

CS 2334: Programming Structures and Abstractions  
Final Exam  
December 18, 2015

General instructions:

- Please wait to open this exam booklet until you are told to do so.
- This examination booklet has 23 pages. You also have been issued a bubble sheet.
- Write your name, university ID number and date, and sign your name below. Also, write your name and ID number on your bubble sheet, and fill in the bubbles for your ID.
- You may have up to five pages of your own notes. No electronic devices or books may be used.
- The exam is worth a total of 220 points. Your grade counts for 20% of your final grade.
- You have 2 hours to complete the exam. Be a smart test taker: if you get stuck on one problem go on to the next.
- Use your bubble sheet to answer all multiple-choice questions. Make sure that the question number and the bubble row number match when you are answering each question.

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this exam.

**Signature:** \_\_\_\_\_

**Name:** \_\_\_\_\_

**ID Number:** \_\_\_\_\_

**Date:** \_\_\_\_\_

Question	Points	Score
Objects and Inheritance	15	
Abstract Classes and Interfaces	15	
Exceptions and Error Handling	14	
Generics	21	
Java Collections Framework	28	
Enumerated Data Types	12	
Graphical User Interfaces and Graphics	35	
Recursion	32	
Ethics	48	
Total:	220	

B C A B C C A B  
C B A A C B A B  
A C A B B C A C

Part I. Objects and Inheritance

1. (5 points) Which of the following lines **will not** compile?

```
public class A {};  
public class B extends A {};  
  
public class InheritanceTest {  
    public static void main(String[] args) {  
        ArrayList<A> a = new ArrayList<A>();  
        ArrayList<B> b = new ArrayList<B>();  
  
        a.add(new A()); // Line 1  
  
        a.add(new B()); // Line 2  
  
        b.add(new B()); // Line 3  
  
        b.add(new A()); // Line 4  
    }  
}
```

- A. Line 1   B. Line 2   C. Line 3   **D. Line 4**   E. All lines will compile

2. (5 points) Is the following class mutable or immutable?

```
public class Person{  
    private String firstName;  
    private String lastName;  
  
    public Person(String firstName, String lastName){  
        this.firstName = firstName;  
        this.lastName = lastName;  
    }  
  
    public StringBuffer getName(){  
        return new StringBuffer(lastName + ", " + firstName);  
    }  
}
```

- A. Immutable**   B. Mutable

3. (5 points) What is the output of the code?

```
int a = 6;  
double c = 8;  
double b = c * 9 - a;  
c += b ;  
  
System.out.println(c) ;
```

- A. 32.0   **B. 74.0**   C. 74.0   D. 74.0   E. Runtime error   F. Compiler error

**Solution:** I gave everyone full credit for this question.

Part II. Abstract Classes and Interfaces

4. (5 points) Any class that implements an interface must provide implementations for all of the interface's abstract methods.
- A. True    **B. False**    C. Answer not shown

**Solution:** If the abstract class implements an interface, then it may leave some of the interface's methods unimplemented.

5. (5 points) What methods must the following class implement?

```
public class MyInteger implements Comparator<Integer>, Comparable<MyInteger>{...}
```

- A. `int compareTo(Integer i)` **and** `int compare(Integer i1, Integer i2)`  
**B. `int compareTo(MyInteger i)` and `int compare(Integer i1, Integer i2)`**  
C. `int compareTo(Integer i)` **and** `int compare(MyInteger i1, MyInteger i2)`  
D. `int compareTo(MyInteger i)` **and** `int compare(MyInteger i1, MyInteger i2)`  
E. Answer not shown
6. (5 points) What methods must the following class implement?

```
public class KeyHandler extends KeyAdapter {...}
```

- A. `void keyPressed(KeyEvent e)`  
B. `void keyReleased(KeyEvent e)`  
C. `void keyTyped(KeyEvent e)`  
D. All of the above  
**E. None of the above**

### Part III. Exceptions and Error Handling

Consider the following program:

```
public class Compute {
    public static int compB(int k) throws IOException{
        if(k < 20) {
            throw new NumberFormatException("Error B");
        }
        if(k < 30) {
            throw new IOException("Error C");
        }
        return k;
    }

    public static int compA(int j){
        int ret = -1;
        try{
            if(compB(j) > 40){
                throw new NumberFormatException("Error A");
            }
            ret = 1;
        }catch(IOException e){
            ret = 2;
        }
        return ret;
    }

    public static void main(String[] args){
        int i = ??????;

        try{
            System.out.println(compA(i));
        }catch(Exception e){
            System.out.println(e.getMessage());
        }
    }
}
```

7. (7 points) Assume that  $i = 10$  in `main()`, what is printed by the program?  
A. 1   B. 2   C. Error A   **D. Error B**   E. Error C   F. Answer not shown

**Solution:** Instructions during exam were to ignore answer F

8. (7 points) Assume that  $i = 25$  in `main()`, what is printed by the program?  
A. 1   **B. 2**   C. Error A   D. Error B   E. Error C   F. Answer not shown

**Solution:** Instructions during exam were to ignore answer F

Part IV. Generics

9. (5 points) Will the following code compile?

```
public class Foo<E extends Comparable<E>> implements Comparable<Foo<E>> {
    E a;

    public Foo(E a){
        this.a = a;
    }

    public int compareTo(Foo<E> b){
        return a.compareTo(b.a);
    }
}
```

A. Yes   B. No   C. Answer not shown

10. (5 points) What is true about the following class definition?

```
public class GenericTreeMap <K extends Comparable<K>, V> extends TreeMap<K, V>{}
```

A. **GenericTreeMap** is-a **TreeMap**  
B. **TreeMap** is-a **GenericTreeMap**  
C. **GenericTreeMap** has-a **TreeMap**  
D. **TreeMap** has-a **GenericTreeMap**  
E. None are true

11. (5 points) What else is also true about the above class definition?

A. **GenericTreeMap** implements *compareTo()*  
B. **K** implements *compareTo()*  
C. **V** implements *compareTo()*  
D. **TreeMap** implements *compareTo()*  
E. None are true

12. (6 points) Which line of code in the main function causes a compiler error **first**?

```
public class Fruit {};  
public class Banana extends Fruit();  
:  
public static void main(String[] args){  
    ArrayList<Fruit> list = new ArrayList<Banana>(); // Line 1  
  
    list.add(new Fruit()); // Line 2  
    list.add(new Banana()); // Line 3  
    list.add(new Fruit()); // Line 4  
}
```

A. **Line 1**   B. Line 2   C. Line 3   D. Line 4   E. All lines will compile

Part V. Java Collections Framework

13. (6 points) What is printed by this block of code?

```
LinkedList<Integer> list = new LinkedList<Integer>();
list.addFirst(1);
list.addFirst(3);
list.addFirst(5);
list.addFirst(2);

System.out.println(list.getFirst());
```

- A. 1    **B. 2**    C. 3    D. 5    E. Answer not shown

14. (7 points) What does the following code print?

```
public class MyString implements Comparable<MyString> {
    private static final int offset = 1;
    private String s;

    public MyString(String s){
        this.s = s;
    }

    public int compareTo(MyString strg){
        return -s.substring(offset).compareTo(strg.s.substring(offset));
    }

    public static void displayList(List<MyString> list){
        for(MyString s: list){
            System.out.print(s.s + " ");
        }
        System.out.println("");
    }

    public static void main(String[] args) {
        LinkedList<MyString> list = new LinkedList<MyString>();

        list.addLast(new MyString("duck"));
        list.addFirst(new MyString("Luke's"));
        list.addLast(new MyString("likes"));
        list.addFirst(new MyString("lakes"));

        Collections.sort(list);
        displayList(list);
    }
}
```

- A. lakes Luke's duck likes  
B. lakes likes Luke's duck  
**C. Luke's duck likes lakes**  
D. Luke's lakes likes duck  
E. Answer not shown

15. (5 points) Which Java Collections Framework class provides an ordered collection of objects that contains no duplicates?  
A. ArrayList   B. HashSet   C. Queue   **D. TreeSet**   E. Answer not shown
16. (5 points) Consider an **ArrayList<Integer>** object instance that currently contains  $n$  items. How many shift operations are performed by *list.add(42)*?  
**A. 0**   B. 1   C.  $n/2$    D.  $n$    E. Answer not shown
17. (5 points) Consider an **ArrayList<Integer>** object instance that currently contains  $n$  items. How many shift operations are performed by *list.add(0, 37)*?  
A. 0   B. 1   C.  $n/2$    **D.  $n$**    E. Answer not shown

Part VI. Enumerated Data Types

Consider the following class definition:

```
public enum Card {
    Ace(1), Two(2), Three(3), Four(4), Five(5),
    Six(6), Seven(7), Eight(8), Nine(9), Jack(10),
    Queen(10), King(10);

    private int value;

    private Card(int value){
        this.value = value;
    }

    public int getValue(){
        return value;
    }

    public static int sumCards(Card[] stack){
        int sum = 0;

        for(Card c: stack){
            sum += c.value;
        }
        return sum;
    }
}
```

18. (6 points) What is printed by the following code block?

```
Card[] stack1 = {Card.Ace, Card.Jack};
Card[] stack2 = {Card.Queen, Card.Five, Card.Six};
System.out.println(Card.sumCards(stack1) + ", " + Card.sumCards(stack2));
```

- A. 11, 11    B. **11, 21**    C. 21, 11    D. 21, 21    E. This code would not compile
19. (6 points) What is the correct test for whether a **Card** is an “Eight”? Assume variable *c* is of type **Card**.

A.

B.

C.

D.

E. None of the implementations are correct



## Part VII. Graphical User Interfaces and Graphics

Consider the following program:

```
public class PolyFrame extends JFrame{

    public class PolyPanel extends JPanel {
        private Shape s;

        public PolyPanel(){
            int [] xs = {100, 100, 200, 200};
            int [] ys = {100, 200, 200, 100};
            s = new Polygon(xs, ys, xs.length);

            addMouseListener(new MouseAdapter(){
                public void mouseClicked(MouseEvent e) {
                    if(s.contains(e.getX(), e.getY())){
                        System.out.println("Inside");
                    }else{
                        System.out.println("Outside");
                    }
                }
            });
        }

        protected void paintComponent(Graphics g){
            super.paintComponent(g);
            Graphics2D g2 = (Graphics2D) g;
            g2.setColor(new Color(100, 200, 0));
            g2.fill(s);
        }
    }

    public PolyFrame(){
        super("Poly Frame");
        setLayout(new BorderLayout());

        add(new PolyPanel(), BorderLayout.CENTER);

        setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        setSize(400,300);
        setVisible(true);
    }

    public static void main(String [] args) {
        PolyFrame frame = new PolyFrame();
    }
}
```

20. (7 points) Suppose that the user clicks at coordinate (75,150). What is printed to the console?  
A. Inside    **B. Outside**    C. Nothing
21. (7 points) Suppose that the user clicks at coordinate (187,122). What is printed to the console?  
**A. Inside**    B. Outside    C. Nothing

Consider the following program:

```
public class MyFrame extends JFrame{
    private Color color;
    private JButton button;

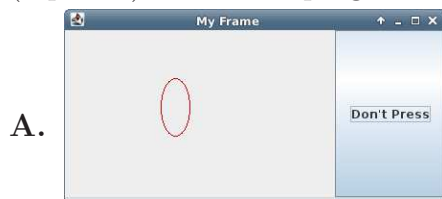
    public class MyPanel extends JPanel{
        protected void paintComponent(Graphics g){
            super.paintComponent(g);
            g.setColor(color);
            g.drawOval(100, 50, 30, 60);
        }
    }

    public MyFrame(){
        super("My Frame");
        setLayout(new BorderLayout());
        color = new Color(200, 0, 0);
        add(new MyPanel(), BorderLayout.CENTER);
        button = new JButton("Don't Press");
        add(button, BorderLayout.EAST);

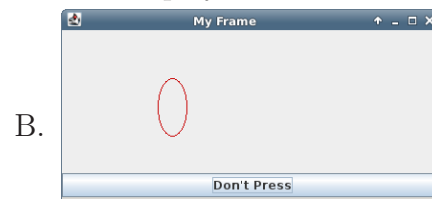
        button.addActionListener(new ActionListener(){
            public void actionPerformed(ActionEvent e) {
                color = new Color(color.getGreen(), color.getBlue(), color.getRed());
                repaint();
            }
        });
        setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        setSize(400,200);
        setVisible(true);
    }

    public static void main(String[] args) {
        MyFrame frame = new MyFrame();
    }
}
```

22. (7 points) When the program first starts, what is displayed?



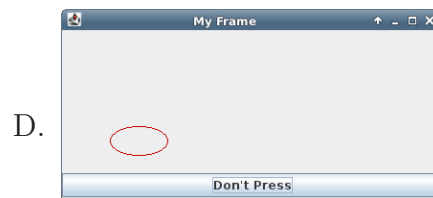
(red ellipse)



(red ellipse)



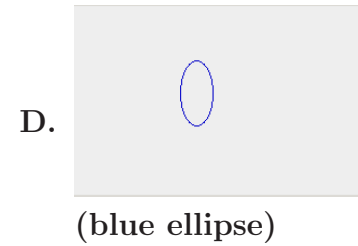
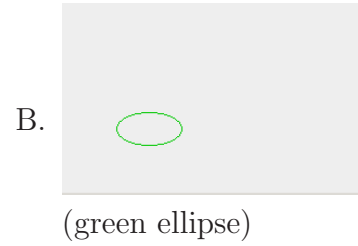
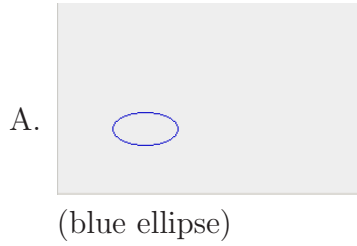
(red ellipse)



(red ellipse)

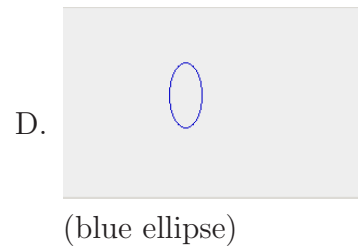
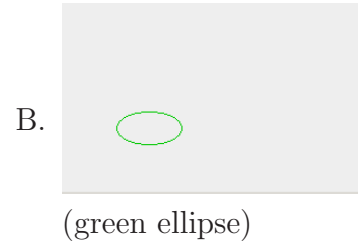
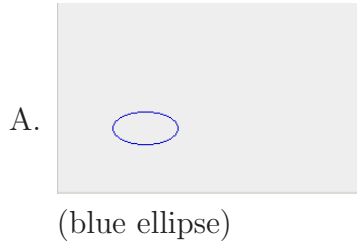
E. Answer not shown

23. (7 points) After the user presses the button once (from the start of the program), what is rendered in the **JPanel**?



E. Answer not shown

24. (7 points) After the user presses the button twice (from the start of the program), what is rendered in the **JPanel**?



E. Answer not shown

Part VIII. Recursion

Consider the following method that tests whether a string is a proper palindrome:

```
public static boolean isPalindrome(String strg) {  
    if(/**/ ADD CONDITION /**/){  
        return true;  
    }  
  
    if(strg.charAt(0) != strg.charAt(strg.length()-1))  
        return false;  
  
    return isPalindrome(strg.substring(1, strg.length()-1));  
}
```

25. (6 points) What is the appropriate condition for the first *if* statement?  
A. *strg.length() == 1*    **B. *strg.length() <= 1***    C. *strg.length() >= 1*  
D. *strg.length() >= 0*    E. Answer not shown
26. (5 points) Is this an appropriate approach to implementing a method that verifies palindromes?  
A. Yes    **B. No**

**Solution:** Note: we can implement this far more efficiently with a loop.

Consider the following class definition:

```
public class Node {
    private int value;
    private Node[] children = new Node[3];

    public Node(int value) {
        this.value = value;
    };

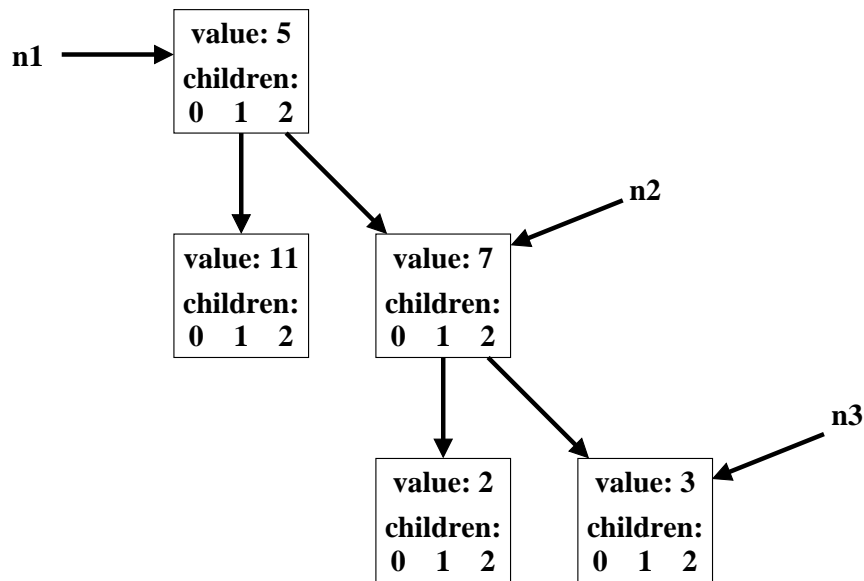
    public void addChild(Node c, int i) {
        if(i >= 0 && i < children.length){
            children[i] = c;
        };
    };

    public int baz(int level, boolean[] list) {
        int out = 0;
        if(list == null || list[level]){
            out += value;
        }

        for(int i = 0; i < children.length; ++i){
            if(children[i] != null){
                out += children[i].baz(level+1, list);
            }
        }

        return out;
    }
};
```

Assume that the following tree has already been constructed using the constructor and the addChild() method, and that n1, n2, and n3 are variables containing references to the indicated nodes. You may also assume that when arrows are not shown for children, their value is null.



27. (7 points) What is printed by this block of code?

```
System.out.println(n3.baz(0, null));
```

A. 0   B. 2   **C. 3**   D. 5   E. 7

28. (7 points) What is printed by this block of code?

```
System.out.println(n2.baz(0, null));
```

A. 0   B. 5   C. 7   D. 10   **E. 12**

29. (7 points) What is printed by this block of code?

```
boolean[] list = {false, true, true};  
System.out.println(n1.baz(0, list));
```

A. 0   B. 5   C. 18   **D. 23**   E. 28

## Part IX. Ethics

This year, Mattel introduced a new product called *Hello Barbie*. This wifi-enabled doll uses voice recognition to “understand” what a child is saying so as to verbally respond appropriately. The doll can play games, tell stories and have conversations over a wide range of topics, including uttering the phrase “Teaching math sounds like a lot of fun” (an improvement over the 1992 *Teen Talk Barbie* that could utter the phrase “Math class is tough!”). Over time, the doll can construct a model of your child’s preferences and interests, allowing the doll to customize its dialog. Because there is not much internal computing power, the doll will record audio clips and send them to a central server for processing.

30. (6 points) What ethical principles should have been considered in the design of this toy? What are their sources? List at least four.

### **Solution:**

- Privacy (protecting a person from having information gathered about them). The 4th and 9th amendments are interpreted as protecting privacy. The ACM code of ethics calls for a “respect for the privacy of others.”
- Confidentiality (protecting information that has already been gathered about someone). The ACM code of conduct asks its members to “Honor Confidentiality.”
- Opacity: the privacy, confidentiality and security implications of these devices are not always made clear to the customers. The ACM code of ethics calls for members to “improve public understanding of computing and its consequences.”
- Protection of children: COPPA (Children’s Online Privacy Protection Act) and the protection of the most vulnerable.
- Be fair: ACM code of ethics
- Avoid harm: ACM code of ethics)

31. (6 points) What steps could be taken to address the ethical concerns? List at least three.

**Solution:**

- Mattel should ensure the security of the centrally stored data and of the individual dolls.
- Centrally stored data about the child's interaction with the doll should be separated from any personal identity information.
- The doll could transmit audio data only under specific conditions (in fact, a button on Barbie must be pressed in order for audio to be recorded).
- The parents could be given some form of privacy and/or access control. This could be used to monitor the use of the doll and even determine when the doll could be connected to the network.
- Wifi may not be available for all children. The doll should have some capabilities that do not require connection to the Internet.





Ford Motor Company has for some time been shipping vehicles with a feature called “911 Assist.” A set of sensors installed in the vehicle can detect when it is involved in a collision. In response to such an event, the system automatically sends vehicle identity, GPS location and other details about the collision to the local 911 emergency telephone office. Features like this have saved many lives because emergency services can be deployed very quickly.

Last week, a Florida woman was involved in a hit-and-run collision (after hitting two vehicles with her own, the woman fled the scene of the accident). Nevertheless, her own vehicle sent the collision information to 911, which led to a call to her from the 911 office and to her eventual arrest (i.e., her own car “ratted her out”).

32. (6 points) What ethical principles should be considered by the Ford Motor Company in the design of the system? What are their sources? List at least three.

**Solution:**

- Privacy (protecting a person from having information gathered about them). The 4th and 9th amendments are interpreted as protecting privacy. The ACM code of ethics calls for a “respect for the privacy of others.”
- Avoid harm to others (ACM code of ethics). We expect that the system will properly report collisions.
- Opacity: the privacy, confidentiality and security implications of these devices are not always made clear to the customers. The ACM code of ethics calls for members to “improve public understanding of computing and its consequences.”

33. (6 points) What steps could be taken to address the ethical concerns about the

system? List at least three.

**Solution:**

- Protect identity and ownership data. (security)
- Be clear to customers what data are collected and stored, and how the data are shared and with whom.
- Perhaps give the customers the option of activating this monitoring system.

34. (6 points) Given this unexpected behavior, is this a good feature for all vehicles to have? Why or why not?

**Solution:**

- Pro: other individuals or their property are generally harmed when collisions happen. Hence, we should accept this behavior
- Con: because the vehicle is owned by an individual, the digital information collected by the vehicle is owned in some sense by the individual. The owner should have the ability to control the flow of that information.
- Con (for all): Individuals should have the ability to select between reporting or not (no matter the consequences).

35. (6 points) Does your above answer change if we add a feature that reports speeding? Why or why not?

**Solution:**

- Pro: speeding is still breaking the law.
- Con: speeding may be breaking the law but does not, in and of itself, cause harm.
- Con: the ownership of information question is still in play.

Bob works for *Zipgrade*, a company that makes and sells an app that grades bubble sheets used for exams. As part of his project, Bob uses *OpenCV*, an open source computer vision library that he has downloaded. This library makes it easy for him to write code that reliably detects which bubbles have been filled in using a tablet's camera. Assume that OpenCV is released under a *Creative Commons* license.

36. (6 points) What factors must Bob consider in deciding whether to use this library without making changes to the library's code?

**Solution:**

- The Creative Commons license must allow commercial use.
- The CC license may require attribution of the originator of the code base.
- Bob should be clear to his employer that he is using the work of others as part of his project.

37. (6 points) Suppose that Bob now makes changes to the OpenCV code base so that it will work well for his project. What additional factors must he consider?

**Solution:**

- The CC license must allow derivative works.
- If the CC license requires *share-a-like*, then Bob is obligated to make his changes available. This may be at odds with company policy!