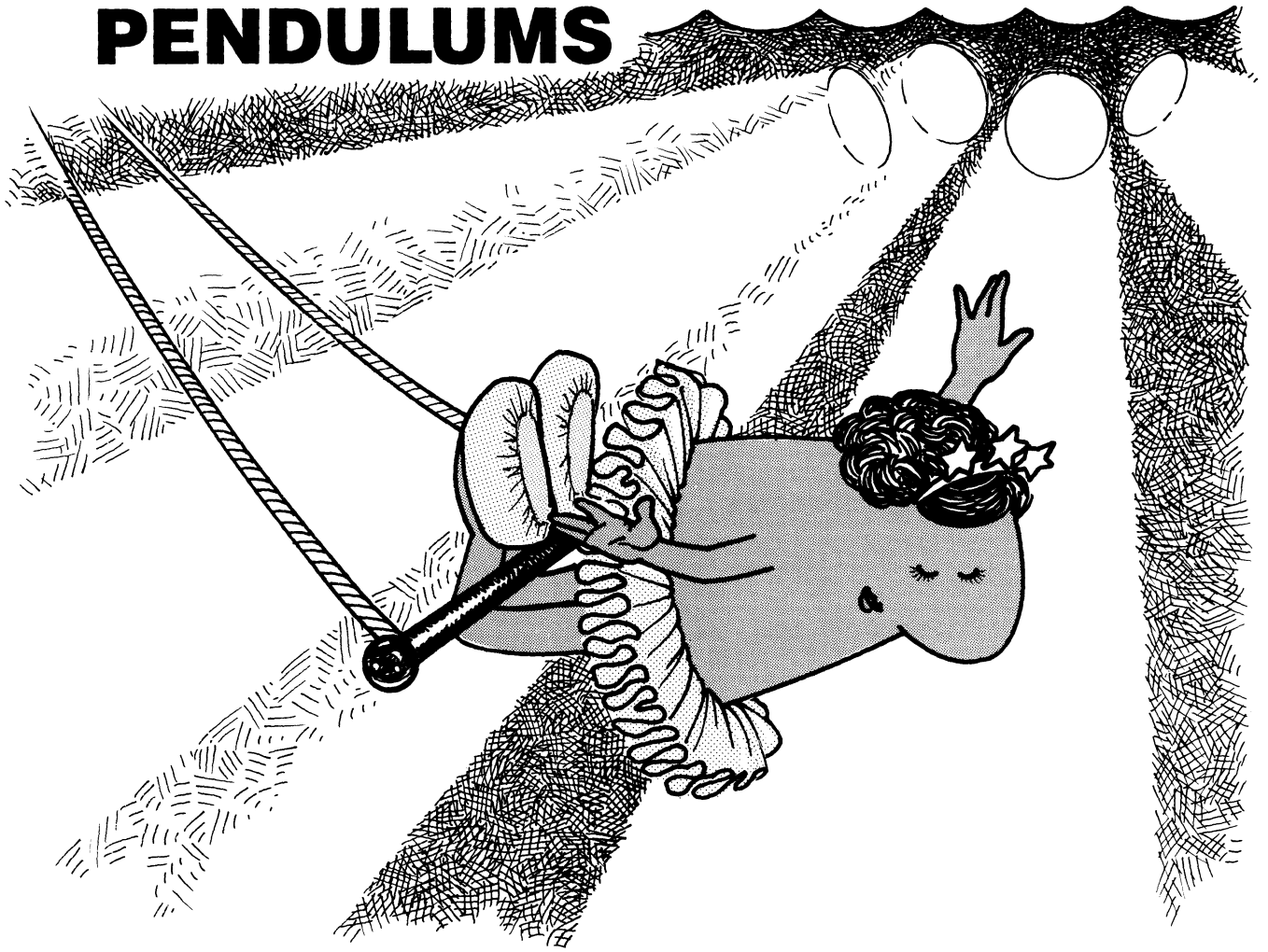
PENDULUMS



TASK CARD SERIES

Conceived and
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TOPS LEARNING SYSTEMS

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CONTENTS

INTRODUCTION

TEACHING NOTES

REPRODUCIBLE STUDENT TASK CARDS

Gathering Materials

Listed below is everything you'll need to teach this module. You already have many of these items. The rest are available from your supermarket, drugstore and hardware store. Laboratory supplies may be ordered through a science supply catalog. Hobby stores also carry basic science equipment.

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

special in-a-box 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 the next time you teach this module.	general on-the-shelf materials: Normal type suggests that these materials are common. 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.
(substituted materials): Parentheses enclosing any item suggests a ready substitute. These alternatives may work just as well as the original, perhaps better. Don't be afraid to improvise, to make do with what you have.	*optional materials: An asterisk sets these items apart. They are nice to have, but you can easily live without them. They are probably not worth the extra trip, 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 student activity under the heading "Extensions." Materials for these optional experiments are listed neither here nor in the teaching notes. Read the extension itself to find out what new materials, if any, are required.

Needed 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 10 lab groups, all self-paced.
- **Traditional Approach:** Enough for 30 students, organized into 10 lab groups, all doing the same lesson.

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

Q_1 / Q_2 / Q_3	
1/10/10	*cereal boxes — see notes 1*
2/20/20	cups gravel (sand or soil)
1/5/5	rolls masking tape
1/10/10	scissors
1/2/2	spools thread
2/20/20	washers sized to fit quarter inch bolts — see note 1
1/2/3	boxes paper clips of uniform size — see note 1
1/1/1	wall clock with second hand (wrist watches)
1/10/10	stopwatches — see notes 1
1/10/10	hand calculators
1/1/1	*roll thin, bare iron wire, about 30 or 32 gauge*
1/5/10	meter sticks
1/2/5	*wire cutters
1/4/10	batteries, size-D, dead or alive
1/4/10	clothespins
1/10/10	index cards (any straightedge)
1/20/20	straws
4/30/40	straight pins
1/10/10	*plastic lids —see notes 20*
1/2/5	paper punches
1/1/1	working video screen

Sequencing Task Cards

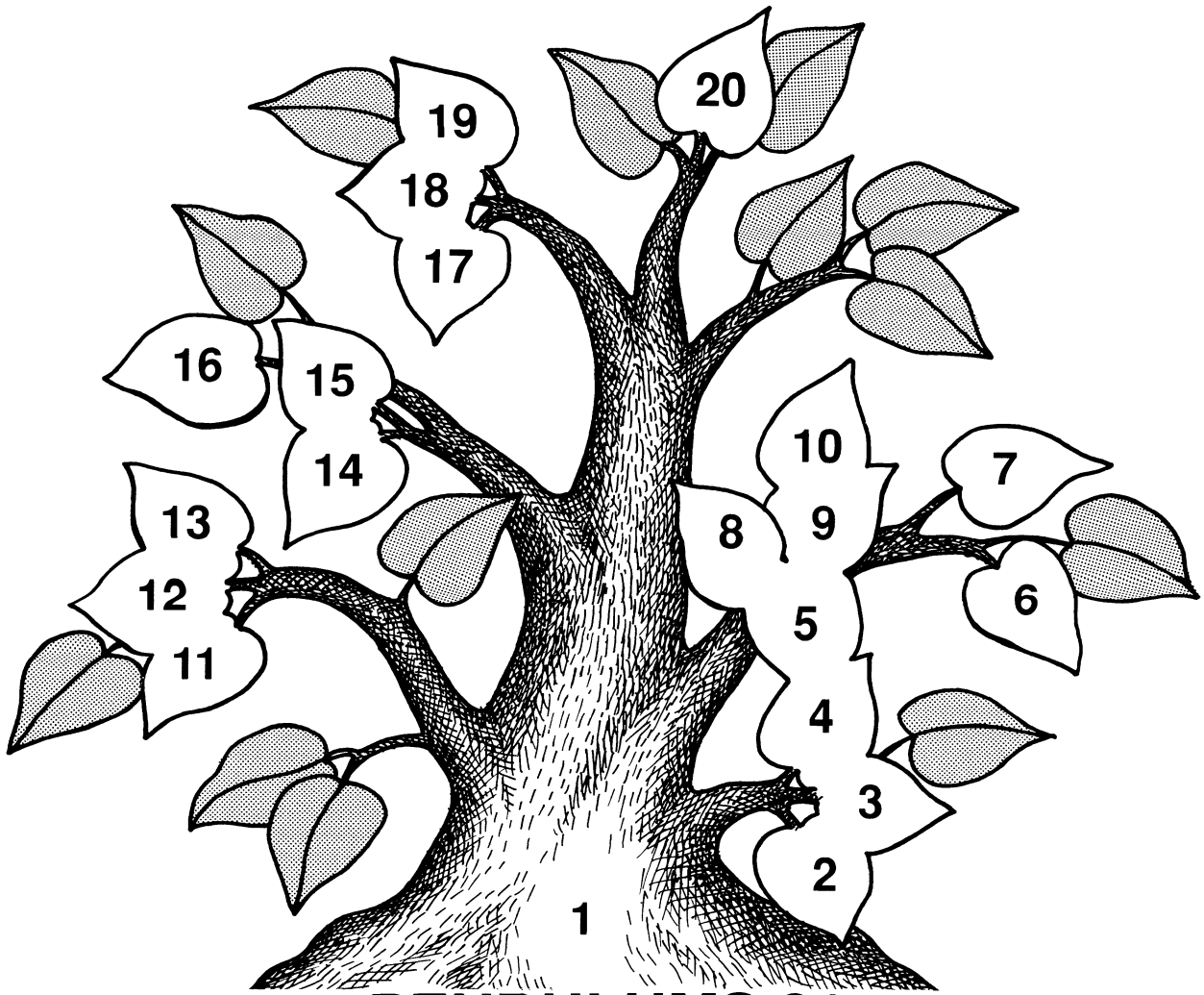
This logic tree shows how all the task cards in this module tie together. In general, students begin at the trunk of the tree and work up through the related branches. As the diagram suggests, the way to upper level activities leads up from lower level activities.

At the teacher's discretion, certain activities can be omitted or sequences changed to meet specific class needs. The only activities that must be completed in sequence are indicated by leaves that open *vertically* into the ones above them. In these cases the lower activity is a prerequisite to the upper.

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

On the other hand, if students complete all the activities at a certain horizontal concept level, then experience difficulty at the next higher level, you might go back down the logic tree to have students repeat specific key activities for greater reinforcement.

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 task card allow you total flexibility. They are left blank so you can pencil in sequence numbers of your own choosing.



PENDULUMS 01

Review / Test Questions

Photocopy the questions below. On a separate sheet of blank paper, cut and paste those boxes you want to use as test questions. Include questions of your own design, as well. Crowd all these questions onto a single page for students to answer on another paper, 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 review in preparation for the final exam.

task 1-2

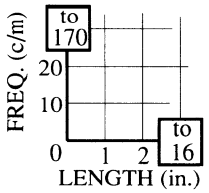
A pendulum makes 16 *single* swings in 20 seconds. What is its frequency in cycles per minute?

task 1-3, 8

Using a foot ruler and wristwatch, you collect the following pendulum data:

LENGTH (inches)	1	2	4	6	8	12
FREQUENCY (c/m)	164	132	91	77	67	53

a. Plot these data points on graph paper, then make a graph line.



b. According to your graph, what's the frequency of a 10 inch pendulum?

c. Extrapolate to find the frequency of a 16 inch pendulum.

task 3, 5

A pendulum has a frequency of 120 cycles/minute.

a. What is its frequency in Hz units?

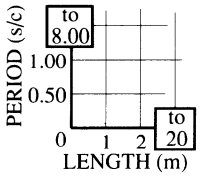
b. What is its period?

task 3-5, 8

Using a meter stick and stop watch, you collect this pendulum data for length *vs* period:

LENGTH (m)	0	1	2	4	8	12
PERIOD (s/c)	0	2.00	2.84	4.02	5.68	6.96

a. Plot these data points on graph paper, then form a graph line.



b. According to your graph, what is the length of a pendulum with a period of 5.00 s/c?

c. Extrapolate to find the length of a pendulum with a period of 8 s/c.

task 4-5

A pendulum swings 20 cycles in 5 seconds.

a. What is its period?

b. What is its frequency in Hz units?

task 4, 6

Summarize how the variables of length, amplitude and bob weight affect the period of a pendulum.

task 6-7

a. Name a variable that affects a thread-and-washer pendulum the same as a spring pendulum.

b. Name another variable that affects them differently.

task 9-12 A

This pendulum data will *not* graph as a straight line.

L = LENGTH (cm)	0	2	6	12
T = PERIOD (s/c)	0	.3	.5	.7

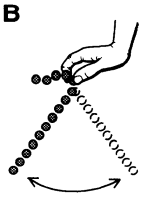
a. Change it *mathematically* so it does.

b. Graph it.

c. Derive a pendulum equation from your graph.

task 9-12 B

Using a stopwatch, you time the period of a swinging chain for different numbers of beads:



L = LENGTH (beads)	0	10	20	40
T= PERIOD (s/c)	0	.48	.69	.97

a. Develop a data table for L and T^2.

b. Graph your results.

c. Write an equation relating T^2 to L.

d. Use this equation to predict the period of a 100 bead chain.

task 13

Recall that: $\sqrt{\frac{L_1}{L_2}} = \frac{T_1}{T_2}$

Use the data in this table to find $\sqrt{6}$.

LENGTH (cm)	0	2	6	12
PERIOD (s/c)	0	.29	.51	.71

task 14-15 A

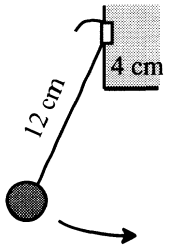
Your car is stuck in a deep rut. To free it should you push straight forward, or rock it back and forth? Explain.

task 14-15 B

A short pendulum has exactly twice the frequency of a long pendulum. Suppose you connect these with a straw energy bridge, then start the long one swinging. What happens to the short straw? Explain.

task 16

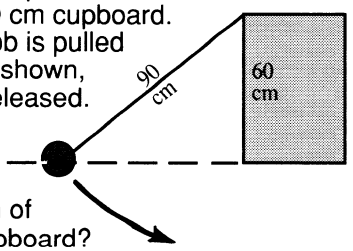
A 12 cm pendulum is taped 4 cm from the bottom of a cupboard and then set in motion so it swings underneath. Use this data table for other pendulums to calculate its particular frequency.



LENGTH (cm)	0	4	8	12
PERIOD (s/c)	0	.42	.58	.70

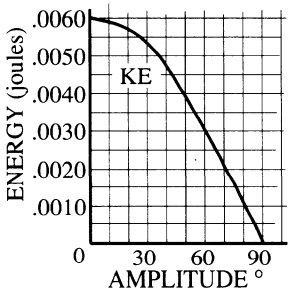
task 16-17

A 90 cm pendulum is attached to a 60 cm cupboard. The bob is pulled out as shown, then released. Will it strike the bottom of the cupboard? If so, where? Explain.



task 17-19 A

A pendulum is gently pushed to maintain its maximum amplitude at an energetic 90°. Its KE (kinetic energy) changes with amplitude like this:



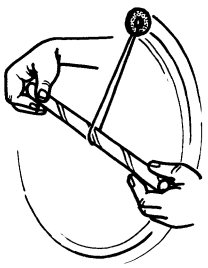
a. Why does KE reach a maximum at 0° and a minimum at 90°?

b. Draw another curve on this same graph to represent the pendulum's PE (potential energy).

c. At what amplitude does KE = PE?

task 17-19 B

A weight tied to a thread loop is gently twirled around a straw like this:



a. Where does this system have maximum potential energy? Maximum kinetic energy? Explain.

b. Where does this system have minimum potential energy? Minimum kinetic energy ? Explain.

c. Compare and contrast this system to a normal back-and-forth pendulum.

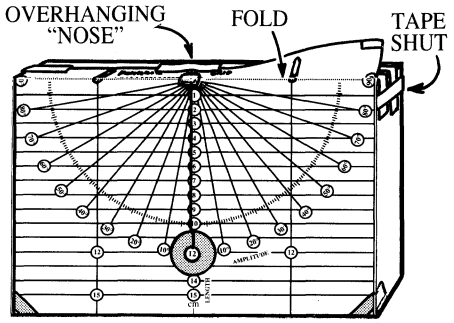
task 20

A wheel is turned faster and faster in front of a video screen until its 24 spokes appear to stand still. A tag on its rim is found to make 10 turns in 4 seconds. Calculate the refresh frequency of this video screen.

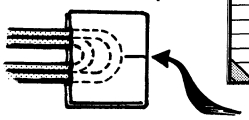
Task Objective (TO) construct a cereal-box pendulum support with a length and amplitude background grid for use in activities throughout this module.

PENDULUM BOX ○

Pendulums ( )



1. Fill an empty cereal box about 1/6 full of gravel. Tape it closed, then tip it on its side.
2. Cut out the Pendulum Grid. Fold it back on the dotted line to fit neatly over the upper edge of your box. Tape in place.
3. Fold a tab of tape over the double-loop end of a paper clip. *Lightly* tape it to the center top of the box with its taped "nose" sticking out.



4. Tie thread to a washer. Insert this thread into a slit that you cut in the tape tab to the center "nose" of the clip. Tilt the box forward to let the washer unwind.
5. Tape the thread at the top of the box so its washer centers perfectly over the 12 cm circle (adjust the clip as needed). Now release your pendulum at an *amplitude* of 10°.
   a. Check that the pendulum swings for at least 1 minute without stopping. Adjust, if necessary, for minimum friction with maximum closeness to the box. Then tape the clip (not the pendulum thread) firmly in place.
   b. Write your name on top.

Answers / Notes

1. *Don't overfill. This will bulge out the sides of the box, possibly interfering with the swing of the pendulum.*

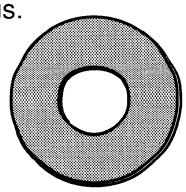
3. *The overhanging paper clip support is taped lightly for now. It may require fine adjustments in step 5a before being taped more permanently in place.*

5. Secure this thread with a second piece of tape, overlaying the first layer that already holds the paper clip.

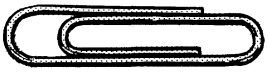
5a. *The washer should clear the box by a millimeter or so when swinging parallel to its surface. It should show little preference for twisting right or left, only lightly brushing the box's surface when it turns. After the paper clip is adjusted perfectly, secure it with additional tape. If the pendulum thread is inadvertently taped to the box along with the paper clip, simply pull it free. There is no need to retape.*

Materials

☐ A Pendulum Grid. Photocopy this from the supplementary page at the back of this book.
☐ A cereal box. We prefer a 2 pound Post Grape-Nuts box for its sturdy construction, and have sized our pendulum grid to fit it perfectly. Any larger box with square corners and flat sides will also serve.
☐ Gravel, sand or dirt. This provides ballast to prevent box movement as the pendulum swings.
☐ Masking tape.
☐ Scissors.
☐ Thread.
☐ Uniform washers that fit 1/4 inch bolts. The circles on our Pendulum Grid match their 3/8 inch holes. While other sizes may be used in initial activities, they are not suitable for activities 17-19.



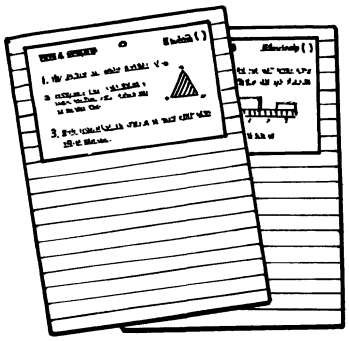
☐ A flat working surface.
☐ Paper clips of uniform size. We use No. 1 Gem paper clips about this size. If your particular brand is longer or shorter than this, tell your class that the "nose" of the clip should stick out about 5 mm.



☐ A stopwatch. A clock with a second hand may be conveniently substituted in the first two activities, but not in experiments that follow. Digital stopwatches are relatively inexpensive, well worth the gains in speed and accuracy that your students will realize throughout this module.

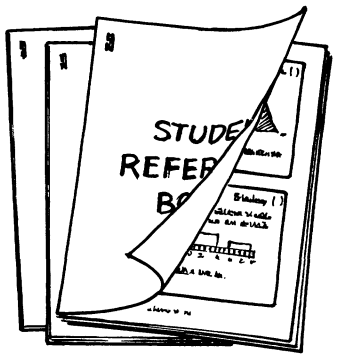
Task Cards Options

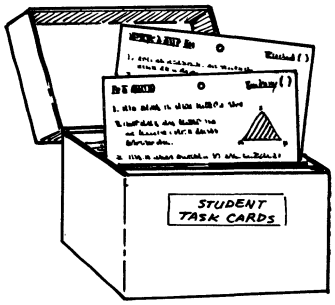
Here are 3 management options to consider before you photocopy:



1. Consumable Worksheets: Copy 1 complete set of task card pages. Cut out each card and fix it to a separate sheet of boldly lined paper. Duplicate a class set of each worksheet master you have made, 1 per student. Direct students to follow the task card instructions at the top of each page, then respond to questions in the lined space underneath.

2. Nonconsumable Reference Booklets: Copy and collate the 2-up task card pages in sequence. Make perhaps half as many sets as the students who will use them. Staple each set in the upper left corner, both front and back to prevent the outside pages from working loose. Tell students that these task card booklets are for reference only. They should use them as they would any textbook, responding to questions on their own papers, returning them unmarked and in good shape at the end of the module.

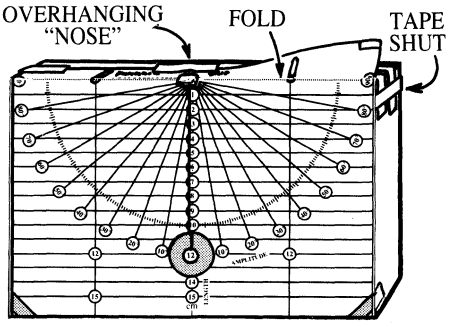




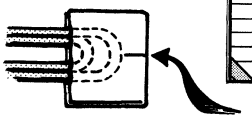
3. Nonconsumable Task Cards: Copy several sets of task card pages. Laminate them, if you wish, for extra durability, then cut out each card to display in your room. You might pin cards to bulletin boards; or punch out the holes and hang them from wall hooks (you can fashion hooks from paper clips and tape these to the wall); or fix cards to cereal boxes with paper fasteners, 4 to a box; or keep cards on designated reference tables. The important thing is to provide enough task card reference points about your classroom to avoid a jam of too many students at any one location. Two or 3 task card sets should accommodate everyone, since different students will use different cards at different times.

PENDULUM BOX

Pendulums ( )



1. Fill an empty cereal box about 1/6 full of gravel. Tape it closed, then tip it on its side.
2. Cut out the Pendulum Grid. Fold it back on the dotted line to fit neatly over the upper edge of your box. Tape in place.
3. Fold a tab of tape over the double-loop end of a paper clip. *Lightly* tape it to the center top of the box with its taped "nose" sticking out.

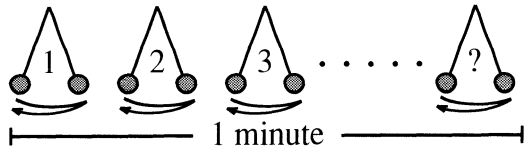


4. Tie thread to a washer. Insert this thread into a slit that you cut in the tape tab to the center "nose" of the clip. Tilt the box forward to let the washer unwind.
5. Tape the thread at the top of the box so its washer centers perfectly over the 12 cm circle (adjust the clip as needed). Now release your pendulum at an *amplitude* of 10°.
   a. Check that the pendulum swings for at least 1 minute without stopping. Adjust, if necessary, for minimum friction with maximum closeness to the box. Then tape the clip (not the pendulum thread) firmly in place.
   b. Write your name on top.

FREQUENCY

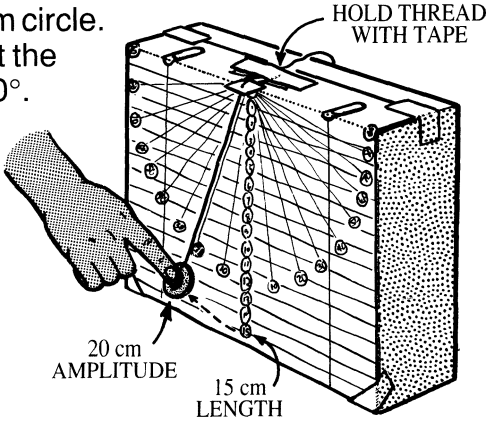
Pendulums ( )

1. Set the center of the washer over the 15 cm circle. Secure the thread at the top with tape. Start the pendulum swinging with an amplitude of 20°.
   a. Find its *frequency*, the number of *cycles* the pendulum makes in 1 minute.



   b. Complete this data table for each length.

LENGTH (cm)	FREQ (c/m)
15	
14	
13	
⋮	
2	



2. Is it necessary to count cycles over a whole minute to find the pendulum's frequency? Describe a short-cut method.
3. Summarize how changes in the length of a pendulum affect its frequency.