Lecture 6, Sep 22, 2021

Collisions and Inertia

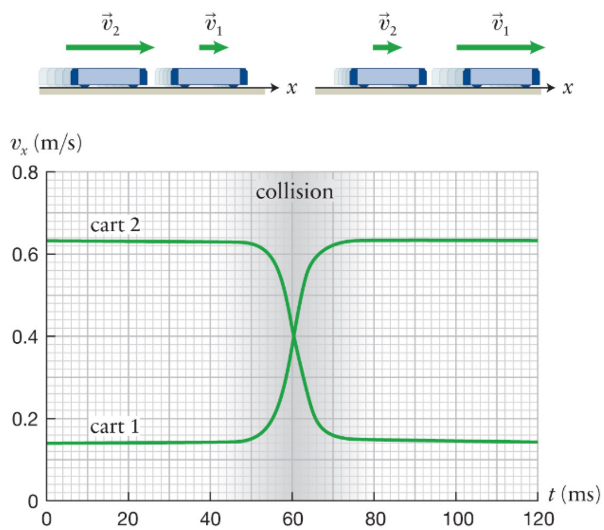

Figure 1: colliding carts

- Consider two identical carts on an airtrack undergoing elastic collision; in an ideal work the two carts will always exchange speeds, regardless of their initial speeds
- If one cart is twice as heavy as the other, after the collision the lighter cart will lose twice as much speed as the heavier cart (possibly reversing)
- From this we can observe that inertia is proportional to the mass of the cart; we can also determine the inertia of an object by colliding it with a known mass
  - The ratio of the velocity changes is the inverse ratio of the masses; e.g. if object 2 had a velocity change that is twice as much as object 1, then it is half as massive
- If friction is introduced, the straight parts have a downward slope determined by the friction

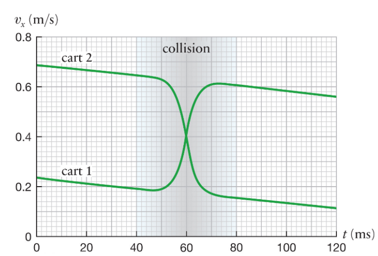

Figure 2: colliding carts with friction

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  - This might differ depending on the type of friction, e.g. kinetic vs viscous friction
- With this we can define inertia: $\frac{m_u}{m_s} \equiv -\frac{\Delta v_{sx}}{\Delta v_{ux}} \implies m_u \equiv -\frac{\Delta v_{sx}}{\Delta v_{ux}} m_s$
  - A one kilogram mass is the inertial standard m_s
  - **Mass is a way to measure inertia/mass is inertia**

Momentum

- We can rearrange the equations to get $m_u\Delta v_u + m_s\Delta v_s = 0$, leading us to define *momentum* as $p_x \equiv mv_x$
- Since $m_u\Delta v_u + m_s\Delta v_s = 0 \implies m_u(v_{uf} - v_{ui}) + m_s(v_{sf} - v_{si}) = 0 \implies m_u v_{ui} + m_s v_{si} = m_u v_{uf} + m_s v_{sf}$, momentum is conserved; change in momentum of s is balanced by change in momentum of u
  - $\Delta p_u + \Delta p_s = 0 \iff p_{ui} + p_{si} = p_{uf} + p_{sf}$
- We can use this formula and go back to the carts before (s is the standard cart, d is the double cart): $\Delta p_s + \Delta p_d = 0 \implies m_s\Delta v_s + m_d\Delta v_d \implies \Delta v_d = -\frac{m_s}{m_d}\Delta v_s = -2\Delta v_s$