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Physics Science in Motion

Elective 7: Reading and Writing in Science

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Was Einstein Wrong?

Read the following two articles:

- Lasers make measurement Einstein called 'impossible' – Physics World- while reading this article use the Learning Lens tool that is located on the sidebar of the resource, this is a great source on how to use text annotations. This will also help with the Cornell Notes
- Experiments Einstein could only dream of- while reading this article you can take notes on the Cornell Sheet to answer the focus questions.

Topics to focus on while reading-

- Why did it take so long to do these experiments?
- How does Brownian motion relate to position,velocity, and acceleration?
- How does Brownian motion relate to motion in two dimensions?
- Why is the topic of Brownian motion even an important topic for science?
- Compare the two articles to each other, was the information the same in both.
- Which article did you find the most interesting and why?

As you are reading these articles take notes on the Cornell Note sheet provided. Directions on how to complete the notes are also listed below.

Cornell Notes Directions

Cornell Notes-Blank

After completing the above activities working alone or in pairs, come up with a presentation about the article answering the discussion questions and the prompt “Was EInstein Wrong?”.

Lesson Standards

The Common Core English and Language Arts Standards:

- http://www.corestandards.org/ELA-Literacy/RST/11-12 -RST.11-12.6: Analyze the author's purpose.

6-12 Science Grade-Level Expectations- Missouri Department of Elementary and Secondary Education

- 9-12.PS2.A.3 Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

The Science and Engineering Practices that appear in the Next Generation Science Standards

- Practice 1: Asking questions.
  How is asking questions an important part of scientific research? Big questions help scientists to narrow and define important areas of research.

  What are some other "big questions" in science? Select one of your "big questions" and narrow it down to a question that could be investigated.

- Practice 8: Obtaining, evaluating, and communicating information.
  Scientific findings are often communicated through a research paper. The abstract is a place where scientists briefly discuss the questions they were asking and the results they obtained while doing so. What is the purpose of an abstract in a research paper? An abstract is a brief summary of an article, and is often used to help the reader quickly ascertain the paper's purpose. An academic abstract typically outlines four elements relevant to the completed work:
    A statement of the question being asked
    The research methods used
    The results/findings of the research; and
    The main conclusions and recommendations

- How is an abstract useful to another researcher in the same field?
  It gives a brief overview of the question and results so researchers can quickly tell if this research will be applicable to their own.

Teachers Expectation: To guide students during the reading process of the scientific article and help them become independent thinkers.

- Lasers make measurement Einstein called 'impossible' – Physics World- while reading this article the student's will use the Learning Lens tool that can be found on the sidebar of the resource, this is a great source to teach students how to use text annotations.

General Overview:
Sometimes, scientists have to wait for technology to catch up. Albert Einstein, arguably one of the greatest scientists in modern history, fell victim to this himself. While working on Brownian motion, Einstein proposed ideas that he did not yet have the tools to examine, prompting him to conclude that the instantaneous velocity of a Brownian particles would be impossible to measure in practice. Now, almost 100 years later, scientists have access to the tools necessary to measure the instantaneous velocity of a Brownian particle, proving Einstein wrong in the process.

Topics covered:
kinetic energy
motion of particles
Brownian motion
nondiffusive motion
mean square displacement
diffusion constant
Boltzmann's constant
Stokes friction coefficient.

Why this Research is Important:
Brownian motion is the movement of small particles that float in a liquid. Understanding how these particles move, and how they influence the movement of other particles around them, has implications beyond Physics, specifically relating to mathematics, neuroscience, and the stock market.

Methods used in the Research:
The trapping and monitoring of a silica bead in air and vacuum through the use of optical tweezers.

Conclusions:
The authors have directly verified the energy equipartition theorem of Brownian motion.

Work Cited

Authors Mark Raizen, and Mark Raizen. “Experiments Einstein Could Only Dream Of.” *Science in the Classroom*, www.scienceintheclassroom.org/research-papers/experiments-einstein-could-only-dream.

“Lasers Make Measurement Einstein Called 'Impossible'.” *Physics World*, 29 Aug. 2017, physicsworld.com/a/lasers-make-measurement-einstein-called-impossible/.