Measurement of Diamagnetism in Water

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Introduction

- Diamagnetic materials create magnetic fields that opposes an externally applied magnetic field.
- Water is a diamagnetic material[1]. However, the interaction is extremely weak, and visually noticeable effects can only be obtained using powerful superconducting magnets[2 3].
- In the past, demonstrations of diamagnetism in water using more accessible permanent magnets have been qualitative[4 5 6].

Goal

- The goal of the experiment was to quantify the diamagnetic effect of a permanent magnet on water using techniques accessible at a high school or introductory college physics level.

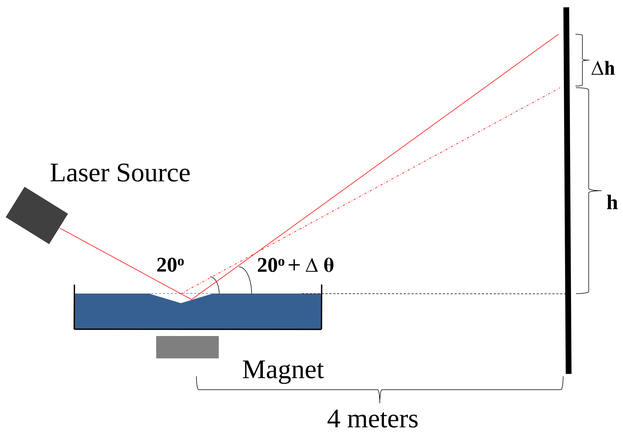
Theory

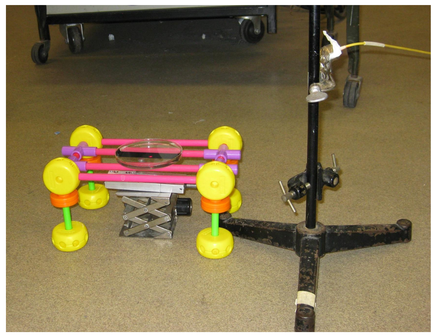
- Magnetic Energy Density [2]: $\mu = \frac{\chi B^2}{2\mu_0}$
- Gravitational Potential Energy Density: $\mu = \rho g \Delta h$
- By the law of conservation of energy, the two energies should be equal.

Methods

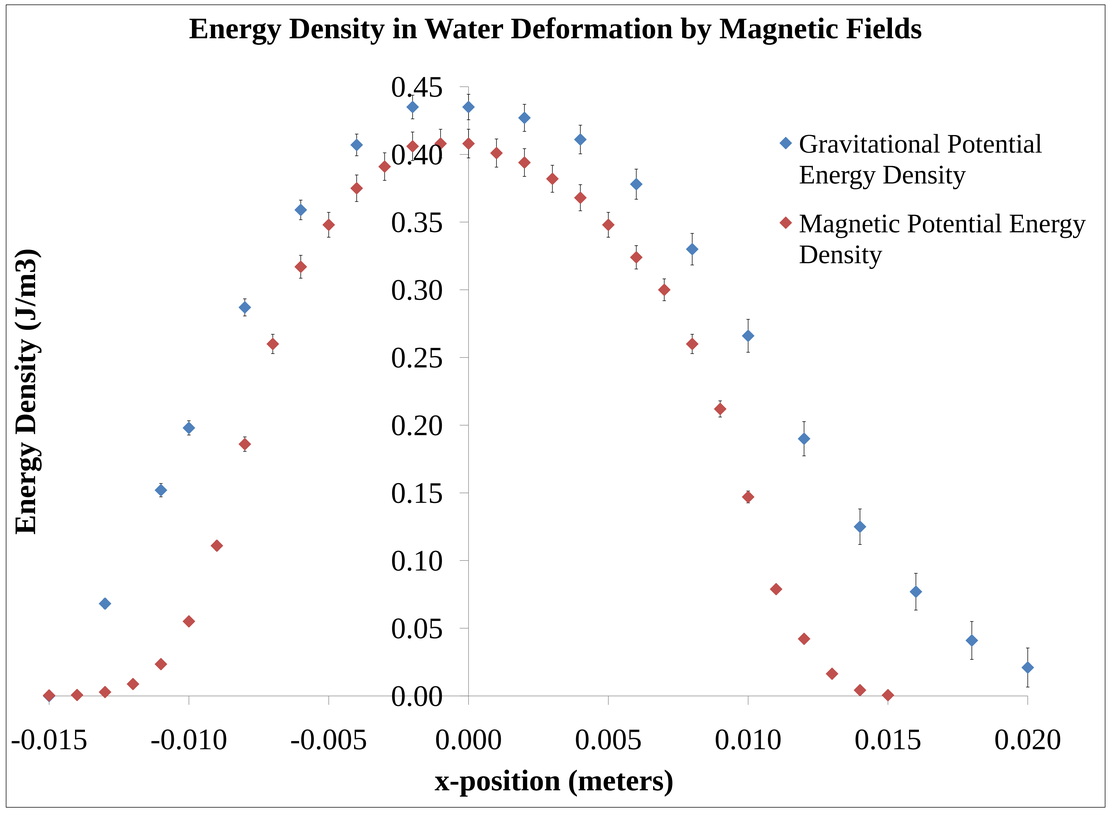
- A Petri dish was filled with water 0.25 cm deep. A neodymium (NdFeB) magnet was placed under the dish, creating a dimple in the water.
- A laser was reflected off the surface of the water, allowing us to measure the slope of the water. The position of the magnet was altered using a precision micrometer stage to obtain a profile of the dimple.
- The magnetic field profile of the magnet was measured using a gaussmeter. This allowed us to compare the energies of the magnetic interaction with the change in gravitational energy of the water.

Apparatus





Results



Conclusions

- At the maximum energy densities, the difference between the two energies is within two standard deviations.
- The magnetic field strength varies more than 5% for every 0.1 mm of variance in the measurement height, so the uncertainty on the magnetic measurements is likely underestimated.
- A better method for measuring the magnetic fields is required for an accurate comparison between the energies.
- The experiment shows that this method for measuring the diamagnetic effect is simple to carry out, precise, and can be accurate given some additional refinement .

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Acknowledgements

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