Constant Acceleration & Freefall

Pre-Class Questions:

Problem Set #4 (due next time)

Lecture Outline

1. A Summary of the Equations of Motion for Constant Acceleration
2. The Rule of Falling Bodies
3. Examples and More Examples

Pre-Class Summary:

Starting with the definitions of position, velocity, and acceleration, we found the equations of motion for constant acceleration.

Given the initial position, x_o, the initial velocity, v_o, and the constant acceleration, a, we found…

Quantity	Mathematically
The acceleration at any time	$a(t) = a$
The velocity at any time	$v(t) = v_o + a\,t$
The position at any time	$x(t) = x_o + v_o\,t + {}^1/_2\,a\,t^2$
The acceleration at any position	$a(x) = a$
The velocity at any position	$v^2(x) = v_o^2 + 2\,a\,(x - x_o)$

Pre-Class Summary:

These equations of motion are more conveniently written for problem solving in the following form which are known as the "kinematic equations."

Kinematic Equation	Missing Quantity
$x(t) = x_o + v_o\, t + {}^1\!/_2\, a\, t^2$	v – the final speed
$v(t) = v_o + a\, t$	$(x - x_o)$ – the displacement
$v^2(x) = v_o^{\,2} + 2\, a\, (x - x_o)$	t – the time
$(x - x_o) = {}^1\!/_2\, (v + v_o)\, t$	a – the acceleration

Example 1: The last pitch of Matt Cain's perfect game had a speed of 137ft/s when it was 50.0ft from home plate. Assume it decelerated at a constant rate of 27.1ft/s^2 due to air resistance. Find (a)the initial velocity in mph, (b)the final velocity in mph, (c)the time it took to reach home plate.

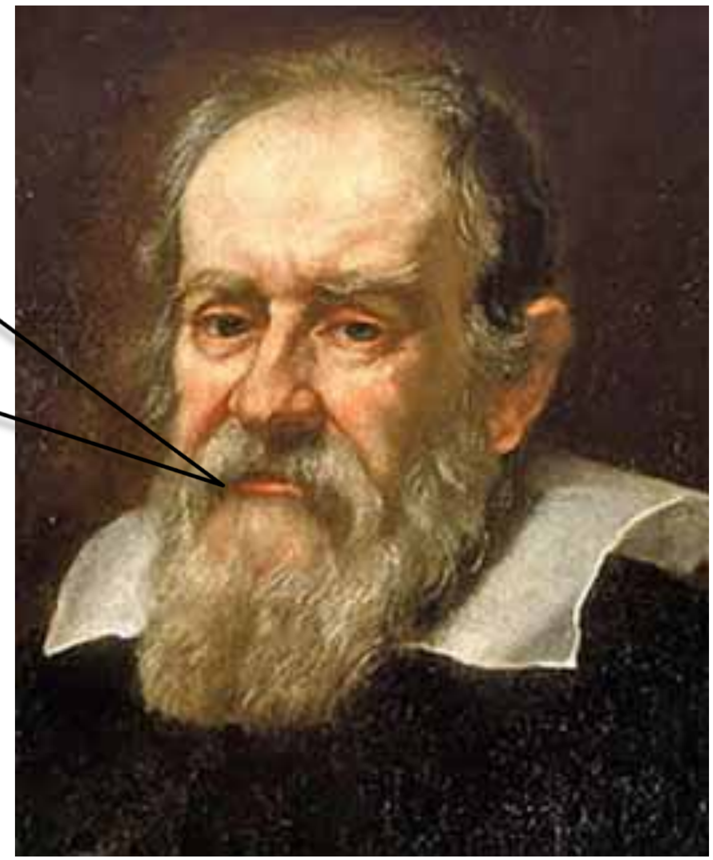
COMMENT ON PROBLEM SOLVING:
First, notice that it is critical to indicate the coordinate system because the value of x_o depends upon this choice. You must always indicate your coordinate system in your sketch of the problem. Second, in these Kinematic problems it is convenient to start by listing the six quantities, then fill in the knowns stated in the problem. The unknowns that remain help decide which Kinematic Equation is needed. Finally, you should always do the algebra first to solve the quantity you seek, then plug the numbers into the resulting equation.

Drop a ball and a sheet of paper….

http://www.youtube.com/watch?v=5C5_dOEyAfk

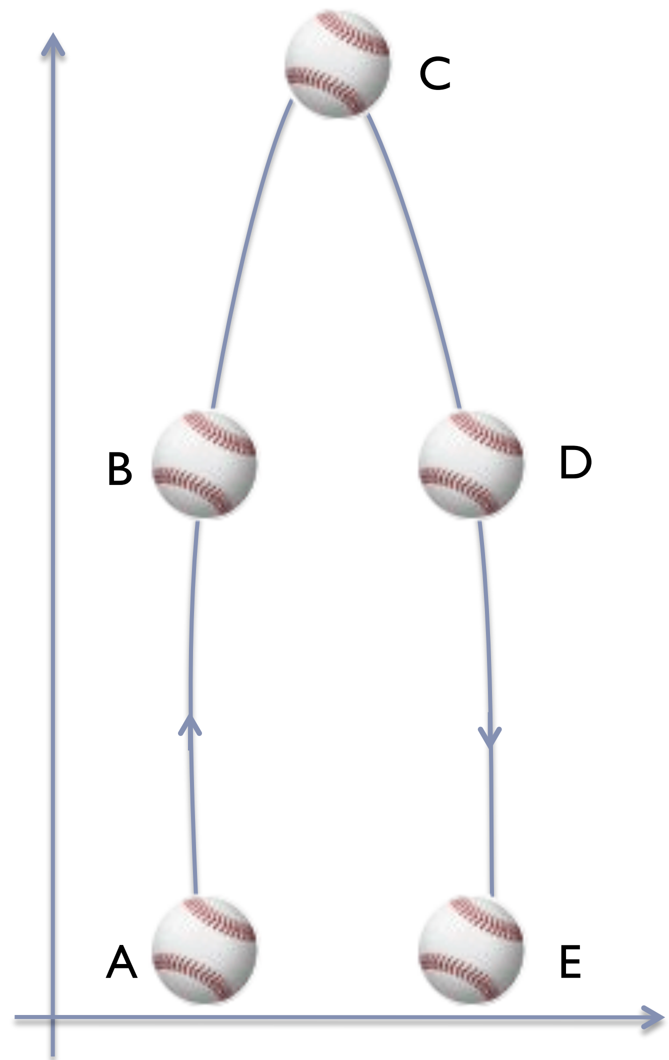
Galileo's Rule of Falling Bodies:

"In the absence
of air resistance, all objects
fall toward Earth with a
constant acceleration
of 9.80m/s^2."



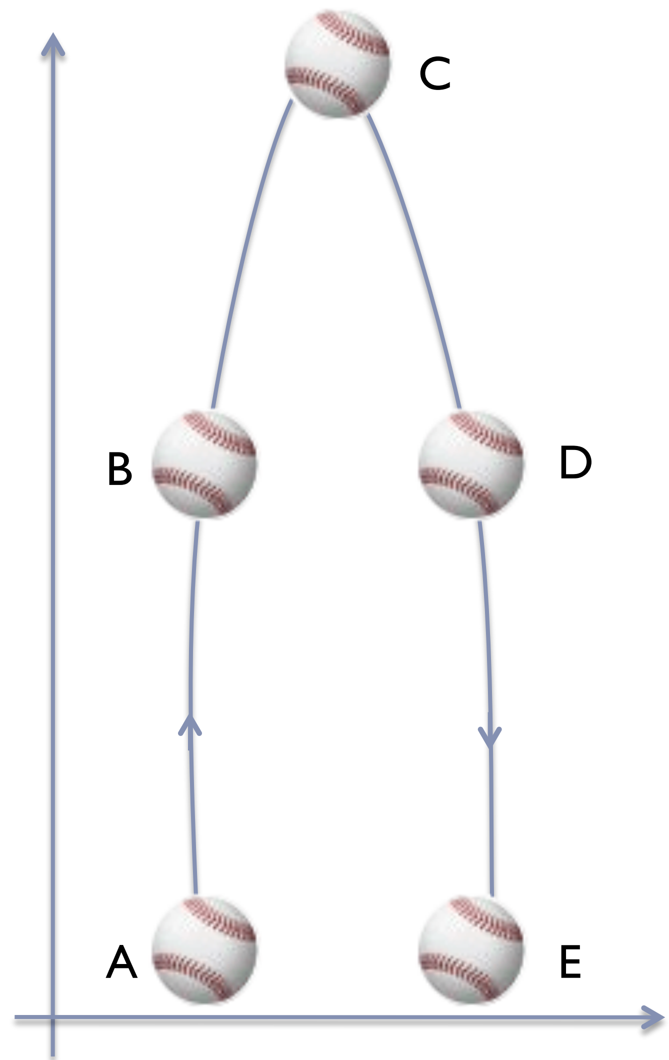
A baseball is tossed straight upward. It is shown just after being released, half way up, at the top, half way down, and just before being caught.

Rank these situations from greatest to least based upon the velocity (not speed) of the ball.

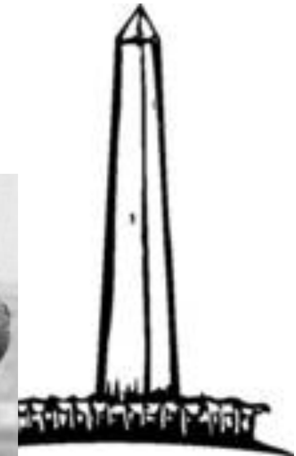


A baseball is tossed straight upward. It is shown just after being released, half way up, at the top, half way down, and just before being caught.

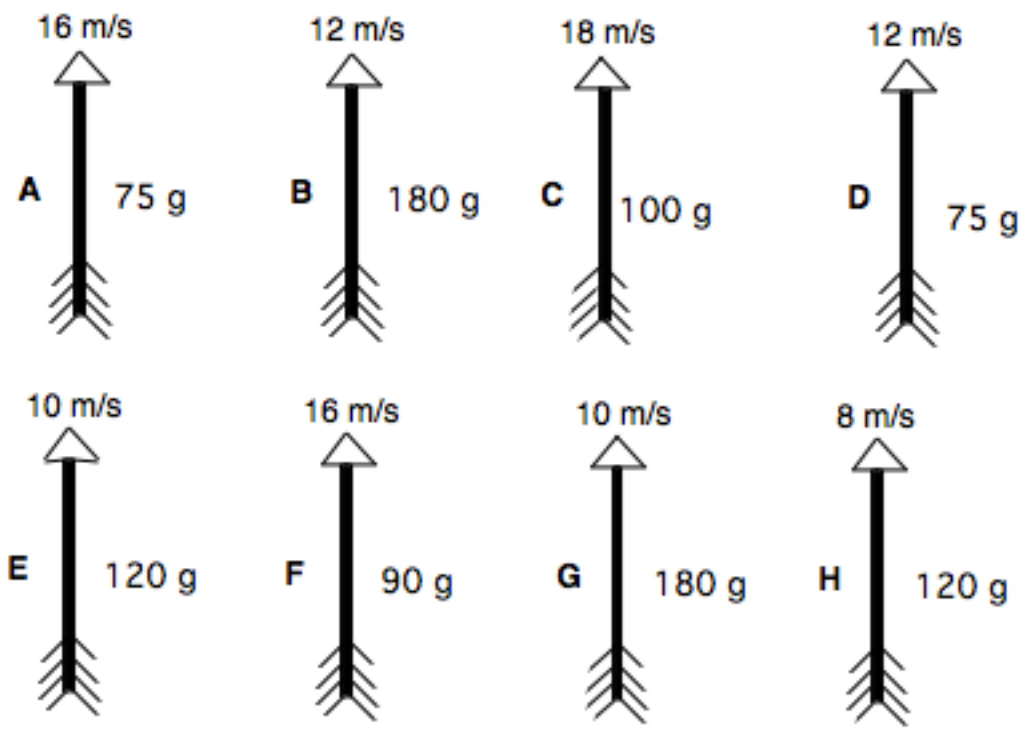
Rank these situations from greatest to least based upon the acceleration of the ball.



Example 2: Gabby Street was a catcher for the Washington Senators from 1909 to 1911. He reputedly caught a baseball (m = 150g) dropped from the top of the Washington Monument known to be 555ft (170m) tall. Assume there is no air resistance. Find (a)the time for the fall and (b)the speed of the ball when he caught it.



Eight different arrows are shot vertically into the air. Their masses and initial speeds are given. Assuming air resistance is negligible, rank them based upon the maximum height they reach.



Lecture 04 - Summary

The kinematic equations predict the motion for objects with constant acceleration.

Kinematic Equation	Missing Quantity
$x(t) = x_o + v_o\, t + {}^1/_2\, a\, t^2$	v – the final speed
$v(t) = v_o + a\, t$	$(x - x_o)$ – the displacement
$v^2(x) = v_o^2 + 2\, a\, (x - x_o)$	t – the time
$(x - x_o) = {}^1/_2\, (v + v_o)\, t$	a – the acceleration

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"In the absence of air resistance, all objects fall toward Earth with a constant acceleration of $9.80 m/s^2$."