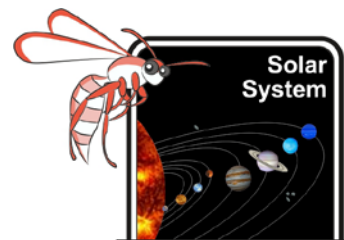# Harmony of the Spheres – Teacher Notes

Ancient philosophers and musicians noted that the length of a string when it is plucked controlled the note produced. They also noted that certain notes played together produced beautiful harmonies (*harmonia* means 'joining' in Latin). This inspired people to think about mathematics as the basis of music and whether numbers had special powers.

Task 1: Musical notes depend on the length of string plucked

Let's examine the idea that mathematics and music are linked by testing whether the length of a string (which we can measure) affects the musical note it makes when plucked.
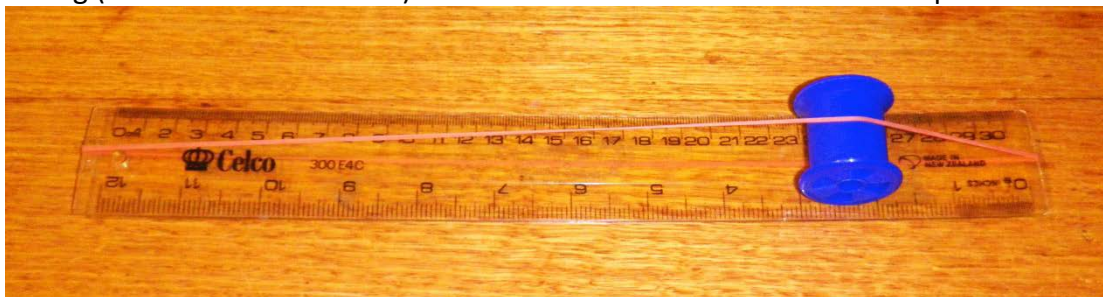
Materials
- A ruler
- An elastic band
- An eraser or other small solid object that can be placed under the elastic band. I used a cotton reel.

Method
1. Stretch the elastic band lengthwise over the ruler.
2. Insert the eraser under the stretched elastic band.
3. Slide the eraser up to the right end of the band and pluck the left hand side of the band.
4. Progressively move the eraser left plucking the left hand side of the band
5. Observe any changes.

Observations
What happens as the eraser moves to the left?
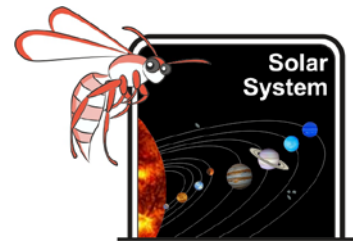The note produced became progressively higher.

On the picture of a harp, mark which string would produce the
lowest note when plucked.
The longest string

Option
You (or a musical student) could produce a musical scale on this instrument and demonstrate the underlying mathematics using scale measurements of the ruler.

Task 2: Testing the idea of "harmony of the spheres"

The philosopher Pythagoras (580 – 500BC) and his disciples believed the Earth and the other planets circled around a big central fire. Pythagoreans also believed that the distances between the Earth and other heavenly bodies were scaled to musical intervals and created music. They had no simple measurement to check if this was correct, but we can try to test this idea today using the planets which are visible by the naked eye: Mercury, Venus, Mars and Saturn.

Materials
- Access to books or the internet to find out the distances of the other planets observed by ancient astronomers.
- A ruler (30cm)
- Large elastic band
- An eraser or other small solid object that can be placed under the elastic band.

Method
1. Determine the distance of each planet from the Sun and fill it into the table below. Since planets have elliptical orbits their distance from the Sun varies. I have used measurements when are all at perihelion (when they are furthest from the Sun).
2. Work out the distance this would be scaled down to a 30 centimetre ruler. Each centimetre on the ruler represents roughly 45 million kilometres.

Planet	Distance from the Sun (millions of kilometres)	Distance along band (centimetres)
Mercury	45.9	1.02 (45.9/45)
Venus	107.4	2.39 (107.4/45)
Earth	147	3.26 (147/45)
Jupiter	740.9	16.46 (740.9/45)
Saturn	1,347	29.93 (1,347/45)

3. Stretch the elastic band lengthwise over the ruler.
4. Insert the eraser under the stretched elastic band.
5. Slide the eraser up to the right end of the band so that its right side is the distance from the end of Mercury, pluck the left hand side of the band and listen to the sound it makes.
6. Progressively move the eraser left, to the distances of each of the other planets, plucking the left hand side of the band
7. Observe any changes.

Observations

Does this observed and measured data above support or disprove the idea of "The harmony of the spheres"?
It disproves this idea.