CS 051 Laboratory # 3
Repulsive Behavior
Due: Monday 9/20 at 11pm

Objective: To gain experience implementing classes and methods.

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Intro

The Scenario For this lab you will write a program that simulates the action of two bar magnets. Each magnet will be represented by a simple rectangle with one end labeled "N" for north and the other labeled "S" for south. Your program should allow the person using it to move either magnet around the screen by dragging it with the mouse. You know that opposite poles attract, while similar poles repel each other. So, if one magnet is dragged to a position where one or both of its poles is close to the similar poles of the other magnet, the other magnet should move away as if repelled by magnetic forces. If, on the other hand, opposite poles come close to one another, the free magnet should move closer and become stuck to the magnet being dragged.

To make things a bit more interesting one should be allowed to flip a magnet from end to end (swapping the poles) by clicking on the magnet without moving the mouse. This will provide a way to separate the two magnets if they get stuck together (since as soon as one of them is reversed it will repel the other).

The html version online has a working version of the code here.

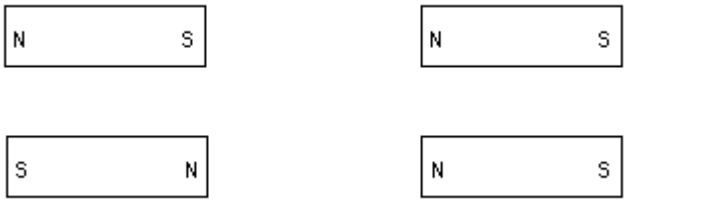
In the lab As usual, copy the folder `Lab3-Magnet` from the `cs051/labs` folder into the `cs51workspace` folder on your desktop. Start up eclipse and import the project. (Reminder: To do this you'll go into the file menu and select import. You'll select "Existing project into workspace" and click the "next" button. Then click on "browse" next to the "Select root directory" entry and navigate to the magnet folder in your `cs51workspace` folder. When the folder is selected, push the finish button and you will be ready to work.) The "default package" subdirectory in the left panel of eclipse will now contain three files: `Magnet.java`, `Pole.java`, and `MagnetGame.java`. We've provided you the complete `Pole` class, and initial skeletons for `Magnet` and `MagnetGame`, which you will be required to flush out, including adding some new methods not listed.

Some Video Game Physics If you are worried that you might not remember (or never knew) enough about magnetic fields to do this assignment, relax. First, we will be providing you with most of the code that does the "physics". Even if you had to write all the code yourself, you still would not need a deep knowledge of magnetism and mechanics. Instead, you could exploit something every special effects expert or video game author must know. Most humans observe the world carelessly enough that even a very coarse approximation of reality will appear "realistic". Our code takes advantage of this by simplifying the behavior of our magnets. We never compute the force between two magnets, just the distance between them. If they get too close together, our code moves them apart or makes them stick together.

Despite the fact that we will provide most of the code to handle this approximate version of physics, there are two aspects of the magnet's behavior that will impact the code you write. The first is a simplifying assumption. The magnets will not be allowed to rotate. They only slide up, down and across the screen.

More significantly, there is one aspect of the behavior of the real magnets that we must model fairly well. Above, we said that we just compute the distance between two magnets. This would not really be accurate enough, since it is not the distance between the magnets that matters, but the distances between their similar and opposite poles.

Consider the two pairs of magnets shown below:



The magnets shown in the left pair are the same distance apart as the magnets in the right pair. In the pair on the left, however, the opposite poles are close together while the similar poles are relatively far apart. The situation is reversed in the other pair. In one case, one would expect the magnets to attract, in the other to repel.

So it is the poles rather than the magnets that really matter when deciding whether something should be attracted or repelled. As a result, instead of just manipulating magnet objects in your program, you will also need objects that explicitly represent poles.

Design

We will help you design this program by identifying the classes and methods needed. In particular, there will be two classes named `Magnet` and `Pole` and a third class `MagnetGame` that is an extenstion of `WindowController`. We will provide the code for the `Pole` class. You will write the other two class definitions.

As with the previous assignment, you should come to this lab with a written design (which we will grade) for (at least) Part 1 of the lab. I promise you, the more time you spend thinking about the design, the faster and easier the whole process will be.

The design should show us how you plan to organize your `Magnet` and `MagnetGame` classes to accomplish the actions required of the first part of this lab only. We have told you what methods each class should have and the behavior that they should provide. You should follow the design specifications described in class, which means you should not have any code except the class and method headers and the variables (including constants). You should have comments describing what the class will do, what the variables are for and what the methods will do.

We've provided a sample design for the first part of the laundry lab at the end of this document to give you a better sense of what should be included in the design you bring.

Pole You will be able to use the `Pole` class we have defined much like one of the built-in graphics classes in the objectdraw library. In this handout, we explain how to construct a new `Pole` and describe the methods that can be used to manipulate `Pole`s. You can then write code to work with `Pole`s just as you wrote code to work with `FilledRect`s. We will see, however, that the interaction of `Pole`s with the rest of your program is a little more complex than that of rectangles.

A `Pole`'s constructor will expect you to specify the coordinate position at which it should initially appear and the label that should be displayed (i.e. "N" or "S"). It will also require you to provide

as parameters the `canvas` and the `Magnet` to which the new pole will belong. The signature of the constructor for the `Pole` class is:

```
public Pole( Magnet container,
             double x, double y,
             String poleName,
             DrawingCanvas canvas )
```

Since you will usually create the `Pole`s within the code of the `Magnet` constructor, the name `this` will refer to the `Magnet` that contains the `Pole`. Thus, the code to construct a `Pole` might look like:

```
new Pole( this, poleX, poleY, "N", canvas);
```

where `poleX` and `poleY` are the coordinates around which the label "N" should be displayed.

The `Pole` class provides several methods similar to those associated with graphical objects. In particular, `Pole`'s methods will include `getX`, `getY`, `getLocation`, and `move`, which all behave like the similarly named methods associated with basic graphic classes.

In addition, the `Pole` class has two more specialized methods: `attract` and `repel`. Each of these methods expects to be passed the `Pole` of another magnet as a parameter. If you say,

```
somePole.attract( anotherPole )
```

then `somePole` and `anotherPole` should have opposite polarities. If `somePole` is a north pole, then `anotherPole` must be a south pole and vice versa. The `repel` method, on the other hand, assumes that the pole provided as its parameter has the same polarity as the object to which the method is applied. Therefore, if you write:

```
somePole.repel( anotherPole )
```

and `somePole` is a north pole, then `anotherPole` should also be a north pole.

Each of these methods checks to see if the two `Pole`s involved are close enough together to exert enough force to move the magnets to which they belong. If so, they use the `move` and `moveTo` methods of the magnets to either bring the magnets closer together or move the free magnet so that they are far enough apart that they would no longer interact.

The good news is that we have already written the code for all the methods described above and will provide these methods to you.

In summary, the `Pole` class provides the following methods. Note that we have given you complete method headers here, illustrating the format to follow in defining your own methods. Think carefully about how you will invoke each of the following methods.

- `public double getX()`
- `public double getY()`
- `public Location getLocation()`
- `public void move( double xoff, double yoff )`
- `public void attract( Pole opposite )`
- `public void repel( Pole similar )`

Important: Do not modify the provided `Pole` class!

Part 1: Moving the magnets

For the first part of this program, you should just worry about creating the magnets and moving them around. We'll worry about their interactions (attracting and repelling) later.

The key to this lab is the design of the `Magnet` class. A magnet is represented by a `FramedRect` and two poles. To ensure that our `Pole`s work well with your `Magnet`s, each magnet should be 150 by 50 pixels. The poles should be located near each end of the magnet. We recommend locating them so the distance from the pole to the closest end, top, and bottom, are all 1/2 the height of the magnet (*i.e.* 25 pixels away from each).

Your `Magnet` class will have to provide the methods that will enable someone running your program to drag magnets about within a window. The `Magnet` class will have to include the following methods:

- `public void move( double xoff, double yoff )`
- `public void moveTo( Location point )`
- `public Location getLocation()`
- `public boolean contains( Location point )`

The headers for these methods are already included in the starter file for the `Magnet` class. These methods should behave just like the corresponding methods for rectangles and ovals. In particular, the offsets provided to the `move` method are `double`s, `someMagnet.getLocation()` should return a `Location` value, and `someMagnet.contains(point)` should return a `boolean`. (You will add other methods later, but we'll postpone discussing them until you need them.)

In order to write these methods, your magnet will need to contain several instance variables. A magnet should consist of a rectangle and two poles, and you will need instance variables for each of those. The constructor for a `Magnet` needs the following parameters:

- Coordinates of the upper-left corner of the magnet,
- The canvas that will hold the magnet

The header of the constructor for the `Magnet` class should be:

- `public Magnet(Location upperLeft, DrawingCanvas canvas)`

It should construct the framed rectangle forming the outline of the magnet (using the parameters), and should create two poles in the correct positions inside the magnet (see the earlier discussion on the constructor for `Pole`).

Once these instance variables have been declared and initialized, writing the methods should be easy. The `move` and `moveTo` methods should simply move the rectangle and poles to their new positions. The `move` method is pretty straightforward as all three items get moved the same distance, but `moveTo` takes a little thought as the `Pole` class does not have a `moveTo` method. Instead you'll need to calculate how far to move it. (Hint: check to see how far the rectangle is moving from its current position.) The method `getLocation` will simply return the location of the rectangle, while a magnet `contains` a point exactly when the rectangle does.

When you have this much of the `Magnet` class written, you can test it by filling in some of the details of `MagnetGame`, an extension of the `WindowController` class that creates a magnet, and then write methods `onMousePress` and `onMouseDrag` that will allow you to drag it around. To run your program, you need to create a new applet configuration using the `Run...` command from the Run menu as in the past two labs. For this lab, set the width of the applet to 420 and the height to 400 on the `Parameters` tab.

Once `onMousePress` and `onMouseDrag` work, it should be pretty easy to add a second magnet and be able to drag either of them around. We suggest declaring a variable (`movingMagnet`) that can be associated with the appropriate magnet and used to remember which magnet to move whenever the mouse is dragged. This variable will be useful in other parts of your assignment as well.

As you were writing the methods for the `Magnet` class, you probably noticed that two additional methods are already included there. They are `getWidth` and `getHeight`. These are used by the `Pole` class in ensuring that the methods `attract` and `repel` draw the magnets appropriately in the window.

Part 2: Flipping the magnet

When you click on a magnet, it should reverse its north and south poles. Add method `flip` to class `Magnet` that interchanges the north and south poles. Remember that you can move a `Pole`, and one possible way to implement `flip` is to just move the north pole to the south pole's position and vice versa.

Add an `onMouseClick` method to your `MagnetGame` class that invokes `flip`.

Part 3: Interacting magnets

Finally, after you `move` or `flip` a magnet, you will need to tell the magnet to check if it is close enough to the other magnet to move it. To make this possible, include a method named `interact` in your `Magnet` class.

The method `interact` should be invoked on the moving (or changing) magnet, and should take as a parameter the `Magnet` that has not just been moved or flipped. It should effect the interaction by calling the `attract` and `repel` methods of its poles with the poles of the other magnet passed as parameters appropriately. For simplicity, you should just check for attraction first, and only worry about repelling after the attraction works correctly.

When writing `interact` you will discover you need to add two more methods in the `Magnet` class to enable you to access the other magnet's poles: `getNorth` and `getSouth`. Both of these methods will return objects belonging to our `Pole` class. Also, note that the `attract` method that we have provided in the `Pole` class calls the `moveTo` method that you must define in the `Magnet` class. If you do not fill in the body of this method correctly, attraction will not work properly.

You will need to call the `interact` method every time one of the magnets is either moved or flipped. Because you want to send the `interact` message to the magnet that moved and provide the other magnet as the parameter, you will need to keep track of which is which. As we suggested above, whenever you start dragging a magnet (i.e., in the `onMousePressed` method), you should associate a name with the moving magnet. You will also find it convenient to associate a name with the resting magnet in order to call your `interact` method appropriately.

When your program is finished, your `Magnet` class should have a constructor and method bodies implemented for `getLocation`, `move`, `moveTo`, and `contains`, for which headers were provided.

In addition, you will need to provide the methods `interact`, `getNorth`, `getSouth`, and `flip`. We have specifically not given you these methods so that you can start to learn about writing your own methods. You should think carefully about the structure of the method headers for each of these. The key questions to ask yourself are: does the method return a value? if so, what type does it return? does the method have any parameters? if so, how many, and what are their types? To help you in formulating your ideas, the following gives typical uses of the methods:

- `someMagnet.interact( otherMagnet ); // someMagnet & otherMagnet are magnets`

- `Pole theNorthPole = someMagnet.getNorth();`
- `Pole theSouthPole = someMagnet.getSouth();`
- `someMagnet.flip(); // someMagnet is a magnet`

Turning in your work

Before submitting your work, make sure that each of the .java files includes a comment containing your name. Also, before turning in your work, be sure to double check both its logical organization and your style of presentation. Make your code as clear as possible and include appropriate comments describing major sections of code and declarations. You can use the `Format` command in the `Source` menu to make sure all of your indentation is consistent.

Turn in your project the same as in past weeks. Use the `Export` command from the `File` menu. Check that the `Magnet` project is being exported to a new folder whose name includes your name and identifies the lab. Then quit Eclipse and drag your folder to the dropbox folder.

Table 1: Grading Guidelines

Value	Feature
	Design (2 pts total)
2 pts.	Well thought-out design brought to lab
	Style (7 pts total)
2 pts.	Descriptive comments
2 pts.	Good names
2 pts.	Good use of constants
1 pt.	Appropriate formatting
	Logical Organization (3 pts total)
1 pts.	Good use of boolean expressions
1 pt.	Not doing more work than necessary
1 pt.	Using most appropriate methods
	Correctness (8 pts total)
1 pt.	Drawing magnets correctly at startup
1 pt.	Dragging a magnet
1 pt.	Ability to move either magnet
1 pt.	Moving a magnet to the right place when attracted
1 pt.	On attraction, moving the magnet not pointed to
1 pt.	Flipping a magnet
1 pt.	Attracting and repelling at the right times
1 pt.	No other problems

Grading Guidelines

Quick Reference for the Pole Class

This section provides no new information. It is a quick reference to the constructor and methods provided in the `Pole` class that you will be using.

Constructor To create a new pole:

```
public Pole (Magnet parent, double x, double y, String name, DrawingCanvas canvas)
```

Example Usage

```
Pole myPole = new Pole (this, xLoc, yLoc, "N", canvas);
```

Accessor Methods To get information about a pole:

Getting the x coordinate of the pole's center:

```
public double getX()
```

Example Usage

```
double x = somePole.getX();
```

Getting the y coordinate of the pole's center:

```
public double getY()
```

Example Usage

```
double y = somePole.getY();
```

Getting the coordinate pair of the pole's center:

```
public Location getLocation()
```

Example Usage

```
Location loc = somePole.getLocation();
```

Mutator Methods To modify a pole:

Moving the pole relative to its current location:

```
public void move (double xoff, double yoff)
```

Example Usage

```
somePole.move (xOffset, yOffset);
```

Attracting another pole if close enough:

```
public void attract (Pole oppositePole)
```

Example Usage

```
somePole.attract (anotherPole);
```

Repelling another pole if close enough:

```
public void repel (Pole similarPole)
```

Example Usage

```
somePole.repel (anotherPole);
```

Sample Design for part 1 of the Laundry lab

This section shows the sample design for the first part of the laundry lab. Use this to help you understand what to include in your own sample design.

The lab contains with header:

`public class Laundry extends WindowController`

The laundry lab includes constants for the following values:

- `LEFT_BASKET_X` and `LEFT_BASKET_Y` - the location of the leftmost basket.
- `BASKET_SIZE` - the size of the baskets. They will be square and all the same size.
- `BASKET_SPACING` - the amount of space between baskets.
- `SWATCH_LOC` - the starting location of the laundry.
- `SWATCH_SIZE` - the size of the laundry. It is square.

The program contains the following instance variables:

- `swatch` - a FilledRect representing the laundry
- `swatchFrame` - a FramedRect drawn around the laundry. This is necessary so that we can see the laundry when it is white. The swatch and swatchFrame will always be moved together.
- `whites`, `darks`, `colors` - 3 FramedRects representing the 3 laundry baskets
- `correctBasket` - a FramedRect representing the basket where the current swatch should be dragged to. It will have the same value as one of whites, darks, and colors depending on the color of the laundry.
- `colorGenerator` - a random int generator used to select the next color for the swatch. It will range over the values 1 to 3 since we are selecting from 3 colors.

`public void begin()` method - creates the display and initializes the correct basket. It does this as follows:

- Draw the swatch and swatch frame in the initial position. The initial color is white.
- Draw the 3 baskets labeling them "whites", "darks", and "colors".
- Set `correctBasket` to `whites` since the first laundry is white.

`public void onMouseClick(Location pt)` method - checks if the user clicks the mouse in the correct basket, and then changes the color of the laundry. It does this as follows:

- If the user clicks in the correct basket
  - Use the random number generator to get the next color.
  - If the random number generator returns 1, the next laundry will be white and the correct basket is the white basket.
  - Else if the random number generator returns 2, the next laundry will be black and the correct basket is the darks basket.
  - Otherwise, the next laundry will be red and the correct basket is the colors basket.