Standard Benchmarks and Values:

Mathematics Common Core State Standards (CCSS):

• 4.G.A.2: Classify two-dimensional figures based on the presence or absence of parallel or perpendicular lines, or the presence or absence of angles of a specified size. Recognize right triangles as a category, and identify right triangles.

Hawai‘i Content & Performance Standards (HCPS) III:

• MA.4.5.1: Classify different types of triangles and quadrilaterals according to their properties and identify the properties that define the classifications.

• MA.4.5.2: Describe lines in the plane (i.e., parallel, perpendicular, intersecting).

Nā Honua Mauli Ola (NHMO) Cultural Pathways:

• ‘Ike Pilina (Relationship Pathway): Nurturing respectful and responsible relationships that connect us to akua, ʻāina and each other through the sharing of history, genealogy, language and culture.

• ‘Ike Na‘auao (Intellectual Pathway): Fostering lifelong learning, curiosity and inquiry to nurture an innate desire to share knowledge and wisdom with others.
Enduring Understandings:

- Mathematics has more than one form and is derived from all corners of the world. Civilizations have been using mathematics to grow, prosper, and build (e.g., architecture), even before mathematics was called “mathematics.”
- Mathematics is already a part of the natural, social, cultural, and imaginary environments in which we live.

Background/Historical Context:

Architecture Styles

- **Antiquity:** The earliest architecture in Hawai‘i dates back to its period of initial settlement by Polynesian voyagers during the 1100s. Hawaiians constructed loko i‘a (fishponds), ‘auwai (irrigation systems for lo‘i or taro patches), heiau (sacred platforms), and other large structures primarily using stones and required the efforts of the whole community. For protection against rough weather or for storage, smaller hale (houses) were constructed with a wooden framwork, thatching material (e.g. pili grass, banana trunk fiber, and pandanus, ti, and sugar cane leaves), and lashing made of braided ‘uki’uki grass, coconut husk fiber, or ‘ie‘ie leaves. Examples of such stone and natural fiber structures are modernly-constructed hale kia‘i upon the kuapā (enclosing wall) of He‘eia Fishpond on O‘ahu.

- **Mission:** With the arrival of New England missionaries in the 1820s, frame houses with high-pitched roofs and brick churches were built, though using locally available materials (e.g., ‘ōhi‘a lehua trees, coral blocks with burnt coral as mortar). The Mission Houses Museum is a well-preserved example of the early wood frame houses, and Kawaiaha‘o Church is not only O‘ahu’s oldest (dedicated in 1842) and largest church but is also one of Hawai‘i’s oldest coral block structures.

- **Gothic:** The Cathedral Church of Saint Andrew (http://cathedralofsaintandrew.org/), whose construction was initiated by Kamehameha IV but completed under his brother Kamehameha V in 1867, was the first use of “vaulting” in Hawai‘i, the better to show off its stained glass windows. Other notable examples include the Royal Mausoleum and the Aloha Tower.

- **Hawaiian Renaissance:** “Renaissance” derives from the Italian word for “rebirth,” and in Hawai‘i, traditional Roman architectural principles of aesthetics (paired with Hawaiian motifs) were given new life by Kamehameha V when he commissioned Ali‘ilani Hale in 1850, but the most famous example of Hawaiian renaissance architecture is ‘Iolani Palace, which was completed in 1882 under King Kalākaua and rivals the royal palaces of Europe.

- **Romanesque:** Having gained popularity during the last years of the Hawaiian monarchy and Hawai‘i’s earliest years as a U.S. territory (i.e., late 19th century), Hawaiian Romanesque architecture is reminiscent of European styles of the 11th and 12th centuries but with a local innovation – the usage of dark basalt boulders. The Bernice Pauahi Bishop Museum is among the most notable examples of this style.

- **Plantation:** This style gets its name from the sugarcane and pineapple plantations that employed the design for residential homesteads for laborers (circa 1850 to 1950) and was later revived in the 1990s in a contemporary manner.
Art Deco and Beaux-Arts: Introduced to Hawai‘i during the 1920s and 1930s, Art Deco and Beaux-Arts architecture combine classic (e.g., ancient Greek and Roman in particular for the latter) with modern styles while also incorporating Hawaiian and tropical motifs. The Hawai‘i Theatre famously exhibits Art Deco architecture, while the Waikiki War Memorial Natatorium showcases Beaux-Arts style.

International: The American form of Bauhaus architecture (which was popularized in the 1960s) is called “international” and became trendy among architects of downtown Honolulu office buildings, most notably the Hawai‘i State Capitol building.

Skyscrapers only recently became part of the skyline (and only in downtown Honolulu, for the most part), starting with the First Hawaiian Center, whose design attempts to incorporate as much natural light into the building’s interior as possible.

Authentic Performance Task:

Recognize geometric concepts and use geometric terms to describe Hawaiian architectural designs.

Build a model of an example of Hawaiian architecture using food.

Authentic Audience:

School community (e.g., other students, administration, art teachers) and family members.

Learning Plan:

- Show a PowerPoint or slideshow of different examples of architecture from within your immediate community as well as famous examples from throughout Hawai‘i. Have students try to identify each one. After the students have made their guesses, provide them with each structure’s name, historical context, and significance.

- Review the names and properties of different angles:
a. An **acute** angle has a measure between 0 and 90 degrees;
b. A **right** angle has a measure of exactly 90 degrees;
c. An **obtuse** angle has a measure between 90 and 180 degrees;
d. A **straight** angle has a measure of exactly 180 degrees; and
e. A **reflex** angle has a measure between 180 and 360 degrees.

- Introduce (and/or review) the definitions of the following geometric terms and concepts:
  - 2 lines **intersect** when they cross each other within a plane. When 2 lines intersect to form right (90-degree) angles, they are **perpendicular** to each other. When 2 lines do not intersect at any point, they are **parallel** to each other.
  - A **polygon** is a shape with 3 or more sides. In a **regular** polygon, all of the sides have the same length, and all of the interior angles have the same measure, whereas an **irregular** polygon has sides of different lengths and interior angles of different measures.
  - A **triangle** is a polygon with exactly 3 sides (and 3 interior angles), and the sum of the measures of its interior angles is exactly 180 degrees. An **acute** triangle has exactly 3 acute interior angles. An **obtuse** triangle has 1 obtuse interior angle and 2 acute interior angles. An **isosceles** triangle has 2 sides of the same length (and 2 interior angles of the same measure). An **equilateral** triangle has all sides of the same length (and all angles of the same measure). A right triangle has 1 right angle (and 2 acute angles).
  - A **quadrilateral** is a polygon with exactly 4 sides (and 4 interior angles), and the sum of the measures of its interior angles is 360 degrees. A **square** has 4 equal sides and 4 equal interior angles (that each measure 90 degrees). A **rhombus** has 4 equal sides, but its angles may not necessarily be equal to each other. A **rectangle** has 4 equal angles, but its sides may not necessarily be equal to each other. A **parallelogram** may have sides and angles of different sizes, but both pairs of its opposite sides are parallel to each other. A **trapezoid** has only 1 pair of its opposite sides parallel to each other.

- Distribute pictures of previously shown local and famous examples of architecture in Hawai‘i. Have students identify and trace examples of the different aforementioned geometric terms and concepts within each example of local architecture. Ask the following:
  a. Where do lines appear to intersect? If they do intersect, are they also perpendicular? If they do not appear to intersect, are they parallel? In either case, how can you tell?
  b. What kind(s) of triangles are there? Are they regular or irregular? How can you tell?
  c. What kind(s) of quadrilaterals are there? Are they regular or irregular? How can you tell?

Then, have the students share their findings and explanations with the rest of the class.
**Extension activities:**

a. **On-campus field trip:** Tour your school’s campus. Have students sketch, identify, and trace examples of the highlighted geometric terms and concepts.

b. **Off-campus fieldtrip:** Visit a historic building or structure as a class (or have students visit with their families outside of class). Students will again be tasked with sketching, identifying, and tracing examples of geometric terms and concepts.

c. **Building a model:** Have students reconstruct a small-scale model of a well-known local (or statewide) example of historic Hawaiian architecture using different foods and identifying the various geometric concepts within its design.

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<td>MA.4.5.1 Classify different types of triangles and quadrilaterals according to their properties and identify the properties that define the classifications.</td>
<td>- Identifying and classifying two dimensional shapes.</td>
<td>- Logic</td>
<td>- Accurate representation of key concepts using sketches, verbal descriptions, and visual models.</td>
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<td>- Describing and illustrating different lines present in the two-dimensional shapes.</td>
<td>-Parallel vs. intersecting (e.g., perpendicular) lines.</td>
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<td>- Classifying two-dimensional shapes based on the relationships between their lines and the relatives sizes of their angles.</td>
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**References:**

