Project 3: Ants Vs. SomeBees

ants.zip (ants.zip)

The bees are coming!
Create a better soldier
With inherit-ants.

Introduction

Important submission note: For full credit,

- Submit with Phases 1 & 2 complete by **Tuesday, October 20** (worth 1 pt).
- Submit with Phases 3 & 4 complete by **Friday, October 23**.

You may work with one other partner for the entire project. You will get an extra credit point for submitting the entire project by Thursday, October 22.

In this project, you will create a tower defense (https://secure.wikimedia.org/wikipedia/en/wiki/Tower_defense) game called Ants Vs. SomeBees. As the ant queen, you populate your colony with the bravest ants you can muster.

Your ants must protect their queen from the evil bees that invade your territory. Irritate the bees enough by throwing leaves at them, and they will be vanquished. Fail to pester the airborne intruders adequately, and your queen will succumb to the bees' wrath. This game is inspired by PopCap Games' Plants Vs. Zombies (https://www.ea.com/studios/popcap/plants-vs-zombies).

This project combines functional and object-oriented programming paradigms, focusing on the material from Chapter 2.5 (http://composingprograms.com/pages/25-object-oriented-programming.html) of Composing Programs. The project also involves understanding, extending, and testing a large program.

Download starter files

The ants.zip (ants.zip) archive contains several files, but all of your changes will be made to `ants.py`.

- `ants.py` : The game logic of Ants Vs. SomeBees
- `ants_gui.py` : The original GUI for Ants Vs. SomeBees
- `gui.py:` A new GUI for Ants Vs. SomeBees. Note that this doesn't work / is very buggy, but you can see the cute ants in motion here :)
- `graphics.py` : Utilities for displaying simple two-dimensional animations
- `utils.py` : Some functions to facilitate the game interface
- `ucb.py` : Utility functions for CS 61A
- `state.py` : Abstraction for gamestate for gui.py
- `assets` : A directory of images and files used by `gui.py`
- `img` : A directory of images used by `ants_gui.py`
- `ok` : The autograder
- `proj3.ok` : The `ok` configuration file
- `tests` : A directory of tests used by `ok`

Logistics

This is a project. You may work with one other partner. You should not share your code with students who are not your partner or copy from anyone else's solutions. In the end, you will submit one project for both partners. **We strongly encourage you to work on all parts of the project together rather than splitting up the work.** Switch off who writes the code, but whoever is not coding should contribute by looking at the code and providing comments on a direction to go and catching bugs.

The project is worth 25 points. 22 points are assigned for correctness, 1 point for submitting Phases 1-2 by the checkpoint date, and 2 points for the overall composition (https://cs61a.org/articles/composition.html).

You will turn in the following files:

- `ants.py`

You do not need to modify or turn in any other files to complete the project. To submit the project, run the following command:

```
python3 ok --submit
```

You will be able to view your submissions on the Ok dashboard (http://ok.cs61a.org).

For the functions that we ask you to complete, there may be some initial code that we provide. If you would rather not use that code, feel free to delete it and start from scratch. You may also add new function definitions as you see fit.

However, please do **not** modify any other functions. Doing so may result in your code failing our autograder tests. Also, please do not change any function signatures (names, argument order, or number of arguments).

Throughout this project, you should be testing the correctness of your code. It is good practice to test often, so that it is easy to isolate any problems. However, you should not be testing *too* often, to allow yourself time to think through problems.

We have provided an **autograder** called `ok` to help you with testing your code and tracking your progress. The first time you run the autograder, you will be asked to **log in with your Ok account using your web browser**. Please do so. Each time you run `ok`, it will back up your work and progress on our servers.

The primary purpose of `ok` is to test your implementations.

We recommend that you submit **after you finish each problem**. Only your last submission will be graded. It is also useful for us to have more backups of your code in case you run into a submission issue. **If you forget to submit, your last backup will be automatically converted to a submission.**

If you do not want us to record a backup of your work or information about your progress, you can run

```
python3 ok --local
```

With this option, no information will be sent to our course servers. If you want to test your code interactively, you can run

```
python3 ok -q [question number] -i
```

with the appropriate question number (e.g. `01`) inserted. This will run the tests for that question until the first one you failed, then give you a chance to test the functions you wrote interactively.

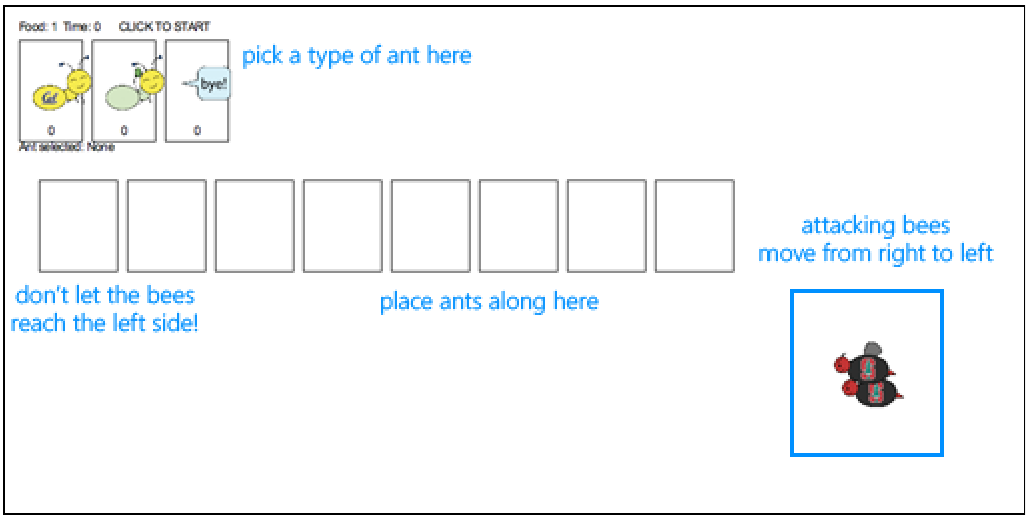
You can also use the debug printing feature in OK by writing

```
print("DEBUG:", x)
```

which will produce an output in your terminal without causing OK tests to fail with extra output.

The Game

A game of Ants Vs. SomeBees consists of a series of turns. In each turn, new bees may enter the ant colony. Then, new ants are placed to defend their colony. Finally, all insects (ants, then bees) take individual actions. Bees either try to move toward the end of the tunnel or sting ants in their way. Ants perform a different action depending on their type, such as collecting more food, or throwing leaves at the bees. The game ends either when a bee reaches the end of a tunnel (you lose), or the entire bee fleet has been vanquished (you win).



Core concepts

The Colony. This is where the game takes place. The colony consists of several *places* that are chained together to form a tunnel where bees can travel through. The colony has some quantity of food that can be expended to deploy ant troops.

Places. A place links to another place to form a tunnel. The player can place a single ant into each place. However, there can be many bees in a single place.

The Hive. This is the place where bees originate. Bees exit the beehive to enter the ant colony.

Ants. Ants are the usable troops in the game that the player places into the colony. Each type of ant takes a different action and requires a different amount of food to place. The two most basic ant types are the `HarvesterAnt`, which adds one food to the colony during each turn, and the `ThrowerAnt`, which throws a leaf at a bee each turn. You will be implementing many more.

Bees. Bees are the antagonistic troops in the game that the player must defend the colony from. Each turn, a bee either advances to the next place in the tunnel if no ant is in its way, or it stings the ant in its way. Bees win when at least one bee reaches the end of a tunnel.

Core classes

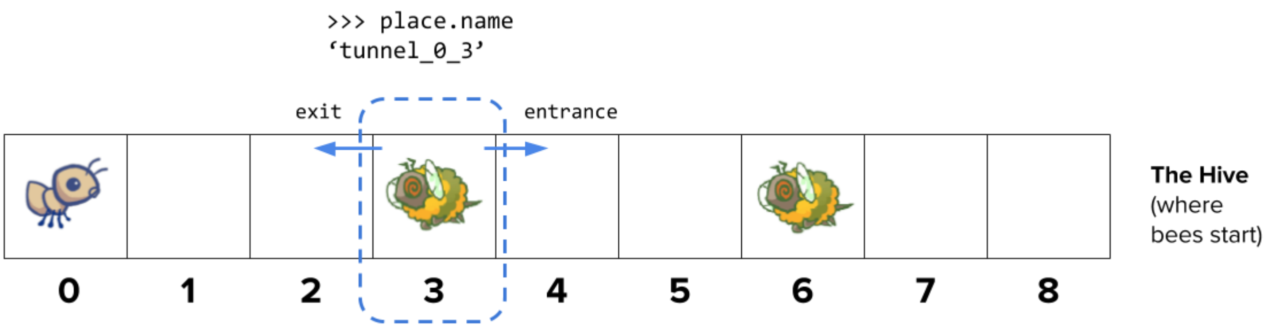
The concepts described above each have a corresponding class that encapsulates the logic for that concept. Here is a summary of the main classes involved in this game:

- `GameState`: Represents the colony and some state information about the game, including how much food is available, how much time has elapsed, where the `QueenAnt` resides, and all the `Place`s in the game.

- `Place` : Represents a single place that holds insects. At most one `Ant` can be in a single place, but there can be many `Bee` s in a single place. `Place` objects have an `exit` to the left and an `entrance` to the right which are also places. Bees travel through a tunnel by moving to a `Place` 's `exit` .
- `Hive` : Represents the place where `Bee` s start out (on the right of the tunnel).
- `AntHomeBase` : Represents the place `Ant` s are defending (on the left of the tunnel). If Bees get here, they win :(
- `Insect` : A superclass for `Ant` and `Bee` . All insects have an `armor` attribute, representing their remaining health, and a `place` attribute, representing the `Place` where they are currently located. Each turn, every active `Insect` in the game performs its `action` .
- `Ant` : Represents ants. Each `Ant` subclass has special attributes or a special `action` that distinguish it from other `Ant` types. For example, a `HarvesterAnt` gets food for the colony and a `ThrowerAnt` attacks `Bee` s. Each ant type also has a `food_cost` attribute that indicates how much it costs to deploy one unit of that type of ant.
- `Bee` : Represents bees. Each turn, a bee either moves to the `exit` of its current `Place` if no ant blocks its path, or stings an ant that blocks its path.

Game Layout

Below is a visualization of a GameState. As you work through the unlocking tests and problems, we recommend drawing out similar diagrams to help your understanding.



Example: AntColony with dimensions (1, 9)

Playing the game

The game can be run in two modes: as a text-based game or using a graphical user interface (GUI). The game logic is the same in either case, but the GUI enforces a turn time limit that makes playing the game more exciting. The text-based interface is provided for debugging and development.

The files are separated according to these two modes. `ants.py` knows nothing of graphics or turn time limits.

To start a text-based game, run

```
python3 ants_text.py
```

To start a graphical game, run

```
python3 ants_gui.py
```

When you start the graphical version, a new browser window should appear. In the starter implementation, you have unlimited food and your ants can only throw leaves at bees in their current `Place`. Before you complete Problem 2, the GUI may crash since it doesn't have a full conception of what a Place is yet!

The game has several options that you will use throughout the project, which you can view with `python3 ants_text.py --help`.

```
usage: ants_text.py [-h] [-d DIFFICULTY] [-w] [--food FOOD]

Play Ants vs. SomeBees

optional arguments:
  -h, --help     show this help message and exit
  -d DIFFICULTY  sets difficulty of game (test/easy/medium/hard/extra-hard)
  -w, --water    loads a full layout with water
  --food FOOD    number of food to start with when testing
```

Phase 1: Basic gameplay

> **Important submission note**: For full credit,
>
> - Submit with Phases 1-2 complete by **Tuesday, October 20** (worth 1 pt).

In the first phase you will complete the implementation that will allow for basic gameplay with the two basic `Ant` s: the `HarvesterAnt` and the `ThrowerAnt`.

Problem 0 (0 pt)

Answer the following questions with your partner after you have read the *entire* `ants.py` file.

To submit your answers, run

```
python3 ok -q 00 -u
```

If you cannot answer these questions, read the file again, consult the core concepts/classes sections above, or ask a question in the Question 0 thread on Piazza.

1. What is the significance of an insect's `armor` attribute? Does this value change? If so, how?
2. What are all of the attributes of the `Insect` class?
3. Is the `armor` attribute of the `Ant` class an instance attribute or class attribute? Why?
4. Is the `damage` attribute of an `Ant` subclass (such as ThrowerAnt) an instance attribute or class attribute? Why?
5. Which class do both `Ant` and `Bee` inherit from?

6. What do instances of `Ant` and instances of `Bee` have in common?
7. How many insects can be in a single `Place` at any given time (before Problem 9)?
8. What does a `Bee` do during its turn?
9. When does the game end?

Remember to run

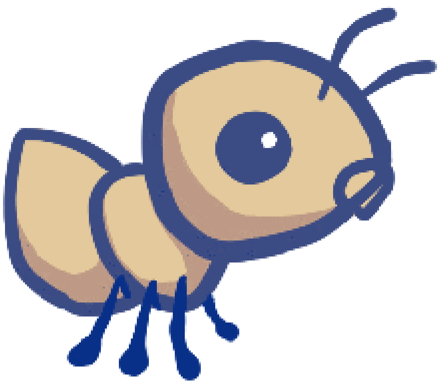
```
python3 ok -q 00 -u
```

Problem 1 (1 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 01 -u
```

First, add food costs and implement harvesters. Currently, there is no cost for deploying any type of `Ant`, and so there is no challenge to the game. You'll notice that `Ant` has a base `food_cost` of zero. Override this value in each of the subclasses listed below with the correct costs.

Class	Food Cost	Armor
 `HarvesterAnt`	2	1
 `ThrowerAnt`	3	1

Now that deploying `Ant` s cost food, we need to be able to gather more food! To fix this issue, implement the `HarvesterAnt` class. A `HarvesterAnt` is a type of `Ant` that adds one food to the `gamestate.food` total as its `action`.

After writing code, test your implementation:

```
python3 ok -q 01
```

Try playing the game by running `python3 ants_gui.py`. Once you have placed a `HarvesterAnt`, you should accumulate food each turn. You can also place `ThrowerAnt` s, but you'll see that they can only attack bees that are in their `Place`, so it'll be a little difficult to win.

Hint Video

Problem 2 (3 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 02 -u
```

Complete the `Place` constructor by adding code that tracks entrances. Right now, a `Place` keeps track only of its `exit`. We would like a `Place` to keep track of its entrance as well. A `Place` needs to track only one `entrance`. Tracking entrances will be useful when an `Ant` needs to see what `Bee` s are in front of it in the tunnel.

However, simply passing an entrance to a `Place` constructor will be problematic; we would need to have both the exit and the entrance before creating a `Place`! (It's a chicken or the egg (https://en.wikipedia.org/wiki/Chicken_or_the_egg) problem.) To get around this problem, we will keep track of entrances in the following way instead. The `Place` constructor should specify that:

- A newly created `Place` always starts with its `entrance` as `None`.
- If the `Place` has an `exit`, then the `exit` 's `entrance` is set to that `Place`.

> *Hint:* Remember that when the `__init__` method is called, the first parameter, `self`, is bound to the newly created object

> *Hint:* Try drawing out two `Place` s next to each other if things get confusing. In the GUI, a place's `entrance` is to its right while the `exit` is to its left.

After writing code, test your implementation:

```
python3 ok -q 02
```

Hint Video

Problem 3 (3 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 03 -u
```

In order for a `ThrowerAnt` to attack, it must know which bee it should hit. The provided implementation of the `nearest_bee` method in the `ThrowerAnt` class only allows them to hit bees in the same `Place`. Your job is to fix it so that a `ThrowerAnt` will `throw_at` the nearest bee in front of it that is not still in the `Hive`.

The `nearest_bee` method returns a random `Bee` from the nearest place that contains bees. Places are inspected in order by following their `entrance` attributes.

- Start from the current `Place` of the `ThrowerAnt`.
- For each place, return a random bee if there is any, or consider the next place that is stored as the current place's `entrance`.
- If there is no bee to attack, return `None`.

> *Hint*: The `rANTdom_else_none` function provided in `ants.py` returns a random element of a sequence or `None` if the sequence is empty.
>
> *Hint*: Having trouble visualizing the test cases? Try drawing them out on paper! The example diagram provided in Game Layout shows the first test case for this problem.

After writing code, test your implementation:

```
python3 ok -q 03
```

After implementing `nearest_bee`, a `ThrowerAnt` should be able to `throw_at` a `Bee` in front of it that is not still in the `Hive`. Make sure that your ants do the right thing! To start a game with ten food (for easy testing):

```
python3 ants_gui.py --food 10
```

Hint Video

Phase 2: Ants!

Now that you've implemented basic gameplay with two types of `Ant` s, let's add some flavor to the ways ants can attack bees. In this phase, you'll be implementing several different `Ant` s with different offensive capabilities.

After you implement each `Ant` subclass in this section, you'll need to set its `implemented` attribute to `True` so that that type of ant will show up in the GUI. Feel free to try out the game with each new ant to test the functionality!

With your Phase 2 ants, try `python3 ants_gui.py -d easy` to play against a full swarm of bees in a multi-tunnel layout and try `-d normal`, `-d hard`, or `-d extra-hard` if you want a real challenge! If the bees are too numerous to vanquish, you might need to create some new ants.

Problem 4 (3 pt)

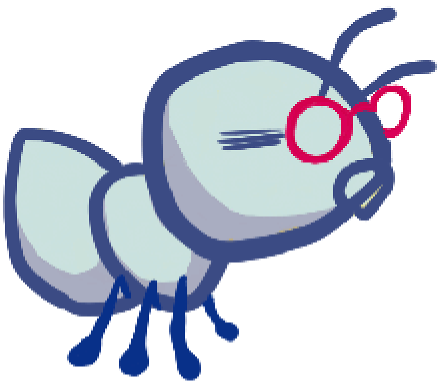
Before writing any code, read the instructions and test your understanding of the problem:

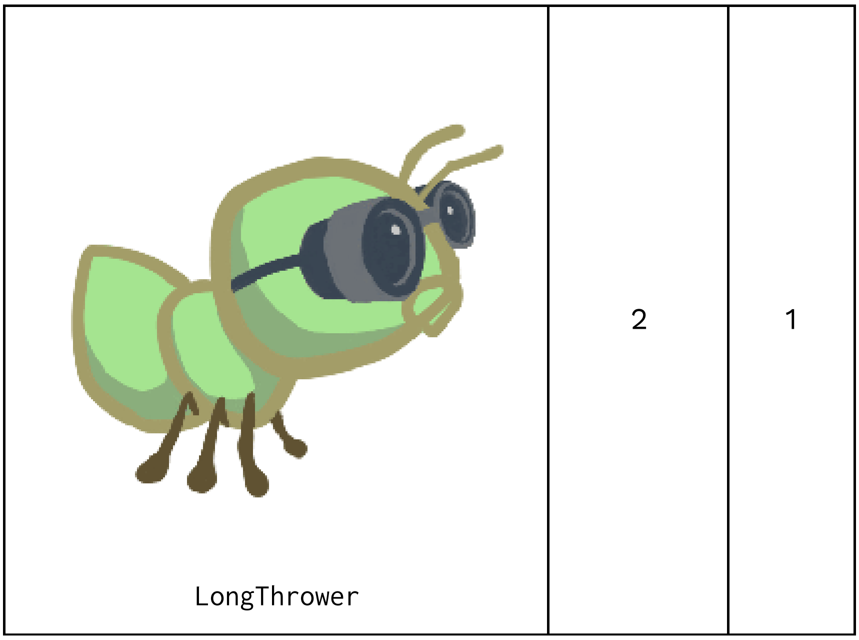
```
python3 ok -q 04 -u
```

The `ThrowerAnt` is a great offensive unit, but it'd be nice to have a cheaper unit that can throw. Implement two subclasses of `ThrowerAnt` that are less costly but have constraints on the distance they can throw:

- The `LongThrower` can only `throw_at` a `Bee` that is found after following at least 5 `entrance` transitions. It cannot hit `Bee` s that are in the same `Place` as it or the first 4 `Place` s in front of it. If there are two `Bees` , one too close to the `LongThrower` and the other within its range, the `LongThrower` should throw past the closer `Bee` , instead targeting the farther one, which is within its range.
- The `ShortThrower` can only `throw_at` a `Bee` that is found after following at most 3 `entrance` transitions. It cannot throw at any ants further than 3 `Place` s in front of it.

Neither of these specialized throwers can `throw_at` a `Bee` that is exactly 4 `Place` s away.

Class	Food Cost	Armor
 ShortThrower	2	1



A good way to approach the implementation to `ShortThrower` and `LongThrower` is to have it inherit the `nearest_bee` method from the base `ThrowerAnt` class. The logic of choosing which bee a thrower ant will attack is essentially the same, except the `ShortThrower` and `LongThrower` ants have maximum and minimum ranges, respectively.

To implement these behaviors, you will need to modify the `nearest_bee` method to reference `min_range` and `max_range` attributes, and only return a bee that is in range.

Make sure to give these `min_range` and `max_range` sensible defaults in `ThrowerAnt` that do not change its behavior. Then, implement the subclasses `LongThrower` and `ShortThrower` with appropriately constrained ranges and correct food costs.

> *Hint:* `float('inf')` returns an infinite positive value represented as a float that can be compared with other numbers.
>
> *Hint:* You can chain inequalities in Python: e.g. `2 < x < 6` will check if `x` is between 2 and 6. Also note that `min_range` and `max_range` should mark an inclusive range.

Don't forget to set the `implemented` class attribute of `LongThrower` and `ShortThrower` to `True`.

> Note! Please make sure your attributes are called `max_range` and `min_range` rather than `maximum_range` and `minimum_range` or something. The tests directly reference this variable name.

After writing code, test your implementation (rerun the tests for 03 to make sure they still work):

```
python3 ok -q 03
python3 ok -q 04
```

Hint Video

Problem 5 (3 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 05 -u
```

Implement the `FireAnt`, which does damage when it receives damage. Specifically, if it is damaged by `amount` armor units, it does a damage of `amount` to all bees in its place (this is called *reflected damage*).

If it dies, it does an additional amount of damage, which is specified by its `damage` attribute (by default 3).

To implement this, we have to override the `FireAnt`'s `reduce_armor` method. Normally, `Insect.reduce_armor` will decrement the insect's `armor` by the given `amount` and remove the insect from its place if `armor` reaches zero or lower. However, `FireAnt` also does damage to all the bees in its place when it receives damage, with an additional damage specified by its `damage` attribute when its armor drops to 0, before being removed from its `place`.

Class	Food Cost	Armor
 `FireAnt`	5	3

Hint: To damage the `FireAnt`, call the `reduce_armor` method inherited from `Ant`. Do *not* call `self.reduce_armor`, or you'll end up stuck in a recursive loop. (Can you see why?)

Hint: To damage a `Bee`, call the `reduce_armor` method inherited from `Insect`.

Hint: Damaging a bee may cause it to be removed from its place. If you iterate over a list, but change the contents of that list at the same time, you may not visit all the elements (https://docs.python.org/3/tutorial/controlflow.html#for-statements). This can be prevented by making a copy of the list. You can either use a list slice, or use the built-in `list` function.

```
>>> lst = [1,2,3,4]
>>> lst[:]
[1, 2, 3, 4]
>>> list(lst)
[1, 2, 3, 4]
>>> lst[:] is not lst and list(lst) is not lst
True
```

Once you've finished implementing the `FireAnt`, give it a class attribute `implemented` with the value `True`.

> Note, even though you are overriding the `Insect.reduce_armor` function, you can still use it in your implementation by calling it directly (rather than via `self`). Note that this is not recursion (why?)

After writing code, test your implementation:

```
python3 ok -q 05
```

Hint Video

You can also test your program by playing a game or two! A `FireAnt` should destroy all co-located Bees when it is stung. To start a game with ten food (for easy testing):

```
python3 ants_gui.py --food 10
```

Make sure to submit by the earlier deadline using the following command

```
python3 ok --submit
```

You can check to ensure that you have completed Phase 1-2's problems by running

```
python3 ok --score
```

Congratulations! You have finished Phases 1 and 2 of this project!

Phase 3: More Ants!

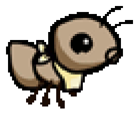
> **Important submission note**: For full credit,
>
> - Submit with Phases 3-4 complete by **Friday, October 23**.
>
> You will get an extra credit point for submitting the entire project by Thursday, October 22

Problem 6 (3 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 06 -u
```

Implement the `HungryAnt`, which will select a random `Bee` from its `place` and eat it whole. After eating a `Bee`, it must spend 3 turns digesting before eating again. If there is no bee available to eat, it will do nothing.

Class	Food Cost	Armor
 HungryAnt	4	1

Give `HungryAnt` a `time_to_digest` class attribute that holds the number of turns that it takes a `HungryAnt` to digest (default to 3). Also, give each `HungryAnt` an instance attribute `digesting` that counts the number of turns it has left to digest (default is 0, since it hasn't eaten anything at the beginning).

Implement the `action` method of the `HungryAnt` to check if it is digesting; if so, decrement its `digesting` counter. Otherwise, eat a random `Bee` in its `place` by reducing the `Bee`'s armor to 0 and restart the `digesting` timer.

After writing code, test your implementation:

```
python3 ok -q 06
```

Hint Video

We now have some great offensive troops to help vanquish the bees, but let's make sure we're also keeping our defensive efforts up. In this phase you will implement ants that have special defensive capabilities such as increased armor and the ability to protect other ants.

Problem 7 (2 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 07 -u
```

We are going to add some protection to our glorious home base by implementing the `WallAnt`, which is an ant that does nothing each turn. A `WallAnt` is useful because it has a large `armor` value.

Class	Food Cost	Armor

 WallAnt	4	4

Unlike with previous ants, we have not provided you with a class header. Implement the `WallAnt` class from scratch. Give it a class attribute `name` with the value `'Wall'` (so that the graphics work) and a class attribute `implemented` with the value `True` (so that you can use it in a game).

After writing code, test your implementation:

```
python3 ok -q 07
```

Phase 4: Water and Might

In the final phase, you're going to add one last kick to the game by introducing a new type of place and new ants that are able to occupy this place. One of these ants is the most important ant of them all: the queen of the colony.

Problem 8 (2 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 08 -u
```

Let's add water to the colony! Currently there are only two types of places, the `Hive` and a basic `Place`. To make things more interesting, we're going to create a new type of `Place` called `Water`.

Only an ant that is watersafe can be deployed to a `Water` place. In order to determine whether an `Insect` is watersafe, add a new attribute to the `Insect` class named `is_watersafe` that is `False` by default. Since bees can fly, make their `is_watersafe` attribute `True`, overriding the default.

Now, implement the `add_insect` method for `Water`. First, add the insect to the place regardless of whether it is watersafe. Then, if the insect is not watersafe, reduce the insect's armor to 0. *Do not repeat code from elsewhere in the program.* Instead, use methods that have already been defined.

After writing code, test your implementation:

```
python3 ok -q 08
```

Once you've finished this problem, play a game that includes water. To access the `wet_layout` which includes water, add the `--water` option (or `-w` for short) when you start the game.

```
python3 ants_gui.py --water
```

Hint Video

Problem 9 (2 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q 09 -u
```

Currently there are no ants that can be placed on `Water`. Implement the `ScubaThrower`, which is a subclass of `ThrowerAnt` that is more costly and watersafe, but otherwise identical to its base class. A `ScubaThrower` should not lose its armor when placed in `Water`.

Class	Food Cost	Armor
 `ScubaThrower`	6	1

We have not provided you with a class header. Implement the `ScubaThrower` class from scratch. Give it a class attribute `name` with the value `'Scuba'` (so that the graphics work) and remember to set the class attribute `implemented` with the value `True` (so that you can use it in a game).

After writing code, test your implementation:

```
python3 ok -q 09
```

Extra Credit (2 pt)

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q EC -u
```

Finally, implement the `QueenAnt`. The queen is a waterproof `ScubaThrower` that inspires her fellow ants through her bravery. In addition to the standard `ScubaThrower` action, the `QueenAnt` doubles the damage of all the ants behind her each time she performs an action. Once an ant's damage has been doubled, it is *not* doubled again for subsequent turns.

> Note that the reflected damage of a fire ant should not be doubled, only the extra damage it deals when its armor is reduced to 0

Class	Food Cost	Armor
 QueenAnt	7	1

However, with great power comes great responsibility. The `QueenAnt` is governed by three special rules:

1. If the queen ever has its armor reduced to 0, the bees win. The bees also still win if any bee reaches the end of a tunnel. You can call `bees_win()` to signal to the simulator that the game is over.
2. There can be only one true queen. Any queen instantiated beyond the first one is an impostor, and should have its armor reduced to 0 upon taking its first action, without doubling any ant's damage or throwing anything. If an impostor dies, the game should still continue as normal.
3. The true (first) queen cannot be removed. Attempts to remove the queen should have no effect (but should not cause an error). You will need to override `Ant.remove_from` in `QueenAnt` to enforce this condition.

Some hints:

- All instances of the same class share the same class attributes. How can you use this information to tell whether a QueenAnt instance is the true QueenAnt?
- You can find each `Place` in a tunnel behind the `QueenAnt` by starting at the ant's `place.exit` and then repeatedly following its `exit`. The `exit` of a `Place` at the end of a tunnel is `None`.
- To avoid doubling an ant's damage twice, mark the ants that have been buffed in some way, in a way that persists across calls to `QueenAnt.action`.

After writing code, test your implementation:

```
python3 ok -q EC
```

Hint Video

Optional Problems

> During Office Hours and Project Parties, the staff will prioritize helping students with required questions. We will not be offering help with these questions unless the queue (https://oh.cs61a.org/) is empty.

Optional Problem 1

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q optional1 -u
```

Implement the `NinjaAnt`, which damages all `Bee`s that pass by, but can never be stung.

Class	Food Cost	Armor
 NinjaAnt	5	1

A `NinjaAnt` does not block the path of a `Bee` that flies by. To implement this behavior, first modify the `Ant` class to include a new class attribute `blocks_path` that is `True` by default. Set the value of `blocks_path` to `False` in the `NinjaAnt` class.

Second, modify the `Bee`'s method `blocked` to return `False` if either there is no `Ant` in the `Bee`'s `place` or if there is an `Ant`, but its `blocks_path` attribute is `False`. Now `Bee`s will just fly past `NinjaAnt`s.

Finally, we want to make the `NinjaAnt` damage all `Bee`s that fly past. Implement the `action` method in `NinjaAnt` to reduce the armor of all `Bee`s in the same `place` as the `NinjaAnt` by its `damage` attribute. Similar to the `FireAnt`, you must iterate over a list of bees that may change.

> *Hint*: Having trouble visualizing the test cases? Try drawing them out on paper! See the example in Game Layout for help.

After writing code, test your implementation:

```
python3 ok -q optional1
```

For a challenge, try to win a game using only `HarvesterAnt` and `NinjaAnt`.

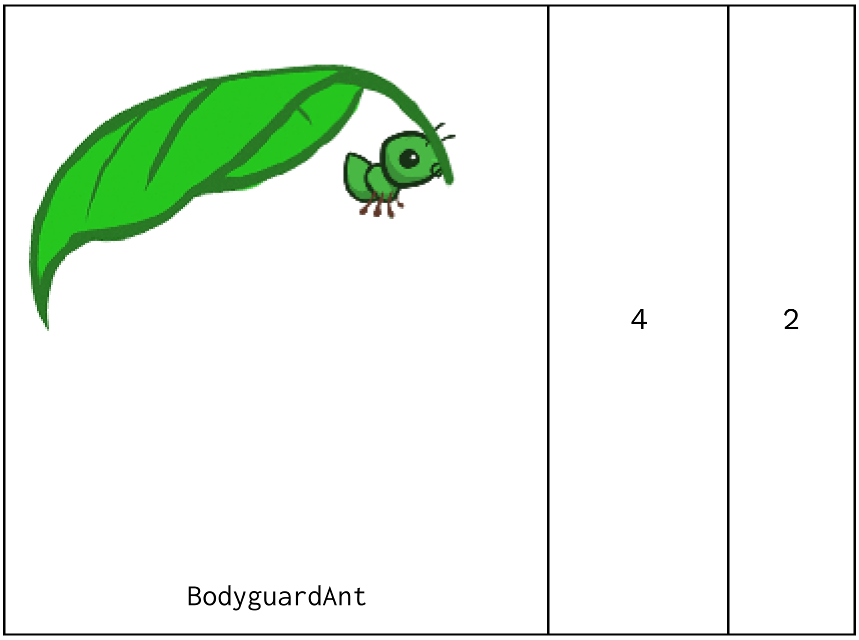
Optional Problem 2

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q optional2 -u
```

Right now, our ants are quite frail. We'd like to provide a way to help them last longer against the onslaught of the bees. Enter the `BodyguardAnt`.

Class	Food Cost	Armor



A `BodyguardAnt` differs from a normal ant because it is a `ContainerAnt`; it can contain another ant and protect it, all in one `Place`. When a `Bee` stings the ant in a `Place` where one ant contains another, only the container is damaged. The ant inside the container can still perform its original action. If the container perishes, the contained ant still remains in the place (and can then be damaged).

Each `ContainerAnt` has an instance attribute `contained_ant` that stores the ant it contains. It initially starts off as `None`, to indicate that no ant is being protected. Implement the `contain_ant` method so that it sets the bodyguard's `contained_ant` instance attribute to the passed in `ant` argument. Also implement the `ContainerAnt`'s `action` method to perform its `contained_ant`'s action if it is currently containing an ant.

In addition, you will need to make the following modifications throughout your program so that a container and its contained ant can both occupy a place at the same time (a maximum of two ants per place), but only if exactly one is a container:

1. Implement the method `ContainerAnt.can_contain` which takes an `other` ant as an argument and returns `True` if:
   - This ant does not already contain another ant.
   - The other ant is not a container.

   Currently `Ant.can_contain` returns False by default; it needs to be overridden in `ContainerAnt`
2. Modify `Ant.add_to` to allow a container and a non-container ant to occupy the same place according to the following rules:
   - If the ant currently occupying a place can contain the current ant, then it does.
   - If the current ant can contain the ant in the space, then it does.
   - If neither `Ant` can contain the other, raise the same `AssertionError` as before (the one already present in the starter code).
3. Add a `BodyguardAnt.__init__` that changes the default amount of armor.

Hint: You may find the `isinstance` function useful for checking if an object is an instance of a given class. For example:

```
>>> a = Foo()
>>> isinstance(a, Foo)
True
```

Note: the constructor of `ContainerAnt.__init__` is implemented as such

```
def __init__(self, *args, **kwargs):
    Ant.__init__(self, *args, **kwargs)
    self.contained_ant = None
```

As we saw in Hog, we have that `args` is bound to all positional arguments (that is all arguments not passed not with keywords, and `kwargs` is bound to all the keyword arguments. This ensures that both sets of arguments are passed to the Ant constructor).

Effectively, this means the constructor is exactly the same as `Ant.__init__` but sets `self.contained_ant = None`

After writing code, test your implementation:

```
python3 ok -q optional2
```

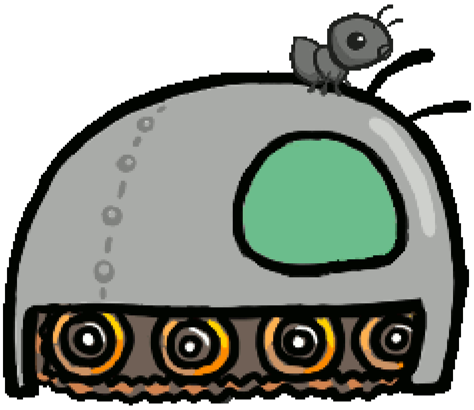
Optional Problem 3

Before writing any code, read the instructions and test your understanding of the problem:

```
python3 ok -q optional3 -u
```

The `BodyguardAnt` provides great defense, but they say the best defense is a good offense. The `TankAnt` is a container that protects an ant in its place and also deals 1 damage to all bees in its place each turn.

Class	Food Cost	Armor

 TankAnt	6	2

You should not need to modify any code outside of the `TankAnt` class. If you find yourself needing to make changes elsewhere, look for a way to write your code for the previous question such that it applies not just to `BodyguardAnt` and `TankAnt` objects, but to container ants in general.

After writing code, test your implementation:

```
python3 ok -q optional3
```

Optional Problem 4

Before writing any code, read the instructions and test your understanding of the problem:

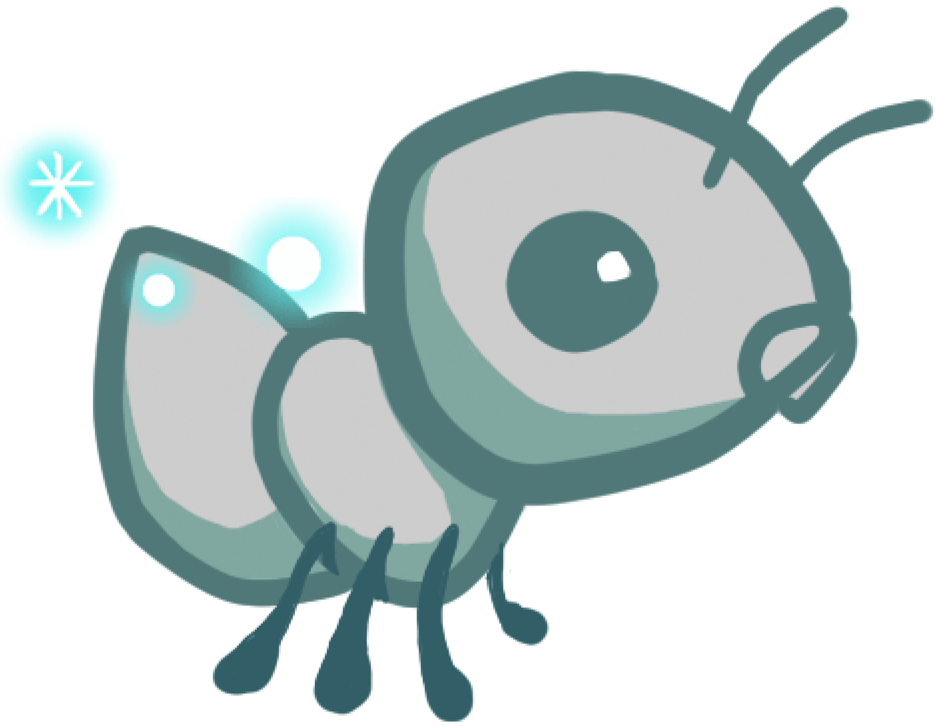
```
python3 ok -q optional4 -u
```

Implement two final thrower ants that do zero damage, but instead produce a temporary "status" on the `action` method of a `Bee` instance that they `throw_at`. This status is an alternative action that lasts for a certain number of `.action(gamestate)` calls, after which the `Bee`'s action reverts to its previous behavior.

We will be implementing two new ants that subclass `ThrowerAnt`.

- `SlowThrower` throws sticky syrup at a bee, applying a slow status for 3 turns.
- `ScaryThrower` intimidates a nearby bee, causing it to back away instead of advancing. (If the bee is already right next to the Hive and cannot go back further, it should not move.) The scare status lasts for 2 turns. *Once a bee has been scared once, it can't be scared again.*

Class	Food Cost	Armor

 `SlowThrower`	4	1
 `ScaryThrower`	6	1

In order to complete the implementations of these two ants, you will need to set their class attributes appropriately and implement the following three functions:

1. `make_slow` is a status that takes an `action` method and a `bee`, and returns a new `action` method that performs the original `action` on every turn that `gamestate.time` is even and does nothing on other turns.
2. `make_scare` is a status that takes an `action` method and a `bee`, and returns a new `action` method that makes the bee go backwards.

3. `apply_status` takes a `status` (either `make_slow` or `make_scare`), a `Bee`, and a `length`. The way it works is as so: imagine that a `Bee` has a bunch of statuses, each of which modifies `action` in sequence. When a status's length is up, it removes itself from the list. `apply_status` adds the given status to the end of the list, so that it is applied latest. Note that you don't necessarily need to make a literal list of statuses - it is just helpful to think of statuses in this way.

Hint: to make a bee go backwards, consider adding an instance variable indicating its current direction. Where should you change the bee's direction? Once the direction is known, how can you modify the `action` method of `Bee` to move appropriately?

Hint: You will need to rebind a method in one of the functions. Note that when assigning to an instance, the self parameter isn't bound.

```
class X: pass
def f(x): return x ** 3
x = X()
x.f = f
print(x.f(2)) # prints 8
```

As an example of what "previous behavior" means, take the example of a bee that has been slowed twice (say by two separate `SlowThrower`s). It will have the following behavior:

- on time 1, it will do nothing. The outer slow has 2 turns to go, the inner one still has 3 turns
- on time 2, it moves forward. The outer slow has 1 turn to go, the inner one has 2 turns
- on time 3, it will do nothing. The outer slow has no turns left, the inner one has 2 turns
- on time 4, it moves forward. The inner slow has 1 turn left
- on time 5, it does nothing. The inner slow has no turns left

You can run some provided tests, but they are not exhaustive:

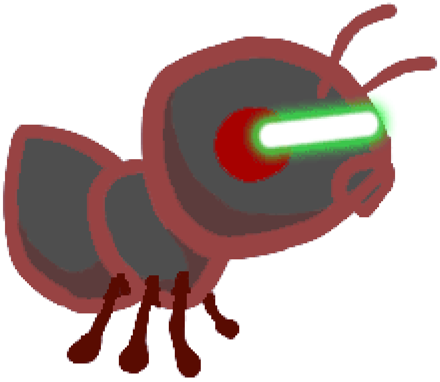
```
python3 ok -q optional4
```

Make sure to test your code! Your code should be able to apply multiple statuses on a target; each new status applies to the current (possibly affected) action method of the bee.

Optional Problem 5

We've been developing this ant for a long time in secret. It's so dangerous that we had to lock it in the super hidden CS61A underground vault, but we finally think it is ready to go out on the field. In this problem, you'll be implementing the final ant -- `LaserAnt`, a `ThrowerAnt` with a twist.

Class	Food Cost	Armor

 LaserAnt	10	1

The `LaserAnt` shoots out a powerful laser, damaging all that dare to stand in its path. Both `Bee` s and `Ant` s, of all types, are at risk of being damaged by `LaserAnt` . When a `LaserAnt` takes its action, it will damage all `Insect` s in its place (excluding itself, but including its container if it has one) and the `Place` s in front of it, excluding the `Hive` .

But, if that were it, `LaserAnt` would be too powerful for us to contain. The `LaserAnt` has a base damage of `2` . But, `LaserAnt` 's laser comes with some quirks. It is weakened by `0.2` each place it travels away from `LaserAnt` 's place. Additionally, `LaserAnt` 's laser has limited battery. Each time `LaserAnt` actually damages an `Insect` its laser's total damage goes down by `0.05` . If `LaserAnt` 's damage becomes negative due to these restrictions, it simply does 0 damage instead.

> Note that the exact order in which things are damaged within a turn is unspecified

In order to complete the implementation of this ultimate ant, read through the `LaserAnt` class, set the class attributes appropriately, and implement the following two functions:

1. `insects_in_front` is an instance method, called by the `action` method, that takes in `beehive` (the current `Hive`), and returns a dictionary where each key is an `Insect` and each corresponding value is the distance (in places) that that `Insect` is away from `LaserAnt` . The dictionary should include all `Insects` on the same place or in front of the `LaserAnt` , excluding `LaserAnt` itself.
2. `calculate_damage` is an instance method that takes in `distance` , the distance that an insect is away from the `LaserAnt` instance. It returns the damage that the `LaserAnt` instance should afflict based on:
    1. The `distance` away from the `LaserAnt` instance that an `Insect` is.
    2. The number of `Insects` that this `LaserAnt` has damaged, stored in the `insects_shot` instance attribute.

In addition to implementing the methods above, you may need to modify, add, or use class or instance attributes to the `LaserAnt` class as needed.

You can run the provided sanity test, but it is not exhaustive:

```
python3 ok -q optional5
```

Make sure to test your code!

Submission

Again, you will be turning in the following files:

- `ants.py`

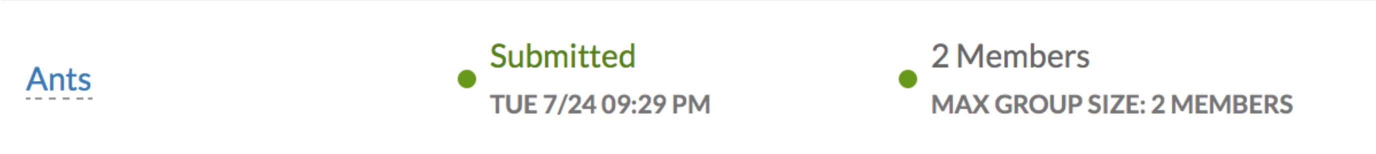
Please run the following command to submit the project:

```
python3 ok --submit
```

You can check to ensure that you have completed all the problems by running

```
python3 ok --score
```

Then, go to your OK dashboard (https://okpy.org) and verify that your submission was successful. You should see something like this:



You can click on the name of the assignment for more information about your submission. If you're experiencing issues with the autograder, remember that you can submit manually online.

Conclusion

You are now done with the project! If you haven't yet, you should try playing the game!

```
python3 ants_gui.py [-h] [-d DIFFICULTY] [-w] [--food FOOD]
```

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