



THE SCHOOL OF ARTIFICIAL INTELLIGENCE

# AI Programming with Python

```
def update(self):  
    """ Determine  
    if self.left <  
        self.dx =  
    elif random.ro  
        self.dx = -  
  
    self.check_dro
```



NANODEGREE SYLLABUS

# Overview

## AI Programming with Python

In this program, you'll learn all the foundational skills necessary to start using AI techniques and develop your skills in programming, linear algebra, and neural networks. A graduate of this program will gain essential knowledge of:

- Programming tools Python, NumPy, PyTorch
- Calculus and linear algebra applications
- Key techniques of neural networks, including gradient descent and backpropagation

This program is comprised of four courses and four projects. Each project presents an opportunity to demonstrate mastery of lesson content.

### Program Information



#### TIME

3 months  
Study 10 hours/week



#### LEVEL

Foundational



#### PREREQUISITES

Basic calculus knowledge, including how to calculate derivatives. Basic algebra and programming knowledge will shorten the time to mastery.



#### HARDWARE/SOFTWARE REQUIRED

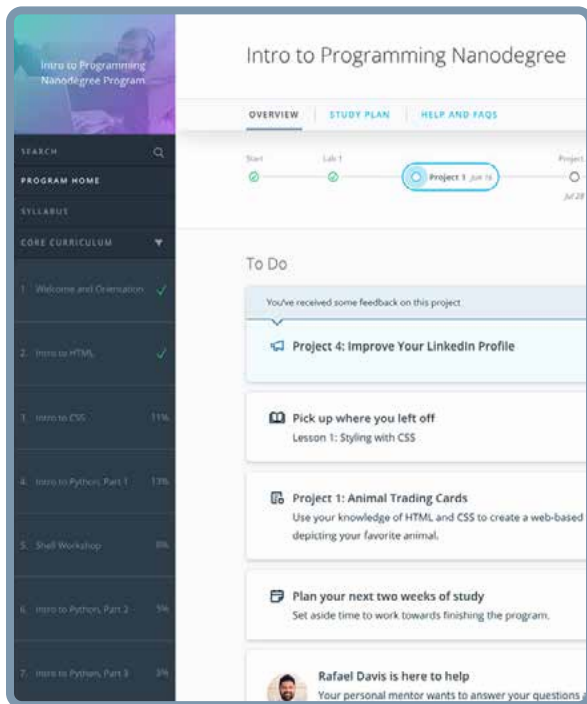
Computer running OS X or Windows



#### INTERESTED IN THIS NANODEGREE?

Contact us at  
[enterpriseNDs@udacity.com](mailto:enterpriseNDs@udacity.com).

# Our Classroom Experience



## REAL-WORLD PROJECTS

Learners build new skills through industry-relevant projects and receive personalized feedback from our network of 900+ project reviewers. Our simple user interface makes it easy to submit projects as often as needed and receive unlimited feedback.

## KNOWLEDGE

Answers to most questions can be found with Knowledge, our proprietary wiki. Learners can search questions asked by others and discover in real-time how to solve challenges.

## WORKSPACES

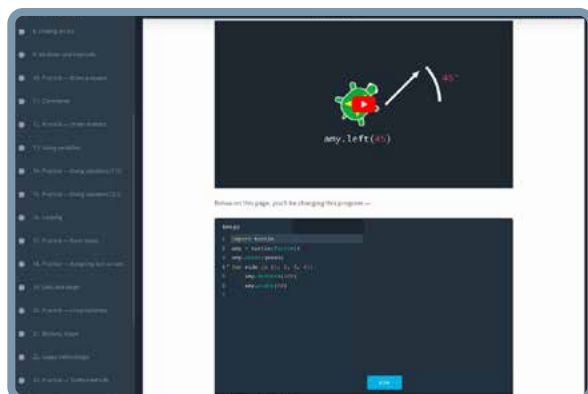
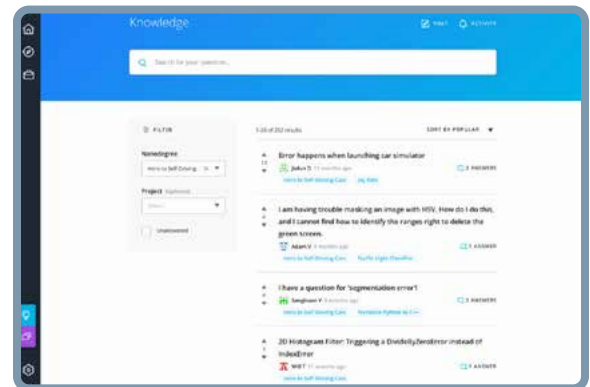
Learners can check the output and quality of their code by testing it on interactive workspaces that are integrated into the classroom.

## QUIZZES

Understanding concepts learned during lessons is made simple with auto-graded quizzes. Learners can easily go back and brush up on concepts at anytime during the course.

## CUSTOM STUDY PLANS

Create a custom study plan to suit your personal needs and use this plan to keep track of your progress toward your goal.



## PROGRESS TRACKER

Personalized milestone reminders help learners stay on track and focused as they work to complete their Nanodegree program.

# Learn with the Best



**Ortal Arel**

CURRICULUM LEAD

Ortal Arel holds a PhD in Computer Engineering, and has been a professor and researcher in the field of applied cryptography. She has worked on design and analysis of intelligent algorithms for high-speed custom digital architectures.



**Luis Serrano**

INSTRUCTOR

Luis was formerly a Machine Learning Engineer at Google. He holds a PhD in mathematics from the University of Michigan, and a Postdoctoral Fellowship at the University of Quebec at Montreal.



**Juan Delgado**

CONTENT DEVELOPER

Juan is a computational physicist with a Masters in Astronomy. He is finishing his PhD in Biophysics. He previously worked at NASA developing space instruments and writing software to analyze large amounts of scientific data using machine learning techniques.



**Mat Leonard**

INSTRUCTOR

Mat is a former physicist, research neuroscientist, and data scientist.

He completed his PhD and Postdoctoral Fellowship at the University of California, Berkeley.



**Mike Yi**

INSTRUCTOR

Mike is a Content Developer with a BS in Mathematics and Statistics. He received his PhD in Cognitive Science from the University of Irvine. Previously, he worked on Udacity's Data Analyst Nanodegree program as a support lead.



## Grant Sanderson

### INSTRUCTOR

Grant Sanderson is the creator of the YouTube channel 3Blue1Brown, which is devoted to teaching math visually, using a custom-built animation tool. He was previously a content creator for Khan Academy.



## Jennifer Staab

### INSTRUCTOR

Jennifer holds a PhD in Computer Science and a Master's in Biostatistics; she was a professor at Florida Polytechnic University. She previously worked at RTI International and United Therapeutics as a statistician and computer scientist.



## Juno Lee

### CONTENT DEVELOPER

As a data scientist at Looplist, Juno built neural networks to analyze and categorize product images, a recommendation system to personalize shopping experiences for each user, and tools to generate insight into user behavior.



## Andrew Paster

### INSTRUCTOR

Andrew has an engineering degree from Yale, and has used his data science skills to build a jewelry business from the ground up. He has additionally created courses for Udacity's Self-Driving Car Engineer Nanodegree program.

# Nanodegree Program Overview

## Course 1: Introduction to Python

Start coding with Python, drawing upon libraries and automation scripts to solve complex problems quickly.

### Project

### Use a Pre-trained Image Classifier to Identify Dog Breeds

In this project, you will be testing your newly-acquired Python coding skills by using a trained image classifier. You will need to use the trained neural network to classify images of dogs (by breeds) and compare the output with the known dog breed classification. You will have a chance to build your own functions, use command line arguments, test the runtime of the code, create a dictionary of lists, and more.

LESSON TITLE	LEARNING OUTCOME
WHY PYTHON?	<ul style="list-style-type: none"><li>• Learn why we program.</li><li>• Prepare for the course ahead with a detailed topic overview.</li><li>• Understand how programming in Python is unique.</li></ul>
DATA TYPES AND OPERATORS	<ul style="list-style-type: none"><li>• Understand how data types and operators are the building blocks for programming in Python.</li><li>• Use the following data types: integers, floats, booleans, strings, lists, tuples, sets, dictionaries.</li><li>• Use the following operators: arithmetic, assignment, comparison, logical, membership, identity.</li></ul>
CONTROL FLOW	<ul style="list-style-type: none"><li>• Implement decision-making in your code with conditionals.</li><li>• Repeat code with for and while loops.</li><li>• Exit a loop with break, and skip an iteration of a loop with continue.</li><li>• Use helpful built-in functions like zip and enumerate.</li><li>• Construct lists in a natural way with list comprehensions.</li></ul>
FUNCTIONS	<ul style="list-style-type: none"><li>• Write your own functions to encapsulate a series of commands.</li><li>• Understand variable scope, i.e., which parts of a program variables can be referenced from.</li><li>• Make functions easier to use with proper documentation.</li><li>• Use lambda expressions, iterators, and generators.</li></ul>



## Course 1: Introduction to Python, cont.

### SCRIPTING

- Write and run scripts locally on your computer.
- Work with raw input from users.
- Read and write files, handle errors, and import local scripts.
- Use modules from the Python standard library and from third-party libraries.
- Use online resources to help solve problems.

### CLASSES

- Object Oriented programming provides a few benefits over procedural programming. Learn the basics by understanding how to use Classes.

## Course 2: Anaconda, Jupyter Notebook, NumPy, Pandas, and Matplotlib

Learn how to use all the key tools for working with data in Python: Jupyter Notebooks, NumPy, Anaconda, Pandas, and Matplotlib.

LESSON TITLE	LEARNING OUTCOME
ANACONDA	<ul style="list-style-type: none"><li>• Learn how to use Anaconda to manage packages and environments for use with Python.</li></ul>
JUPYTER NOTEBOOKS	<ul style="list-style-type: none"><li>• Learn how to use Jupyter Notebooks to create documents combining code, text, images, and more.</li></ul>
NUMPY BASICS	<ul style="list-style-type: none"><li>• Learn the value of NumPy and how to use it to manipulate data for AI problems.</li><li>• Mini-Project: Use NumPy to mean normalize an darray and separate it into several smaller ndarrays.</li></ul>
PANDAS BASICS	<ul style="list-style-type: none"><li>• Learn to use Pandas to load and process data for machine learning problems.</li><li>• Mini-Project: Use Pandas to plot and get statistics from stock data.</li></ul>
MATPLOTLIB BASICS	<ul style="list-style-type: none"><li>• Learn how to use Matplotlib to choose appropriate plots for one and two variables based on the types of data you have.</li></ul>

# Nanodegree Program Overview

## Course 3: Linear Algebra Essentials

Learn the foundational math you need for AI success: vectors, linear transformations, and matrices — as well as the linear algebra behind neural networks.

LESSON TITLE	LEARNING OUTCOME
INTRODUCTION	<ul style="list-style-type: none"><li>• Learn the basics of the beautiful world of Linear Algebra and why it is such an important mathematical tool.</li></ul>
VECTORS	<ul style="list-style-type: none"><li>• Learn about the basic building block of Linear Algebra.</li></ul>
LINEAR COMBINATION	<ul style="list-style-type: none"><li>• Learn how to scale and add vectors and how to visualize them in 2 and 3 dimensions.</li></ul>
LINEAR TRANSFORMATION AND MATRICES	<ul style="list-style-type: none"><li>• Learn what a linear transformation is and how is it directly related to matrices. Learn how to apply the math and visualize the concept.</li></ul>
LINEAR ALGEBRA IN NEURAL NETWORKS	<ul style="list-style-type: none"><li>• Learn about the world of Neural Networks and see how it related directly to Linear Algebra.</li></ul>
LABS	<ul style="list-style-type: none"><li>• Vectors Lab – Learn how to graph 2D and 3D vectors.</li><li>• Linear Combination Lab – Learn how to computationally determine a vector's span and solve a simple system of equations.</li><li>• Linear Mapping Lab – Learn how to solve problems computationally using vectors and matrices.</li></ul>





## Course 4: Calculus Essentials

Learn the foundations of calculus to understand how to train a neural network: plotting, derivatives, the chain rule, and more. See how these mathematical skills visually come to life with a neural network example.

LESSON TITLE	LEARNING OUTCOME
INTRODUCTION	<ul style="list-style-type: none"><li>• Visualize the essence of calculus. Learn why it is such a powerful concept in mathematics.</li></ul>
DERIVATES THROUGH GEOMETRY	<ul style="list-style-type: none"><li>• Learn about the derivative, one of the most important tools in calculus.</li><li>• See how a derivative can measure the steepness of a function and why it is such an important indicator in the world of machine learning.</li></ul>
CHAIN RULE AND DOT PRODUCT	<ul style="list-style-type: none"><li>• Learn how to find the derivative of a composition of two or more functions, a very important tool in training a neural network.</li></ul>
MORE ON DERIVATIVES	<ul style="list-style-type: none"><li>• Learn more about derivatives while focusing on exponential and implicit functions.</li></ul>
LIMITS	<ul style="list-style-type: none"><li>• Learn about the formal definition of a derivative through understanding limits.</li></ul>
INTEGRATION	<ul style="list-style-type: none"><li>• Learn about the inverse of a derivative: the integral.</li></ul>
CALCULUS IN NEURAL NETWORKS	<ul style="list-style-type: none"><li>• Learn more about the world of neural networks and see how it relates directly to calculus through an explicit example.</li></ul>

# Nanodegree Program Overview

## Course 5: Neural Networks

Gain a solid foundation in the latest trends in AI: neural networks, deep learning, and PyTorch.

### Project

### Create your own Image Classifier

Successful software developers need to know how to incorporate deep learning models into everyday applications. Any device with a camera will be using image classification, object detection, and face recognition, all based on deep learning models. In this project you will implement an image classification application. This application will train a deep learning model on a dataset of images. It will then use the trained model to classify new images. First you will develop your code in a Jupyter notebook to ensure your training implementation works well. Then, you will convert your code into a Python application that you will run from the command line of your system.

#### LESSON TITLE

#### LEARNING OUTCOME

##### INTRODUCTION TO NEURAL NETWORKS

- Acquire a solid foundation in deep learning and neural networks.
- Implement gradient descent and backpropagation in Python.

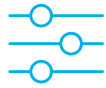
##### TRAINING NEURAL NETWORKS

- Learn about techniques for how to improve training of a neural network, such as: early stopping, regularization and dropout..

##### DEEP LEARNING WITH PYTORCH

- Learn how to use PyTorch for building deep learning models.

# All Our Nanodegree Programs Include:



## Industry Validation & Reviews

Learners' progress and subject knowledge is tested and validated by industry experts and leaders from our advisory board. These in-depth reviews ensure your teams have achieved competency.



## Real World Hands-on Projects

Through a series of rigorous, real-world projects, your employees learn and apply new techniques, analyze results, and produce actionable insights. Project portfolios demonstrate learners' growing proficiency and subject mastery.



## Pre-Assessments

Our in-depth workforce assessments identify your team's current level of knowledge in key areas. Results are used to generate custom learning paths designed to equip your workforce with the most applicable skill sets.



## Dashboard & Progress Reports

Our interactive dashboard (enterprise management console) allows administrators to manage employee onboarding, track course progress, perform bulk enrollments and more.

# Our Review Process

## Real-life Reviewers for Real-life Projects

Real-world projects are at the core of our Nanodegree programs because hands-on learning is the best way to master a new skill. Receiving relevant feedback from an industry expert is a critical part of that learning process, and infinitely more useful than that from peers or automated grading systems. Udacity has a network of over 900 experienced project reviewers who provide personalized and timely feedback to help all learners succeed.



Vaibhav

UDACITY LEARNER

*"I never felt overwhelmed while pursuing the Nanodegree program due to the valuable support of the reviewers, and now I am more confident in converting my ideas to reality."*

now at

CODING VISIONS INFOTECH

## All Learners Benefit From:



Line-by-line feedback for coding projects



Industry tips and best practices



Advice on additional resources to research



Unlimited submissions and feedback loops

## How it Works

Real-world projects are integrated within the classroom experience, making for a seamless review process flow.

- Go through the lessons and work on the projects that follow
- Get help from your technical mentor, if needed
- Submit your project work
- Receive personalized feedback from the reviewer
- If the submission is not satisfactory, resubmit your project
- Continue submitting and receiving feedback from the reviewer until you successfully complete your project

## About our Project Reviewers

Our expert project reviewers are evaluated against the highest standards and graded based on learners' progress. Here's how they measure up to ensure your success.

900+

### Expert Project Reviewers

Are hand-picked to provide detailed feedback on your project submissions.

1.8M

### Projects Reviewed

Our reviewers have extensive experience in guiding learners through their course projects.

3

### Hours Average Turnaround

You can resubmit your project on the same day for additional feedback.

4.85 / 5

### Average Reviewer Rating

Our learners love the quality of the feedback they receive from our experienced reviewers.



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