Constant Acceleration

In many practical situations:
-The magnitude of the acceleration is uniform (constant)
AND
-The motion is in a straight line

In such cases, the following kinematic equations are valid.

$$v = v_0 + at$$

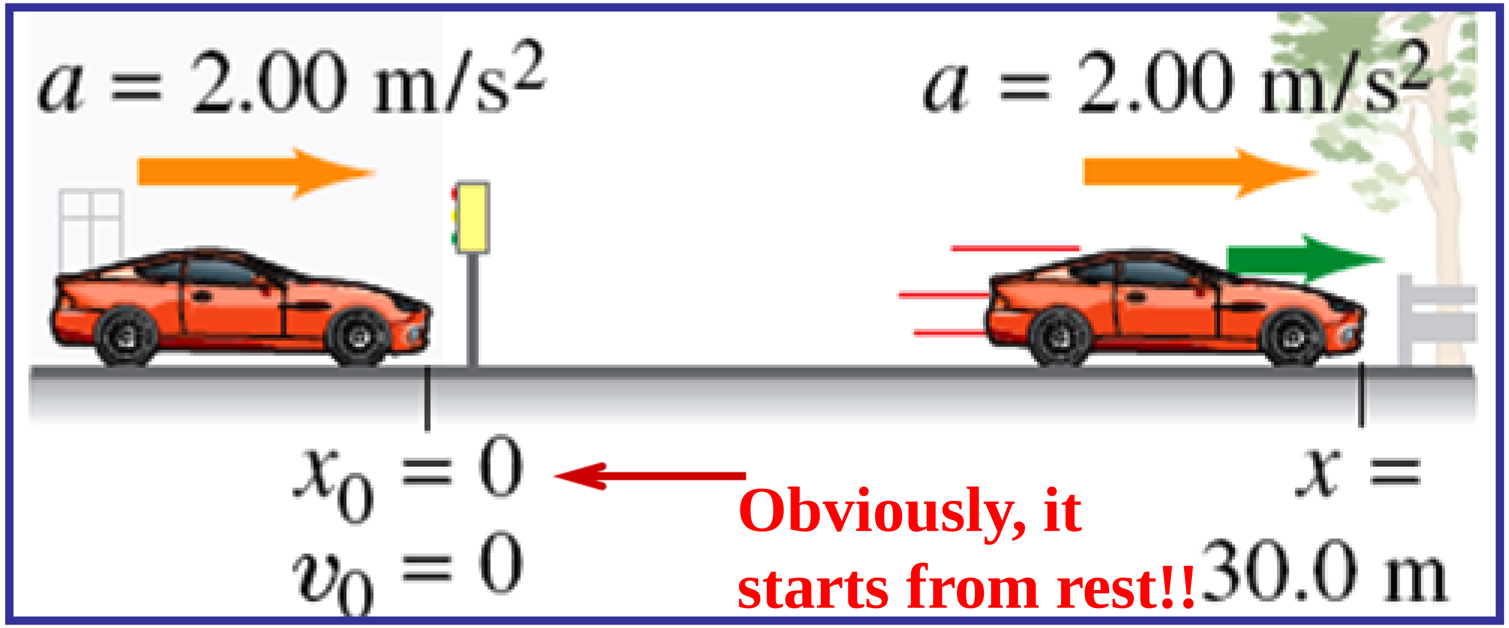
$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$\bar{v} = \frac{v + v_0}{2}.$$

Example 2.8: Acceleration of a Car

How long does it take a car to cross a 30 m wide intersection after the light turns green if it accelerates at a constant $2.0\ m/s^2$?



Known: $x_0 = 0$, $x = 30\ m$, $v_0 = 0$, $a = 2.0\ m/s^2$

Wanted: t. **Use:** $x = x_0 + v_0 t + (½)at^2 = 0 + 0 + (½)at^2$

$\Rightarrow \quad t = (2x/a)^{½} = 5.48\ s$

Problem 2.25: Fastball

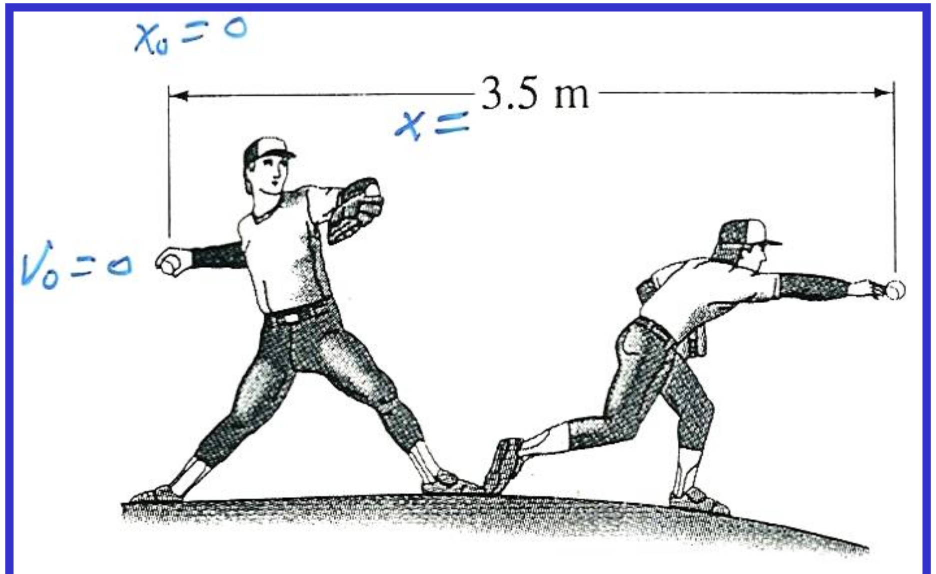


FIGURE 2–14 A baseball pitcher accelerates the ball through a displacement of about 3.5 m.

Known: $x_0 = 0$, $x = 3.5$ m, $v_0 = 0$, $v = 44$ m/s

Wanted: a **Use:** $v^2 = (v_0)^2 + 2a(x - x_0)$

$$\Rightarrow a = (½)[v^2 - (v_0)^2]/(x - x_0) = 280 \text{ m/s}^2 \,!$$

Example: Carrier Landing

A jet lands on an aircraft carrier at velocity

v_0 = 140 km/h (**63 m/s**).

a) Calculate the acceleration (assumed constant) if it stops in **t = 2.0 s** due to the arresting cable that snags the airplane & stops it.

b) If it touches down at position **$x_0 = 0$**, calculate it's final position.

Solutions

a) v_0 = 63 m/s, t = 2.0 s = time to stop.

When it is stopped, **$v = 0$**. So, use **$v = v_0 + at = 0$**, which gives

$$a = -(v_0/t) = -(63/2) = -31.5\ \text{m/s}^2$$

b) Use **$x = x_0 + v_0t + (\frac{1}{2})at^2$**, which gives

$$x = x_0 + v_0t + (\tfrac{1}{2})at^2 = 0 + (63)(2) + (\tfrac{1}{2})(-31.5)(2)^2 = 63\ \text{m}$$

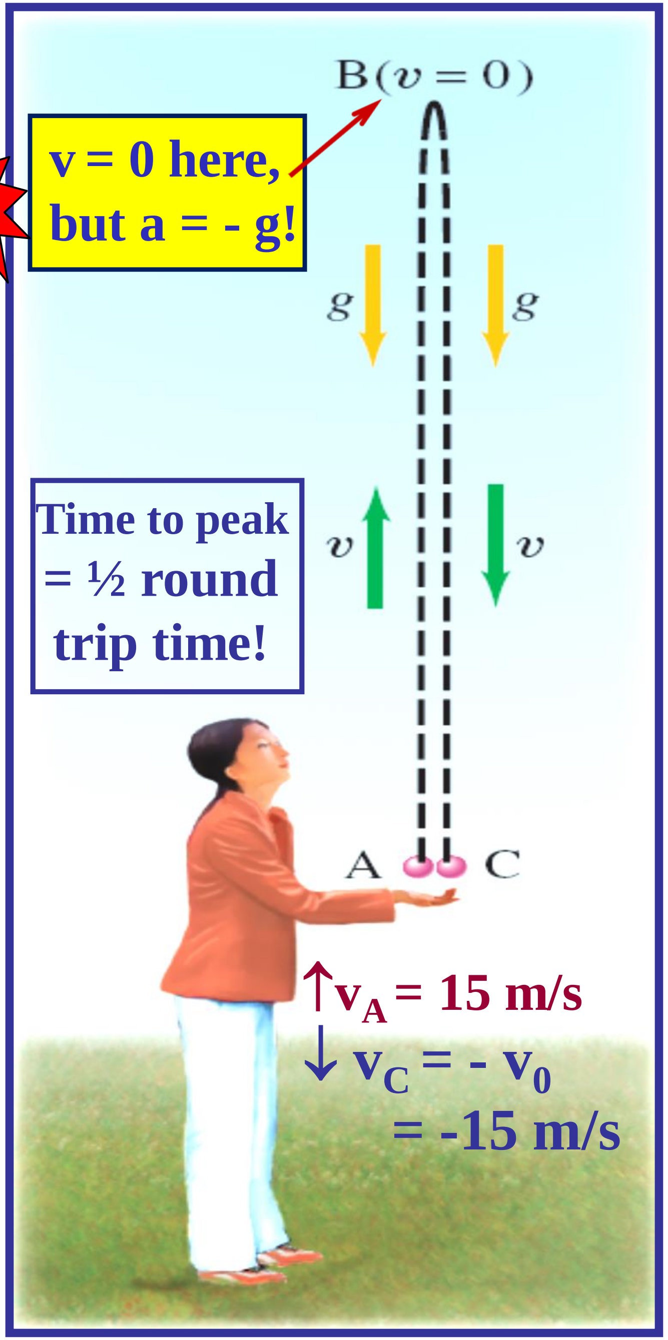
Freely Falling Objects

An important & common special case of uniformly accelerated motion is **"*FREE FALL*"**

Experiment finds that the acceleration of falling objects (**neglecting air resistance**) **is always the same**, no matter how light or heavy the object.

The *magnitude* of the acceleration due to gravity is:

$$g = 9.8\ \mathrm{m/s^2}$$



Examples 2.12 & 2.13 & 2.15:

- A person throws a ball up into the air with an initial velocity **v_0 = 15.0 m/s**.

Calculate:

a. The time to reach maximum height.
b. The maximum height.
c. The time to come back to the hand.
d. Velocity when it returns to the hand.

Note: g is always *downward!*
v is antiparallel to g while the ball goes up, and it becomes parallel to g when the ball falls back

Don't panic: we will elucidate this in class!