STEAM &Sports

Lesson 11 - Under Pressure

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Under Pressure

Concept

This lesson guides students through an engaging, hands-on exploration of air pressure and mechanical energy conservation, linking physics concepts to real-life applications and sports.

Learning objectives and Outcomes

Upon completion of this lesson, students will:

1. Know how the air pressure inside a ball affects its bounce height and energy transfer.
2. Understand the concept of the coefficient of elasticity and how it relates to the bounce height and pressure inside the ball.
3. Know how the law of conservation of mechanical energy applies to bouncing balls and how energy is lost during collisions.
4. Be aware of how different variables (e.g., surface type, initial height, pressure) and errors (e.g., measurement inaccuracies) affect experimental results.

Students will be able to:

1. set up and conduct experiments to investigate how varying the air pressure inside a ball influences its bounce height.
2. record and analyze experimental data using technology and calculate averages to account for variations.
3. to apply the concept of the coefficient of elasticity to their experimental data and use it to calculate and explain the observed results.
4. to relate their findings to practical situations, such as the importance of pressure in sports equipment, and suggest further experiments or modifications to enhance accuracy.

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Educational standards in connection with sports

Through this lesson on pressure and bounce dynamics, students connect scientific principles to their physical activities, enhancing their understanding, performance, and appreciation of sports while meeting science and physical education standards.

1. Students practice critical thinking and problem-solving skills in a physical education context.
2. Students recognize the scientific elements of physical activities they enjoy by exploring how ball dynamics affect sports performance.
3. Students understand how the air pressure of balls influences movement and performance in sports.

This lesson includes elements of these school subjects

1. Physics.
2. Physical Education.

Timeframe

The expected total duration of the lesson is 90 minutes

Students Age

12-15 years

Material needed

1. At least two footballs with adjustable air pressure.
2. Air pump for adjusting the pressure.
3. Meter stick or measuring tape.
4. Smartphones with slow-motion video capability.
5. Markers
6. Calculators

Short description of the content

In the "Under Pressure" lesson, students explore how the air pressure inside a football affects its bounce height. Through hands-on experiments, they will drop footballs with different internal pressures from a set height, recording the bounce height after each drop. Students will accurately measure and analyze the results to understand the relationship between pressure and bounce height. They'll also calculate the coefficient of elasticity and apply the law of conservation of mechanical energy. Students will connect these physics principles to real-life applications in sports, enhancing their understanding of how pressure affects sports performance.

Sequence of Lesson

1. Engage (10 minutes)

Begin with a demonstration using a deflated and inflated football. Drop them from the same height and let students observe the differences in bounce height.

Discussion Questions:

- What do you notice about the two footballs when they bounce?
- Why do you think the bounce heights are different?
- How might the air pressure inside the ball affect its bounce?

Encourage students to think about the role of air pressure in everyday sports equipment and connect it to the concept of energy.

2. Explore (25 minutes)

Conduct experiments to explore the relationship between air pressure and bounce height.

Divide students into small groups and provide each group with two footballs (one with high pressure, one with low pressure), a measuring tape (or meter stick), or a smartphone for recording videos.

Experiment.

- Students drop the balls from a set height □ and record the bounce height □ using their phones, or other ways to measure the height.
- Each group will repeat the experiment ten times to collect data, focusing on measuring the maximum height accurately. They can use measuring tapes or even their smartphones to make videos and determine the heights when the video is in slow motion.
- At the end of the experiment, students gather data, make table representations of the data and charts, and observe how pressure impacts the height of the bounce.

3. Elaborate (20 minutes)

Analyze the collected data and connect it to theoretical concepts.

When a ball is falling, it lands at a certain velocity concerning the ground, which is called its velocity of approach. After the elastic collision with the ground, the velocity of separation will have a different value from the velocity of approach because a part of the initial kinetic energy will be lost:

$$e=\frac{V_{separation}}{V_{approach}}$$

We use the law of the conservation of mechanical energy:

$$E_p=mgh_1=\frac{mV_{separation}}{2}=E_k \qquad E_p=mgh_2=\frac{mV_{approach}}{2}=E_k$$

To introduce the concept of the coefficient of elasticity e. From above we have. $e=\sqrt{\frac{h_1}{h_2}}$.

Link experimental observations with theoretical principles, demonstrating how energy is transferred and lost during the bounce.

Discuss how the ratio of bounce height □ to the initial drop height □ relates to this coefficient. Use the collected data to calculate the coefficient of elasticity for each ball.

4. Evaluate (15 minutes)

Evaluate students' understanding and provide feedback.

- Have students present their findings in small groups using visual charts, focusing on the differences they observed and how air pressure affected the bounce height.
- Discuss sources of error in their experiments (e.g., different surfaces, variations in pressure measurement, human error, and the importance of taking averages to account for these factors.

Assess students' ability to apply the concepts learned and their understanding of experimental variables.

5. Extend (20 minutes)

Expand the lesson and apply concepts to real-life scenarios.

- Ask students to brainstorm other types of balls (e.g., basketballs, tennis balls) or sports equipment where pressure might play a role in performance.
- Explore how changing the type of surface (e.g., grass vs. concrete) might influence the bounce height.
- Students can also discuss how the physics concepts learned relate to professional sports or practical scenarios (e.g., adjusting ball pressure for different playing conditions).

Encourage students to connect the experiment to broader contexts and consider real-world applications of the principles studied.

5. Extend (10 min) – Reflection & Real-World Connection

- Class discussion: "How can we use data to improve personal and school-wide health habits?"
- Students reflect on one personal change they can make based on the results.
- Option: Extend by tracking personal wellness habits over a week and analyzing trends.

Lesson Developer

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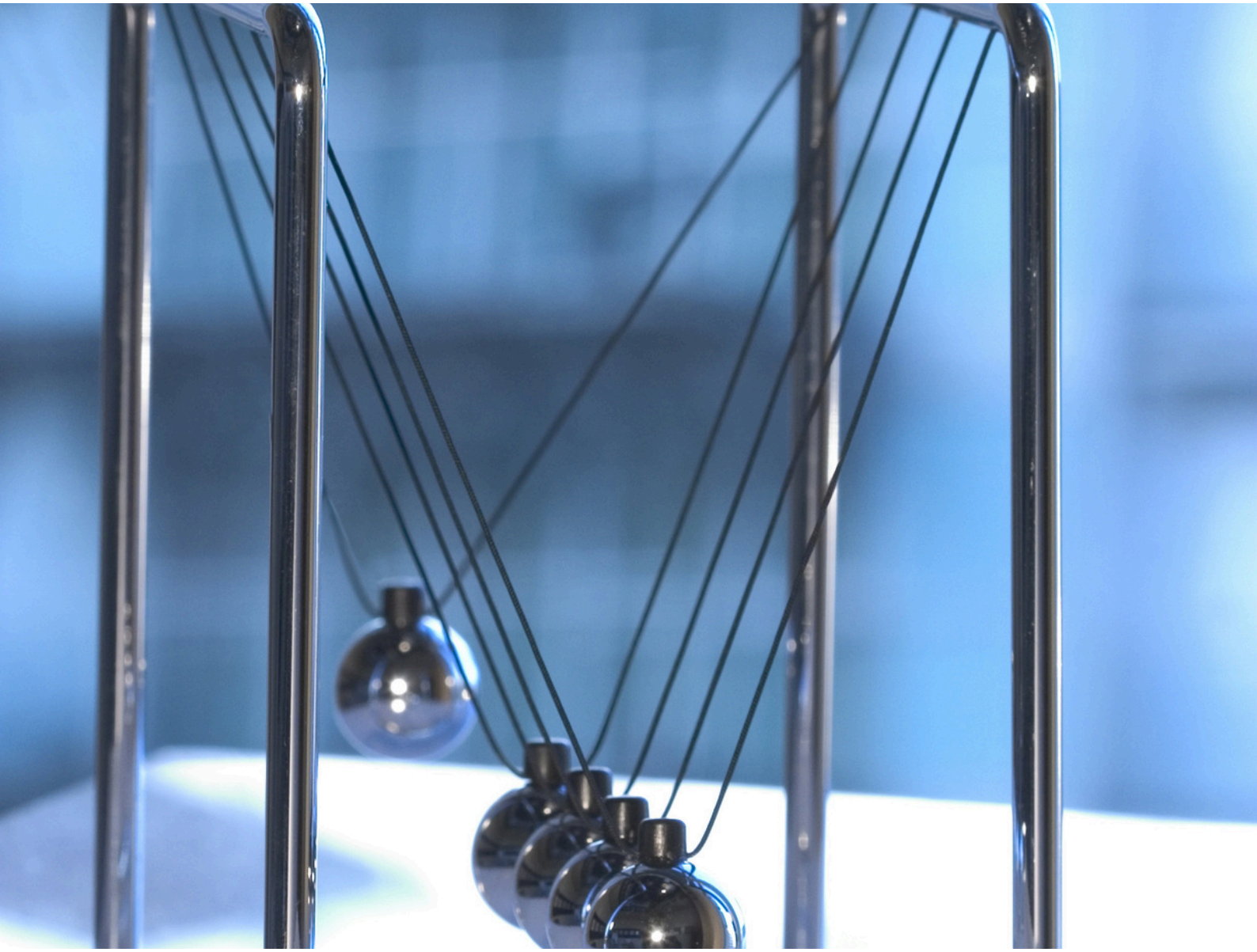

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Tips for age group differentation (for older/younger kids than indicated in the lesson)

Younger students (10–11):
- Focus on observation and discussion instead of coefficient calculations.
- Use stickers or visuals to represent height instead of numbers.

Older students (12-15):
- Ask students to derive formulas and connect them to kinetic energy equations.

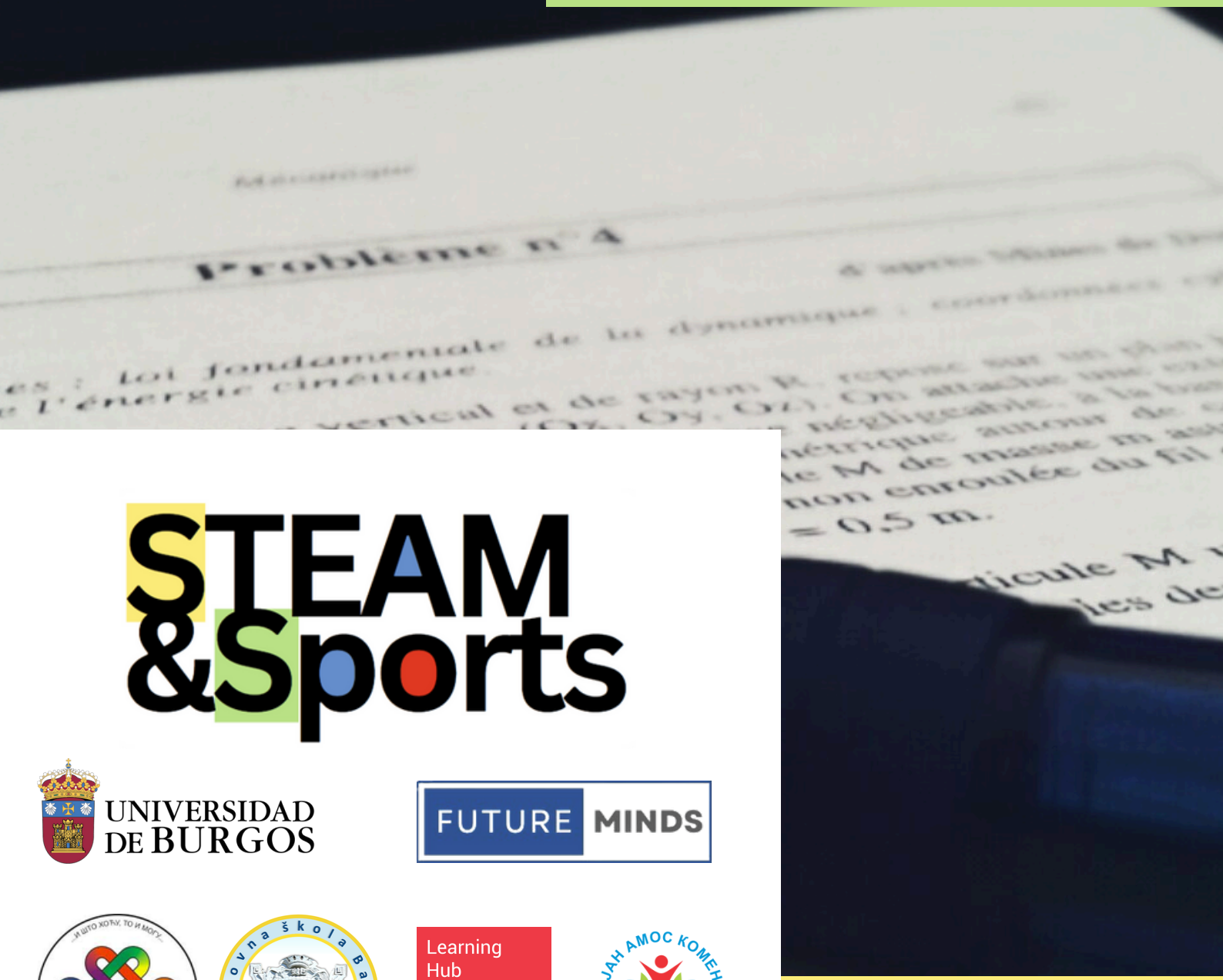
To which SDG(s) does the lesson relate most

SDG 4 – Quality Education
(by promoting inquiry-based science learning).

SDG 9 – Industry, Innovation, and Infrastructure
(by linking physics to real-world sports equipment innovation).

What Inclusivity and Accessibility measures can or should the teacher take for this lesson

1. Use role rotation to ensure all students engage, including those who are shy or need physical assistance.
2. Offer slower-paced alternatives for groups who need more time.
3. Ensure that physical materials (balls, measuring tools) are adapted for students with motor impairments.



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