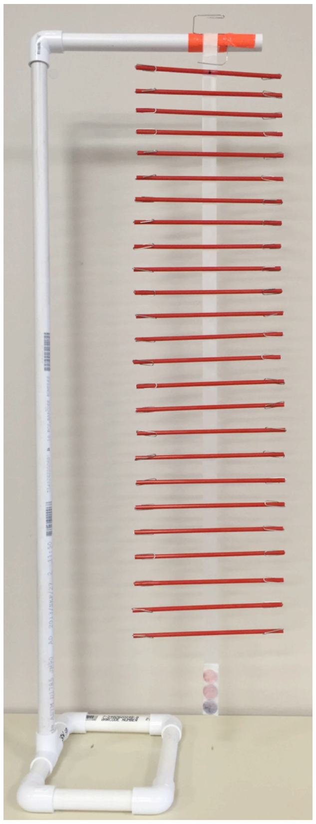
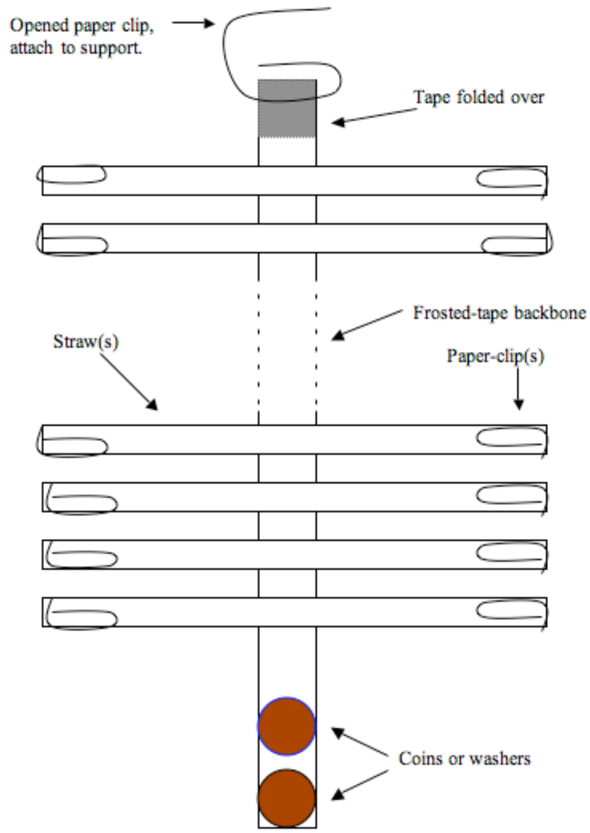
Straws and tape t-wave generator

Flick a straw to produce a wave





Materials:

About 100 cm of frosted tape.

2-3 steel washer (coins work fine)

40-45 plastic straws

80-100 paper clips

ruler

scissors (optional)

Introduction

Attach straws onto a piece of frosted tape, hang the tape with the attached straws from the ceiling, flick the bottom straw and you will see a **torsional** (**transverse**, if viewed from the side) wave propagate towards the ceiling. Light (electromagnetic spectrum), water and stadium waves are **transverse** waves, while sound waves travel as **compression** waves (**longitudinal** waves)

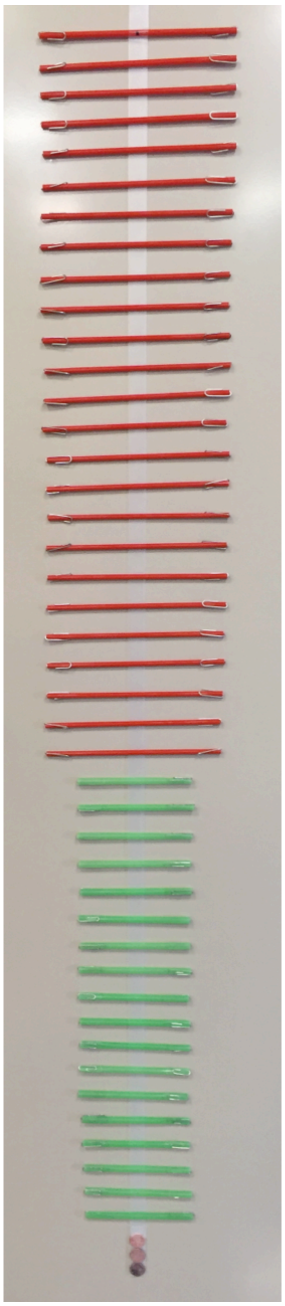
Assembly

Attach paper clips to each end of the straws. Repeat this for all the straws. Stretch out the frosted tape on the top of a table with the **sticky side facing up**. It will be helpful to *lay the tape parallel to the edge of the table and about half the length of a single straw away from the edge of the table,* so that when attaching the straws, it is easier to line them up evenly and centered. Secure both ends of the tape on the table using a couple of heavy items. Attach the straws onto the length of the tape at 2-3 cm intervals (you can vary this distance as you experiment with later versions) leaving about 10 centimeters on both the top and bottom ends free of straws.

Place two or three coins (or washers) about 3 cm from the bottom straw, then fold the tape over the coins to keep the coins on the tape. On the other end (the top) attach an opened paperclip and suspend the “tape-straws-paper clips-coins” wave generator from the ceiling, or any type of support. Allow the wave generator to “settle”.

To Do and Notice

Gently (with feeling!) flick the paper-clip end of the bottom straw with your index or middle finger so that the straw rotates **horizontally** (not vertically!). Notice how a wave front propagates up towards the ceiling, yet each straw stays pretty much at the same height. What happens to the wave front when it reaches the top? When it reaches the bottom? How many trips does the wave make before it becomes motionless? How fast does the wave travel? What factors influence the speed of the wave? What kind of wave was produced? What happens when you start from the top? What about at the middle?



Further experimentation

a) Change the spacing/interval between straws
b) Remove (or add more) paper clips
c) Use different colored straws
d) Remove (or add more) coins on the bottom
e) Try to determine the **wavelength** (λ), and **frequency** (f)
f) Vary the length of the straws* (demonstrates **refraction**)

* To demonstrate a *change in the speed* of the wave going from one type material to another, cut 1/3 of the total number of straws in half. Attach the straws in one of two ways:

1) Long/full length straws on top, short/half length straws on the bottom
2) Short straws on top, long on the bottom

What's Going On?

All the straws are interconnected by the "backbone" made of frosted tape. The twist given to the bottom straw starts it rotating, this rotation twists the tape, which in turn twists the next straw and this continues up the length of the tape. The energy of rotation of the straws moves up the tape.

When the wave front reaches the top it turns around and comes back down again, this is called **reflection**. The same thing happens at the bottom.

The speed of the wave depends on the *rotational inertia* of the straws, which depends on their mass and their length (would be squared), the *restoring force*, which depends on the type of tape and the tension produced by the hanging weights. A higher tension makes the wave travel faster, while a higher rotational inertia makes the wave travel slower.

The wave will continue to travel until all the rotational energy has been transferred into heat by air resistance and frictional forces.

The wave travels faster through the shorter straws and slower in the longer straws. If you start with the shorter straws, when the wave front encounters the longer straws you might notice:

a) The *wave slows down* **(refraction)**
b) And it also bounces back or *reverses direction* (**reflection**).

*** Comments, questions, or suggestions please email: tien@ligo-la.caltech.edu