COPY THIS PAGE ONTO HEAVY CARD STOCK. If this is not possible, make a copy on regular paper (or cut out this page and use it) and glue it to thin cardboard.
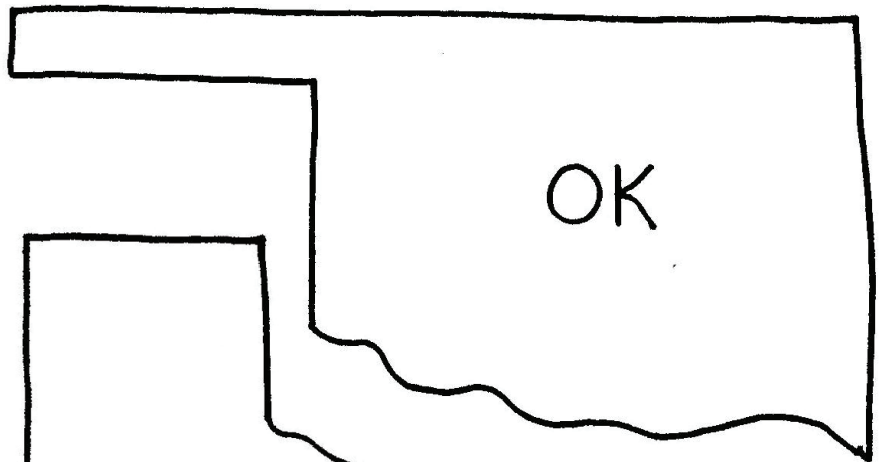
NJ

NOTE: These states are not drawn to scale. Vermont and New Jersey are much smaller than Texas and Oklahoma! In this activity, we are interested in just their shapes, not in their relative sizes. We could have used other odd shapes, but state shapes are fun to work with.

UT

OK

TX

VT
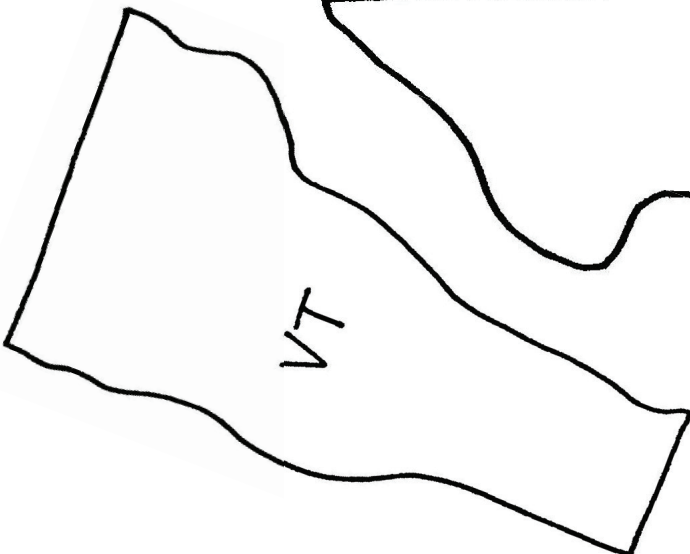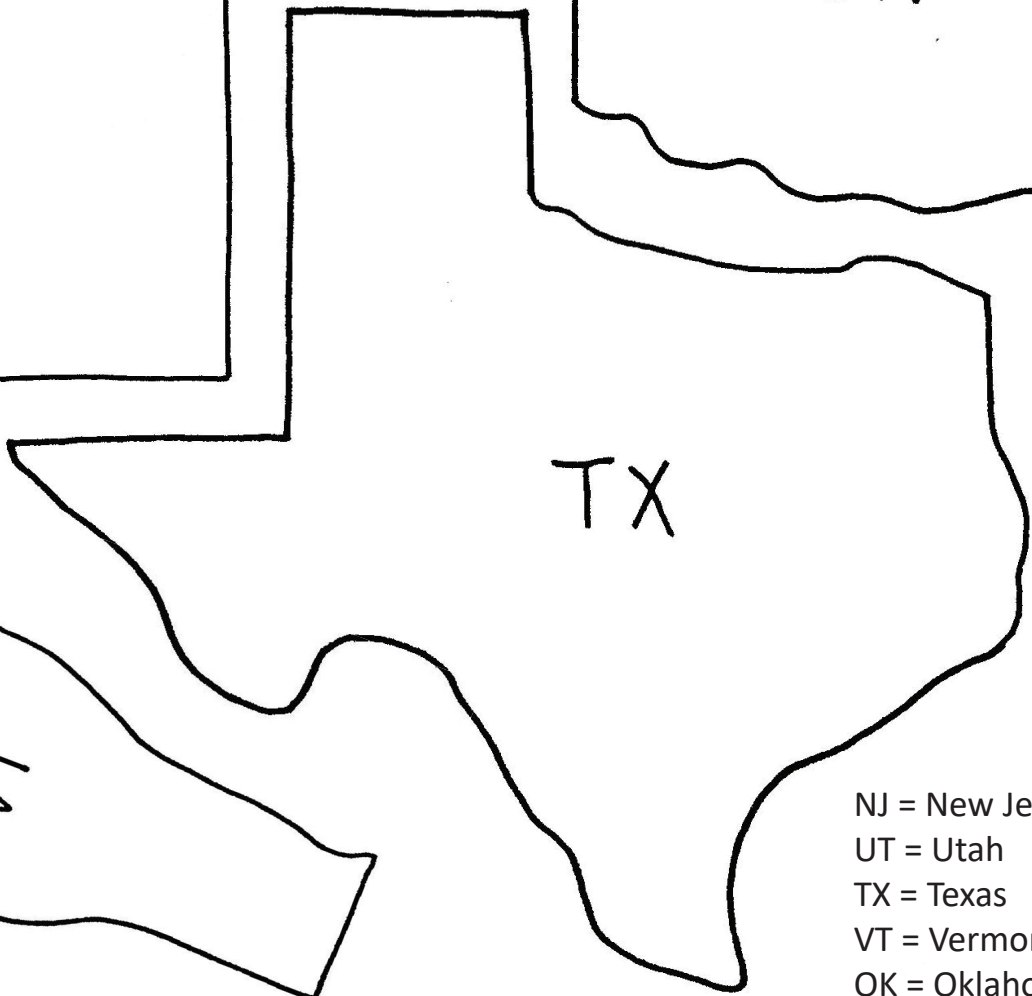
NJ = New Jersey
UT = Utah
TX = Texas
VT = Vermont
OK = Oklahoma

CA

FL

TN

ID

NV

WV

ID = Idaho
CA = California
TN = Tennessee
FL = Florida
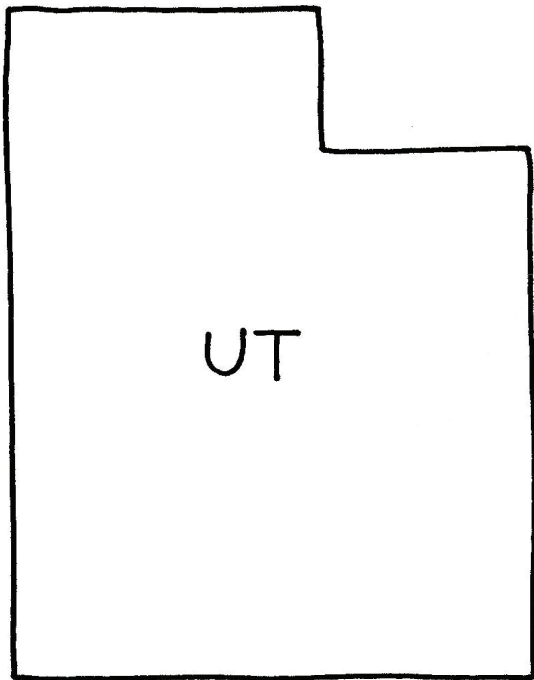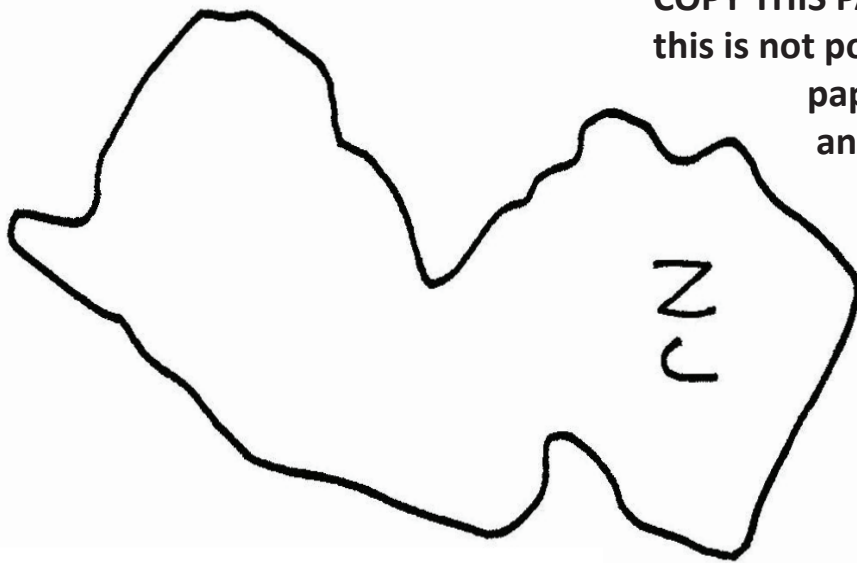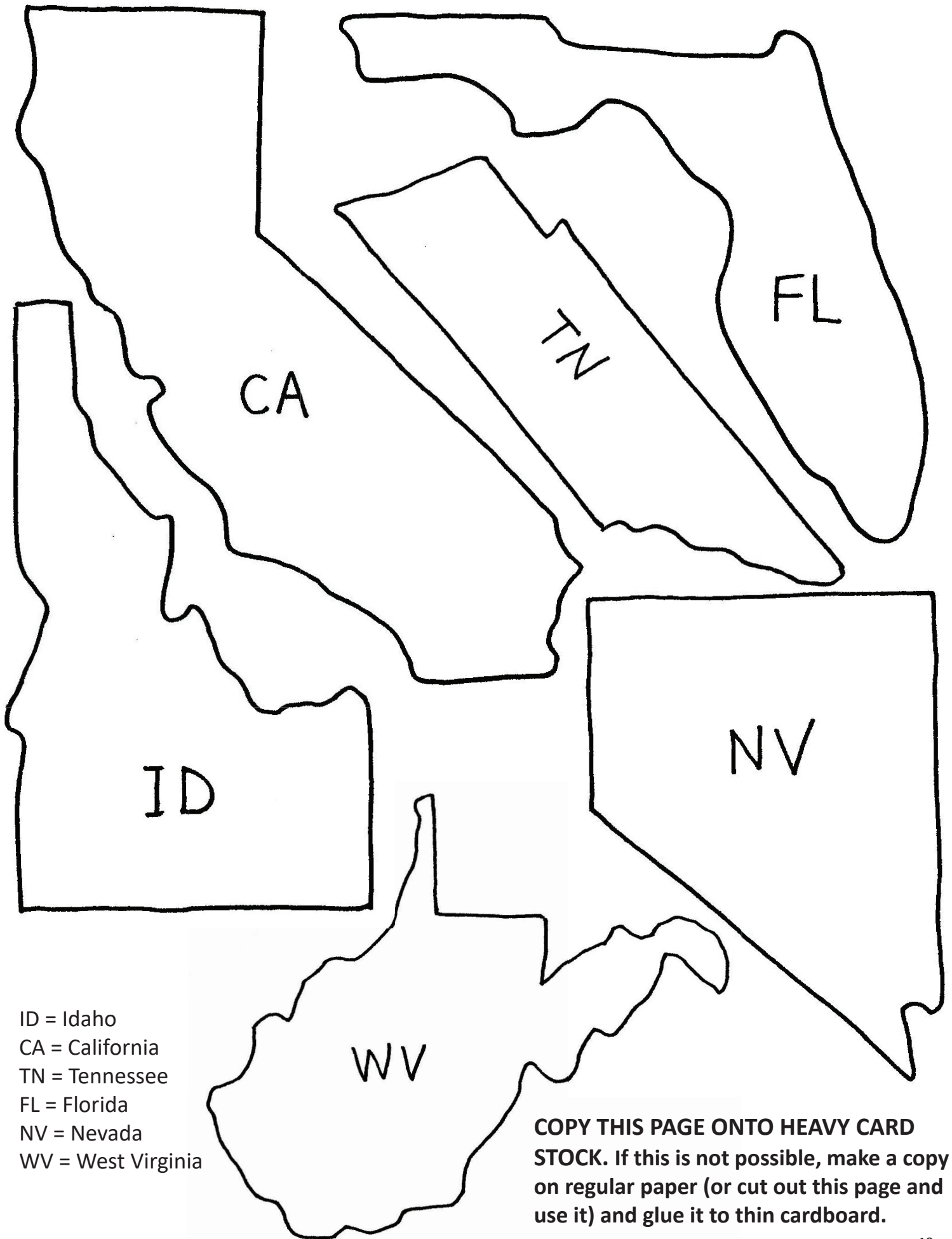NV = Nevada
WV = West Virginia

COPY THIS PAGE ONTO HEAVY CARD STOCK. If this is not possible, make a copy on regular paper (or cut out this page and use it) and glue it to thin cardboard.
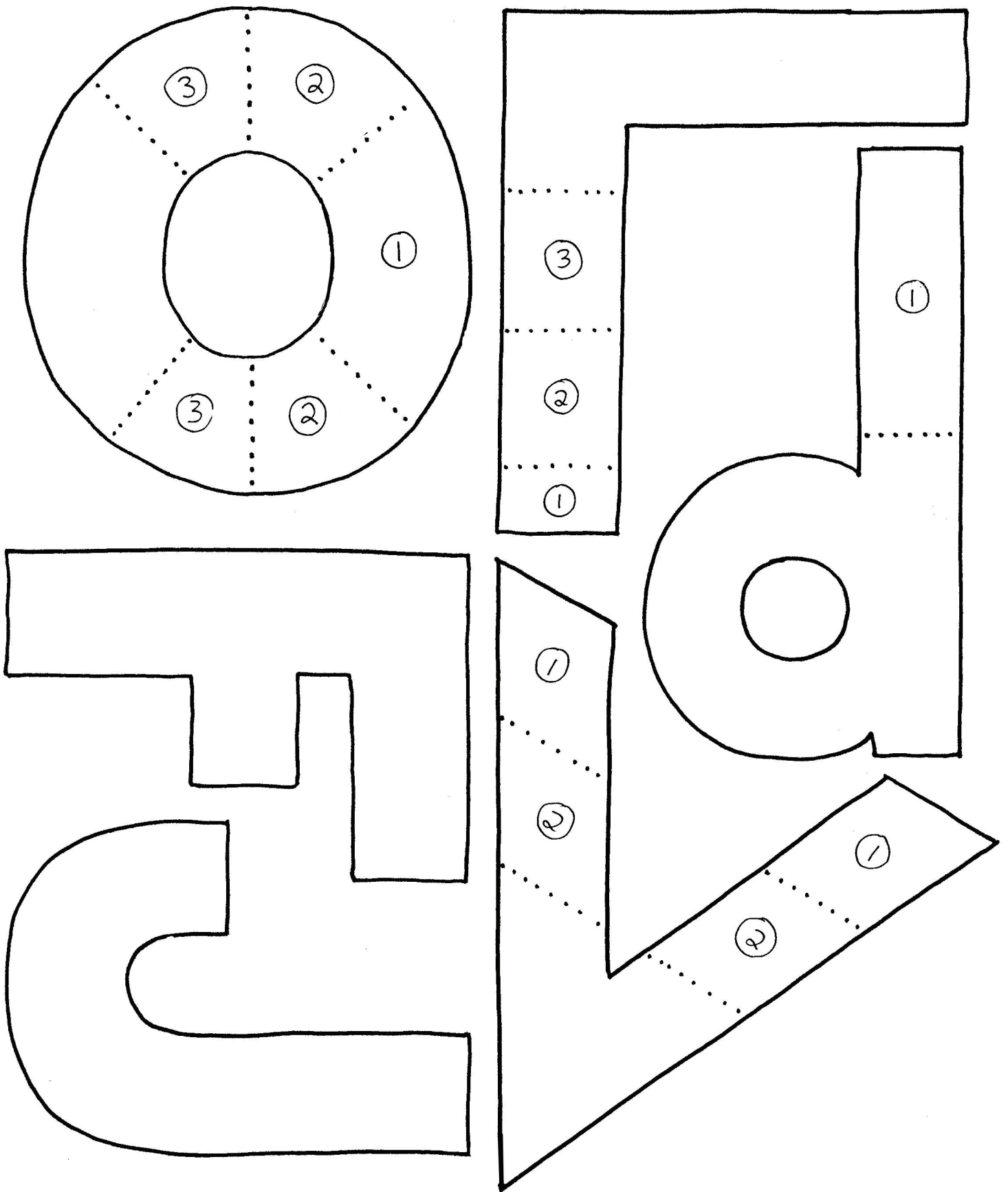
Copy this page onto heavy card stock paper. If this is not possible, you can copy it onto regular paper (or cut this page out of the book) and glue to thin cardboard.)
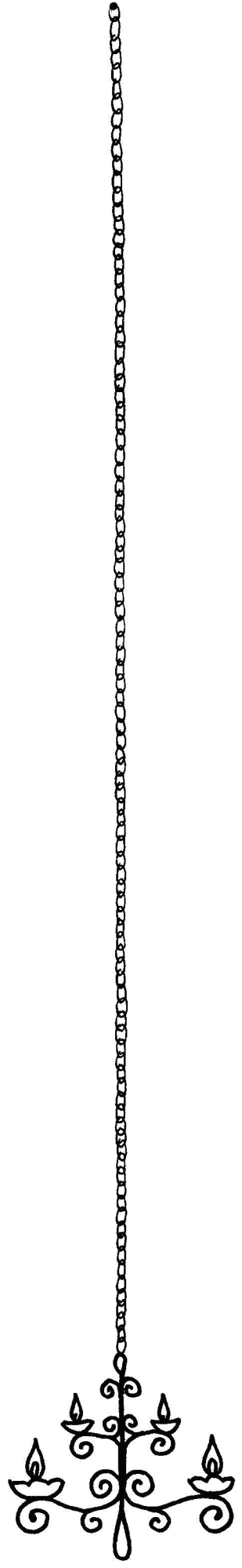
HOW TO ASSEMBLE THE ACCELEROMETER

It is recommended that you "score" the fold lines (the dotted lines) before you fold them.
Scoring is just a light scratching or pressing of the paper, not cutting. Score will make the folding very easy.

1
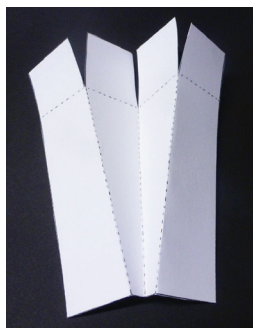
2
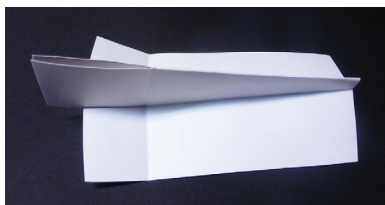
3
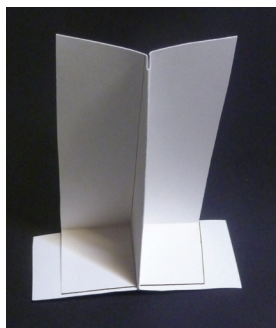
4
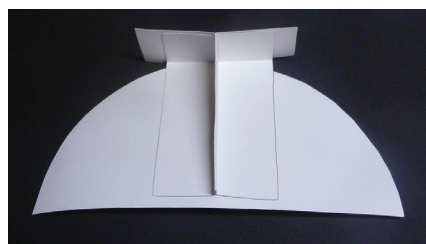
5
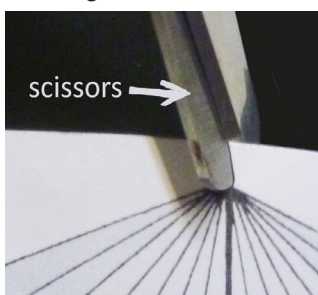
6- finished, and mounted on track car

scissors →

60
50
40
30
20
10
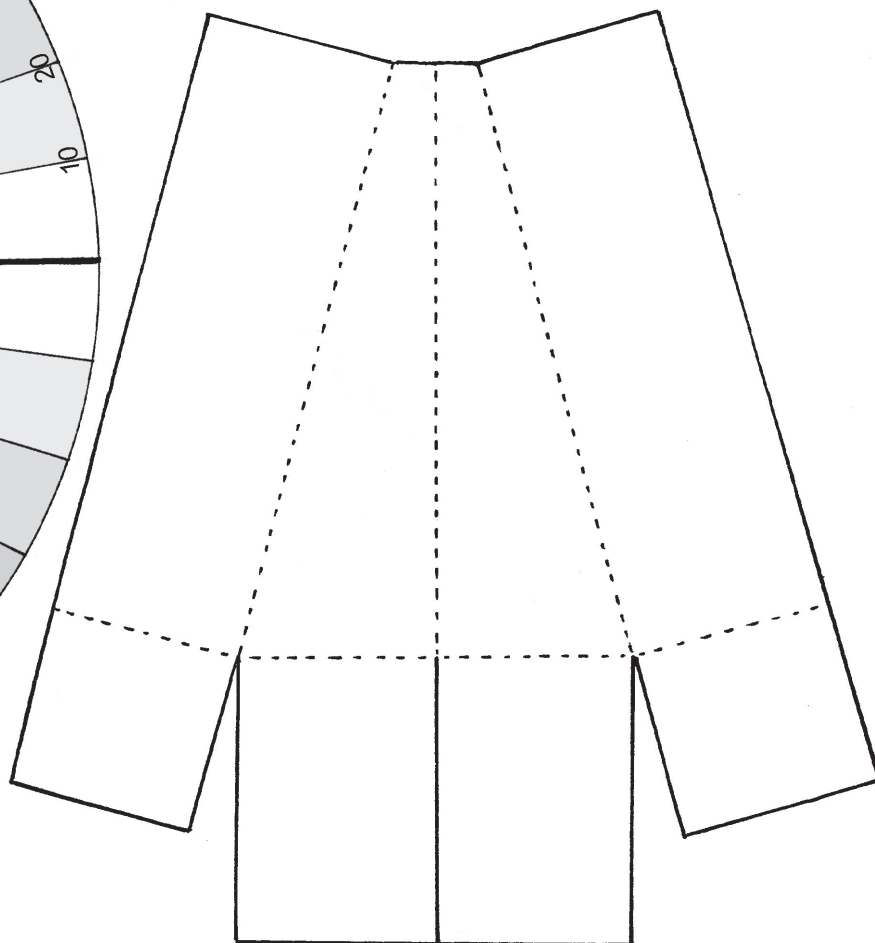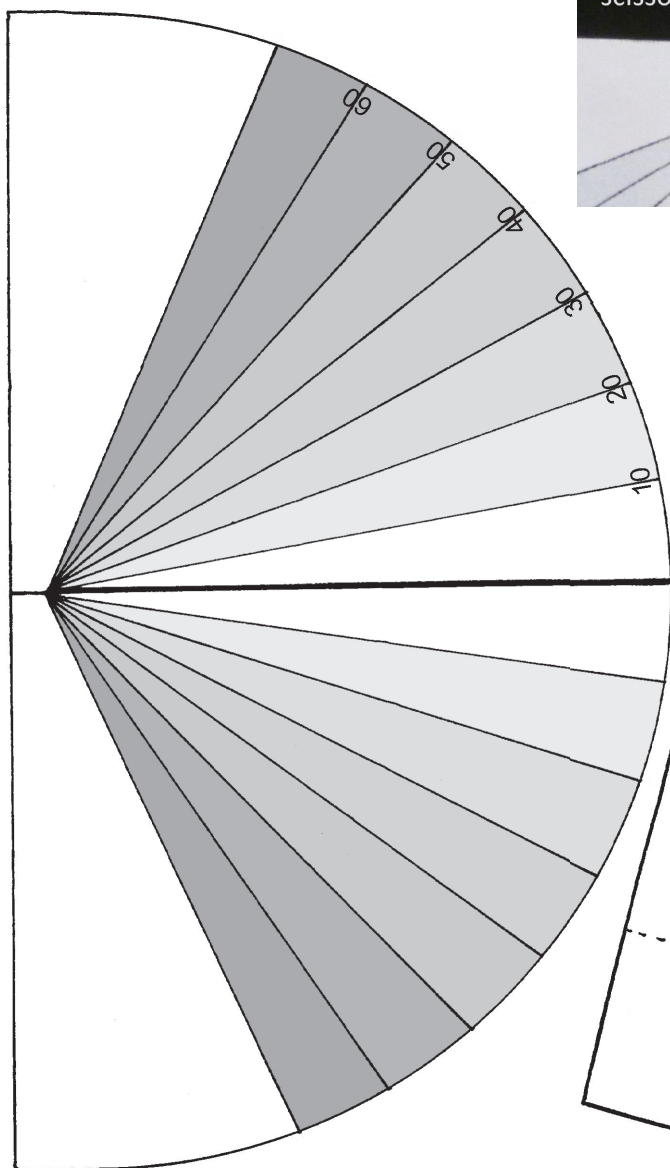
You won't need the numbers on the accelerometer
for this activity. We will use them in activity 8.10.
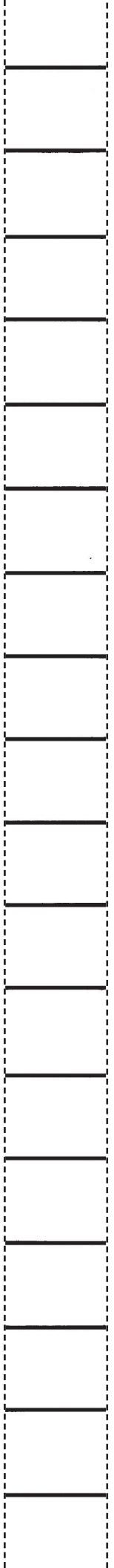
MAKE 1 COPY OF THIS PAGE ON CARD STOCK
Cut out ring. Also cut the slit on the bottom of the ring.
You won't need the center circle piece, so we used it for the diagram of set-up.

40cm

60 cm
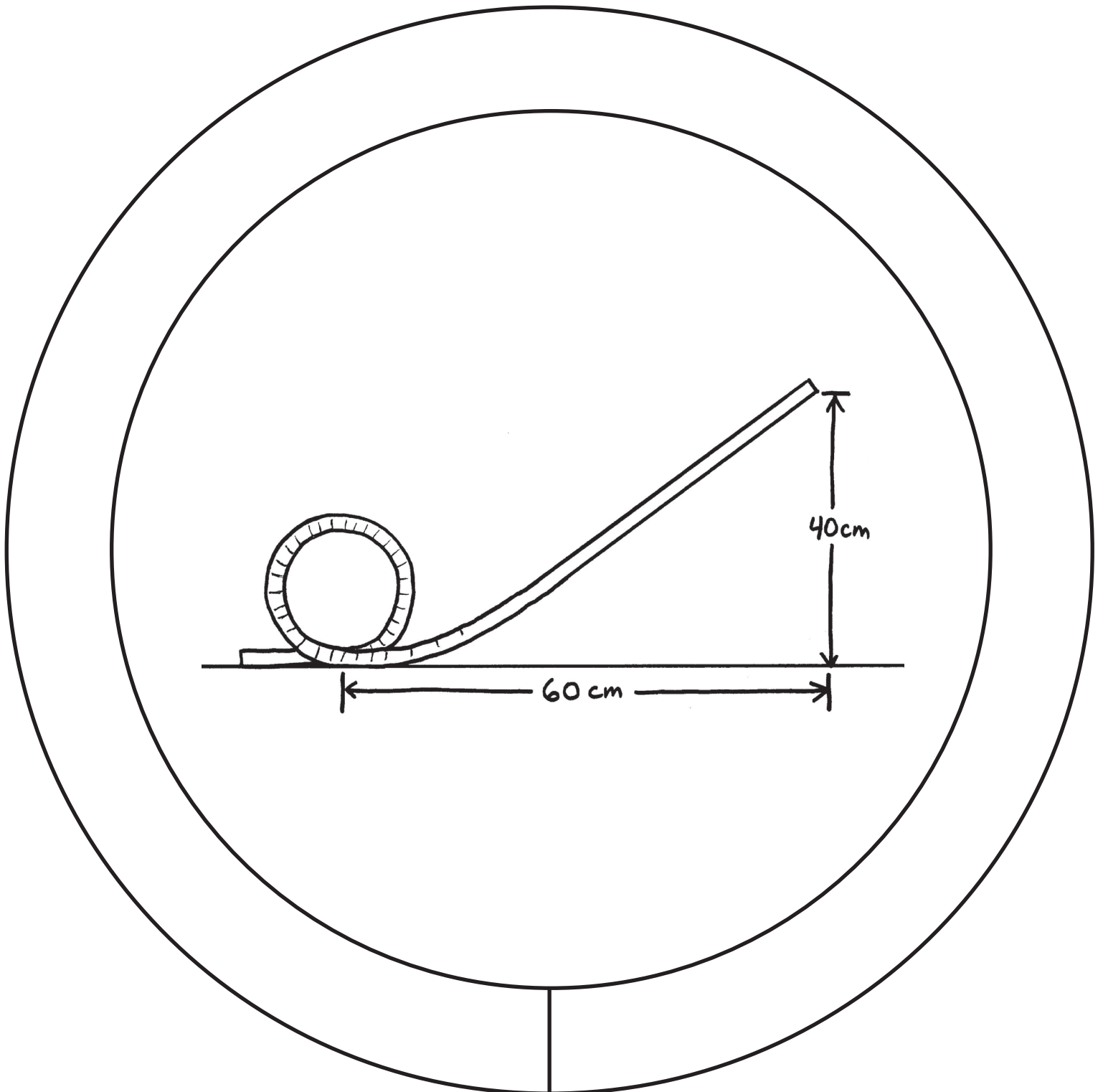
BALANCING BIRD TOY

You will need:
• two pennies, a toothpick, clear tape, glue stick (optional: coloring supplies)

1) Do any coloring you want to do. 2) Cut out bird and tail. Make sure to cut along the wing lines that go into the body area. 3) Fold the bird in half. 4) Apply glue stick to inside of the forward half of head (eye and beak area) and stick halves together. (Note: Beak can be reinforced with clear tape if it seems too flimsy.)
5) Make a slight crease along the lengths of the wings, to stiffen them. 6) Tape toothpick to underside of wings, across the center, (like the cross bar of a kite).   7) Insert tail piece and secure with tape on the underside. 8) Roll two pieces of tape and apply one to each penny. Stick pennies on the undersides of the ends of the wings and then check balance. Adjust the pennies if necessary to make the bird balance well. Once pennies are in the right place, secure them with a little more tape.

5

6

toothpick

7

8

PRINT THIS PAGE ON CARD STOCK

LOAD

BODY WEIGHT

FORCE
pull
of
muscle

FULCRUM

FULCRUM

FORCE (masseter muscle)
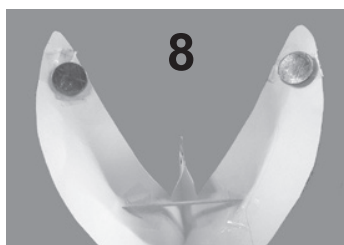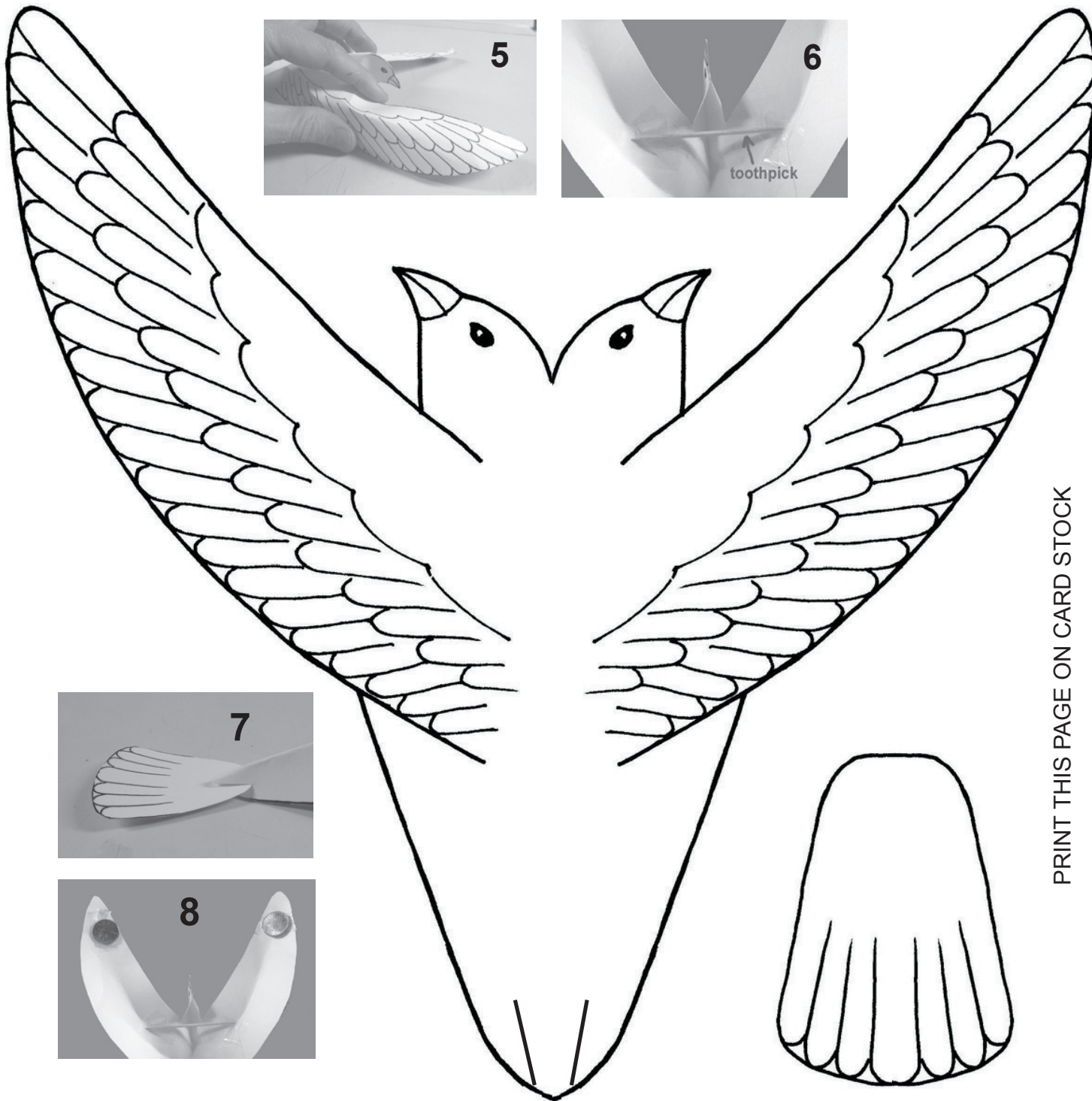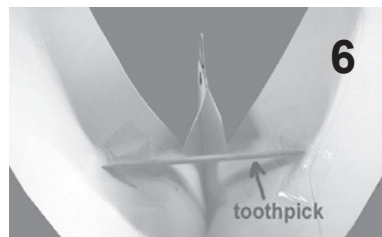
FORCE

LOAD
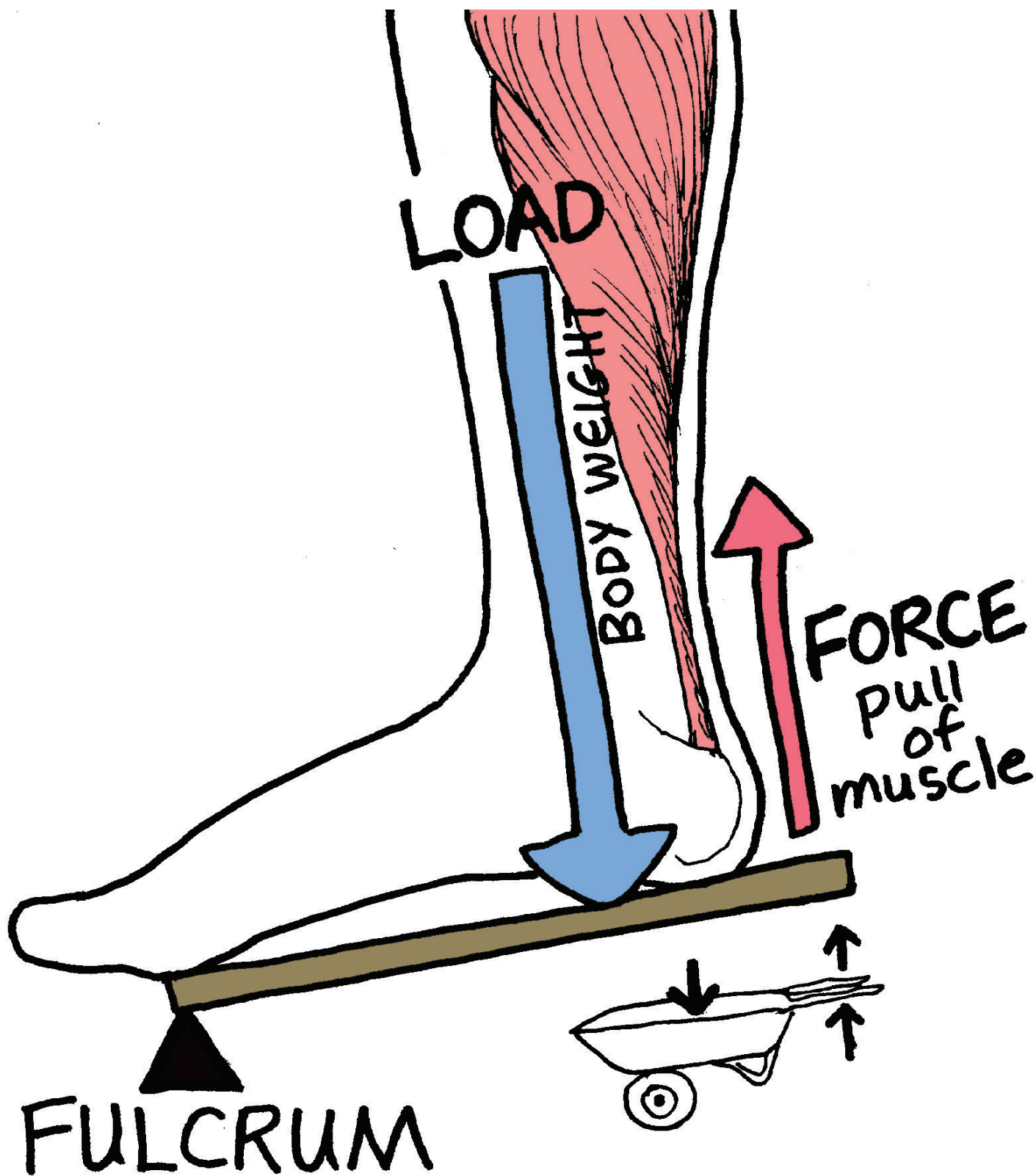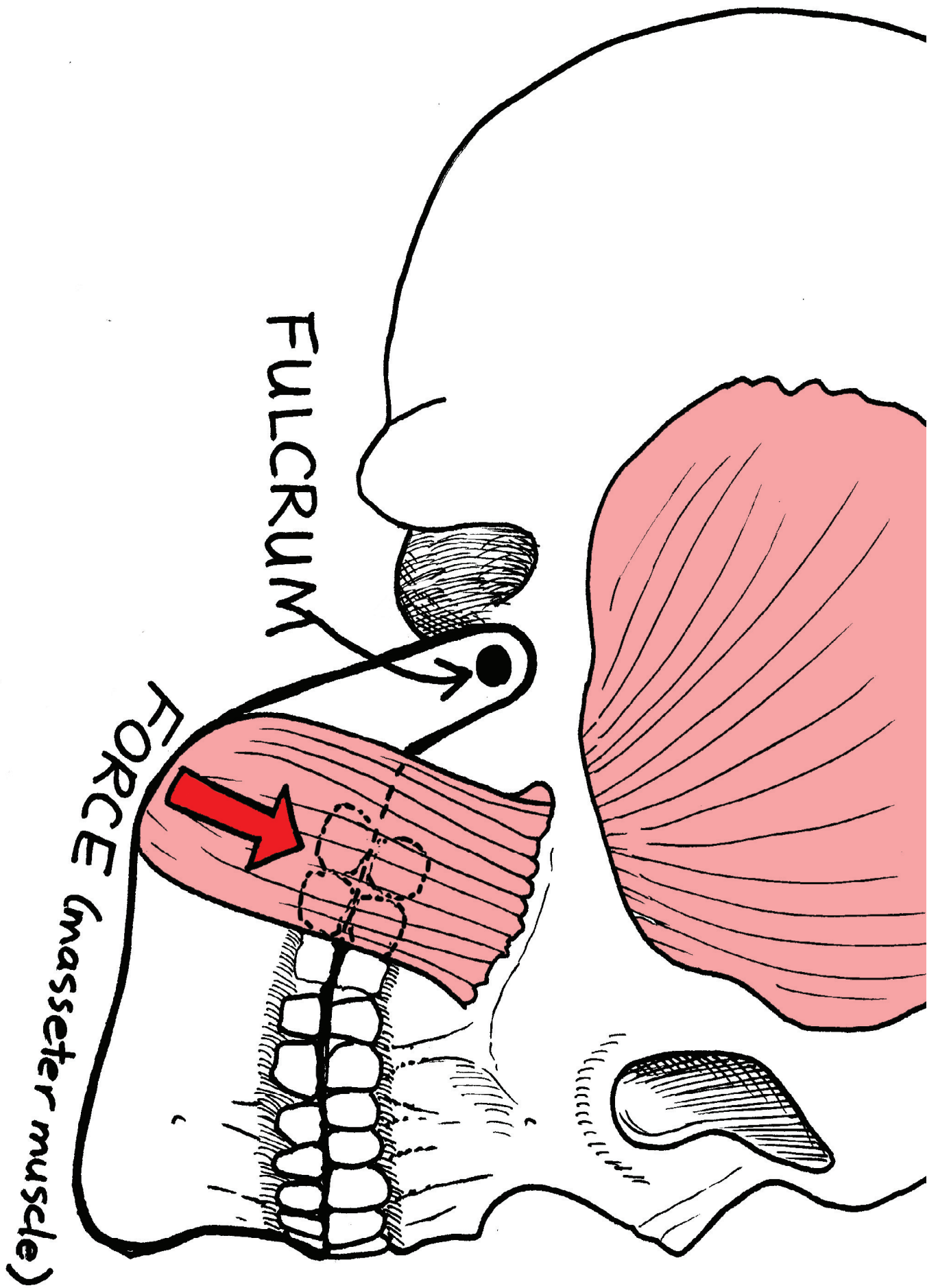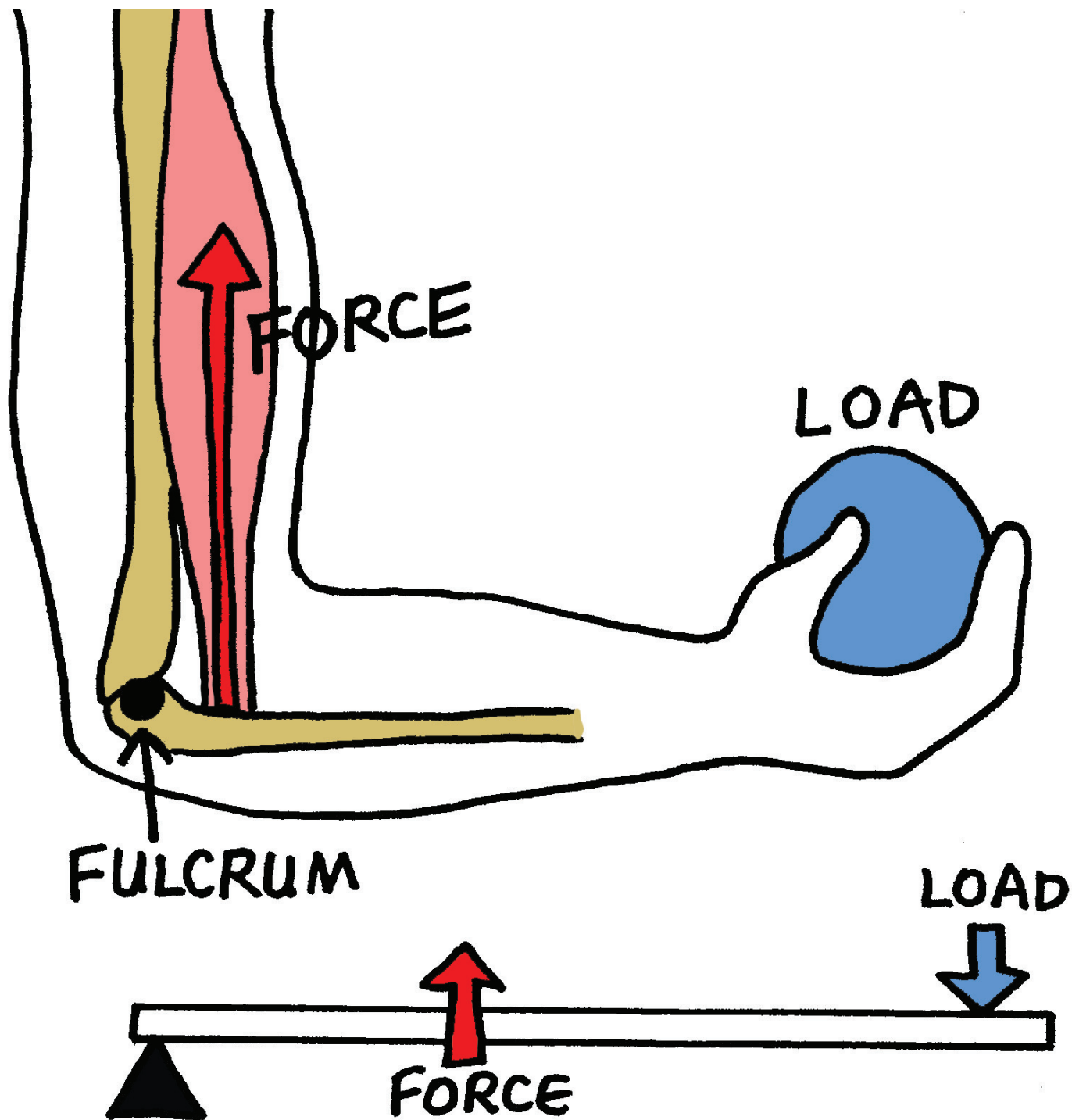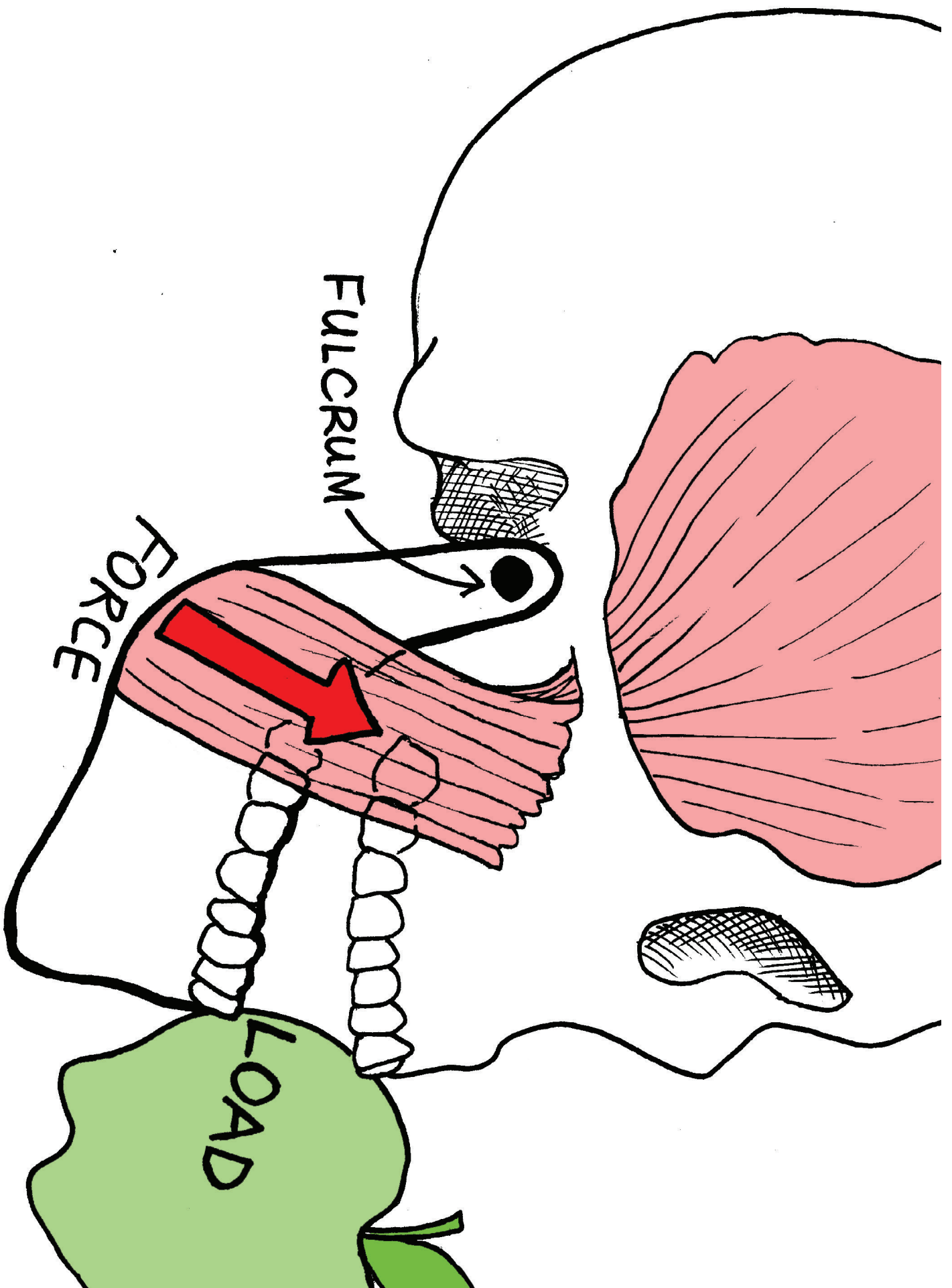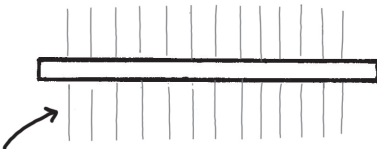
FULCRUM

LOAD

FORCE

FULCRUM

FORCE

LOAD

1

TIP: If using corrugated cardboard, the slot will be easier to cut if you place the pattern so that the corrugates are perpendicular to the slot.
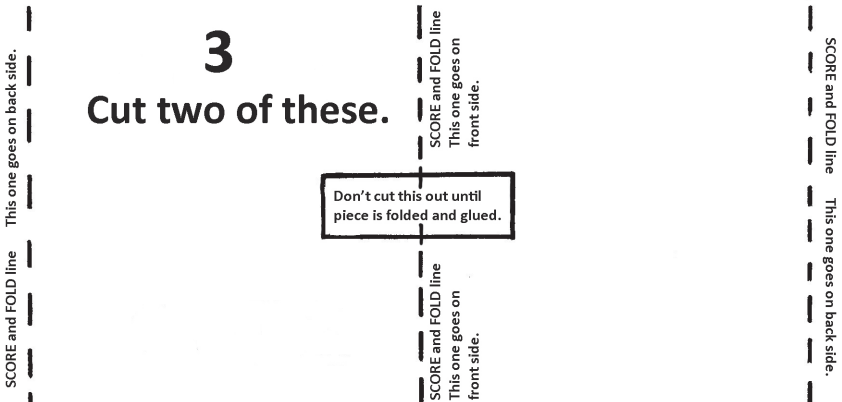
2

Cut two of these.

3

Cut two of these.

SCORE and FOLD line   This one goes on back side.

SCORE and FOLD line   This one goes on front side.

Don't cut this out until piece is folded and glued.

SCORE and FOLD line   This one goes on front side.

SCORE and FOLD line   This one goes on back side.

Dotted lines are fold lines that need to be scored with your knife first.

Don't cut out the center area of 3 until after it is folded and glued.

4

This is the base.

YOU MIGHT WANT TO PRINT THIS PATTERN PAGE ONTO CARDSTOCK.

For 7.2: Make three copies of this pattern page. Trim the ends of two of them so you can make them overlap in a way that gives you a continuous 3-page graph. Use glue stick, not tape, and try to make sure that the overlap goes in the direction that will not create a smooth ride for the cardboard corner that will be gliding over the paper. You don't want to create a "speed bump" that the cardboard corner might get caught on.

Z

Y

END

X

START

PRINT ONTO CARD STOCK IF YOU ARE
WORKING FROM A DIGITAL BOOK.

If you are working from a paperback copy of this
book and you tear out this page and cut out the
patterns, be VERY careful as you trace around
them. Tracing a paper pattern can be a bit tricky.

Tape these two pieces
together to make the final
pattern. Match the letters
XYZ to make sure you
get the pieces taped
together correctly.

X

Y

Z

This is the bottom edge.

QUIZ for Adventure 1   Name _____

1) TRUE or FALSE? An object's center of mass is always inside the object itself.

2) What do you call the point around which two objects orbit?
   a) center of gravity   b) barycenter   c) epicenter   d) focal point   e) none of these

3) TRUE or FALSE? "Center of mass" and "center of gravity" are the same when we are on earth.

4) Who was the librarian in the Egyptian city of Alexandria?
   a) Archimedes   b) Euclid   c) Eratosthenes   d) Phidias

5) The measurement around the outside of a circle is called its _____.

6) What did Archimedes discover in his bathtub?
   a) buoyancy   b) the Archimedes screw   c) the value of pi   d) the area under a parabola   e) soap

7) TRUE or FALSE? The ancient Greeks did not know that the world is a sphere.

8) Archimedes lived on the island of _____.

9) TRUE or FALSE?   If the center of mass of an object is not over its base, it will fall over.

10) Which one of these authors did Archimedes NOT read?
    a) Aristotle   b) Plato   c) Socrates   d) Copernicus   e) Euclid

11) Which of these letters is the only one that you could balance on the head of a pin?
    a) L   b) O   c) C   d) D   e) Y   f) U   g) V

12) A balanced object becomes (more/less) stable if its center of mass is lowered. (circle one)

Name three practical applications of center of mass:

13) _____

14) _____

15) _____

QUIZ for Adventure 2   Name _____

Calculate the mechanical advantage of these levers:

1) _____   2) _____

 8 cm   40 cm   33 ft.   11 ft.
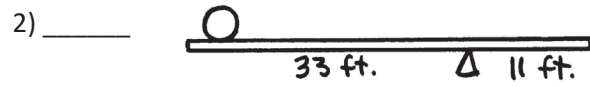
3) "In a first class lever, the fulcrum's _____"

4) Where is the load in a second class lever?_____

5) "If you want some speed to swat or bat, the _____ class lever is where it's at."

6) Which type of lever is a pair of scissors?   a) first   b) second   c) third

7) Which type of lever is a wheelbarrow?   a) first   b) second   c) third

8) The principle of the lever is that you can trade _____ for a gain in force.

9) In a second class lever, if you want to make your work easier, where should you position the load?
   a) closer to the fulcrum   b) farther away from the fulcrum

10) Something that is made of more than one simple machine is a _____.

11) Which one of these is NOT a way to calculate mechanical advantage?
   a) radius of wheel/radius of axle   b) radius of follower/radius of driver
   c) length of lever/length of fulcrum   d) length of force arm/lenght of resistance arm

12) TRUE or FALSE?   An idler gear has no effect on mechanical advantage.

13) If a driver gear has 12 teeth and its follower has 24 teeth, this will result in multiplication of: _____

14) The wheel of a windlass is 60 centimeters. The shaft with the rope wound around it has a diameter of 15 cm.
Will the mechanical advantage of the windlass be enough for you to have 5 times your ordinary lifting power? _____

15) What did Archimedes use pulleys for?
   a) lifting buckets of water   b) lifting ships   c) lifting logs   d) lifting houses

16) Archimedes lived in the city of _____.

17) TRUE or FALSE?   To calculate the mechanical advantage of gears you can use either the number of teeth or the
radius of the gears-- it doesn't matter which.

18) TRUE or FALSE? A mechanical advantage of less than 1 means that your work is much easier.

19) Which pulley provides no mechanical advantage?

   a) fixed pulley   b) movable pulley

20) Which part of the
rope is not helping
to bear the weight of
the iron block?

a) A
b) B
c) C
d) D
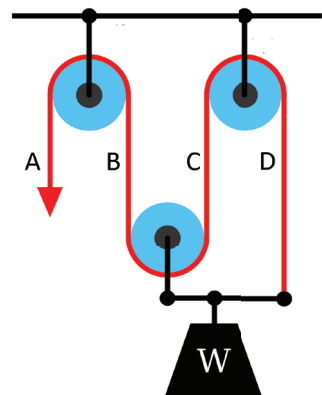
QUIZ for Adventure 3   Name _____

1) What did Galileo's father want him to become?
   a) doctor   b) lawyer   c) musician   d) artist   e) scientist   f) priest

2) What determines how fast a pendulum swings?
   a) the weight of the bob   b) the initial force   c) the length of the rod   d) the size of the swing

3) TRUE or FALSE? Pendulum swings always have exactly the same period no matter how high or low the bob goes.

4) The size of a pendulum's swing is called its:
   a) frequency   b) period   c) amplitude   d) cycle

5) What happens when you make the bob heavier?
   a) The pendulum swings for a longer period of time before it comes to rest.
   b) The frequency of the pendulum increases.
   c) The frequency of the pendulum decreases.
   d) The pendulum comes to rest more quickly.

6) What type of clock did Galileo use to time his pendulums? _____

7) What do we call the "law" of pendulums that Galileo discovered? _____

8) This law (in previous question) says that if we make a pendulum 4 times as long, its frequency will decrease by:
   a) 1/8   b) 1/4   c) 1/2   d) 1

9) Why did Foucault hang a pendulum from the ceiling of the Paris Pantheon?

_____

10) When something swings at its natural frequency, we call this: _____

Name two places you might find tuned mass dampers:

11) _____   12) _____

13) When something goes in and out, or back and forth, or up and down, in a steady rhythm, we call this:
   a) resonance   b) oscillation   c) pendulum motion   d) extrapolation   e) variation

14) When you extend the lines on a graph, going beyond your collected data, this is called: _____

15) When you graph the up and down motions of a pendulum, you can produce a curve called:
   a) cycloid   b) parabola   c) oscillation   d) sine wave

QUIZ for Adventure 4   Name _____

1) The Latin word "inert" means: a) not moving   b) incapable   c) stiff   d) lazy

2) What scientist/philosopher was considered the ultimate authority until Galileo's time?
    a) Archimedes   b) Aristotle   c) Euclid   d) Plato

3) TRUE or FALSE? Isaac Newton was born into a fairly wealthy family.

4) Newton developed a lifelong interest in chemistry while he was attending a boarding school (as a young teen). This might have been because he lived with a man who was _____.
    a) an apothecary   b) a doctor   c) a fireworks manufacturer   d) the inventor of the Periodic Table

5) Who said "I think therefore I am"? _____

6) Which one of these did Newton not study?   a) light   b) motion   c) gravity   d) astronomy   e) electricity

7) What was the name of Newton's famous book? _____

8) TRUE or FALSE? Newton broke tradition by writing in English.

9-11) Fill in these blanks.

A body at rest will _____; a body in motion will _____

unless _____ acts upon it.

12) What is a measure of inertia?   a) weight   b) mass   c) resistance   d) force

13) Which one changes if you travel from the earth to the moon?   a) mass   b) weight

14) TRUE or FALSE? A spring scale can measure in both Newtons and grams.

15) About how much does a pineapple weigh?   a) 1 gram   b) 10 grams   c) 100 grams   d) 1 kg

16) TRUE or FALSE? There isn't any way to measure mass without a scale that relies on gravity.

17-18) Mass is the measure of an object's resistance to a _____ in _____.

19) Where did Newton work during the last two decades of his life? _____

20) Why was Newton not as brilliant in his later years?
    a) He suffered from severe fatigue due to old age.
    b) He had suffered from heavy metal poisoning.
    c) He suffered from a lifetime of poor nutrition.
   d) He contracted small pox, which left him weak.

QUIZ for Adventure 5   Name _____

1) TRUE or FALSE? Friction always opposes motion.

2) What is the force you feel as you drag a heavy box across the floor?   a) static friction   b) kinetic friction

3) Which one of these will register the highest force on a spring scale?
   a) a box dragged with its largest, flattest side on the table
   b) the same box dragged with its short and narrow top side on the table
   c) the same box dragged with its long and narrow side on the table
   d) they will all register the same force

4) Something that has a rough surface has a very (high/low) coefficient of friction.   (circle one)

5) Which one of these probably has the lowest coefficient of friction?
   a) glass   b) sandpaper   c) wood   d) metal   e) rubber   f) concrete

6) When is static friction at its maximum?
   a) when the box is not moving
   b) when you are pushing the box across the floor
   c) when you are pushing the box but it has not moved yet

7) TRUE or FALSE? At the microscopic level, friction involves some electrical attraction between atoms.

8) The strength of a force is called its: a) force   b) mass   c) magnitude   d) mechanical advantage

9) Kinetic means _____.

10) What does "normal" mean in physics? _____

11) What is the normal force?
   a) The force of gravity pulling you towards the ground
   b) The force of the ground pushing up on your feet
   c) The force of your weight
   d) The force of your feed pushing on the ground

Match the descriptions with the free body diagrams.

12) _____ The box is going up.
13) _____ The box is moving on a frictionless surface.
14) _____ Two people are pushing the box with equal strength in opposite directions.
15) _____ Someone is pushing on the box but it is not moving.
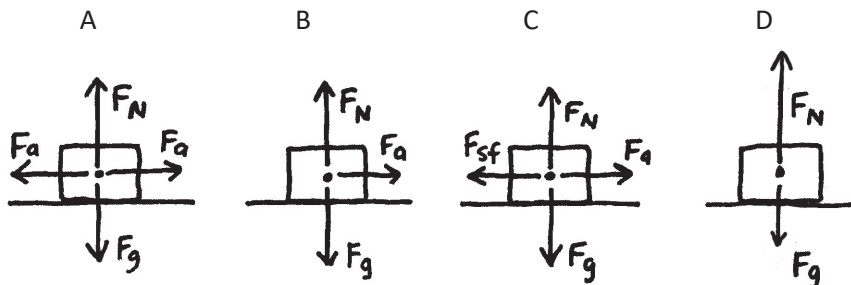
16) Technically, motion is the result of:
   a) kinetic forces   b) unbalanced forces   c) direction and magnitude   d) equilibrium

QUIZ for Adventure 6   Name _____

1) TRUE or FALSE?   Falling is just a very fast version of rolling downhill.

2) What kind if timer did Galileo use for his ramp experiment? _____

3) TRUE or FALSE? Galileo found that heavier balls produced different mathematical patterns than lighter balls.

4) Acceleration measures:
   a) the velocity of an object   b) the rate at which velocity is increasing
   c) the rate at which velocity is changing   d) how fast a car is traveling at a certain point

5-6) Vectors have both _____ and _____.

7) Where would gravity be stronger: mountains or valleys? _____

8) What is the acceleration due to gravity on earth? _____

9) TRUE or FALSE? When you are traveling at a very fast speed, an accelerometer will be swinging backwards.

10) TRUE or FALSE? A skydiver's terminal velocity would be the same on the moon as it is on earth.

11) TRUE or FALSE? The shape of an object has no effect on terminal velocity.

12) Which number is larger?   a) little g   b) big G

13) Who actually invented the device that (indirectly) measured the value of big G?
     a) Cavendish   b) Michell   c) Newton   d) Galileo

14) Who was the first person to propose that gravity is a giant "field" that is warped by giant objects?
     a) Newton   b) Einstein   c) LaPlace   d) Michell   e) Cavendish

15) Which one of these is the correct formula for the Universal Law of Gravitation?

   a) $F_g = \dfrac{G(m1)(m2)}{r^2}$ b) $F_g = \dfrac{g(m1)(m2)}{r^2}$ c) $F_g = \dfrac{G(m1-m2)}{r^2}$ d) $F_g = \dfrac{G(m1)(m2)}{r}$

16) TRUE or FALSE? You and the earth both have gravity and are pulling on each other.

17) TRUE or FALSE? If an astronaut was in a rocket that was accelerating at 9.8 m/sec², it would feel to him the same as normal gravity.

18) TRUE or FALSE? Einstein proposed that time isn't affected by gravity.

19) TRUE or FALSE? Einstein said that gravity isn't a force.

20) Name a branch of science that doesn't line up with relativity: _____

QUIZ for Adventure 7   Name _____

1) TRUE or FALSE?   Because of earth's greater mass, it pulls harder on the moon than the moon pulls on the earth.

2) Does F=ma work in zero gravity? _____

3) Newtons are the units used to measure _____.

4) How much does a 20 kg child weigh in newtons? _____

5) How much force is needed to accelerate a 1,500 kg truck at 2 meters per second? _____

6) TRUE or FALSE? The earth has more inertia than the moon.

7) The center of gravity around which two objects orbit is called the _____.

8) A nerf gun shoots a dart with a force of 1 newton. If the dart weighs 50 grams, how much acceleration will the dart experience? _____

9) To prevent something from breaking when it falls, do you want Δt to be large or small? _____

10) When the mass of an object doubles and acceleration stays the same, what happens to the resulting force?
   a) It stays the same.   b) It doubles.   c) It triples.   d) It increases by the square of 2, which is 4.

11) TRUE or FALSE? Conservation of momentum occurs in all collisions.

12) TRUE or FALSE? According to Newton's Third Law, the reaction occurs first, then the reaction occurs.

Definitions:

13) The measure of how fast something is going in a particular direction: _____

14) The measure of how fast something is moving: _____

15) The measure of how resistant something is to a change in velocity: _____

16) The measure of how fast velocity is increasing: _____

17) Mass multiplied by velocity gives you: _____

18) Force times the time interval in which the force is applied: _____

19) The measure of how large or small something is: _____

20) Measuring mass while in a particular gravitational field: _____

WORD BANK FOR DEFINITIONS: (There are 2 extra words that you won't use.)

acceleration, conservation, impulse, force, mass, magnitude, momentum, speed, velocity, weight

QUIZ for Adventure 8   Name _____

1) TRUE or FALSE?   A ball dropped straight down from a tower will hit the ground sooner than a ball thrown
   out horizontally from the tower.

2) What is "the amount something moves in a certain direction"?
   a) distance   b) impulse   c) velocity   d) displacement

3) TRUE or FALSE? If you multiply both sides of an equation by the same thing, both sides will remain equal.

4) What angle will give a cannon the longest range?
   a) 15 degrees   b) 25 degrees   c) 45 degrees   d) 75 degrees   e) 90 degrees

5-6) Velocity and acceleration are vectors. What two things does a vector have?

   _____ and _____

7) TRUE or FALSE? Any launched object (baseball, cannonball, etc.) will <u>always</u> follow a parabolic path
   (even if it is only half of a parabola).

8) TRUE or FALSE? When you analyze the parabolic motion of a ball, you can separate the motion in the
   x direction (horizontal) from the motion in the y direction (vertical).

9) TRUE or FALSE? It is impossible to graph a circle on a Cartesian grid.

10) If a ball is dropped from a tower and takes 5 seconds to hit the ground, how tall is the tower? _____
    (Use 10 for the acceleration due to gravity, instead of 9.8)

**The displacement-time graph on the right shows the path
of a turtle in a zoo. The time starts a sunrise and ends 15 hrs.
later at sunset. The turtle's starting point is his little house.**
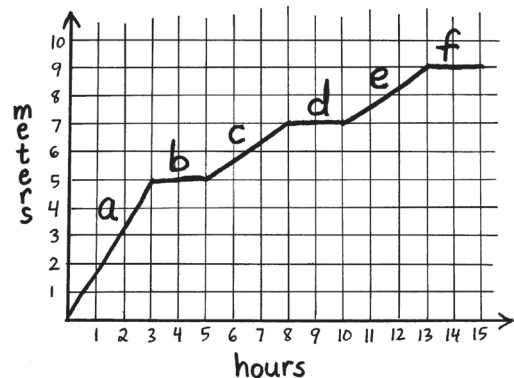
11) Letters "a" and "c" both show a 3-hour time periods.
    During which period did the turtle travel faster? _____

12) How much time did the turtle spend sitting still? _____ hours

13) Did the turtle return to its house? _____

14) Does this graph show acceleration? _____

Match the problem with the formula you need to solve it:

15) ____ A 10-kg ball is rolling along at 2 m/sec. What is its momentum?

16) ____ A beetle is crawling along at the rate of 2 cm per second.
        How many cm can it crawl in one minute?

17) ____ Find the strength of the gravity between the sun and Jupiter.

18) ____ If a falling apple hits the ground in 1.2 seconds, how high
        is the branch it fell from?

19) ____ A 50-kg satellite is launched with a force of 1,000 newtons. What will be its acceleration?

20) ____ If a rock is dropped off a 50-meter cliff, how long will it take for it to hit the ground?

Ⓐ $F = ma$ Ⓑ $d = rt$ Ⓒ $p = mv$

Ⓓ $d = \frac{1}{2}gt^2$ Ⓔ $t = \sqrt{\frac{2d}{g}}$ Ⓕ $F_g = \frac{G(m_1)(m_2)}{r^2}$

244

QUIZ for Adventure 9   Name _____

1) TRUE or FALSE? An orbiting moon is constantly changing direction.

2) A change in acceleration can be due to a change in velocity or a change in _____

3) TRUE or FALSE? It is not possible for a human to experience constant acceleration.

4) Which one of these is NOT a vector quantity?
   a) acceleration   b) velocity   c) speed   d) angular momentum

5) Which one of these is NOT something that can provide centripetal force?
    a) gravity   b) friction   c) string   d) velocity

6) What is the maximum number of G forces that you'll experience on a roller coaster?
    a) 3   b) 5   c) 8   d) 10

7) What do you call a line that touches a circle at just one point? _____ line

8) What would happen to the moon if gravity suddenly disappeared?
    a) nothing   b) It would hit the earth.
    c) It would keep going in its orbit.   d) It would fly off along a straight-line path.

9) What rule do you use to find the direction of angular momentum? _____

10) The direction of angular momentum is always _____ to the direction of spin.
     a) parallel   b) perpendicular   c) opposite   d) unrelated

11) When you use $F_c=mv^2/r$ to find centripetal force, your answer will be in _____. (what unit?)

12) A hammer thrower is whirling his hammer in a circle. If the rope is 2 meters long, the velocity of the weight
     is 5 meters per second, and the mass of the weight is 2 kg.
     What is angular momentum? _____   (Remember to include the unit of measurement.)

13) TRUE or FALSE? The same formula can be used to calculate angular momentum for any object, regardless of
whether it is a disc, a sphere, or a ball on a string.

14) Why did Foucault invent the gyroscope?
     a) To prove that spinning objects have angular momentum.   b) To see moment of inertia of the earth.
     c) To see the turning of the earth.   d) To make better navigational instruments for boats and planes.

15) TRUE or FALSE? If the earth shrinks, its rotational speed will slow down.

16) If an ice skater pulls in her arms, she will go: a) faster   b) slower   c) the same

17) A solid cylinder and a hoop had a race to the bottom of a ramp. Who won? _____

18) What letter is used to represent moment of inertia?   a) L   b) ω   c) I d) θ

19) TRUE or FALSE? Increasing the length of a wrench will increase its torque.

20) The rotational equivalent of "force" is: a) moment of inertia   b) torque   c) angular momentum

QUIZ for Adventure 10   Name _____

1) Which one of these is NOT a factor in determining gravitational potential energy, PE?
   a) mass   b) height   c) velocity   d) acceleration due to gravity (g)

2) Where does a roller coaster car have its maximum potential energy?
   a) at the top of the first hill   b) at the bottom of the first hill   c) at the top of the second hill

3) TRUE or FALSE?   Some of the coaster car's potential energy will be lost due to friction.

4) The equation for calculating potential energy is PE = _____.

5) What energy unit is used for all forms of energy? _____

6) Force is measured with this unit: _____.

7) What is the formula for kinetic energy, KE?
   a) mv²/r   b) mgh   c) 1/2gt²   d) rmv   e) MR²   f) 1/2(mv²)

8) TRUE or FALSE? Energy cannot be created or destroyed.

9) For an ideal loop in a physics lab, the ball has to be _____ times higher than the radius of the loop.
   a) 2.0   b) 2.5   c) 2.7   d) 2.9

10) What Greek letter is used to represent angles? _____

11) What units are used to measure work? _____

12) How much work is done when a force of 15 newtons is applied through 2 meters? _____

13) Who invented the steam engine (originally called the atmospheric engine)?
   a) Newcomen   b) Watt   c) Joule   d) Newton

14) Who coined the word "horsepower"?   a) Newcomen   b) Watt   c) Joule   d) Newton

15-16) How do you find the cosine of an angle?

      You divide the _____ by the _____.

17) What unit is used to measure power? _____

18) Which one of these did Watt NOT contribute to make an improved steam engine?
   a) a centrifugal governor
   b) a chamber for turning water into steam
   c) planet and sun gears
   d) flywheel
   e) separate chamber for cooling steam
   f) automatic valves

19) What was the first use for steam engines? Pumping water out of _____.

20) Energy is "the ability to _____."