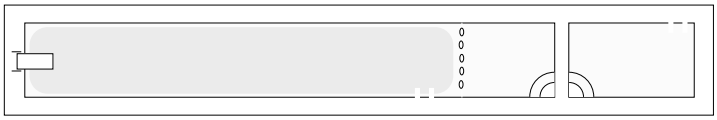
PhyzSpringboard:
Free Fall Possibilities

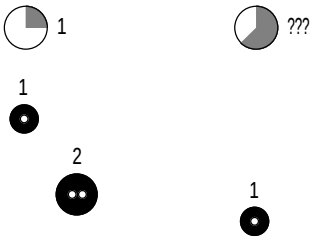


FREE FALL OPTIONS

What kind of motion results when a body is dropped? This simple question perplexed the minds of the best thinkers for thousands of years. The brilliant Greek philosopher and scientist Aristotle proposed a solution that, although it was incorrect, maintained its status as the accepted theory for about 2000 years. One principal flaw in the thinking of Aristotle and his followers was the instinctive desire to explain the cause of motion while also describing the motion itself. Explaining both cause and effect does make for a more powerful scientific argument, unless one or both explanations are incorrect. Such was the case with the Aristotelian model. Galileo Galilei came to a correct description of the motion by conducting experiments on the motion itself. He sought to accurately describe the motion without regard to what caused the motion.

But one does not enter into experimentation without some anticipation of the results. Let us now consider a few possibilities for free fall.

1. CONSTANT SPEED THAT IS PROPORTIONAL TO WEIGHT ($v \propto W$)
Hypothesis: A body in free fall moves with constant velocity toward the ground. The speed of the body is in proportion to its weight.

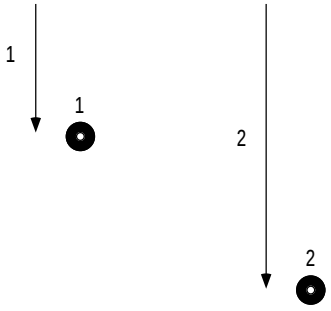


Experimental Outcomes: A falling body has the same speed after falling 2 units of distance that it had after falling 1 unit of distance. A falling body has the same speed after falling for 2 units of time that it had after falling for 1 unit of time. A body with twice the weight falls with twice the speed.

a. Do you have any experience or observational evidence that contradicts any part of this hypothesis?

b. Do you have any experience or observational evidence that coincides with any part of this hypothesis?

2. SPEED INCREASES WITH DISTANCE ($v \propto d$)
Hypothesis: A body in free fall undergoes an equal increase in speed for each unit of distance it moves.



Experimental Outcomes: A falling body has twice the speed after falling 2 units of distance that it had after falling 1 unit of distance.

a. What—if anything—about this theory is preferable to the first theory?

b. What—if anything—about this theory remains uncertain until experimentation can be done?

3. SPEED INCREASES WITH TIME ($v \propto t$)

Hypothesis: A body in free fall undergoes an equal increase in speed during each unit of time it moves.

Experimental Outcomes: A falling body has twice the speed after falling for 2 units of time that it had after falling for 1 unit of time.

a. What—if anything—about this hypothesis is preferable to the first theory?

b. What—if anything—about this hypothesis remains uncertain until experimentation can be done?

c. Could **both** hypotheses 2 and 3 be correct? If they were, then speed would be proportional to distance and speed would be proportional to time. If $v \propto d$ and $v \propto t$, then it would follow that $d \propto t$. Could this be true for an accelerating body? Why or why not?

4. SPEED INCREASES SOME OTHER WAY ($v \propto ???$)

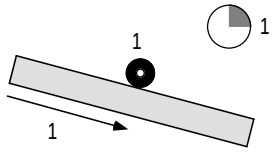
Hypothesis: A body in free fall undergoes an increase in speed that does not have a simple relationship with either the distance it has moved or the time during which it has moved. It may be that the speed is proportional to the square of the distance moved or the square root of the time interval. The rate at which speed increases may also be in proportion to the weight of the body.

Experimental Outcomes: Too many possibilities to list here.

a. Under what circumstances would we have to investigate this hypothesis?

DILUTED FREE FALL

Galileo was not equipped to perform accurate experiments on free fall: bodies moved too rapidly for his measuring techniques. He weakened the effect of free fall by conducting his experiments on inclined planes (ramps). Motion on the ramp is the same in its nature to that of free fall. But it develops more slowly, allowing easier measurements.



Identify each outcome shown below with its corresponding theoretical basis (from the list above).