Easy 2D Game Creation With Python And Arcade

Paul Vincent Craven

Speaker notes

Hi, I'm Paul Craven.

I'm going to show you how to get started creating 2D video games with Python and the Arcade library.

Explore On-Line!

http://arcade.academy

Speaker notes

You can explore and get more information about this by going on-line to "arcade.academy".

There is a ton of information on this website.

It is designed to get you up and going creating 2D games as painlessly as possible whether you are experienced or new to programming.

There is also a link to a live view of these slides, so you can see the code easily, and follow any links for more information.

Installation

```
pip install arcade
```

Requires

- Python 3.6+
- OpenGL Capable Hardware

For detailed installation instructions on Windows, MacOS, and Linux, see:

http://arcade.academy/installation.html

Speaker notes

In order to get started, you need to install the Arcade library.

You can install the Arcade library like any other package on PyPi.

Usually just typing "pip install arcade" will work. Or for Mac/Linux "pip3 install arcade"

Arcade requires Python 3.6 or greater.

It does require OpenGL support. That shouldn't be a problem for any semi-modern hardware.

For more details on installation, see the installation instructions on arcade.academy.

Open a Window

```
1 import arcade

  # Set constants for the screen size
  SCREEN_WIDTH = 600
  SCREEN_HEIGHT = 600

  # Open the window. Set the window title and dimensions
2 arcade.open_window(SCREEN_WIDTH, SCREEN_HEIGHT, "Drawing Example"

  # --- Drawing Code Will Go Here ---

  # Keep the window open until the user hits the 'close' button
3 arcade.run()
```

Speaker notes

First step is opening a window.

There are three lines of code you need to get this far.
1. Import the arcade library.
2. Use the open_window command, giving it how wide and high for the window. You also give a title of the window.

If you just stopped here, you'd get a window that would pop up, but since your program ends, the window would immediately go away.
That's no good.
So you need the third line, which will keep the program running until you close the window.

In a bit, we will start adding drawing code, and we'll put that where the arrow is.

Drawing Setup

```
import arcade

SCREEN_WIDTH = 600
SCREEN_HEIGHT = 600

# Open the window. Set the window title and dimensions
arcade.open_window(SCREEN_WIDTH, SCREEN_HEIGHT, "Drawing Example"

# Set the background color
arcade.set_background_color(arcade.color.WHITE)

# Clear screen and start render process
arcade.start_render()

# --- Drawing Commands Will Go Here ---

# Finish drawing and display the result
arcade.finish_render()

# Keep the window open until the user hits the 'close' button
arcade.run()
```

1

2

3

Speaker notes

After getting a window open, the next step is to get it ready for drawing.

Step one, use the set_background_color command to set the background color. We can use named colors or set the RGB value by using a three number tuple.

Step Two, tell the computer to clear the screen to the current background color and get ready for drawing.
Our drawing commands we'll eventually put where the arrow is

Step Three, after we are done drawing, we want to "flip" the screen and show what we've drawn. That's what 'finish render' does.

Nothing of what we have drawn is shown until we run the finish_render command.


Drawing Example

Speaker notes

Ok, let's draw something simple. Like a smiley face.

We'll need to draw one circle for the yellow face.

Draw two circles for the eyes

and an arc for the mouth.

Drawing

```
# Draw the face
x = 300; y = 300; radius = 200
1 arcade.draw_circle_filled(x, y, radius, arcade.color.YELLOW)

# Draw the right eye
x = 370; y = 350; radius = 20
2 arcade.draw_circle_filled(x, y, radius, arcade.color.BLACK)

# Draw the left eye
x = 230; y = 350; radius = 20
3 arcade.draw_circle_filled(x, y, radius, arcade.color.BLACK)

# Draw the smile
x = 300; y = 280; width = 120; height = 100
start_angle = 190; end_angle = 350; line_width = 10
4 arcade.draw_arc_outline(x, y, width, height, arcade.color.BLACK,
                          start_angle, end_angle, line_width)
```

http://arcade.academy/examples/happy_face.html

Speaker notes

* Here we have the four drawing commands for the smiley face.
* I've declared variables and set those to the values we need to make the code easier to read.
* Just for the record, you should put variables each on their own line and NOT use semicolons. But it is really hard to fit the code on a slide if I do that.
* We use three draw_circle_filled commands. One for the face and two for the eyes.
* Our window is 600 by 600, so you can see we are drawing the face at 300, 300 making it at the exact center.
* We use an arc for the smile.
* An arc is one of the most complex things that we can draw, with the center, width, height, start and end angles.
* You can see the full code for the program at the link below.

Drawing Commands

```
draw_rectangle_filled()
draw_rectangle_outline()
draw_lrtb_rectangle_filled()
draw_lrtb_rectangle_outline()
draw_xywh_rectangle_filled()
draw_xywh_rectangle_outline()

draw_polygon_filled()
draw_polygon_outline()

draw_text()

load_texture()
draw_texture_rectangle()
draw_xywh_rectangle_textured()

draw_triangle_filled()
draw_triangle_outline()
```

```
draw_arc_filled()
draw_arc_outline()

draw_circle_filled()
draw_circle_outline()

draw_ellipse_filled()
draw_ellipse_outline()

draw_line()
draw_line_strip()
draw_lines()

draw_parabola_filled()
draw_parabola_outline()

draw_point()
draw_points()
```

http://arcade.academy/quick_index.html

Speaker notes

There are several commands available for use in drawing primitive shapes.

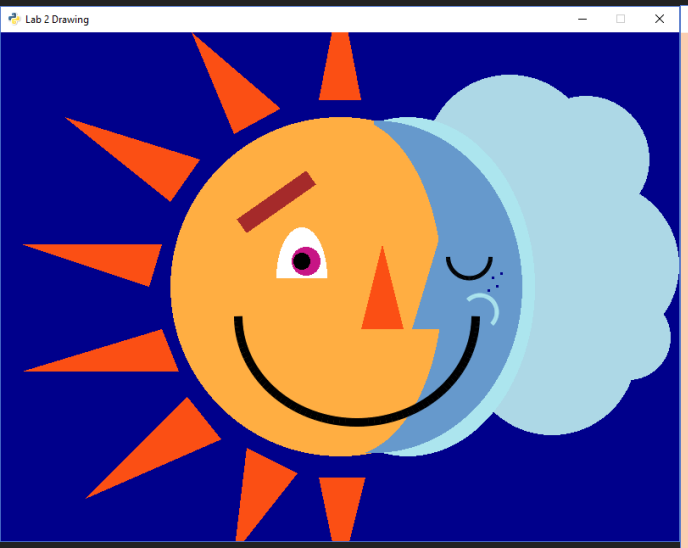
You can draw rectangles several different ways, depending on how you want to specify the coordinates.

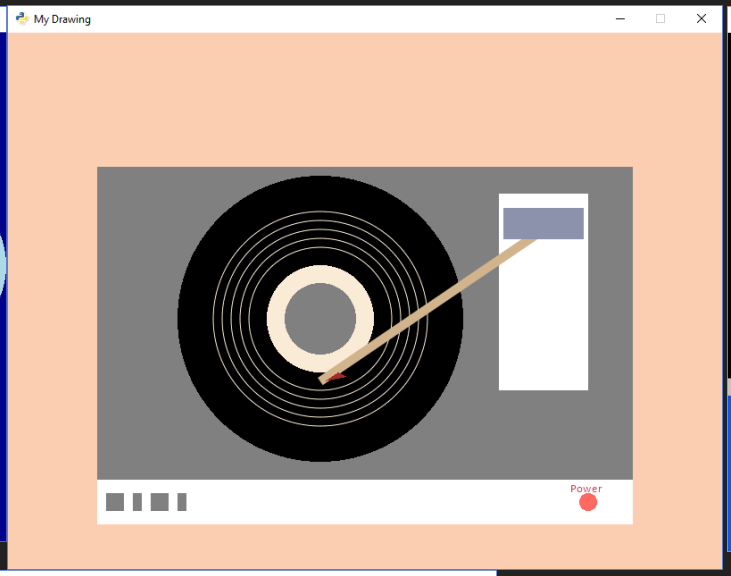
You can draw arcs, ellipses, lines, polygons, and text.
You can rotate any of these as well.

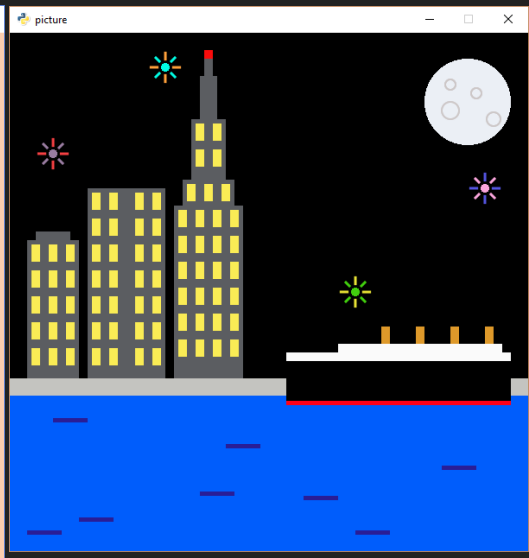
"textures" allow you to load images from the disk and display them.

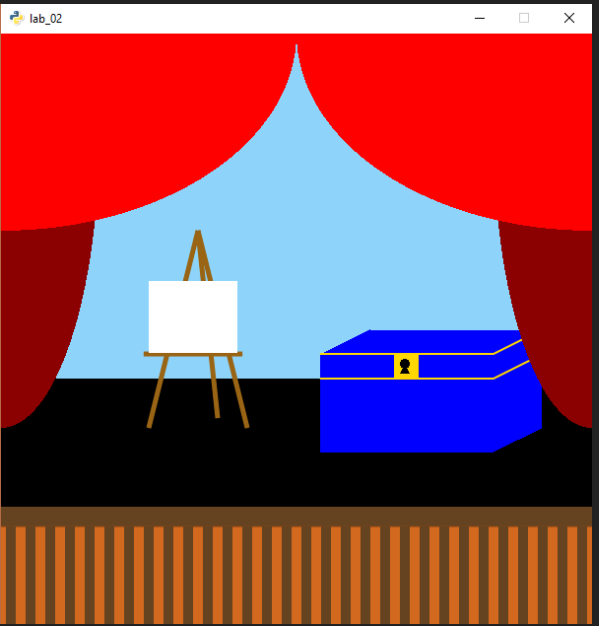
You can look up the details of each command by using the quick index at arcade academy.

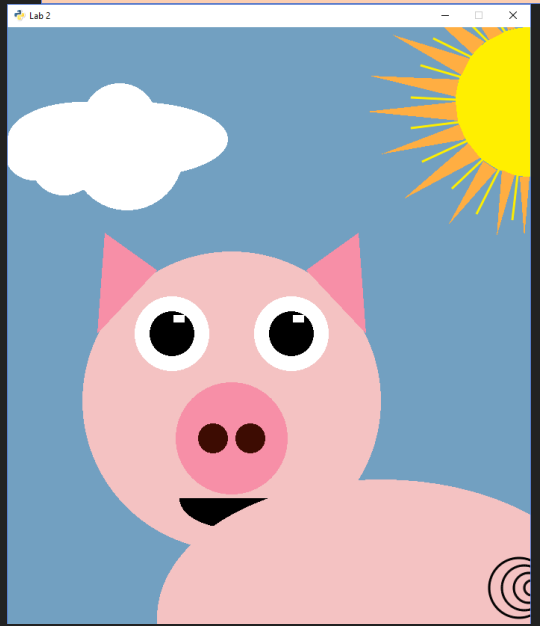
Sample Images

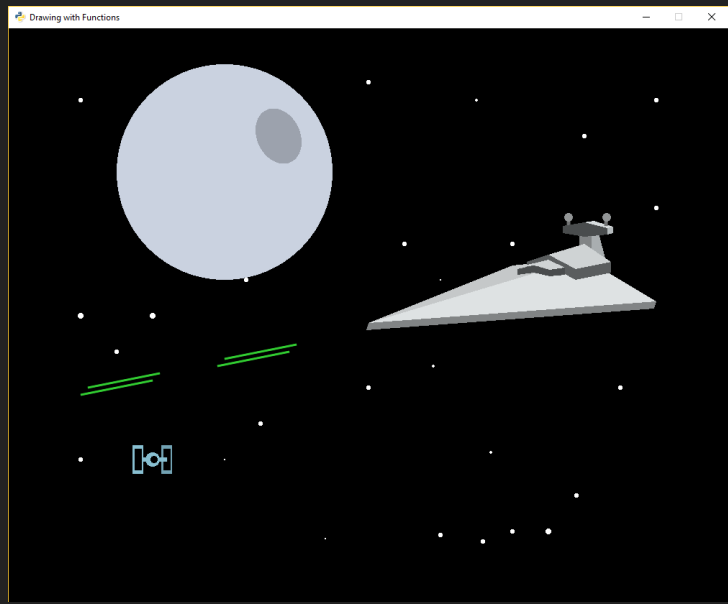












Speaker notes

Even just with simple drawing primitives, it is possible to create some nice images.

These are all from new programmers who were able to create these programs just a couple weeks into learning to program.

For someone new to programming, it is a great way to get used to working with coordinates, using variables, calling functions, and looking up documentation.

Even for expert programmers, it is just fun to make art.

Wait!

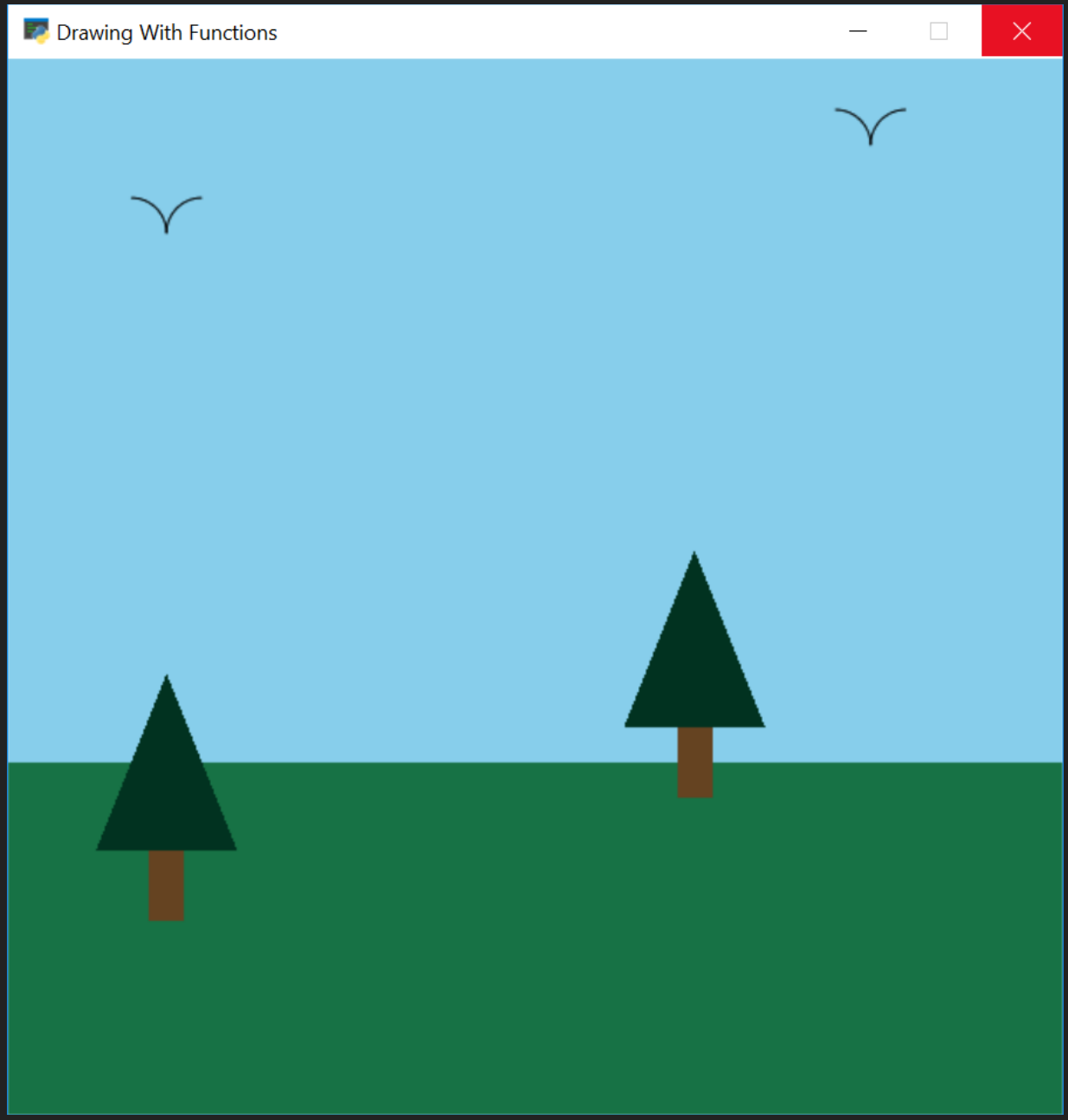
Put code in functions!

Speaker notes

Wait! It is better programming if we put our code into functions.

We don't want to leave our code and variables all strewn about.

Not only do we want people to look at our images and say they look good, we want our code to be beautiful.


Drawing With Functions

Speaker notes

Functions also give us the ability to reuse our code.

We can create a library of functions for drawing trees, birds, and more.

Then we don't have to re-write the code every time we want a tree.

To create this image, I have a function for drawing a tree, and one for drawing a bird.

Let's look at the tree drawing function.

Draw With Functions

```
1 def draw_pine_tree(x, y):
      """
      This function draws a pine tree at the specified location.
      """
      # Draw the triangle on top of the trunk
2     arcade.draw_triangle_filled(x + 40, y,
                                  x, y - 100,
                                  x + 80, y - 100,
                                  arcade.color.DARK_GREEN)

      # Draw the trunk
3     arcade.draw_lrtb_rectangle_filled(x + 30, x + 50,
                                        y - 100, y - 140,
                                        arcade.color.DARK_BROWN)
```

http://arcade.academy/examples/drawing_with_functions.html

Speaker notes

This is an example of using a function that draws the pine tree from the previous image.
* Line 1 defines a draw_pine_tree function We take in an x and y as parameters, and use that to position the tree.
* If you name the function well, this code becomes "self documenting." Even a non-programmer could look at this code and see that with a name like "draw_pine_tree" there's a good chance the code draws a pine tree.
* Line 2 draws a dark green triangle for the top. We specify three x, y coordinates for each point in the triangle. We calculate where those are based on the x, y that was passed into the function.
* Line 3 draws a brown rectangle for the trunk.
If you are new to creating functions, this is an excellent way to hone your skills while creating a library of different things to draw.

The Main Function

1

```
def main():

    arcade.open_window(SCREEN_WIDTH, SCREEN_HEIGHT,
                       "Drawing With Functions")
    arcade.start_render()

    # Call our drawing functions.
    draw_background()
    draw_pine_tree(50, 250)
    draw_pine_tree(350, 320)
    draw_bird(70, 500)
    draw_bird(470, 550)

    arcade.finish_render()
    arcade.run()


if __name__ == "__main__":
    main()
```

3

2

http://arcade.academy/examples/drawing_with_functions.html

Speaker notes

If you are putting all your code into functions, you can create a "main" function that is the starting code for our game.
I've defined this in step one.

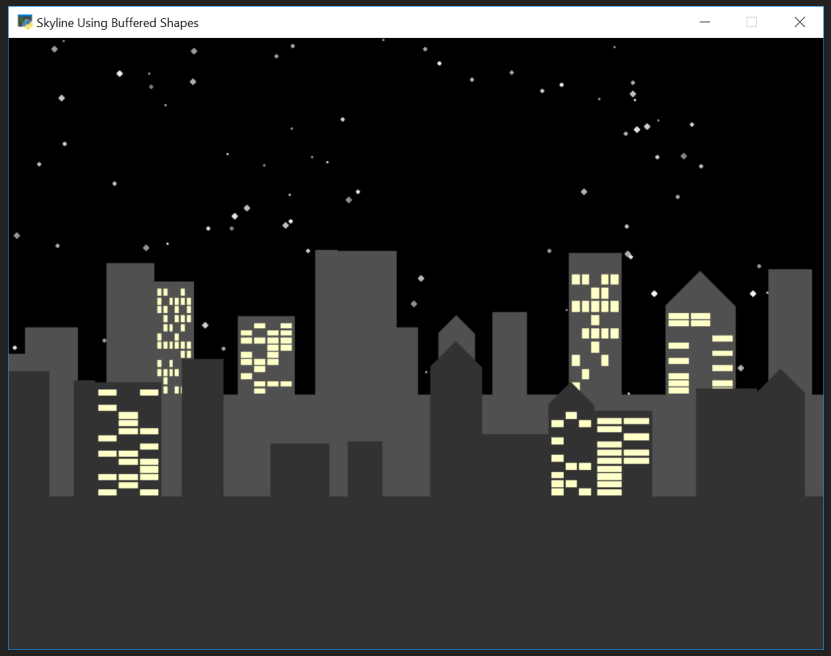
Now if you look down at the bottom on step 2, this will call the main function and start our program.

You can skip the 'if' statement and just call main() with the second line if you want.
Keeping the 'if' statement will prevent the program from being run if we import it instead of run it.

Looking at step 3, I'm calling all my functions that draw. With good function names, this can be self-documenting. Even a non-programmer can understand what is happening here.

Wait!

That's not fast...



Explore using buffered shapes

http://arcade.academy/examples/shape_list_demo_skylines.html

Speaker notes

Wait!

The experienced graphics programmer in the audience will know that the method of drawing that I've just described is very slow.

Think about it, if I had a sky with 200 stars in it, then if my game ran at 60 times per second I'd be drawing 200 times 60 = 12,000 stars per second.

It is much faster if I load those 200 stars on the graphics card ahead of time, and just tell the graphics card to draw the stars for me. That takes 12,000 drawing commands per second down to 60.

Arcade supports this as well, and it is worth looking into.

Use Classes

```
1 class MyGame(arcade.Window):

2     def __init__(self, width, height, title):
          """ Initialize everything """

          # Initialize the parent class
          super().__init__(width, height, title)

          arcade.set_background_color(arcade.color.AMAZON)

3     def setup(self):
          """ Create the sprites and set up the game """
          pass

4     def on_draw(self):
          """ Render the screen. """

          arcade.start_render()

          # TODO: Drawing code goes here
```

Speaker notes

* To make your program into an interactive game, you can use classes.
* You can also use decorators, but I don't have time to cover that in this talk.
* Step 1, we create our own class. We derive it from a parent Window class in the Arcade library.
* Then we can over ride functions and add in the new functionality that we want.
* Step 2, we are adding functionality to the init method, and we can set up our instance variables we'll use in our game here.
* Step 3, in this setup method we will put all the code where we create the characters for our game, set up the walls, and everything else.
* We don't put that code in our 'init' function, because if we separate it out, we can just add the ability to restart our game by simply calling setup again.
* Step 4, we will put our code for drawing inside the on_draw function.
* This is where all our drawing code goes

Use Classes

```
1   def update(self, delta_time):
        """ All the logic to move, and the game logic goes here.
        pass

2   def on_key_press(self, key, key_modifiers):
        """ Called whenever a key on the keyboard is pressed. """
        pass

3   def on_mouse_motion(self, x, y, delta_x, delta_y):
        """ Called whenever the mouse moves. """
        pass

4   def on_mouse_press(self, x, y, button, key_modifiers):
        """ Called when the user presses a mouse button. """
        pass
```

http://arcade.academy/examples/starting_template.html

Speaker notes

Item 1, the update function is where we can put our code to move the objects in our the game, and to run other game logic, like detect collisions.

It is important to keep the game logic code separated from the game drawing code.

We can respond to user input by over-riding functions like these.

* Item 2 is called any time the user presses a key.
* Item 3 is called for mouse movement.
* Item 4 is called for pressing a mouse button.

You can look at the starting template code at the URL below to get an idea of all the functions that can be filled in.

Oh, and if you haven't seen it before, "pass" is a keyword in Python that you can use when you don't have any code for a function or some other block of code.

You should replace the "pass" keyword with your code.

Or, if you don't have any code you want to run, just remove the function.
Don't leave "pass" in your program as it is just a placeholder.

Use Classes

```
def main():
    """ Main method """
    game = MyGame(SCREEN_WIDTH, SCREEN_HEIGHT, "My Game Title")
    game.setup()
    arcade.run()


if __name__ == "__main__":
    main()
```

1. def main():
2. game.setup()
3. main()

http://arcade.academy/examples/starting_template.html

Speaker notes

So we've defined our own window class, how do we get it to run?

Usually, I use code like this. I have a main function that creates an instance of the class I just defined, call the setup method to start the game, and then run it.

Use Sprites

Images from Kenney.nl

Speaker notes

Sprites represent items on the screen that can be interacted with.

In this screenshot, each coin is a sprite. The player is also a sprite.

We manage sprites in lists. This makes it easy to detect collisions, draw, and update objects on the screen.

Now, we'll go over code for a very simple game that allows the player to move around the screen collecting sprites.

Create Sprites

```
# This code goes in the setup() method of our MyGame class

# Set up the player
1 self.player_sprite = arcade.Sprite("images/character.png")

self.player_sprite.center_x = 50
2 self.player_sprite.center_y = 50

# Add player to a sprite list
3 self.player_list = arcade.SpriteList()
self.player_list.append(self.player_sprite)
```

http://arcade.academy/examples/sprite_collect_coins.html

Speaker notes

It is easy to create a sprite.

Section 1 here creates a sprite from an image on the disk. You can also include an optional scaling factor if you want the sprite larger or smaller.

Section 2 positions the sprite.

Section 3 adds the sprite to a sprite list.

The SpriteList Class

- Optimizes drawing by using vertex buffers and more
- Optimizes collision detection by using spatial hashing
- Allows you to control drawing order
- Easier management of your game logic

Speaker notes

The SpriteList class is important in creating your game.
There are a lot of built-in optimizations to this class that help your game run faster.

By using vertex buffers we can turn thousands of drawing calls per frame into one drawing call.

This is particularly beneficial for groups of sprites that don't move, like walls. Static, non-moving sprites should be grouped separately from moving sprites.

Detecting if one sprite is touching another sprite can take time. If there are a thousand walls in your level, then everything that can run into a wall needs to do a thousand checks, 60 times per second.

We can get around that by using spatial hashing. We keep track of what sprites are close together, and can turn those thousand checks down to only the few sprites that are close by.

By using sprite lists you can control what sets of sprites appear on top of other sprites.

You can also use sprite lists for easier management in the logic of your game. You can keep the logic around coins, laser beams, platforms, and enemies all separate.

Create Sprites

```
# This code goes in the setup() method of our MyGame class

COIN_COUNT = 50
self.coin_list = arcade.SpriteList()

# Create the coins
for i in range(COIN_COUNT):

    # Create the coin instance
    coin = arcade.Sprite("images/coin_01.png")

    # Position the coin
    coin.center_x = random.randrange(SCREEN_WIDTH)
    coin.center_y = random.randrange(SCREEN_HEIGHT)

    # Add the coin to the lists
    self.coin_list.append(coin)
```

1

2

http://arcade.academy/examples/sprite_collect_coins.html

Speaker notes

This next bit of code places 50 coin sprites in random positions on the screen.

The loop in part 1 runs our code block 50 times,

and part 2 positions the sprite in a random location.

We can use similar techniques to place sprites in a grid or some other pattern.

As you can see, it doesn't take much code at all to do this.

Drawing Sprites

```
    def on_draw(self):
        """
        Render the screen.
        """

        # This command has to happen before we start drawing
        arcade.start_render()

        # Draw all the sprites.
        self.wall_list.draw()
        self.coin_list.draw()
        self.player_sprite_list.draw()
```

1

2

http://arcade.academy/examples/sprite_collect_coins.html

Speaker notes

Drawing with sprite lists is easy.

The on_draw command in my game class, just needs to look like this.

I call start_render
I go through each sprite list I have, and draw it.

Drawing should be done in back-to-front order.

In this case, if a coin and a wall are in the same spot, the coin will appear over the wall rather than under it.

Sprite Collisions

```
def update(self, delta_time):
    # Generate a list of all coin sprites that collided with the player.
1   coins_hit_list = arcade.check_for_collision_with_list(self.player_sp
                                                          self.coin_list

    # Loop through each colliding sprite, remove it, and add to the scor
    for coin in coins_hit_list:
2       coin.kill()
        self.score += 1
```

http://arcade.academy/examples/sprite_collect_coins.html

Speaker notes

You can detect if a sprite is hitting any other sprite in a list with the check_for_collision_with_list function.

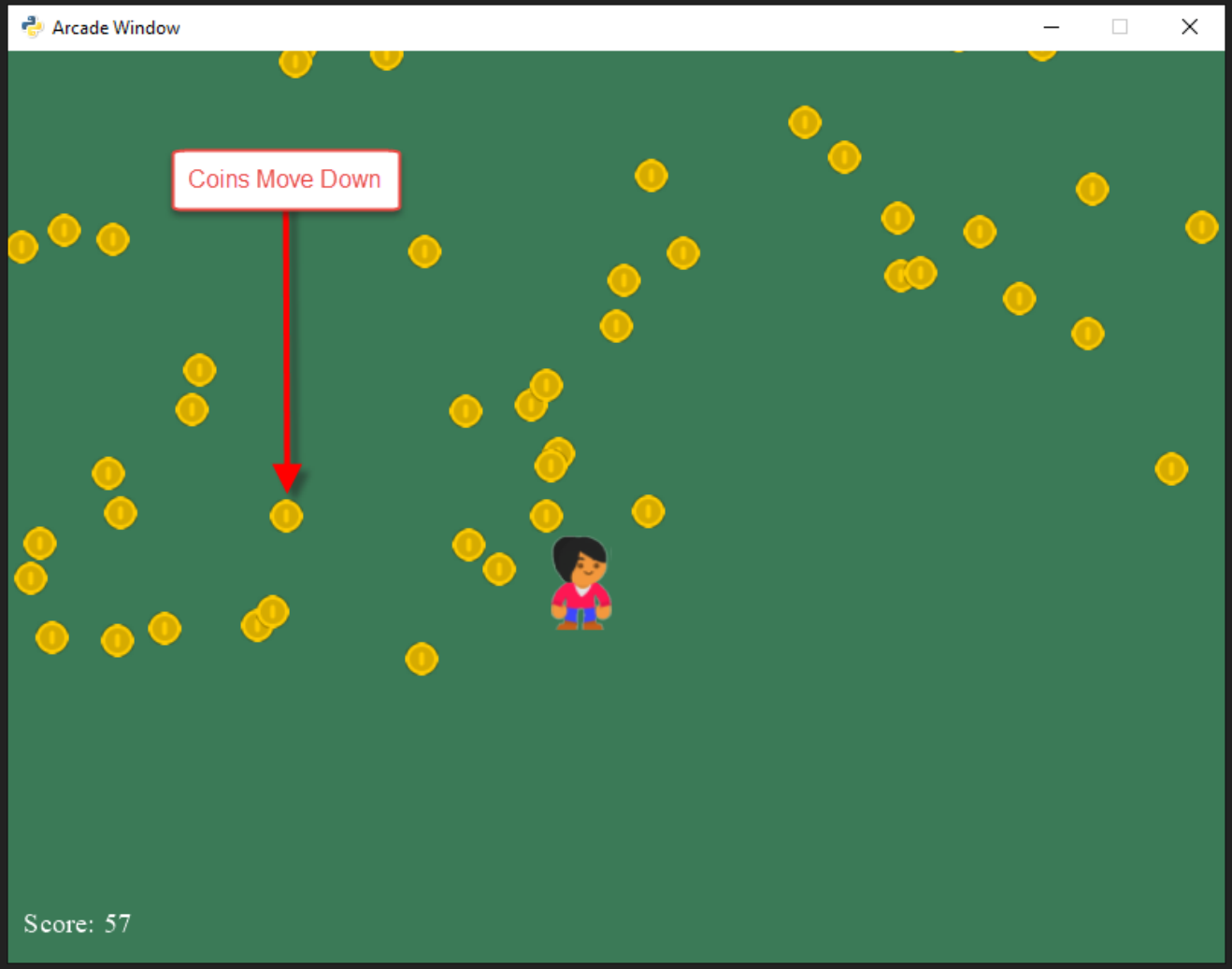
I am giving it two pieces of information. My player sprite. And a list of all the coin sprites.

This function returns a new list that tells me what coins the player is in contact with.

In this example, we loop through each colliding sprite and remove it with the kill function, then add a point to our score.

This is code is not complicated. You can easily write this code.

Moving Sprites



http://arcade.academy/examples/sprite_collect_coins_move_down.html

Speaker notes

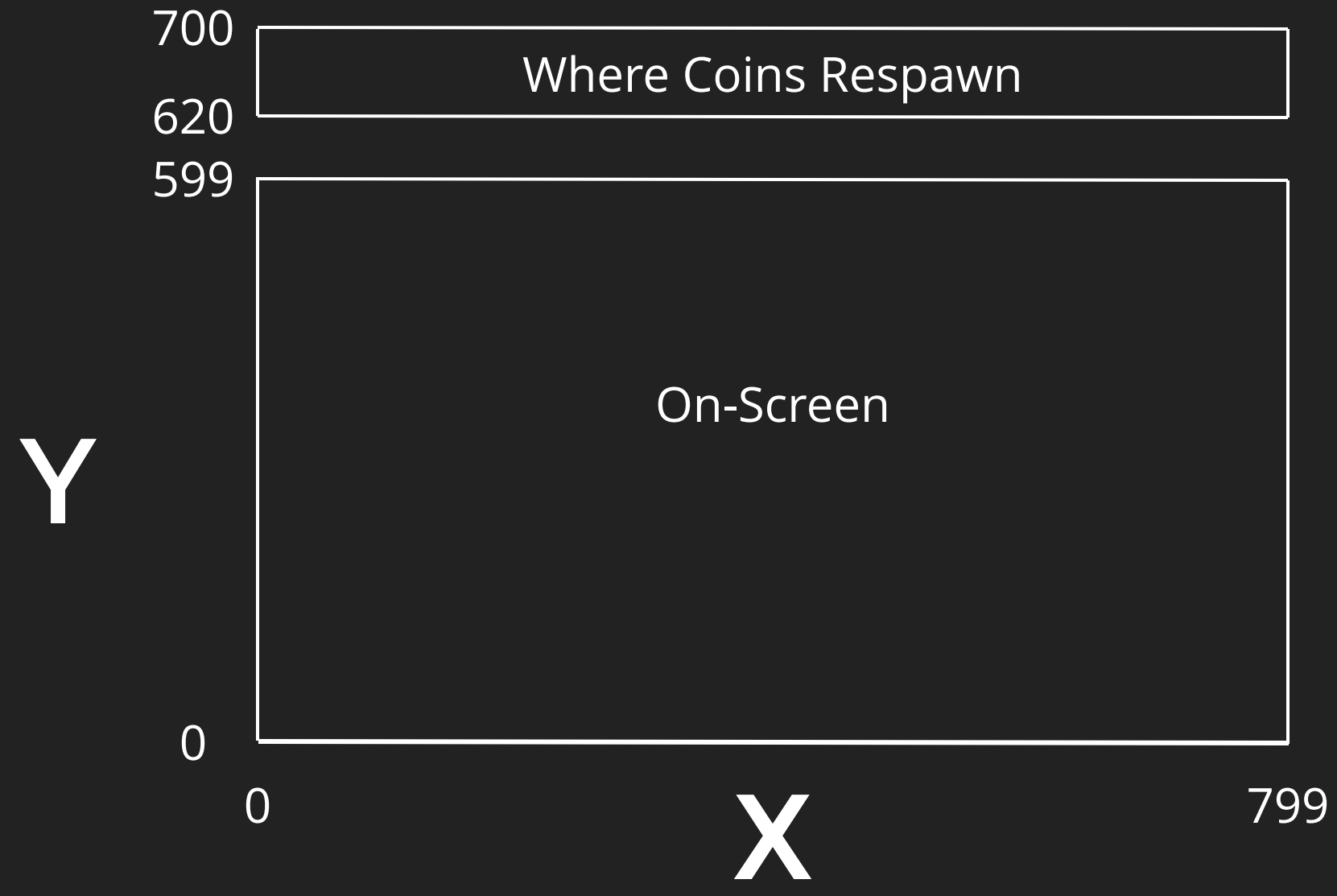
I haven't yet said how to move these sprites.

How do we move the player with the mouse?

How could we spice up the game by having the coins move down?

Before we show that code, we need to understand the coordinate system.

Moving Coins Down



http://arcade.academy/examples/sprite_collect_coins_move_down.html

Speaker notes

The coordinates of the world in our simple example look like this.

For a 800 wide by 600 tall window, (0, 0) is in the lower left corner of our window. And (799, 599) is the upper right corner of our window. (Remember we start counting at zero.)

To move a coin down, we'll need to make the y coordinate of our coin smaller.

When a coin moves off the screen, the top of the coin will have a y coordinate less than zero.

When we respawn a coin, we'll do it 20 to 100 pixels above the screen so it can smoothly slide into view.

Moving The Player

1

```
    def on_mouse_motion(self, x, y, dx, dy):
        """ Handle Mouse Motion """

        # Move the center of the player sprite to match the mouse x,
        self.player_sprite.center_x = x
2       self.player_sprite.center_y = y
```

http://arcade.academy/examples/sprite_collect_coins_move_down.html

Speaker notes

The easiest part of this is moving the player with the mouse.

Remember the on_mouse_motion function?

Just fill this function by removing the "pass" command and replacing it with code that takes the player sprite and setting its center to the mouse location.

That's it!

Moving Coins Down

```
1 class Coin(arcade.Sprite):

2     def reset_pos(self):

          # Reset the coin to a random spot above the screen
          self.center_y = random.randrange(SCREEN_HEIGHT + 20,
3                                          SCREEN_HEIGHT + 100)
          self.center_x = random.randrange(SCREEN_WIDTH)

4     def update(self):

          # Move the coin
5         self.center_y -= 1

          # See if the coin has fallen off the bottom of the screen.
          # If so, reset it.
          if self.top < 0:
6             self.reset_pos()
```

http://arcade.academy/examples/sprite_collect_coins_move_down.html

Speaker notes

The coins are more complex.

Step 1, we can create a Coin class. Derive from Arcade's Sprite class so we get all the functionality of a Sprite, and just add our own.

Skip down to step 4. Here we define an update() function to be called 60 times per second.

Part 5 moves the sprite down 1 pixel. So, 60 pixels per second. Change the one to a bigger number to go faster, or a smaller number to go slower.

Part 6 sees if the y-coordinate of the top of the sprite has gotten less than zero. If so, we reset the sprite to a random location at the top of the screen.

That causes us to jump up to part two, reset_pos

Here, in part 3 we respawn the coin in a random spot somewhere 20 to 100 pixels above the visible portion of the screen.

Moving Coins Down

```
# This code goes in the setup() method of our MyGame class

COIN_COUNT = 50
self.coin_list = arcade.SpriteList()

# Create the coins
for i in range(COIN_COUNT):

    # Create the coin instance
    coin = arcade.Sprite("images/coin_01.png")

    # Position the coin
    coin.center_x = random.randrange(SCREEN_WIDTH)
    coin.center_y = random.randrange(SCREEN_HEIGHT)

    # Add the coin to the lists
    self.coin_list.append(coin)
```

1

2

Coin

http://arcade.academy/examples/sprite_collect_coins.html

Speaker notes

Then, instead of creating an instance of Arcade's Sprite class, create an instance of our own class we just wrote.

Forgetting to do this is a frequent mistake with new programmers that I've observed.

Moving a Sprite

1
```
def update(self, delta_time):
    """ Movement and game logic """

    # Call update on all sprites (The sprites don't do much in this
    # example though.)
2   self.coin_sprite_list.update()

    # Generate a list of all sprites that collided with the player.
    hit_list = arcade.check_for_collision_with_list(self.player_spri
                                                    self.coin_sprite

    # Loop through each colliding sprite, remove it, and add to the
    for coin in hit_list:
        coin.kill()
        self.score += 1
```

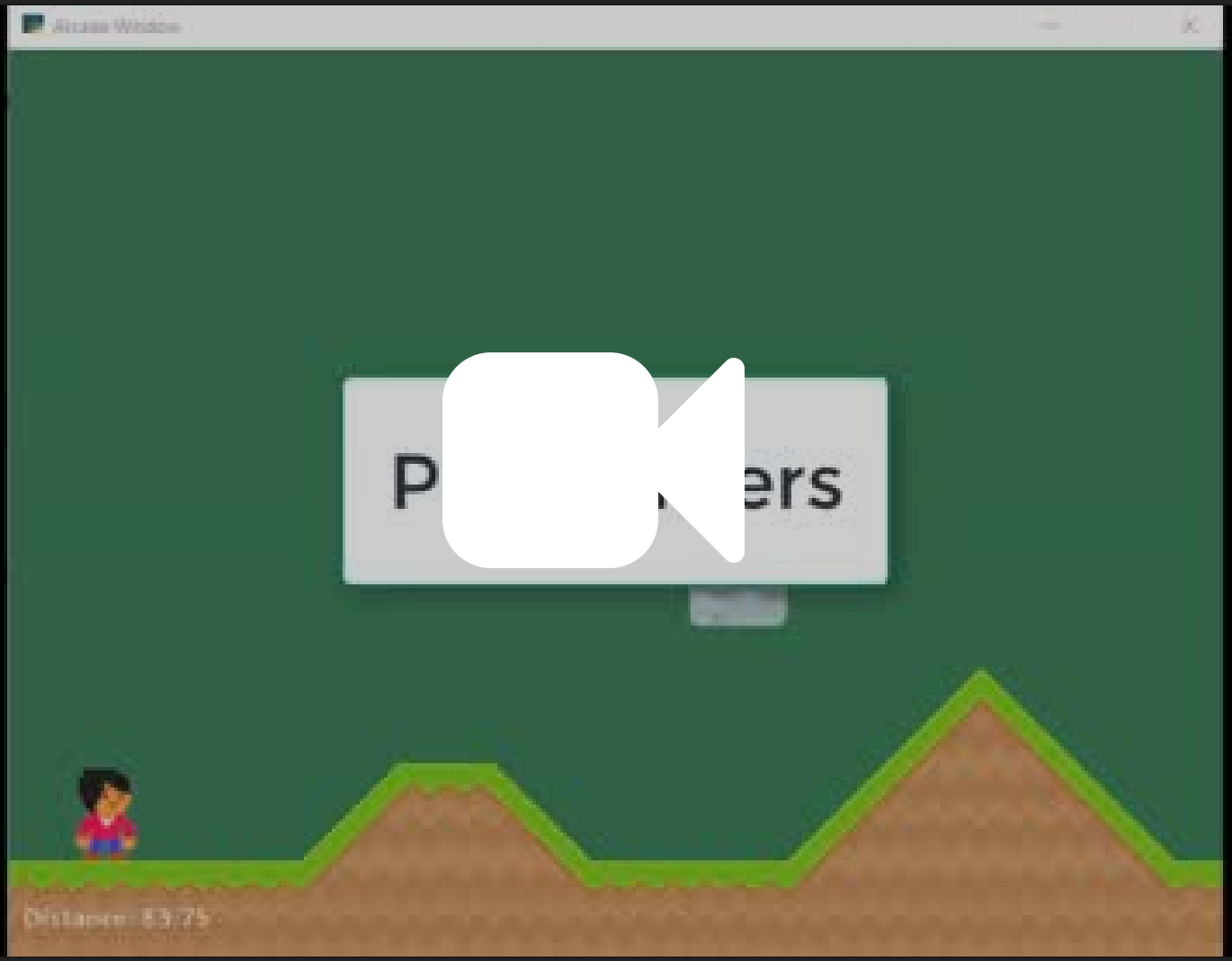
http://arcade.academy/examples/sprite_collect_coins_move_down.html

Speaker notes

The sprite still won't move though.

In the MyGame class we created, it also has an update method.

Go back to the that update method, and add the code at point 2.
Now when the window's update method is called, we call the update method on each sprite in that sprite list.


Arcade Window
ers
Distance: 83/75

Speaker notes

Here are some examples of what you can do.

We can easily create platformers with ramps and moving platforms.

You can add in the PyMunk library, which works great for 2D physics.

I had a student create a tower defense game.
This game has a lot of sprites, collisions, explosions, and other things going on.
Arcade keeps up with no problem.
The student had programmed some in high school, and this was his first college programming class. This game is pretty amazing.

You can have large maps. This is a procedurally generated dungeon with over 10,000 sprites making up the walls. We can go through it with no problem.

Learn By Example

Bullets

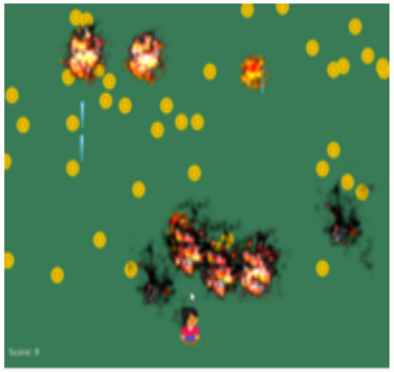
Shoot Bullets Upwards

Aim and Shoot Bullets

Have Enemies Periodically Shoot

Have Enemies Randomly Shoot

Have Enemies Aim at Player



Sprite Explosions

Speaker notes

One of the best ways to learn is not by textbook, but by example.

There are many examples showing how to do code common techniques.

I've taught students how to create games for ten years. Each time they say "How do you do this?" I create an example to show them. They are all here.

You can see example code on how to shoot upward and hit items, like in a space invaders game.

How to aim bullets with the mouse.

What if you want the enemies to shoot back? They can do so at regular intervals, or randomly. They can even aim at the player.

And what is a game without explosions? Learn how to add those.

Learn By Example

Platformers

Move with Walls

Place Coins Away From Walls And Other Coins

Move with a Scrolling Screen

Move with a Sprite Animation

Work with a tiled map

Ramps

Moving Platforms

Platformer With Enemies

Speaker notes

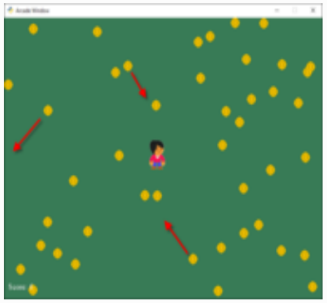
If you want an adventure, learn how to add walls the player can't move through.

How to add items randomly, but not on walls.
How to use a scrolling screen for a large world.
How to animate sprites
How to tile maps, add ramps, and moving platforms.
How do you get enemies to move around?

Learn By Example

Sprite Movement

Collect Coins Moving Down

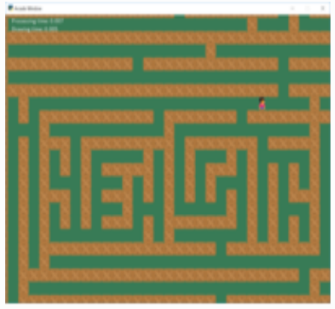


Collect Coins that are Bouncing

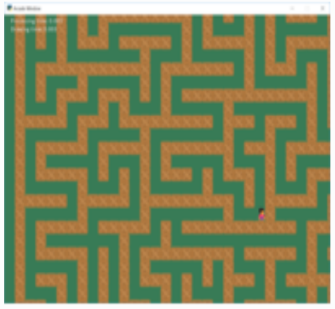
Collect Coins that are Moving in a Circle

Collect Rotating Coins

Procedural Generation



Creating a Recursive Maze



Creating a Depth First Maze

Procedural Caves - Cellular Automata

Procedural Caves - Binary Space Partitioning

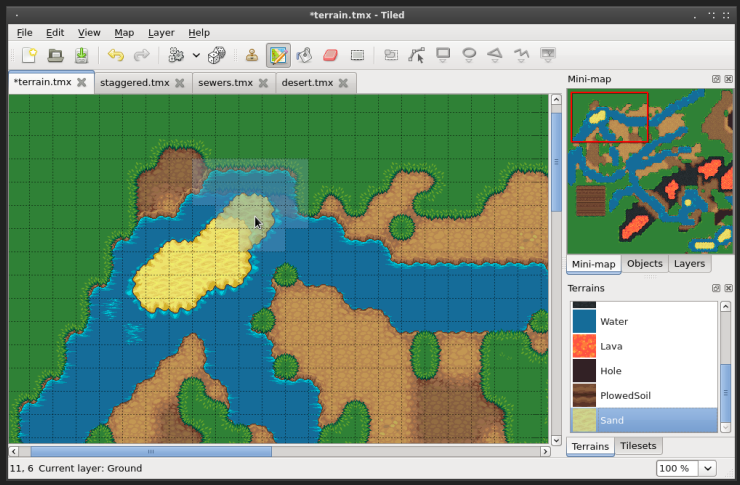
Speaker notes

Besides having sprites move down, how can you get them to:
Bounce around
Move in a circle
Rotate?

There are examples for creating random mazes, caves, and rooms.

What's Next?

- Immediate:
  - Isometric map examples and support
  - Better support for the Tiled Map Editor
- Soon:
  - Better decorator support
  - Particle support
  - Lighting / shader support



Speaker notes

What is up and coming with the Arcade library?

Soon we'll have examples showing how to use isometric tiles and maps.
Currently, support for the popular "Tile Map Editor" is limited. That's about to change. You'll easily be able to import maps created in Tiled.

Soon, we plan on adding better support for decorators, particles for effects, and support for lighting and shaders.

How Does It Compare To PyGame?

- Easier
- Arcade is based on OpenGL, PyGame SDL1
- Uses modern design, Python features like type hinting

Speaker notes

A question I often get is, how does this compare with PyGame?

1. It is easier. Now, I think PyGame is great. Arcade was inspired by PyGame. But after teaching with PyGame for about 10 years, one popular website, and one book, I had put together a lot of things on how I wished PyGame was better. And this is it.

2. SDL1 is an old, out of date, unsupported, cross-platform C++ library for graphics. OpenGL is a lot more powerful.

3. Using Python 3, type hinting, decorators, not having to manually program an event loop, Arcade is a better framework for programming, and learning to program

Want To Contribute?

- Use GitHub!
- Code and documentation open for pull requests.
- There's also an open-source book on learning to program with Arcade and Python.

Speaker notes

Do you want to contribute to an open source library?

We'd love to to have your contributions!

All the code is on GitHub. The documentation as well.

If you are new to pull requests, suggest documentation changes or grammar fixes to get some experiences.

There's also an open-source book on learning how to program with Arcade that is available. If you are teaching someone how to program, you are welcome to use parts out of it.

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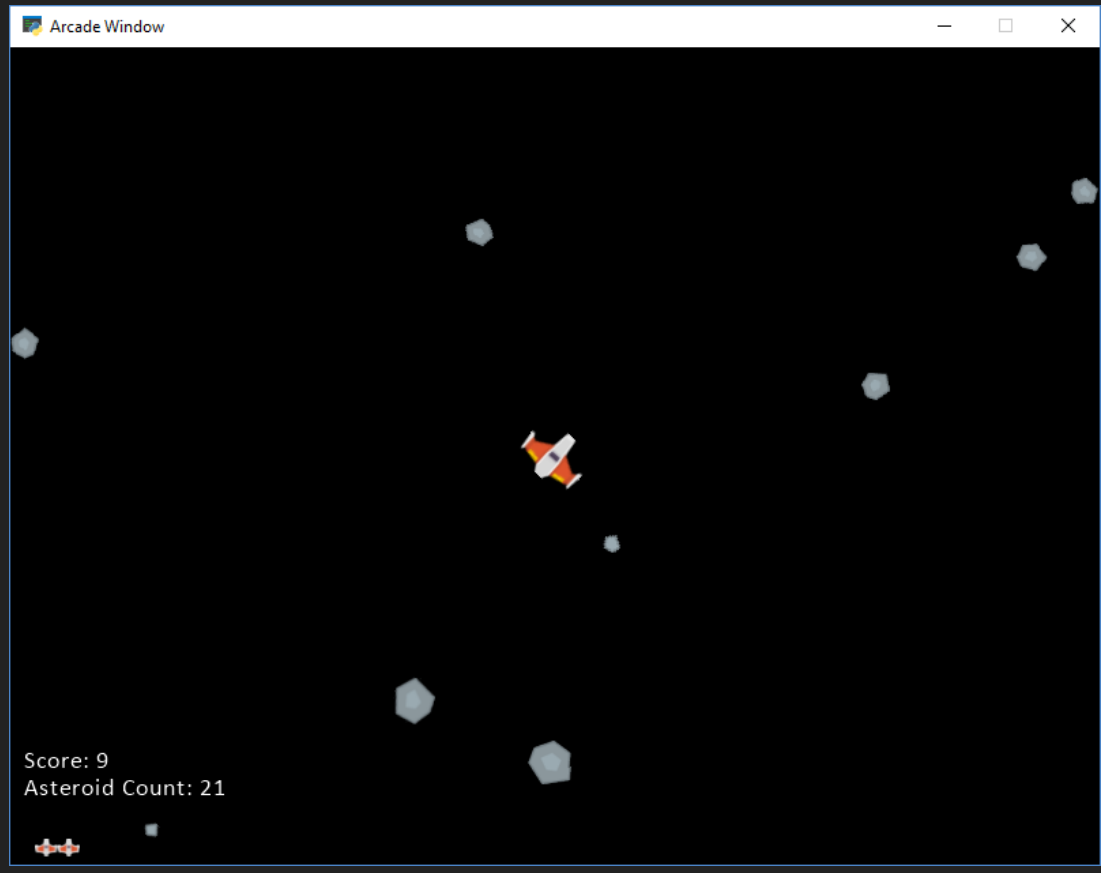
@professorcraven

Learn More:

http://arcade.academy

Support:

www.reddit.com://r/pythonarcade



Speaker notes

If you would like to talk more about creating 2D games with Python, talk to me after this presentation.

Give me a tweet, or shoot me an e-mail.

I like talking about almost anything Python related, and networking with other enthusiasts is the best part of this conference.