Combination Pendulum Snake and Slinky Snack
Instructions for Assembly
Worksheets and Math Roots

Materials Needed:
Basic Frame
1/2" Schedule 40 PVC

- **2-18" PVC**
- **4-10" PVC**
- **6-$7^{1/2}$" PVC**
- **6-elbows**
- **2-crosses**
- **6-end caps**

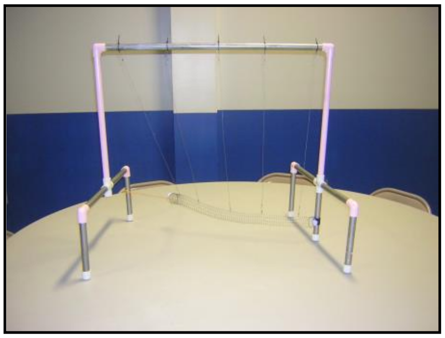
Slinky snack uses 30" PVC
Pendulum snake uses 23" PVC

Slinky Snack
1-30" PVC
1-3/4" metal slinky
5-24" fishing leaders
5 Cable ties
3" of Velcro
12" of string

Pendulum Snake Snack
1- 23" PVC will holes drilled
10 - 1/2" hex nuts
10 – Strings cut 4 ft.
1 sewing needle 18 gauge
Masking tape
Scissors

Basic Frame Assembly

1. Assemble the frame: add an elbow joint to each end of the
   (30" PVC Slinky Snack) or the
   (23" drilled PVC for Pendulum Snake)
2. Insert two 18" long pieces into the ends of the open end of the elbow.
3. Put one cross at each 18" end.
4. Put one 10" pipe on each side of the cross.
5. Place elbow on each end of the 10" PVC.
6. Insert the $7^{1/2}$" pipes into the open end of the 4 elbow and the two cross.
7. Your basic frame should look like the picture below.



Note: Assembly for the Slinky Snack.

8. Thread fishing leaders with one cable tie on the end without the clasp
9. Attach cable tie to 30" PVC pipe.
10. Repeat for additional fishing leaders.
11. Attach slinky to fishing leader clasp as shown in picture on page 1.
12. Loosely tie 12" string to one end of slinky beneath the cross.
13. Attach Velcro to opposite end of slinky.
14. Attach the other side of the Velcro to the PVC pipe below the cross.
15. Adjust cable ties to make sure slinky is level and fishing leaders are evenly distributed across the slinky.

Slinky Snack Activity

Using your slinky snack you will be able to:

1. Compare and contrast transverse and compression waves
2. Identify the properties of both types of waves and give examples.
3. Create a traveling wave and a standing wave.
4. Calculate the period and frequency of a wave using the formula, $T=1/f$
5. Calculate wave speed using the formula, $\nu = f\gamma$

About Waves:

A **wave** is any disturbance from an equilibrium condition that travels (or propagates) with time from one point in space to another or simply a vibration.

A **vibration** can be a repeating, or periodic, type of motion (or oscillation) that disturbs the surroundings.

A **pulse** is a disturbance of a single event of short duration.

Both pulses and periodic vibrations can create a physical wave in the surroundings. A wave is a disturbance that **transfers energy** from one place to another.

Part 1: Modeling Electromagnetic Waves

A **transverse wave** is a disturbance that causes motion (or oscillations) perpendicular to the direction that the wave is moving.

Ex: Electromagnetic Spectrum

Practice making transverse waves by moving the open end of the slinky in a left to right motion or up and down.

Send only one pulse and watch the wave travel. This is a **traveling wave**. Notice that the wave moves to the fixed end and back to your hand.

Continue sending pulses, observe the **crests** and **troughs**, and notice the number of waves produced.

A) How can you increase the number of crests and troughs (**frequency**) on the slinky?

B) How can you change the size of the crest and troughs (**amplitude**)?

C) Can you measure the distance from one crest to another crest (**wavelength**)?

Do you know?

As the frequency of a wave increases, its wavelength (increases or decreases).

Two or more waves can be in the same place at the same time, traveling through one another from opposite directions. A confined wave will be **reflected** at a hard **boundary**, and the reflected wave will be inverted (a crest becomes a trough). Reflected waves interfere with incoming waves of the same frequency to produce **standing waves**. At a "soft" boundary, there is no inversion.

Make standing waves by sending a series of wave pulses from one end of the slinky to the other and allowing them to reflect back. **Notice** that there are areas on the slinky where it appears that there is no movement, that is a **node** or "no movement". In other locations along the slinky, there appears lots of movement. These are antinodes.

Nodes- places of destructive interference, which show no disturbance.

Antinodes – place of constructive interference, which show the crests and troughs of the two wave patterns produce a disturbance that rapidly alternates upward and downward.

This pattern of alternating nodes and antinodes does not move along the slinky and is a standing wave.

(A) How many nodes and antinodes can you produce? (**Standing waves**)

(B) What do you notice about the motion of the crests and troughs? (**Interference**)

Part 2: Modeling Sound Waves

A **compression** (longitudinal) wave is a disturbance that causes particles to move closer together or farther apart in the same direction that the wave is moving. The amount of movement is the **displacement**.

<u>Ex: Sound, these waves move through the air.</u>

Make a compression (longitudinal) wave. **Move** the free end of the slinky back and forth parallel to the spring and allowing the coils to gather and spread apart. **Notice** the areas where the coils are close together. These are **compressions** and the areas where the coils are farther apart are **rarefactions**.

(A) Where do you think the nodes and antinodes are on a compression wave?

(B) Where is the amplitude of a compression wave located?

(C) How would you measure the wavelength?

Important Note: It is important to note that **compression waves** require a **medium** or matter in which to transfer energy. **Electromagnetic waves do not** require a medium to transfer energy and therefore can travel in the **vacuum of space**.

Diagram:

In the space below, draw a **transverse wave**. Label the **crest**, **trough**, **amplitude**, and **wavelength**.

We will use this diagram to discuss interference (nodes, antinodes)

In the space below, draw a **compression wave**. Label the **compression** and **rarefaction**. Identify the **nodes** and **antinodes** on your diagram.

Slinky snack Math
Worksheet

The period and frequency are two ways of describing the time involved in a vibration. Since the period (T) is the total time involved in one cycle and the frequency (f) is the number of cycles per second, the relationship is:

Frequency= 1/period (Inverses of each other) Period (T) = 1/frequency

Practice:

1. A nurse counts 76 heartbeats in one minute. What are the period and frequency of the heart's oscillations?

2. New York's 300-m Citicorp Building oscillates in the wind with a period of 6.80s.
3. Calculate its frequency of vibration.
4. A vibrating system has a period of 0.1 sec. What is the frequency in Hz?

   Wave speed = frequency ● wavelength

   m/s = hz ● meters

   $\mathbf{v = f\lambda}$

5. Calculate the speed of waves in a puddle that are 0.15 m apart and made by tapping the water surface twice each second.

6. A sound wave with a frequency of 260 Hz has a wavelength of 1.27 m. With what speed would you expect this sound wave to move?

7. The following sound waves have what velocity?
   a) Middle C, or 256 Hz and 1.34 m λ.
   b) Note A, or 440.0 Hz and 78.0 cm λ
   c) A siren at 750.0 Hz and λ of 45.7 cm.
   d) Note from a stereo at 2500.0 Hz and λ of 13.72 cm.

Answers to math problems:

1. f =76/min, T= (1/76) min

2. f = 1/6.80s = 0.15 Hz

3. f = 1/0.1s or 10 Hz

4. $v = f\lambda$ so (2/s)(0.15m) = 0.3 m/s

5. $v = f\lambda$ so (1.27m)(260)(1/s), (1.27m) (260m/s) = 330m/s

6. $v = f\lambda$ = (a) (256)(1/s)(1.34m) = 343m/s (b) (440)(1/s)(0.780m) = 343m/s
   (c) (750.0)(1/s) (0.457m) = 343m/s (d) (2500.0)(1/s)(0.1372m) = 343m/s

Note: Assembly for Pendulum Snake

16. Measure lengths and mark dowel stick with lengths below: (Note: indicate top to the stick)
    - 55.90 cm is #1
    - 50.70 cm is #2
    - 46.20 cm is #3
    - 42.30 cm is #4
    - 38.80 cm is #5
    - 35.75 cm is #6
    - 33.05 cm is #7

    30.65 cm is #8
    - 28.50 cm is #9
    - 26.56 cm is #10

17. Add a knot to the end of each string to prevent fraying on end of each string.
18. Thread string # 1 with needle.
19. Start on the top of the drilled PVC and thread needle through.
20. Put the hex nut through the string and thread needle to next hole then tape to the PVC. (Do not worry about the length at this point)
21. Repeat for the other 9 strings.
22. Use dowel stick to measure the lengths of the string as indicated above- #1, #2, #3...

Important Note: Each pendulum bob (hex nut) will hang from two strings that are 3 cm apart - one string is fixed in place with a knot, and the other string is taped and adjustable.
Note: Be sure to measure from the center of the two hanging strings to the center of mass of the bob (hex nut).

To Do:

1. Use dowel stick to pull all the hex nuts to the side simultaneously.
2. Release the hex nut simultaneously.
3. Not all hex nuts will be in "tune" at first. Verify length as necessary to get desired results.

Things to notice:

Release the pendulums again and notice that at first they all move together, then some begin to change position relative to their neighbors, creating the eponymous snake pattern! Eventually, all apparent pattern is lost until suddenly, every other pendulum is moving opposite its neighbors.
Then chaos returns again.
Eventually, all the pendulums return and move together in one line.
You might want to number your pendulums
Ex: 20. 21.22. Etc... (The number of swings per 30 sec.)

You can study individual pendulums and pairs of pendulums, by moving only the pendulums you select.
Example: Start pendulum # 24 and #28. Using a stopwatch notice what occurs during 30 seconds. Try different pairs and find patterns that occur between the pendulums.

Pendulum Snake Snack
Math Root -Worksheet

Calculate the LENGTHS of each pendulum using your math skills.

The longest pendulum on this snack is 55.9 cm. (Measured to the center of mass of the hex nut to the string underneath the PVC) and will swing back and forth 20 times in 30 seconds.

Length (L)
55.9 cm

Number of Back and Forth Swings in 30 seconds (N)

N = 20
L= 55.90 cm

Subsequent lengths can be calculated by using the following formula:

$L_{n+1} = L_n (N/N+1)^2$

For example,

$L_{21} = L_{20} (20/21)^2$

$L_{21} = 50.70$ cm

Length (L)	Number of Back and Forth Swings in 30 Seconds (N)
55.90 cm	20
50.70 cm	21 (answer)
46.20 cm	
42.30 cm	
38.80 cm	
35.75 cm	
33.05 cm	
30.65 cm	
28.50 cm	
26.56 cm	

GLE Text and Benchmarks

Science as inquiry

4.	Design, predict outcomes, and conduct experiments to answer guiding questions (SI-M-A2)
6.	Select and use appropriate equipment, technology, tools, and metric system units of measurement to make observations (SI-M-A3)
7.	Record observations using methods that complement investigations (e.g., journals, tables, charts) (SI-M-A3)
9.	Use computers and/or calculators to analyze and interpret quantitative data (SI-M-A3)
10.	Identify the difference between description and explanation (SI-M-A4)
22.	Use evidence and observations to explain and communicate the results of investigations (SI-M-A7)
33.	Evaluate models, identify problems in design, and make recommendations for improvement (SI-M-B4)
38.	Explain that, through the use of scientific processes and knowledge, people can solve problems, make decisions, and form new ideas (SI-M-B6)

Physical Science

28.	Explain the law of conservation of energy (PS-M-C2)
31.	Compare types of electromagnetic waves (PS-M-C3)
32.	Identify and illustrate key characteristics of waves (e.g., wavelength, frequency, amplitude) (PS-M-C4)