Harmonic Motion — Torsionally

Buffalo State College, July 9–12, 2017.

One or Two set-ups available

Host and Mentor

David Van Baak (B.S. 1973, Calvin College; M.A., 1975, Ph.D. 1979, Harvard University) is Professor Emeritus of Physics at Calvin College. His academic career included teaching and developing in the advanced-lab at Calvin College from 1980 through 2014; and since 2005 it has included collaborations with TeachSpin. One of those was a development project for the Torsional Oscillator featured in this Immersion, specially developed to match the needs of teaching physicists, and deliberately designed to be seen and touched, and to operate at visibly low frequencies. Another design goal was to create 'linear damping' that could be varied continuously from very low, to critical damping (and beyond); we also found a way to change the damping from v1 to v0 or ≈v2 laws. Finally, we found ways in which any parameter used to describe the system could be measured by two or more independent methods. We were pleased that the system which emerged could also be used to study more exotic phenomena, such as coupled oscillators or parametric drive. In the process, we confirmed that for physicists, there's no better way to understand a concept than to work with it in hands-on fashion.

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The harmonic-oscillator problem is perhaps the most generally-applicable model system in all of physics, and this workshop introduces attendees to the wealth of topics that can be taught, and learned, about this system via hands-on investigation. The results obtained in this table-top investigation then apply to any system that can be modelled as a damped, driven, harmonic oscillator. The system under investigation also forms a fine instance of a 'linear system' described by a transfer function, another concept of extremely wide applicability.

The apparatus chosen is an electro-mechanical harmonic-oscillator system using (for convenience) a torsional degree of freedom, in which a variety of damping laws, and an entirely general driving torque waveform, can be introduced. In addition to reinforcing concepts in the statics and dynamics of 1-d rotational motion, the TeachSpin Torsional Oscillator we use permits variation of the rotational inertia, and the restoring-force constant, of the oscillator.

The ‘drive’ and the ‘read-out’ of this oscillator are both electronic signals of low (~1 Hz) frequency, and ordinary signal generators and oscilloscopes are the preferred tools for interacting with the oscillator. Particpants will use the TeachSpin oscillator to measure, statically and dynamically, the parameters of the system, and will learn to compare observations with theory. In particular, the transient response, and the steady-state response to sinusoidal drive, can be investigated in detail; both the magnitude response,

and the phase shift, can be measured as a function of frequency, and compared with expectations for resonant behavior.

Participants ought to bring a laptop and/or notebook, and optionally may bring their own oscilloscopes if desired. Replication of this Immersion costs about $3600, assuming ordinary lab tools are available.

Please note that the Jonathan F. Reichert Foundation has established a grant program (ALPhA webpage; Foundation website) to help purchase apparatus used in Laboratory Immersions. Limitations and exclusions apply, but generally speaking the foundation may support up to 40% of the cost of the required equipment.
