1 Submission Instructions

- In the submission instructions, we mention your ASURITE ID several times. Your ASURITE ID is the user name you use to log in to ASU computer systems such as MyASU and Canvas, e.g., the instructor's ASURITE ID is kburger2. It is not the same as your 10-digit ASU ID number printed on your SunCard.
- Note that for each homework assignment, only some of the exercises will be graded. A list of the exercises that will be graded can be found in the *Module 2 > HW1* submission page in Canvas.
- There are two primary reasons we grade only some of the exercises: first, this course has a large enrollment so there are many assignments to be graded. Second, in the accelerated time frame for online courses, we want to return graded homework assignments as quickly as we can.
- Please understand that it is time-consuming to manually grade assignments, particularly programming exercises, so it may take as long as one week to return scores. We will always try to return them sooner.
- Not grading all of the exercises does not mean that the ungraded exercises are unimportant or that you will not be tested on the concepts in the exercise. They are equally important as the graded exercises and the concepts you learn may be on the exams. Consequently, we **strongly recommend** that you complete *all* of the exercises.
- Some of your solutions must be submitted in a PDF document. To start the assignment, create a word processing document named **group-*nn*-h1.ext** where *nn* is your two digit group number and *ext* is likely .docx if you are using Microsoft Word or .odt if you are using Libre Office or Open Office. For example, if group number 7 is using Microsoft Word, then their document shall be named **group-07-h1.docx**. If group 23 is using Libre Office, then their document shall be named **group-23-h1.odt**.
- Near the top of the document, please type the following information: (1) Your group number, e.g., **Group 12**; (2) The names, ASURITE ID's, and email addresses of each member of the group; (3) The homework assignment number, e.g., **HW1** or **Homework 1.**
- For the **short-answer and description** exercises which will be graded, please neatly type your solutions in the document. Clearly number each exercise so there is no confusion for the grader.
- Some exercises may ask you to submit an **image** (e.g., see Exs. 7.1–7.2). Hand-drawn images are unacceptable and will result in zero points being assigned for an exercise. The reason is because hand-drawn images are often illegible, which cause graders to have to spend extra time scrutinizing the handwriting in order to decipher it and oftentimes, they cannot read your handwriting, in which case your work may be marked as incorrect. For images, use an appropriate software drawing tool to draw the image, then export the image in a suitable image file format, and then copy-and-paste the image file into your word processing document. Please ensure the image is sufficiently sized so that the text is readable.
- Please carefully read and follow the instructions in §1.1 and §1.2 regarding submission of **Java source code files** (e.g., Ex. 3.1). We will be using an automated grading script to grade these exercises, so it is extremely important that you follow the assignment instructions—especially in regard to naming—so your submission will not cause the script to fail resulting in point deductions.
- If a graded exercise asks you to write **Java code, but does not request that you submit your solution** in a separate Java source code file (e.g., see Exs. 3.3, 3.6, 3.7), then copy-and-paste your code from your IDE or text editor into your word processing document. Make sure to neatly format your code, i.e., indentation.
- When you are done with the document, please convert the document to **Adobe PDF format** and name the file **group-*nn*-h1.pdf**.
- Next, create an empty folder named **group-*nn*-h1** and copy **group-*nn*-h1.pdf** to this folder.
- Next, copy any requested Java source code files into this folder. (Note: Java source code files are the files with a *.java* file name extension; do not include any *.class* or other files in your zip archive as we do not need those.)
- Next, compress the **group-*nn*-h1** folder creating a **zip archive** file named **group-*nn*-h1.zip**. Upload **group-*nn*-h1.zip** to Canvas using the *Module 2 > HW1* submission page prior to the assignment deadline
- Please consult the *Syllabus > Course Summary* section of Canvas for the assignment deadline. The deadline may also be found on the *Module 2 > HW1* project submission page.
- Please consult the course Syllabus for the late and academic integrity policies.

1.1 Submitting Java Source Code Files Containing Methods.

For Exs. 3.1, 3.4, 3.5—which ask you to submit Java files containing just methods (not a complete runnable program) that solve the problem—we want you to encapsulate the requested method within a class (i.e., in a *.java* file) named as requested in the exercise. Remember that Java is case-sensitive so your filenames, method names, variable names, etc. must be named **exactly** as requested in the homework document. Failure to do this will cause you to lose points on an exercise. For example, here is what we want you to submit for Ex. 3.1, where you will complete the code in method *arrayListInit*() in a class named *H1_31* to solve the problem:

```java
/**
 * CLASS: H1_31 (H1_31.java)
 * GROUP nn
 * AUTHOR 1: your name, your ASURITEID username, your email address
 * AUTHOR 2: your name, your ASURITEID username, your email address
 * AUTHOR 3: your name, your ASURITEID username, your email address
 */
import java.util.ArrayList;  // Import any required classes so your code will build

public class H1_31 {  // Remember that class name and filename have to be the same. Case matters.

    public H1_31() {  // Provide a default constructor even if it is empty.
    }                 // Some exercises may require other ctors.

    // This is the method you are asked to write for Ex. 3.1. Name it exactly as requested.
    public ArrayList<Integer> arrayListInit() {
        // 1. Declare and instantiate an ArrayList<Integer> object named list.
        // 2. Write single for/while loops or a pair of for/while loops to fill list with the specified values.
        // 3. Return list.
    }
}
```

- The CLASS, GROUP, and AUTHOR lines must be included in the header comment block.
- All other comment lines are optional but we strongly encourage you to thoroughly comment your code because in some cases, the comments may permit the grader to understand your code and assign points when he or she might otherwise deduct them.
- Note that the instructor indents using 4 spaces. It does not matter to us how many spaces you indent but be consistent and please configure your text editor to insert **spaces** and not hard tabs when you hit the Tab key.
- Be sure for each exercise that you import the required classes so that your class will build.
- It is preferable to import just the one class from a package, e.g., `import java.util.ArrayList` rather than writing `import java.util.*;` which imports all classes within the package.
- Given your standalone class, we will write a **testing driver/program** that instantiates an object of your class and then our testing driver shall call *arrayListInit*() on that object to test your solution.
- Do not provide a *main*() method or a testing driver routine in your class: for testing on your end, write your own *main*() method and testing driver in a class separate from *H1_31*.
- For exercises in this category, you **do not** need to copy-and-paste your code into the word processing document. But, for us to be able to test and grade your code, you shall include the requested *.java* file(s) in your assignment zip archive.

1.2 Submitting Java Source Code Files for Complete Programs.

For exercises which ask you to write a complete program (see Ex. 4.3), your program must contain a *main*() method and any requested testing driver methods or code. In general, unless the exercise specifically asks you to write class (static) methods, all the methods in your class(es) except for *main*() must be instance methods. Shown below is the required template for the main class, i.e., the class containing the *main*() method, of a complete program. For these exercises, you **do not** need to copy-and-paste your code into the word processing document, but for us to be able to test and grade your code, you shall include the requested *.java* file(s) in your assignment zip archive.

```
/**
 * CLASS: MainClassName (MainClassName.java)
 * GROUP nn
 * AUTHOR 1: your name, your ASURITEID username, your email address
 * AUTHOR 2: your name, your ASURITEID username, your email address
 * AUTHOR 3: your name, your ASURITEID username, your email address
 */
import required stuff ...;  // Do not use import package.* notation

public class MainClassName {

    // Declare instance data as required...

    public static void main(String[] pArgs) { // I often preface method parameter names with a p
        new MainClassName().run();  // Instantiate an object of this class and then call run() on the object
    }

    public MainClassName() { // Provide a default constructor, even if it is empty.
    }

    // Provide other ctors as required...

    // run() is where the action starts taking place. I like to say that when we leave main() and reach run(), we
    // leave "static land" and enter "object land." Static (class) methods have their uses but they should rarely
    // be used. Note: run() is private because it is intended to be only called from main().
    private void run() {
    }

    // Provide other instance or class methods as required...
}
```

2 Learning Objectives

1. To effectively use the *Integer* and *Double* wrapper classes.
2. To declare and use *ArrayList<E>* class objects.
3. To write code to read from, and write to, text files.
4. To understand exception processing and write an exception handler for I/O exceptions.
5. To write Java classes and instantiate objects of those classes.
6. To read and comprehend UML class diagrams and convert the diagrams into Java classes.
7. To identify and implement dependency, aggregation, inheritance, and composition relationships.

3 ArrayLists

3.1 Learning Objective: To declare, create, and initialize an *ArrayList<Integer>* list.

Submission Instructions: See the instructions in §1.1 for what to submit for grading. This is not a complete program. Name your class *H1_31* and save it in a file named *H1_31.java*. When you are done, copy *H1_31.java* to your group-*nn*-h1 folder, i.e., to the same folder as the PDF.

Problem: Write a public instance method named *ArrayList<Integer> arrayListInit*() that creates an *ArrayList<Integer>* object named *list* and fills *list* with the numbers shown below (using one or a pair of **for** or **while** loops, i.e., if you just call *add*() to add the numbers to *list*, your solution will be marked as incorrect). *list* shall be returned from *arrayListInit*(). Note that your method shall not output the contents of the list, just return it.

```
0  1  2  3  4  0  1  2  3  4
```

Testing: We will be testing your method using our driver routine. For testing on your end, write your own driver routine in a class different than *H1_31*.

3.2 Learning Objective: To use the *ArrayList<E>* class *get*() and *set*() methods.

Problem: Consider the *ArrayList<Integer>* object named *list* containing these *Integers*:

```
list = { 1, 2, 3, 4, 5, 4, 3, 2, 1, 0 }
```

What are the contents of *list* after this loop completes?

```
for (int i = 1; i < 10; ++i) {
    list.set(i, list.get(i) + list.get(i-1));
}
```

3.3 Learning Objective: To use an enhanced for loop to iterate over the elements of an *ArrayList<Integer>* list.

Problem: Write an enhanced for loop that counts how many integers in an *ArrayList<Integer>* object named *list* are negative. Print the count after the loop terminates. You may assume that the *list* reference variable is non-null but the list itself may be empty.

3.4 Learning Objective: To compute a running sum of the elements of an *ArrayList<Integer>* list.

Submission Instructions: See the instructions in §1.1 for what to submit for grading. This is not a complete program. Name your class *H1_34* and save it in a file named *H1_34.java*. When you are done, copy *H1_34.java* to your group-*nn*-h1 folder, i.e., to the same folder as the PDF.

Problem: See the instructions in §1.1 for what to submit for grading. This is not a complete program. Name your Java source code file *H1_34.java*. Write a public instance method named *Integer arrayListSum*(*ArrayList <Integer> pList*). The method shall return the sum of the elements of *pList* as an *Integer*. The method shall return 0 when: (1) the *pList* parameter variable is `null`; or (2) *pList* is the empty list.

Testing: We will be testing your method using our driver routine. For testing on your end, write your own driver routine in a class different than *H1_34*. Make sure to test the cases where list is empty and where the *pList* parameter is `null`.

3.5 Learning Objective: To declare, create, and initialize an *ArrayList<Integer>* list.

Submission Instructions: See the instructions in §1.1 for what to submit for grading. This is not a complete program. Name your class *H1_35* and save it in a file named *H1_35.java*. When you are done, copy *H1_35.java* to your group-*nn*-h1 folder, i.e., to the same folder as the PDF.

Problem: Write a public instance method named named *ArrayList<Integer> arrayListCreate*(*int pLen, int pInit Value*). The method shall use a while or for loop to create a new *ArrayList<Integer>* object which has exactly *pLen* elements, *pLen* ≥ 0. Each element shall be initialized to *pInitValue*. The method shall return the *ArrayList*. When *pLen* is 0, no list shall be created and the method shall return `null`.

Testing: We will be testing your method using our driver routine. For testing on your end, write your own driver routine in a class different than *H1_35*. Make sure to test the case where *pLen* is 0.

3.6 Learning Objective: To insert a *String* into a *ArrayList<String>* list and maintain the sort order of the list.

Problem: Write a void method named *insertName*() that has two input parameters: (1) *pList* which is an object of *ArrayList <String>* where each element of *pList* is a person's name; and (2) a *String* object named *pName*. Assume the names in *pList* are already sorted into ascending order. The method shall insert *pName* into *pList* such that the ascending sort order is maintained. The *pList* parameter variable will be non-null but the list itself may be empty.

Algorithm: There are at least two algorithms one could use to solve this problem. The first—and the method you shall not use—is to add *pName* to the end of *pList* and then sort *pList*. The second—and this is the algorithm you shall use—is to write a **for** or **while** loop that iterates over the Strings in *pList* (starting at index 0) until the index is reached where *pName* must be inserted so *pList* remains sorted. We will study algorithmic complexity and Big O notation later in the course, so what I say here may not make sense, but the first algorithm has time complexity $\Theta(n$

lg n) and the second is $O(n)$. This means the first algorithm is slower than the second and this is one of the the reasons I want you to use the second method.

Testing: Make sure to test the cases where *pList* is empty, where the new element is added at the beginning of the list, in the middle of the list, and at the end of the list.

3.7 Learning Objective: To remove elements from an *ArrayList<Integer>* list.

Problem: Write a void method named *arrayListRemove*() which has two parameters: *pList* is an object of the *ArrayList <Integer>* class and *pValue* is an int. The method shall remove all elements from *pList* that are equal to *pValue*. The *pList* parameter variable will be non-null but the list itself may be empty.

Testing: Make sure to test the cases where *pList* is empty, where no elements are removed, where all elements are removed, where the only element that is removed is at the beginning of the list, in the middle of the list, and at the end of the list.

4 Text File Input/Output

4.1 Learning Objective: To understand how files are opened.

Problem: Explain what happens if you try to open a file that does not exist for reading.

4.2 Learning Objective: To understand how files are opened.

Problem: Explain what happens if you try to open a file that does not exist for writing.

4.3 Learning Objective: To read and write text files.

Submission Instructions: See the instructions in §1.2 for what to submit for grading. This is complete program with one Java source code file named *H1_43.java* (your main class is named *H1_43*). When you are done, copy *H1_43.java* to your group-*nn*-h1 folder, i.e., to the same folder as the PDF.

Problem: Write a program that prompts the user for the name of a Java source code file (you may assume the file contains Java source code and has a *.java* filename extension; we will not test your program on non-Java source code files). The program shall read the source code file and output the contents to a new file named the same as the input file, but with a *.txt* file name extension, e.g., if the input file is *foo.java* then the output file shall be named *foo.java.txt*. Each line of the input file shall be numbered with a line number (formatted as shown below) in the output file. For example, if the user enters *H1_43.java* as the name of the input file and *H1_43.java* contains:

```
//***************************************************************
// CLASS: H1_43
//***************************************************************
public class H1_43 {
    public static void main(String[] pArgs) {
    }
    private run() {
    }
}
```

then the contents of the output file *H1_43.java.txt* would be:

```
[001] //***************************************************************
[002] // CLASS: H1_43
[003] //***************************************************************
[004] public class H1_43 {
[005]     public static void main(String[] pArgs) {
[006]     }
[007]     private run() {
[008]     }
[009] }
```

You may assume that the file being read exists.

Hint: To print an integer as shown above in a field of width 3 with leading 0's use the Java API *PrintWriter.printf*() method with a format specifier of `%03d`. The `%` symbol tells the compiler this is a format specifier, 3 is the field width for the integer line number, the 0 preceding 3 tells the compiler to output leading 0's rather than leading spaces if the line number does not take up the entire field width, and `d` tells the compiler that we are printing an integer).

Testing: Make sure to test the case where the input file exists but is empty.

5 Exceptions and Exception Handling

5.1 Learning Objective: To demonstrate knowledge of throwing and catching exceptions.

Problem: Explain the difference between throwing an exception and catching an exception, i.e., explain what happens when an exception is thrown and when one is caught?

5.2 Learning Objective: To demonstrate knowledge of checked and unchecked exceptions.

Problem: Explain what a checked exception is. Give one example.

5.3 Learning Objective: To demonstrate knowledge of checked and unchecked exceptions.

Submission Instructions: Include your answer in group-*nn*-h1.pdf.

Problem: Explain what an unchecked exception is. Give one example.

5.4 Learning Objective: To demonstrate knowledge of exception handling.

Problem: Which type of uncaught exceptions must be declared with the throws reserved word in a method header?

5.5 Learning Objective: To demonstrate knowledge of exception handling.

Submission Instructions: Include your answer in group-*nn*-h1.pdf.

Problem: Why don't you need to declare that your method might throw an *IndexOutOfBoundsException*?

5.6 Learning Objective: To demonstrate knowledge of exception handling.

Submission Instructions: Include your answer in group-*nn*-h1.pdf.

Problem: Is the type of the exception object that gets thrown always the same as the exception type declared in the catch clause that catches the exception? If not, why not?

5.7 Learning Objective: To demonstrate knowledge of exception handling.

Problem: What is the purpose of the finally clause? Give an example of how it can be used.

5.8 Learning Objective: To demonstrate knowledge of exception handling in the *Scanner* class.

Problem: Which exceptions can the *next*() and *nextInt*() methods of the *Scanner* class throw? Are they checked exceptions or unchecked exceptions?

6 Objects and Classes

6.1 Learning Objective: To demonstrate knowledge of instance and class methods.

Problem: Explain how an instance method differs from a class method (static method).

6.2 Learning Objective: To demonstrate knowledge of class constructors.

Problem: Explain what happens if we write a class named *C* but do not implement any constructors in *C*.

6.3 Learning Objective: To demonstrate knowledge of instance and class methods.

Submission Instructions: Include your answers in group-*nn*-h1.pdf.

Problem: (a) In a static method, it is easy to differentiate between calls to instance methods and calls to static methods. How do you tell the method calls apart? (b) Why is it not as easy to distinguish between calls to instance and static methods which are called from an instance method?

6.4 Learning Objective: To demonstrate knowledge of constructors, instantiating objects, and calling methods.

Problem: Explain what happens when this application runs and why.

```
public class C {
    private int x;
    private String s;
    public static void main(String[] pArgs) { new C(); }
    public C() {
        x = s.length();
        System.out.println("x = " + x);
    }
}
```

6.5 Learning Objective: To declare a complete class, declare instance and class data, instance and class methods, constants, and to understand the differences between public and private accessibility modifiers.

Submission Instructions: See the instructions in §1.1 for what to submit for grading. This is not a complete program. Name your class *H1_65* and save it in a file named *H1_65.java*. When you are done, copy *H1_65.java* to your group-*nn*-h1 folder, i.e., to the same folder as the PDF.

Create a public class named *H1_65* and write the class declaration for *H1_65* that declares: (1) a private int instance variable named *mX*; (2) a private int class variable named *mY* initialized to 0; (3) a private int class constant named *A* which is equivalent to 100; (4) a public int class constant named *B* which is equivalent to 200; (5) public accessor and mutator methods for *mX* named *getX*() and *setX*(); (6) public accessor and mutator methods for *mY* named *getY*() and *setY*(); (7) a public constructor that has one int input parameter named *pX* which calls *setX*() to initialize *mX* to *pX*; (8) a public default constructor that calls *H1_65*(int) to initialize *mX* to -1.

6.6 Learning Objective: To declare an object of a class, calling a constructor.

Submission Instructions: Continuing the previous exercise, create a class named *H1_66* in *H1_66.java*. This is the main class for the program: see §1.2 for the required template. There is an exception to the template for this exercise: omit the *run*() method and in *main*() do not instantiate an object of the class and call *run*() on the object; rather, for Exercises 6.6–6.8, all of the requested statements will be written directly in *main*().

Problem: Within *main*() write a statement which instantiates an *H1_65* object named *cObj1* by calling the default constructor.

Testing: This program will verify that there are no syntax errors in *H1_65* and that the default constructor and *setX*() are correctly implemented.

6.7 Learning Objective: To declare an object of a class, calling a constructor.

Submission Instructions: Continue the previous exercise by modifying *main*().

Problem: Write a statement in *main*()—below the statement you wrote for Ex. 6.6—that instantiates another *H1_65* object named *cObj2* by calling the second constructor to initialize the *mX* instance variable to 10.

Testing: This program will verify that there are no syntax errors in *H1_65* and that the second constructor and *setX*() are correctly implemented.

6.8 Learning Objective: To demonstrate knowledge of accessing the public/private data and methods of a class.

Submission Instructions: These are short answer questions. Type your solution in your PDF document.

Problem: Continuing the previous exercise. Within *main*(), are the following statements syntactically legal, i.e., do they compile? If so, describe what happens when the statement is executed. If not, explain why the statement is syntactically illegal. You may write these statements in *main*() to solve this exercise, but do not include these statements in the Java file you submit for grading. The data types of *cObj1* and *cObj2* are *H1_65*.

(a) `int a1 = H1_65.mX;`
(b) `int a2 = H1_65.mY;`
(c) `int a3 = H1_65.A;`
(d) `int a4 = H1_65.B;`
(e) `cObj1.H1_65(20);`
(f) `int a5 = cObj1.getX();`
(g) `cObj1.setX(20);`
(h) `cObj2.setX(cObj1.getX());`
(i) `int a6 = H1_65.getX();`
(j) `H1_65.setX(20);`
(k) `int a7 = cObj1.getY();`
(l) `cObj1.setY(20);`
(m) `int a8 = H1_65.getY();`
(n) `H1_65.setY(20);`

6.9 Learning Objective: To demonstrate knowledge of accessing the public/private data and methods of a class.

Problem: Continuing the previous exercise. Suppose we add these two methods to the declaration of class *H1_65*. For each assignment statement, if it is legal (compiles) explain what happens when the statement is executed. For each assignment statement that is illegal (syntax error) explain why the code is illegal. Do not include these methods in the *H1_65.java* file that you submit for grading.

```
public void f() {
    mX = 0;
    mY = 0;
}
```

```
public static void g() {
    mX = 0;
    mY = 0;
}
```

7 Object Oriented Design and UML Class Diagrams

7.1 Learning Objectives: To draw a UML class diagram.

See §1 *Submission Instructions* for the instructions regarding drawing images in exercise solutions. This exercise is not graded so you do not need to insert your image into group-*nn*-h1.pdf.

Problem: Below is the code for a Java class named *C*. Using a UML class diagram drawing tool, draw the UML class diagram that corresponds to this code. There are several free and open-source tools for drawing UML diagrams. Two reasonably simple-to-use and cross-platform (Windows, Mac, Linux) tools are:

Umlet – http://www.umlet.com and the web-based version is Umletino https://www.umletino.com/umletino.html
Violet – http://alexdp.free.fr/violetumleditor

The instructor has been using Umlet for all of the class diagrams he has drawn for the lecture notes and he highly recommends it as it is very easy to learn how to quickly draw a nice-looking class diagram. Using Umlet, you can export your diagram as an image file by selecting File | Export As... on the main menu. For the highest image quality, we recommend you export the diagram as an EPS (Encapsulated Postscript) image and then copy-and paste the EPS image into your word processing document (I do not know if it is just Libre Office or if this would happen in MS Office as well, but I find that EPS images look significantly better and are more readable when pasted into a Libre Office document than PNG or JPG images). If EPS does not work, then export the image as a PNG image.

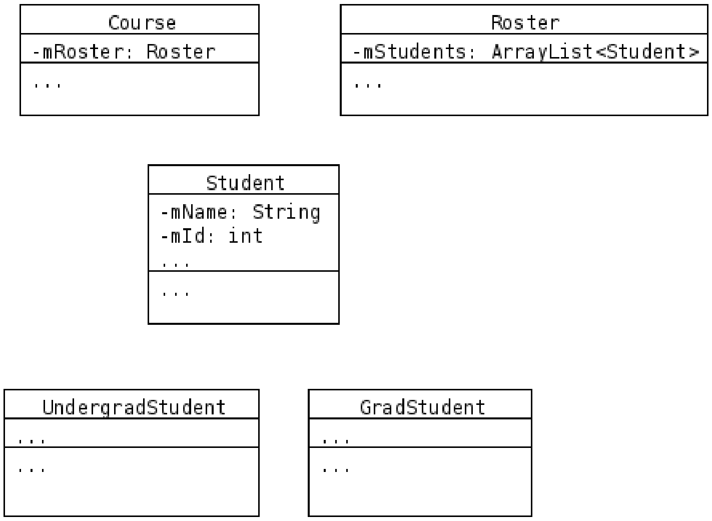
```
public class C {
    public static final int CONST1 = 100;
    private int mX;
    private double mY;
    private String mZ;
    public C() { this(0, 0, ""); }
    public C(int pX, double pY, String pZ) { setX(pX); setY(pY); setZ(pZ); }
    public int getX() { return mX; }
    public double getY() { return mY; }
    private String getZ() { return mZ; }
    public void setX(int pX) { mX = pX; }
    public void setY(double pY) { mY = pY; }
    private void setZ(String pZ) { mZ = pZ; }
}
```

7.2 Learning Objectives: To draw a UML class diagram with relationships.

Submission Instructions: Shown below is a UML class diagram which shows several classes that are associated in various ways (this diagram was drawn with Umlet and is in the file *class-relation.uxf* in the homework zip archive). Using Umlet or some other UML class diagram tool, modify the image as requested in the Problem statement and insert the resulting image into group-*nn*-h1.pdf.

Note: Multiplicities do not apply to generalization/inheritance relationships because generalization relationships are always 1 to 1.

Problem: **(a)** Note that in *Course* there is an instance variable *mRoster* which is an instance of *Roster*. When a *Course* object is deleted, the *Roster* instance variable *mRoster* will also be deleted. Given that, what type of class relationship, if any, exists between *Course* and *Roster*? If there is a relationship, modify the diagram to indicate the relationship and label each end of the relationship with a multiplicity. **(b)** Note that in *Roster* there is an instance variable *mStudents* which is an *ArrayList* of *Student* objects. When a *Roster* object is deleted, *mStudents* is also deleted, but each *Student* object within *mStudents* is not deleted. Given that, what type of class relationship, if any, exists between *Roster* and *Student*. If there is a relationship, modify the diagram to indicate the relationship and label each end of the relationship with a multiplicity. **(c)** What type of class relationship, if any, exists between Student and UndergradStudent? If there is a relationship, modify the diagram to indicate the relationship. Should there be a multiplicity applied to this relationship? If you think so, then indicate it. **(d)** What type of class relationship, if any, exists between Student and GradStudent? If there is a relationship, modify the diagram to indicate the relationship. Should there be a multiplicity applied to this relationship? If you think so, then indicate it. **(e)** What type of class relationship, if any, exists between UndergradStudent and GradStudent? If there is a relationship, modify the diagram to indicate the relationship. Should there be a multiplicity applied to this relationship? If you think so, then indicate it.


Course
-mRoster: Roster
...
Roster
-mStudents: ArrayList<Student>
...
Student
-mName: String
-mId: int
...
...
UndergradStudent
...
...
GradStudent
...
...