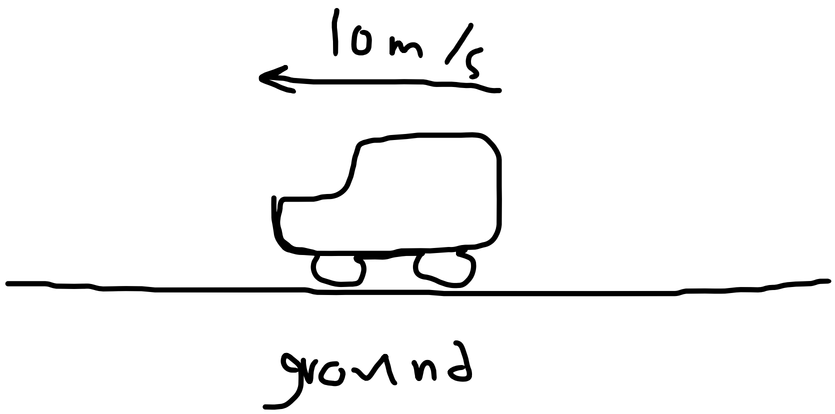
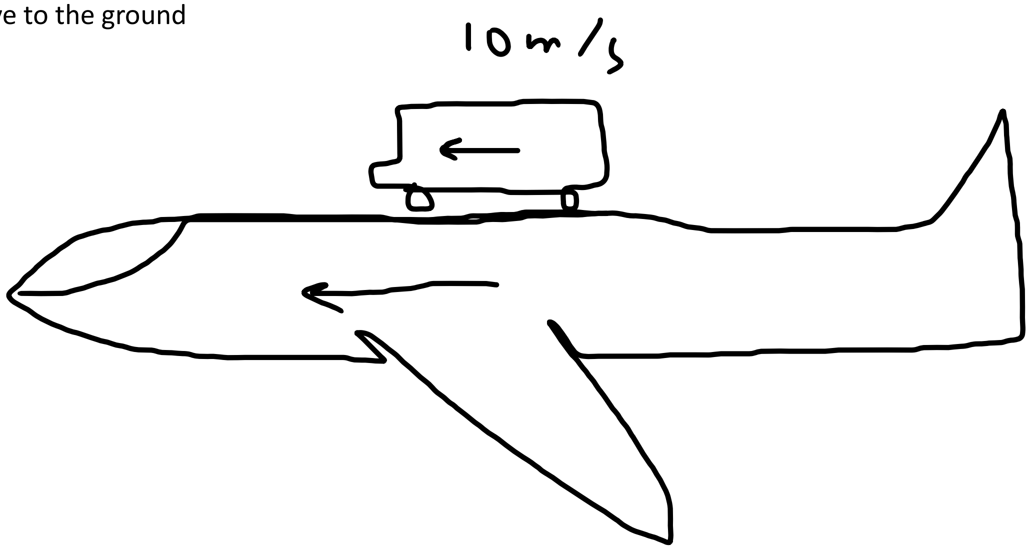
Reference frames

Whenever you’re discussing an object’s motion, you need to compare it to something, that something is the reference frame



In this scenario, the reference frame is the ground, and the velocity of the car, 10m/s, is the velocity relative to the ground



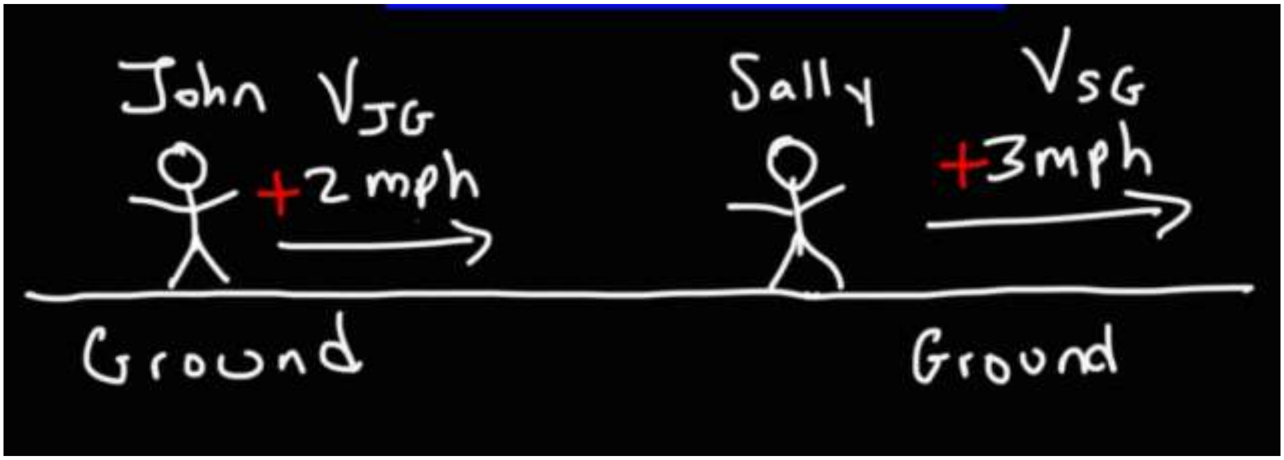
Another scenario, the reference frame is the moving plane, and the velocity of the car, 10m/s, is the velocity relative to the moving plane, as you can see, the car’s real velocity is more than the plane’s velocity, that is why the **relative velocity** of the car is +10, so the car **is moving at a speed of 10m/s** if the plane’s speed was 0

So a reference frame of an object or **reference object**, is if we set the object’s motion to static, what will other objects’ motion look like

Now here is the tricky part

Let’s say you have John moving at +2 mph relative to the ground, his velocity is called $\mathbf{V_{JG}}$

Let’s say you have Sally moving at 3+ mph relative to the ground, her velocity is called $\mathbf{V_{SG}}$



Now what is the velocity for Sally relative to John, or $\mathbf{V_{SJ?}}$

- **Well,** Sally is faster than John
- So every hour, Sally will be farther than John by 1 mi, or in other terms, **she is moving 1mph faster than he is**
- So if john was standing still, sally will be moving at +**1mph**
- So $\mathbf{V_{SJ}}$ **= +1mph**

Now what is the velocity for john relative to sally, or $\mathbf{V_{JS?}}$

- **Well,** john is slower than sally
- So every hour, john will be getting away from sally by 1 mi, or in other terms, **john is moving -1mph faster than sally or 1 mph slower than sally**
- So if sally was standing still, john will be moving at -**1mph**
- So $\mathbf{V_{JS}}$ **= -1mph**

Now this “relativity & reference” can be summarized in two words

Relative velocity

It's the velocity of an object relative to a reference frame, reference object, or another object

We are going to study relative velocity in **1D**

Here it is summarized in a few laws

You have 3 scenarios

Observer is moving in the same direction

Relative velocity = actual velocity - observer velocity

Relative velocity < actual velocity

Observer is moving in the opposite direction

Relative velocity = actual velocity + observer velocity

Relative velocity > actual velocity

Observer is static

Relative velocity = actual velocity

When we have two objects moving at opposite direction and have a space between them, how to calculate the time?
(1) get the relative velocity
(2) distance / relative velocity = time
if you want to get the space then

Relative velocity x time = space

when he gives you trains, lets say 1 and 2, if he said

- 1 catches 2 -> واحد في ديل التاني

- 1 surpass 2 -> تاني في ديل الاول

TYPES OF QUANTITIES

Scalar Quantities	**Vector Quantities**
A physical quantity that only uses a value with a unit	A physical quantity that uses a value with a unit and direction
It has no direction	It has a direction
Mass – length – time – density – temperature	Displacement – velocity - acceleration
Mass = 50 kg	Displacement = 50 m, east

Velocity is a vector, which means that when velocity is in positive

- **If it is a reference frame** -> it is moving in the positive set direction
- **If it is not a reference frame & reference frame is moving**-> it is moving in the same direction as the reference frame
- **If it is not a reference frame & reference frame is static**-> it is moving in the positive set direction

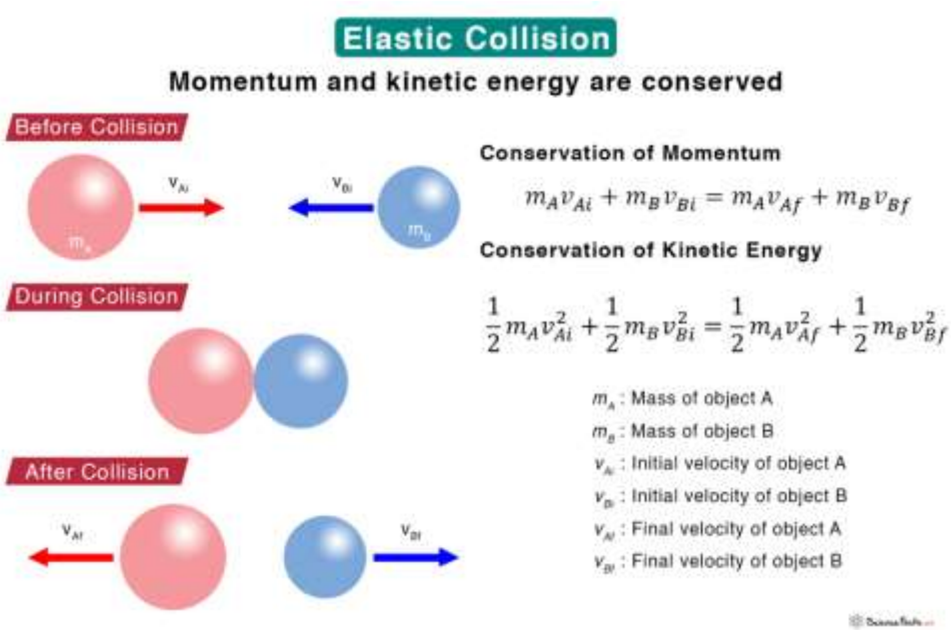
when velocity is in negative

- **If it is a reference frame** -> it is moving in the opposite direction of a positive set direction
- **If it is not a reference frame & reference frame is moving**-> it is moving in the opposite direction as the reference frame
- **If it is not a reference frame & reference frame is static**-> it is moving in the opposite direction of a positive set direction

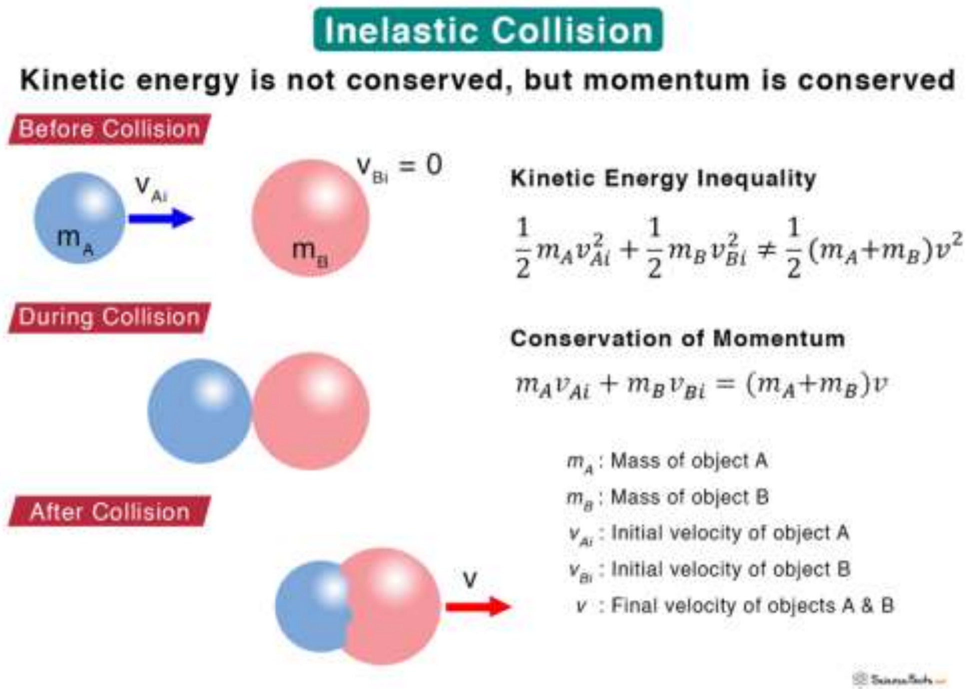
COLLISIONS

They are a short interaction between two or more bodies for a short period of time

It has two types



$$u_1 + v_1 = v_2 + u_2$$



If colliding bodies stick together and move as a single body after collision, then the collision is said to be *perfectly inelastic collision*. In such collision, momentum of the system remains conserved, but the loss of kinetic energy is maximum. Ex. A bullet fired into a wooden block and remains embedded in it.

PERFECTLY INELASTIC COLLISION IN 1-D

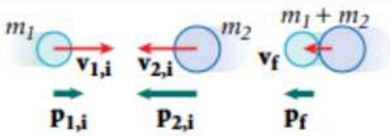
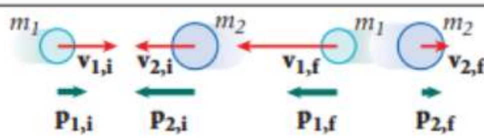
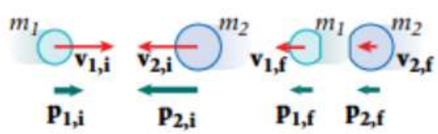
Consider two bodies of masses m_1 and m_2 moving with velocities u_1 and u_2 along a straight line. They make perfectly inelastic collision. Let after collision, their common velocity becomes v, then by conservation of momentum, we have

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

$$v = \left[\frac{m_1u_1 + m_2u_2}{m_1 + m_2}\right].$$

Aka, **perfectly inelastic collision** is when an object collides with another object and joins it

Table 2 Types of Collisions

Type of collision	Diagram	What happens	Conserved quantity
perfectly inelastic		The two objects stick together after the collision so that their final velocities are the same.	momentum
elastic		The two objects bounce after the collision so that they move separately.	momentum kinetic energy
inelastic		The two objects deform during the collision so that the total kinetic energy decreases, but the objects move separately after the collision.	momentum