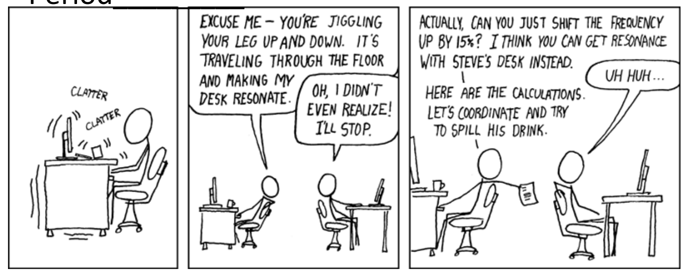
Name______________________________________
Period____

Lesson 14: Simple Harmonic Motion and Resonance



14.1 Experiment: Period of a Pendulum

(a) Release the pendulum from a small angle and time the period (T) of oscillation (the time it takes to get back to the same point in its repeated motion).

$T_{\text{small angle}}$ = ______________ seconds

(b) PREDICT: What would happen to the period if the angle (and therefore the Amplitude) is increased?

(c) Now test it out. Release the same pendulum from a larger angle. What is its period now?

$T_{\text{large angle}}$ = ______________ seconds

(d) What effect did changing the amplitude have on the period of the pendulum?

(e) PREDICT: What would happen to the period if the mass of the pendulum bob is decreased?

(f) Now add mass and try again.

$T_{\text{larger mass}}$ = ______________ seconds

(g) What effect did changing the mass have on the period of the pendulum?

(h) PREDICT: What would happen to the period if the length of the pendulum is decreased?

(i) Now decrease the length of the string and try again.

$T_{\text{shorter string}}$ = ______________ seconds

(j) What effect did decreasing the length have on the period of the pendulum?

"See? I told you our yard was too small for a swing set."

(k) What factors affect the period of a pendulum?

*To calculate the period of a pendulum, use the equation $T_{pendulum} = 2\pi\sqrt{\frac{l}{g}}$ where l is the length of the pendulum and g is the gravitational acceleration. Similarly, the period of a mass oscillating on a spring is $T_{mass\text{-}spring} = 2\pi\sqrt{\frac{m}{k}}$ where m is the mass and k is the spring constant.

14.2 Experiment: Driven Pendulum

For this experiment, you will need a pendulum and a folded small sheet of paper.

(a) Hit the pendulum at a rate of 4Hz (about four times a second – it should seem pretty fast). Fold the small sheet of paper such that the force on the pendulum will be very small. What does the pendulum do in response? Describe your observations.

(b) How can you use the same small force (the paper) to get the pendulum going higher?

(c) Try a different method this time. Using the same small force, wait until the pendulum bob comes back to the side and hit it again, but only when it is at that point in its swing! It should happen at pretty regular time intervals. What happens this time

(d) What is the main difference that causes the pendulum to increase its amplitude rapidly?

*Resonance is the rapid increase in amplitude when driven at the object's natural frequency.

14.3 Standing Waves and Resonance

(a) Stretch a long spring between two lab partners. Have one lab partner hold the spring rigidly without moving at all (a "fixed end" of the spring) and the other will move that end of the spring up and down. Try moving the spring up and down at a rate of about 0.25 Hertz (about once every 4 seconds). This should seem very slow. What does the spring do?

What happens to the amplitude of the spring waves?

(b) Now try to make one "loop" in the spring. What did you have to do to make this happen?

(c) Calculate the frequency:

cycles = ___________

time for that many cycles = ____________ s

freq. = #cycles / #seconds = ____________________ Hz

(d) Now try to make two loops in the spring. Calculate the frequency this time:

cycles = ___________

time for that many cycles = ____________ s

freq. = #cycles / #seconds = ____________________ Hz

(e) Compare the frequency for two loops to the frequency for one loop. Which is larger and by how much?

(f) Now try to make three loops in the spring. Calculate the frequency this time:

cycles = ___________

time for that many cycles = ____________ s freq. = #cycles / #seconds = __________________ Hz

(g) When the “loop” patterns form, the amplitude is automatically increased.
Can you make “loop” patterns in the spring at *any* frequency? Which frequencies work?

(h) How does your answer to the previous question relate to resonance?

14.4 Resonance and Sound In Tubes

(a) Stretch a sound tube to its maximum length and, holding it at one end, rotate it in a circular pattern. What happens as the wind blows across the top of it?

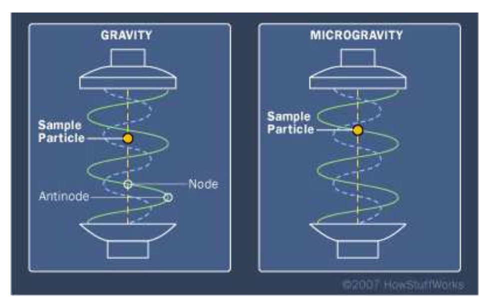
(b) Now try to get a different note. What did you have to do to produce a different note?

(c) The pitch (“highness” or “lowness” of a note) corresponds to the frequency of sound.
Did the frequency increase or decrease when you rotated the tube differently?

(d) For a tube open at both ends, the wavelength of the lowest note is twice the length of the tube. Assuming the speed of sound in the room to be about 340 m/s, calculate the frequency of the sound wave using $v = f\lambda$.

length of tube = _________________ m

λ = 2x(length of tube) = ______________________m

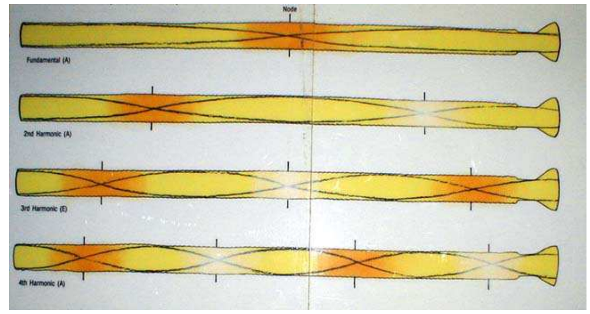


(e) Only some notes can be heard. In other words, only certain frequencies are amplified. What other evidence for multiple resonant frequencies have we seen? Compare this to another similar experiment we have done.

(f) PREDICT: What will happen if you shorten the tube a bit and try producing a note again?

(g) Now try it. What happened to the frequency?

(h) Why did the frequency change in this way?



14.5 <u>Demonstrations: Resonance</u>

For each demonstration, briefly describe how the concept of resonance applies.

(a) Meter stick on side of table is struck

(b) Tube whirled in the air

(c) Air blown across the top of an open bottle

(d) Tuning fork hit by a mallet

(e) Adjustable tuning fork hit with mass changing height

(f) Two tuning forks at same frequency played together

(g) Glass vibrated with sound

(h) Reuben's Tube

(i) TACOMA NARROWS BRIDGE