# Probing Students' Understanding of Resonance

Sytil Murphy, Dyan McBride, Josh Gross and Dean Zollman

Kansas State University

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## Motivation

To investigate how students apply the knowledge learned about resonant systems in the traditional context of a pendulum to the novel context of a compass in a magnetic field.

## Novel Resonance System

The torque on a compass with moment of inertia, I, and magnetic dipole moment, m, due to an external magnetic field, B, is given by:

$$\vec{\tau} = I\vec{\alpha} = \vec{m} \times \vec{B}$$

The natural frequency is given by:

$$f = \sqrt{\frac{mB}{I}}$$

Resonance is achieved by tapping the switch at the natural frequency of the compass, typically around a couple of Hz.

## Methodology

- Teaching and learning interviews[1]
- Activity-based
- Post-test questions
- Eight K-State REU students
- Phenomenographic data analysis

## Student Responses in the Traditional Context

• After looking at the length dependence of the pendulum's period, one student commented:

*"I think it was faster when it was shorter, which makes sense if you think about it with the planets, because the ones that are closer to the sun have got shorter periods ..."*

## Student Responses in the Novel Context

• After looking at the dependence of a compass's frequency placed 2-3 cm above the wire, one student commented:

*"They should be the same, because it said that amplitude doesn't matter ... like it doesn't matter how far you pull back the pendulum. ... it should still have the same frequency..."*

• *After looking at the dependence of a compass's frequency with a bar magnet placed various distances from it:*

*Student 1: "The frequency of the compass has to depend on the magnetic field, might be similar in a way the pendulum was dependent on the length of the string."*

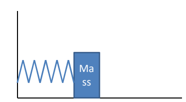
*Student 2: "...it's the strength of the field that determines the strength of the force, the torque on the needle. ... I guess I can think about it in terms of the pendulum. If you increase gravity, then intuitively the pendulum is going to swing faster because it's more attracted to the center of the Earth"*

## Student Responses to the Post-Test Questions

• The "apparatus" you worked with today has been taken by scientists to the newly discovered Planet X. Planet X has a weaker magnetic field than the Earth. Will this affect the frequency of the compass being used? Why do you think so?

*"The period of a pendulum depends on gravity, and since the oscillation of the compass are acting as a pendulum, it will also depend on the external magnetic field."*

• Pictured below is a mass on a spring. Is this a resonant system? How do you know?




*"(After reorienting the system vertically) When the mass on the spring was set into an oscillating up and down motion and an outside force pushed the mass at the same frequency as the spring, then it would be a resonant system."*

## Preliminary Conclusions

Students were able to apply previous learning to the magnetic resonant system with the following:

- Resonant frequency for the pendulum is independent of initial amplitude and therefore for the compass
- The static magnetic field for the compass has the same role as the gravitational field for the pendulum, and
- Understanding the meaning of a resonant system

## References

1. P. V. Engelhardt and E. G. Corpuz. "The Teaching Experiment – What it is and what it isn't." in *Physics Education Research Conference.* 2003. Madison, WI.