Lesson 45: Resonance

If we look at examples of SHM we may find that we can come up with some interesting effects. Imagine pushing a child on a swing. How do you make her go higher?

- Well, you make sure that you time your pushes so that you push in sync with the way she is already swinging.
    - If you push randomly (out of sync), then the child will never go very high.
    - This causes the simple harmonic motion of the child to have an increasing amplitude. We give this kind of "in sync" motion the special name "**resonance**."

Resonant Frequency & Forced Frequency

From the last lesson you learned that the only thing that changes the period of a pendulum is its length.

- Even if we change other things, like the mass on the end of the pendulum, the period will stay the same.
- Every pendulum that has the same length has the same period, and also the same frequency.
- This particular frequency is the natural frequency that the pendulum will always swing at.
    - This particular frequency is the **resonant frequency** of the pendulum.

This is like the example of the swinging child above.

- The important thing is that if you just walk away from the child on the swing, eventually the swing will stop.
    - This is because over time friction will cause energy to be drained out of the system until it stops.
- In order to keep the child swinging, you must continue to push her at the natural **resonant frequency** of the swing.
    - By doing this you are constantly adding energy back in to the swing to replace the energy that was lost due to friction.
- Since this is required to force the swing to keep on going, it is called the **forced frequency**.

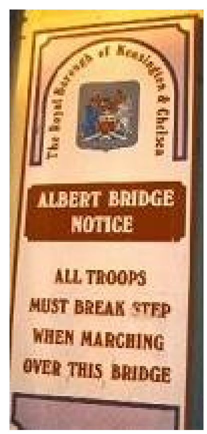
Mechanical Resonance

You may have noticed that once you get a child swinging on the swing, it is really easy to keep the child swinging.

- That's because all that is needed is to replace that little bit of energy that is being lost to friction.
- As long as your **forced frequency** exactly or closely matches the **resonant frequency** of the swing, it will continue or even go higher very easily.
- In fact, if the two match exactly then the amplitude of the swing can easily become very large very quickly.

DID YOU KNOW?

According to legend, a large number of Roman legionnaires were moving from one location to another by foot. They had to cross a rather large bridge to get across a large river. As they crossed the bridge, they continued to walk as every good soldier is trained to… in sync. ***Left, right, left, right, etc.*** You can imagine that this started some waves shaking through the bridge. Unfortunately for the legionnaires, they were walking in just the right (or I guess from their view, wrong) way that the fofrced frequency of their feet matched the resonant frequency of the bridge. The mechanical resonance caused the bridge to collapse. Most of them died from the fall or drowned in the water.



    - You might have heard of someone singing to break a wine glass. It is recorded as having been done, and although the singer needs to sing loud enough to produce enough energy, it is the frequency that is so special. It is most important to sing at a **forced frequency** that matches the **resonant frequency** of the glass.
- Examples such as this, where there is an exact match, are referred to as **mechanical resonance**.

Mechanical resonance is a very real concern for people designing and building large structures.

- If it is not taken in to account then the entire structure could collapse.
- It might seem that you need to make the structure stronger, more solid.
    - This is not the case. It is better to build the structure to have some flexibility in order to absorb and release the energy without breaking.
- Sometimes if you are standing still in a large building you might feel these vibrations momentarily.

For more information...

Do a search on the internet for the "Tacoma Narrows Bridge" to see an extreme example of modern day resonant frequency. This bridge fell apart because the winds blowing across it matched its natural resonant frequency. You can watch a brief video of "Galloping Gerdy" (as the bridge was called) bouncing around by clicking here .