Acceleration

by

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P2.1B Represent the velocities for linear and circular motion using motion diagrams (arrows on strobe pictures).

P2.1C Create line graphs using measured values of position and elapsed time.

Items:

1. Acceleration, Velocity and Time.

2. Positive Acceleration.

3. Negative Acceleration (Deceleration) .

Acceleration (Symbol: a)

Acceleration shows the change in velocity in a unit time. When an object's velocity changes, it accelerates. Acceleration is the rate of change of velocity.

Acceleration ($\vec{a}$) is a vector quantity. It has a magnitude, a unit and a direction. Acceleration units are (km/h)/s or (m/s)/s = m/s^2.

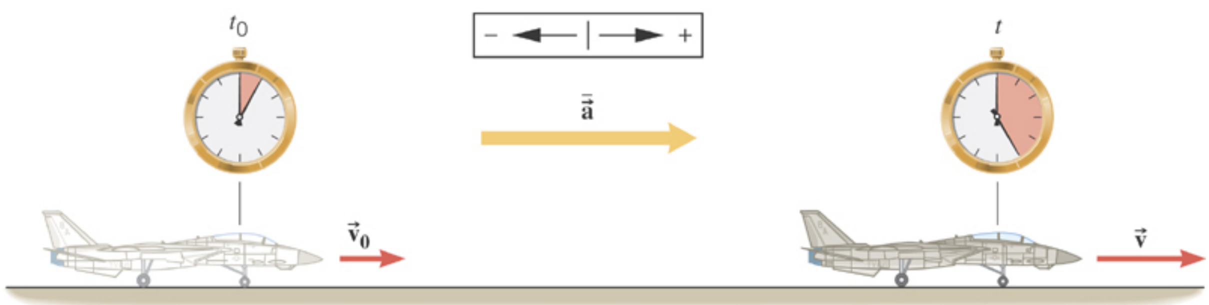
If a car acceleration is 1 m/s^2 [E]: We say that 1 is the magnitude (number, value), m/s^2 is the unit and E is the east direction.

Acceleration can be both positive (speeding up) and negative (slowing down).

The picture below shows a plane during a takeoff. The plane accelerates from an initial velocity v_0 at an initial time t_0, to a final velocity v at the final time t toward east. So, the velocity changes ($\Delta v = v - v_0$) during the time interval $\Delta t = t - t_0$

Note that we call the east direction to be the positive direction, so the west direction is negative direction.

The plane is moving forward toward the east positive direction. The acceleration (a) is positive (yellowish arrow)



The average acceleration can be calculated with the formula:

Average Acceleration	
$\vec{\bar{a}} = \dfrac{\vec{v} - \vec{v}_o}{t - t_o} = \dfrac{\Delta\vec{v}}{\Delta t}$	Acceleration = $\dfrac{\text{(final velocity - initial velocity)}}{\text{final time - initial time}}$

$\vec{a}$: the object's average acceleration

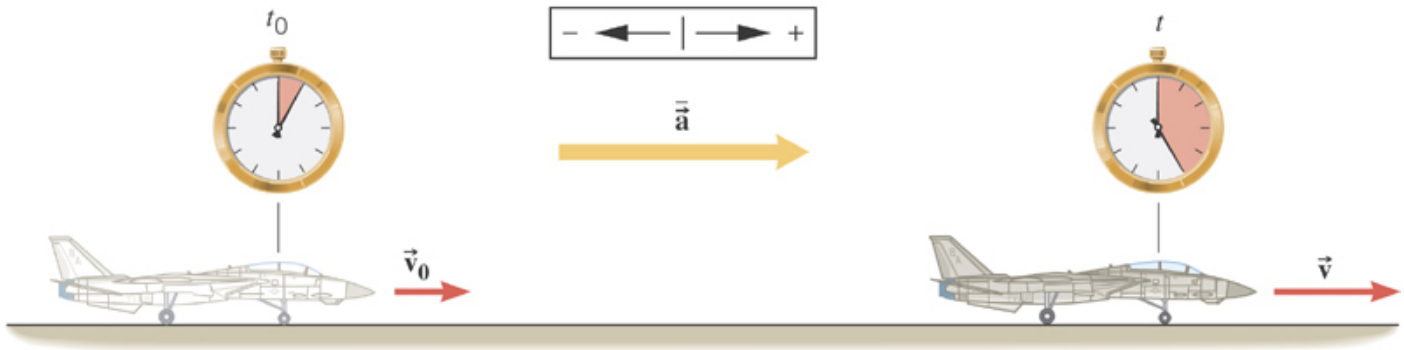
Δt: time interval over which the object's velocity changed

$\vec{v}$: The object's final velocity at the end of the time interval

$\vec{v_0}$: the object's initial velocity at the beginning of the time interval

Example 1: if a car moves from the rest to 5 m/s in 5 seconds, its average acceleration = 5/5 = 1 m/s^2

Positive Acceleration: Increasing Velocity ($a > 0$, speeding up)



Suppose the plane starts from rest (v_0 = 0 m/s) when t_0 = 5 s. The plane accelerates down the runway and at t = 25 s attains a velocity (v) of 240 km/h, where the plus sign indicates that the velocity points to the right.

Plane Data				
v	v_o	a	t	t_o
240 km/h	0 m/s	?	25 s	5 s

we can determine the average acceleration of the plane as follows:

$$\text{Acceleration} = \frac{(\text{final velocity - initial velocity})}{\text{final time - initial time}}$$

a = 240 - 0 / 25 - 5

= 240 / 20

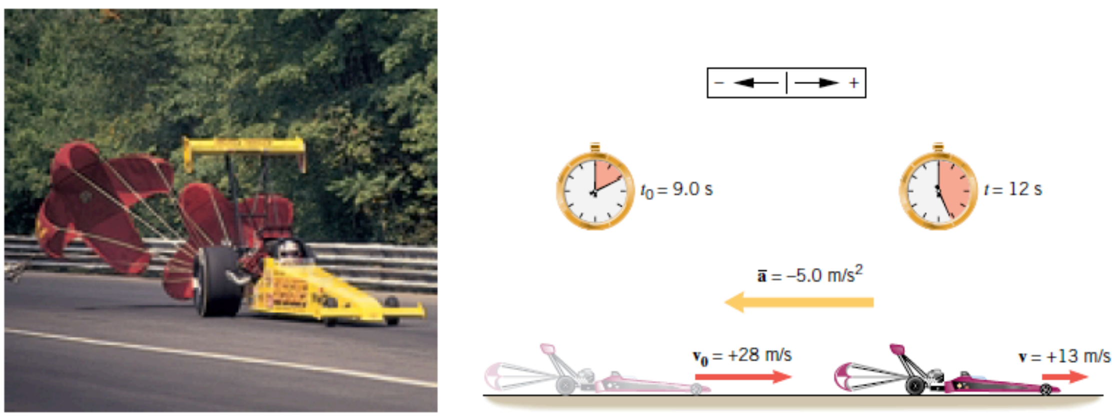
= 12 m/s^2 [East]

So, the velocity of the of the plane increases 12 m/s every one second.

Negative Acceleration: Decreasing Velocity (deceleration $a < 0$, slowing down)

When an object slows down, its acceleration is in the opposite direction to its velocity. We call slowing down deceleration. it is easier an acceleration in the opposite direction to the velocity.

A drag racer slowing down in figures (a) and (b) below. The drag racer was moving with a velocity of $v_0 = 28$ m/s. At $t = 9.0$ s , the drag racer started slowing down using a parachute and braking. When $t = 12$ s, the velocity was reduced to $v = 13$ m/s. What is the average acceleration of the dragster?



(a) (b)

Drag Racer Data Table				
v	v_o	a	t	t_o
13 km/h	28 m/s	?	12 s	9 s

$$\text{Acceleration} = \frac{\text{(final velocity - initial velocity)}}{\text{final time - initial time}}$$

a = 13 - 28 / 12- 9 = -15 / 3 = - 5.0 m/s^2 [East] or 5.0 m/s^2 [West]

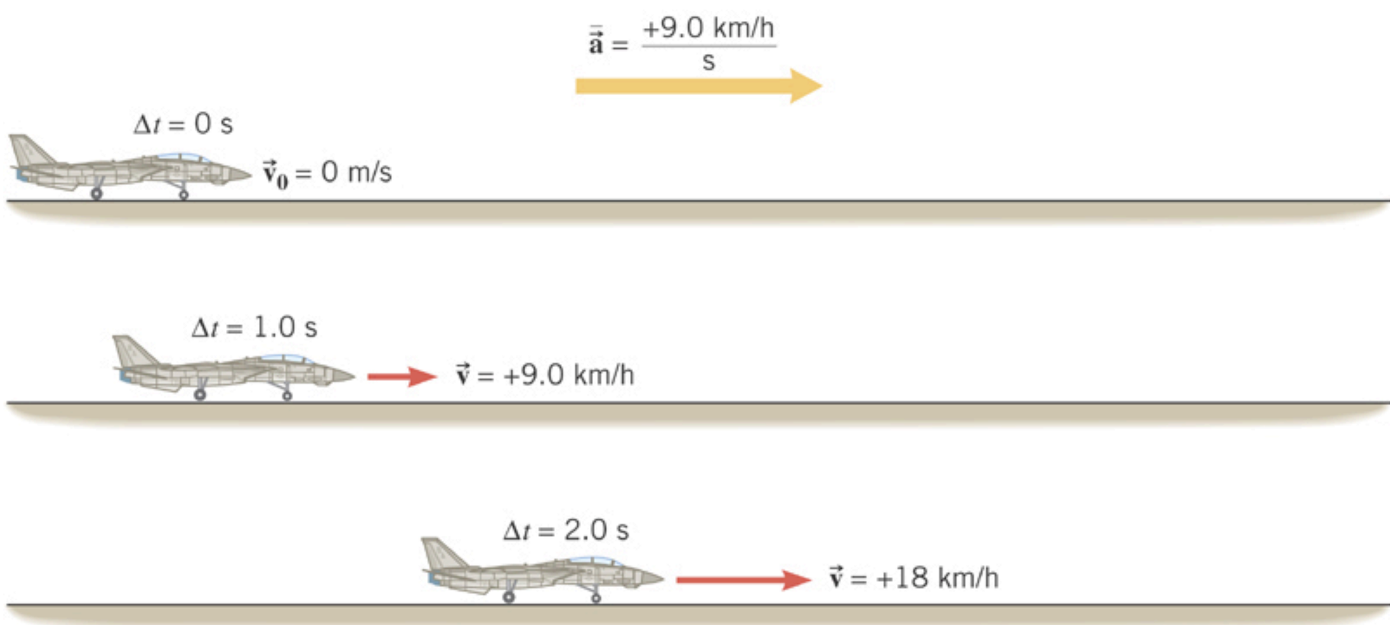
So, the velocity of the drag racer decreases -5.0 m/s every one second.

Notice how the negative sign in the final answer (**-** 5.0 m/s^2 [E]) is removed and replace with the opposite direction west (5.0 m/s^2 [w])

Example 2: A Plane, Accelerating;

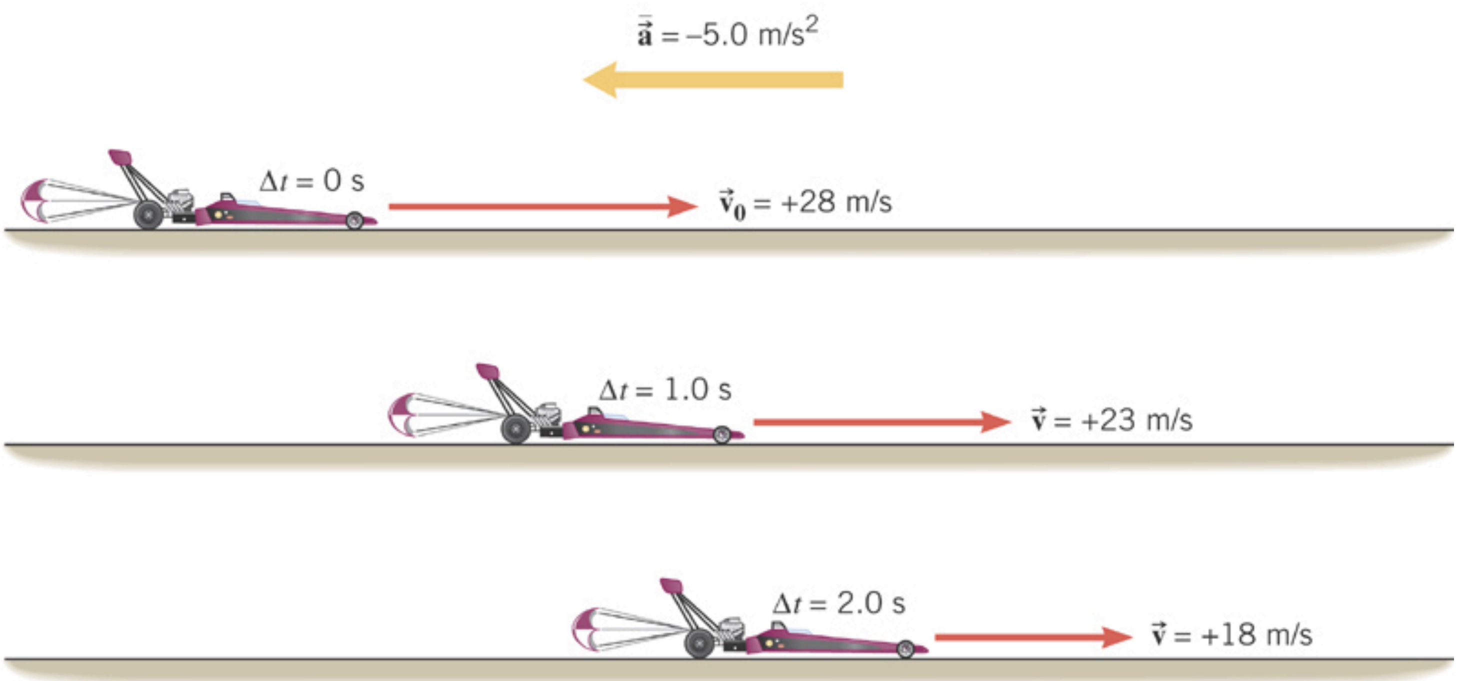
A plane has an acceleration (a) of +9.0 km/h/s, which means that the velocity (v) of the plane increases by 9.0 km/h during each second of the motion toward the positive direction. The "+" direction for (a) and (v) is to the right.

During the first second ($\Delta t = 1.0$ s), the velocity increases from 0 to 9.0 km/h; during the next second ($\Delta t = 2.0$ s), the velocity increases to 18 km/h, and so on.



***Example 3:** A Dragster, Deccelerating;*

The picture below shows how the velocity (v) of the dragster changes during the braking, assuming that the acceleration (a) is constant throughout the motion. The acceleration and velocity point are in opposite direction. The initial velocity is + 28 m/s. Here, an acceleration of - 5.0 m/s² means the velocity decreases by 5.0 m/s each second of elapsed time (Δt).



References:

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2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department: "We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

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