Tropical Cyclones: Ocean Fuel and Land Obstacles (Typhoon Physics)

Materials Needed

- World Map or Regional Map (Focusing on a storm-prone area like the Western Pacific/Asia or the Atlantic/Caribbean)
- Markers, highlighters, or colored pencils (minimum three colors)
- Printout or digital access to the Saffir-Simpson Hurricane Wind Scale (or equivalent local scale)
- Notebook or worksheet for recording observations (Storm Tracker Log)
- Optional Demonstration Materials (For Kinesthetic Learners): Large bowl, warm water, a few ice cubes, a small fan or hair dryer (on a cool setting, used only by the adult/instructor)

Introduction: Setting the Stage (Tell Them What You'll Teach)

Hook: The Climate Conundrum

Imagine the most powerful engine in the world—a massive storm that can span hundreds of miles and generate 150-mph winds. If this engine is so strong, why does it always die shortly after it hits the coast? What "turns off" the power?

Learning Objectives (I Can... Statements)

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

1. Identify the three primary ingredients (fuel) necessary for a tropical cyclone (typhoon/hurricane) to form and intensify.
2. Explain exactly how large landmasses cause a tropical cyclone to weaken rapidly.
3. Apply knowledge of geography (coastlines, mountains, ocean depths) to predict intensity changes in a simulated storm path.

Body: Exploring the Physics of Cyclones (Teach It)

Section 1: The Fuel Tank (I Do – Modeling)

Concept Presentation: The Heat Engine

Tropical cyclones are giant heat engines powered exclusively by warm ocean water. To maintain Category 3+ strength, the storm needs an endless supply of heat and moisture.

- **Ingredient 1: Warm Water:** The ocean temperature must be at least 80°F (26.5°C) down to a depth of about 150 feet. This depth is key because the storm churns the water, and if it brings cold water to the surface, it weakens itself.
- **Ingredient 2: Moisture/Humidity:** High humidity provides the water vapor that rises, cools, and releases massive amounts of latent heat, which fuels the storm's rotation and pressure drop.
- **Ingredient 3: Low Wind Shear:** Wind shear (winds changing direction or speed with height) tears the storm apart. Low shear keeps the vertical structure intact.

Activity: Map the Warm Water

Using the world map, identify the primary tropical cyclone basins (e.g., the Caribbean, the Western Pacific, the Indian Ocean). Note that these areas are characterized by major warm ocean currents (like the Gulf Stream or the Kuroshio Current).

Section 2: The Decaying Force (We Do – Interactive Demonstration)

Focus: The Land Barrier

When a tropical cyclone hits land, two things happen immediately that drain its power:

1. **Fuel Cutoff:** The storm is suddenly cut off from its source of warm, moist air (the ocean). It begins drawing in drier, cooler air from the land.
2. **Friction:** The smooth surface of the ocean offers little friction. Land, covered in trees, buildings, and mountains, creates significant friction, slowing the surface winds immediately. This slowing disrupts the organized circulation of the storm.

Demonstration: The Cooling Effect and Friction (Kinesthetic/Visual)

Cooling Effect: Place warm water in the bowl. Discuss how this represents the warm ocean. Add a few ice cubes. Discuss how this represents the storm moving over cooler water or how intense rain can cool the surface water, showing self-weakening.

Friction Analogy: The instructor uses the hair dryer/fan (on a safe, low, cool setting) pointed at an open surface (representing the ocean). Note the smooth, uninterrupted airflow. Then, aim the air stream directly at an obstruction (a stack of books or a textured object, representing a mountain range or city). Note how the airflow immediately slows down, breaks up, and becomes turbulent—this is the friction effect.

Discussion & Check-in (Formative Assessment)

Question: A Category 4 storm is heading toward a large, flat desert coastline. Will it weaken instantly or gradually? Why?

Success Criterion: The learner accurately states that friction and lack of moisture will cause rapid weakening upon landfall, even if the land is flat.

Section 3: Storm Tracking Simulation (You Do – Application)

Task: Predict the Path and Intensity

The learner will now act as a meteorologist, tracking a simulated tropical cyclone, Typhoon ‘Atlas.’

Scenario Setup:

1. On your regional map, draw a hypothetical path for Typhoon Atlas starting over open, warm ocean water (Category 4).
2. The path should move close to, but not over, a small island chain (e.g., the Bahamas or the Philippines).
3. The path should then cross directly over a major landmass with high mountains.
4. Finally, the path should track back out over the ocean (potentially crossing cooler waters).

Storm Tracker Log (Individual Practice)

Using the Saffir-Simpson Scale as reference, the learner fills out the log, marking their predicted intensity change at each point (1, 2, 3, 4).

Point	Location Context (Water Temp, Land Proximity, Topography)	Predicted Intensity Change (Stronger, Weaker, No Change)	Reasoning
1 (Initial)	Open, warm ocean	N/A (Starting point)	Ideal conditions for maintenance.
2	Grazing a small, low-lying island chain		
3	Crossing a large landmass with mountains		
4	Re-emerging over ocean water (possibly slightly cooler)		

Conclusion: Review and Assessment (Tell Them What You Taught)

Recap: The Three Fates

Ask the learner to state the three main scenarios that cause a tropical cyclone to weaken or die, linking them back to the physics discussed:

1. Hitting a large landmass (Friction & Fuel cutoff).
2. Moving over cold water (Losing the heat engine source).
3. Encountering high wind shear (Structure is torn apart).

Summative Assessment: Predict & Justify

Evaluate the learner's "Storm Tracker Log." The instructor reviews the reasoning for points 2, 3, and 4.

Success Criteria: The learner successfully justifies the following:

- At Point 2 (grazing low islands), the storm might temporarily weaken slightly due to minor friction but will quickly re-intensify over warm water.
- At Point 3 (crossing mountains), the storm must weaken rapidly (likely below Category 1 or dissipating) due to friction and the complete cutoff of ocean fuel.
- At Point 4 (re-emerging), re-intensification is possible, but typically slower and less intense than before, especially if it tracked over cooler waters stirred up by the passage.

Adaptation and Differentiation

Scaffolding (For Struggling Learners)

- Pre-label the map with areas of "Warm Water Fuel Zone" and "High Friction Land Zone."
- Provide a list of intensity change terms (rapid weakening, slight weakening, steady state, rapid intensification) to help them complete the log.

Extension (For Advanced Learners)

- **Climate Challenge:** Research and present a case study of a specific historical storm (e.g., Hurricane Katrina or Typhoon Haiyan). Analyze how local geography (shallow coastal shelf vs.

deep ocean basin) contributed to its ultimate intensity upon landfall (e.g., storm surge vs. wind speed).

- **Vertical Wind Shear Modeling:** Research the role of the jet stream in dictating storm paths and how high-altitude winds can influence storm intensity even hundreds of miles away.