CS 2334: Programming Structures and Abstractions
Final Exam
December 13, 2016

General instructions:

- Please wait to open this exam booklet until you are told to do so.
- This examination booklet has 29 pages. You also have been issued a bubble sheet.
- Fill in the identifying information below (signature, name, ID and date) 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 274 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. Note that some ethics questions require written answers. And - note that the **last question** is a multiple choice question. Please use the given question number for your bubble-sheet answer.
- Other than **this** page, you may tear any other page out of this booklet that does not contain numbered answers.
- If you cannot effectively erase erroneous answers from the bubble sheet, please clearly cross them out.

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	28	
Abstract Classes and Interfaces	20	
Exceptions and Error Handling	39	
Generics	18	
Java Collections Framework	24	
Enumerated Data Types	14	
Graphical User Interfaces and Graphics	28	
Recursion	43	
Ethics	60	
Bonus Question	0	
Total:	274	

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Part I. Objects and Inheritance

Consider the following class definitions:

```
public class A
{
    private int id;

    public A(int id) {
        this.id = id;
    }

    public int getId() {
        return id;
    }

    public String toString() {
        return "A:" + id;
    }

}

public class B extends A
{
    private String name;

    public B(int id, String name) {
      super(id);
      this.name = name;
    }

    public String getName() {
        return name;
    }

    public String toString() {
      return "B:" + name + this.getId();
    }
}

public class C extends B
{

    private int id;

    public C(int val, String name) {
      super(10, name);
      this.id = val;
    }

    public C(String name, int id) {
      super(id, name.toUpperCase());
      this.id = -1;
    }

    public int getId() {
      return id;
    }

    public String toString() {
      return "C:" + super.getId() + ":" + super.toString();
    }
}
```

1. (6 points) What is printed by this block of code?

```
A a = new A(56);
System.out.println(a);
```

A. A: B. A:-1 C. A:10 **D. A:56** E. Answer not shown

2. (6 points) What is printed by this block of code?

```
B b = new B(77, "Chico");
System.out.println(b);
```

A. A:Chico:77 B. B:77 C. B:Chico:10 **D. B:Chico77**
E. Answer not shown

3. (6 points) What is printed by this block of code?

```
C c1 = new C("Harpo", 23);
System.out.println(c1);
```

A. C:-1:B:HARPO23 **B. C:23:B:HARPO-1** C. C:23:B:harpo23
D. C:23:B:HARPO23 E. Answer not shown

4. (6 points) What is printed by this block of code?

```
C c2 = new C(55, "Zeppo");
System.out.println(c2);
```

A. C:10:B:Zeppo55 B. C:55:B:Zeppo55 C. C:10:B:ZEPPO55
D. C:55:B:ZEPPO55 E. Answer not shown

5. (4 points) What is printed by this block of code?

```
String s1 = "thx";
String s2 = "tHx";
s2.toLowerCase();
if(s1.equals(s2))
{
  System.out.println("Yes:" + s1);
}
else
{
  System.out.println("No:" + s2);
}
```

A. No:thx **B. No:tHx** C. Yes:thx D. Yes:tHx
E. Compilation error or answer not shown

Part II. Abstract Classes and Interfaces

6. (4 points) An interface can best be described as what type of relationship?

   A. Contains-a B. Has-a C. Implements-a **D. Is-a** E. Answer not shown

   Solution: In retrospect, we decided to give partial credit for answer C.

7. (4 points) Not considering external factors, any interface could be implemented instead as an abstract class.

   A. True B. False

8. (4 points) Any concrete class that implements an interface must provide implementations for all of the interface's abstract methods.

   A. True B. False

   Solution: A concrete class must implement all abstract methods.

9. (4 points) Will the following class compile as-is?

```
public class KeyHandler extends MouseAdapter implements MouseListener {}
```

   A. Yes B. No

10. (4 points) Will the following interface compile?

```
public interface Foo
{
    abstract int a;
    abstract int compute(int input);
    abstract int doubleValue();
}
```

   A. Yes **B. No**

Part III. Exceptions and Error Handling

Consider the following program:

```
public class Transform
{
  public static int trans2(int i)
  {
    if(i > 10)
    {
      throw new ArithmeticException("Error 1");
    }
    else
    {
      if(i < 5)
      {
        return i + 1;
      }
      throw new IllegalStateException("Error 2");
    }
  }

  public static int trans1(int input)
  {
    int i = 0;

    try
    {
      if (trans2(input/2) > 3)
      {
        return i;
      }
      else
      {
        throw new IllegalStateException("Error 3");
      }
    }
    catch(ArithmeticException e)
    {
      return input;
    }
  }

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

    try{
      System.out.println(trans1(i));
    }catch(Exception e){
      System.out.println(e.getMessage());
    }
  }
}
```

11. (6 points) Assume that $i = 5$ in main(), what is printed by the program?
    A. 0 B. 3 C. Error 1 D. Error 2 **E. Error 3** F. Answer not shown

12. (6 points) Assume that $i = 20$ in main(), what is printed by the program?
    A. 0 B. 3 C. Error 1 **D. Error 2** E. Error 3 F. Answer not shown

13. (6 points) Assume that $i = 27$ in main(), what is printed by the program?
A. 0 B. 3 C. Error 1 D. Error 2 E. Error 3 **F. Answer not shown**

14. (6 points) Assume that $i = 9$ in main(), what is printed by the program?
A. 0 B. 3 C. Error 1 D. Error 2 E. Error 3 F. Answer not shown

15. (6 points) Assume that $i = 10$ in main(), what is printed by the program?
A. 0 B. 3 C. Error 1 **D. Error 2** E. Error 3 F. Answer not shown

Consider the following method prototype:

```
public void loadData(String fileName) throws IOException {...}
```

16. (4 points) A method that calls loadData() must catch IOException
A. True **B. False**

17. (5 points) What is printed by this block of code?

```
Integer[] a = {3, 78, 5, 3, 22, 18, 4, 2};
HashSet<Integer> b = new HashSet<Integer>();
Collections.addAll(b, a);  // Add contents of a to b
b.addAll(b);

System.out.println(b.size());
```

A. 0 **B. 7** C. 8 D. 9 E. Answer not shown

Part IV. Generics

18. (4 points) What is true about the following class definition?

```
public class MySet<V extends Number> extends TreeSet<V>
      implements Comparable<Set<V>> {}
```

A. *MySet* is-a $TreeSet < V >$
B. *MySet* is-a $Comparable < Set < V >>$
C. *MySet* is-a *Number*
D. *MySet* has-a *Number*
E. Answer not shown

Solution: Technically, both A and B are true (hence the correct answer of E). Because of the wording, I am giving everyone credit for this question.

19. (4 points) Will the following code compile?

```
public class Bar<E extends Comparator<E>> implements Comparable<E>
{
  private E e;

  public int compareTo(E e)
  {
    return e.compare(e, this.e);
  }
}
```

A. Yes B. No

20. (5 points) Which line of code in the main method causes a compiler error **first**?

```
1   public abstract class Mammal{};
2   public class Canine extends Mammal{};
3   public class Feline extends Mammal{};
4     :
5   public static void main(String[] args)
6   {
7     TreeSet<Mammal> set = new TreeSet<Mammal>();
8
9     set.add(new Canine());
10    set.add(new Feline());
11    set.add(new Mammal());
12  }
```

A. Line 7 B. Line 9 C. Line 10 **D. Line 11** E. All lines will compile

21. (5 points) Suppose that we would like to implement a method that will take as input any Set that is parametrized by a subclass of Mammal. What would the method prototype be?

A.
```
public static void processSet(Set set)
```

B.
```
public static void processSet(Set<?> set)
```

C.
```
public static void processSet(Set<? implements Mammal> set)
```

D.
```
public static void processSet(Set<? extends Mammal> set)
```

E. None of the implementations are correct

Part V. Java Collections Framework

22. (6 points) What is printed by this block of code?

```
HashMap<String, String> map = new HashMap<String, String>();

map.put(" cl", "oth");
map.put(" em", "per");
map.put("es ", "bot");
map.put(" no", " cl");
map.put("or ", "has");
map.put("the", " em");
map.put("oth", "es ");
map.put("has", " no");
map.put("per", "or ");

String s = "";
for(String key = "the"; map.containsKey(key); key = map.get(key))
{
  s += key;
}

System.out.println(s.substring(19,22)); }
```

A. clo B. emp C. lot D. the E. Answer not shown

23. (4 points) Which Java Collections Framework class provides an unordered collection of objects that contains no duplicates?

A. ArrayList **B. HashSet** C. Queue D. TreeSet E. Answer not shown

24. (4 points) Consider a **LinkedList<Integer>** object instance that currently contains n items. How many reference copies are performed by $list.add(42)$?

A. 0 **B. 1** C. n/2 D. n E. Answer not shown

25. (4 points) Consider a **LinkedList<Integer>** object instance that currently contains n items. How many reference copies are performed by $list.add(0, 42)$?

A. 0 **B. 1** C. n/2 D. n E. Answer not shown

26. (6 points) What does the following code block print?

```
TreeMap<String, Boolean> map = new TreeMap<String, Boolean>();

map.put("Ham", false);
map.put("And", false);
map.put("I", true);
map.put("Eggs", false);
map.put("Am", true);
map.put("Green", false);
map.put("Sam", true);

String out = "";

for(String s: map.navigableKeySet())
{
  if(map.get(s)){
    out = s + " " + out;
  }
}

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

A. Sam I Am B. Am I Sam C. Ham And I Eggs Am Green Sam
D. Sam Green Am Eggs I And Ham E. Answer not shown

Part VI. Enumerated Data Types

Consider the following class definition:

```
1   public enum ProcessState
2   {
3     NEW(), RUNNING(), TERMINATED(), READY();
4
5     private ProcessState next;
6
7     static
8     {
9       RUNNING.next = TERMINATED;
10      READY.next = RUNNING;
11      TERMINATED.next = TERMINATED;
12      NEW.next = READY;
13    }
14
15    public ProcessState getNext()
16    {
17      return next;
18    }
19
20    public static void main(String[] args)
21    {
22      ProcessState state = ProcessState.NEW;
23
24      while(*** CONDITION ***) {
25        System.out.print(state.name() + " ");
26        state = state.getNext();
27      }
28    }
```

27. (4 points) What is the correct condition for line 24 if this loop is to end when the TERMINATED state is reached?

A.
```
state != 2
```

B.
```
!state.equal("TERMINATED");
```

C.
```
state != "TERMINATED"
```

D.
```
state != ProcessState.TERMINATED
```

E. None of the implementations are correct

28. (6 points) Assuming that the condition is properly implemented, what is printed by the loop in the main() method?

A. NEW RUNNING READY
B. NEW READY RUNNING
C. NEW READY RUNNING TERMINATED
D. NEW RUNNING TERMINATED READY
E. Answer not shown

29. (4 points) Would it be appropriate to use an enumerated data type to represent red-green-blue colors?

A. Yes **B. No**

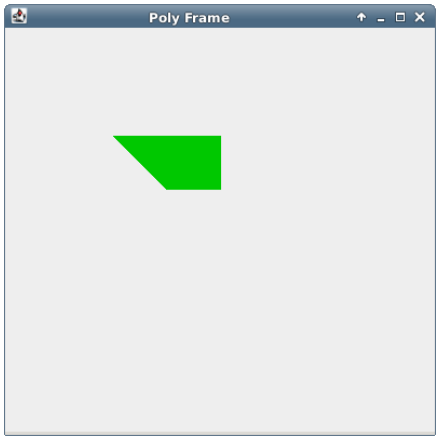
Solution: In Swing, RGB color is captured using 8 bits each for red, green and blue (so, a lot of different combinations). Furthermore a color with red=200 would be very similar to a color with red=201. If we represented colors as an enumerated data type, we would have **a lot** of different combinations that would have to be explicitly declared. And – we would lose the notion of color similarity.

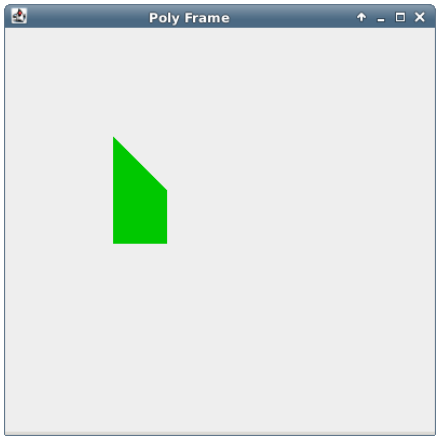
Part VII. Graphical User Interfaces and Graphics

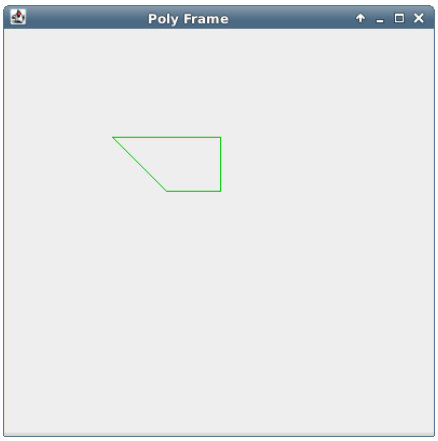
Consider the following program:

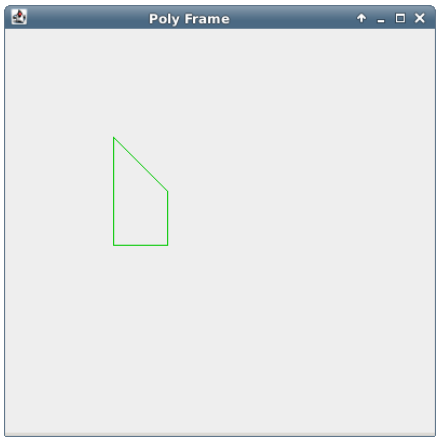
```
public class PolyFrame extends JFrame{
  public class PolyPanel extends JPanel {
    private Polygon p;
    private boolean fill;

    public PolyPanel(){
      p = new Polygon();
      fill = true;
      p.addPoint(100, 100);
      p.addPoint(100, 200);
      p.addPoint(150, 200);
      p.addPoint(150, 150);

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

      this.addKeyListener(new KeyAdapter() {
        public void keyTyped(KeyEvent e){
          System.out.println(e);
          if(e.getKeyChar() == ' ') {
            fill = !fill;
          }
          repaint();
        }
      });
      this.setFocusable(true);
      this.requestFocus();
    }

    protected void paintComponent(Graphics g){
      super.paintComponent(g);
      Graphics2D g2 = (Graphics2D) g;
      g2.setColor(new Color(0, 200, 0));
      if(fill){
        g2.fill(p);
      } else {
        g2.draw(p);
      }
    }
  }

  public PolyFrame(){
    super("Poly Frame");
    setLayout(new BorderLayout());
    PolyPanel panel = new PolyPanel();
    add(panel, BorderLayout.CENTER);
    setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    setSize(400,400);
    setVisible(true);
  }

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

30. (6 points) When the program first starts, what is displayed?

A. 

B. 

C. 

D. 

E. Answer not shown

31. (4 points) What color is the Polygon?

A. Green B. Red C. Blue D. Cyan E. Answer not shown

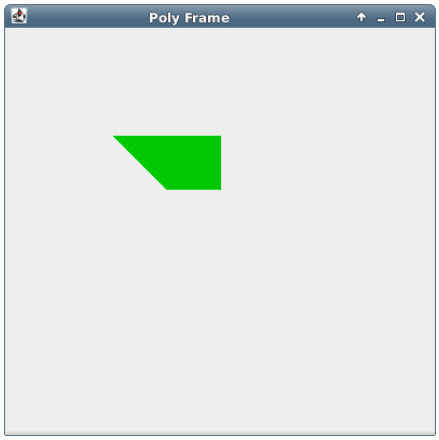
32. (6 points) Suppose that the user clicks at coordinate $x = 170, y = 120$. What is printed to the console?

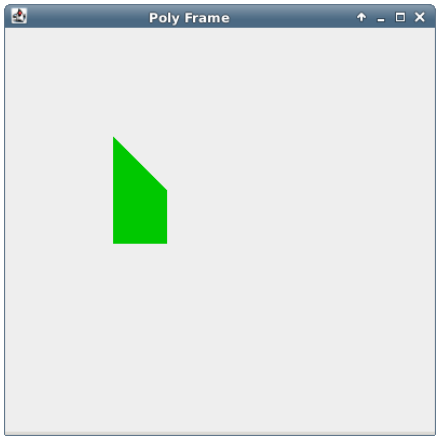
A. Inside **B. Outside** C. Nothing

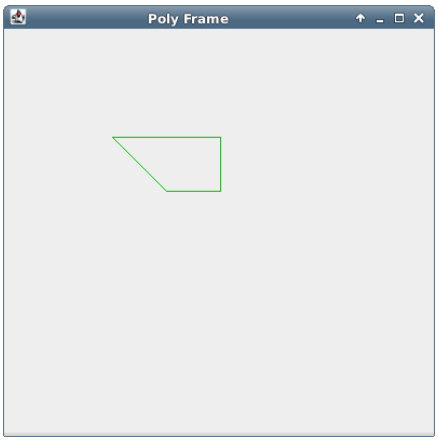
33. (6 points) Suppose that the user clicks at coordinate $x = 145, y = 180$. What is printed to the console?

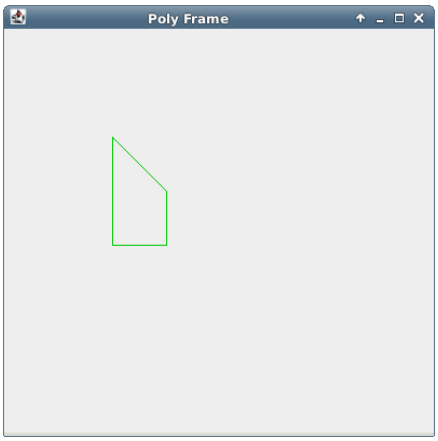
A. Inside B. Outside C. Nothing

34. (6 points) After a user presses the SPACE key three times, what is displayed?

A. 

B. 

C. 

D. 

E. Answer not shown

Part VIII. Recursion

Consider the following method that implements a merge sort of ints:

```
1   public static int[] sort(int[] list)
2   {
3     if(**** CONDITION ****)
4     {
5       return list;
6     }
7
8     int[] list1 = new int[list.length/2];
9     int[] list2 = new int[*** LENGTH ***];
10
11    for(int i = 0; i < list1.length; ++i)
12    {
13      list1[i] = list[i];
14      list2[i] = list[*** INDEX ***];
15    }
16
17    list2[list2.length - 1] = list[list.length - 1];
18
19    return merge(sort(list1), sort(list2));
20  }
```

35. (5 points) What is the best condition to use for line 3?

A. $list.length == 0$ B. $list.length == 1$ **C.** $list.length <= 1$
D. $list.length <= 2$ E. Answer not shown

36. (5 points) What is the appropriate length for list2 (line 9)?

A. $list.length$ B. $list.length/2$ C. $list.length/2 + 1$
D. $(list.length + 1)/2$ E. Answer not shown

37. (5 points) What is the appropriate index on line 14?

A. i B. $i + list.length$ **C.** $i + list1.length$
D. $i + list2.length$ E. Answer not shown

38. (4 points) Is this algorithm an appropriate use of recursion?

A. Yes B. No

Consider the following class definition:

```
public class Node extends ArrayList<Node>
{
  private int val;

  public Node()
  {
    val = Integer.MAX_VALUE;
  }

  public int find()
  {
    if(val < Integer.MAX_VALUE){
      return val;
    }

    for(Node n: this){
      int newVal = n.find() + 1;
      if(newVal < val){
        val = newVal;
      }
    }

    return val;
  }

  public void setVal(int val)
  {
    this.val = val;
  }
}
```

39. (6 points) What is printed by this block of code?

```
Node n1 = new Node();
Node n2 = new Node();
n2.setVal(0);
System.out.println(n1.find());
```

A. 0 B. 1 C. 2 **D. 2147483647 (*MAX_VALUE*)**
E. Answer not shown

40. (6 points) What is printed by this block of code?

```
Node n1 = new Node();
Node n2 = new Node();
n1.add(n2);
n2.setVal(0);
System.out.println(n1.find());
```

A. 0 **B. 1** C. 2 D. 2147483647 (*MAX_VALUE*)
E. Answer not shown

41. (6 points) What is printed by this block of code?

```
Node n1 = new Node();
Node n2 = new Node();
Node n3 = new Node();
n3.setVal(0);
n1.add(n2);
n1.add(n3);
n2.add(n3);

System.out.println(n1.find());
```

A. 0 **B. 1** C. 2 D. 2147483647 (MAX_VALUE)
E. Answer not shown

42. (6 points) What is printed by this block of code?

```
Node n1 = new Node();
Node n2 = new Node();
Node n3 = new Node();
Node n4 = new Node();

n3.setVal(0);
n1.add(n2);
n2.add(n3);
n2.add(n4);
n4.add(n3);

System.out.println(n1.find());
```

A. 0 B. 1 **C. 2** D. 2147483647 (MAX_VALUE)
E. Answer not shown

Part IX. Ethics

This year, the Washington D.C. police department initiated a security camera program in which the department would provide security cameras and recording systems (in the form of rebates) to residents of the city. The residents may choose to install the cameras anywhere on their premises and have full access to the footage. In addition, these cameras are registered with the police department and footage can be requested by the department if it is relevant to the investigation of a crime.

43. (4 points) In what sense do residents *opt-in* to the program?

Solution:

- The residents get to choose whether they are participating in the program.

44. (5 points) List two ways in which residents do not *opt-in* to the release of footage and yet may be affected by it.

Solution:

- If a resident agrees to the program at one point in time, that resident will not have an ability to entirely control whether the footage shot by the camera will be given to the police.
- Someone can set up a camera and point it at a neighbor's property. The neighbor would have no control over how the footage is used

45. (5 points) Provide an argument in favor of the program. Support with the appropriate ethical principle(s).

Solution:

- With our **right to property**, we have the ability to own property and determine how that property is used. Thus, we have the right to take steps to protect that property.

46. (5 points) Provide an argument against the program. Support with the appropriate ethical principle(s).

Solution:

- As described, there are plenty of opportunities for our **right to privacy** to be violated.

47. (5 points) Suppose Washington P.D. does not have direct access to the video footage: in order to obtain the footage, they must do so with permission of the resident or by warrant. Does this address our above concerns?

Solution:

- One possibility: because of these restrictions, then this is no difference than the residents installing the cameras themselves.
- Other possibility: The police department still knows where the cameras are located because they have been registered. They therefore have much more information than before.
- Another possibility: We are still placing more cameras in the environment because of the program. Overall, this represents an aggregate loss of privacy to the citizens of the city.
- Notes: This is indeed the policy. Also – Washington D.C. is the first city in the nation to employ a **privacy officer** who is responsible for working with the community and crafting privacy policies.

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) is intended as a key step in protecting the privacy and security of the medical data of individuals. In particular, the *privacy rule* dictates that certain medical data are protected, including information placed in your medical record by health care providers. This rule also dictates that information from your medical record can only be transmitted to certain other entities, including those directly involved in your care and those that are indicated by you. In addition, this rule gives you the right to inspect your own records. The *security rule* dictates that entities managing your data must take a range of precautions to ensure that your data are not accessed inappropriately. These include physical access control (computers containing or having access to your data are physically secured), digital access control (appropriate authentication steps) and transmission security (data cannot be "snooped" from the network).

48. (5 points) List and explain the recent changes in the computing world that have driven (in part) the need for these rules.

Solution:

- Data are often in a digital format, and can be located on remote servers. While this improves dissemination to your health care providers, it also makes it very easy for data to be copied and used by others who are not authorized to do so.
- This copying does not even require physical access to the computers (computers or network can be compromised).
- The digital form makes it possible for different aspects of your medical records to be brought together, along with any other records identified as yours.
- We have a growing number of techniques for "mining" large data sets to identify patterns that allow an organization to make reasonable guesses about an individual that they cannot observe directly. For example, an insurance company may be able to infer the presence of genetic-based diseases and use this information as part of the assessment of risk (and hence

use it to set pricing). The Genetic Information Nondiscrimination Act (2008) explicitly disallows the use of genetic information for the purposes of discrimination in health insurance and employment. Another example: a pharmaceutical company may use this information to perform direct marketing.

49. (5 points) List and explain the ethical principles that relate to these rules.

Solution:

- ACM code of ethics: "avoid harm to others". Making these data available to unauthorized persons could result in discrimination, or being subjected to targeted marketing
- ACM code of ethics: "respect privacy of others", "honor confidentiality". Take actions to properly secure data and to ensure the accuracy of data.
- Kant: "treat people as ends in themselves"
- Utilitarianism: "increase utility (needs and values) of people" (in particular, do not decrease it)
- Natural rights: "respect fundamental rights of others, including liberty; "maximize free choice"

50. (5 points) Suppose that you are a software developer designing a browser-based interface that allows users to access the medical data that have been collected by your company. Discuss the advantages and disadvantages of using cookies to manage the interaction with the customer (from both the company and user perspectives).

Solution:

- Cookies are one means of allowing a web server to ensure (or at least infer) that you are who you say you are over a set of queries in an individual "session" or across multiple sessions. This makes the development of the server easier from the company's perspective. However, these data also become available for viewing by other web sites. Depending on the content of the cookies, this could give other companies an advantage.
- Cookies make it easier for the customer to interact as an individual with the web site. However, they can reveal information to other companies that the customer may not want revealed.
- Also - as currently implemented in most browsers, cookies are turned on by default. This is a serious opacity problem.

51. (5 points) As a member of the software team, suppose that you have discovered a bug in the code that manipulates the patient data in an incorrect way. List and

discuss the ethical principles that compel you to address this bug. List at least two.

Solution:

- ACM code of ethics: "Strive to achieve the highest quality, effectiveness and dignity in both the process and products of professional work." This compels us to act on this bug.
- ACM code of ethics: "Accept and provide appropriate professional review." In some cases, the key action is to report the bug to the appropriate individuals ("owner" of the code or to management).
- ACM code of ethics: "Honor contracts, agreements, and assigned responsibilities". As an employee or a contractor, one has obligations to properly address problems in deployed systems.

As part of a commercial software project, Bob uses *Qt*, an open source graphical user interface tool kit. This library makes it easy for him to write code that can be ported reliably across platforms. Assume that Qt is released under a *GNU Public License*.

52. (5 points) What factors must Bob consider in deciding whether to use this library without making changes to the library's code?

Solution:

- Bob may need to publicly release his code under the GPL.
- So far, the courts have allowed hidden-source projects if they are dynamically linked with the GPL'd library.
- Bob should be clear to his employer that he is using the work of others as part of his project.
- Notes: the GPL technically is not intended for commercial use. However, the courts have made a distinction between static and dynamic linking.

53. (5 points) Suppose that Bob now makes changes to the Qt code base so that it will work well for his project. What additional factors must he consider?

Solution:

- Bob/his company **must** make these changes publicly available, keeping the same license.

54. (6 points) What would be the closest Creative Commons license configuration to the Gnu Public License? What differences remain?

Solution:

- CC license would need to allow commercial use.
- The CC must allow derivative works.
- The CC must use share-a-like.
- The CC must include attribution.
- The CC does not specifically require the public release of derivative works, whereas GPL does.

Part X. Bonus Question

55. (0 points) Select whether you want 2 points or 6 points added onto your final exam grade. If more than 10% of the class selects 6 points, then no one will receive any bonus points. Otherwise, everyone will receive the points that they select.

A. 0 B. 2 **C. 6**