

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 Phase 1 complete by **Friday, October 14** (worth 1 pt).
- Submit with Phase 2 complete by **Tuesday, October 18** (worth 1 pt).
- Submit with all phases complete by **Friday, October 21**.

Try to attempt the problems in order, as some later problems will depend on earlier problems in their implementation and therefore also when running ok tests.

The entire project can be completed with a partner.

You can get 1 bonus point by submitting the entire project by **Thursday, October 20**.

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 uses an object-oriented programming paradigm, focusing on 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.

When students in the past have tried to implement the functions without thoroughly reading the problem description, they've often run into issues.  **Read each description thoroughly before starting to code.**

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.
- `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

The project is worth 25 points. 23 points are for correctness, 1 point is for submitting Phase 1 by the first checkpoint date and 1 point is for submitting Phase 2 by the second checkpoint date.

Additionally, there are some extra credit point opportunities. You can get 1 EC point for submitting the entire project by **Thursday, October 20**, and 2 EC points for submitting the extra credit problem.

Important: In order to receive all of the possible extra credit points for Ants, your implementation of the entire project, *including* the EC problem, must be submitted by the early submission deadline.

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 or edit any files not listed above.

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 debugging print 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 the tunnel (you lose), the bees destroy the QueenAnt if it exists (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 Place s that are chained together to form a tunnel where bees can travel through. The colony also has some quantity of food which can be expended in order to place an ant in a tunnel.

Places. A place links to another place to form a tunnel. The player can put 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. Players place an ant into the colony by selecting from the available ant types at the top of the screen. Each type of ant takes a different action and requires a different amount of colony 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. In this game, bees are the antagonistic forces that the player must defend the ant 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.

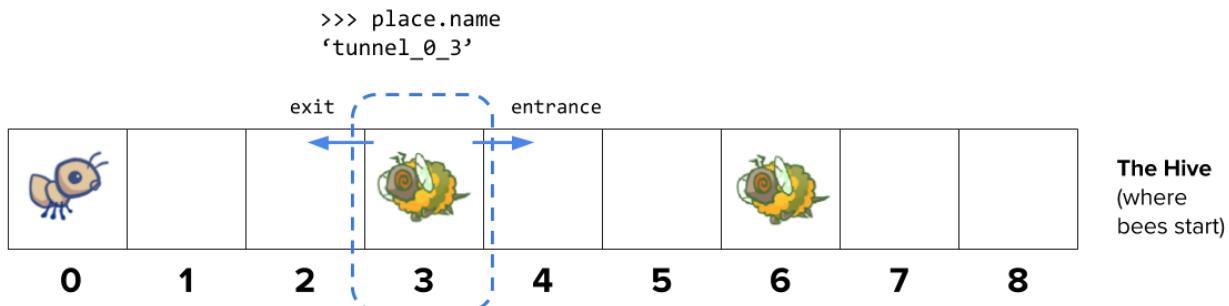
Core classes

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 `AntHomeBase` is, 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 `Bee`s get here, they win :(
- **Insect** : A superclass for `Ant` and `Bee`. All insects have `health` 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 the `Place` is not blocked by an ant, or stings the ant occupying its same `Place` .

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)

Object map

To help visualize how all the classes fit together, we've also created an object map for you to reference as you work, which you can find here ([diagram/ants_diagram.pdf](#)):



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 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! Also, right now the `ThrowerAnt`s can only attack bees that are in their `Place`, making it a little difficult to win with just these. Try playing the game anyway! You'll need to place a lot of `ThrowerAnt`s (the second type) in order to keep the bees from reaching your queen.

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/normal/hard/extrahard)
- w, --water loads a full layout with water
- food FOOD number of food to start with when testing

Getting Started Videos

These videos may provide some helpful direction for tackling the coding problems on the project.

To see these videos, you should be logged into your berkeley.edu email.



YouTube link (https://youtu.be/playlist?list=PLx38hZJ5RLZcPhl1MLltyPpPQi_8kdtGQ)

Phase 1: Basic gameplay

Important submission note: For full credit, submit with Phase 1 complete by **Friday, October 14** (worth 1 pt).

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

Problem 0 (0 pt)

Answer the following questions after you have read the *entire* ants.py file.

If you get stuck while answering these questions, you can try reading through ants.py 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 health attribute? Does this value change? If so, how?
2. Which of the following is a class attribute of the Insect class?
3. Is the health attribute of the Ant class an instance attribute or a 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 8)?
8. What does a Bee do during one of its turns?
9. When is the game lost?

To submit your answers, run:

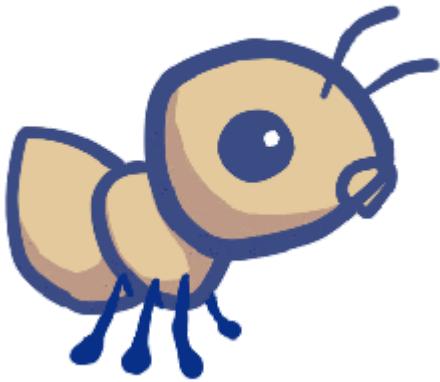
```
python3 ok -q 00 -u
```



A note on unlocking tests: If you'd like to review the unlocking questions after you have completed the unlocking test, you can navigate to (within the `ants` folder), the `tests` folder. For example, after unlocking Problem 0, you can review the unlocking test at `tests/00.py`.

Problem 1 (1 pt)

Part A: Currently, there is no cost for placing any type of `Ant`, and so there is no challenge to the game. The base class `Ant` has a `food_cost` of zero. Override this class attribute for `HarvesterAnt` and `ThrowerAnt` according to the "Food Cost" column in the table below.

Class	Food Cost	Initial Health
 HarvesterAnt	2	1
 ThrowerAnt	3	1

Part B: Now that placing an `Ant` costs 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.

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 01
```



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

Problem 2 (1 pt)

In this problem, you'll complete `Place.__init__` 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.

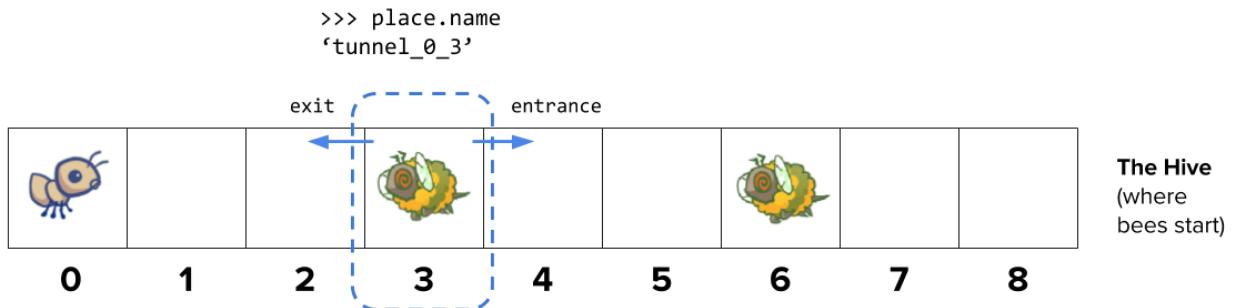
However, simply passing an entrance to a Place constructor will be problematic; we would need to have both the `exit` and the entrance before creating a Place! (It's a chicken or the egg (https://en.wikipedia.org/wiki/Chicken_or_the_egg) problem.) To get around this problem, we will keep track of entrances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

- 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.

Hint: Remember that Place's are not stored in a list, so you can't index into anything to access them. This means that you **can't** do something like `colony[index + 1]` to access an adjacent Place. How *can* you move from one place to another?



Example: AntColony with dimensions (1, 9)

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 02
```



Problem 3 (2 pt)

In order for a `ThrowerAnt` to throw a leaf, it must know which bee to 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**. This includes bees that are in the same `Place` as a `ThrowerAnt`

Hint: All `Place`s have an `is_hive` attribute which is `True` when that place is the Hive.

Change `nearest_bee` so that it returns a random `Bee` from the nearest place that contains bees. Your implementation should follow this logic:

- Start from the current `Place` of the `ThrowerAnt`.
- For each place, return a random bee if there is any, and if not, inspect the place in front of it (stored as the current place's `entrance`).
- If there is no bee to attack, return `None`.

Hint: The `random_bee` function provided in `ants.py` returns a random bee from a list of bees or `None` if the list is empty.

Hint: As a reminder, if there are no bees present at a `Place`, then the `bees` attribute of that `Place` instance will be an empty list.

Hint: Having trouble visualizing the test cases? Try drawing them out on paper! The sample diagram provided in Game Layout shows the first test case for this problem.

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
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 gui.py --food 10
```

Make sure to submit by the checkpoint deadline using the following command:

```
python3 ok --submit
```

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

```
python3 ok --score
```

Congratulations! You have finished Phase 1 of this project!

Phase 2: More Ants!

Important submission note: For full credit, submit with Phase 2 complete by **Tuesday, October 18** (worth 1 pt).

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 problem and on, you'll be implementing several different `Ant`s with different attack strategies.

After you implement each `Ant` subclass in these sections, you'll need to set its implemented `class 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!

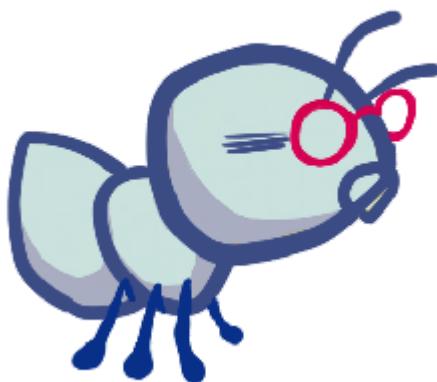
With all following ants from now on, try `python3 gui.py -d easy` to play against a full swarm of bees in a multi-tunnel layout and try `-d normal`, `-d hard`, or `-d extra-hard` if you want a real challenge! If the bees are too numerous to vanquish, you might need to create some new ants.

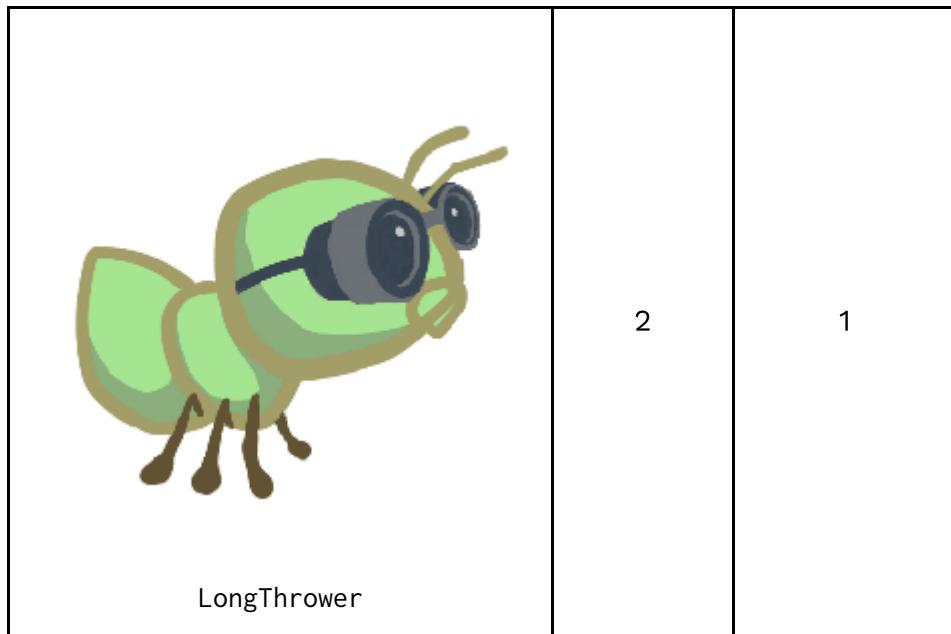
Problem 4 (2 pt)

A ThrowerAnt is a powerful threat to the bees, but it has a high food cost. In this problem, you'll 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 Bee s, one too close to the LongThrower and the other within its range, the LongThrower should only throw at the farther Bee , which is within its range, instead of trying to hit the closer Bee .
- The ShortThrower can only `throw_at` a Bee that is found after following at most 3 entrance transitions. It cannot throw at any bees 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	Initial Health
 ShortThrower	2	1



To implement these new throwing ants, your `ShortThrower` and `LongThrower` classes should inherit the `nearest_bee` method from the base `ThrowerAnt` class. The logic of choosing which bee a thrower ant will attack is the same, except the `ShortThrower` and `LongThrower` ants where their range is limited by a lower and upper bound, respectively.

To do this, modify the `nearest_bee` method to reference `lower_bound` and `upper_bound` attributes, and only return a bee if it is within range.

Make sure to give these `lower_bound` and `upper_bound` attributes appropriate values in the `ThrowerAnt` class so that the behavior of `ThrowerAnt` is unchanged. Then, implement the subclasses `LongThrower` and `ShortThrower` with appropriately constrained ranges.

You should **not** need to repeat any code between `ThrowerAnt`, `ShortThrower`, and `LongThrower`.

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, `lower_bound` and `upper_bound` should mark an inclusive range.

Important: Make sure your class attributes are called `upper_bound` and `lower_bound`. The tests directly reference these attribute names, and will error if you use another name for these attributes.

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

Before writing any code, unlock the tests to verify your understanding of the question:

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



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
```



Pair programming? ([/articles/pair-programming](#)) Remember to alternate between driver and navigator roles. The driver controls the keyboard; the navigator watches, asks questions, and suggests ideas.

Problem 5 (3 pt)

Implement the `FireAnt`, which does damage when it receives damage. Specifically, if it is damaged by `amount` health 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, as specified by its `damage` attribute, which has a default value of 3 as defined in the `FireAnt` class.

To implement this, override `Insect`'s `reduce_health` method. Your overridden method should call the `reduce_health` method inherited from the superclass (`Ant`) which inherits from its superclass `Insect` to reduce the current `FireAnt` instance's health. Calling the *inherited* `reduce_health` method on a `FireAnt` instance reduces the insect's health by the given `amount` and removes the insect from its place if its health reaches zero or lower.

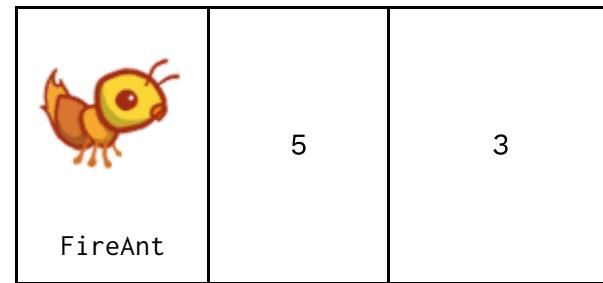
Hint: Do *not* call `self.reduce_health`, or you'll end up stuck in a recursive loop. (Can you see why?)

However, your method needs to also include the reflective damage logic:

- Determine the reflective damage amount: start with the `amount` inflicted on the ant, and then add `damage` if the ant's health has dropped to or below 0.
- For each bee in the place, damage them with the total amount by calling the appropriate `reduce_health` method for each bee.

Important: Remember that when any `Ant` loses all its health, it is removed from its place, so pay careful attention to the order of your logic in `reduce_health`.

Class	Food Cost	Initial Health
-------	-----------	----------------



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 to make sure we do not affect the original list.

```
>>> 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 superclass's `reduce_health` function (`Ant.reduce_health`), you can still use this method in your implementation by calling it. Note this is not recursion. (Why not?)

Before writing any code, unlock the tests to verify your understanding of the question:

`python3 ok -q 05 -u`



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

`python3 ok -q 05`



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

`python3 gui.py --food 10`

Problem 6 (1 pt)

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

Class	Food Cost	Initial Health
	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).

Hint: To start, take a look at how the previous problems' ants were implemented!

Hint: Make sure you implement the `__init__` method too so the `WallAnt` starts off with the appropriate amount of health!

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 06
```



Problem 7 (3 pt)

Implement the `HungryAnt`, which will select a random Bee from its place and deal damage to the Bee by eating it whole. After eating a Bee, a `HungryAnt` must spend 3 turns chewing before being able to eat again. While the `HungryAnt` is chewing, it is not able to eat (deal damage to) any Bees. After 3 turns, if there is no bee available to eat, the `HungryAnt` will do nothing.

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

Hint: When a Bee is eaten, it should lose all its health. Is there an existing function we can call on a Bee that can reduce its health to 0?

Class	Food Cost	Initial Health
 HungryAnt	4	1

Give HungryAnt a chewing_turns **class** attribute that stores the number of turns that it will take a HungryAnt to chew (set to 3). Also, give each HungryAnt an **instance** attribute turns_to_chew that counts the number of turns it has left to chew (initialized to 0, since it hasn't eaten anything at the beginning. You can also think of turns_to_chew as the number of turns until a HungryAnt can eat another Bee).

Implement the action method of the HungryAnt : First, check if it is chewing; if so, decrement its turns_to_chew . Otherwise, eat a random Bee in its place by reducing the Bee 's health to 0. Make sure to set the turns_to_chew when a Bee is eaten!

Hint: Other than the action method, make sure you implement the __init__ method too in order to define any instance variables and make sure that HungryAnt starts off with the appropriate amount of health !

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 07
```

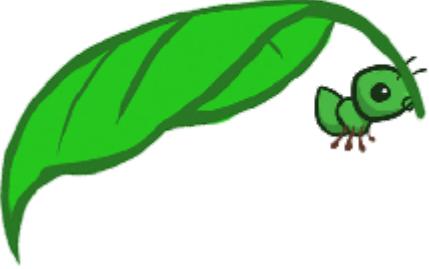


We now have some great offensive troops to help vanquish the bees, but let's make sure we're also keeping our defensive efforts up. In this phase you will implement ants that have special defensive capabilities such as increased health and the ability to protect other ants.

 Pair programming? (/articles/pair-programming) This would be a good time to switch roles. Switching roles makes sure that you both benefit from the learning experience of being in each role.

Problem 8 (3 pt)

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	Initial Health
	4	2

BodyguardAnt

To implement the `BodyguardAnt`, we will break up this problem into 3 subparts. In each part, we will making changes in either the `ContainerAnt` class, `Ant` class, or `BodyguardAnt` class.

Note: There are separate unlocking tests for each part you must complete. We recommend going through the unlocking test for each subpart before writing any code for it. You will test the code for all subparts at once at the very end of this problem.

Problem 8a

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 `ant_contained` that stores the ant it contains. This ant, `ant_contained`, initially starts off as `None` to indicate that there is no ant being stored yet. Implement the `store_ant` method so that it sets the `ContainerAnt`'s `ant_contained` instance attribute to the passed in `ant` argument. Also implement the `ContainerAnt`'s `action` method to perform its `ant_contained`'s action if it is currently containing an ant.

In addition, to ensure 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, we can create an `can_contain` method.

There is already an `Ant.can_contain` method, but it always returns `False`. Override the method `ContainerAnt.can_contain` so that it takes an ant other as an argument and returns `True` if:

- This `ContainerAnt` does not already contain another ant.
- The other ant is not a container.

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 08a
```



The constructor of `ContainerAnt.__init__` is implemented as follows:

```
def __init__(self, *args, **kwargs):
    super().__init__(*args, **kwargs)
    self.ant_contained = None
```

As we saw in Hog, `args` is bound to all positional arguments (which are all arguments passed without 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 its parent class's constructor (`Ant.__init__`) but here we also set `self.ant_contained = None`. Note that you do not need to modify this constructor.

Hint: You may find the `is_container` attribute that each `Ant` has useful for checking if a specific `Ant` is a container.

Problem 8b

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 originally occupying a place can contain the ant being added, then both ants occupy the place and original ant contains the ant being added.
- If the ant being added can contain the ant originally in the space, then both ants occupy the place and the (container) ant being added contains the original ant.
- If neither `Ant` can contain the other, raise the same `AssertionError` as before (the one already present in the starter code).

- **Important:** If there are two ants in a specific Place , the ant attribute of the Place instance should refer to the container ant, and the container ant should contain the non-container ant.

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 08b
```



Hint: You should also take advantage of the `can_contain` method you wrote and avoid repeating code.

Note: If you're getting an "unreachable code" warning for `Ant.add_to` via the VSCode Pylance extension, it's fine to ignore this specific warning, as the code is actually run (the warning *in this case* is inaccurate).

Problem 8c

Add a `BodyguardAnt.__init__` that sets the initial amount of health for the ant. We do not need to create an `action` method here since the `BodyguardAnt` class inherits it from the `ContainerAnt` class.

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

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 08c
```



Before writing any code, unlock the tests to verify your understanding of the question:

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



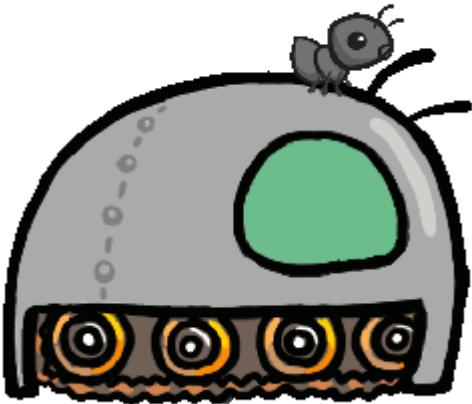
Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 08
```



Problem 9 (2 pt)

The BodyguardAnt provides great defense, but they say the best defense is a good offense. The TankAnt is a ContainerAnt that protects an ant in its place and also deals 1 damage to all bees in its place each turn. Like any ContainerAnt, a TankAnt allows the ant that it contains to perform its action each turn.

Class	Food Cost	Initial Health
 TankAnt	6	2

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

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.

Hint: The only methods you need to override from TankAnt's parent class are `__init__` and `action`.

Hint: Like with FireAnt, it is possible that damaging a bee will cause it to be removed from its place.

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 09
```



Make sure to submit by the checkpoint deadline using the following command:

```
python3 ok --submit
```

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

```
python3 ok --score
```

Congratulations! You have finished Phase 2 of this project!

Phase 3: 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 10 (1 pt)

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 insect that is waterproof can be placed in `Water`. In order to determine whether an `Insect` is waterproof, add a new class attribute to the `Insect` class named `is_waterproof` that is set to `False`. Since bees can fly, set their `is_waterproof` attribute to `True`, overriding the inherited value.

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

Before writing any code, unlock the tests to verify your understanding of the question:

```
python3 ok -q 10 -u
```



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 10
```



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 gui.py --water
```

Pair programming? (/articles/pair-programming) Remember to alternate between driver and navigator roles. The driver controls the keyboard; the navigator watches, asks questions, and suggests ideas.

Problem 11 (1 pt)

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 waterproof, *but otherwise identical to its base class*. A `ScubaThrower` should not lose its health when placed in Water .

Class	Food Cost	Initial Health
 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).

Before writing any code, unlock the tests to verify your understanding of the question:

```
python3 ok -q 11 -u
```



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 11
```



Problem 12 (3 pt)

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: The reflected damage of a `FireAnt` should not be doubled, only the extra damage it deals when its health is reduced to 0.

Class	Food Cost	Initial Health
 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 health reduced to 0, the ants lose. You will need to override `Insect.reduce_health` in `QueenAnt` and call `ants_lose()` in that case in order to signal to the simulator that the game is over. (The ants also still lose if any bee reaches the end of a tunnel.)
2. There can be only one queen. A second queen cannot be constructed. To check if an Ant can be constructed, we use the `Ant.construct()` class method to either construct an Ant if possible, or return `None` if not. You will need to override `Ant.construct` as a class method of `QueenAnt` in order to add this check. To keep track of whether a queen has already been created, you can use an instance variable added to the current `GameState`. (The `GameState` class is defined near the bottom of `ants.py`).
3. The 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.

Hint: For doubling the damage of all ants behind her, you may fill out the `double` method defined in the `Ant` class. The `double` method can be used within the appropriate `QueenAnt` instance method. To avoid doubling an ant's damage twice, mark the ants that have been double damaged in a way that persists across calls to `QueenAnt.action`.

Hint: When doubling the ants' damage, keep in mind that there can be more than one ant in a `Place`, such as if one ant is guarding another.

Hint: Remember that QueenAnt's `reduce_health` method adds the additional task of calling `ants_lose` to the superclass's `reduce_health` method. How can we make sure we still do everything from the superclass's method without repeating code?

Hint: Think about how you can call the `construct` method of the superclass of QueenAnt. Remember that you ultimately want to construct a QueenAnt, not a regular Ant or a ScubaThrower.

Note: The `construct` method has `cls` as an argument. This functions similar to how we use `self` in instance methods. So when we call a class method, we do not need to call it with `cls` as an argument. To read more about class methods, check out this (<https://pencilprogrammer.com/python-self-vs-cls/>) online guide about `cls` vs. `self`.

Hint: 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`.

Before writing any code, unlock the tests to verify your understanding of the question:

```
python3 ok -q 12 -u
```



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q 12
```



Extra Credit (2 pt)

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

Implement a final thrower ant that does zero damage, but instead applies a temporary effect on the `action` method of a Bee instance that it calls `throw_at` on. We will be implementing this new ant, `SlowThrower`, which inherits from `ThrowerAnt`.

`SlowThrower` throws sticky syrup at a bee, slowing it for 5 turns. When a bee is slowed, it takes the regular Bee action when `gamestate.time` is even, and takes no action (does not move or sting) otherwise. If a bee is hit by syrup while it is already slowed, it is slowed for

5 turns starting from the *most recent* time it is hit by syrup. That is, if a bee is hit by syrup, takes 2 turns, and is hit by syrup again, it will be slowed for 5 turns after the *second* time it is hit by syrup.

Class	Food Cost	Initial Health
	6	1

In order to complete the implementations of this `SlowThrower`, you will need to set its class attributes appropriately and implement the `throw_at` method in `SlowThrower`.

Important Restriction: You may *not* modify any code outside the `SlowThrower` class for this problem. That means you may *not* modify the `Bee.action` method directly. Our tests will check for this.

Hint: Assign `target.action` to a function that sometimes calls `Bee.action`. You can use an instance attribute to track how many more turns the bee will be slowed, and once the effect is over, `Bee.action` should be called every turn.

Before writing any code, unlock the tests to verify your understanding of the question:

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



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

```
python3 ok -q EC
```



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 previously affected) action method of the bee.

Optional Problems

Optional Problem 1

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

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

Class	Food Cost	Initial Health
 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 set to `True`, then override 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 health of all `Bee`s in the same place as the `NinjaAnt` by its `damage` attribute. Similar to the `FireAnt`, you must iterate over a potentially changing list of bees.

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

Before writing any code, unlock the tests to verify your understanding of the question:

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



Once you are done unlocking, begin implementing your solution. You can check your correctness with:

```
python3 ok -q optional1
```

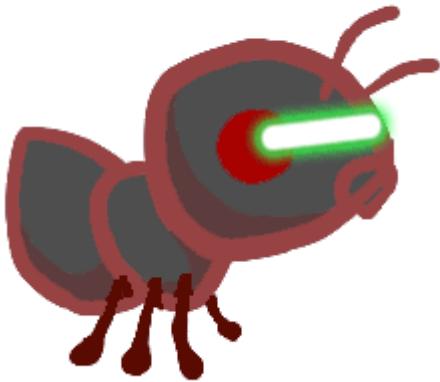


For a challenge, try to win a game using only `HarvesterAnt` and `NinjaAnt`.

Optional Problem 2

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

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	Initial Health
	10	1

LaserAnt

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`.

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. The laser is weakened by 0.25 each place it travels away from `LaserAnt`'s place. Additionally, `LaserAnt` has limited battery. Each time `LaserAnt` actually damages an `Insect` its laser's total damage goes down by 0.0625 (1/16). If `LaserAnt`'s damage becomes negative due to these restrictions, it simply does 0 damage instead.

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 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:
 3. The distance away from the LaserAnt instance that an Insect is.
 4. 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 in the LaserAnt class as needed.

Note: There are no unlocking tests for this question.

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

```
python3 ok -q optional2
```



Make sure to test your code!

Project submission

At this point, run the entire autograder to see if there are any tests that don't pass:

```
python3 ok
```

You can also check your score on each part of the project, including the extra credit problem:

```
python3 ok --score
```

Once you are satisfied, submit to complete the project.

```
python3 ok --submit
```

If you have a partner, make sure to add them to the project submission on okpy (<https://okpy.org/>).

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

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

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