Fri: HW 3 due by 5pm

* Please write on separate sheet
* Provide convincing reason that your solution is correct.

Read

Thurs: Physics Seminar.

This class: acceleration

Velocity

The velocity of an object describes the rate at which the object's position changes. In this course we will use

velocity = speed AND description of direction of motion

The Law of Inertia then states

If there is no overall (net) external influence on an object then its velocity stays constant.

This describes the default or inherent state of motion of an object.

This will not always be the case in physical situations and the interesting cases involve changes in velocity.

DEMO: * Ball launcher / cart

* Ask where ball will land.

Acceleration

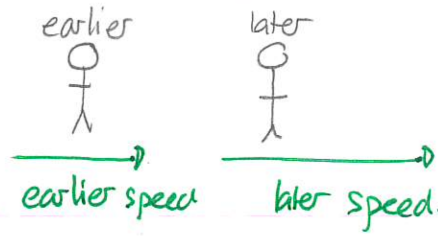
We will clearly need to describe <u>how</u> velocity changes. We first consider an object whose motion is restricted to a straight line. For example consider an object which could move left or right.

DEMO: PHET Moving Man. – Intro Tab

A. Position = -8 , Velocity = 1 → Observe

B. Position = -8, Velocity = 1 Accel = 3 → Observe.

We consider this simplest case first – the object only moves in one direction.

> Consider an object moving in one direction.
>
> 1) observe object's speed at two moments.
> 2) record the time elapsed between the two moments.
>
> 
>
>
> Then the (average) acceleration is
>
> $$\text{(average) acceleration} = \frac{\text{change in speed}}{\text{time elapsed}}$$
>
> where
>
> change in speed = later speed - earlier speed
>
> units: m/s^2

DEMO: Rerun previous animation with charts.

	earlier instant	later instant
time	1s	3s
speed	4m/s	10m/s

$$\Rightarrow \text{accel} = \frac{10\,m/s - 4\,m/s}{2s} = 3\,m/s^2$$

Quiz 1 90%

The definition of acceleration can be extended to situations where the object does not always move in the same direction. This can be made quantitative using more sophisticated mathematical descriptions of velocity.

In this course we will not provide these but, for motion in more than one direction, we will only focus on questions of whether acceleration is zero or not. Here:

Acceleration $= 0\,m/s^2 \Leftrightarrow$ speed is constant AND direction of motion is constant.

Quiz 2

1 Accelerating car

A car travels in a straight line to the right. At one moment it moves with speed 4.5 m/s (roughly 10 mph). At another moment 10 s later it it moves with speed 15.5 m/s (roughly 35 mph). Determine its acceleration during this period.

Answer:

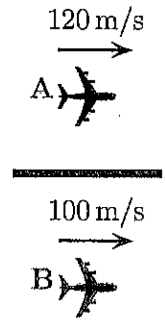
$$\text{accel} = \frac{\text{change in speed}}{\text{time elapsed}}$$

change in speed = 15.5 m/s − 4.5 m/s = 11.0 m/s

$$\text{accel} = \frac{11.0\,\text{m/s}}{10\,\text{s}} = 1.1\,\text{m/s}^2$$

2 Accelerating aircraft

Two aircraft travel in straight lines directly East. At one initial moment the aircraft have the illustrated speeds. For a while after this aircraft A has acceleration $5\,\text{m/s}^2$ and aircraft B has acceleration $10\,\text{m/s}^2$. Both of these result in increasing speed.



a) After the illustrated initial moment, does it seem that aircraft A will always move faster than aircraft B? Explain your answer.

b) After the illustrated initial moment, does it seem that aircraft B will always move faster than aircraft A? Explain your answer.

c) Determine the speed of each aircraft 2.0s after the initial moment.

d) Determine the speed of each aircraft 4.0s after the initial moment.

e) Determine the speed of each aircraft 6.0s after the initial moment.

f) Based on your calculations, do your answers to the first two questions change?

Answer: a) Initially it moves faster. However, B speeds up at a faster rate and may eventually move faster.

b) No, initially A moves faster.

For the rest, (change in speed = acceleration x time elapsed)

c) For A, change in speed = $5.0\,\text{m/s}^2 \times 2.0\,\text{s} = 10\,\text{m/s}$

⇒ speed after 2.0s = 120m/s + 10m/s (= 130m/s A) — A faster

For B, change in speed = $10\,\text{m/s}^2 \times 2.0\,\text{s} = 20\,\text{m/s}$

⇒ speed after 2.0s = 100m/s + 20m/s = (120m/s B)

d) For A change in speed = $5.0\,\text{m/s}^2 \times 4.0\,\text{s} = 20\,\text{m/s}$ — same

⇒ speed after 4.0s = 120m/s x 20m/s = (140m/s A)

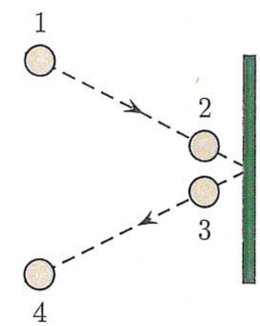
For B change in speed = $10\,\text{m/s}^2 \times 4.0\,\text{s} = 40\,\text{m/s}$ ⇒ (140m/s B)

e) similarly ... (150m/s A) (160m/s B) B faster

f) It's NO for both – see c), d), e)

3 Pool ball collision

A pool ball travels in a straight line at a constant speed toward the cushion on the edge of a pool table. It bounces off the cushion with no change in speed. Four moments during this process are illustrated. Describe whether the acceleration is zero or not between instants 1 and 2, 2 and 3, and 3 and 4.



From 1→2 speed AND direction are constant } ⇒ accel = 0

From 2→3 direction changes ⇒ accel ≠ 0

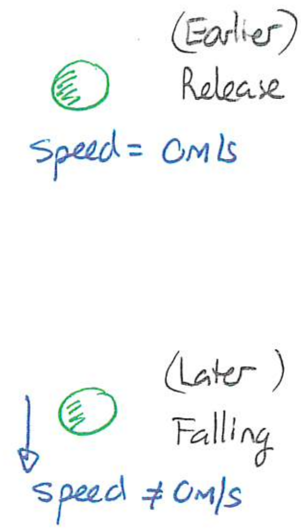
From 3→4 speed and direction are constant } ⇒ accel = 0

Thus acceleration only refers to a period of motion.

Free fall

Consider an object that falls near Earth's surface. If the air resistance can be ignored, then the object is in free fall.

Clearly the acceleration of the object is not zero. We can ask for further details.



1) Does acceleration depend on mass?
2) Does " depend on time since release or height?

Experiments show:

1) mass does not affect acceleration.
2) close to Earth's surface acceleration is constant and does not depend on time or height.
3) the exact value of acceleration is

$$g = 9.8 m/s^2 \qquad \text{(book simplifies to } 10 m/s^2\text{)}$$