Inertial and Non Inertial Frames of Reference

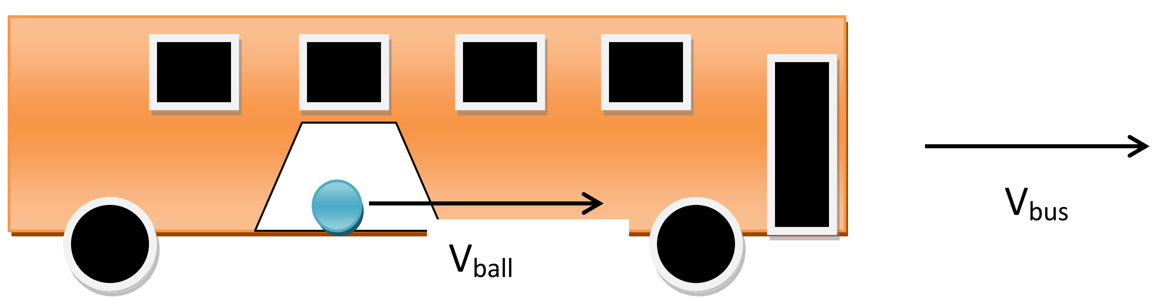
Inertia – resistance of an object to change its state of motion

Inertial Frame of Reference

- Non accelerating
- Newton's 1st law and other laws of physics are valid

For example:

Inside a bus moving at constant velocity with a ball inside

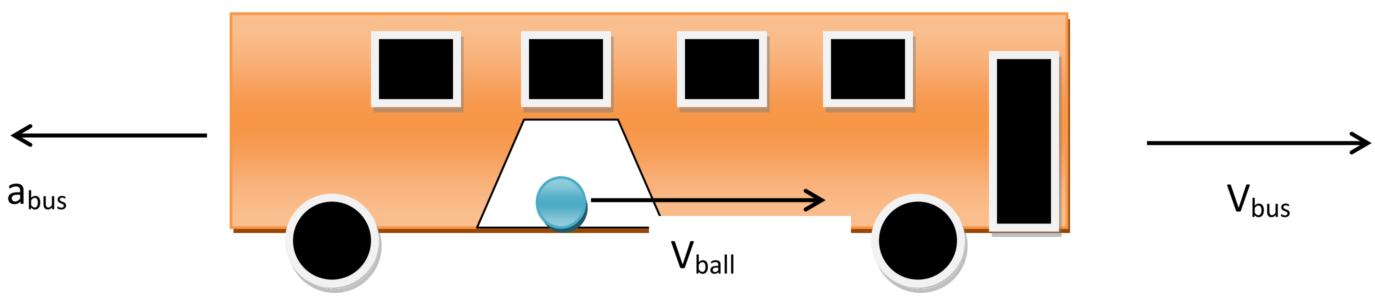


Non-inertial Frame of Reference

- Accelerating
- Newton's 1st law does not hold

For example:

If you are in the bus when it starts to slow down (accelerating backward) the ball seems to be accelerating forward inside the bus. No external force has acted on the ball so how can it be accelerating?



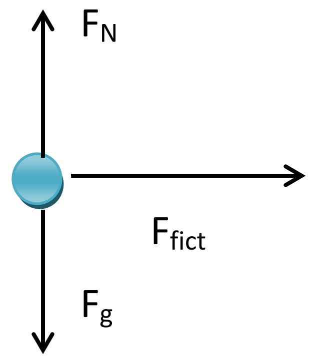
There appears to be an external force because we see it from an accelerated frame of reference inside the bus (non inertial frame).

From an inertial frame (such as the ground)

- The bus will slow down
- The ball inside the bus will continue to move at a constant velocity (as explained by Newton's 1st Law)

To explain the motion observed in non-inertial frames we can invent fictitious forces.

For the ball inside the bus as it slows down:

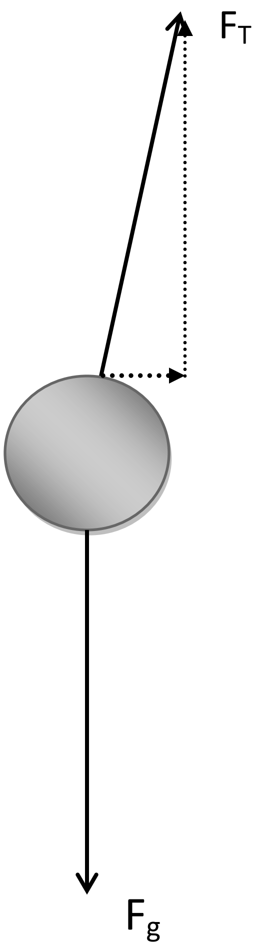


Or we examine the motion from an inertial frame.

Example Problem:

Disco Stu has a miniature disco ball hanging from his rear view mirror. As he slows down for a red light the cord holding the disco ball makes an angle of 10 degrees from the vertical. Determine magnitude of the acceleration of Disco Stu's funky fun mobile.

FBD



$\sum F_y = 0 \Rightarrow F_T\cos\theta - F_g = 0$

$$F_T = \frac{mg}{\cos\theta}$$

$\sum F_x = ma_x \Rightarrow F_T\sin\theta = ma_x$

$$a_x = \frac{F_T \sin\theta}{m}$$

Now sub in $F_T = \frac{mg}{\cos\theta}$

$$a_x = \frac{mg}{\cos\theta}\frac{\sin\theta}{m}$$

$$a_x = g\left(\frac{\sin\theta}{\cos\theta}\right)$$

$$a_x = g(\tan\theta)$$

$$a_x = 9.8(\tan 10)$$

$$a_x = 1.72\ m/s^2$$