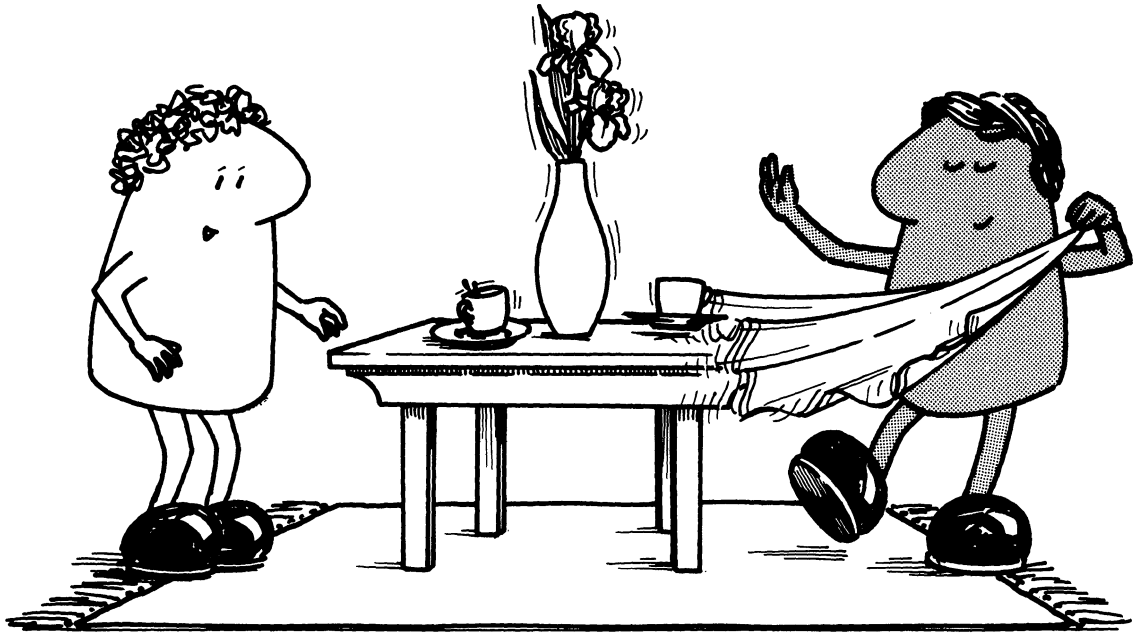
MOTION



TASK CARD SERIES

Conceived and
written by
Ron Marson
Illustrated by
Peg Marson

TOPS LEARNING SYSTEMS

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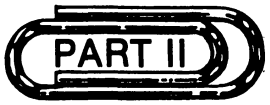
INTRODUCTION



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:	general on-the-shelf 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.	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):	*optional materials:
A parentheses following 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.	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* (substituted materials) general on-the-shelf materials *optional materials

$Q_1 / Q_2 / Q_3$	
1/10/10	meter sticks
8/80/80	meters of string
20/200/200	*size #16 rubber bands* — see activity 13
5/50/50	books to incline a meter stick (any solid support)
1/2/2	rolls masking tape
1/10/10	paper drinking cups
1/10/10	scissors
3/30/30	marbles
8/60/80	pennies
2/20/20	sheets lined notebook paper
1/10/10	*small flat buttons*
1/1/1	roll adding-machine tape
1/5/10	felt-tipped pens
1/1/1	spool thread
1/1/1	wall clock with second hand (watches)
1/10/10	*calculators
5/50/50	index cards, 4x6 or larger
1/1/1	bottle dishwashing liquid (bar of soap)
1/1/1	bottle food coloring
1/5/10	jar lids or crucibles
1 /5/10	Ping-Pong balls
.5/5/5	cups of oil-based clay
3 /15/30	baby food jars
1/4/10	narrow-mouth bottles (Erlynmeyer flasks)
1/1/1	roll aluminum foil
1/3/3	boxes paper clips - must have uniform size
1/1/1	corrugated cardboard box at least 30 cm high
1/2/5	paper punches
1/10/10	spring scales with a 2 or 3 N capacity, 2.5 N (250 grams) is ideal — see activity 14
1/4/10	*plastic gallon milk jugs with handle*
1/4/10	flat washers
1/ 4/10	protractors
1/10/10	manila file folders
1/5/10	plastic straws (glass tubing with smooth fire-polished ends works even better)
1/1/1	*cotton ball (feathers)*
1/20/30	clothespins
1/10/10	balloons
1/10/10	flexible plastic drinking straws
1/10/10	straight pins
1/4/10	*bath or beach towels*
1/10/10	stopwatches
1/4/10	*pillows (coats)

Sequencing Task Cards

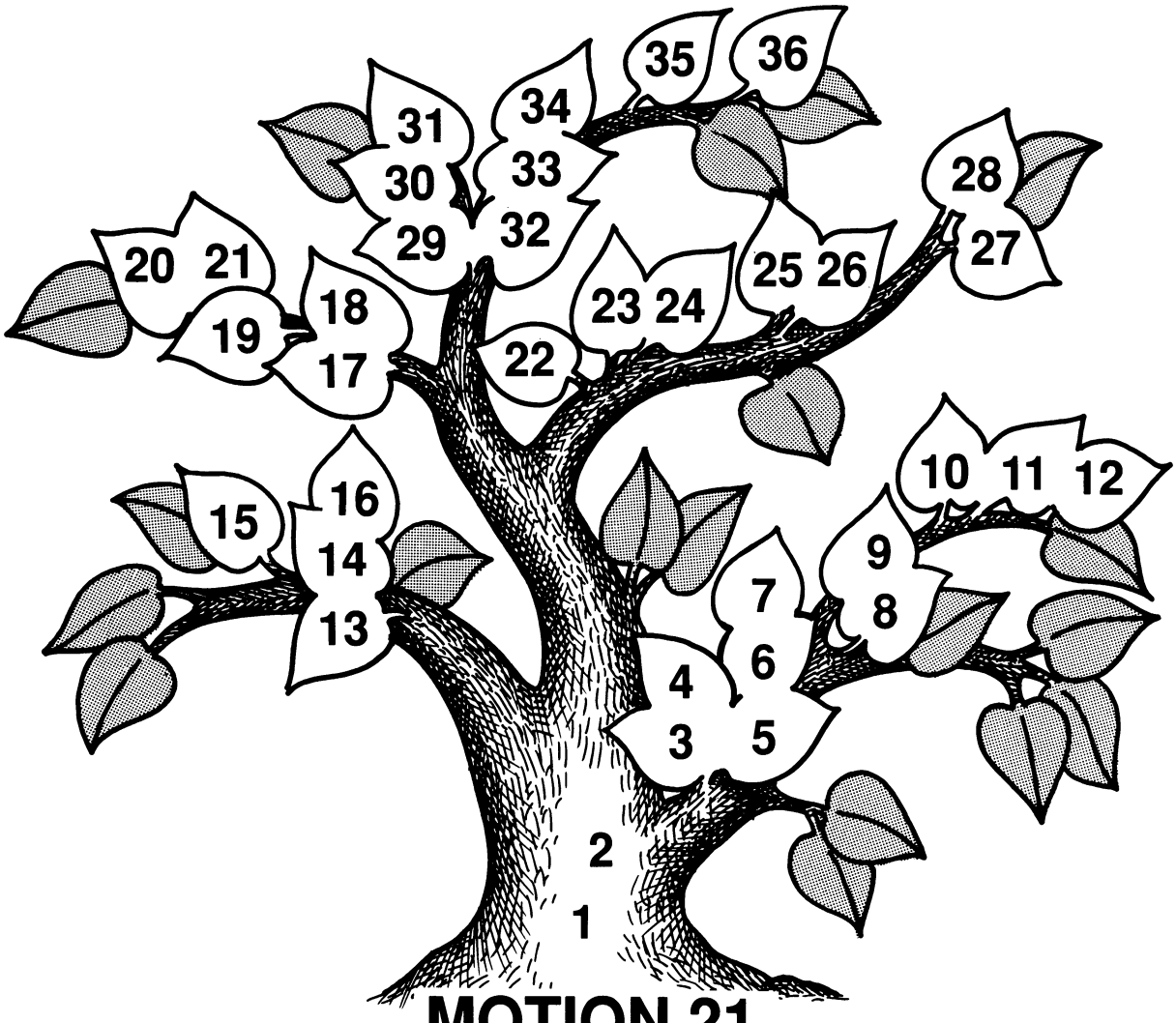
This logic tree shows how all the task cards in this module tie together. In general, students begin at the trunk of the tree and work up through the related branches. As the diagram suggests, the way to upper level activities leads up from lower level activities.

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.



MOTION 21

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.

tasks 1-2

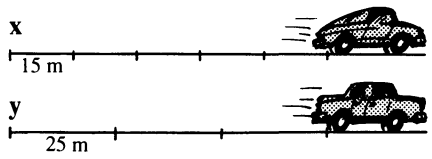
Winning football teams tend to have big men in the lineup. What advantage does extra mass give to...
a. a player at rest?
b. a player in motion?

task 2

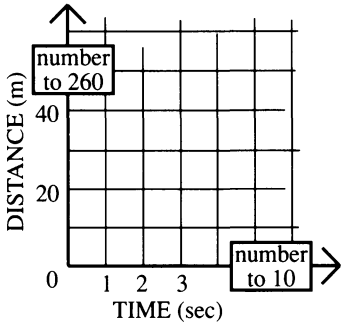
Before going down a long hill, road signs often warn truck drivers to test their brakes. Passenger car drivers are not cautioned to do this. Why?

tasks 3-7

The position of each car is marked after each second of travel. The distance between marks is 15 meters for car (x) and 25 meters for car (y).



a. How fast does each car move?
b. Draw a data table and graph. Label each graph line.



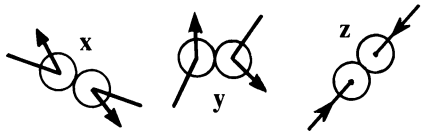
c. Interpret your graph: Why are the graph lines straight? Why does one have a steeper slope?

tasks 5-7

You drive about 990 km from Denver to Kansas City in 11 hours, stopping exactly 1 hour for lunch in Salina along the way.
a. What is your average speed?
b. What is your estimated freeway speed.?
c. Why is your average speed different than your freeway speed?
d. If you stopped for lunch after 7 hours, what is the distance between Denver and Salina?

tasks 8-9

Consider these separate collision events labeled x, y, and z. Assume that all balls move at the same speed.



a. Which are elastic; inelastic? Why?
b. Which involve balls of unequal mass? Explain.
c. Which involve balls of equal mass? Explain.

tasks 10-12

In a two-car accident, one driver suffers whiplash (a neck injury from the head being tossed back). The other driver suffers a broken nose. Use the idea of inertia to explain how this accident likely happened.

tasks 10-12

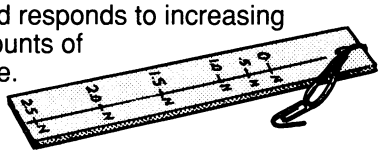
Explain each statement in terms of Newton's first law of motion.
a. The head of a hammer is made from heavy iron.
b. You pitch a shovelful of dirt; when the shovel stops, the dirt flies off.

task 13

A chain is pulled with increasing force until it breaks. Can you predict which link will fail first?

task 14

This simple scale is calibrated in Newtons. Describe how its rubber band responds to increasing amounts of force.



task 15

Is more force required to start a book sliding, or keep a book sliding at uniform speed? Explain.

tasks 15,18

Use labeled arrows to illustrate *all* forces that act upon each brick. Say if they are balanced or unbalanced.
a. A brick rests on the table.
b. A brick slows down as it slides across the floor.
c. You push lightly on a brick, but it doesn't move.
d. A brick drops to the floor. It hasn't yet landed.

tasks 15, 18

Tell if the forces acting on each object are balanced or unbalanced. Explain how you know.
a. A car moves down a flat road at a constant 50 km/hr.
b. A snowflake falls to earth on a silent, windless day.
c. The moon orbits the earth.
d. This test paper rests motionless on the table.
e. A stone is tossed straight up into the air.

task 16

A gymnast weights 500 N. How much tension is on each arm when she hangs from an overhead bar by...
a. 1 arm?
b. 2 parallel arms?
c. 2 widely separated arms? Explain.

task 16

Two adults and a child pull as hard as they can on a 3-way rope. Both adults have equal strength; the child half as much as either one. If no one is able to move the other, show the relative magnitudes and directions of each applied force. (Draw a bird's-eye perspective. Label your arrows.)

tasks 17-18

You are standing on a bus facing forward. Your legs are relaxed because you are firmly grasping an overhead bar. What is the bus doing if you find yourself...
a. leaning back?
b. leaning right?
c. leaning forward?
d. not leaning at all?

task 18

Light travels in a straight line at a constant speed of 300,000 km/s. What is its acceleration?

task 19

A stone falls 10 m/s after 1 second, 20 m/s after 2 seconds, 30 m/s after 3 seconds, and so on.
a. What is its acceleration?
b. If you plotted time vs. distance, would you graph a straight line?

Review / Test Questions (continued)

task 20

At a football game you watch the quarterback throw a "desperation pass" as far as possible down the field.

a. Sketch the flight path of the football. Use an arrow to show the direction it moves.

b. Label where the ball accelerates and decelerates along its path.

task 21

Gravity constantly attracts the earth and sun together. Yet the earth remains in orbit around the sun without crashing into it. Explain how this is possible. Use a diagram to illustrate your answer.

task 22

Explain each event in terms of Newton's second law;

a. A passenger car accelerates away from a traffic light better than a heavy truck.

b. Adults usually throw baseballs farther than children.

task 23

A 1 kg mass weighs about 10 Newtons. Use Newton's second law to calculate the acceleration of gravity.

task 24

A feather and a marble are sealed in a large jar and dropped from a high bridge. Where does each object rest in the jar on the way down? Explain.

task 25

A little girl and her father are both standing on roller skates.

a. What happens to the little girl as she pushes her father forward? Frame your answer in terms of Newton's third law.

b. Who travels farthest? Use Newton's second law to support your answer.

task 26

It is easier to start running on a cinder track than on a sheet of ice. Use Newton's third law to explain why.

task 26

You are in a small boat with no oars. But you do have a load of heavy stones. Use Newton's third law to propose a way of propelling the boat forward with these stones.

task 27-28

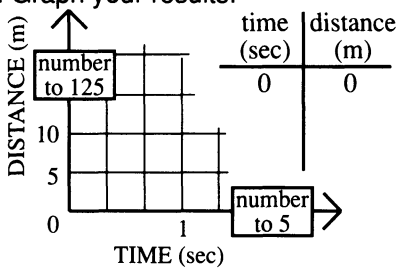
Design a sling shot and projectile to travel a maximum distance.

task 29-30

A piano falls out the window of a very tall building. The distance (d) through which it falls is given by $d = 1/2gt^2$, where (g) is the acceleration of gravity and (t) is the time in seconds. Because g is nearly 10 m/s² on earth, the distance in meters for this equation is given by $d = 5\ t^2$.

a. Complete this table of time vs. distance over the first 125 meters.

b. Graph your results.



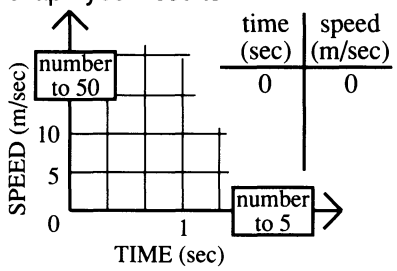
c. Interpret the physical significance of the graph line.

task 31

A piano falls out the window of a very tall building. (It is the same piano. Throwing out a new one would be too expensive.)

a. Knowing the acceleration of gravity on earth to be about 10 m/s², complete this table of time vs. speed over the first 5 seconds.

b. Graph your results.



c. Interpret the physical significance of the graph line.

task 32

Explain how the force of gravity (a marble's weight) is resolved by an inclined plane into a smaller accelerating force. Illustrate your answer with a labeled diagram.

task 33

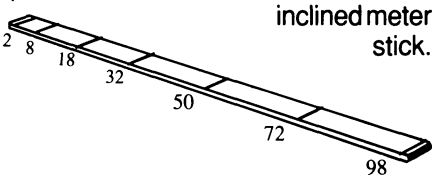
A meter stick is tipped at just the right angle so that a marble accelerates through 20 cm in 1 second.

a. How far would the same marble travel down the same incline in 2 seconds?

b. In what fraction of a second would a marble travel 5 cm down this incline?

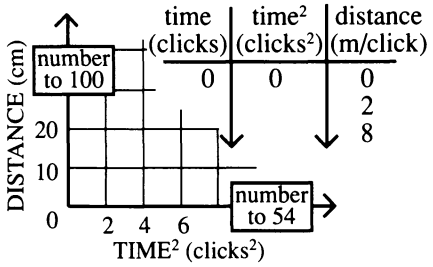
task 34

A marble clicks out 7 equally-spaced units of time when it rolls across strings positioned at these intervals on an inclined meter stick.



a. Complete this data over the first 7 clicks for the distance shown.

b. Graph time² vs, distance.



c. Interpret your graph line.

tasks 10-12, 24, 35

A bicycle and a fully loaded cement truck are at rest, balancing on the top of a long steep hill ready to begin a "gravity race." At the command "go" the cyclist and truck driver both push their respective vehicles as hard as they can, then jump aboard to coast to the finish line several miles away. Use your knowledge of Newton's laws of motion to predict...

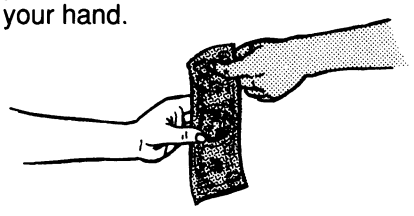
a. How the race will start.

b. How the race will finish.

c. How a similar race on the moon would be different.

task 36

It is difficult to catch a dollar bill that a friend drops through your fingers if you start at the center and don't lower your hand.



a. Would this trick be easier to do on the moon? (You are not wearing a space suit because you are inside a protective bubble.)

b. Where on earth could you make this trick easier to do?

Task Objective (TO) experience how the total mass of a resting body affects its tendency to remain at rest.

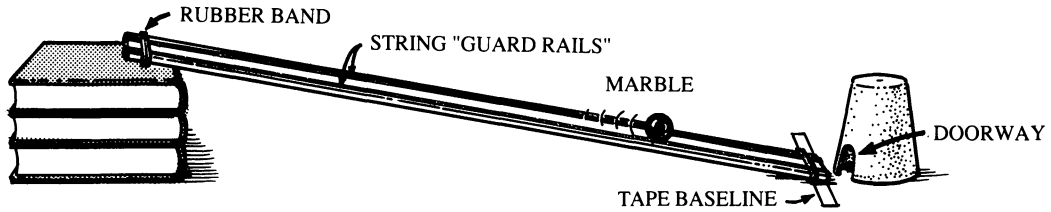
BODIES AT REST

Motion ( )

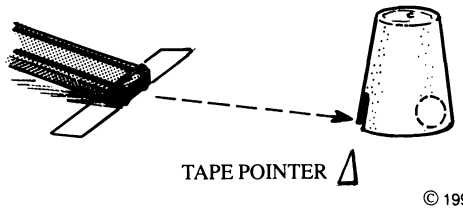
1. Run 2 string guard rails down the length of a meter stick. Fix them tightly at each end with rubber bands.

2. Raise one end with 3 books. Mark the other end with masking tape.

3. Cut a "doorway" in a small drinking cup so a marble can roll down the ramp and land inside.



4. Cut a pointer from masking tape to mark how far the cup slides.



5. Repeat with 1 penny, 2 pennies, and 3 pennies taped to the top of the cup.

6. Measure distances. Organize a data table and draw a bar graph on lined paper.

7. Describe how increasing mass (more pennies), affects a body at rest (the cup).

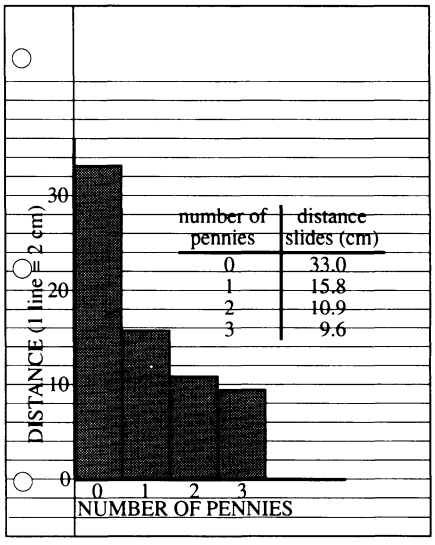
Answers / Notes.

4. *The cup should slide over a reasonably large distance without being bowled over. Adjust the slope of the incline up or down as necessary by adding or removing books. Keep the tape pointers well back from the sliding area. Otherwise they can snag the cup as it slides by.*

6. *Measure distances without removing the string guard rails. These meter sticks will be used again and again as inclined planes.*

Data will vary widely, affected by a host of variables — mass of the marble, slope of the incline, smoothness of the table surface, how the marble strikes the cup, etc. But overall trends in the data remain definite.

7. As the mass of the cup increases (with the addition of more pennies) its tendency to remain at rest increases (it moves through shorter distances).

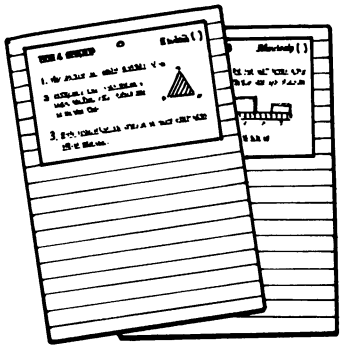


Materials

- ☐ A meter stick and string.
- ☐ Rubber bands.
- ☐ Books or other objects to raise one end of the incline.
- ☐ Masking tape.
- ☐ A disposable drinking cup. Styrofoam cups are least desirable. They are easily knocked over when captured by the marble, and tend to build up a static charge with the table top.
- ☐ Scissors.
- ☐ A marble.
- ☐ Pennies.
- ☐ Lined notebook paper.

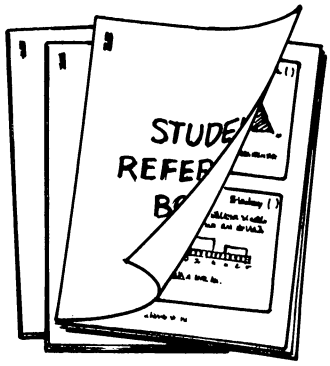
Task Cards Options

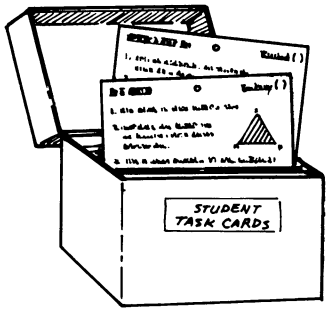
Here are 3 management options to consider before you photocopy:



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.

BODIES AT REST

Motion ( )

1. Run 2 string guard rails down the length of a meter stick. Fix them tightly at each end with rubber bands.

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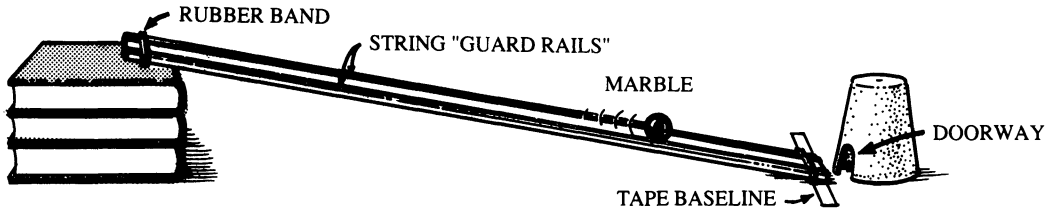

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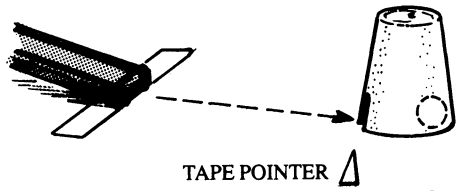


5. Repeat with 1 penny, 2 pennies, and 3 pennies taped to the top of the cup.

6. Measure distances. Organize a data table and draw a bar graph on lined paper.

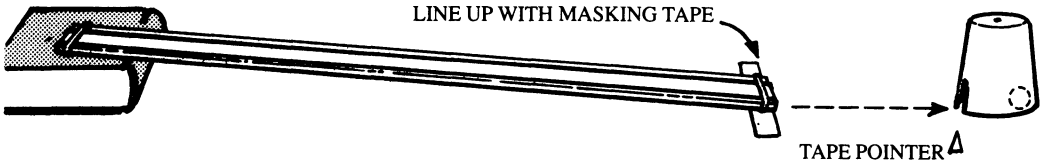
7. Describe how increasing mass (more pennies), affects a body at rest (the cup).

BODIES IN MOTION

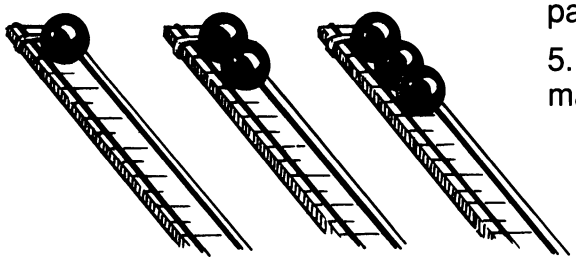
Motion ( )

1. Lower the incline from 3 books to 1 book. Line up the other end with a masking tape baseline.

2. Mark how far the cup slides when one marble rolls off the ramp.



3. Add more marbles. Repeat the experiment after each addition.



4. Measure distances. Organize a data table and draw a bar graph on lined paper.

5. Describe how increasing mass (more marbles), affects bodies in motion.