Livermore Valley Joint Unified School District

Course Title:	Geometry with Python
Grade Level(s):	9 - 10
Length of Course:	Two semesters or equivalent term
Credit:	10 units
Prerequisite:	Completed Algebra I with C or above
Co-requisite:	Geometry and Python programming

Course Overview:

This course introduces programming into a curriculum in line with the California State Standards for Mathematics for Geometry. Through the application of Python programming, students build upon their knowledge of mathematical concepts by analyzing real-life situations, interpreting given information, decomposing the operations into a defined step-by-step algorithm, checking the results for accuracy, and revising the program as necessary. As per the Geometry standards, topics covered include area and perimeter, parallel and perpendicular lines, transformations, congruent triangles, quadrilaterals and other polygons, similarity, right triangles and trigonometry, coordinate proofs, circles, circumference, area, volume, and probability. Industry and academic standard software will be used to reinforce and extend students' understanding of the areas of study listed above. Programming allows students to more easily visualize mathematical problems through software graphing and emphasizes an explicit understanding of the process over an implicit one by demanding from students a step-by-step process for finding a solution, instead of just the solution itself.

Schools Offering:	Del Valle High School Granada High School Livermore High School Vineyard High School
Meets University of California Entrance Requirements:	Seeking C approval
Board Approval:	Pending Board Approval
Course Materials:	Big Ideas Math Geometry Larson, Ron; Website: www.bigideasmath.com

Python 3 for Absolute Beginners
Tim Hall
901 Grayson Street Suite 204 Berkeley, CA States
ISBN:978-1-4302-1632-2

Supplemental Materials:

Khan Academy
Website: https://www.khanacademy.com
Desmos
Website: https://www.desmos.com/
Kuta Software
Website: https://www.kutasoftware.com/
Ed Puzzle
Website: https://edpuzz1e.com/
Python development environment: Jupiter Lab application
Webiste: https://www.bigideasmath.com

COURSE TITLE

COURSE CONTENT:

Unit 1: Basics of Geometry

In this unit, students will be able to identify and name points, lines, segments, rays, planes, and angles, and angle relationships. They will learn basic geometric formulas such as the midpoint and distance formulas and apply them to solve given problems. Students will write a program using Python language to calculate midpoint and distance and use it to solve given problems. Students will also use basic geometric postulates, theorems, and definitions, such as the segment addition postulate, the linear pair theorem, and the definition of midpoint, to generate equations to solve for missing values. They will learn how to construct geometric concepts such as congruent angles and bisectors of angles.

Summary of Key Assignments and/or Activities

Students will solve key assignments that include a variety of explorations, skills practice, and/or real-life, problem-based activities. Sample assignments may include solving algebraic equations involving variables on both sides of the equation, and adding equations setting them equal to a constant. Students will use/apply midpoint formula, Pythagorean Theorem, distance formula, area, and perimeter formulas for basic geometric figures. Students will master vocabulary specific to geometry. Students will write computer programs to solve these assignments.

Unit 2: Reasoning and Proofs

Students will go in depth in logical reasoning. They will learn how to structure conditional statements and bi-conditional statements and determine the validity of given statements. They will also utilize inductive reasoning to determine patterns when given a sequence as well as apply laws of deductive reasoning to create conjectures about given situations. Students will also learn how to structure algebraic and geometric proofs using a two-column table, a flowchart, and in a written paragraph. Students will apply conditional statements in computer programs and solve a variety of real life problems where computer programs make conditional decisions.

Summary of Key Assignments and/or Activities

Students will solve assignments, which include a variety of explorations, skill practice, and/or real-life, problem-based activities. An example of an assignment from this unit is students will read, write, and interpret conditional and bi-conditional statements and change conditional statements into their converses, inverses, and contrapositive statements. The basics of algebraic and geometric proofs will be practiced with the students being introduced to the structure of two-column, flowchart, and paragraph proofs. Students will write computer programs with conditional statements where programs solve problems based on input values.

Unit 3: Parallel and Perpendicular Lines

Students will revisit how to determine if lines are parallel, perpendicular, or neither, as well as write equations of lines. They will also be able to identify angle pair relationships given parallel lines and transversals and the corresponding theorems and postulates to create equations to solve for missing values. Students will also utilize those theorems and postulates to write geometric proofs involving parallel and perpendicular lines. Students will learn constructions related to the unit such as the construction of a perpendicular line through a point. Students will write computer programs to solve these problems.

Summary of Key Assignments and/or Activities
Students will solve assignments with a variety of explorations, skill practice, and/or real-life, problem-based activities. A sample of an assignment for this unit is that students will apply slope formula, distance formula, and midpoint formula to determine if lines are parallel or perpendicular. Constructions will be used to bisect angles and segments, and create perpendicular and parallel lines. Students will write computer programs to determine if lines are parallel, perpendicular, or neither.

Unit 4: Transformations
Students will identify translations, reflections, rotations, and dilations and use given transformation rules to generate graphs of single transformations and composite transformations. They will also be able to write a transformation rule based on existing graphs. Students will learn how to prove figures are congruent using transformations and will also learn how to prove figures are similar using dilations. Students will also create constructions related to the unit, such as dilations, given a scale factor and a center of dilation.

Summary of Key Assignments and/or Activities
Students will solve assignments that can include a variety of explorations, skill practice, and/or real life problem-based activities. Sample assignments for this unit may include problems where coordinate geometry will be used to identify and graph translations, reflections, rotations, and dilations. The basics of vector geometry will be practiced to solve real world situations with computer programming.

Unit 5: Congruent Triangles
Students will learn and apply basic theorems involving triangles such as the triangle angle sum theorem and the exterior angle theorem to solve for missing angle values in triangles. Students will learn how to prove triangles are congruent to each other using the definition of congruence as well as theorems and postulates such as the side-side-side congruence theorem. They will then be able to write geometric proofs in any format to prove given triangles and corresponding parts of congruent triangles are congruent. Students will also learn how to write coordinate proofs involving congruent triangles using coordinate geometry concepts such as the distance formula and the slope formula.

Summary of Key Assignments and/or Activities
Students will solve assignments that include a variety of explorations, skill practice, and/or real-life, problem-based activities. Sample assignments may include writing geometric proofs using one of the five theorems on triangle congruence. Algebraic equations will be used with the triangle sum theorem and the exterior angle theorem. Students will write computer programs to solve assignments.

Unit 6: Relationships Within Triangles
Students will be able to identify points of concurrency such as the circumcenter and the incenter. Students will be able to apply theorems involving bisectors of triangles, points of concurrency, and mid-segments of triangles to solve problems. They will also be able to use theorems involving inequalities in one and two triangles to write proofs and solve problems. Students will also revisit the Pythagorean Theorem, as well as learn to use relationships in special right triangles to solve for missing values in right triangles.

Summary of Key Assignments and/or Activities
Students will solve assignments with a variety of explorations, skill practice, and/or real-life, problem-based activities. Examples of activities for this unit may include constructions to create

circumcenter, incenter, centroids, and orthocenters. Students will use algebraic functions to determine the four points of concurrency. The students will use the midpoint formula, slope formula, distance formula, Pythagorean Theorem, and coordinate geometry. Students will write computer programs to solve these problems.

Unit 7: Quadrilaterals and Other Polygons
Students will learn and apply basic theorems involving polygons like the polygon angle sum theorem to solve for missing angles and values in polygons. They will also be able to identify if quadrilaterals are parallelograms, rectangles, rhombuses, kites, trapezoids, or squares and use the properties of the different quadrilaterals to solve problems. Students will also write geometric and coordinate proofs to prove quadrilaterals are a specific type, such as proving a quadrilateral is a parallelogram.

Summary of Key Assignments and/or Activities
Students will solve assignments with a variety of explorations, skill practice, and/or real-life, problem-based activities. Some examples of assignments may include using the midpoint, slope, and distance formulas with the definitions of various quadrilaterals to write geometric and coordinate proofs to prove a quadrilateral is a specific parallelogram. They will use computer programs to solve midpoint and distance formulas.

Unit 8: Similarity
Students will prove figures are similar using the definition of similarity and also be able to prove triangles are similar using theorems and postulates like the side-angle-side similarity theorem. They will also be able to use proportions to solve for unknown lengths in problems based on the proportional relationships of the sides of similar figures. Students will also recognize and apply proportional relationships in similar triangles to solve problems.

Summary of Key Assignments and/or Activities
Students will solve assignments with a variety of explorations, skill practice, and/or real-life problem-based activities. This unit may include activities where students will practice two-column proofs, paragraph proofs, and algebraic proofs to show geometric figures are similar. Ratios and proportions will be used extensively to prove figures are similar.

Unit 9: Right Triangles and Trigonometry
Students will learn how to set up and use basic trigonometric functions, sine, cosine, and tangent, to solve for missing angles and side lengths of right triangles. They will also be able to apply the Law of Sines and Law of Cosines to solve for missing side lengths and angles of triangles that are not right triangles. Students will also be able to work with vectors and be able to draw a vector on a coordinate plane, calculate magnitude of a vector, and calculate direction of a vector.

Summary of Key Assignments and/or Activities
Students will solve assignments with a variety of explorations, skill practice, and/or real-life, problem-based activities. This unit may include activities where students must learn how to correctly operate their calculators in order to use the trigonometric functions and write programs to solve specific assignments applying Laws of Sines and Cosines. Students will apply the trigonometric functions to word problems involving real world situations and will apply vectoring to physics problems.

Unit 10: Circles
Students will use segment and angle relationships in circles to solve for missing values. They will also be able to use theorems involving segments and angles in circles to prove relationships in circles. Students will also be able to use right triangles formed by lines intersecting circles to solve for missing values. They will apply formulas for arc length and sector area to calculate those values in given circles. Students will create constructions related to circles, such as tangent lines to a given circle, as well as write equations of circles and graph circles on the coordinate plane. This unit will also include deriving the equation of a parabola given a focus and directrix.

Summary of Key Assignments and/or Activities
Students will solve assignments with a variety of explorations, skill practice, and/or real-life, problem-based activities. Some assignments can include problem sets to practice key concepts from the unit including problems involving right triangles which requires students connect previous content to the current unit. They will write geometric proofs to prove relationships in circles to demonstrate their knowledge of relationships of angles and segments within circles. They will write computer programs to solve problems.

Unit 11: Circumference, Area, and Volume
Students will calculate perimeter and circumference of various shapes, such as circles, rectangles, rhombuses, and regular polygons. Students will be able to apply area formulas to a variety of shapes as well as be able to find any missing information necessary to apply area formulas to given shapes, specifically with regular polygons. They will also be able to find the composite area of irregular shapes both by using formulas and by estimating on a grid. Students will learn how changing dimensions of shapes proportionally affect perimeter and area.

Summary of Key Assignments and/or Activities
Students will solve assignments with a variety of explorations, skill practice, and/or real life, problem-based activities. Examples of activities from this unit may include problem sets where students must apply the correct area formula to the given shape. Students may also complete an error analysis assignment where they must determine the error in the existing work and show the correct solution using the correct formulas and methods. They will write computer programs to solve problems.

Unit 12: Probability
Students will create sample spaces and create two-way frequency tables to calculate probability of events. They will also determine if events are independent or dependent and calculate their corresponding probabilities. Students will calculate conditional probability given a situation or a frequency table as well as calculate compound probability of both overlapping and disjoint events. Students will also be able to calculate geometric probability using areas of different shapes.

Summary of Key Assignments and/or Activities
Students will solve assignments which include a variety of explorations, skill practice, and/or real-life, problem-based activities. Some sample activities may include students using Venn diagrams and logic to determine if events are dependent or independent of one another. They will create fractions and use them to calculate probabilities. Students will write computer programs implementing lists to solve a variety of probability problems.

Provide the complete document title, section header, and exact verbiage of the standards addressed in the course

1. HSG-C.A.1 Prove that all circles are similar.
2. HSG-C.A.2 Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.
3. HSG-C.A.3 Construct the inscribed and circumscribed circles of a triangle, and prove properties of angles for a quadrilateral inscribed in a circle.
4. HSG-C.A.4 Construct a tangent line from a point outside a given circle to the circle.
5. HSG-C.B.5 Derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius, and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector. Convert between degrees and radians.
6. HSG-CO.A.1 Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.
7. HSG-CO.A.2 Represent transformations in the plane using, e.g., transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch).
8. HSG-CO.A.3 Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.
9. HSG-CO.A.4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.
10. HSG-CO.A.5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.
11. HSG-CO.B.6 Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.
12. HSG-CO.B.7 Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if, and only if, corresponding pairs of sides and corresponding pairs of angles are congruent.
13. HSG-CO.B.8 Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions.
14. HSG-CO.C.10 Prove theorems about triangles. Theorems include: measures of interior angles of a triangle sum to 180°; base angles of isosceles triangles are congruent; the segment joining midpoints of two sides of a triangle is parallel to the third side and half the length; the medians of a triangle meet at a point.
15. HSG-CO.C.11 Prove theorems about parallelograms. Theorems include: opposite sides are congruent, opposite angles are congruent, the diagonals of a parallelogram bisect each other, and conversely, rectangles are parallelograms with congruent diagonals.

16. HSG-CO.C.9 Prove theorems about lines and angles. Theorems include: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints.
17. HSG-CO.D.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.
18. HSG-CO.D.13 Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.
19. HSG-GMD.A.1 Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments.
20. HSG-GMD.A.3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.
21. HSG-GMD.B.4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
22. HSG-GPE.A.1 Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation.
23. HSG-GPE.B.4 Use coordinates to prove simple geometric theorems algebraically. For example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle; prove or disprove that the point $(1, \sqrt{3})$ lies on the circle centered at the origin and containing the point (0, 2).
24. HSG-GPE.B.5 Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).
25. HSG-GPE.B.6 Find the point on a directed line segment between two given points that partitions the segment in a given ratio.
26. HSG-GPE.B.7 Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.
27. HSG-MG.A.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
28. HSG-MG.A.2 Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
29. HSG-MG.A.3 Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).
30. HSG-SRT.A.1a Verify experimentally the properties of dilations given by a center and a scale factor: a. A dilation takes a line not passing through the center of the dilation to a parallel line, and leaves a line passing through the center unchanged.
31. HSG-SRT.A.1b The dilation of a line segment is longer or shorter in the ratio given by the scale factor.

32. HSG-SRT.A.2 Given two figures, use the definition of similarity in terms of similarity transformations to decide if they are similar; explain using similarity transformations the meaning of similarity for triangles as the equality of all corresponding pairs of angles and the proportionality of all corresponding pairs of sides.
33. HSG-SRT.A.3 Use the properties of similarity transformations to establish the Angle-Angle (AA) criterion for two triangles to be similar.
34. HSG-SRT.B.4 Prove theorems about triangles. Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely; the Pythagorean Theorem proved using triangle similarity.
35. HSG-SRT.B.5 Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.
36. HSG-SRT.C.6 Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.
37. HSG-SRT.C.7 Explain and use the relationship between the sine and cosine of complementary angles.
38. HSG-SRT.C.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.
39. HSG-SRT.D.10 Prove the Laws of Sines and Cosines and use them to solve problems
40. HSG-SRT.D.11 Understand and apply the Law of Sines and the Law of Cosines to find unknown measurements in right and non-right triangles (e.g., surveying problems, resultant forces).
41. HSG-SRT.D.9 Derive the formula A = 1/2 ab sin(C) for the area of a triangle by drawing an auxiliary line from a vertex perpendicular to the opposite side.
42. HSS-CP.A.1 Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events (“or,” “and,” “not”).
43. HSS-CP.A.2 Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities, and use this characterization to determine if they are independent.
44. HSS-CP.A.3 Understand the conditional probability of A given B as P(A and B)/P(B), and interpret independence of A and B as saying that the conditional probability of A given B is the same as the probability of A, and the conditional probability of B given A is the same as the probability of B.
45. HSS-CP.A.4 Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities. For example, collect data from a random sample of students in your school on their favorite subject among math, science, and English. Estimate the probability that a randomly selected student from your school will favor science given that the student is in tenth grade. Do the same for other subjects and compare the results.
46. HSS-CP.A.5 Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations.
47. HSS-CP.B.6 Find the conditional probability of A given B as the fraction of B’s outcomes that also belong to A, and interpret the answer in terms of the model.

48. HSS-CP.B.7 Apply the Addition Rule, P(A or B) = P(A) + P(B) – P(A and B), and interpret the answer in terms of the model.
49. HSS-CP.B.8 Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A)P(B|A) = P(B)P(A|B), and interpret the answer in terms of the model.
50. HSS-CP.B.9 Use permutations and combinations to compute probabilities of compound events and solve problems.

Instructional Methods and/or Strategies
Students will learn content through a variety of methods, such as direct instruction in the form of in-class lectures and discussions, online sites and activities, or content videos. Students may be expected to take notes to use as reference with their work. Students may also complete practice problems on the class content as individuals, in partners, or in groups to tackle in-depth problems that will challenge their critical thinking skills. Explaining mathematical understanding may occur in discussions, presentations, and written work of tasks that can include demonstrating understanding of procedures and concepts, as well as misconceptions. Students will learn by writing a variety of computer programs.

Assessment Methods and/or Tools
Students will be assessed in a variety of ways that include both formative and summative assessment types. Formative assessments include students completing problems in class, participating in class discussions, verbally answering questions, as well as homework. Formative assessments are used to assess daily learning and provide opportunities for students to demonstrate knowledge through verbal explanations and written work. Other assessments include group projects and group assessments. These are used to support students in demonstrating their knowledge of the content as well as learning to communicate, collaborate, and think critically in a group or with a partner. Groups may be asked to present information both in written explanation and oral presentations. Summative assessments require that students will demonstrate their individual knowledge of the course material over time and include quizzes, unit assessments and finals. This supports students in being responsible for understanding and retaining the course content.

Summative Assessments
Students will be assessed in a variety of ways:

- Daily problem solving (class work and board presentation work).
- Written quizzes and exams (comprehensive by unit and overall subject).
- Written computer programs in Python language to simulate lesson topic.
- Daily class work and regular formal assessments enforce lessons learned daily and previously, as well as consistent responsibility required of college-preparatory mathematics courses.
- Programming Challenges will be used as a key method to assess critical thinking skills and
- connections that the student makes to geometry problems.
- Assignment rubrics-specific, formalized rubrics for assignments are reviewed to enhance learning and understanding of expectations, and to support feedback given to students to enhance learning and understanding.

Example:

- Students will write computer programs in Python language to simulate the congruence of triangles, or draw the parallel and perpendicular line to the given one.

- Students will have to develop mathematical model and write a program for general polygon to solve for missing parameters.
- Students will write programs to solve trigonometry problems using Python programming language and present their applications to their classmates.
- Students will discuss particular solutions and exchange their experiences to improve application.

Assessment Criteria
Grading will follow district recommendations.

A+ > 99%
93% < A < 99%
90% < A- < 92%
87% < B+ < 89%
83% < B < 86%
80% < B- < 82%
77% < C+ < 79%
73% < C < 76%
70% < C- < 72%
67% < D+ < 69%
63% < D < 66%
60% < D- < 62%
F < 59%