A Content Secondary Science Newsletter from the
Southern Nevada Regional Professional Development Program

Science Dissected

Mass and Acceleration
Model-Evidence Link Diagram (MEL)

A student's perception of the natural world often comes from first hand personal experiences. Those experiences can conflict with what is being taught in a science classroom and hinder the students learning. One very common misconception (alternative conception) deals with falling objects. Students may believe that if an object has more mass, then it will fall faster than an object with less mass.

The tentative nature of scientific knowledge allows the ideas we have of our natural world to change as information, tests, and technology progress. The idea how objects fall has changed from the time of Aristotle, to Galileo to Newton. Newton's laws of Motion allow us to explain what an object will do when it drops. When young students see falling objects, they do not stop to consider which forces are acting on the falling object, rather the physical properties of the object such as size and weight.

Model A: The rate at which an object falls is dependent on the mass of the object..

Model B: The rate at which an object falls is <u>NOT</u> dependent on the mass of the object.

Evidence #1: According to Aristotle, heavier objects would strive harder and fall faster than light ones.

Evidence #2: Galileo showed that, except for the effects of air friction, objects of different weights fell to the ground at the same time.

Evidence #3: Personal experiment. Drop three balls of similar size, but different mass all from the same height. Record the mass of each ball and the time it takes to hit the ground. Analyze your findings

Evidence #4: Virtual experiment. Galileo's experiment is revisited as a simulation and can be performed in normal atmospheric conditions as well as in a vacuum. This may be done in the computer lab or as a teacher demonstration.

The following is a suggestion for using this MEL with students:

1. Hand out the Mass and Acceleration Model Evidence Link Diagram (page 1). Instruct students to read the directions, descriptions of Model A and Model B, and the four evidence texts presented.
2. Handout the four evidence text pages (pages 3-6).
3. Instruct students to carefully review the Evidence #1 text page (page 3), then construct two lines from Evidence #1; one to Model A and one to Model B. Remind students that the shape of the arrow they draw indicates their plausibility judgment (potential truthfulness) connection to the model.
4. Repeat for Evidence #2-4 (pages 4-6).
5. Handout page 2 for the students to critically evaluate their links and construct understanding.

Once students have completed page 2, they can then engage in collaborative argumentation as they compare their links and explanations with that of their peers. Students should be given the opportunity to revise the link weighting during the collaborative argumentation exercise. If time permits, have students reflect on their understanding of mass and acceleration and create questions that they might explore in the future.

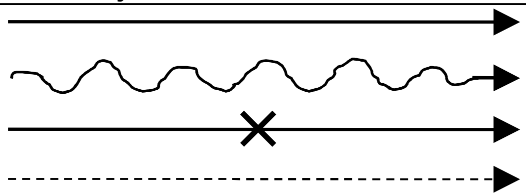
Archived Issues of Science Dissected, http://www.rpdp.net/link.news.php?type=sciencedis. Instructional Resource resulting from Plausibility, It's All About Connecting the Models Workshop co-sponsored by CPDD and SNRPDP Science March 6, 2012

Written by: Andy Agan

Name:____ ____________________ **Period:**________________

Directions: First read or perform a piece of evidence. After reading/performing a piece of evidence, draw two arrows from that evidence box, one to each model. You will draw a total of 8 arrows.

Arrow Key:



The evidence **supports** the model

The evidence **STRONGLY supports** the model

The evidence **contradicts** the model (shows its wrong)

The evidence has **nothing to do with** the model

Standard: P.12.B.1

Students know laws of motion can be used to determine The effects of forces on motion of objects

Evidence #1

According to Aristotle, heavier objects would strive harder and fall faster than light ones.

Model A

The rate at which objects fall is dependent on the mass of the object falling.

Evidence #3

Experiment. Drop three balls of similar size, but different mass all from the same height. Record the mass of each ball and the time it takes to hit the ground. Analyze your findings.

Evidence #2

Galileo showed that, except for the effects of air friction, objects of different weights fell to the ground at the same time.

Model B

The rate which objects fall is **not** dependent on the mass of the object falling.

Evidence #4

Follow a link to perform Galileo's experiments in normal circumstances and in a vacuum.

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

A. Write the number of the evidence you are writing about.
B. Circle the appropriate descriptor (**strongly supports | supports | contradicts | has nothing to do with**).
C. Write the letter of the model you are writing about.
D. Then write your reason.

1. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

2. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

3. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

4. Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)									Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

5. Circle the model which you think is correct. [Only circle one choice below.]

Very certain that Model A is correct	Somewhat certain that Model A is correct	Uncertain if Model A or B is correct	Somewhat certain that Model B is correct	Very certain that Model B is correct

Evidence 1: According to Aristotle, heavier objects would strive harder and fall faster than light ones.

Aristotle on Motion

Some two thousand years ago, Greek scientists understood some of the physics we understand today... One of the first to study motion seriously was Aristotle, the most outstanding philosopher-scientist in ancient Greece. Aristotle attempted to clarify motion by classification. He classified all motion into two kinds of motion: *natural motion* and *violent motion*.

In Aristotle's view, natural motion proceeds from the "nature" of an object. He believed that all objects were some combination of the four elements – earth, water, air, and fire- and he asserted that motion depends on the particular combination of elements an object contains. He taught that every object in the universe has a proper place, which is determined by its "nature"; any object not in its proper place will "strive" to get there. For example, an unsupported lump of clay, being of the earth, properly falls to the ground; an unimpeded puff of smoke, being of the air, properly rises; a feather properly falls to the ground, but not as rapidly as a lump of clay beaus it is a mixture of air and earth. Aristotle stated that heavier objects would strive harder and fall faster than light ones.

Natural motion was understood to be either straight up or straight down, as in the case of all thing son Earth. Natural motion beyond Earth, such as the motion of celestial objects, was circular. Both the Sun and Moon continually circle the Earth in paths without beginning or end. Aristotle taught that different rules apply in the heavens and that celestial bodies are perfect spheres make of a perfect and unchanging substance, which he called *quintessence*.

Violent motion, Aristotle's other class of motion, is produced by pushes and pulls. Violent motion is imposed motion. A person pushing a cart or lifting a heavy boulder imposes motion, as does someone hurling a stone or winning a tug-of-war. The wind imposes motion on ships. Floodwaters impose it on boulders and tree trunks. Violent motion is externally caused and is imparted to objects, which move not of themselves, but by their nature, but because w of impresses *forces*- pushes or pulls.

Hewitt, P., Lyons, S., Suchocki, J., & Yeh, J. (2007). *Conceptual integrated science*. (1st ed., pp. 17-18). San Francisco: Pearson Education, Inc.

Evidence #2: Galileo showed that, except for the effects of air friction, objects of different weights fell to the ground at the same time.

Galileo's Concept of Inertia

According to legend, Galileo dropped both heavy and light objects from the Leaning Tower of Pisa. He showed that, except for the effects of air friction, objects of different weights fell to the ground in the same amount of time…

Rather than philosophizing about ideas, Galileo did something that was quite remarkable at the time. Galileo tested his revolutionary idea by *experiment*. This was the beginning of modern science. He rolled balls down inclined planes and observed and recorded the gain in speed as rolling continued. On downward-sloping planes, the force of gravity increases a ball's speed. On an upward slope, the force of gravity decreases a ball's speed. What about a ball rolling on a level surface? While rolling on a level surface, the ball neither rolls with nor against the vertical force of gravity- it neither speeds up nor slows down. The rolling ball maintains a constant speed. Galileo reasoned that the ball moving horizontally would move forever, if friction we entirely absent. Such a ball would move all by itself- of its own *inertia.*

Galileo noted that moving objects tend to remain moving, without the need of an imposed force. Objects at rest tend to remain at rest. This Property of objects to maintain their state of motion is called **inertia.**

Hewitt, P., Lyons, S., Suchocki, J., & Yeh, J. (2007). *Conceptual integrated science*. (1st ed., pp. 17-18). San Francisco: Pearson Education, Inc.

Evidence #3: (Experiment) Drop three balls of similar size, but different mass all from the same height. Record the mass of each ball and the time it takes to hit the ground. Analyze your findings.

Ball Drop Experiment

Drop three balls of similar size, but different mass all from the same height. Record the mass of each ball and the time it takes to hit the ground. Analyze your findings

Drop height __________

Ball 1 mass __________ Time ball 1 __________

Ball 2 mass __________ Time ball 2 __________

Ball 3 mass __________ Time ball 3 __________

Did the balls all fall at the same rate?______________________

Are there any factors that might affect how fast the balls fall besides mass?
____

Use the data from this experiment to link evidence box three to **Model A** and **Model B**

Evidence 4: Follow this link to perform Galileo's experiments in normal circumstances and in a vacuum. http://www.planetseed.com/node/20129

Revisiting Galileo's Experiment

- Type this link into a web browser. http://www.planetseed.com/node/20129
- Read the few short paragraphs on the page and then click the picture of Galileo on the left.
- Experiment on your own, but make sure you drop the items in both the normal mode and vacuum mode.