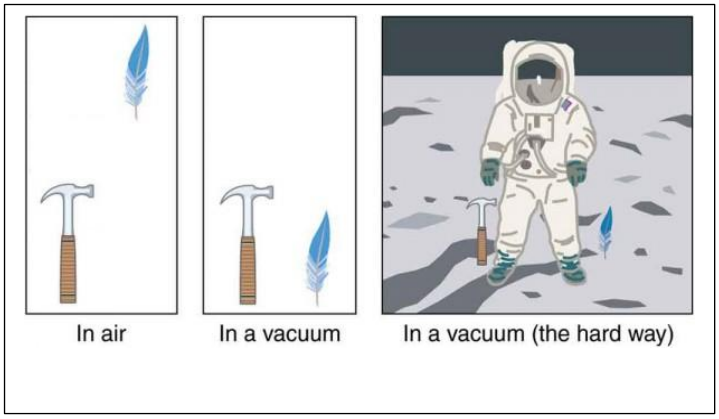
Lesson 2 Physics (All Series Combined – SS, CS, SS+, CP)
Student Challenge

Classical Physics



OBSERVE:
Look at the world around you.
How do objects fall? Do light objects fall slower than heavy objects?

EXPLORE: If the velocity of a falling object is caused by Earth's mass, why do objects fall at vastly different rates on Earth?

(Quess) Answers will vary; a good hypothesis was that heavier objects fall faster because they have greater attraction. But, the video and image above suggest that AIR has something to do with the velocity.
TRUE ANSWER: lighter, less dense, more surface area objects are more strongly affected by air resistance.

EXPERIMENT 1:
Try dropping an 8 x 11" paper one meter. How does it fall? Why does it float in various ways?
If its horizontal to the ground, it zigs and zags as it falls. Why? Air molecules moving at high speeds create resistance as they hit and bounce off the paper. Air is composed of 78% Nitrogen, 21% Oxygen, and 1% Argon (approx) – each molecule has tiny mass and momentum (affect is known as Browning motion).
Try dropping an 8 x 11" paper that is tightly wadded (a ball) one meter? How is it different than a flat paper of the same weight?
Less air resistance due to less surface area (weight is identical). Fewer air molecules strike the wad of paper than the flat piece of paper.
Think about the cause of the acceleration (the mass of the earth).
What causes the difference observed? Since the mass of earth is so much greater than anything we could drop, the weight of an object is not what affects its velocity/rate or acceleration. The 2 objects (a wad of paper and a sheet of peper) were identical weights yet they fell at different rates. Without further experimentation, however, it's possible to assume, like many did for thousands of years, that density causes the rate of acceleration to be greater. Galileo (~1600's) sought to determine whether this was true or not.

EXPERIMENT 2:
Watch the Apollo 10 video of the hammer and feather drop. Each are dropped ~ 1 meter.
https://youtu.be/Oo8TaPVsn9Y?si=ftgrdTQUiwUm1FT1
What happens to the hammer and the feather in this video?

The hammer and feather fall at the same velocity on the Moon. Although they fall more slowly than on Earth, the density difference has almost no observable difference.
Think about the cause of the acceleration (the mass of the moon). The acceleration is only about ~1.6 m/s^2. That is about $1/6^{th}$ the acceleration as Earth at ~10 m/s^2.

ANALYZE:

1. Why are results different between a wad of paper and a flat piece of paper? Surface area and the difference in air resistance.

2. Why does a heavy object fall at the same rate/velocity as a light object on the moon but not on the earth? There is almost no air resistance on the moon (virtually no oxygen or nitrogen).

Basic (SS) Math Skills ASSUME NO AIR RESISTANCE/VACUUM

PROBLEM: If an object on earth falls 1 second, its velocity is 10 m/s (in a vacuum). At the end of 2 seconds, its velocity is 20 m/s; at the end of 3 seconds, its velocity is 30 m/s.

What do you think its velocity will be if it falls 5 seconds? 50 meters per second

Advanced (CS) Math Skills ASSUME NO AIR RESISTANCE/VACUUM

Since acceleration (10 m/s^2) in the previous question means velocity increases every second, what does that mean about the distance an object falls during each second?

After 1 sec 10 meters After 2 sec 10 meters + 20 meters = 30 meters

After 3 sec 10 meters + 20 meters + 30 meters = 60 meters (carried down for next problem)

After 5 sec (60 meters) + 40 meters + 50 meters = 150 meters

Applied (SS+) Math Skills/

Average velocity can be determined by adding total meters traveled over the 5 seconds (calculated in the previous problem), then divide by 5 seconds.

Total distance an object on earth falls (in a vacuum) in 5 seconds 150 meters

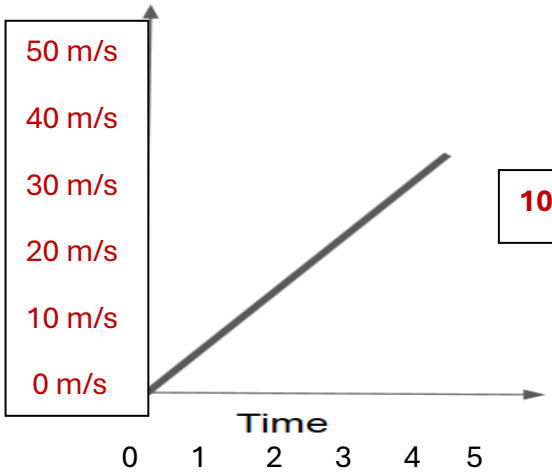
Equation to give average velocity: Total distance in meters/Total time in seconds

150 meters ÷ 5 seconds = avg velocity in meters/seconds
30 meters/secon or 30 m/s

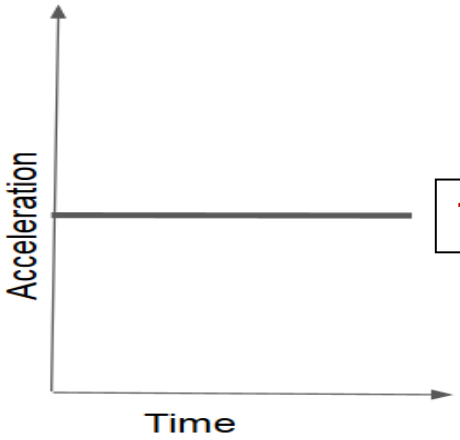
ANSWER: 30 m/s (average velocity)

Compute (CP) Math Skills

Make a graph of speed/velocity and time by adding the numbers to the graph below. Make a graph of acceleration by adding numbers to the graph below.



10 m/s²



10 m/s²