ACE
ARGUMENT-CENTERED EDUCATION

Free Fall Argument-Based Assessment

ANSWER KEY

I'm gonna free fall, out into nothin'
Gonna leave this world for awhile
I'm free, free fallin'
-- Tom Petty (1989)

Directions

You will make two scientific arguments on the physics of free-falling objects.

Argument 1

In Galileo's famous demonstration, a 10-kg cannonball and a 1-kg stone strike the ground at practically the same time.

Make an argument addressing the question, Will a heavier cannonball and a lighter stone dropped from a height into free fall strike the earth at approximately the same time or at different times?

Claim

The heavier cannonball and the lighter stone dropped from the same height will fall and strike the earth at approximately the same time.

ACE
ARGUMENT-CENTERED EDUCATION

Evidence

Evidence in a scientific argument is typically quantitative: for example, a portion of a data set created by an experiment or mathematical computation based on a formula.

$$a = \frac{F}{m} = \frac{\text{weight}}{m} = \frac{10\text{ N}}{1\text{ kg}} = \frac{10\text{ kg}\cdot\text{m/s}^2}{1\text{ kg}} = 10\text{ m/s}^2 = g$$

$$a = \frac{F}{m} = \frac{\text{weight}}{m} = \frac{100\text{ N}}{10\text{ kg}} = \frac{100\text{ kg}\cdot\text{m/s}^2}{10\text{ kg}} = 10\text{ m/s}^2 = g$$

Reasoning

Explain why the math and/or data you provided in your evidence is applicable and has been properly applied. Also, explain why it is proof of the claim.

The relevant scientific principle and formula here is Newton's Second Law, which is the accepted science on acceleration and falling objects. Since the weight of a 1 kg stone is 10 N at the earth's surface, and the weight of 10 kg cannonball is 100 N at the earth's surface, data is properly plugged into the formula above. Doing the computation in each equation produces equivalent acceleration. Therefore, the two objects strike the ground from the same height at the same time.

Argument 2

We now drop a very small square-shaped, flat rock that weighs 10 grams and is approximately 2 cm X 2 cm, and a piece of paper that has the same mass of 10 grams with a surface of 28 cm X 43 cm (11" X 17"). They are dropped from the same height on Earth with normal air resistance. Would both objects hit the ground at practically the same time?

Claim

The small pebble will hit the ground much faster than the piece of paper.

ACE
ARGUMENT-CENTERED EDUCATION

Evidence

Evidence in a scientific argument is typically quantitative: for example, a portion of a data set created by an experiment or mathematical computation based on a formula.

2 cm X 2 cm = 4 square cm

28 cm X 43 cm = 1,204 square cm

Reasoning

Explain why the math and/or data you provided in your evidence is applicable and has been properly applied. Also, explain why it is proof of the claim. Think of how this scenario on earth would be different than applying it to the moon, where there is negligible air resistance.

The computation above shows that there is significantly greater surface area on the piece of paper than there is on the pebble. This means that there is significantly greater air resistance imposed upon the sheet of paper due to a much greater surface area than the pebble. Newton's Second Law tells us that air resistance slows acceleration by acting as a counter-force on it. However, if we were to do this same experiment on the moon where there is negligible air resistance, both the pebble and the sheet of paper would hit the moon at practically the same time.