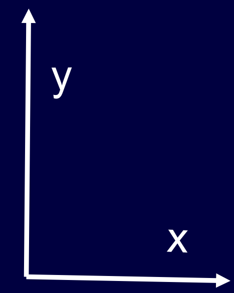
Physics 2A: Lecture 2
Today's Agenda

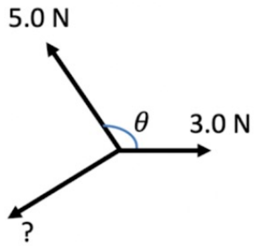
- The study of motion
  - Describing motion
  - Example from last week
- Kinematics
  - Position
  - Velocity
  - Acceleration
- Special case: Constant acceleration

Clicker Question 0.1:



Question 3

The figure below shows a birds-eye-view of three people pulling on ropes that are connected together at a single point. One person pulls with a force of 3.0 N and a second person pulls with a force of 5.0 N at angle of $\theta = 120$ degrees from the first person, as in the figure. With what magnitude of force must the third person pull with such that the three forces cancel out?



What is the y-component of the 5.0 N vector? Assume our usual xy-axis as shown.

(a) 4.33 N

(b) -4.33 N

(c) 2.5 N

(d) -2.5 N

Clicker Question 0.2:

Question 3

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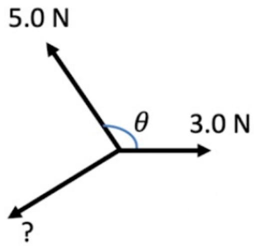

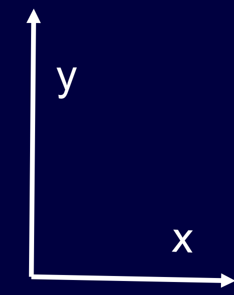

What angle does the vector sum of the 3.0 N and 5.0 N vector make with the x-axis?

(a) 6.6 degrees
(b) 12.6 degrees
(c) 35.2 degrees
(d) 59.1 degrees
(d) 83.4 degrees

Clicker Question 0:

Question 3

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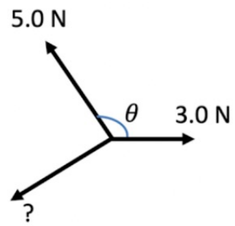


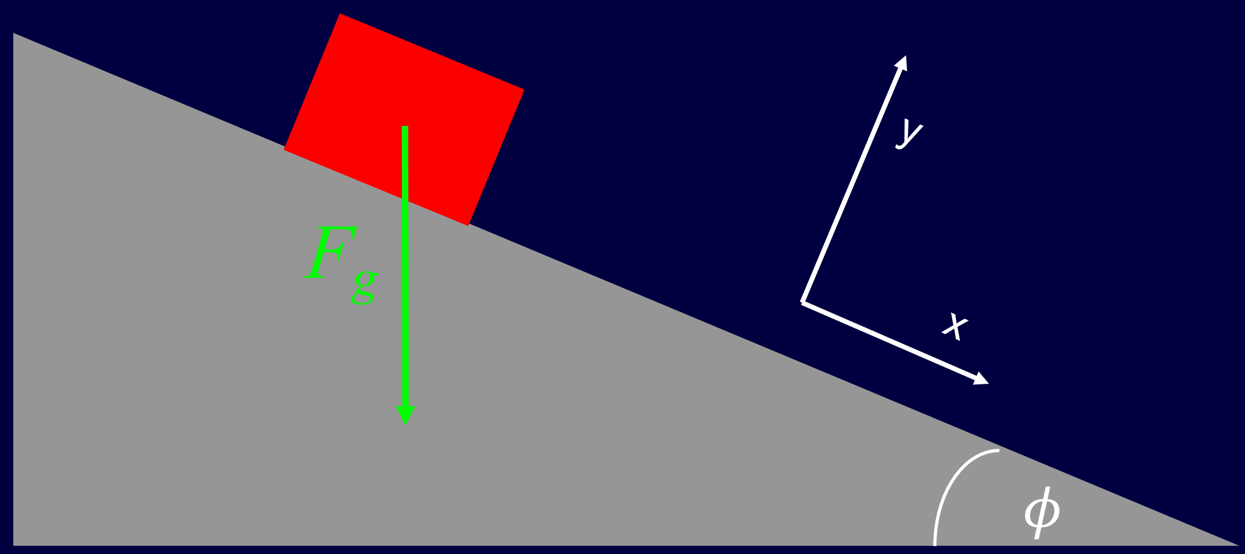
(A) 2.5 N (B) 7.0 N (C) 2.8 N. (D) 4.4 N. (E) 5.2 N. (F) 6.3 N

Clicker Question 2:

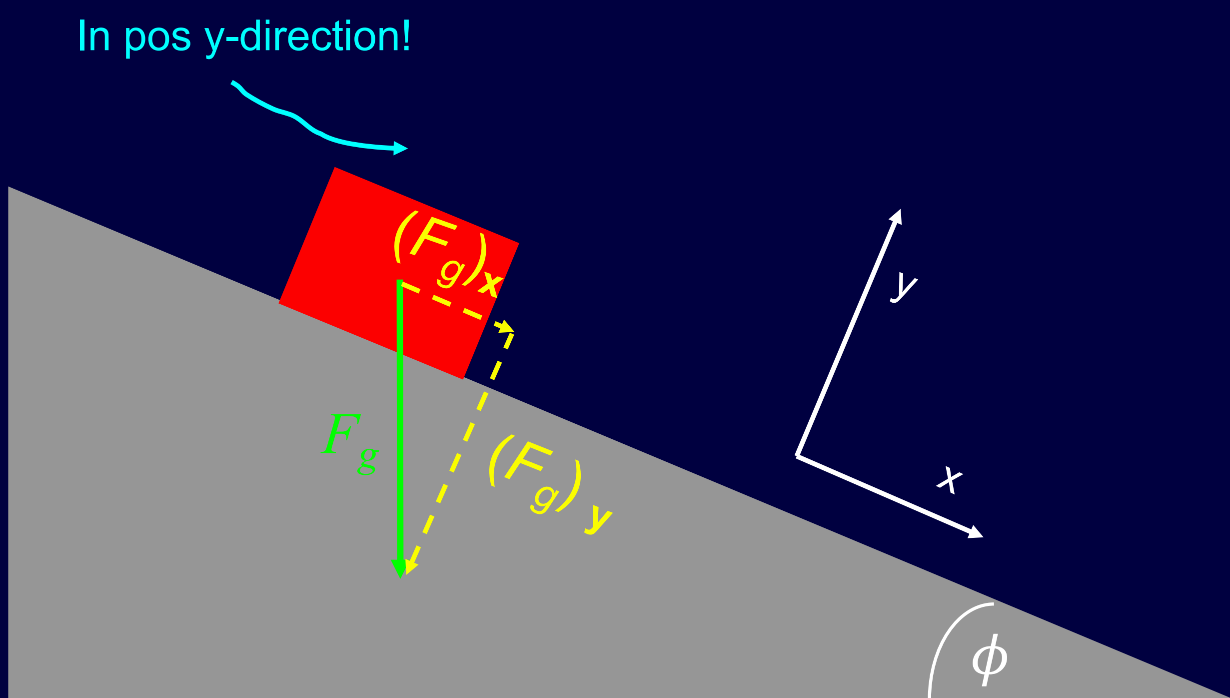
A box rests on an incline. The force of gravity pulls straight down as shown. When dealing with inclined planes we will often find it convenient to rotate our coordinate system as shown. How would you express the gravitational force in the new *x*-direction?

(a) $F_g\cos(\phi)$ (b) $F_g\sin(\phi)$ (c) $-F_g\cos(\phi)$ (d) $-F_g\sin(\phi)$

(e) None of the above



Example: Inclined surface



Speed and velocity

- How fast is the object changing position?

$$\text{speed} = \left|\vec{\mathbf{v}}\right|$$

$$\text{speed}_{\text{ave}} = \left|\vec{\mathbf{v}}_{ave}\right| = \frac{\text{distance}}{\text{time}}$$

- Speed is only a magnitude, how fast an object moves
- Instantaneous speed: Speed at an instant in time.
- Velocity is a vector, speed and direction

Acceleration

- Acceleration: Change in velocity over time **(It's a vector)**
- Average acceleration = change in velocity / elapsed time

$$\vec{a}_{ave} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i}$$

- Instantaneous acceleration: Acceleration at an exact instant in time
- Units = meters per second per second = m/s^2
- For velocity and acceleration we'll drop the instantaneous from now on

Units of acceleration

- Think about as m/s per second (It's like the speed of the velocity)

$$a = \frac{\frac{m}{s}}{s} = \frac{m}{s^2}$$

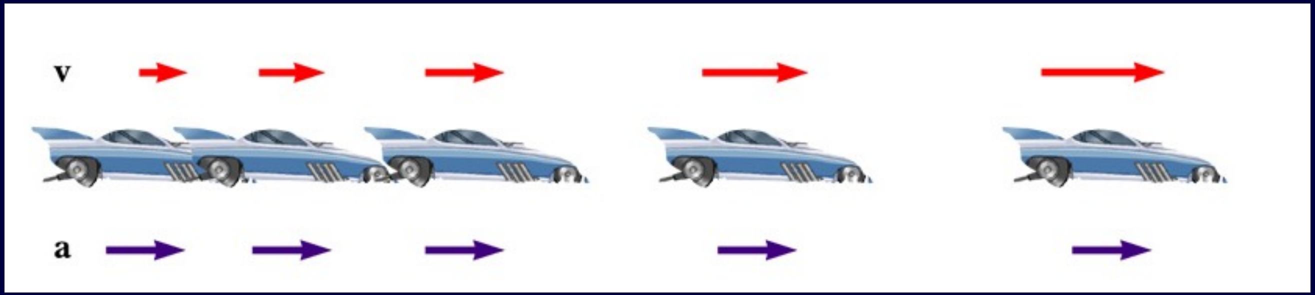
Acceleration

- Assume we start at rest with acceleration of 5 m/s^2
- At time = 1s we have velocity 5 m/s
- At time = 2s we have velocity 10 m/s
- At time = 3s we have velocity 15 m/s

Object is speeding up, or accelerating!

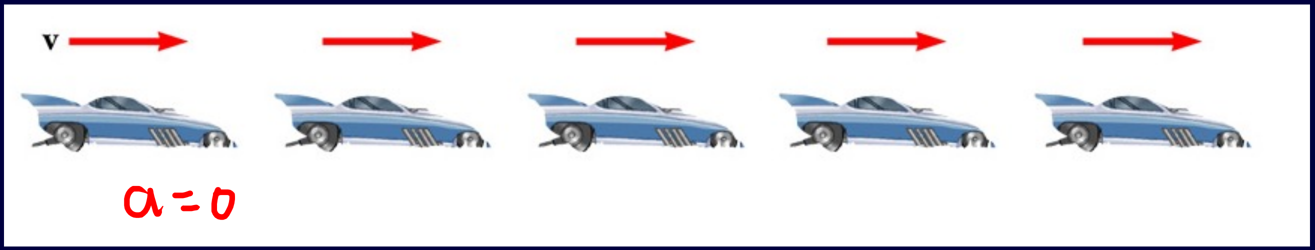
And its doing it at a constant rate!

Relationship Between Velocity and Acceleration



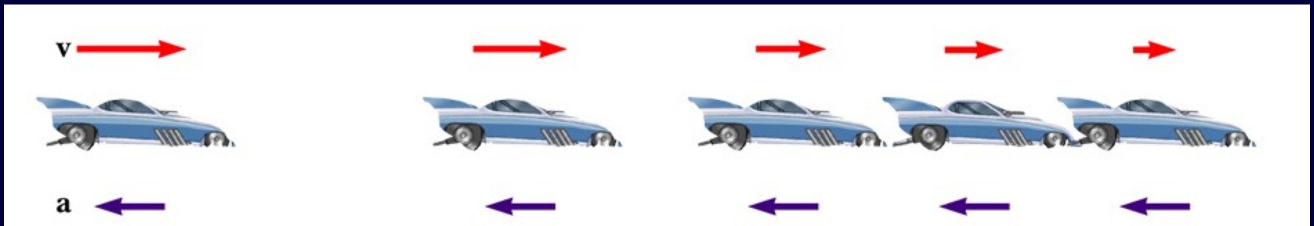
- Velocity and acceleration are in the same direction
- Acceleration is uniform (blue arrows maintain the same length)
- Velocity is increasing (red arrows are getting longer)
- Positive velocity and positive acceleration

Relationship Between Acceleration and Velocity



- Uniform velocity (shown by red arrows maintaining the same size)
- Acceleration equals zero

Relationship Between Velocity and Acceleration



- Acceleration and velocity are in opposite directions
- Acceleration is uniform (blue arrows maintain the same length)
- Velocity is decreasing (red arrows are getting shorter)
- Velocity is positive and acceleration is negative

Clicker Question 3:

A ball is thrown vertically upward. At the very top of its trajectory, which of the following statements is true:

(a) The velocity of the ball is zero and the acceleration of the ball is zero
(b) The velocity of the ball is not zero and the acceleration of the ball is zero
(c) The velocity of the ball is zero and the acceleration of the ball is not zero
(d) The velocity of the ball is not zero and the acceleration of the ball is not zero

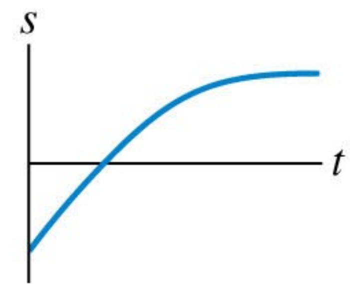
Instantaneous Velocity

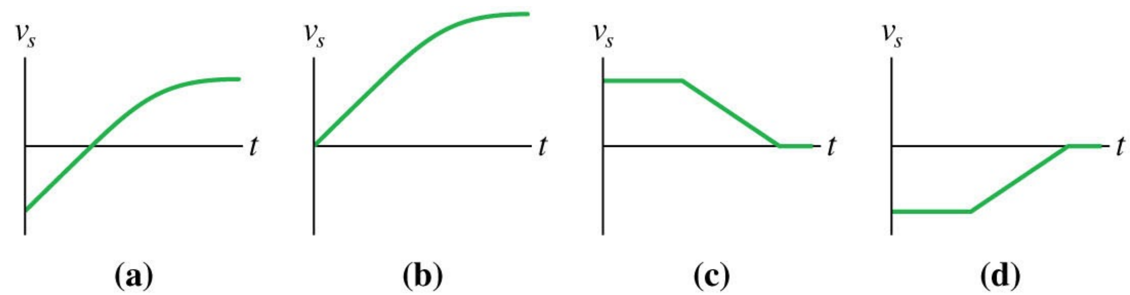
- Objects rarely travel for long with a constant velocity.
- Far more common is a velocity that changes with time.
- If you watch a car's speedometer, at any instant of time, the speedometer tells you how fast the car is going *at that instant*.
- If we include directional information, we can define an object's **instantaneous velocity**—speed and direction—as its velocity at a single instant of time.
- The average velocity $v_{avg} = \Delta s/\Delta t$ becomes a better and better approximation to the instantaneous velocity as Δt gets smaller and smaller.

$$v_s \equiv \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt} \qquad \text{(instantaneous velocity)}$$

Clicker Question 4:

Which velocity-versus-time graph goes with this position graph?

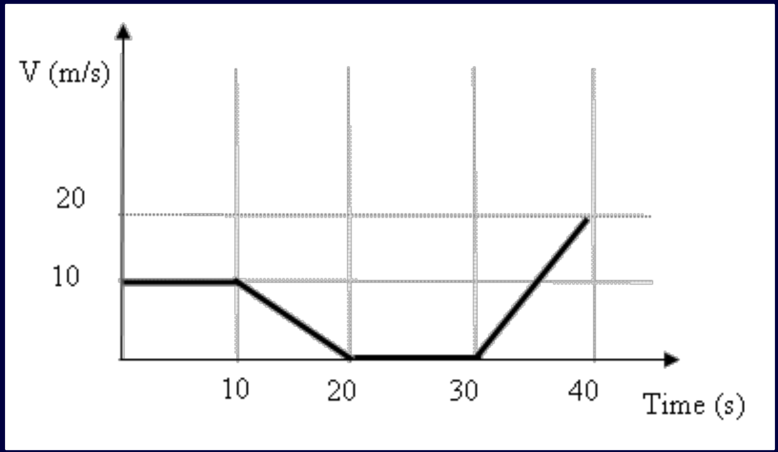




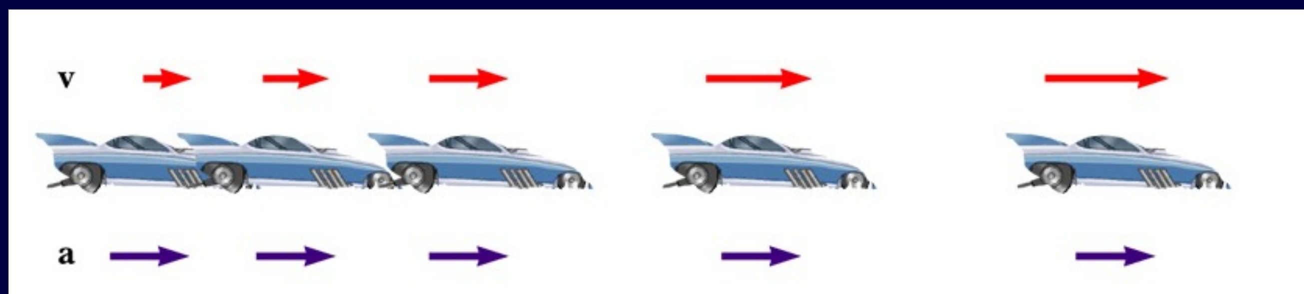
Clicker Question 4.5:

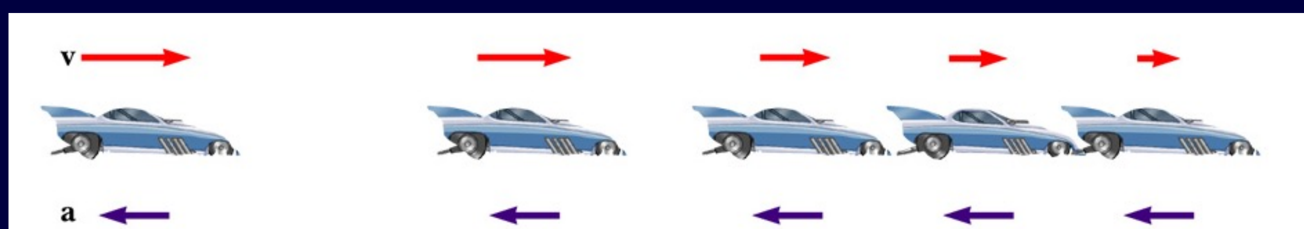
Below is a v vs. t graph for a car. What was the displacement of the car between t = 0 s and t = 40 s ?

(a) 0 m
(b) 200 m
(c) 250 m
(d) 350 m
(e) 550 m




v


v
a


v
a

The Constant Acceleration Model

$$v_F = v_0 + at$$

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

These can be combined to make:

$$v_F^2 = v_0^2 + 2a(\Delta x)$$

Student: I am confused about whether or not when should i use negative 9.81 for gravity and when should I use 9.81 for gravity?

Student: How do you know which equation to use, whether it's the velocity and position equations or the combined one?

Constant Acceleration Equations

$$v_F = v_0 + at$$

$$y_F = y_0 + v_0 t + \tfrac{1}{2} a t^2$$

$$v_F^2 = v_0^2 + 2a\left(\Delta y\right)$$

Same equations but in the up and down direction.

Clicker Question 5:

I drop a ball off a cliff of height 80 m. How long will it take the ball to reach the ground? What speed will it have right before it hits the ground?

(a) $t = 2.35$ s, $v_F = 23.0$ m/s
(b) $t = 9.81$ s, $v_F = 56.2$ m/s
(c) $t = 5.34$ s, $v_F = 52.4$ m/s
(d) $t = 4.03$ s, $v_F = 39.6$ m/s
(e) $t = 2.45$ s, $v_F = 24.0$ m/s

Student: Shouldn't the answer for problem 2 be -39.6 instead of positive because it is a downward velocity

Clicker Question 6:

A car decelerates constantly from an initial velocity to a complete stop. As it does this it covers a total distance D. When the velocity of the car has decreased to half its initial velocity the remaining distance is

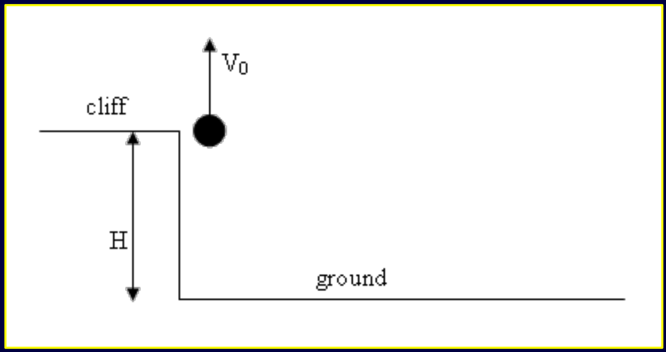
(a) greater than half the total distance D required to stop.
(b) half the total distance D required to stop.
(c) less than half the total distance D required to stop.

Clicker Question 7:

At t = 0 a ball is thrown straight upward from the edge of a cliff with initial velocity V_0 = 25 m/s. It lands on the ground at the base of the cliff 7 seconds later.

What is the height *H* of the cliff?

(a) H = 46 m
(b) H = 53 m
(c) H = 65 m
(d) H = 76 m
(e) H = 82 m



Clicker Question 8:

A uniformly accelerating car starting at rest travels a distance *x* and reaches a velocity *v* in a certain time interval. At the point that the same car has travelled a distance of 5*x* what is its velocity?

a) 2 *v*

b) 5 *v*

c) 2.5 *v*

d) 2.24 *v*

e) 1.73 *v*

Clicker Question 10:

Nicole throws a ball straight up. Chad watches the ball from a window 5.0 m above where Nicole released it. The ball passes Chad on the way up, and it has a speed of 10m/s as it passes him on the way back down.

How fast did Nicole throw the ball?

(a) 14 m/s
(b) 22 m/s
(c) 10 m/s
(d) 17 m/s
(e) 26 m/s

Clicker Question 9:

Below is a graph of position (*x*) vs. time (*t*) for some object. For which time interval is the velocity of the object always positive?

(a) From 0s to 1s
(b) From 3s to 4s
(c) From 5.5s to 6s
(d) From 1s to 2s
(e) From 2s to 4s