SSBAL

Task Objective (TO) begin building a sturdy, accurate equal-arm balance to use in all experiments that require weight measure.

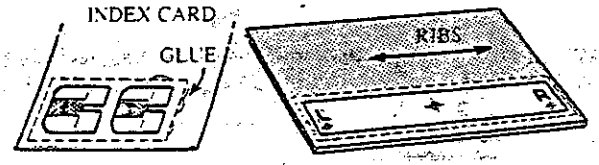
BUILD AN EQUAL-ARM BALANCE (1)

Weighing ( )

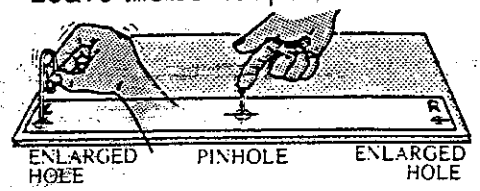
1. Get paper patterns for 2 pivots and a beam from your teacher...

...Glue 2 pivots to a piece of index card...

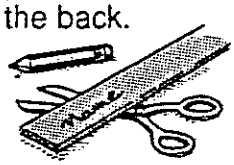
...Glue 1 beam to some corrugated cardboard, parallel to the "ribs."



2. Push a pin *straight* through the *exact* center of the 3 bull's-eyes. Force the end of a paper clip through both *outside* pin holes. Leave the center pin hole small.

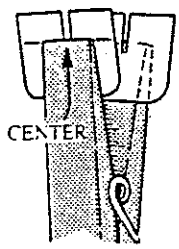


3. Cut out this beam and write your name on the back.



4. Cut out the small squares, then cut out the long narrow slot in each one. Write your name on the back of one.

5. Glue where marked. Fix to the *inside* of clothespin wings with the slots centered.



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Answers / Notes

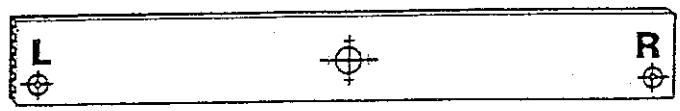
1. *It is important to place this rectangle* parallel *to the corrugations. Beams cut with perpendicular ribs are not as strong.*

2. *This step is crucial to building an accurate balance. Make sure that each pinhole is poked* exactly *on the bull's-eye; that the pin is pushed* straight *through from an upright perpendicular position. If your students lack good eye-hand coordination, do this step for them.*

An easier way to enlarge the end pin holes is to drill them front and *back with a sharp pencil. If your students use this method, make sure they don't get carried away and enlarge the hole too much. The paper clip should easily fit the hole, but not wobble excessively.*

5. *Students may proceed directly to the next task card. The glue will dry by the time they need to use their clothespins.*

The unfinished balance so far looks like this:



Materials

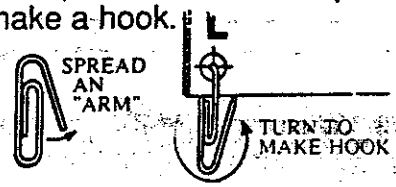
- ☐ Cut-out patterns. Photocopy the last page in this book. The multiple patterns serve up to 5 students per page. Copy an extra page to accommodate students who spoil their patterns and need to start over.
- ☐ Scissors. These should be sharp enough and heavy-duty enough to cut through corrugated cardboard.
- ☐ A bottle of white paper glue or wood glue.
- ☐ An index card. One 4x6 card will serve 4 to 8 students.
- ☐ Corrugated cardboard. Cut cardboard boxes into strips that are somewhat larger than the 3 cm x 25 cm beam pattern itself. Remember to cut the longest dimension of each piece *parallel* to its corrugations.
- ☐ A straight pin. Extra long pins work best.
- ☐ A paper clip.

(TO) continue building a sturdy, accurate equal-arm balance to use in all experiments that require weight measure.

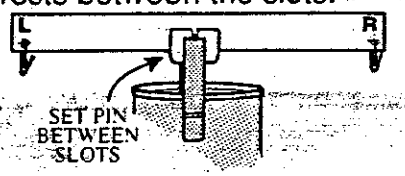
BUILD AN EQUAL-ARM BALANCE (2)

Weighing ( )

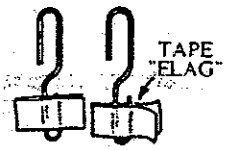
1. Pull out the "arms" of 2 paper clips just a little. Push these arms through the end holes, then rotate each clip to make a hook.



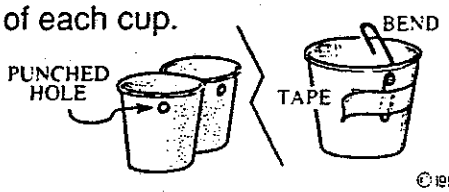
2. Stick a straight pin through the center hole. Clip your clothespin to a can and balance your beam so the pin rests between the slots.



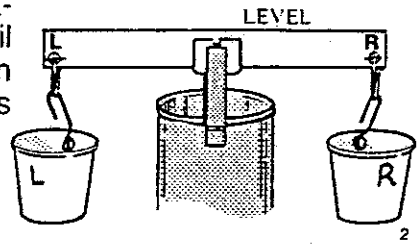
3. Unbend 2 paper clips like these. Flag the small end with masking tape.



4. Paper-punch a hole below the lip of 2 drinking cups. Push your clips through, taping each flagged end. Bend the free ends toward the center of each cup.

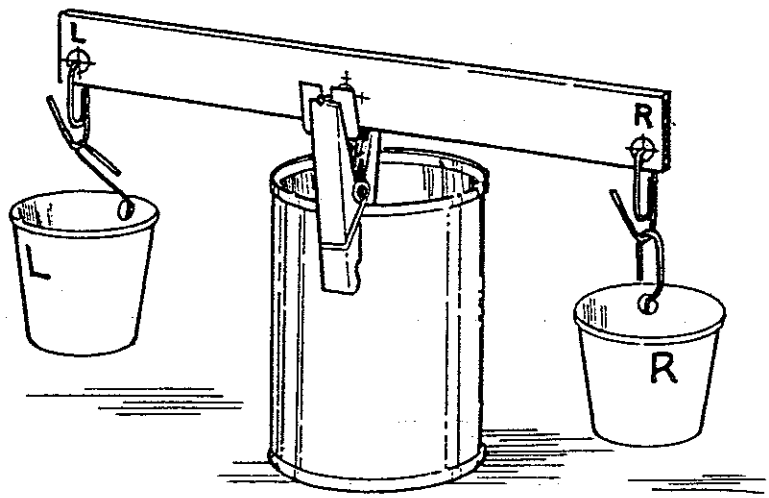


5. Hook each cup on the beam. Label them "L" and "R". Add tape to the bottom of the lightest cup until the beam balances level.



Answers / Notes

5. *The balance is not quite finished. Several refinements remain to be added. It now looks like this:*



Materials

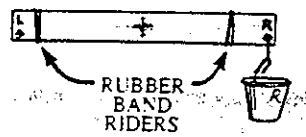
- ☐ Materials from the previous task card: a cardboard beam and clothespin with glued index card slots.
- ☐ Paper clips of equal size and weight. Use only one brand, banishing all others from your classroom.
- ☐ A straight pin.
- ☐ A medium-sized tin can.
- ☐ Masking tape.
- ☐ A paper punch.
- ☐ Small paper drinking cups with flat bottoms. Avoid styrofoam cups. These tend to hold an electrostatic charge and cling to many table surfaces.

(TO) finish building a sturdy, accurate equal-arm balance to use in all experiments that require weight measure.
To learn how to center the balance and make accurate weighings.

BUILD AN EQUAL-ARM BALANCE (3)

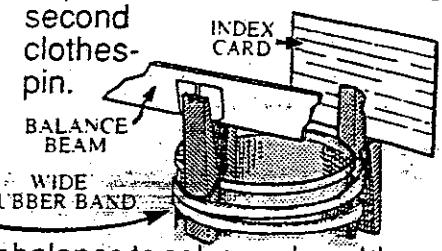
Weighing ( )

1. Lift off the cardboard beam. Wrap a thin rubber band on each end so it grips gently.

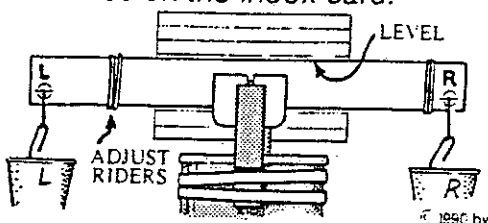


2. Attach a second clothespin to your can, opposite and upside-down to the first, with a tightly stretched, wide band. Pull it over the nose of the first paper clip as well.

3. Reassemble your balance. Clip a ruled index card into the second clothes-pin.



4. Center your balance: move the rubber band riders right or left until the top of the beam lines up with the lines on the index card.



5. Use your balance to solve each problem. Recenter after each weighing.

a. How many rice grains balance 1 paper clip?

b. How many paper clips plus rice grains balance 1 penny?

c. Predict how many rice grains balance 1 penny. Test your prediction. Why isn't it exact?

Answers / Notes

4. *Besides moving the rubber-band riders, minor centering adjustments can also be made by tilting the ruled index card even with the beam. The whole idea of centering is to establish a unique beam position, level or otherwise, that begins the measurement with empty pans and ends the measurement with the material to be weighed. Both before and after, the beam should return to exactly the same position.*

If the beam fails to properly recenter, its because the paper clips are not yet rotating freely at each end of the beam. Correct this problem by enlarging both holes: work the clips back and forth until they always hang straight down, independent of the tilt of the beam.

The 2 rubber bands must grip tightly enough to remain stationary on the tilting beam. But they should not be stretched so tightly that the bands are difficult to shift or roll when centering the beam.

5. *Answers will vary according to the brand of paper clips used, the variety of rice and kind of penny. In the U.S., pennies minted after 1982 weigh less than those minted before 1982. Here is one result:*

a. 1 paper clip = 31 rice grains

b. 1 penny = 5 paper clips + 5 rice grains

c. Five paper clips should weigh 5 x 31 rice grains, and a penny should weigh 5 grains more, or 160 grains total. This can be confirmed on a balance to within a 5 -10% error. The prediction is not exact (unless it is a lucky guess) because individual rice grains have variable masses.

Materials

- ☐ The equal-arm balance under construction.
- ☐ Light and heavy rubber bands.
- ☐ A clothespin.
- A ruled 4 x 6 inch index card. Other sizes will also work.
- ☐ Paper clips of uniform size and weight.
- ☐ Uncooked long-grained white rice. Other varieties OK. Avoid packages with many broken grains.
- ☐ A penny.

INSTRUCTIONS FOR MAKING APPROXIMATE GRAM MASSES

Using graph paper provided:

2.85	squares = 10 milligrams
5.7	squares = 20 milligrams
8.5	squares = 30 milligrams
14.25	squares = 50 milligrams
28.5	squares = 100 milligrams
57.	squares = 200 milligrams
142.5	squares = 500 milligrams
285.	squares = 1 gram

Other equivalents: post 1982 US penny = 2.5 grams
US nickel = 5 grams
US dime = 2.35 grams
US quarter = 5.55 grams
Clothespin = 7.6 grams
Thumbtack = .53 grams