# HarmonyMuse

A system for organizing and categorizing musical harmony

# Michael Kramer

# Assignment 1 --1/12/2021 7:08 AM

For this assignment, you will describe and implement release 1 of your term project. You will incorporate *an abstract class*, *inheritance*, *upcasting or downcasting*, and *polymorphism*. You are free to choose a project that interests you but if you prefer, the instructor and your facilitator will be happy to suggest a topic. If you are already an experienced developer, this is an opportunity to build a challenging application (check with your facilitator if it requires significant API’s) or discuss research with the instructor. It is OK to name a project with much more scope than you can accomplish in the course (as in the example above): we will not hold you to completing everything associated with it. What we do expect is that you specify and implement a set of do-able requirements within such scope.

Submit this completed Word document. Replace as indicated. Please observe and retain the gray text. Your materials—in black 12-point Times New Roman—should not exceed 5 pages excluding references, figures, and appendices. Use the Appendix sections for additional material if you need to. These will be read only on an as-needed basis.

We want you to develop in Eclipse preferably or else IntelliJ (talk to your facilitator about exceptions). As you code, use JUnit tests whenever possible but certainly by week 2—package-by-package, class-by-class, and method-by-method, except for trivial methods and those requiring I/O. Use non-Junit classes for testing the latter. Keep the evaluation criteria in mind, listed at the end.

For this assignment, you do not need to read data from a file—you can build all data into the code.

Include a ReadMe file describing where to run the application from, and including necessary execution notes. All JUnit tests will be assumed runnable.

# 1.1 SUMMARY DESCRIPTION *EVALUATION CRITERION (i) APPLIES*

One- or two-paragraph overall description of your proposed term project—half-page (12-point Times New Roman) limit. By the end, term projects will incorporate most of the techniques discussed in the course. To do this, you may need to alter the direction of your project or introduce an additional project in future. You may alter this or even replace it as the semester progresses. You will probably find it useful to use your project acronym.

This project concerns a system for organizing and categorizing harmony (chords, a collection of musical notes). To use this system, called *HarmonyMuse*, a musician inputs either a collection of notes or a chord quality with an accompanying complexity and a context for the sonority of the chord. *HarmonyMuse* analyzes the given input and provides a performance solution based on the provided context.

## 1.2 I/O EXAMPLE FROM *PROJECTED* COMPLETED PROJECT *EVALUATION CRITERION (i) APPLIES*

Provide an example of projected *concrete* output for designated input. You will not be held to fulfilling exactly this—it is just explanatory at this point, to indicate where your project is going. We recognize that project direction and details will change as the term progress. This section refers to the project as a whole, not just to what you will produce this week, so we can gain an idea of what you have in mind overall.

**Musician:**

C, E, G

**System:**

* Simple Possibilities:
  + C major triad (root position)
  + E minor b6 (omit 5th)
  + G6sus4
* Would you like to see complex possibilities?

**Musician:**

Y

**System:**

* Complex Possibilities:
  + Db maj7(#11, #9)
  + D7sus4
  + Eb 13(b9)
  + Fmaj9
  + F#7alt
  + Abmaj7(#5)
  + Amin7
  + Bbmaj13(#11)
  + Bphrygian
* What is your context? type “piano” or “guitar”

**Musician:**

piano

**System:**

<Outputs PDF of music notation on grand staff including all possibilities listed above>

<https://lilypond.org/doc/v2.22/Documentation/learning/index#top>

## 1.3 REQUIREMENTS IMPLEMENTED IN THIS RELEASE *EVALUATION CRITERION (ii) APPLIES*

Supply [functional requirements](https://docs.google.com/document/d/1eU7eINLDxmrf793D4OF2yGT4ry_SW3GQGoVDYzecGHc/edit?usp=sharing) statement that you accomplished for this assignment, i.e., functionality that the application provides for the user. Please state requirement in declarative form, as illustrated in the examples, because here we want to know the functionality intended (*what*, not *how*). For example, the following is *not* a proper functional requirement: *TicTac will have a class for O’s and a class for X’s.* It is common to mistake design elements like this for requirements. To get started, state what the application will accept as input, like requirement 1.3.1 below.

Keep in mind that the implementation of your requirements will incorporate *an abstract class*, *inheritance*, *upcasting or downcasting*, and *polymorphism*; that will probably influence the requirements you choose to implement in this assignment. The example material supplied should be deleted before you submit.

### 1.3.1 Create and Classify Chord Objects from raw input

*HarmonyMuse* should accept raw data (currently hard-coded String arrays, accepting Midi data arrays is the eventual goal in addition to String arrays), build a Chord object and classify that object. At this stage the classification process is arbitrary, later to be implemented dynamically by the system.

### 1.3.2 Report Chord classification and associated attributes

Each chord object should know its classification (i.e. triad, seventh chord etc.), quality (i.e. major, minor etc.) and its degrees (i.e. root, third, fifth, etc.) and the intervals it contains (i.e. major third, perfect fifth) and report all of this information to the console.

### 1.3.3 Create and Classify Note Objects from raw input

Given raw String (currently hard-coded) input *HarmonyMuse* should clean data and create a Note Object such that Interval Objects may be accurately determined. This includes accounting for enharmonic (two notes with different spelling that sound the same frequency i.e. “b#” and “c”) pitch spelling possibilities.

### 1.3.3 Create and Classify Interval Objects from raw input

Perhaps the most important data structure to this system is the Interval as the basic unit of musical harmony. After creating two Note Objects, *HarmonyMuse* should determine the interval quality (and enharmonic intervals where applicable, two intervals with the same distance in half-steps but different spellings, i.e. “minor third” and “augmented second”).

## 1.4 ILLUSTRATIVE OUTPUT FROM IMPLEMENTATION *EVALUATION CRITERION (ii) APPLIES*

### Provide illustrative output from your implemented application (so far) showing that the requirements have been met. Explain what class.method(s) produce it.

The following is produced by

* the respective types overridden *toString()* methods
* the respective types *getRoot(), getThird. getFifth()* and *getSeventh()* methods (where applicable)
* A substantial amount of thought, work and design went into the non-trivial task of determining how to successfully implement the output that results from *Chord.getIntervals(),* see the Note class and the Interval class
  + - In the Note class constructor the active attributes are name, intValue, and enharmonics
      * A Map structure of an Integer object and an ArrayList (containing all of the enharmonic spellings for a given pitch class) is built in the buildNotesMap() function and this map is used to determine the enharmonics attribute for any given note.
    - The Interval class attributes firstly track the number of half steps in each interval (within one octave – this is a natural compression function used for classification)
      * The indices of the elements of the arrays intervalQualities and enharmonicIntervals correspond to the number of half steps in the respective interval for which these names are representations (with a few exceptions thoroughly noted in code comments)
    - The distance attribute is acquired via the .setDistance() method which calls the .distance() method of the CircularlyLinkedList class in the package (code modified from sources noted in the file, the .distance() function is self-authored).
      * The .distance() function determines the interval family (i.e. how many “steps” in the musical alphabet the bottom note name is from the top).
        + The Circularly linked list is an optimal data structure here as the musical alphabet wraps around like so (a, b, c, d, e, f, g -> a…) and the distance from a to c (3) is the same as from g to b (3, wrapping around).
      * Once the distance is set the appropriate interval can be determined from the individual notes intValues producing the intValue attribute for the Interval class.
        + With the intValue of the Interval Class, the number of half steps in each “proper” interval (the first 13 Interval class attributes) and the two arrays, intervalQualities and enharmonicQualities (recall each element index corresponds to the number of half steps in the name string representation at that index) we can assign the Interval attribute quality (and enharmonic when applicable) as seen in the setQuality() function.

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## 1.5 YOUR DIRECTORY

### Show a screenshot of your directory. This should include a parallel directory of JUnit tests where possible—package-by-package, class-by-class, and method-by-method, except for trivial ones.

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Please note:

The Interfaces Extensions, AlteredExtensions and Voicing are rough sketches and essentially are placeholder “TODO” at this current stage of development.

* Extensions builds the ninth, eleventh and thirteenth on-top of SeventhChord
* AlteredExtensions does something similar but allows for building both the FlatNinth and the SharpNinth, a common requirement for Dominant Seventh chords in practice.

## 1.6 TECHNIQUES IMPLEMENTED *EVALUATION CRITERION (iii) APPLIES*

Your implementation should include *inheritance*, *polymorphism*, and *either an abstract class or interface* at least once, and in a manner that is useful to your application. Explain where and how you applied these, using the headings below.

### 1.6.1 Class model and Sequence Diagram

Identify where you included *inheritance*, *polymorphism*, and *abstract classes* or *interfaces* in your class model. Make classes and members *static* or not as per their intended usage. To do this use tools (e.g., Visio and Lucidchart), PowerPoint, or a combine models as in [this example](https://docs.google.com/spreadsheets/d/1vBmDVtWWh3EX0oehFFLRU0P6eR-fn4d0qVg1-XOUooM/edit?usp=sharing) (which you are free to cut and paste from). Insert indications in red (as in [this example](https://docs.google.com/spreadsheets/d/1ZvkerE9FkWHWwVGdzuy7YMBU6oBMFGZbA4sotFETs8Y/edit?usp=sharing)) to show where the three features below apply. Diagram

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Class Model for HarmonyMuse (Above):

* Chord is Abstract – polymorphism occurs in the versions getRoot()
* ChordBuilder, MajorTriad, MinorTriad and DominantSeventhChord inherit from Chord.
* ChordBuilder should serve as the intermediary between input to the system and the creation and classification of any resultant chord object – cleaning and analyzing data as necessary.
* MajorTriad and MinorTriad are both additionally dependencies of the Triad Interface
* DominantSeventhChord is additionally a dependency of the SeventhChord Interface – downcasting is shown with getSeventh()
* Interval aggregates with a many to one relationship to chord
* Note aggregates to Interval with a 2 to 1 relationship and further to Chord with a 3 (or greater) to 1 relationship
* Voicing (not shown) is an interface that will voice (arrange and draw) chords that utilize it as a dependency

Diagram

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Sequence Diagram 1) Use Case: Create and classify chord from raw input (above)

Diagram

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Sequence Diagram 2) Use Case: Report class associated attributes (above)

### 1.6.2 Code showing an abstract class or interface

Show the relevant code (only) and explain why an abstract class or interface is appropriate here. It should be clear where the code is located (class and method).

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Abstract Class Chord (Above)

* A chord is by nature one of the most fundamental abstractions in conceiving of harmony in modern music
  + It is simply a collection of notes regardless of classification
    - It deserves noting, this collection should be greater than two notes
      * Two notes constitute an Interval
  + Every chord regardless of specific classification needs to be contextualized with a root (line 42)
    - Although the design for this system should be flexible enough to be able to examine any of the input data as the root and classify the resultant chord accordingly
      * We want the ability and flexibility to handle and contextualize all permutations of a given data

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Interface Triad (above)

* A Triad is an abstraction on a three-note chord
  + Not every three-note chord is a triad – these are very specific arrangements of notes built on the Interval of a third (the basis for Tertian, third based harmony, the harmony of the Western world).
    - There are 4 specific qualities of triads
      * Major
      * Minor
      * Diminished
      * Augmented
    - Each of the 4 qualities have the following common attributes
      * A root (method inherited from Chord)
      * A third (method to be implemented from Triad Interface dependency)
      * A fifth (method to be implemented from Triad Interface dependency)

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Interface SeventhChord (above)

* A Seventh chord, in Tertian harmony (based on the Interval of a third) is simply adding one more third to the base Triad (one of the 4 qualities)
  + The DominantSeventhChord class thusly demonstrates multiple inheritance from the abstract Chord class, and the Interfaces Triad and SeventhChord

### 1.6.3 Code showing polymorphism

Show the relevant code (only) and explain why *polymorphism* is appropriate here. Recall that polymorphism is implemented in one of two ways – overriding methods in subclasses or overloading methods in the same class where the method signatures are different – and allowing the language runtime to dynamically invoke the correct method. It should be clear where the code is located (class and method).

The method *getRoot()* in the following for each loop illustrates polymorphic calls to objects of types MajorTriad, MinorTriad, and DominantSeventhChord, each of whom have inherited and overridden this function from the abstract Chord class and additionally have been stored in variables of names descriptive of their respective types. The below code snippet additionally demonstrates downcasting (explained below in Section 1.6.4).

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### 1.6.4 Code showing upcasting or downcasting

Show the relevant code (only) and explain why upcasting or downcasting is appropriate here. It should be clear where the code is located (class and method).

Because a DominantSeventhChord type object is the only object in the Chord array with the method *getSeventh()* it is necessary to **downcast** in order to reach the DominantSeventhChord.seventh attribute of the appropriate object (determined by the instanceof query at line 64).

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## 1.7 YOUR CODE

Unless your facilitator requests another method, copy your Eclipse project to your file system, zip it, and attach it. Please contact your facilitator in advance if you want to request an alternative means.

Project and Test folders are zipped in a folder named metcs622\_Assignment1\_mgkramer.zip

\*\*\*Please Note\*\*\*

The directory referenced in section [1.5](#_1.5_YOUR_DIRECTORY) in this document belongs in the src project directory (in IntelliJ this is a dark blue folder)

TO RUN TESTS:

The directory in the zipped folder named ***HarmonyMuseTests*** belongs in the test root directory (in IntelliJ this is a green folder traditionally named test) and needs to be renamed to ***HarmonyMuse*** as shown below:

Graphical user interface, text

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## 1.8 EVALUATION OF ASSIGNMENT 1



## Appendix 1 (if needed; should be referenced above, and will be read as-needed only)

## Appendix 2 (if needed; should be referenced above, and will be read as-needed only)