STEM Lesson Plan:

Unveiling the Unseen: Mathematical Explorations in Tomography and Imaging Techniques (Middle & High School)

Grade Level:
7th to 12th Grade

Subject:
Mathematics and Physics

Lesson Overview
Students will explore inversion problems and imaging techniques through hands-on activities that simulate real-world applications, such as shadow imaging and tomography. These activities are inspired by the cutting-edge research conducted at the National High Magnetic Field Laboratory. Students will learn how to infer unseen structures using indirect data, geometric tricks, and mathematical algorithms.

Objectives
- Understand inversion problems and their applications.
- Use geometric and mathematical techniques to reconstruct hidden objects.
- Build and calibrate a shadow imaging device.
- Explore how X-ray tomography uses mathematical algorithms for reconstruction.

Standards
- CCSS.MATH.CONTENT.HSG.GPE.B.7: Solve problems involving geometric methods.
- NGSS.PS4.B: Electromagnetic Radiation.
- ISTE Standards for Students: Computational Thinker.

Materials
- Cardboard box
- Tracing paper
- Light source (e.g., flashlight)
- Ruler
- Protractor
- Paper
- Calculator

The National MagLab is funded by the **National Science Foundation** (DMR-1644779) and the **State of Florida**

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- Graph paper
- Worksheets (pre-prepared for SPED and ELL differentiation)

Lesson Sequence

Introduction (15 minutes)
1. Discussion: Introduce inversion problems and their real-world relevance (e.g., shadow imaging and tomography).
2. Philosophical Link: Discuss Plato's allegory of the cave to draw parallels between indirect data and real-world challenges.

Activity 1: Building a Shadow Imaging Device (30 minutes)
1. Construction:
- Guide students in creating a shadow imaging device using a cardboard box, light source, and tracing paper.
2. Calibration:
- Ensure accurate alignment of the light source and object.
- Practice rotating the setup to observe changes in shadow projection.
3. Analysis:
- Students measure and record angles and lengths to reconstruct the object's outline.

Activity 2: Exploring Tomography Through Math (45 minutes)
1. Introduction to Tomography:
- Explain how X-ray tomography works, including the concept of inverse problems and logarithmic algorithms.
2. Simulated Tomography:
- Provide students with graph paper and a set of measurements mimicking X-ray data from multiple angles.
- Students use algorithms to reconstruct a "slice" of an imaginary object.

Wrap-Up (15 minutes)
Students compare their reconstructed shapes to the original objects.
Discuss real-world applications, such as medical imaging and material science.

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Differentiation Strategies

For SPED Students:
- Pre-printed templates and step-by-step instructions.
- Partner them with peers for collaborative work.
- Use tactile materials for constructing devices.

For ELL Students:
- Provide bilingual glossaries with key terms (e.g., tomography, inversion).
- Incorporate visuals and diagrams to enhance understanding.
- Allow verbal explanations for reconstructed objects as an alternative to written work.

For Advanced Learners:
- Challenge them to solve more complex inversion problems using additional angles and data.
- Introduce filtered back projection methods and their mathematical basis.

Assessment

- Formative: Observation during activities, guiding questions, and peer feedback.
- Summative: Completed worksheets, accuracy of reconstructed objects, and a short reflection on the connection to real-world applications.

Extensions

- Students research additional imaging techniques, such as MRI or ultrasound.
- Experiment with modifying the shadow imaging device to capture finer details.

Culminating Project

Students create a presentation or poster demonstrating their understanding of inversion problems, their reconstructed images, and the implications of these techniques in fields such as medicine and materials science.

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