- I have three balls: small, medium, and large. I drop them all at the same time. In what order will the balls touch the ground?
- Text ‘PHYSJC’ and your answer to 22333

Ch 2.5-6: Acceleration, Velocity and Position

PHYS 1210 Prof. Jang-Condell

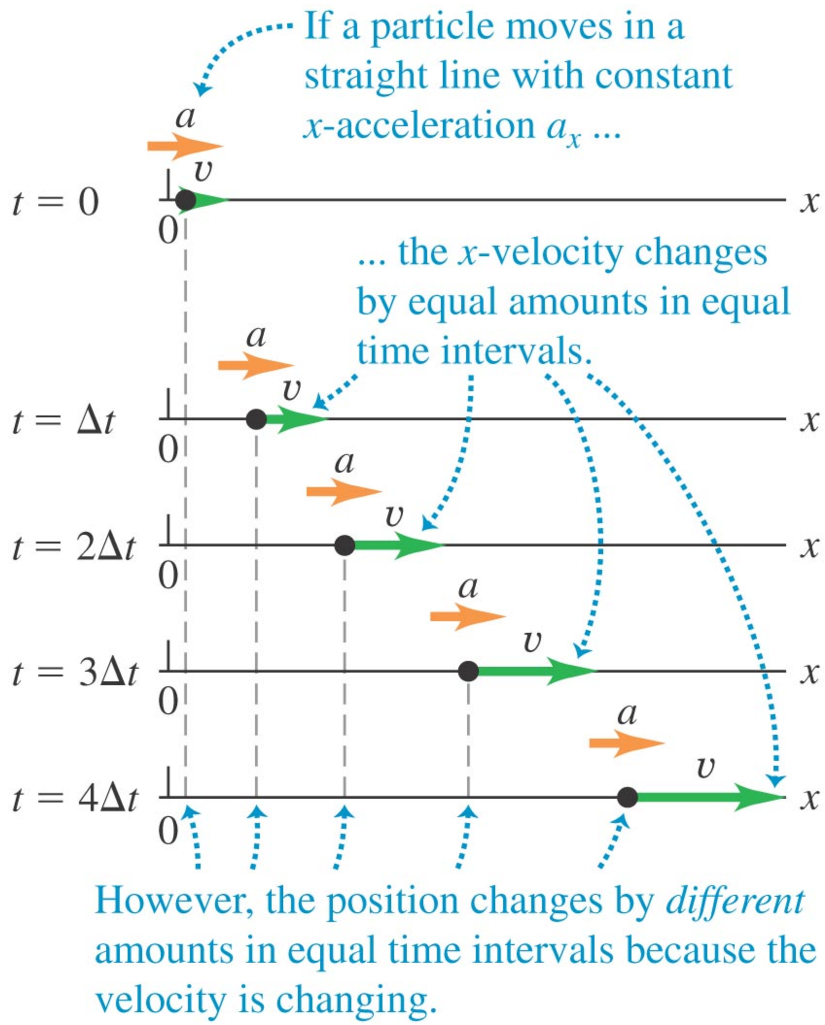
Goals for Chapter 2

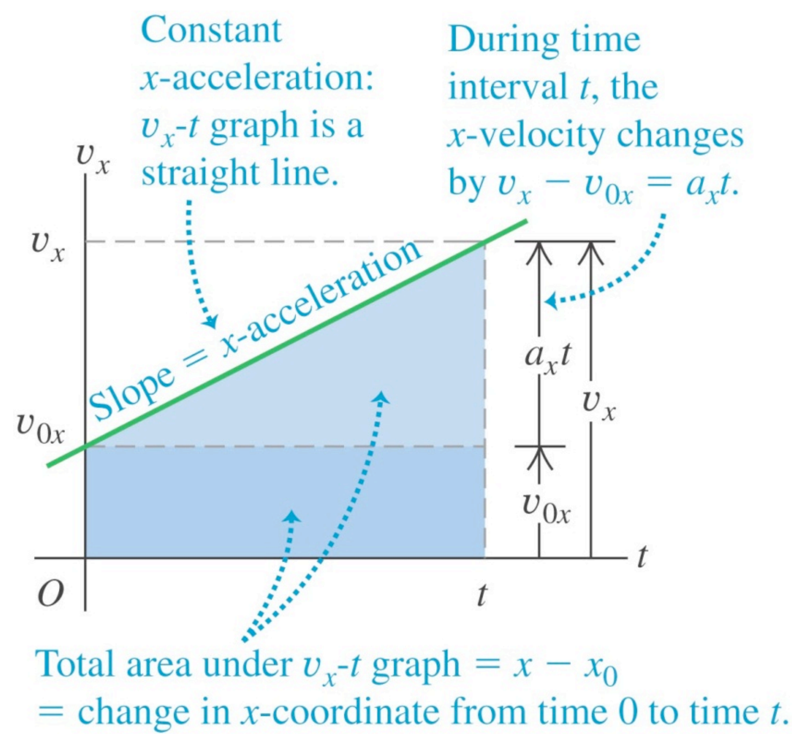
- To describe straight-line motion in terms of velocity and acceleration
- To distinguish between average and instantaneous velocity and average and instantaneous acceleration
- To interpret graphs of position versus time, velocity versus time, and acceleration versus time for straight-line motion
- To understand straight-line motion with constant acceleration
- To examine freely falling bodies
- To analyze straight-line motion when the acceleration is not constant

Constant acceleration

Motion with constant acceleration—Figures 2.15 and 2.17

- For a particle with constant acceleration, the velocity changes at the same rate throughout the motion.





The equations of motion with constant acceleration

- The four equations shown to the below apply to any straight-line motion with constant acceleration a_x.

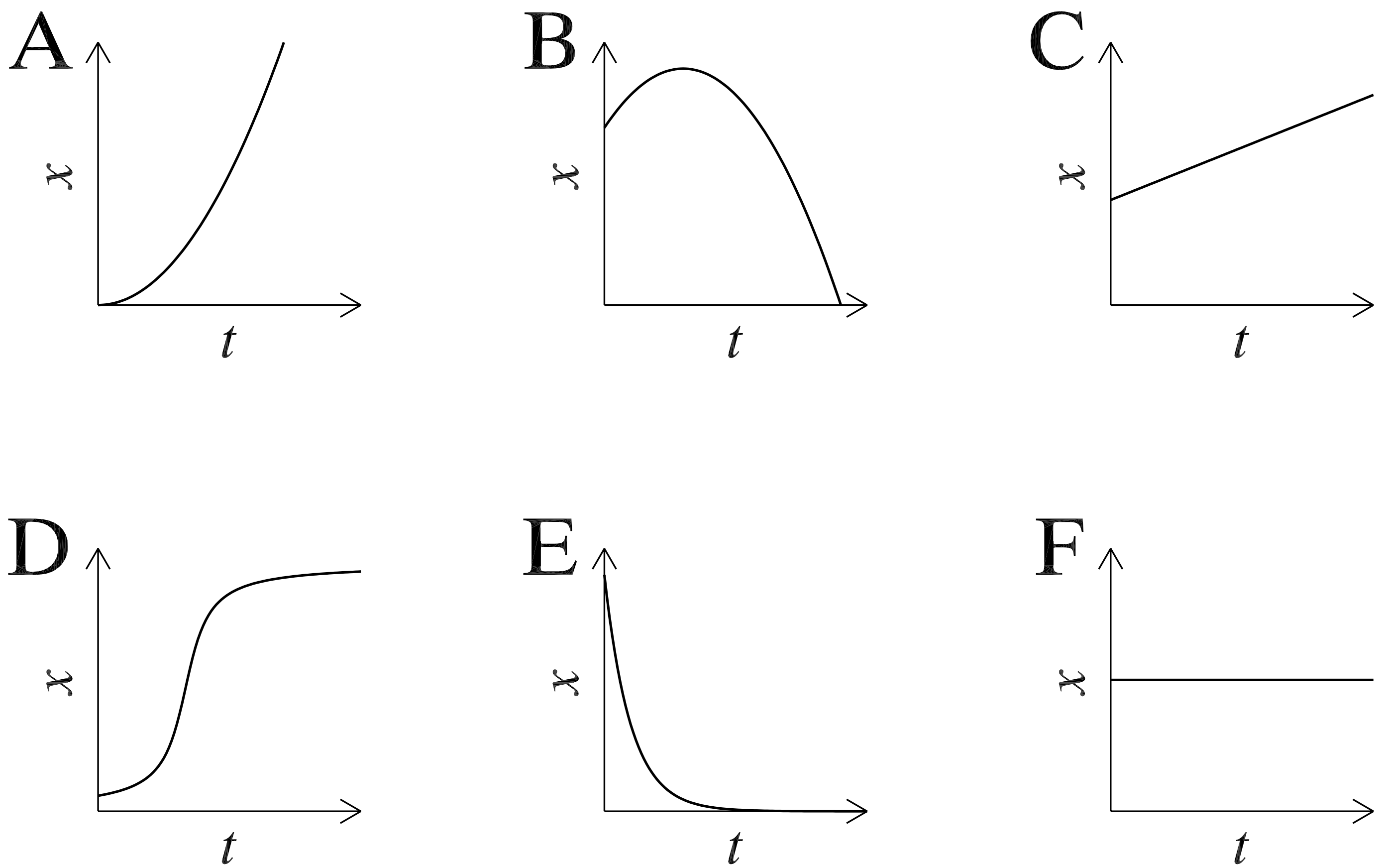
$$v_x = v_{0x} + a_x t$$

$$x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$

$$v_x^2 = v_{0x}^2 + 2a_x \left(x - x_0\right)$$

$$x - x_0 = \left(\frac{v_{0x} + v_x}{2}\right) t$$

Which of these position-time plots shows constant acceleration?



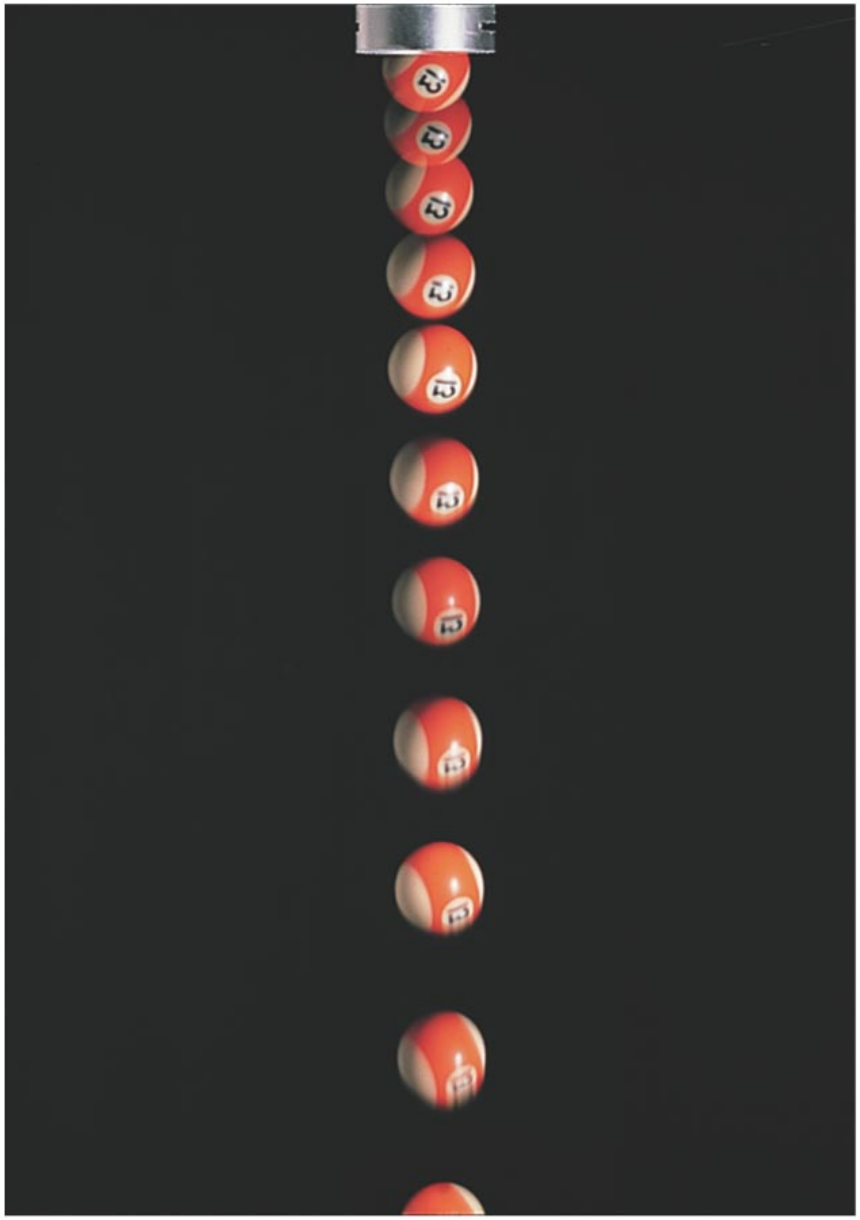
Text PHYSJC to 22333 to join the session

Text your answer to 22333

Demonstration

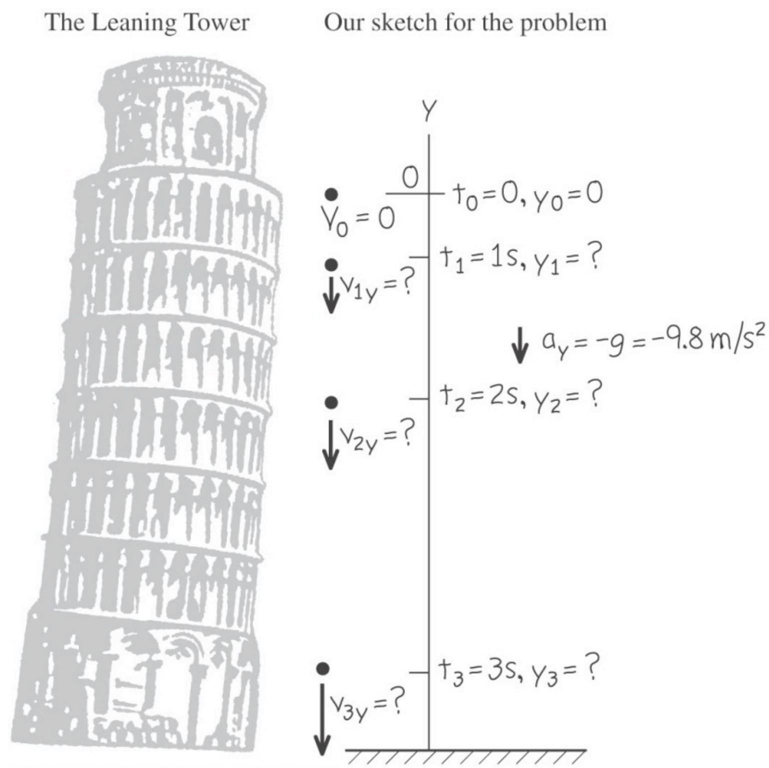
Freely falling bodies

- *Free fall* is the motion of an object under the influence of only gravity.
- In the figure, a strobe light flashes with equal time intervals between flashes.
- The velocity change is the same in each time interval, so the acceleration is constant.



A freely falling coin

- Aristotle thought that heavy bodies fall faster than light ones, but Galileo showed that all bodies fall at the *same* rate.
- If there is no air resistance, the downward acceleration of any freely falling object is g = 9.8 m/s^2 = 32 ft/s^2.



Polleverywhere

- After I throw the ball up, at what point in the trajectory does the acceleration have the greatest magnitude?

A. Just after leaving my hand

B. At the highest point

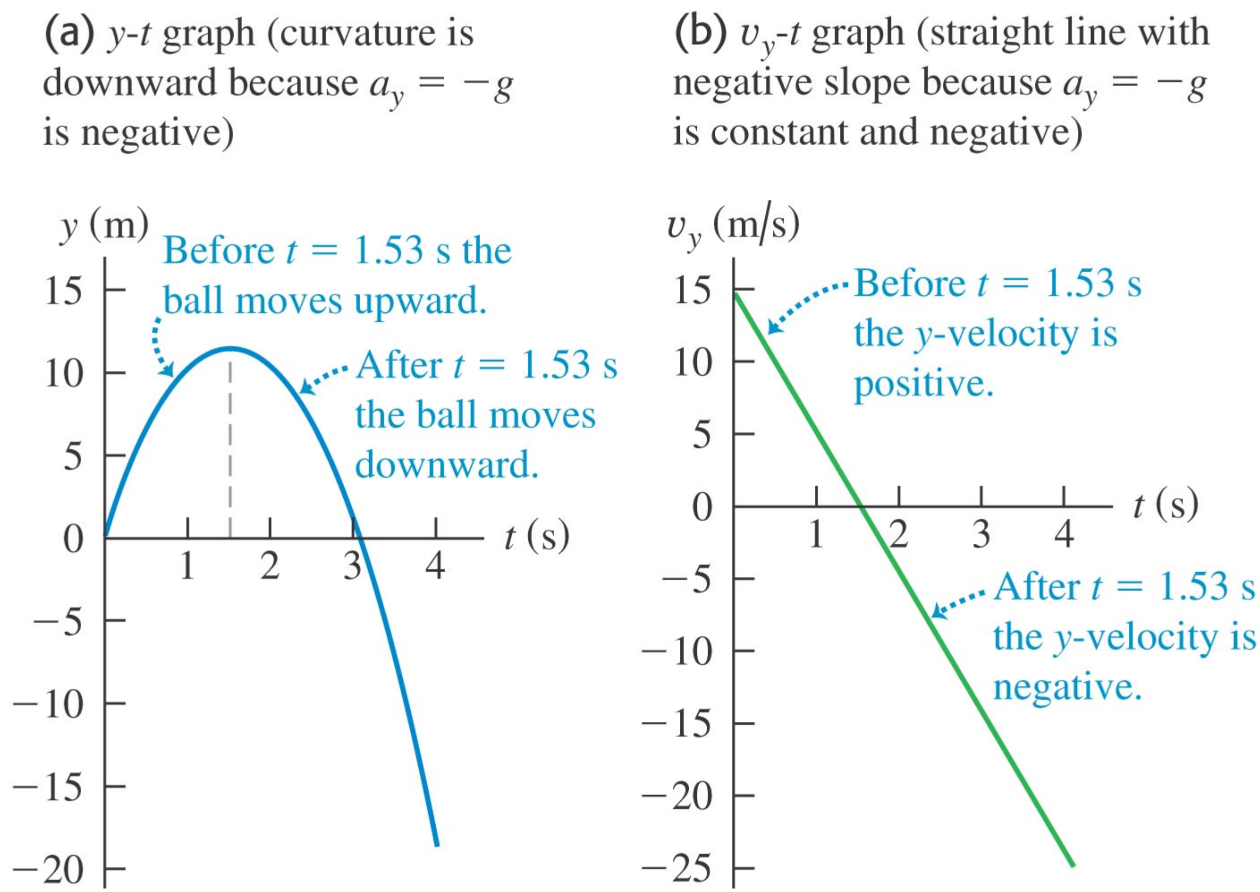
C. At the level of my hand on the way back down

D. Just before it touches the floor

E. None of the above

Is the acceleration zero at the highest point?—Figure 2.25

- The vertical velocity, but *not the acceleration*, is zero at the highest point.



Example Problem

You launch a water balloon vertically from the top of a tall building as shown. Neglect air resistance.

1. The speed of the balloon at B compared to D is

A. Higher B. Lower C. The same D. Cannot tell

2. The speed of the balloon at A compared to E is

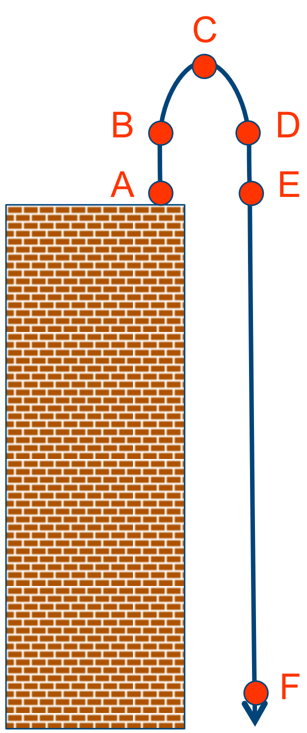
A. Higher B. Lower C. The same D. Cannot tell

3. The speed of the balloon at F compared to A is

A. Higher B. Lower C. The same D. Cannot tell

4. The time required to travel A→C compared to C→E is

A. Longer B. Shorter C. The same D. Cannot tell



Text your answers to 22333

Example Problem

You launch a water balloon vertically from the top of a tall building as shown. Neglect air resistance.

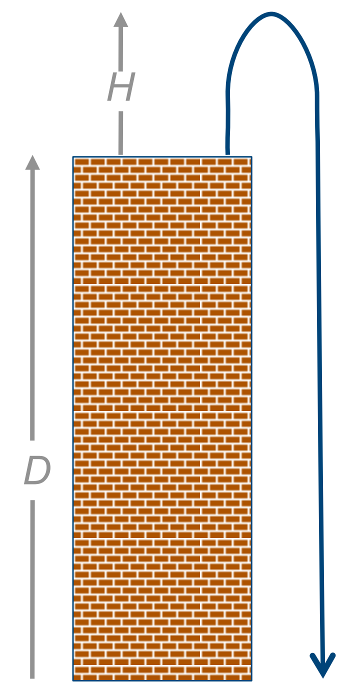
5. Find the initial velocity of the balloon.
6. Find its total time in the air.
7. Find its velocity when it hits the ground.

$$v_x = v_{0x} + a_x t$$

$$x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$

$$v_x^2 = v_{0x}^2 + 2a_x (x - x_0)$$

$$x - x_0 = \left(\frac{v_{0x} + v_x}{2} \right) t$$



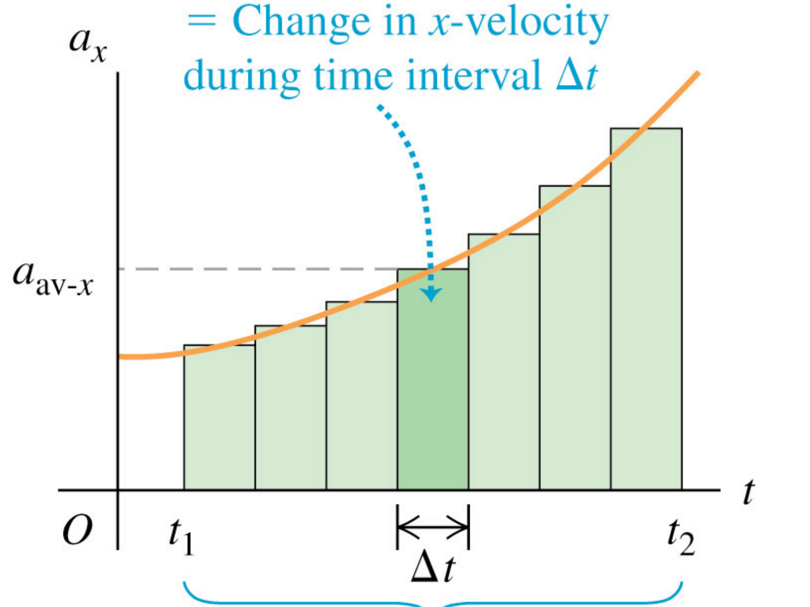
Problem-Solving Strategy

1. Identify the Problem
   - Picture of the problem
   - Given information
   - Problem to be solved
   - General approach
2. Set up the Physics
   - Diagram axes and define variables
   - Target variables
   - Relevant equations
3. Solve the Problem
   - Construct specific equations
   - Outline the solution
   - Solve for target variables
4. Evaluate your Solution
   - Units of solution correct?
   - Insert numerical values
   - Answer reasonable? Correct units?

Velocity and position by integration

- The acceleration of a car is not always constant.
- The motion may be integrated over many small time intervals to give

$$v_x = v_{ox} + \int_0^t a_x dt \quad \text{and} \quad x = x_0 + \int_0^t v_x dt.$$



- http://www.sciencemag.org/news/2016/01/math-whizzes-ancient-babylon-figured-out-forerunner-calculus

Motion with changing acceleration

- Follow Example 2.9.
- Figure 2.29 illustrates the motion graphically.