Resonance Experiment – bouncy tube

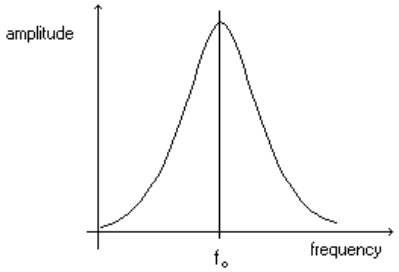
Theory

The time period for free oscillations of a uniform tube immersed in water to a depth, *l* is given by a familiar s.h.m. equation:

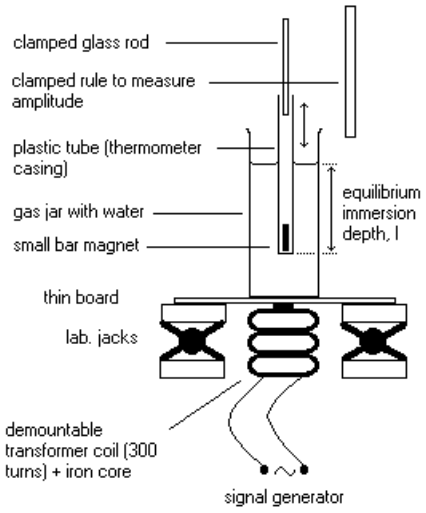
$$T = 2\pi\sqrt{\frac{l}{g}}$$

However, the oscillations are very heavily damped, making an accurate determination of T difficult.

If the tube is forced to oscillate, it will exhibit the phenomenon of **resonance**, when the driving frequency is equal to the natural frequency, f_0.



Apparatus



Method

Set up the arrangement shown in the diagram. The signal generator will need to be set on a low frequency to get any response from the tube. Also the amount of water in the gas jar is critical: too much and the bar magnet will not be close enough to the electromagnet, too little and the tube will hit the bottom of the gas jar at resonance.

Once you have found settings that give an acceptable resonance, leave the signal generator output (amplitude) constant. Vary the frequency of the signal generator and observe the amplitude of the resulting oscillations. This is difficult to do accurately – it is easier to measure the range of movement of the tube (2 x amplitude) and repeat readings will be necessary. Also, do not rely on the accuracy of the signal generator scale – the frequency is best found by timing the oscillations.

You will also need to determine the equilibrium immersion depth of the tube. This is best done by measuring the tube length above the water, and subtracting it from the total length – why?

Processing of results

For each setting, work out the frequency from the average time period (f = 1/T).

Now plot a graph of amplitude against frequency and draw a best-fit resonance curve. Determine the resonant frequency, f_0 from the graph and convert this back into the corresponding time period.

According to theory, the resonant frequency is the same as the natural frequency, and so the time period should be given by the equation in the theory section:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Use this equation to calculate a value for 'g' from the time period and immersion depth.

Conclusion and Discussion

Did the experiment perform as expected? How does your value of 'g' compare with the standard value and the values you have obtained in previous experiments? Considering the sources of error in the measurements you have made, is this reasonable?