Lesson Title	Staircases and Slopes
Length of Lesson	2 50-minute lessons
Created By	Sean Owens
Subject	Mathematics, Algebra, Geometry
Grade Level	10^{th} – 12^{th}
State Standards	9^{th} - 12^{th} Transition to Algebra: 2 g; 4 b Geometry: 1 c; 2 a
DOK Level	DOK 1 – Transition to Algebra DOK 2 – Transition to Algebra, Geometry DOK 3 – Geometry
DOK Application	1 – Illustrate, Calculate, Draw, Measure 2 – Graph, Construct, Estimate 3 – Construct, Assess, Critique, Use concepts to solve non-routine problems
National Standards	9-12: B: Geometry C: Measurement
Graduate Research Element	This lesson focuses on the concept of slope. I use slopes in my research to perform minimization operations on power, weight and size costs of different system implementations.

Student Learning Goal:
After performing this lesson, students will be able to apply the concept of slope to different real-world applications including construction.

This lesson will address Mississippi 9-12 Mathematics standards: Transition to Algebra 2g and 4b and Geometry 1c and 2a. It will also address National 9-12 Mathematics standards B and C by giving the students the opportunity to design and construct a staircase that meets National Building Code (NBC).

State Standards: 9^{th} – 12^{th} Mathematics

Transition to Algebra – 2g: Identify domain, range, slope, and intercepts of functions.

Transition to Algebra – 4b: Explain and apply the appropriate formula to determine length, midpoint, and slope of a segment in a coordinate plane.

Geometry – 1c: Solve real-world or application problems that involve square roots and the Pythagorean Theorem.

Geometry – 2a: Represent data from geometric and real-world contexts with expressions, formulas, tables, charts, graphs, relations, and functions.

National Standards: 9^{th} – 12^{th} Mathematics

B (Geometry):

- Specify locations and describe spatial relationships using coordinate geometry and other representational systems.

- Use visualization, spatial reasoning, and geometric modeling to solve problems.

C (Measurement):

- Understand measureable attributes of objects and the units, systems, and process of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.

Materials Needed (supplies, hand-outs, resources):

- Day 1
  - Graph Paper
  - Rulers (1 per student)
- Day 2
  - Balsa wood (2-3 pieces per team) (Alternative in teacher's notes)
  - Cutting tools (1 per team)
  - Glue

Lesson Performance Task/Assessment:

Students will design and construct a scale model of a staircase that meets design and building code requirements. They will design the staircase to reach a specified height using the rise-over-run method. The students will also perform scaling operations on the model to scale down building code requirements to the model's scale.

Lesson Relevance to Performance Task and Students:

The students will design and build a staircase to show their understanding of slope. They will scale down real-world measurements and building code requirements to demonstrate an understanding of ratios.

Anticipatory Set/Capture Interest:

This lesson will begin with the question, "Have you ever stumbled on a set of stairs because the step was higher or lower than expected?" The instructor will then explain that this is because there are specific standards that must be met when designing and constructing a staircase.

Guided Practice:

Day 1:

In the guided practice section of this lesson, the instructor will begin by explaining the three key parts of a staircase: stringers, risers, and treads (definitions can be found in the teacher's notes). The instructor will then give the students the requirements for the staircase they are to design including building codes that the students must adhere to and the height that the staircase must reach. Then they will be shown how they are to draw their designs on the graph paper using accurate scale drawings.

Day 2:

In the guided practice section for the second day of this lesson, the instructor will group the students into teams of 2-4 students. The instructor will return the students designs from day 1 and the teams will choose one of their designs to construct (the teacher will provide feedback for which designs meet the specified criteria). Finally, the supplies will be passed out and the instructions for constructing the staircases given.

Independent Practice:

Day 1:

In the independent practice section, the students will use the graph paper and rulers to design a staircase that meets the requirements given by the instructor as well as any National Building Codes that apply. The relevant NBCs can be found in the teacher's notes. The students should produce drawings of the stringers, risers and treads, as well as a side view of the staircase put together. The students will turn in their drawing for review prior to the second class.

Day 2:

During the independent practice section for day two, the student teams will cut the balsa wood into stringers, risers, treads and supports and glue them together to create a model staircase based on the design chosen in the guided practice portion of the lesson. The students will attach the support posts to the top of the staircase so that it can stand up properly. The instructor will observe the construction process and provide assistance when needed.

Remediation and/or Enrichment:

Day 1

Remediation: Individual IEP

Enrichment: Have the students consider and add more aesthetically pleasing components (i.e. tread noses (defined in Teacher's notes)) to their designs.

Day 2

Remediation: Individual IEP; have instructor assist with staircase construction.

Enrichment: Have the students implement their enhanced designs from day 1.

Check(s) for Understanding:

What is a stringer, riser, tread? How wide must the tread be? How tall can the riser be? How can you scale down the national building codes to match the model requirements?

Closure:

To close the lesson, let each team display their staircases and explain what design choices they made and why. Discuss with the class why slope is important not only for staircase design but many other real-world applications as well, including how slopes are used to perform minimization and maximization operations on data.

Possible Alternate Subject Integrations:

None

Teacher Notes:

- Applicable National Building Codes [1]:
    1. The NBC currently states that stair treads must have a minimum depth of 9". In addition the nose of the stair tread cannot extend out more than 1" from the stair riser.
    2. In regards to stair risers, the NBC specifies a maximum height of 8 ¼".
    3. In residential building the NBC and most local building codes require stairs to be a minimum of 36" wide to allow two people to simultaneously ascend or descend them.
- The most effective tools for cutting balsa wood are exacto knives/box cutters but can be cut with less dangerous tools such as scissors if necessary. Care should be taken if these tools are used.
- An alternative to balsa wood is cardboard. Using cardboard can reduce material cost and the necessity for sharp cutting tools (e.g. exacto knives).
- An example design can be found in the included file: staircase_design.pdf
- Definitions [2]:
    - Stringers - The inclined boards or laminations in which the treads and risers are attached. Stringers provide the support for the stairs.
    - Risers - The vertical face of a step.
    - Treads - The horizontal part of a staircase upon which the foot is placed.
    - Noses - The front edge of the tread which projects beyond the face of the riser. It is usually rounded, chamfered or sometimes shaped.