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Research Question: To investigate how the torsional oscillations of a suspended bar magnet over a fixed bar magnet change with spacing between the two magnets.

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Aim:
To see how the torsional oscillations of a bar magnet suspended above a fixed bar magnet changes with separation between the two magnet

I. INTRODUCTION:

The interaction between magnetism and mechanical systems has been a subject of scientific interest for centuries. This research focuses on studying the torsional oscillations of a suspended bar magnet over a fixed bar magnet and their relationship with the spacing between the two magnets. Investigating this relationship can provide valuable insights into the dynamics of magnetism and contribute to various fields, including condensed matter physics and mechanical engineering. Understanding how the spacing influences the torsional oscillations is crucial for developing precise models and applications involving magnetism.

Experimental Setup:
The experimental setup comprises a torsion balance system, a suspended bar magnet, and a fixed bar magnet. The torsion balance system consists of a thin rod with a torsion wire attached to it. The suspended bar magnet is affixed to the lower end of the torsion wire, allowing it to rotate freely. The fixed bar magnet is placed horizontally below the suspended magnet, and the spacing between the two magnets can be adjusted by varying the vertical position of the fixed magnet. The torsion balance system provides the necessary framework for observing and measuring the torsional oscillations.

II. METHODOLOGY:

1. Calibration: Before conducting the experiments, the torsion balance system is calibrated to establish the relationship between the angular deflection of the torsion wire and the applied torque. This calibration enables accurate measurements of the torsional oscillations.
2. Initial Positioning: The suspended bar magnet is positioned at an initial equilibrium point, ensuring stability. This can be achieved by aligning the magnet with the Earth's magnetic field or introducing an opposing magnetic field using a small magnet.
3. Measurement: The initial angular displacement of the suspended magnet is recorded, and the system is allowed to oscillate freely. The subsequent angular displacements and corresponding time intervals are measured and recorded for a specific period.
4. Varying Spacing: The vertical position of the fixed bar magnet is adjusted to change the spacing between the two magnets. Steps 2 and 3 are repeated for each spacing value, allowing the investigation of how the spacing affects the torsional oscillations.

III. HYPOTHESIS:

The torsional oscillations of a suspended bar magnet over a fixed bar magnet will exhibit a shorter period as the spacing between the two magnets decreases.

Table 1: Raw data table

Exp no	Distance between the two magnets d/m ±0.001	Time for ten oscillations T1/ s ±0.01	Time for ten oscillations T2/ s ±0.01	Time for ten oscillations T3/ s ±0.01

1	0.050	8.07	8.72	8.39
2	0.060	10.88	11.23	11.00
3	0.070	13.41	12.94	12.19
4	0.080	13.44	13.98	14.01
5	0.090	15.15	14.76	15.06
6	0.100	17.26	17.62	17.85
7	0.110	18.92	18.75	18.32
8	0.120	19.89	20.14	20.19

Here we see that as the distance between the magnets increases so does the time taken to complete one oscillation

They might be directly proportional
The graph will then be of the type

y=mx+c

Where y is the time taken for each oscillation k
m is the gradient of the graph
x is the distance between the magnets
and c is the y intercept

Using the calculations below the values of m and c can be found
The time taken for ten oscillations is measured to reduce the error
This time is divided by ten to get the time period of a single oscillation
The second table shows this

Table 2: Time taken for a single oscillation

Exp no	Distance between the magnets d ±0.001	Time for one oscillation T1/10 ±0.01	Time for one oscillation T2/10 ±0.01	Time for one oscillation T3/10 ±0.01
1	0.053	0.805	0.872	0.839
2	0.061	1.093	1.125	1.101
3	0.079	1.347	1.293	1.214
4	0.084	1.347	1.392	1.405
5	0.093	1.513	1.475	1.507
6	0.105	1.725	1.767	1.788
7	0.113	1.890	1.878	1.833
8	0.126	1.984	2.013	2.016

Using the time periods for single oscillations the average time period as well as the error in the time period can be found.

Table 3: Average time for a single oscillation and the error in each

Exp. No	Distance between the magnets d /m ±0.001	Average time period/ s ±0.01	Error in the time period
1	0.050	0.84	±0.044
2	0.060	1.11	±0.065
3	0.070	1.26	±0.087
4	0.080	1.33	±0.023
5	0.090	1.46	±0.057

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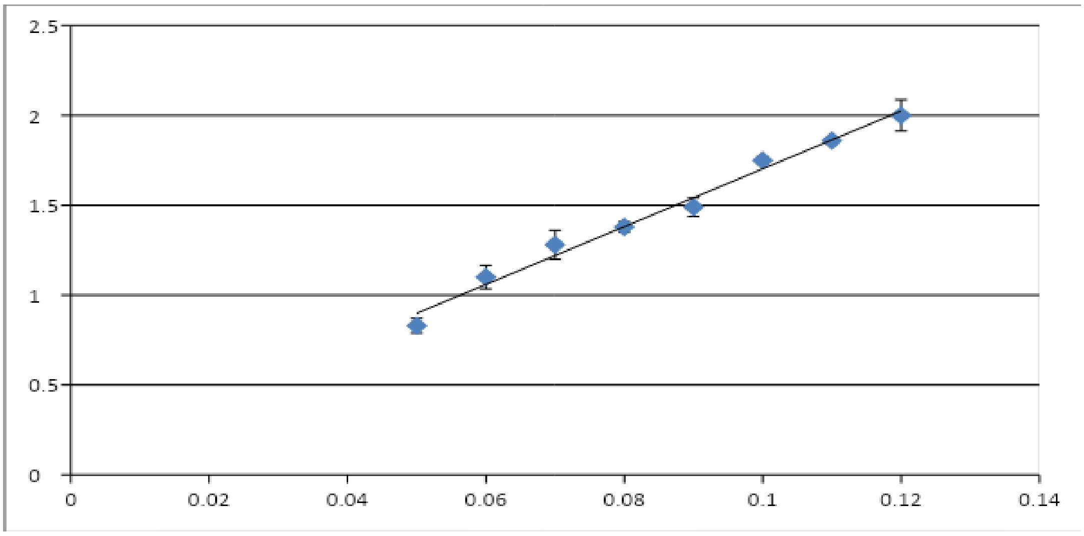
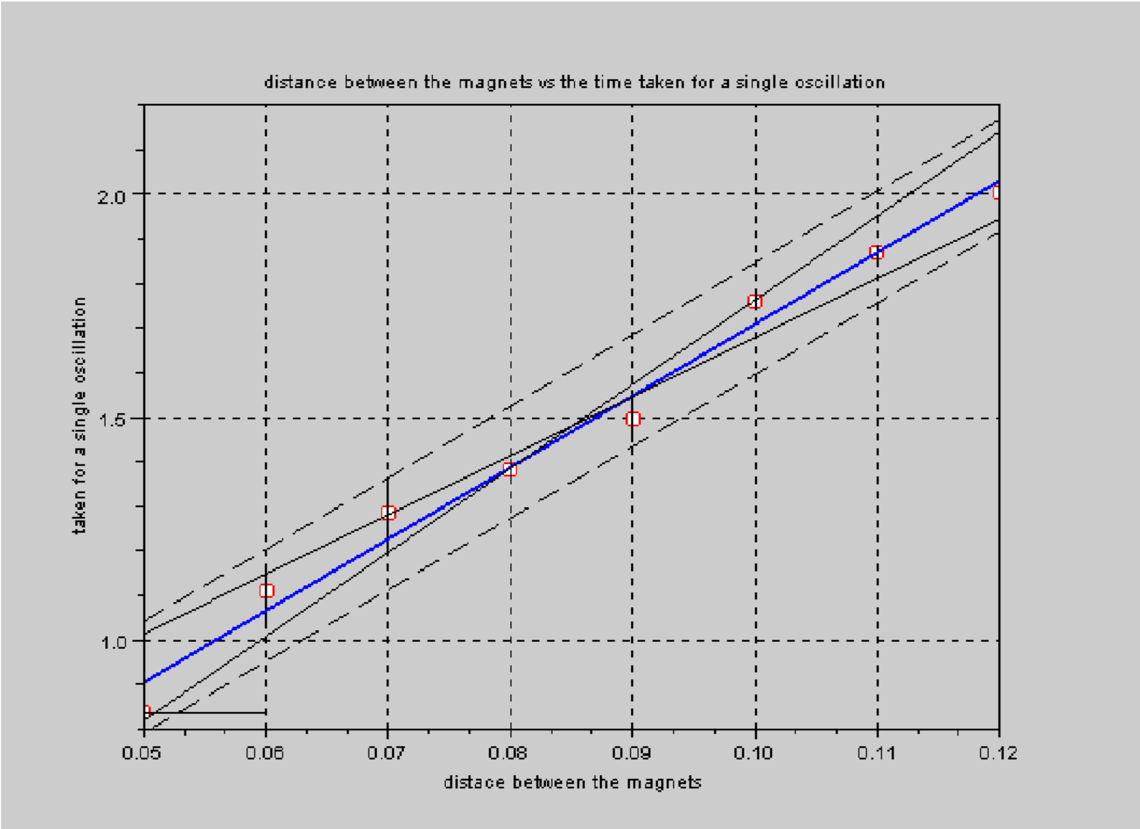
6	0.100	1.78	±0.026
7	0.110	1.83	±0.018
8	0.120	2.08	±0.082



Graph 2: distance between the magnets vs the time taken for a single oscillation



Input vector of x values: [0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12]

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Input vector of y values: [0.83833333 1.109 1.283333 1.38066 1.49666 1.759 1.86966 2.00366]
Input vector of errors in x direction: [0.01]
Input vector of errors in y direction: [0.041654022 0.0658768 0.08048 0.02865 0.05291 0.021411 0.018088 0.087]
Input the title of your graph: "distance between the magnets vs the time taken for a single oscillation"
Input the x label of your graph: "distace between the magnets"
Input the y label of your graph: "taken for a single oscillation"

Slope of the best fit line: 16.0757
Slope of extreme fit line 1: 18.863899
Slope of extreme fit line 2: 13.2875

The error in the value of the gradient is the slope of the extreme fit line 1- slope of the worst fit line
18.863899 -13.2875 2
=2.7822
Thus the gradient is 16.0757 ± 2.7822

Using points on the graph the value of the y intercept can also be using points on the graph

Since it is a line in the form y=mx+c
Where m is the gradient that is 16.0757
X is the distance between the magnets
And y is the time period for a single oscillation

Using the point (0.08, 1.38) we can find the value of the y intercept
Since according to the graph drawn by SciLab it falls on the graph

Distance between the magnets d ±0.001	Average time period
0.08	1.38

1.38=16.0757 (0.08)+c
1.38=1.286056+c

c=0.093944

IV. CONCLUSION:

We can find the percentage error in this gradient

2.782216.0757X 100

17.3419 %

Thus the gradient is 16.0757 with a 17.34% error

The graph is a straight line graph of the type y=mx+c

Using the graphs the gradient was calculated to be 16.0757 the y intercept was 0.093944

But this straight line graph is not appropriate since after a certain distance between the magnets the torrisional oscillation will stop and there will be no value of T

Thus for very large values the equation cannot be used

V. LIMITATIONS:

- The experiment was carried out only 3 times, this leaves some room for error
- The strength of the two magnets was unknown and if they are different it will affect the torisional oscillation
- The length of the thread was measured and since the thread moved it cannot have been very accurate
- The stop clock was stopped after ten oscillations but since they moved fast there might have been a time gap which resulted in the time being different
- There might have been a wind which might have exerted a force on the magnets effecting the oscillation

Scope for improvement:

- The magnet could have initially been oscillated about 15 times so the reading of the time period for a single oscillation could have been more accurate
- The length of the magnets could have been further separated to about 0.3 m to see when the magnets will stop attracting each other altogether
- The gradient could have been calculated by multiple methods to find the best value for m
- Instead of only using an equation to find the y intercept, technology could have been used to extrapolate the graph and get the accurate value
- The experiment could be conducted again with a different set of bar magnets of same strength to check of the values are similar

VI. RESULTS:

The experimental results demonstrate a clear correlation between the spacing and the torsional oscillations of the suspended bar magnet.

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As the spacing between the magnets decreases, the period of torsional oscillation decreases as well. This observation indicates that the proximity of the magnets influences the strength of the torque acting on the suspended magnet, leading to changes in the oscillation behaviour.

VII. DISCUSSION:

The observed relationship between spacing and oscillatory period can be attributed to the changing magnetic field strength and the resulting torque experienced by the suspended magnet. As the spacing decreases, the magnetic field from the fixed magnet becomes stronger, resulting in an increased torque and a decrease in the period of torsional oscillation. It is crucial to consider other factors, such as the magnetic properties of the magnets, the torsion wire's strength, and any damping effects present in the system, as they can impact the observed behavior.

VIII. CONCLUSION:

This research paper investigated the torsional oscillations of a suspended bar magnet over a fixed bar magnet with varying spacing. The findings revealed a significant dependence of the oscillatory period on the spacing between the magnets. Understanding this relationship contributes to our understanding of magnetism and its interaction with mechanical systems. Further studies can explore different magnet configurations, magnetic field strengths, and additional damping mechanisms to deepen our understanding of this phenomenon.