The Par-fectly Calculated Miniature Golf Course: A Geometry Design Challenge

Subject: Mathematics (Measurement and Geometry)
Grade Level: Year 9 (14-year-old)
Time Allotment: 90-120 minutes

Materials Needed

- Graph paper (A4 or larger)
- Pencil and eraser
- Ruler
- Compass (for drawing circles/arcs)
- Calculator
- "Design Materials": Cardboard (e.g., from a cereal box), construction paper, scissors, glue or tape, empty paper towel roll or other recyclable items.
- Formula Reference Sheet (optional, for support) containing formulas for area and perimeter of squares, rectangles, triangles, circles, and surface area/volume of prisms and cylinders.

Lesson Overview

This lesson transforms the student into a miniature golf course designer. Instead of simply solving textbook problems, they will design, calculate, and build a model of a unique golf hole. The project requires the creative application of geometric principles to solve a fun, real-world challenge, focusing on composite shapes, area, perimeter, surface area, and volume.

Learning Objectives

By the end of this lesson, the student will be able to:

1. **Apply** formulas to accurately calculate the area and perimeter of a composite 2D shape.
2. **Analyze** a 3D object by calculating its surface area and volume.
3. **Create** a scale drawing that accurately represents a design concept.
4. **Synthesize** mathematical calculations and creative design to produce a final product (a model and report).

Curriculum Alignment

- **ACARA Australian Curriculum (Year 9 Mathematics):**
  - **Measurement and Geometry:** Calculate the areas of composite shapes (AC9M9M01).
  - **Measurement and Geometry:** Solve problems involving the surface area and volume of right prisms and cylinders (AC9M9M02).

- **AoPS & Beast Academy Philosophy:** Emphasizes problem-solving, logical reasoning, and applying concepts in novel situations rather than rote memorization.

Lesson Procedure

Part 1: The Design Brief (10 minutes)

Introduction & Hook:

"You've just been hired as the lead course architect for 'Geometry Golf,' a company famous for its creative and challenging miniature golf courses. Your first project is to design their signature hole. The client has a few specific requirements:"

- The hole's playing green must be a **composite shape**, made from at least **three** basic shapes (e.g., a rectangle, a triangle, and a semi-circle combined).
- The design must include at least **one 3D obstacle** (like a ramp, tunnel, or block).
- You will need to provide a complete 'Architect's Report' with a scale drawing and all necessary calculations so the construction team knows the material requirements.

Part 2: The Blueprint - 2D Design & Calculations (30-40 minutes)

Activity:

1. **Establish a Scale:** On your graph paper, decide on a scale. A good starting point is **1 cm = 10 cm**. This means every centimeter on your drawing represents 10 centimeters in the real world.
2. **Sketch the Green:** Draw the top-down view of your miniature golf hole. Remember to combine at least three shapes. Be creative! It could be shaped like a key, an ice-cream cone, or an abstract design.
3. **Label Dimensions:** Carefully label the lengths of all sides and radii on your blueprint in their 'real-world' measurements (using your scale).
4. **Calculate the Perimeter:** Calculate the total length of the border for your course. This is the perimeter of your composite shape. You will need to show how you calculated the length of each segment (straight and curved) before adding them together. This will determine how much material is needed for the walls.
5. **Calculate the Area:** Calculate the total surface area of the green. To do this, break your composite shape back into its simple components (rectangles, triangles, etc.). Calculate the area of each one and then add them together. This will determine how much turf is needed.

Guiding Questions:

- "How do you find the circumference of the curved part of your design?"
- "Which parts of the shapes' perimeters are 'inside' the design and shouldn't be counted for the outer wall?"
- "What's your strategy for breaking down this complex shape to find its total area?"

Part 3: The Obstacle - 3D Design & Calculations (20-30 minutes)

Activity:

1. **Design an Obstacle:** Choose a 3D obstacle for your course. Ideas include a rectangular prism (a ramp or block), a triangular prism (a wedge), or a cylinder (a tunnel).

2. **Sketch and Dimension:** Sketch your obstacle and label its dimensions (length, width, height, radius).
3. **Calculate Surface Area:** Calculate the total surface area of your obstacle. This will determine how much paint is needed to cover it. Be careful to exclude the surface that is glued to the green!
4. **Calculate Volume:** Calculate the volume of your obstacle. This tells the construction crew how much material (e.g., concrete or wood) is needed to build it.

Part 4: Construction & Presentation (30-40 minutes)

Activity:

1. **Build a Model:** Using your cardboard, paper, and other craft materials, build a simple physical model of your course design based on your blueprint. This helps visualize the final product and makes the connection between the 2D drawing and the 3D reality. It doesn't have to be perfect, but it should represent your design.
2. **Prepare the Architect's Report:** Organize your work into a clean report. This should include:
    - Your final, labeled blueprint (the graph paper drawing).
    - Your clear, step-by-step calculations for the green's perimeter and area.
    - Your sketch and calculations for the obstacle's surface area and volume.
    - A short paragraph describing your design choices and why your hole would be fun and challenging to play.

Closure & Reflection: Present your report and model. Discuss the challenges. "What was the trickiest part to calculate? If you had to build this full-size, what other mathematical information might you need?"

Assessment

Assessment is based on the final "Architect's Report" and the model. Evaluate based on:

- **Accuracy:** Are the calculations for area, perimeter, surface area, and volume correct? Is the work shown clearly?
- **Application of Concepts:** Did the student correctly identify how to break down the composite shape and apply the right formulas?
- **Clarity:** Is the blueprint neat, scaled, and easy to understand?
- **Creativity:** How original and thoughtful is the golf hole design?

Differentiation and Extension

- **For Support:**
    - Provide the Formula Reference Sheet at the start of the lesson.
    - Begin with a simpler composite shape requirement (e.g., just a rectangle and a semi-circle).
    - Work through one example calculation together before the student begins their own design.
- **For an Advanced Challenge (choose one):**
    - **The Budget Challenge:** Add financial constraints. "Border material costs $8 per meter, turf costs $30 per square meter, and obstacle material costs $100 per cubic meter. Your total budget for this hole is $1,500. Does your design fit the budget? If not, how can you re-design it?"

- **The Trigonometry Challenge:** If the obstacle is a ramp (triangular prism), require it to have a specific angle of incline (e.g., 12°). The student must then use trigonometry (SOH CAH TOA) to calculate the length of the ramp's slope and its height.
- **Complex Volume Challenge:** Design an obstacle that requires subtracting volumes, such as a large block with a cylindrical tunnel drilled through the middle. The student would need to calculate the volume of the block and subtract the volume of the cylinder.