**2. Coupling constant**

* 1. **AIM**

1. To determine the effect of coupling strength on the normal mode frequencies of a coupled oscillator.
   1. **PRINCIPLE**

Any oscillation of a coupled system can be expressed as a superposition of normal modes. The normal modes and their frequencies were observed and measured in the previous experiment. The in-phase frequency was equal to the frequency of the un-coupled oscillator and the frequency of the out-of –phase depends on the coupling length. Equation for coupling strength is giving by this.

Here

* 1. **EQUIPMENTS REQUIRED**

Table I : Equipment and the items required for performing the experiment.

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Required item** | **Utility** |
| 1 | gravity pendulums(2) | To be used as coupled pendulums |
| 2 | Spring(1) | The spring used for coupling |
| 3 | Rotary motion sensor(2) | To sense the movement of pendulums while in motion |
| 4 | Data logging Interphase(1) | To record values and for graphical representation of data |



Figure 1: coupled pendulum apparatus

* 1. **PROCEDURE**

Three physical quantities need to be measured in this experiment – time ,mass and length.

Make the following table –

Table II : The details of the physical quantities to be measured.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| S.No | Physical quantity | Independent /  Dependent | Measured  with | Measuring instrument’s | | |
| Minimum | Maximum | Least count |
| 1 | Time | dependent | stopwatch |  |  |  |
| 2 | Length | Independent | Meter scale |  |  |  |
| 3 | Mass | independent | Weighting machine |  |  |  |

1. Measure the spring constant of the coupling spring. (Remember the first semester experiment). Record the data in a table.
2. Refer to experiment 1. Procedure for measuring the normal mode frequency is described there.
3. Start the experiment by attaching the coupling spring at the topmost position.
4. Measure the normal mode frequencies.
5. Repeat the measurement of normal mode frequencies by attaching the coupling spring at different positions.

**How to measure spring constant :**

1. It can be found from the slope of the graph
2. Slope =

So

K=

b

Table III: normal mode frequency measurement.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S.No.** | **Coupling length** | **In phase** | | **Out of phase frequency** | |
| **Time period** | **Frequency** | **Time period** | **Frequency** |
|  | **In cms** | **seconds** |  | **Rad/s** | **Rad/s** |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 10 |  |  |  |  |  |

**Plot the following Graph**

vs

* 1. **STUDY QUESTIONS**

1. What happens if the coupling spring is replaced by a thread?
2. Why is first normal mode frequency same as the frequency of individual pendulum?
3. What happens if the masses are unequal ?
   1. **FURTHER SCOPE OF EXPERIMENTS**
4. Perform the FFT of the time vs angular displacement graphs.
   1. **PRECAUTIONS**
5. Avoid the use of fan while doing the experiment to reduce the interference of the wind.
6. Be careful while handling the Gravity pendulums, which are heavy, to prevent injuries.
   1. **SOURCES OF ERROR**
7. Inaccuracy in the measurement of time.
8. Mass of spring is not taken into consideration.
9. The inaccuracy in the displacement of the Gravity Pendulums by equal distances.
   1. **THEORY**

**2.11 FURTHER READING AND RESOURCES**

**Text books**

Book - Gardner, Robert, 1990. *Famous Experiments You Can Do.* New York, NY: Franklin Watts (pp. 103–104).

**Internet**

Internet -Blauch, D., 2004. "Gas Laws: Pressure", Department of Chemistry, Davidson College [accessed January 23, 2006]  <http://www.chm.davidson.edu/ChemistryApplets/GasLaws/Pressure.html>

**Java apps/apps**

University of Colorado, B. (n.d.). *Masses & Springs*. Retrieved from PhET Interactive Simulations: [**https://phet.colorado.edu/en/simulation/mass-spring-labA**](https://phet.colorado.edu/en/simulation/mass-spring-labA)

**Videos**

1. Andersen, P. (2014, August). *Simple Harmonic Motion, Bozeman Science*. Retrieved from YouTube: <https://www.youtube.com/watch?v=tudxily5Qu0>
2. Lewin, W. H. (1999). MIT 8.01 Physics I: Classical Mechanics, Fall 1999. *Lecture 10: Hooke's Law - Springs - Simple Harmonic Motion - Pendulum - Small Angle Approximation*. Retrieved from Internet Archive:<https://ia601409.us.archive.org/6/items/MIT8.01F99/10.mp4>

**Bibliography**