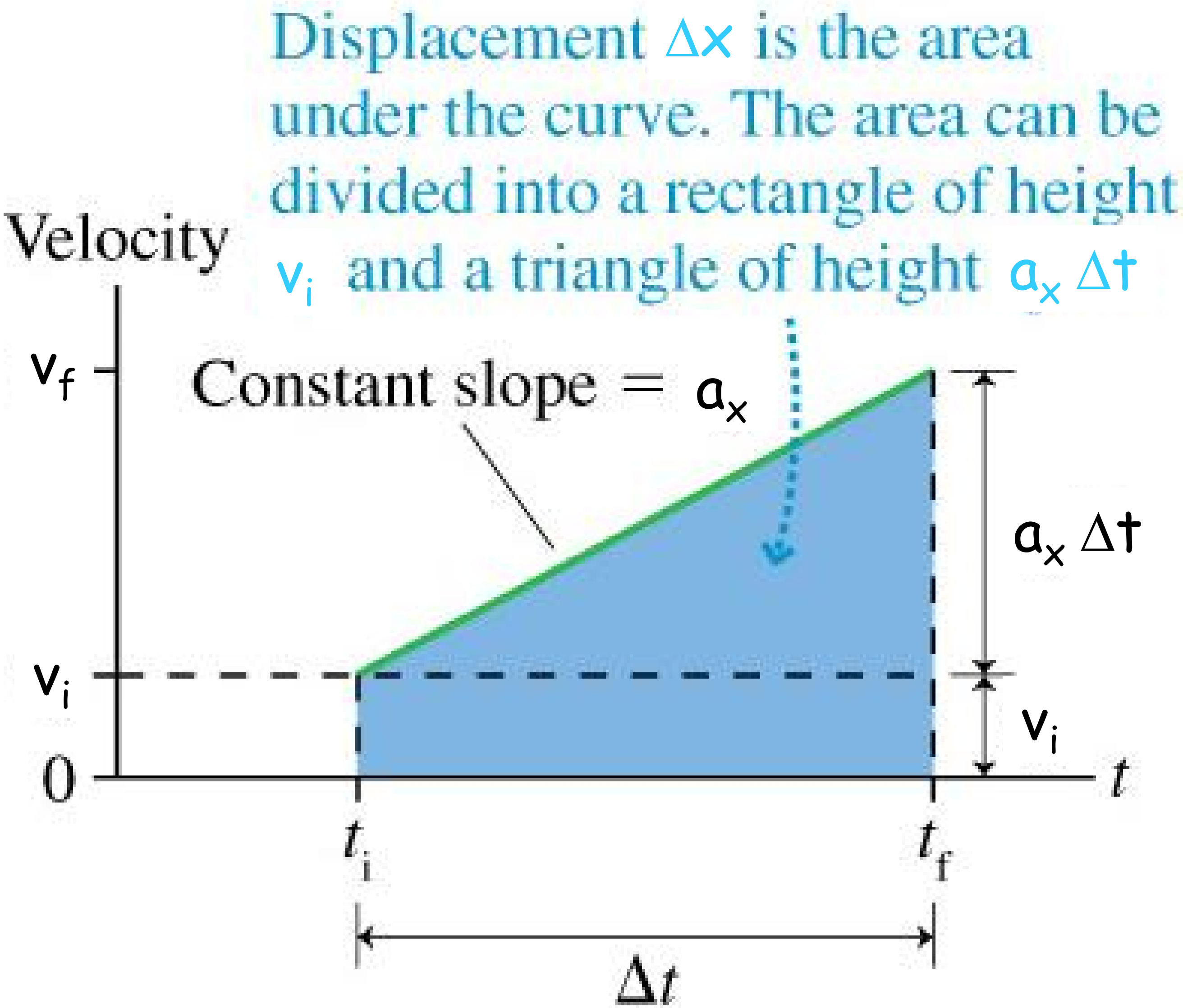
Motion on an Inclined Plane

- Kinematic Equations of Constant Acceleration
- Freefall
- Components
- Inclined Plane Geometry
- Kinematics on an Inclined Plane
- Vector Magnitudes

Using our definitions of acceleration and velocity:

$$a_x = \frac{\Delta v_x}{\Delta t} \qquad v_x = \frac{\Delta x}{\Delta t}$$

We can derive the kinematic equations for constant acceleration



Displacement Δx is the area under the curve. The area can be divided into a rectangle of height v_i and a triangle of height $a_x \Delta t$
Velocity
v_f
v_i
0
Constant slope = a_x
$a_x \Delta t$
v_i
t
t_i
t_f
Δt

The "equations of motion"

$$a = \text{constant}$$

$$v = v_0 + at$$

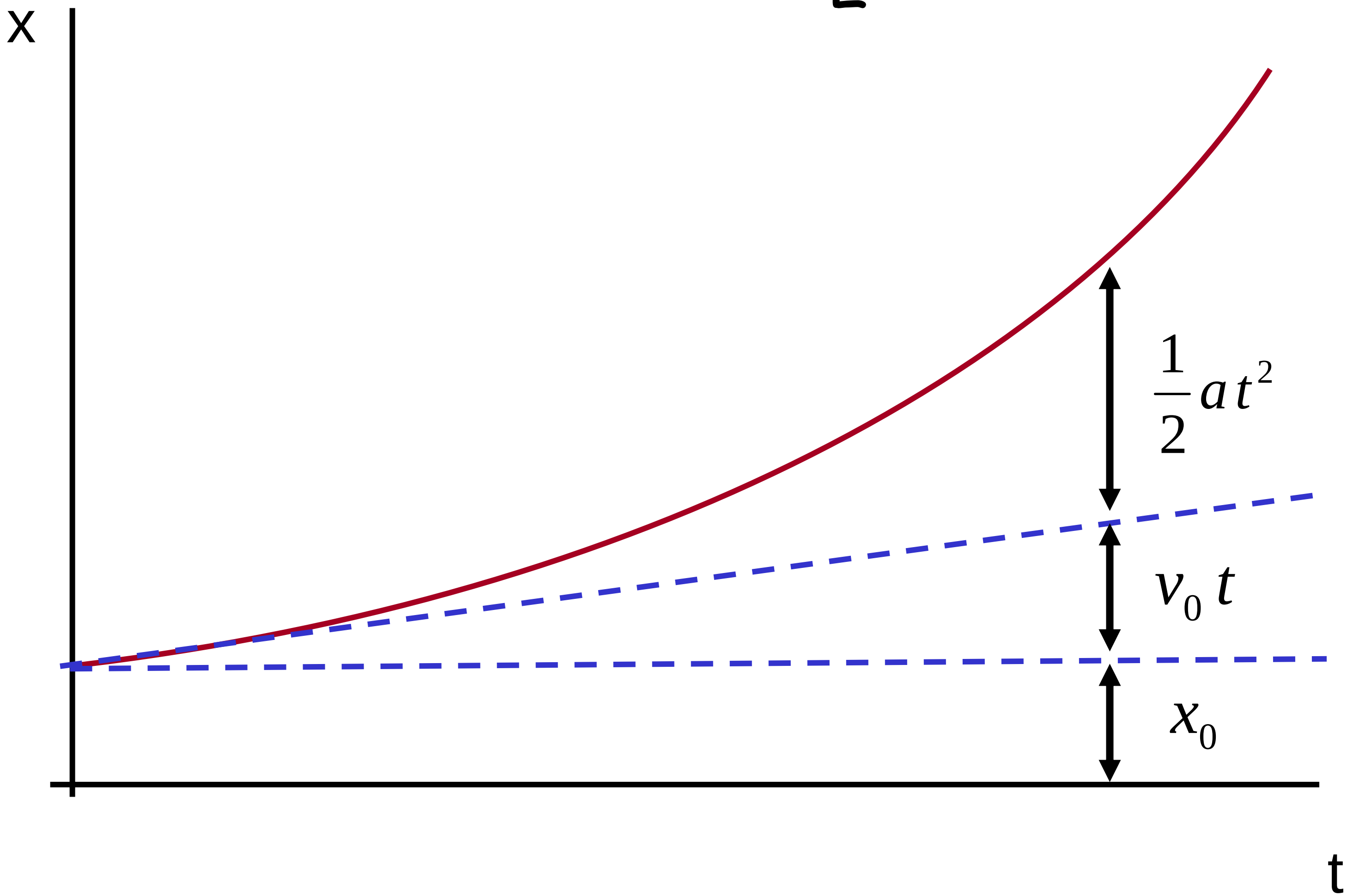
$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$\Big\} \quad v_2^2 = v_1^2 + 2ad$$

<u>Caution</u>: These are correct only if a is constant!

The equation of motion in graphical form

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



Worked Example

You are bicycling down the street at a speed of 5 m/s and a parked car opens its door 3 m in front of you. It takes you 0.5s to apply the brakes, and then your deceleration is 10 m/s^2. How fast are you traveling when you hit the door?

Objects in free fall

It is *experimentally* true that objects near the surface of the Earth fall at nearly constant acceleration of $a = 9.80 \text{ m/s}^2$ (downward)

If gravity is the only force on an object, it is said to be in *free fall*

- Far from Earth's surface, $g < 9.8 \text{ m/s}^2$
- Air resistance will also cause real acceleration $< 9.8 \text{ m/s}^2$

Near the surface of the earth, and neglecting air friction, this is a key example of *uniformly accelerated motion*

Quick Quiz 19

Two balls are thrown off a cliff at the same speed. One is thrown directly upward, the second is thrown directly downward. Ignore air resistance.

a) The first ball lands at higher speed

b) The second ball lands at higher speed

c) Both land at the same speed

The Gravity Vector

- $\vec{g}$ is a vector that points toward the centre of the Earth
- The acceleration of an object in freefall is $\vec{g}$
- The largest acceleration that gravity can give an object is $\vec{g}$

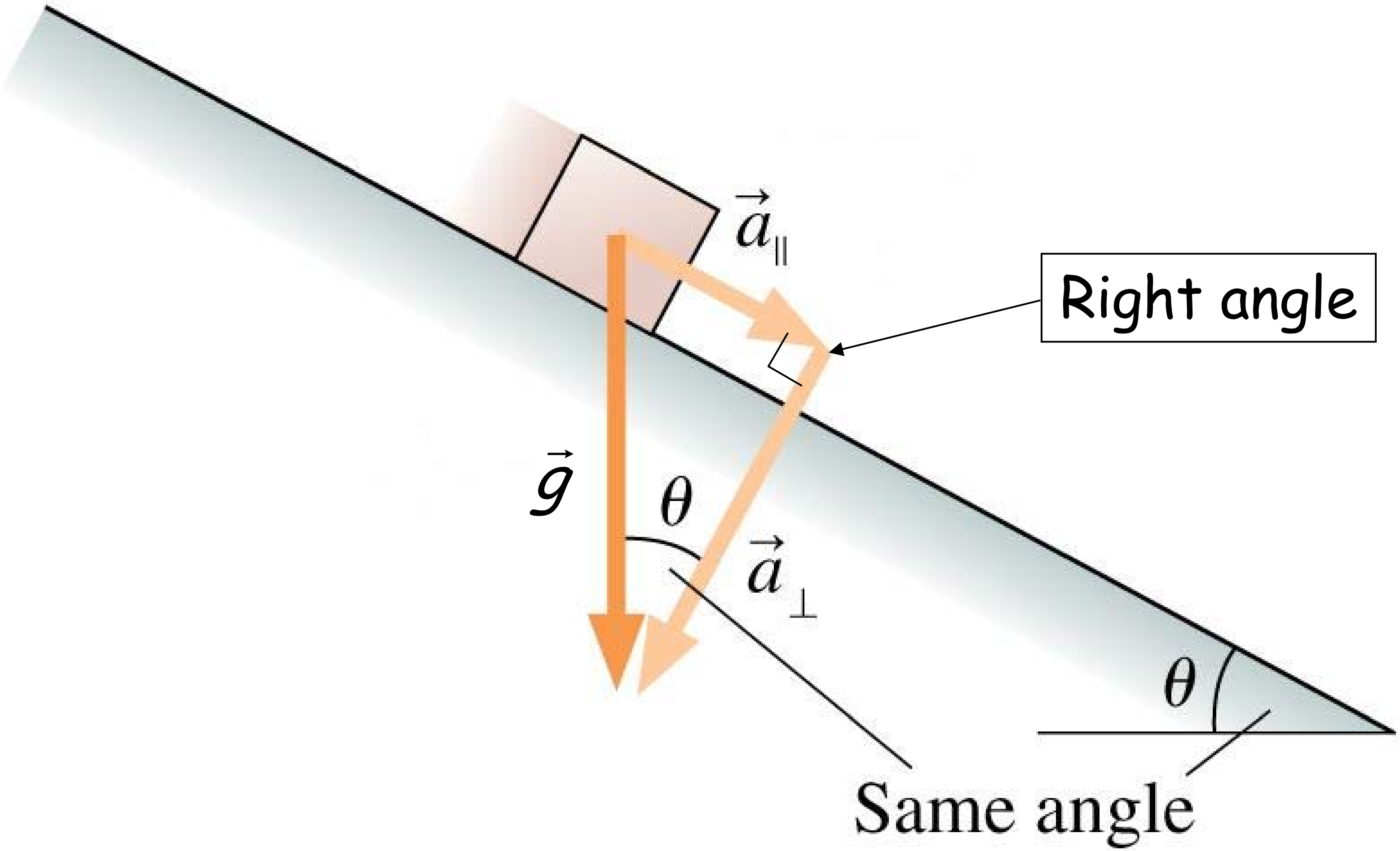
Components

- Gravity can make things slide down ramps

- If the ramp is somewhere in between being perpendicular and parallel to $\vec{g}$, an object on the ramp is accelerated at some fraction of $\vec{g}$

- The acceleration that an object on a tilted ramp experiences is the "**component** of $\vec{g}$ that is parallel to the surface of the ramp"

How to find Components



Quick Quiz 20

A block is on a plane that makes an angle of $\theta = 15°$ to horizontal. The component of $\vec{g}$ parallel to the surface of the ramp is:

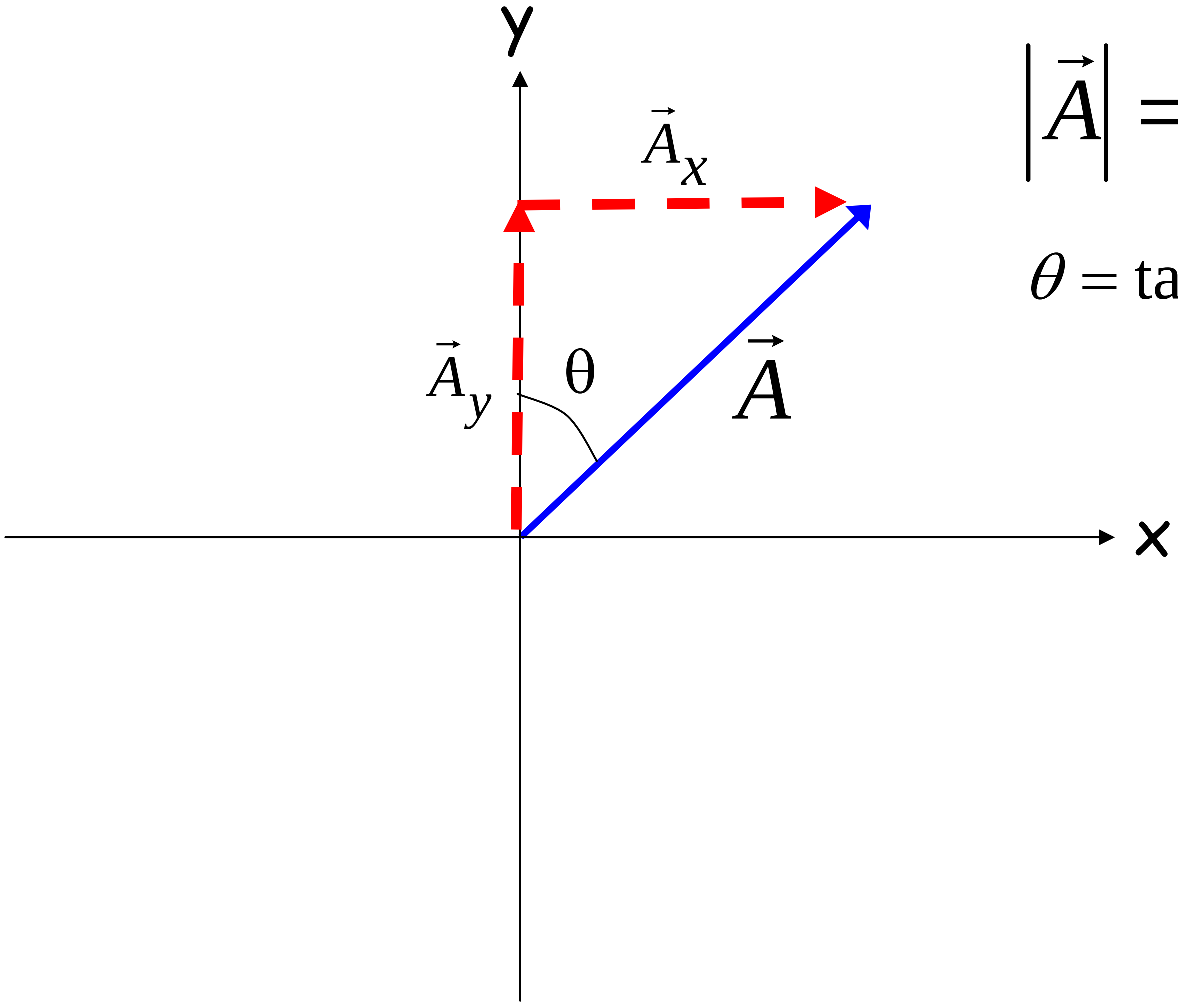
A) g sin(15°)
B) g sin(15°)
C) g sin(75°)
D) g sin(75°)

Quick Quiz 21

A bicycle <u>coasts</u> down a road that makes an angle of 1 degree to the horizontal. If the bike starts at a speed of 2 m/s, approximately how much farther along the road will it have traveled in 10 seconds? (ignore air resistance)

(A) 10 m
(B) 15 m
(C) 20 m
(D) 25 m
(E) 30 m

Given $\vec{A}_x$ and $\vec{A}_y$, you can find the magnitude and direction of $\vec{A}$:



$$\left|\vec{A}\right| = \sqrt{\left|A_x\right|^2 + \left|A_y\right|^2}$$

$$\theta = \tan^{-1}(opposite / adjacent)$$

Quick Quiz 22:

If a_x = 5 m/s and a_y = 2 m/s, which of the following best represent the magnitude and direction of the acceleration vector?

(A) 7 m/s [22° ccw from the x-axis]
(B) 5.4 m/s [68 ° cw from the y-axis]
(C) 4 m/s [22° ccw from the x-axis]
(D) 5.4 m/s [22° ccw from the x-axis]
(E) More than one is correct

Note: (ccw = counterclockwise, cw = clockwise)

Don't use a calculator.