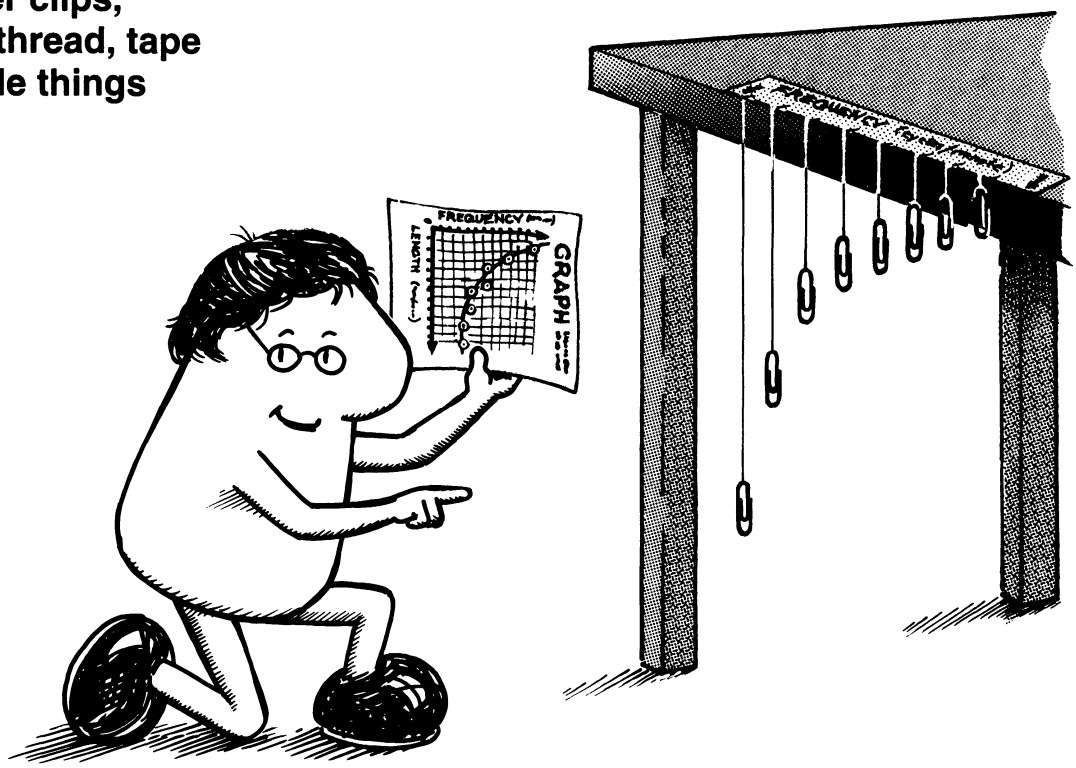
PENDULUMS

**with paper clips,
pennies, thread, tape
and simple things**



SCIENCE WITH SIMPLE THINGS SERIES

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PREPARATION AND SUPPORT

ACTIVITIES AND LESSON NOTES

SUPPLEMENTARY PAGES

Gathering Materials

Listed below is everything you'll need to teach this module. Buy what you don't already have from your local supermarket, drugstore or hardware store. Ask students to bring recycled materials from home.

Keep this classification key in mind as you review what's needed.

general on-the-shelf materials:	*special in-a-box materials:*
Normal type suggests that these materials are used often. Keep these basics on shelves or in drawers that are readily accessible to your students. The next TOPS module you teach will likely utilize many of these same materials.	Italic type suggests that these materials are unusual. Keep these specialty items in a separate box. After you finish teaching this module, label the box for storage and put it away, ready to use again.
(substituted materials):	*optional materials:
Parentheses enclosing any item suggests a ready substitute. These alternatives may work just as well as the original. Don't be afraid to improvise, to make do with what you have.	An asterisk sets these items apart. They are nice to have, but you can easily live without them. They are probably not worth an extra trip to the store, unless you are gathering other materials as well.

Everything is listed in order of first use. Start gathering at the top of this list and work down. Ask students to bring recycled items from home. The Teaching Notes may occasionally suggest additional *Extensions*. Materials for these optional experiments are listed neither here nor under *Materials*. Read the extension itself to determine what new items, if any, are required.

Quantities depend on how many students you have, how you organize them into activity groups, and how you teach. Decide which of these 3 estimates best applies to you, then adjust quantities up or down as necessary:

$Q_1/Q_2/Q_3$

- **Single Student:** Enough for 1 student to do all the experiments.
- **Individualized Approach:** Enough for 30 students informally working in pairs, all self-paced.
- **Traditional Approach:** Enough for 30 students, organized into pairs, all doing the same lesson.

KEY: *special in-a-box materials* (substituted materials) general on-the-shelf materials *optional materials

$Q_1/Q_2/Q_3$	
1 / 2 / 2	boxes paper clips of uniform size and weight – stick with one brand
1 / 2 / 2	spools of thread
1 / 15 / 15	pairs of scissors
1 / 2 / 2	rolls masking tape
1 / 15 / 15	clock or stopwatch to measure seconds – a large wall clock will serve a whole class
1 / 5 / 15	meter sticks
2 / 20 / 30	styrofoam cups
1 / 5 / 15	plastic drinking straws
2 / 10 / 30	rubber bands
10 / 60 / 150	pennies
1 / 5 / 15	*wire clothes hangers*
3 / 15 / 45	heavy books
1 / 1 / 1	ball string
3 / 15 / 45	clothespins
1 / 5 / 15	*felt-tip pens – must be smooth and free-flowing*

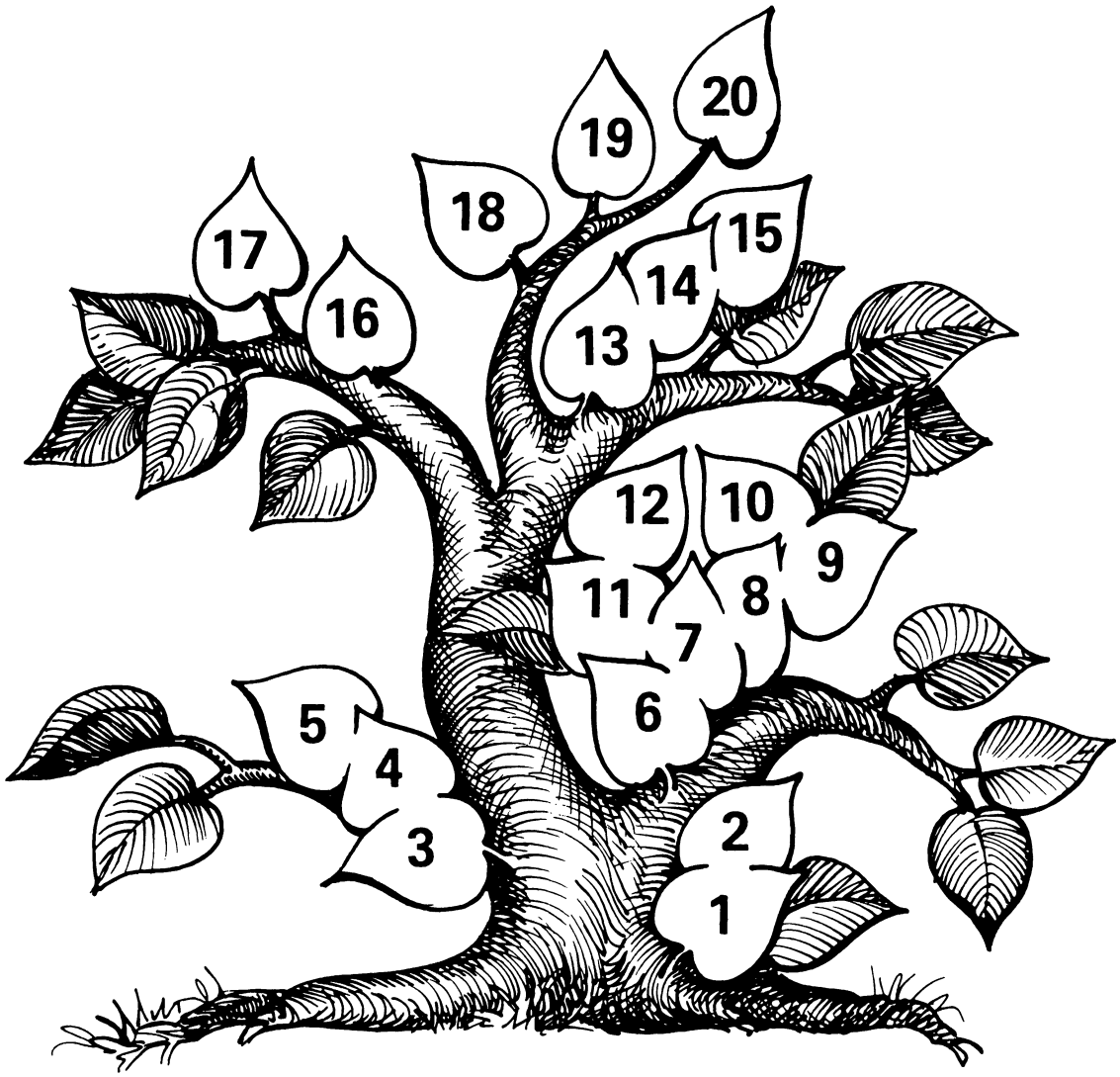
Sequencing Activities

This logic tree shows how all the activities in this book tie together. In general, students begin at the trunk of the tree and work up through the related branches. Lower level activities support the ones above.

You may, at your discretion, omit certain activities or change their sequence to meet specific class needs. However, when leaves open vertically into each other, those below logically precede those above, and should not be omitted.

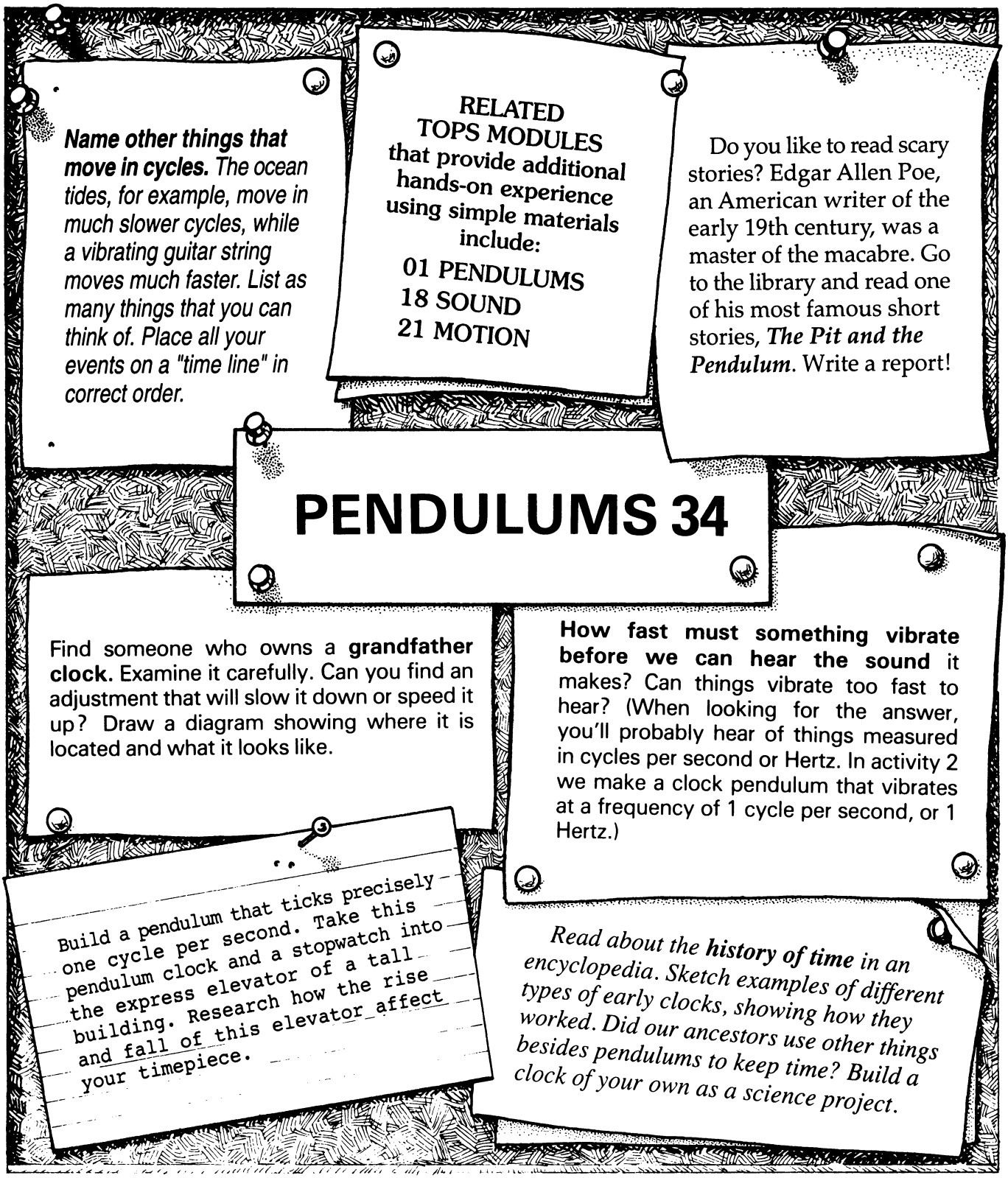
When possible, students should complete the activities in the same sequence as numbered. If time is short, however, or certain students need to catch up, you can use this logic tree to identify concept-related horizontal activities. Some of these might be omitted, since they serve to reinforce learned concepts rather than introduce new ones.

For whatever reason, when you wish to make sequence changes, you'll find this logic tree a valuable reference. Parentheses in the upper right corner of each activity page allow you total flexibility. They are blank so you can pencil in sequence numbers of your own choosing.



Gaining a Whole Perspective

Science is an interconnected fabric of ideas woven into broad and harmonious patterns. Use extension ideas in the teaching notes plus the outline presented below to help your students grasp the big ideas — to appreciate the fabric of science as a unified whole.



Review / Test Questions

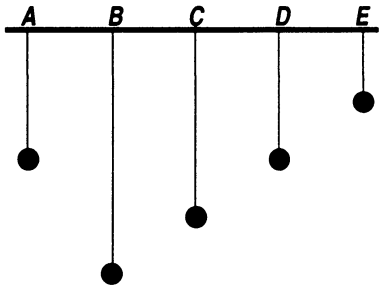
Photocopy these test questions. Cut out those you wish to use, and tape them onto white paper. Include questions of your own design, as well. Crowd them all onto a single page for students to answer on their own papers, or leave space for student responses after each question, as you wish. Duplicate a class set, and your custom-made test is ready to use. Use leftover questions as a class review in preparation for the final exam.

activity 1

a. Which pendulum swings fastest?

b. Which pendulums swing together?

c. Which pendulum swings slowest?



activity 2

Your grandfather clock runs too slow. How would you adjust its pendulum to make it keep better time?

activity 3

A heavy person swings on a swing in the park. Then a light person uses the ***same*** swing, Would one be able to swing faster than the other? Explain.

activity 4

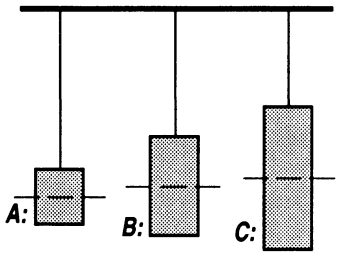
Suppose you are swinging from an overhead bar.

a. If you took bigger swings, could you slow your frequency?

b. How could you best increase your frequency?

activity 5

Suppose you hang 3 strips of wood from a table like this. Which one swings the fastest? Why?



activity 6

A pendulum makes 20 ***swings*** in 15 seconds.

a. How many ***cycles*** does it make in 15 seconds?

b. What is the frequency of the pendulum in cycles per minute?

activity 7

You are given a pendulum that is 20 cm long.

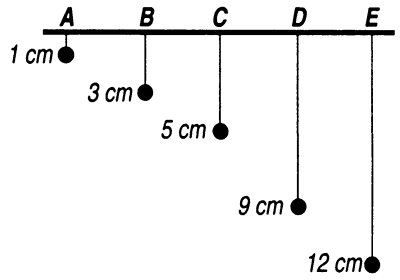
a. How long is a pendulum that swings 2 times faster than this?

b. How long is a pendulum that swings 3 times slower than this?

activity 8

a. Pendulum _____ swings 3 times faster than pendulum _____.

b. Pendulum _____ swings 2 times slower than pendulum _____.

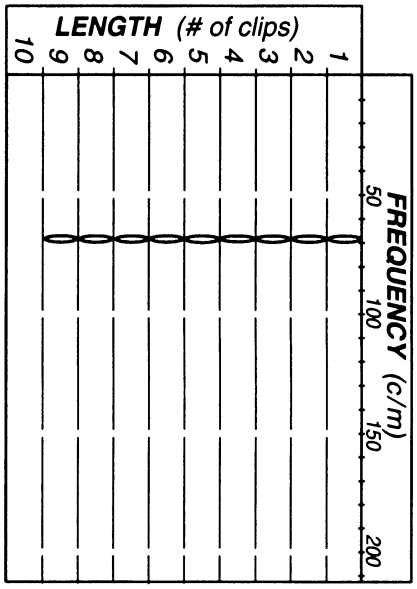


activity 9

Chains of paper clips swing back and forth like pendulums. The table lists the frequencies for these chains from 1 clip to 9 clips long.

LENGTH # of clips	1	2	3	4	5	6	7	8	9
FREQ. c/m	208	146	120	104	92	84	78	73	69

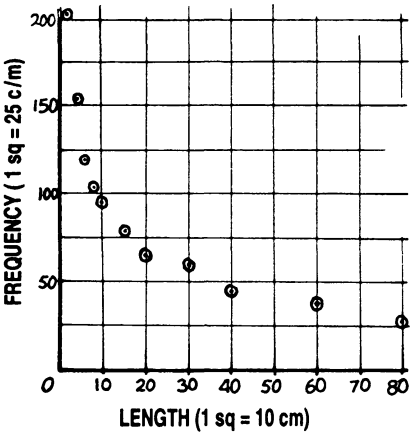
Use the table to complete the line graph below. One chain is drawn as an example. *(Table turned sideways.)*



Review / Test Questions, continued

activity 10

Draw a smooth graph line through these data points.



a. According to your graph, what is the frequency of a pendulum that is 35 cm long?

b. According to your graph, how long is a pendulum that has a frequency of 37 1/2 c/m?

activity 11

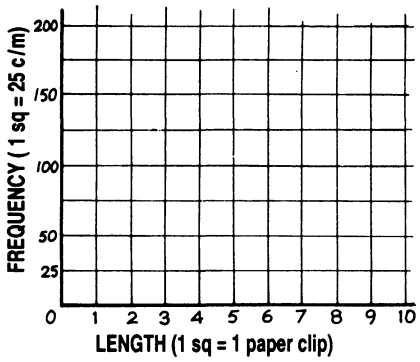
A chain that is 2 paper clips long has a frequency of 147 c/m. Find the frequency of a chain with 18 paper clips. Show your work.

activity 12

Paper clip chains swing like pendulums. The table list the frequencies for chains from 1 clip long to 9 clips long.

LENGTH # of clips	1	2	3	4	5	6	7	8	9
FREQ. c/m	208	146	120	104	92	84	78	73	69

Graph this data on the grid below.

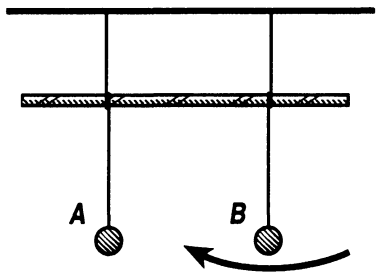


activity 13

A wheel of your car is stuck in a hole. To get your car out, should you push on it steadily, or rock it back and forth? Explain.

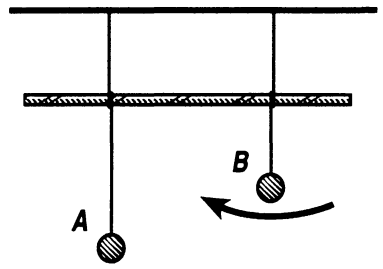
activity 14

Two pendulums with equal lengths are taped to a long straw like this. If you start B swinging toward A, predict what happens.



activity 15

Two pendulums with different lengths are taped to a long straw like this. If you start B swinging toward A, predict what happens.



activity 16

A pendulum 100 cm long swings 30.4 c/m. Another pendulum 200 cm long swings 21.5 c/m. Use this information to find the square root of 2. Show your math.

activity 17

You are rich enough to build a pendulum any way you wish. Design one that comes close to perpetual motion: once you start it swinging, it never stops.

activity 18

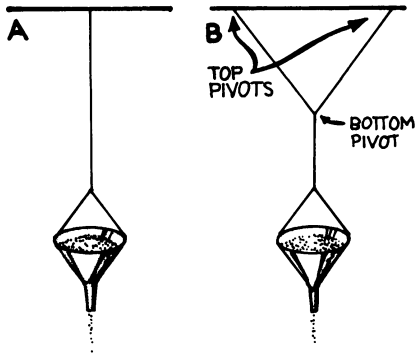
How would you use a pendulum to prove that the earth turns?

activity 19

Who can jump up and down with greater frequency on a diving board, a large adult or a small child? Explain.

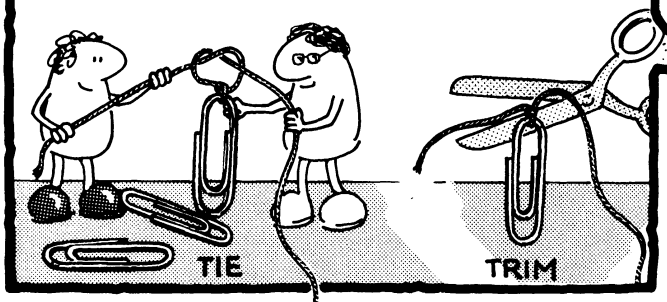
activity 20

Sand flows out of both funnels shown below. Which system will make a more interesting pendulum design when you set the funnel in motion. Why do you think so?

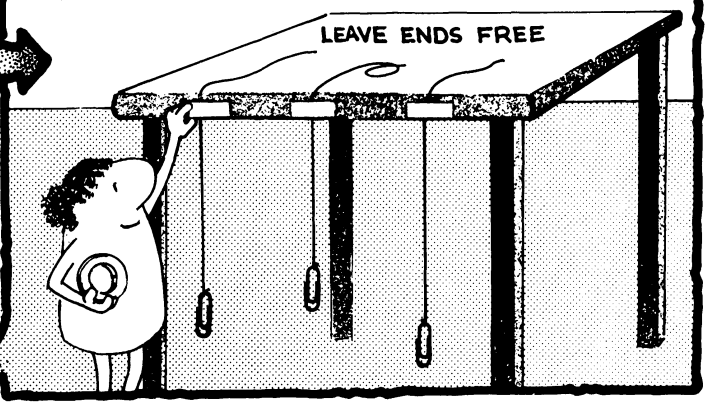


MARCHING PENDULUMS

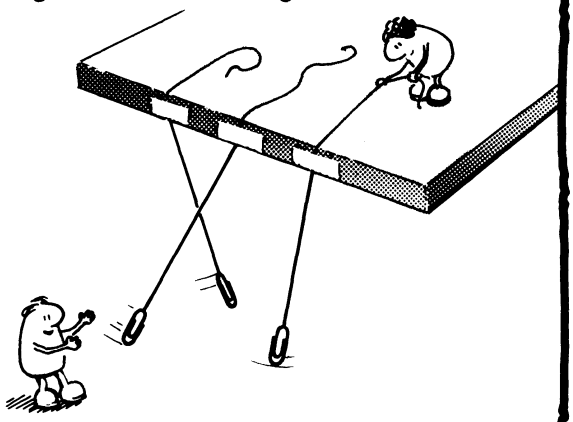
1 Tie 3 paper clips to arm-length pieces of thread. Cut off the short end.



2 Tape each to the *edge* of your desk leaving the ends free.



3 Pull the thread up or down through the tape until the paper clips all march in step (swing back and forth together).

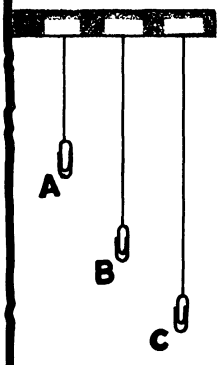


☐ Check point: they must stay in step at least 10 cycles back and forth.

Draw how they look.

4 If pendulums swing back and forth together, what can you say about their lengths?

5 Predict: Which pendulum will . . .



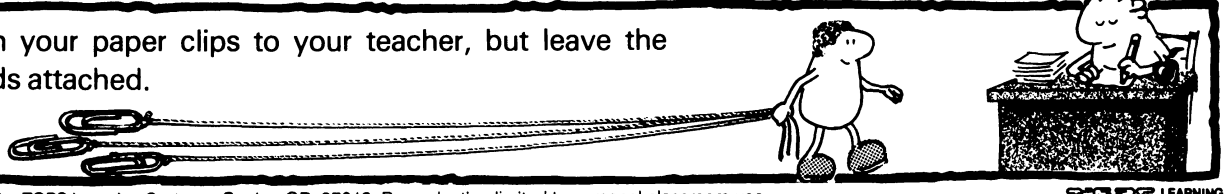
. . . swing fastest?

. . . swing slowest?

Test your prediction.

☐ correct ☐ wrong

6 Return your paper clips to your teacher, but leave the threads attached.



Objective

To make 3 pendulums that swing in step. To understand how their lengths change with frequency.

Lesson Notes

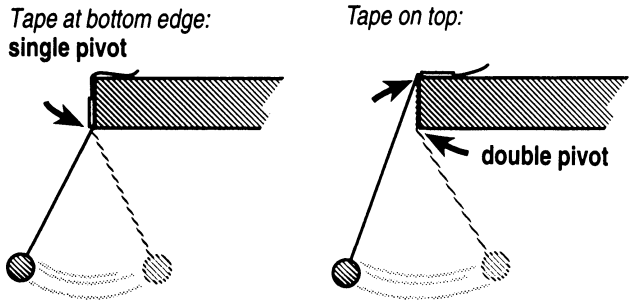
1. Everyone in your class knows how to tie thread to a paper clip, right? Wrong. Wispy thin thread is hard to control, especially in the hands of younger children. Be prepared to give your class a lesson in tying knots (tie two loops, not one). Identify those who are good knot tyers, and have them help those who cannot knot knots!

Knotting thread is an operation that your students will have to do repeatedly throughout this module. Extra work on this now will insure that later activities run more smoothly.

In general, larger loops are easier to tie than smaller loops. So encourage your students to start with big loops using plenty of thread, then trim off the excess. Thread is cheap.

2. Tape the pendulums so they are all suspended from the same height. This happens as a matter of course if students stick each piece of tape to the side of the table, flush with the bottom edge, as illustrated.

Students might also create equal-length pendulums by taping thread to the top of the table instead of its side edge. Technically this creates more complex double-pivot pendulums that swing at two different lengths. Practically, it will not affect experimental results, and no one will notice.



One final point. Avoid snarls and tangles by allowing plenty of swinging room between each pendulum.

3. To lengthen or shorten the pendulum, simply pull the thread down or up through the tape. Moving the tape is not necessary, although some students may do this.

You can never make pendulums (or anything else) ***exactly*** the same length. The best you can do is to keep the length within a specified tolerance. In this step, the checkpoint arbitrarily defines such a tolerance: the pendulums must be so close to the same length that they still march in step after 10 cycles.

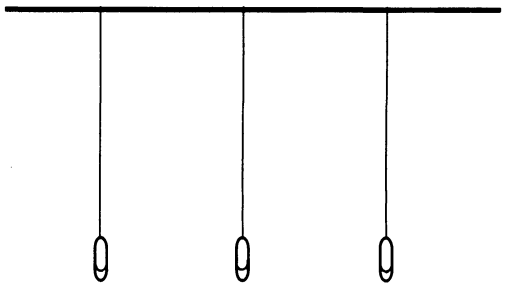
To stay within this tolerance, your students will have to make subtle adjustments of only a millimeter or two. Less coordinated students may find this too difficult. You can decide when each student has done enough adjusting. But don't come to the rescue too early. As students make these minor length adjustments, they will appreciate firsthand the sensitive interdependence between pendulum length and frequency.

6. Hang on to these ready-made pendulums! Hand them out in later activities to students who are all thumbs and can't tie their own. This will save them a lot of frustration, and you a lot of work.

To keep them from tangling, hang the pendulums from slits cut into the top of a styrofoam cups. This technique is illustrated in step 6 of activity 6.

Answers

3. (Student drawings should suggest equal length.)



4. The pendulums must have equal length in order to keep swinging in step together.

5. Pendulum **A** will swing fastest.

Pendulum **C** will swing slowest.

Materials

☐ Paper clips of uniform size and weight. Use just one brand name of medium size, about this large. Banish all odd-sized paper clips from your classroom for the duration of this module.

☐ Thread. With the exception of activity 20, most experiments in this module require thread. Don't substitute string.

☐ Scissors.

☐ Masking tape. Easy to handle and easy to remove from table surfaces, masking tape is used exclusively throughout this module. Don't substitute cellophane tape. It's hard to see and clings tenaciously to desk surfaces. This makes cleanup difficult.