STEM Lesson Plan:

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

Magnetic Mysteries (Grade 4/5)

Purpose:

- Students will be able to explore how different metals react to magnets through hands-on inquiry. They will predict, test, and analyze which materials are magnetic and discuss how magnetism connects to real-world science applications such as engineering, electronics, and medical imaging (MRI).
- Students will be able to investigate magnetism in minerals and understand how a mineral's composition affects whether it is magnetic. Through hands-on observation and testing, students learn that minerals containing metals such as iron are more likely to be magnetic.
- Students will be able to grow iron-infused crystals using Epsom salt (magnesium sulfate), warm water, and fine iron filings. After observing crystal formation, students will test the crystals to determine whether they are magnetic. This investigation introduces crystal formation, mixtures, material properties, and magnetism, key concepts studied by scientists at the National MagLab.

Next Generation Science Standard:

- PS2.B – Types of Interactions: The effect of magnetic forces depends on the properties of the materials.
- 3-5-ETS1-1 – Define a simple design problem reflecting a need or want, including success criteria and constraints.
- Science and Engineering Practices – Planning and Carrying Out Investigations; Analyzing and Interpreting Data.

Florida Science Standard:

- SC.4.P.8.2 – Identify properties of common materials that make them suitable for different purposes.
- SC.5.P.13.1 – Identify familiar forces that cause objects to move, such as pushes or pulls, including magnetic attraction and repulsion.
- SC.5.N.1.1 – Define a problem, plan and carry out scientific investigations, and use data to support explanations.

Time: Duration: Two -Three 50-minute class periods

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

Disciplinary Core Ideas:

ESS3.A: Natural Resources

- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (K-ESS3-1)

Crosscutting Concepts:

Systems and System Models-Observed patterns of magnetic organization and classification, and prompted questions about relationships and influencing factors for magnetics and matter. The materials inside a mineral determine whether it will be attracted to a magnet.

Science and Engineering Practices:

- Planning and carrying out investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

Materials:

Activity 1

- Magnets (bar or neodymium)
- Samples of different metals: iron nail, steel paper clip, aluminum foil, copper wire, brass key, coin, zinc washer, nickel
- Non-metal materials for comparison: plastic spoon, wood stick, rubber band, fabric swatch
- Data recording sheet (provided below)
- Science journal
- Chart paper and markers
- Optional: MagLab video or image set showing magnetic field lines or MRI magnets

Activity 2

- Magnets (bar or neodymium)
- Samples of minerals: Magnetite, Hematite, Pyrite, and Quartz (or pictures if samples unavailable)

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

- Data recording sheet (provided below)
- Hand lens or magnifying glass
- Science notebook or journal

Activity 3

- Epsom salt (magnesium sulfate)
- Warm water
- Clear plastic cups or jars
- Spoons for stirring
- Fine iron filings
- Strong magnets (bar or neodymium)
- Wax paper or paper towels
- Hand lens or magnifying glass
- Data recording sheet
- Science notebook or journal

STEM Rationale for Lesson:

This lesson connects directly to STEM education by fostering inquiry, experimentation, and analytical thinking. Students act as material scientists testing hypotheses, recording data, and drawing conclusions about magnetic properties. Technology is integrated through visual media and research extensions, while engineering is reinforced as students design magnet-based inventions. This lesson supports equity and engagement by encouraging all learners to explore hands-on science phenomena and connect their findings to real-world applications, such as renewable energy and medical imaging.

Lesson 1 Activity Steps: Magnetism in a Bag

1. Engage (10 Minutes): Introduce a mystery bag of items. Ask students to predict which might be magnetic and why. Discuss where magnets are used daily and show MagLab visuals or a video clip.
2. Explore (25 Minutes): Students rotate through 'Metal Detective Stations' to test items with magnets and record data in their tables. Encourage discussion on patterns they notice.
3. Explain (15 Minutes): Facilitate class discussion on results. Define key vocabulary (magnetism, ferromagnetic, alloy, attraction, repulsion, magnetic field). Link to atomic structure and material properties.

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

4. Elaborate (20 Minutes): Students design a magnet-based invention or propose a technological use for magnets. Connect their ideas to MagLab research applications.
5. Evaluate (10 Minutes): Students complete reflection questions and a short exit slip describing magnetic and non-magnetic materials and their real-world applications.

Student Worksheet: Magnetism in a Bag

Object	Material Type	Attracted to Magnet? (Yes/No)	Observations

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

Lesson Assessment

Evaluate (10 Minutes): Students complete reflection questions and a short exit slip describing magnetic and non-magnetic materials and their real-world applications.

Reflection Questions:

1. What pattern did you notice about which metals were magnetic?
2. Why aren't all metals magnetic?
3. How can magnets be used to help people or solve problems?

Evaluate

Category	4 - Exceeds	3 - Meets	2- Developing	1 - Beginning
Prediction & Hypothesis	Insightful and evidence-based predictions	Logical predictions stated	Simple or unclear predictions	No prediction given
Data Collection	Accurate, complete, well-organized table	Mostly accurate and complete	Partially accurate or incomplete	Minimal data recorded
Explanation &Understanding	Thorough explanation using vocabulary	Clear explanation with minor errors	Limited understanding shown	Incorrect explanation
Real-World Connection	Detailed and relevant connection to real science	General connection made	Vague or unrelated connection	No connection provided

Lesson 2 Activity Steps: Magnetic Minerals

1. **Engage** (10 Minutes): Display several mineral samples (Magnetite, Hematite, Pyrite, Quartz) without telling students which are magnetic. Hold a magnet near one sample (without revealing results yet).
   Ask: *Do you think all rocks are magnetic? Why or why not? What might make a mineral magnetic?* Introduce the investigation question: Which minerals are magnetic, and what do they have in common?
2. **Explore** (25 Minutes): Students observe each mineral sample carefully using a hand lens. They record observations about color, texture, weight, and metallic shine on

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

the data sheet. Students predict which minerals will be magnetic and record their predictions. Students test each mineral by bringing a magnet close to it. They observe whether attraction is strong, weak, or none. Students record their findings and classify each mineral as magnetic, weakly magnetic, or nonmagnetic.

3. **Explain** (15 Minutes): Students share their results in small groups and then as a class.
   Guide discussion with questions:

   Which mineral showed the strongest magnetic attraction?
   What do the magnetic minerals have in common?
   What metal might be present inside them?
   The teacher clarifies that minerals containing iron (such as Magnetite) are strongly magnetic, while others, like quartz, are not. Explain that magnetism depends on the material's composition, especially the presence of metals like iron.

4. **Elaborate** (20 Minutes): Students compare magnetic minerals to non-magnetic ones and look for patterns in appearance (metallic luster, color, density). Discuss real-world applications: How are magnetic minerals used in technology? Why might scientists study magnetic materials? Connect to research at the National High Magnetic Field Laboratory, where scientists study how materials behave in strong magnetic fields.

   Optional: Students design a test to sort unknown mineral samples using only a magnet and observation skills.

5. **Evaluate** (10 Minutes): Students complete reflection questions explaining: Which mineral was most magnetic and why? What magnetic minerals have in common? How does magnetism relate to the presence of certain metals?

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

Data Table: Magnetic Minerals

Mineral Name	Appearance (Color / Luster)	Attracted to Magnet? (Strong / Weak / None)	Notes / Observations
Magnetite			
Hematite			
Pyrite			
Quartz			

Lesson Assessment

Evaluate (10 Minutes): Students complete reflection questions explaining: Which mineral was most magnetic and why? What magnetic minerals have in common? How does magnetism relate to the presence of certain metals?

Reflection Questions

1. Which mineral showed the strongest magnetic attraction? Why do you think that is?
2. What do the magnetic minerals have in common?
3. How does this investigation connect to what scientists study at the National MagLab?
4. Why might some minerals that contain iron not be attracted to magnets?

Evaluate

Criteria	4 – Exceeds Expectations	3 – Meets Expectations	2 – Developing	1 – Beginning
Observation Skills	Detailed, accurate descriptions of mineral color, texture, and luster using appropriate scientific vocabulary	Clear and mostly accurate descriptions with minor details missing	Basic descriptions with limited detail or vocabulary	Minimal, inaccurate, or incomplete observations
Prediction & Hypothesis	Thoughtful prediction clearly	Logical prediction with	Predictions stated with	No prediction or unrelated reasoning

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

Criteria	4 – Exceeds Expectations	3 – Meets Expectations	2 – Developing	1 – Beginning
	supported with reasoning	some reasoning	little or unclear reasoning	
Data Collection & Recording	The data table is complete, neat, and accurate; the magnetic strength is correctly classified	The data table is mostly complete and accurate	The data table is partially complete or contains errors	The data table is incomplete or missing
Understanding of Magnetism	Clearly explains that magnetism is related to the presence of metals (e.g., iron) and connects evidence to the conclusion	Correctly explains the basic relationship between magnetism and metal content	Partial understanding; explanation lacks clarity or contains minor misconceptions	Shows a misunderstanding of magnetic properties
Participation & Collaboration	Actively engaged, contributes to discussion, follows procedures and safety expectations consistently	Participates appropriately and follows procedures	Inconsistent participation or needs reminders	Rarely participates or does not follow procedures
Reflection & Scientific Reasoning	Reflection responses are thorough, logical, and supported by investigative evidence	Reflection responses are clear and supported by some evidence	Reflection responses are brief with limited evidence	Reflection responses incomplete or lack understanding

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

Lesson 3 Activity Steps: Steps Growing Iron Crystals & Testing Their Magnetism

1. Engage (10 Minutes): Show students a magnet attracting iron filings. Ask: *What makes something magnetic?* Display Epsom salt and ask: *Do you think salt crystals can be magnetic? Why or why not?* Tell students they will grow their own crystals and test them.
2. Explore (25 Minutes): Mix 1 cup of warm water with ½ cup of Epsom salt. Stir until mostly dissolved. Add a small spoonful of fine iron filings. Stir gently. Leave the mixture undisturbed overnight to allow crystals to form as water evaporates. Observe the crystals using a hand lens. Record color, shape, and texture. Test crystals with a magnet and record whether the attraction is strong, weak, or none.
3. Explain (15 Minutes): Facilitate class discussion on results. Define key vocabulary (magnetism, ferromagnetic, alloy, attraction, repulsion, magnetic field). Link to atomic structure and material properties.
4. based invention or propose a technological use for magnets. Connect their ideas to MagLab research applications.
5. Evaluate (10 Minutes): Students complete reflection questions and a short exit slip describing magnetic and non-magnetic materials and their real-world applications

Data Table: Growing Iron Crystals & Testing Their Magnetism

Sample	Appearance	Magnetic Response	Observations
Epsom Salt (Before Iron)			
Iron Filings Alone			
Iron-Salt Crystals			

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

Lesson Assessment

Evaluate (10 Minutes): Students complete reflection questions and a short exit slip describing magnetic and non-magnetic materials and their real-world applications

Reflection Questions:

1. Why were pure Epsom salt crystals not magnetic?
2. How did adding iron filings change the crystal sample?
3. Is the iron chemically part of the crystal? Explain.
4. How does this investigation relate to what scientists study at the National MagLab?

Criteria	4 – Exceeds Expectations	3 – Meets Expectations	2 – Developing	1 – Beginning
Scientific Observation	Detailed descriptions using accurate vocabulary	Clear descriptions with minor details missing	Limited descriptions	Minimal or inaccurate observations
Data Collection	Complete and accurate data table	Mostly complete and accurate	Partially complete	Incomplete or missing
Understanding of Magnetism	Clearly explains why iron causes magnetism and identifies the mixture correctly	Explains magnetism and mixture with minor errors	Partial understanding	Misconceptions present
Reflection & Explanation	Thorough, logical explanations with evidence	Clear explanation with some evidence	Basic explanation	Limited or unclear response
Participation & Lab Skills	Consistently engaged and follows safety procedures	Usually engaged and follows procedures	Inconsistent engagement	Limited participation

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

Teacher Notes

This mini-lab extends the 'Magnetic Mysteries' lesson by introducing natural sources of magnetism. It encourages students to apply their understanding of magnetic forces to geological materials and connects directly to MagLab research on material properties and magnetic fields. Teachers may show images or short clips of magnetite and hematite in research contexts. If mineral samples are unavailable, use online simulations or rock kit substitutes

This 5E lesson model deepens understanding of crystal formation and magnetism while reinforcing the concept of mixtures. Emphasize safety when handling iron filings and ensure students wash their hands after the activity.

This investigation strengthens connections between classroom science and real-world research conducted at the National High Magnetic Field Laboratory, where scientists explore how materials respond to extremely strong magnetic fields and how material properties can be engineered for technology applications.

Extension Activity: MagLab Research Connections Reading and Questions

Replacing Rare Earth Minerals:

Scientists at the National High Magnetic Field Laboratory are researching new materials that could replace rare-earth elements such as neodymium. These elements are used in powerful magnets found in electronics, wind turbines, and electric cars. At MagLab, scientists are testing metals such as manganese-gallium (Mn-Ga) alloys to determine whether they can be strong magnets without using rare or expensive materials.

Rare-earth metals are expensive and often mined in limited areas around the world. If scientists can find other magnetic metals, it could make technology cheaper, more sustainable, and better for the environment.

Just like MagLab scientists, you are testing different metals to see which ones are magnetic! You're exploring the same question scientists are asking: What makes certain metals attract magnets while others do not?

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**

STEM Lesson Plan:

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

1. What metals did you find were magnetic in your investigation?
2. Why do you think scientists are searching for new magnetic materials?

Center for Rare Earths, Critical Minerals, and Industrial By-Products

At MagLab, a special research group studies rare-earth and critical minerals vital to the production of magnets, electronics, and clean energy technologies. Scientists are also exploring Florida's natural resources to see if the state can become a center for producing these critical materials.

Understanding where and how magnetic materials are found helps scientists and engineers design stronger, safer, and more efficient technology. This research supports renewable energy and helps reduce dependence on foreign materials. In class, you are testing how different metals react to magnets. At MagLab, researchers are doing the same type of work on a larger scale, investigating what makes certain metals magnetic and useful for building technology.

1. Why might some metals be more useful for making magnets than others?
2. How could learning about magnetic materials help people in your community or state?

Lesson by: Dr. Kisha Jarrett

School: Griffin Middle School

Contact info: kishajarrett@gmail.com | kisha.jarrett@leonschools.net

The National MagLab is funded by the **National Science Foundation** (DMR-2128556) and the **State of Florida**