Third AP* Edition

Java Methods

Object-Oriented Programming
and
Data Structures

Answers and Solutions to Exercises

for Students ✓

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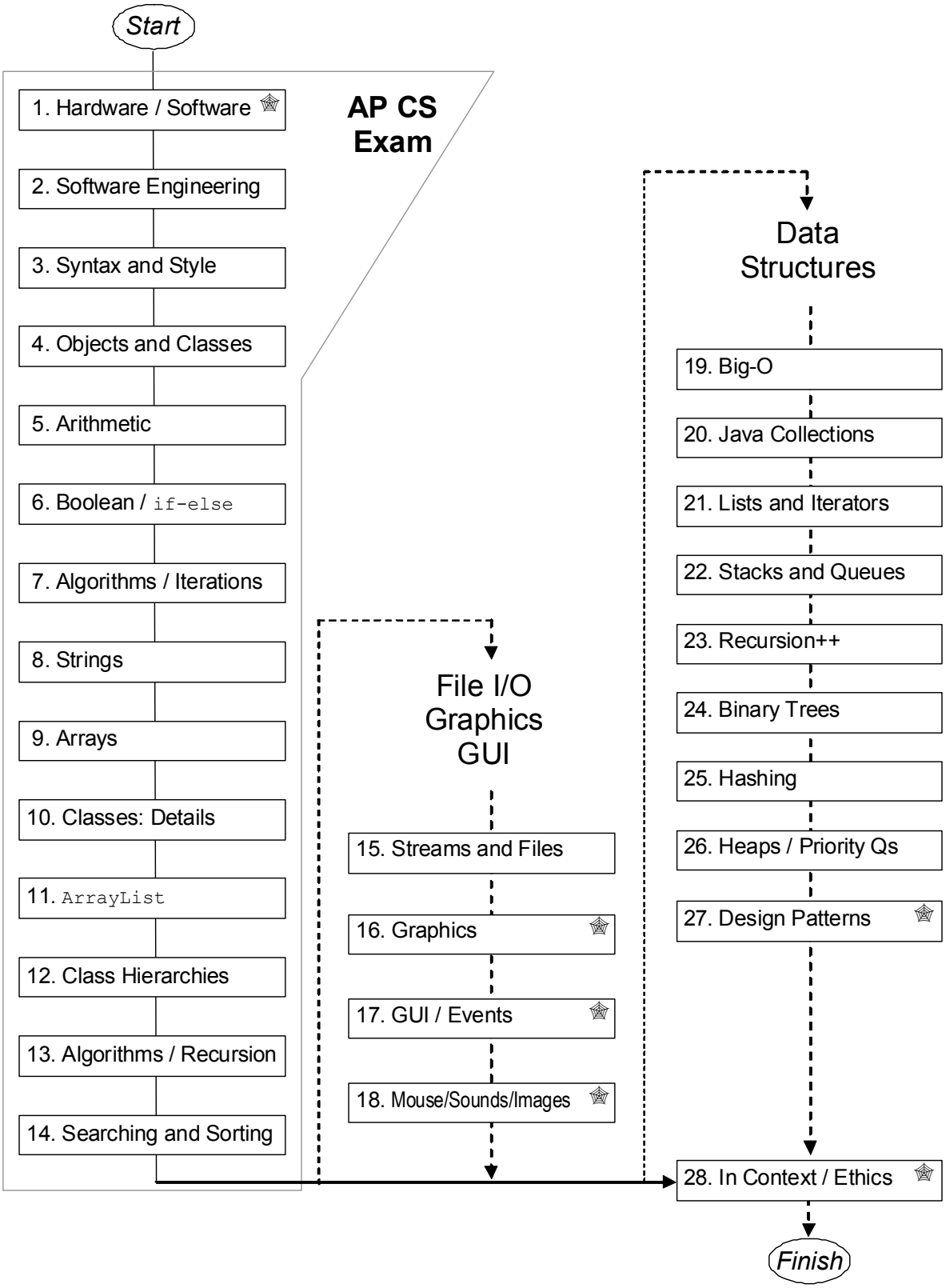
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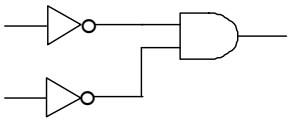
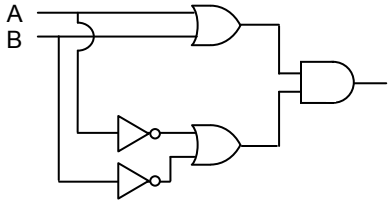
Chapter 1. An Introduction to Hardware, Software, and the Internet

2.

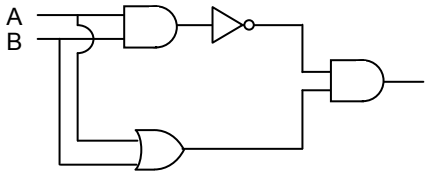


4.

(a)



(b)



6. (b) **F** -- files are created by the operating system
(c) **F** -- only the boot record is in ROM. Actually, it can boot any operating system that it can find on disk.

8. (c) **S**

10. (b) **T** (however, if you refer to "ASCII" characters as a subset of Unicode, then each "ASCII" character, as all Unicode characters, is represented in two bytes, with the first byte equal to 0)

11. (a) $2^3 = 8$

12.

	Binary	Decimal	Hex
(d)	00001101	13	0D
(g)	00000101 10010010	1426	0592

14. 512 * 512 * 8 bits = 256 KB. (It takes 8 bits to represent $256 = 2^8$ different values.)

16. Yes. You can use 2 bits per square, for example 00 = empty, 01 = 'o', 11 = 'x'. Then you need 9 * 2 = 18 bits = 2.25 bytes.

20. (a) **H** (d) **S** (f) **H**

Chapter 2. An Introduction to Software Development

1. (c) **F**

3. (b) **F** (a compiler is needed only for software development)

6. **T**

9. See `JM\Ch02\Exercises\Solutions\PrintFace.java`.

10. `BLACK`, `BLUE`, `CYAN`, `DARK_GRAY`, `GRAY`, `GREEN`, `LIGHT_GRAY`, `MAGENTA`, `ORANGE`, `RED`, `PINK`, `WHITE`, `YELLOW`.

13. (a) See `JM\Ch02\Exercises\Solutions\DoubleInput.java`.
(b) + adds two numbers, but it concatenates strings and concatenates a number to a string. If you remove the parentheses around `n + n`, then concatenation will be performed first, and instead of, say, 10 you will get 55.

16. See `JM\Ch02\Exercises\Solutions\HelloGraphics2.java`.

Chapter 3. Java Syntax and Style

3.

(a) `import`, `public`, `class`, `extends`, `implements`, `private`, `int`, `new`, `this`, `void`, `if`, `else`, `super`, `static`, `false`, `true`

(c) `MovingDisk`, `time`, `clock`, `g`, `x`, `y`, `r`, `sky`, `e`, `args`, `w`, `c`

4. (b) **style** (g) **style** (Java is case sensitive, so `IF` and `if` are two different words.)

6. The Java interpreter reports an error:

```
Error: Main method not found in class MovingDisk
```

(Ironically, "Main" is spelled with a capital "M" in interpreter's error message! It continues in a friendlier manner, though:

```
please define the main method as: public static void main(String[] args)
```

7. The parentheses are required by the syntax, but the braces are optional, since they contain only one statement.

9.

```
public boolean badIndentation(int maxLines)
{
  int lineCount = 3;
  while (lineCount < maxLines)
  {
    System.out.println(lineCount);
    lineCount++;
  }
  return true;
}
```

10. (a) **F** — the compiler ignores indentation and recognizes blocks through braces.
(c) **T** — such text represents literal strings.

11. (a) The `JFrame`'s constructor that sets the title bar is not called. The program runs, but the title bar is empty.

(b) Adding `void` confuses the compiler: it now thinks

```
public void HelloGui()
{
  ...
}
```

is a method! Unfortunately, Java allows you to give the same name to a class and a method in that class. Since `HelloGui`'s constructor has been incapacitated, the default constructor is used, which leaves the window blank. This kind of bug can be very frustrating!

Chapter 4. Objects and Classes

1. (c) **F** — it's the other way around: it tells the compiler where it can find classes used by this class.

2. (a) **F** — it also uses `Balloon` and other classes in `balloondraw.jar` (d) **F** — for example, the `Balloon` class does not.

3. (b) Seems like 363 in Java 8

4. (b) **T** (e) **F** — an object may not even have an `init` method.

10. (a) **T** (b) **F** — a subclass does not inherit any constructors

11. Deriving `Cylinder` from `Circle` is not appropriate — a bad design decision. It would work, but saving a couple of lines of code is not worth introducing an incorrect IS-A relationship between objects: a `Cylinder` is not a `Circle`.

13. In `BalloonPrint.java`:

```
import java.awt.Color;

public class BalloonPrint
{
  public static void main(String[] args)
  {
    Balloon b = new Balloon(100, 100, 20, Color.RED);
    System.out.println(b);
  }
}
```

In `Balloon.java`:

```
  public String toString()
  {
    return "Center = (" + xCenter + ", " + yCenter + ")" +
           " radius = " + radius + " color = " + color;
  }
```

Chapter 5. Data Types, Variables, and Arithmetic

1. (a) Invalid declaration of local variables: different types should be separated by a semicolon, not a comma.
   (b) Field

2. (d) **T** — it is often desirable to give the same name to variables that hold the same types of values for similar purposes in different methods.
   (e) **F** — unfortunately the compiler assumes that the code is correct and that the name refers to the local variable where that variable is defined.

5. **compiled**

7. (a) **0** (c) **5.0**

8. (a) **105**

12. See `JM\Ch05\Exercises\Solutions\FeetToInches.java`.

13.
```
double d = Math.sqrt((double)b * b - 4.0 * a * c);
double x1 = 0.5 * (-b - d) / a;
double x2 = 0.5 * (-b + d) / a;
```

14. Should be: `double temp;`

17. See `JM\Ch05\Exercises\Solutions\InflatableBalloon.java`.

23. See JM\Ch05\Exercises\Solutions\DogsHumanAge.java.

Chapter 6. Boolean Expressions and `if-else` Statements

2.
```
public static int max(int x, int y)
{
  if (x > y)
    return x;
  else
    return y;
}
```

6.
```
(a && !b) || (!a && b)
(a || b) && !(a && b)
a != b
```

8. (a)
```
x && y || !a && !b
```

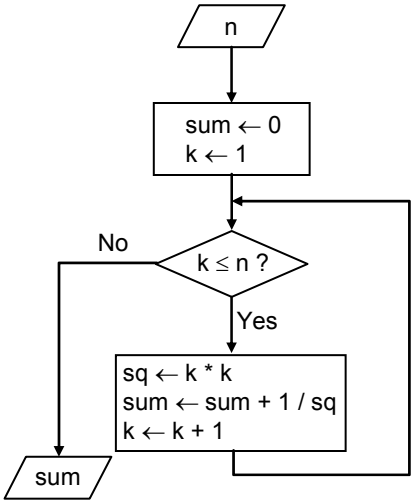
9. (a)
```
if ((x + 2 > a || x - 2 < b) && y >= 0)
```

12. (a)
```
boolean inside = (x >= left && x <= right &&
                  y >= top && y <= bottom);
```

14. See JM\Ch06\Exercises\Solutions\Dates.java.

Chapter 7. Algorithms and Iterations

1.




```
Input: n

sum ← 0

k ← 1

Repeat the following
three steps while
k ≤ n:

  sq = k * k
  sum ← sum + 1 / sq
  k ← k + 1

Output: sum
```

4. See JM\Ch07\Exercises\Solutions\QuotientRemainder.java.

6. See JM\Ch07\Exercises\Solutions\Population.java.

8.

```
public static int addOdds(int n)
{
  int sum = 0;

  for (int k = 1; k <= n; k += 2)
    sum += k;

  return sum;
}
```

9.

```
public static void main(String[] args)
{
  Scanner input = new Scanner(System.in);
  System.out.print("Enter a positive integer under 10: ");
  int n = input.nextInt();
  input.close();

  int sum = 0;
  for (int k = 1; k <= n; k++)
  {
    if (k > 1)
      System.out.print(" + ");
    System.out.print(k);
    sum += k;
  }
  System.out.println(" = " + sum);
  input.close();
}
```

10. (a)

```
public static boolean isPrime(int n)
{
  if (n < 3)
    return n == 2;
  else if (n % 2 == 0)
    return false;

  int m = 3;

  while (m * m <= n)
  {
    if (n % m == 0)
      return false;
    m += 2;
  }
  return true;
}
```

(b)

```
public static boolean isPrime(int n)
{
  if (n < 5)
    return n == 2 || n == 3;
  else if (n % 2 == 0 || n % 3 == 0)
    return false;

  int m = 5;

  while (m * m <= n)
  {
    if (n % m == 0 || n % (m + 2) == 0)
      return false;
    m += 6;
  }
  return true;
}
```

11.

```
public static boolean isPerfectSquare(int n)
{
  int k = 1, sum = 0;

  while (sum < n)
  {
    sum += k;
    k += 2;
  }
  return sum == n;
}
```

16. **6**

```
public static void main(String[] args)
{
  int n = 37, b = 2;
  int p = 1;

  while (p <= n)
  {
    n -= p;
    p *= b;
  }

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

20.

```
public static void printStarTriangle(int n)
{
  for (int row = 1; row <= n; row++)
  {
    int col = 1;
    while (col <= n - row)
    {
      System.out.print(" ");
      col++;
    }
    while (col < n + row)
    {
      System.out.print("*");
      col++;
    }
    System.out.println();
  }
}
```

Chapter 8. Strings

1. Should be

```
String fileName = "c:\\dictionaries\\words.txt";
```

2. (a)

```
private boolean endsWithStar(String s)
{
  int len = s.length();
  return len > 0 && s.charAt(len - 1) == '*';
}
```

or

```
private boolean endsWithStar(String s)
{
  return s.endsWith("*");
}
```

4. (a)

```
dateStr = dateStr.substring(3,5) + '-' +
          dateStr.substring(0,2) + '-' +
          dateStr.substring(6);
```

5. (a)

```
String last4 = ccNumber.substring(15);
```

11.

```
public String cutOut(String s, String s2)
{
  int n = s.indexOf(s2);
  if (n >= 0)
    s = s.substring(0, n) + s.substring(n + s2.length());

  return s;
}
```

15.

```
public boolean onlyDigits(String s)
{
  for (int i = 0; i < s.length(); i++)
    if (!Character.isDigit(s.charAt(i)))
      return false;
  return true;
}
```

Chapter 9. Arrays

1. (a)

```
int a[] = {1, 2, 4};
```

2. (a) **F** (c) **T**
(d) **F** — in arrays, length is not a method but works like a public field.

3.

```
public void swapFirstLast(int[] a)
{
  int i = a.length - 1;
  if (i >= 2)
  {
    int temp = a[0];
    a[0] = a[i];
    a[i] = temp;
  }
}
```

5.

```
public char getRandomRps()
{
  char[] rps =
     {'r', 'r', 'r', 'p', 'p', 'p', 'p', 'p',
      's', 's', 's', 's', 's', 's'};

  int i = (int)(Math.random() * rps.length);
  return rps[i];
}
```

13.

```
  i == j || i + j == n - 1
```

14.

```
private static double positiveMax(double[][] m)
{
  double mMax = 0;

  for (int r = 0; r < m.length; r++)
    for (int c = 0; c < m[0].length; c++)
      if (m[r][c] > mMax)
        mMax = m[r][c];

  return mMax;
}
```

16.

```
private static boolean covers(double[][] m1, double[][] m2)
{
  int count = 0;
  int nRows = m1.length, nCols = m1[0].length;

  for (int r = 0; r < nRows; r++)
    for (int c = 0; c < nCols; c++)
      if (m1[r][c] > m2[r][c])
        count++;

  return 2 * count >= nRows * nCols;
      // return count >= nRows * nCols / 2 doesn't work,
      // for example, nRows = 3, nCols = 3, count = 4
}
```

17.

```
public double average(int[] scores)
{
  int sum = 0;
  for (int s : scores)
    sum += s;
  return (double)sum / scores.length;
}
```

18. (a)

```
public int sumOfValues(int[] a)
{
  int sum = 0;
  for (int x : a)
    sum += x;
  return sum;
}
```

(b)

```
public int[] sumsOfRows(int[][] t)
{
  int[] sums = new int[t.length];

  int k = 0;
  for (int[] row : t)
  {
    sums[k++] = sumOfValues(row);
  }
  return sums;
}
```

25.

```
private static int[] add(int[] a, int[] b)
{
  int[] sum = new int[N];
  int carry = 0;

  for (int i = N-1; i >= 0; i--)
  {
    int d = a[i] + b[i] + carry;
    sum[i] = d % 10;
    carry = d / 10;
  }

  return sum;
}
```

27.

```
public static double averageTopTwo(int[] scores)
{
  int n = scores.length;
  int iMax1 = 0;        // index of the largest element
  int iMax2 = 1;        // index of the second largest element

  // if scores[iMax2] is bigger than scores[iMax1] --
  //   swap iMax1 and iMax2
  if (scores[iMax2] > scores[iMax1])
  {
    int i = iMax1;
    iMax1 = iMax2;
    iMax2 = i;
  }

  for (int i = 2; i < n; i++)
  {
    if (scores[i] > scores[iMax1])
    {
      iMax2 = iMax1;
      iMax1 = i;
    }
    else if (scores[i] > scores[iMax2] )
    {
      iMax2 = i;
    }
  }
  return (double)(scores[iMax1] + scores[iMax2]) / 2;
}
```

Chapter 10. Implementing and Using Classes

1.

```
public String replace(String str, char ch)
```

2. (a) **F** -- a no-args constructor is not specified.
(b) **T** -- the `int` parameter is promoted to double.

4. Yes for `String`: its documentation describes the following constructor:

> "String(String original) — Initializes a newly created String object so that it represents the same sequence of characters as the argument; in other words, the newly created string is a copy of the argument string."

No for `Color`: its documentation describes several constructors, but none of them is a copy constructor.

9. (b)

```
public Disk(Disk d)
{
  center = new Point(d.center);
  radius = d.radius;
}
```

12. Objects of subclasses of `Integer` or `String` would not be necessarily immutable; if such objects were passed to library methods that rely on immutability, these methods may stop working properly.

14. This class will not compile because the two swap methods differ only in their return types. A way to fix it is to rename one of the methods, for example `makeSwappedPair` for the second method.

19. A static method (`main`) calls a non-static method (`hello`). `hello` should be declared `static`.

Chapter 11. `java.util.ArrayList`

1. (a) **T** (c) **F** (e) **T**

4. `[0, 1, 2, 0, 1, 2]`

5.
```
public ArrayList<String> reverse(ArrayList<String> list)
{
  ArrayList<String> reversed = new ArrayList<String>(list.size());

  for (int i = list.size() - 1; i >= 0; i--)
    reversed.add(list.get(i));

  return reversed;
}
```

7.
```
public void filter(ArrayList<Object> list1, ArrayList<Object> list2)
{
  for (Object obj : list2)
  {
    int j = 0;
    while (j < list1.size())
    {
      if (list1.get(j) == obj)
        list1.remove(j);
      else
        j++;
    }
  }
}
```

Chapter 12. Class Hierarchies and Interfaces

1. (a) **T** (e) **F**

3. Only (c) and (d)

4.
```
public class Diploma
{
  private String name, subject;

  public Diploma(String nm, String subj) { name = nm; subject = subj; }
  public String toString()
  {
    return "This certifies that " + name + "\n" +
                      "has completed a course in " + subject;
  }
}

public class DiplomaWithHonors extends Diploma
{
  public DiplomaWithHonors(String nm, String subj) { super(nm, subj); }

  public String toString()
  {
    return super.toString() + "\n*** with honors ***";
  }
}
```

6. (b) The program shows that the ratio of the area to the perimeter in the right isosceles triangle (1.757) is greater than that ratio in the equilateral triangle (1.732). Therefore the right isosceles triangle holds a larger inscribed circle.

8.
```
public String toString()
{
  return super.toString().replace(",", "").
                                  replace("[", "").replace("]", "");
}
```

14.

```
public class Point1D implements Place
{
  private int x;

  public Point1D(int x) { this.x = x; }
  public int getX() { return x; }

  public int distance(Place other)
  {
    return Math.abs(getX() - ((Point1D)other).getX());
  }
}

public class TestPoint1D
{
  public boolean sameDistance(Place p1, Place p2, Place p3)
  {
    return p1.distance(p2) == p1.distance(p3);
  }

  public static void main(String[] args)
  {
    Point1D p1 = new Point1D(0);
    Point1D p2 = new Point1D(-1);
    Point1D p3 = new Point1D(1);
    TestPoint1D test = new TestPoint1D();
    System.out.println(test.sameDistance(p1, p2, p3));
  }
}
```

17. (a) In `Chomp.java`, replace

```
HumanPlayer human = new HumanPlayer(this, game, board);
ComputerPlayer computer = new ComputerPlayer(this, game, board);
computer.setStrategy(new Chomp4by7Strategy());

players = new Player[2];
players[0] = human;
players[1] = computer;
```

with

```
players = new Player[2];
players[0] = new HumanPlayer(this, game, board);
players[1] = new HumanPlayer(this, game, board);
```

(b) In `HumanPlayer.java`, add a name field, a fourth parameter name to the constructor, and a `getName` method; also modify the `getPrompt` and `getWinMessage` methods, adding the name to the messages.

`In Chomp.java`, replace

```
players[0] = new HumanPlayer(this, game, board);
players[1] = new HumanPlayer(this, game, board);
display.setText(" You go first...");
```

with

```
players[0] = new HumanPlayer(this, game, board, "Player 1");
players[1] = new HumanPlayer(this, game, board, "Player 2");
display.setText(players[0].getName() + ", you go first...");
```

(c) Passing a name as a parameter to `HumanPlayer`'s constructor is more flexible than coding specific names in different subclasses. It also reduces the number of classes. From the object-oriented design point of view, it is more appropriate to treat a name of a player as an attribute of an object, rather than its type.

Chapter 13. Algorithms and Recursion

2. `mysterySum(n)` returns 3*n*. `mysterySum(5)` will return 15.

4.
```
public int findMin(int[] list, int n)
{
  if ( n == 1)
    return list[0];
  else
    return Math.min(list[n-1], findMin(list, n-1));
}
```

8. (a)
```
public int sumDigits(int n)
{
  if (n < 10)
    return n;
  else
    return sumDigits(n/10) + n%10;
}
```

(b)
```
public boolean isDivisibleBy3(int n)
{
  if (n < 10)
    return n == 3 || n == 6 || n == 9;
  else
    return isDivisibleBy3(sumDigits(n));
}
```

12. (b) **E**

13. `019. display` prints all the digits of the number except the most significant digit.

16.

```
public long getSize()
{
  long total = 512 + 128*items.size();

  for (FileItem item : items)
    total += item.getSize();

  return total;
}
```

Chapter 14. Searching and Sorting

2.

```
public int compareTo(Person other)
{
  int diff = getLastName().compareTo(other.getLastName());

  if (diff == 0)
    diff = getFirstName().compareTo(other.getFirstName());
  return diff;
}
```

5. A few target values are much more likely than the rest and these values are placed at the beginning of the array.

6. (a) **6** (b) **7**

8.

```
public static int search(int[] a, int m, int n, int target)
{
  if (n <= m)
    return -1;
  int k = (m + n) / 2;
  if (a[k] == target)
    return k;
  int pos = search(a, m, k-1, target);
  if (pos >= 0)
    return pos;
  pos = search(a, k+1, n, target);
  return pos;
}
```

11. (a) T — the number of comparisons in Selection Sort is always the same.
(b) F — Insertion Sort takes $O(n)$ time if the array is already sorted.

13. 0, 2, 3, 5, 7, 8, 1, 9, 4, 3

15. 6, 9, 11, 10, 2, 22, 81, 74, 54

Chapter 15. Streams and Files

1. **A**

3. (a) Check status — this type of error may happen when the user enters the name of the file and mistypes it (b) Exception (c) Exception

4. See JM\Ch15\Exercises\Solutions\Braces.java.

5. See JM\Ch15\Exercises\Solutions\FileCompare.java.

7. See JM\Ch15\Exercises\Solutions\CharImage.java and JM\Ch15\Exercises\Solutions\image.txt.

Chapter 16. Graphics

1. See JM\Ch16\Exercises\Solutions\Drawings1.java.

2. See JM\Ch16\Exercises\Solutions\Drawings2.java.

Chapter 17. GUI Components and Events

1.

JPanel	none	none
JLabel	none	none
JButton	ActionListener	none
JCheckBox JRadioButton	ActionListener or ItemListener	isSelected
JComboBox	ActionListener or ItemListener	getSelectedIndex or getSelectedItem
JTextField	ActionListener	getText
JSlider	ChangeListener	getValue
JMenuItem	ActionListener	none

2. (a) **T** — why not? It's a regular method.
(b) **T** — this object's class must implement both ActionListener and ItemListener interfaces and must supply actionPerformed and itemStateChanged methods.
(c) **T** — then all of their respective actionPerformed methods are called.

7. See JM\Ch17\Exercises\Solutions\PizzaGui.java.

Chapter 18. Mouse, Keyboard, Sounds, and Images

1. See JM\Ch18\Exercises\Solutions\FourSeasons.java.

2. See JM\Ch18\Exercises\Solutions\DrawingPanel.java.

Chapter 19. Big-O Analysis of Algorithms

1. (a) **T** (b) **T**, because $\log_2 n = \log_{10} n \cdot \log_2 10$

2. (a) $O(n^2)$ (c) $O(n)$

3. (c) $O(\log n)$

4. (a) P
(c) E. This task is equivalent to finding the largest clique in a graph. (A graph is a set of nodes with edges connecting some of the nodes; a set of nodes in a graph is called a clique if any two nodes in that set are connected by an edge.) In complexity theory, there is a proof that this is what is called an NP-complete problem: it is equivalent to a whole class of problems for which no polynomial-time algorithms are known and are unlikely to be ever discovered.

7. (a) always (b) sometimes

10. (b) **F**

Chapter 20. The Java Collections Framework

2.

```
public <E> void append(List<E> list1, List<E> list2)
{
  for (int i = 0; i < list2.size(); i++)
    list1.add(list2.get(i));
}
```

6.

```
public double sum2(List<Double> list)
{
  double sum = 0;

  ListIterator<Double> iter1 = list.listIterator();
  while (iter1.hasNext())
  {
    double a = iter1.next().doubleValue();
    ListIterator<Double> iter2 = list.listIterator(iter1.nextIndex());

    while (iter2.hasNext())
    {
      sum += a * iter2.next().doubleValue();
    }
  }

  return sum;
}
```

8.

```
Three-Two
Three-Two-One
Three-Two-One
```

10. (b) The following simplification uses `Point`'s copy constructor:

```
Point cursor;
Stack<Point> stk = new Stack<Point>();
...
// Save cursor position:
stk.push(new Point(cursor));

show(new LoginWindow());
...
// Restore cursor position:
cursor = stk.pop();
```

Recall that a stack holds references to objects. It is necessary to make and push a copy of cursor because subsequent code may change the original.

13. `0 2 1 3 2 4`

21. (a) $O(1)$ (c) $O(n)$

Chapter 21. Lists and Iterators

1.

```
ListNode node3 = new ListNode("Node 3", null);
ListNode node2 = new ListNode("Node 2", node3);
ListNode node1 = new ListNode("Node 1", node2);
ListNode head = node1;
```

3.

```
public ListNode removeFirst(ListNode head)
{
  if (head == null)
    throw new NoSuchElementException();

  ListNode temp = head.getNext();
  head.setNext(null);
  return temp;
}
```

5.

```
public ListNode add(ListNode head, Object value)
{
  ListNode newNode = new ListNode(value, null);
  if (head == null)
    head = newNode;
  else
  {
    ListNode node = head;
    while (node.getNext() != null)
      node = node.getNext();
    node.setNext(newNode);
  }
  return head;
}
```

9.

```
public ListNode insertInOrder(ListNode head, String s)
{
  ListNode node = head, prev = null;

  while (node != null && s.compareTo(node.getValue()) > 0)
  {
    prev = node;
    node = node.getNext();
  }

  if (node != null && s.equals(node.getValue()))
    return head;

  ListNode newNode = new ListNode(s, node);

  if (prev == null)
    head = newNode;
  else
    prev.setNext(newNode);

  return head;
}
```

Chapter 22. Stacks and Queues

1. (a) **F**

4. A stack is not needed because we can process `binNum`'s characters in reverse, starting at the end of the string:

```
public class BinToDecimal
{
  public static int binToInt(String binNum)
  {
    int result = 0, power2 = 1;

    for (int i = binNum.length() - 1; i >= 0; i--)
    {
      char ch = binNum.charAt(i);
      int dig = Character.digit(ch, 2);
      result += dig * power2;
      power2 *= 2;
    }

    return result;
  }
}
```

5.

```
  public boolean moveToTop(Stack<Card> deck, int n)
  {
    Stack<Card> temp = new Stack<Card>();

    while (n > 1 && !deck.isEmpty())
    {
      temp.push(deck.pop());
      n--;
    }

    Card nth = null;

    if (!deck.isEmpty())
      nth = deck.pop();

    while (!temp.isEmpty())
    {
      deck.push(temp.pop());
    }

    if (nth != null)
    {
      deck.push(nth);
      return true;
    }
    else
      return false;
  }
```

6. (b) This implementation is quite inefficient because `String stack` is reallocated in each `push` and `pop` operation.

9. The integer values stored at `40:1A` and `40:1C` are the same, `0028` (in hex). These offsets represent the front and the rear of the ring buffer. The fact that they are the same indicates that the keyboard queue is currently empty. The last eight ASCII codes, stored in the buffer (going from location `0028` and around) are `64 20 34 30 3A 31 61 0D` (in hex), which corresponds to the string "`d40:1a`". Actually, this string is the "dump" command in the *MS-DOS debug* program that was used to produce the memory dump for this question.

10. **C**

Chapter 23. Recursion Revisited

2.

```
public boolean isDivisibleBy9(int n)
{
  if (n < 9)
    return false;
  else if (n == 9)
    return true;
  else
    return isDivisibleBy9(sumDigits(n));
}
```

4. (a) `pow(x, n)` executes $n-1$ multiplications. It is easy to prove this fact using mathematical induction. Therefore, this version is no more economical than a simple `for` loop. The answer is 4.

6. 100. `mysterySum(n)` returns n^2. Indeed, $(n-1)^2 + 2n - 1 = n^2$.

7.

```
public boolean degreeOfSeparation(Set<Person> people,
                                  Person p1, Person p2, int n)
{
  if (n == 1)              // Base case
  {
    return p1.knows(p2);
  }
  else                     // Recursive case
  {
    for (Person p : people)
    {
      if (p1.knows(p) && degreeOfSeparation(people, p, p2, n-1))
        return true;
    }
    return false;
  }
}
```

Let $K(n)$ be the number of times `knows` is called for the parameter value of *n*. Then, for $n = 1$, $K(1) = 1$, and the formula gives $\frac{3N^1 - N^0 - 2N}{N-1} = \frac{3N - 1 - 2N}{N-1} = 1$. For $n > 1$, `knows` is called once for each `Person p` in the group of *N* people who know `p1` (due to the short-circuit evaluation) and $1 + K(n-1)$ times for each `Person p` in the group of *N* people who do not know `p1`. Therefore, $K(n) = N + N(1 + K(n-1)) = 2N + N \cdot K(n-1)$. By the induction hypothesis, $K(n-1) = \frac{3N^{n-1} - N^{n-2} - 2N}{N-1}$. So

$$K(n) = 2N + N \cdot K(n-1) = 2N + N\frac{3N^{n-1} - N^{n-2} - 2N}{N-1} =$$

$$\frac{2N^2 - 2N + 3N^n - N^{n-1} - 2N^2}{N-1} = \frac{3N^n - N^{n-1} - 2N}{N-1}, \text{ Q.E.D.}$$

Chapter 24. Binary Trees

2. A binary tree with *n* levels can have at most $2^n - 1$ nodes. $2^{16} - 1 < 100000 < 2^{17} - 1$, so you need 17 levels.

4. Base case: For *h* = 0 the number of nodes in the tree is 0 and $0 = 2^0 - 1$. Likewise, for *h* = 1 the number of nodes in the tree is 1 and $1 = 2^1 - 1$. Suppose the statement is true for any $q < h$. Take a tree with *h* levels. By the inductive hypothesis, the numbers of nodes in its left and right subtrees do not exceed $2^{h-1} - 1$. Therefore, the total number of nodes for the tree does not exceed $(2^{h-1} - 1) + (2^{h-1} - 1) + 1 = 2^h - 1$, Q.E.D.

6.

```
public boolean isLeaf(TreeNode node)
{
  return node != null && node.getLeft() == null && node.getRight() == null;
}
```

8. Leaves.

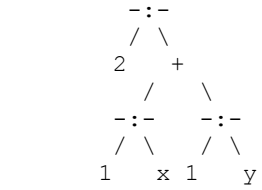
10.
```
public int depth(TreeNode root)
{
  if (root == null)
    return -1;

  return 1 + Math.max(depth(root.getLeft()), depth(root.getRight()));
}
```

12. (a)
```
public TreeNode copy(TreeNode root)
{
  if (root == null)
    return null;

  return new TreeNode(root.getValue(), copy(root.getLeft()),
                                                copy(root.getRight()));
}
```

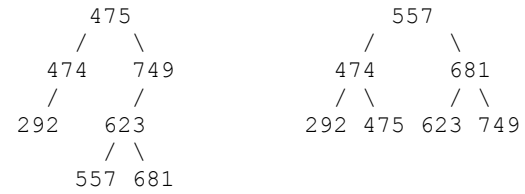
15. (a)



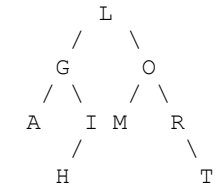
(g) Inorder, preorder, and postorder traversals of a binary tree visit its leaves in the same sequence. You can use mathematical induction (over the total number of nodes) to prove this fact: apply the induction hypothesis to the left and the right subtrees.

16. (b) **T** (c) F — the tree may have degenerated into a near linear shape

18.



19.



Inorder: A G H I L M O R T Preorder: L G A I H O M R T
Postorder: A H I G M T R O L

22.

```
public TreeNode maxNode(TreeNode root)
{
  if (root == null)
    return null;

  TreeNode node = root;
  while (node.getRight() != null)
    node = node.getRight();

  return node;
}
```

Chapter 25. Lookup Tables and Hashing

3.

```
public int busiestHour(List<PhoneCall> dayCalls)
{
  int[] counts = new int[24];

  for (PhoneCall call : dayCalls)
  {
    if (call.getDuration() >= 30)
      counts[call.getStartHour()]++;
  }

  int maxHour = 0;

  for (int hour = 1; hour < 24; hour++)
    if (counts[hour] > counts[maxHour])
      maxHour = hour;

  return maxHour;
}
```

6. (a) **F** — it is $O(1)$
(d) **T** — for a reasonably functioning hash table; also, after several removals and additions, a BST may need rebalancing.

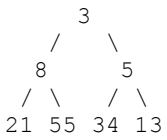
7. (b) A `hashTable` element takes 4 bytes, `ListNode` takes 8 bytes; `Record` takes 20 bytes. With 5 nodes per slot (on average) we need $1000 \cdot 4 + 5000 \cdot (8 + 20) = 144,000$ bytes for the hash table. We need $12000 \cdot 4 + 5000 \cdot 20 = 148,000$ bytes for the lookup table. The lookup table takes less than 3% extra space. Finding a record in a hash table takes one `hashCode` computation plus, on average, three record comparisons. The retrieval operation will run four times faster with the lookup table.

Chapter 26. Heaps and Priority Queues

1. (a) **F** (c) **T** (e) **T**

3. (a) parent: `x[i/2]`; left child: `x[2*i]`; right child: `x[2*i+1]`
   (b) `2*i > n`

5. (a)



Chapter 27. Design Patterns

1. See `JM\EasyClasses\EasyDate.java`.

2. See the Java files in `JM\Ch27\Goofenspiel\Solution\`.

8. If we make a composite expression (`SumExpression` and `ProductExpression`) `Observable`, how will it know when its left or right components have changed? In general in MVC, the model must be self-contained. If some of its fields change independently, outside the model, the MVC design breaks down. One possible solution to this problem is to make a composite object both `Observable` and `Observer` and attach it as an `Observer` to all its components. When one of its components changes, the composite will be notified and then it can update its view and/or pass the change along to other composites that hold this one as a component.