the properties of the elements and add an event handler

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NetBeans GUI builder



```
6 public class DiceGUI extends javax.swing.JFrame {
7     private Die d1;
8     private Die d2;
9
10
11     /** Creates new form DiceGUI */
12     public DiceGUI() {
13         initComponents();
14         this.d1 = new Die();
15         this.d2 = new Die();
16     }
17
18     /** This method is called from within the constructor to
19      * initialize the form.
20      * WARNING: Do NOT modify this code. The content of this method is
21      * always regenerated by the Form Editor.
22      */
23     @SuppressWarnings("unchecked")
24     // Generated Code
25
26
27     private void rollButtonMouseClicked(java.awt.event.MouseEvent evt) {
28         this.rollBox.setText(d1.roll() + d2.roll() + " ");
29     }
30
31
32     public static void main(String args[]) {
33         // See the About dialog box
34         Look and Feel setting code (optional)
35
36         /* Create and display the form */
37         java.awt.EventQueue.invokeLater(new Runnable() {
38             public void run() {
39                 new DiceGUI().setVisible(true);
40             }
41         });
42     }
43
44     // Variables declaration - do not modify
45     private javax.swing.JTextField rollBox;
46     private javax.swing.JButton rollButton;
47     private javax.swing.JLabel rollLabel;
48     private javax.swing.JLabel titleLabel;
49     // End of variables declaration
50 }
```

for each event handler declared in the GUI, a method skeleton is added to the file

you can add fields to the GUI class

initialize those fields in the constructor

then, access those fields within the event handler method