Title: Think Like and Engineer with Phenomenal Science Instruction!

Description: Teachers will learn how student driven engineering internships can incorporate all aspects of the new Science & Engineering Practices from the Michigan Science Standards. This session will engage educators with hands-on activities, digital tools, active reading and dynamic discussion with the purpose to integrate phenomena-based science instruction around real-world problem solving.

Objectives:

● Support Michigan science teachers with a deeper understanding of the Science and Engineering Practices (SEPs)
● Provide teachers with the knowledge and practice to meet the expectations of the new standards.
● Engage teachers with phenomena-based instruction with example model units, lessons and activities.
● Provide teachers from all grade levels (K-8) with resources they can take back and use in their classrooms.

Amplify Connection:

Engineering Internship - Force and Motion.
Participants will engage in a hands-on egg drop as well as use the unit digital tool.
Teachers will leave with print resources as well as digital demo accounts.

Background:
The new Michigan K-12 Science Standards, based upon the Next Generation Science Standards, replace the standards adopted in 2006, commonly known as the Grade Level Content Expectations and High School Content Expectations for Science. The new standards are really a set of student performance expectations. These performance expectations incorporate three main elements:

● Disciplinary Core Ideas (science specific concepts in the life, earth, and physical sciences),
● Science and Engineering Practices (the practices of engaging in scientific investigation to answer questions, and engineering design to solve problems),
● Cross-Cutting Concepts (conceptual ideas common to all areas of science).

These expectations are also interwoven across disciplines, including connections to language arts and mathematics.

The adoption of new standards provides a tremendous opportunity in our state not only to improve science learning, but also to improve literacy and thinking skills of all children.
Amplify Science
Demo Account Access Quick Start Guide

Go to: https://go.info.amplify.com/amplify-science-review

1. Enter the details and click SUBMIT

2. Scroll down the page to click on Preview the Curriculum

3. Click on TEACHER

4. Check I AM NOT A ROBOT and click CONTINUE
1 Scientific and Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

2 Crosscutting Concepts
1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change
3 Disciplinary Core Ideas

Physical Sciences
PS1: Matter and its interactions
PS2: Motion and stability: Forces and interactions
PS3: Energy
PS4: Waves and their applications in technologies for information transfer

Life Sciences
LS1: From molecules to organisms: Structures and processes
LS2: Ecosystems: Interactions, energy, and dynamics
LS3: Heredity: Inheritance and variation of traits
LS4: Biological evolution: Unity and diversity

Earth and Space Sciences
ESS1: Earth’s place in the universe
ESS2: Earth’s systems
ESS3: Earth and human activity

Engineering, Technology, and Applications of Science
ETS1: Engineering design
ETS2: Links among engineering, technology, science, and society
Science and engineering practices are the practices that scientists and engineers use when investigating real world phenomena and designing solutions to problems. There are eight science and engineering practices that apply to all grade levels and content areas.

1. Read the scientific and engineering practices.
2. Use the chart to indicate your perception about how you promote these practices in your classroom.
3. Discuss these practices with your table partners/group.
4. At the bottom of the page reflect on your own practice with the guided questions.

### Scientific and Engineering Practices

<table>
<thead>
<tr>
<th>Scientific and Engineering Practices</th>
<th>Never</th>
<th>Sometimes</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions (for science) and defining problems (for engineering)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing and using models</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning and carrying out investigations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using mathematics and computational thinking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constructing explanations (for science) and designing solutions (for engineering)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engaging in argument from evidence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Reflection

What can I do to increase the fostering of these practices? Which SEPs could I address more easily as a starting point? Which ones will be challenging for me and I could use more support?
Unit Map
Balancing Forces:
Investigating Floating Trains (Grade 3)

How is it possible for a train to float?

Students are challenged to figure out how a floating train works in order to explain it to the citizens of Faraday. People in Faraday are excited to hear that a new train service will be built for their city, but concerned when they hear that it will be a floating train. Students develop models of how the train rises, floats, and then falls back to the track, and then write an explanation of how the train works.

Students figure out:

1. **Why does the train rise?**
   A train is a big object. Objects can move when they are pushed or pulled on by a second object. When the train rises, it does so because of a non-touching force: magnetic force. The train rises because the force acts between magnets on the tracks and magnets on the train.

2. **Why does the train fall?**
   When the train falls, it does so because a force is acting on it. Since a second object is not pushing or pulling the train, there must be a non-touching force at work. The train falls because of the force of gravity. We know that forces always act between two objects. The force of gravity is acting between the train and Earth. Earth attracts the train, and the train moves toward it.

3. **Why does the train float?**
   More than one force can be exerted on the train at a time. The force of gravity is pulling the train toward Earth, and magnetic force is pushing the train up away from the tracks. Those forces work in opposite directions so when the forces are balanced, the train floats and stays in the air.

4. **Why does the train rise, then float, and then fall?**
   When the track’s electromagnet is turned off, magnetic force is no longer exerted and the forces are no longer balanced. When gravity is the only acting force, the train falls.

How they figure it out:

1. **Why does the train rise?**
   Students plan and carry out hands-on investigations and explore text as they seek explanations for why the train rises. As they figure out what they think causes the train to rise, students create both physical models and diagram models that represent the forces at work. They write their first scientific explanation.

2. **Why does the train fall?**
   Students figure out what they think causes the train to fall. They observe chain reactions caused by touching forces and non-touching forces: magnetic force and gravity. They observe that each instance of magnetic force and touching force are between two objects. They analyze which movements are caused by gravity. Students apply what they learned about gravity to make a physical model of the train falling, create diagrams that model what happens when the train falls, and write scientific explanations for why the train falls.

3. **Why does the train float?**
   Students investigate what happens when two forces act on an object at the same time. Students discover that magnetic force can be used to counterbalance gravity. They go on to create physical models and diagrams, then write scientific explanations to describe how the train works. Students apply what they learned about maglev trains to explaining how a hoverboard works.

4. **Why does the train rise, then float, and then fall?**
   Students synthesize all they have learned to explain the forces that move the train to the citizens of Faraday. They create physical models as evidence of how the train could work and then create diagram models to show the role that forces play. Finally, they write scientific explanations to answer the question Why does the train rise, then float, and then fall? At the end of the unit, students read a book about a bridge engineer whose job includes communicating about the safety of bridges to the public. Students apply their understanding of balanced and unbalanced forces as they think about bridges that work and bridges that fail.
Correlations to NGSS and CCSS
Balancing Forces:
Investigating Floating Trains (Grade 3)

Next Generation Science Standards

<table>
<thead>
<tr>
<th>Performance Expectations:</th>
<th>3-PS2-1; 3-PS2-2; 3-PS2-3; 3-PS2-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and Engineering Practices:</td>
<td>Practice 1; 2; 3; 4; 5; 6; 8</td>
</tr>
<tr>
<td>Disciplinary Core Ideas:</td>
<td>PS2.A; PS2.B</td>
</tr>
<tr>
<td>Crosscutting Concepts:</td>
<td>Stability and Change; Cause and Effect; Patterns</td>
</tr>
</tbody>
</table>

Common Core State Standards for English Language Arts

<table>
<thead>
<tr>
<th>Reading Informational Text:</th>
<th>CCSS.ELA-LITERACY.RI.3.1; 3.4; 3.5; 3.7; 3.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing:</td>
<td>CCSS.ELA-LITERACY.W.3.2; 3.4; 3.10</td>
</tr>
<tr>
<td>Speaking and Listening:</td>
<td>CCSS.ELA-LITERACY.SL.3.1; 3.6</td>
</tr>
<tr>
<td>Language:</td>
<td>CCSS.ELA-LITERACY.L.3.6</td>
</tr>
</tbody>
</table>

Common Core State Standards for Mathematics

<table>
<thead>
<tr>
<th>Practices:</th>
<th>CCSS.MATH.PRACTICE.MP1; 2; 4; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content:</td>
<td>CCSS.MATH.CONTENT.3.MD.2; 3.MD.3</td>
</tr>
</tbody>
</table>

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3-D Statements

Balancing Forces (Grade 3)

Crosscutting Concepts
Practices
Disciplinary Core Ideas

Unit Level

Students obtain and evaluate evidence from firsthand investigations and text related to balanced and unbalanced non-touching forces to construct an explanation of how a train can float in the air as one example illustrating the idea of stability and change.
(stability and change, cause and effect, patterns)

Chapter Level

Chapter 1: Why does the train rise?
Students analyze data to determine what magnets attract and apply what they learn to construct an explanation of why the train floats.
(stability and change, cause and effect, patterns)

Chapter 2: Why does the train fall?
Students make observations of the force of gravity and apply what they learn to explain why the train falls.
(stability and change, cause and effect, patterns)

Chapter 3: Why does the train float?
Students investigate how two forces can act on an object at the same time and apply what they learn to explain why the train floats.
(stability and change, cause and effect, patterns)

Chapter 4: Why does the train rise, then float, then fall?
Students create physical models and diagrams as evidence of how the floating train may work and use what they learn to explain why the train rises, then floats, then falls.
(stability and change, cause and effect, patterns)
Lesson Level

**Lesson 1.1: Pre-Unit Assessment: Students’ Initial Explanations**
Students observe a video of a floating train and they explain why they think the train rises, floats, and then falls. (stability and change, cause and effect, patterns)

**Lesson 1.2: Evidence of Touching Forces**
Students investigate various ways of creating touching forces that will move blocks and conclude that while the forces themselves are not visible, when an object starts to move it is evidence that a force is acting. (stability and change, cause and effect, patterns)

**Lesson 1.3: Forces All Around**
Students read Forces All Around and search for evidence of forces acting in the book’s illustrations. (stability and change, cause and effect, patterns)

**Lesson 1.4: Investigating Magnetic Force**
Students investigate how to make a magnet move without touching it to gain firsthand experience with a non-touching force. (stability and change, cause and effect, patterns)

**Lesson 1.5: What Do Magnets Attract?**
Students investigate which objects attract magnets and analyze data in order to draw conclusions about the kinds of things that are or are not attracted to magnets. (stability and change, cause and effect, patterns)

**Lesson 1.6: Investigating Forces Between Magnets**
Students investigate magnets to discover attraction and repulsion and obtain and evaluate information from a reference book to further refine their understanding of magnetic poles. (stability and change, cause and effect, patterns)

**Lesson 1.7: What My Sister Taught Me About Magnets**
Students obtain and evaluate information as they read What My Sister Taught Me About Magnets and analyze data to figure out that magnets attract metals that contain iron in addition to reflecting on the power of organizing data in different ways to observe patterns. (stability and change, cause and effect, patterns)

**Lesson 1.8: Writing a Scientific Explanation**
Students create physical models of how the train rises and write explanations about magnetic force. (stability and change, cause and effect, patterns)
Moving Magnets

Directions:
1. See if you can make a magnet start moving without anything touching it.
2. Draw a picture of two ways that you made a magnet move. Include an arrow in each drawing to show the direction the magnet started moving.
Evidence of Non-Touching Forces

Directions:
1. Answer the question below and then record your evidence.
2. Use the words in the Word Bank when you record your evidence.

Can a force make an object start to move without anything touching the object? ______________

<table>
<thead>
<tr>
<th>Word Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>force</td>
</tr>
<tr>
<td>touching force</td>
</tr>
<tr>
<td>flipped</td>
</tr>
</tbody>
</table>

What is your evidence? ______________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

10 Balancing Forces—Lesson 1.4
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Predict and Test: What Do Magnets Attract?

Directions:
1. For each row, predict whether the magnet (Object 1) will attract Object 2. Record your predictions in the fourth column.
2. Once you receive your magnet, test your predictions. Record your test results in the last column.
3. Continue this process as you complete the table on the next page.

<table>
<thead>
<tr>
<th>Object 1</th>
<th>Object 2</th>
<th>Is Object 2 metal?</th>
<th>Prediction: Do you think the magnet will <strong>attract</strong> or <strong>not attract</strong> this object?</th>
<th>Test: Did the magnet <strong>attract</strong> or <strong>not attract</strong> this object?</th>
</tr>
</thead>
<tbody>
<tr>
<td>magnet</td>
<td>wood</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>washer</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>penny</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>paper clip</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>fastener 1</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>fastener 2</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Predict and Test: What Do Magnets Attract? (continued)

<table>
<thead>
<tr>
<th>Object 1</th>
<th>Object 2</th>
<th>Is Object 2 metal?</th>
<th>Prediction: Do you think the magnet will attract or not attract this object?</th>
<th>Test: Did the magnet attract or not attract this object?</th>
</tr>
</thead>
<tbody>
<tr>
<td>magnet</td>
<td>foil</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>twist tie</td>
<td>partly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>plastic spoon</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>steel spoon</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>balloon</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnet</td>
<td>steel wool</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Floating Paper Clip

Directions:
1. Draw the paper clip, string, and magnets to complete the device.
2. Under the diagram, record one force acting on the paper clip and then record the two objects that the force is acting between.
3. Record a second force acting on the paper clip and then record the two objects the force is acting between.

First force:
_____________________________ is one force acting on the paper clip.
What two objects is this force acting between?
_________________________________ and ________________________________

Second force:
_____________________________ is another force acting on the paper clip.
What two objects is this force acting between?
_________________________________ and ________________________________
Multiple Meaning Words

Directions:
Some words can mean more than one thing. For each word in the chart:
1. Read the sentence from the book *Handbook of Forces* that uses the word.
2. Read the two meanings the word can have.
3. Decide which meaning the word has in the sentence from the book and circle that meaning in the table.

<table>
<thead>
<tr>
<th>Word</th>
<th>Sentence from the book</th>
<th>Meaning 1</th>
<th>Meaning 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>multiple</td>
<td>The movement of the ball up and then down is evidence of <em>multiple</em> forces.</td>
<td>more than one</td>
<td>a number that can be made by multiplying a smaller number (for example, 6 is a multiple of 2)</td>
</tr>
<tr>
<td>acting</td>
<td>The multiple forces <em>acting</em> on an object can have different strengths.</td>
<td>exerted</td>
<td>pretending to be someone else for a movie or play</td>
</tr>
<tr>
<td>wind</td>
<td>When you fly a kite, the <em>wind</em> pushes on the kite while you pull it with the string.</td>
<td>to wrap around something</td>
<td>moving air</td>
</tr>
</tbody>
</table>
Daily Written Reflection

Scientists pay close attention to when things change and when they are stable. If a scientist was looking at the Floating Paper Clip Device, when would she say things are stable? When would she say things are changing?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Make a drawing if it helps you explain your thinking. Label your drawing.
Writing a Scientific Explanation About the Floating Paper Clip

Directions:
1. Write a scientific explanation to answer the question below.
2. Use words from the Word Bank when you are writing.

<table>
<thead>
<tr>
<th>Word Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>attract</td>
</tr>
<tr>
<td>repel</td>
</tr>
</tbody>
</table>

Why does the paper clip float?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
Diagramming Balanced and Unbalanced Forces

Directions:
1. On each diagram, draw arrows to represent the direction of the force or forces acting on the paper clip.
2. Label each arrow with the name of the force.
3. At the top of each box, label each diagram either balanced forces or unbalanced forces.
Data Table: Forces on an Object

Directions:
1. Review the data in the table below and discuss it with your partner.
2. Analyze the data by talking about the patterns you notice.
3. You can use the sentence starters on the board to help you analyze the data.

<table>
<thead>
<tr>
<th>Object</th>
<th>Force 1</th>
<th>Force 2</th>
<th>Balanced or unbalanced?</th>
<th>Does the object start moving?</th>
</tr>
</thead>
<tbody>
<tr>
<td>paper clip</td>
<td>gravity (downward)</td>
<td>magnetic force (upward)</td>
<td>balanced</td>
<td>no</td>
</tr>
<tr>
<td>paper clip</td>
<td>gravity (downward)</td>
<td>none</td>
<td>unbalanced</td>
<td>yes (downward)</td>
</tr>
<tr>
<td>rope in tug-of-war game</td>
<td>touching force (pulling left stronger)</td>
<td>touching force (pulling right weaker)</td>
<td>unbalanced</td>
<td>yes (to the left)</td>
</tr>
<tr>
<td>kite on a string</td>
<td>wind (upward)</td>
<td>touching force of string (downward)</td>
<td>balanced</td>
<td>no</td>
</tr>
<tr>
<td>book held in hand</td>
<td>gravity (downward)</td>
<td>touching force (upward)</td>
<td>balanced</td>
<td>no</td>
</tr>
<tr>
<td>ball magnet</td>
<td>magnetic force (from a ring magnet)</td>
<td>none</td>
<td>unbalanced</td>
<td>yes (toward the ring magnet)</td>
</tr>
</tbody>
</table>
Chapter 1:

Request for Proposals (RFP)

International Disaster Aid is an organization that provides relief during natural disasters. One way it does this is by using helicopters to drop emergency supplies in areas that have been affected by natural disasters like earthquakes or floods. The emergency supplies must be packed in containers called supply pods that protect the supplies as they hit the ground. International Disaster Aid has issued a Request for Proposals (RFP) for the development of supply pods to hold emergency supplies as they’re delivered to people in need. Successful proposal designs will address the following three criteria:

1. Minimize cargo damage
   The supply pods must be designed so that they protect the supplies when the pod hits the ground. Broken or damaged supplies will not help the people who need them.

2. Maximize shell condition
   The shell of the pod should be reusable after the drop. If the supply pod has almost no damage, the whole outer shell may be used as a shelter for up to three people, protecting them from the sun and rain.

3. Keep costs low
   The cost of the pod must be low so that International Disaster Aid can help as many people as possible. The lower the cost of each pod, the more pods International Disaster Aid can build and deliver.

In addition to meeting the above criteria, the design of the supply pod should take into account the constraints, or limits to the possible solutions. These constraints include:

- Supply pod must be delivered by helicopter.
- Supply pod must be dropped from the same height for each test.
Chapter 2:

Collisions and Impact Forces

You may be familiar with collisions. These are events in which two objects hit each other, such as a bug hitting the windshield of a car or a soccer player kicking a ball. Every collision exerts an equal-sized force on each object involved in the collision. These forces can change the objects’ velocity, or speed in a particular direction.

A dropped supply pod hitting the ground is another example of a collision. Earth and the pod experience the same amount of force during the collision, but because Earth is so big, it’s barely affected. The pod, on the other hand, can be damaged by the force of the collision because it experiences a big change of velocity—to zero! Engineers are not concerned with how the collision affects Earth, so they focus on only one of the equal forces exerted during the collision: the force exerted on the pod. This force is called the impact force.

To keep the contents of the supply pod safe, engineers aim to keep the impact force as small as possible. The greater the force when the pod hits the ground, the more likely the materials are to break. Three factors affect the size of the force when the supply pod hits Earth: how long the collision lasts, the velocity of the pod on impact, and the mass of the pod.

Changing the Time of Collision

When a supply pod hits the ground, the collision seems to happen in no time at all. However, if we could use a special slow-motion camera, we could see that some collisions last longer than others. The longer the collision takes, the smaller the impact force on the object. It might seem strange to think that a longer collision would do less damage to the object, but that’s exactly what happens. This is why there are pads wrapped around the goal posts at football and rugby games—if a player collides with the post, the pads compress, or squish down, during the collision. Due to the padding, the time of collision is slightly longer, and the force is spread out over a longer period of time, making the player’s collision with the pole hurt less!
2. Click on the navigation tool in the upper left corner

3. Click on any of the three options

4. Click on the PARACHUTE in the upper right corner to launch the digital design tool.

1. Click on the FUTURA WORKSPACE APP
Egg Drop Design

Team Members ___________________________ Date __________

INSTRUCTIONS
1. Plan: Choose the materials for your Egg Drop Model. Sketch and label your initial design in the space below.
2. Build: Make your design.
   • Before you test, record the mass of your Egg Drop Model in the Plan and Build section below. Be sure your egg is inside!
3. Test: Bring your Egg Drop Model to the test site. After you test, record the results.
4. Analyze: Reflect on your design in the Design 1 Analysis (on page 2).

PART 1: DESIGNING AN EGG DROP MODEL

Plan and Build: Draw your design. Record your Egg Drop Model’s mass.

Mass of the Egg Drop Model (grams): _______

Describe your design:

________________________________________________________________________

________________________________________________________________________

Test Results: Record your results in the space below. Sketch or describe what happened to the pod and to the egg when it collided with the ground.

________________________________________________________________________

________________________________________________________________________
PART 2: ANALYZE YOUR EGG DROP MODEL

Design Successes: Which parts of your design worked? Why do you think they worked?

Design Failures: Which parts of your design did not work? Why do you think they did not work?

PLAN YOUR NEXT ITERATIVE TEST.

Draw and describe your revised design.

What would you change?

Why would you make these changes? Describe the science concepts that support your decisions.
### PLAN

**BUILD**

**Design Details**

**Shell**

**Padding**

- % Air Bags
- % Feathers
- % Metal Foam

**Add-On (Top)**

**Add-On (Bottom)**

**TEST**

**Test Results**

**Impact Force (N)**

**Mass (kg)**

**Velocity (m/s)**

**Shell Condition**

**Total Cost ($)**

**Cargo Damage (%)**

### ANALYZE