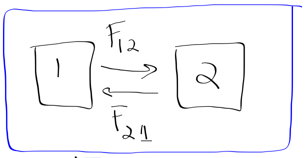
18. A 150-kg astronaut (including space suit) acquires a speed of 2.35 m/s by pushing off with her legs from a 2200-kg space capsule.
   a) What is the change in speed of the space capsule?
   b) If the push lasts 0.200 seconds, what was the average force exerted by each on the other? As the reference frame, use the position of the capsule before the push.

CLEE/WORK:
↳ Something moving, maybe up + down, springs

MOMENTUM/IMPULSE:
↳ "Collisions": Forces that, in a short time, change an object's motion

Momentum: mass/velocities
Impulse: mass/velocity/force/time



system $\Sigma F = \emptyset$ (if there are no other forces)

$$F_{12} + F_{21} = \emptyset = \Sigma F$$

$$\underset{\emptyset}{\Sigma F} = \frac{\Delta p}{\Delta t} = \emptyset \; ; \; \Delta p = \emptyset$$

$$\Delta p_1 + \Delta p_2 = \emptyset$$

astronaut ship

$$\underbrace{m_1 v_1 + m_2 v_2}_{} = m_1 v_1' + m_2 v_2'$$

$$v_1 = v_2 = \emptyset$$

$$\emptyset = m_1 v_1' + m_2 v_2'$$

$$\emptyset = (150)(2.35) + (2200) v_2'$$

(a) $\boxed{v_2' = -0.16 \text{ m/s}}$

(b) $\Sigma F \Delta t = \Delta p$

$$= m_1 v_1' - m_1 v_1$$

$$= (150)(2.35) - \emptyset$$

$$\Sigma F (0.2) = 352.5 \frac{\text{kg} \cdot \text{m}}{\text{s}}$$

(b) $\boxed{\Sigma F = 1762.5 \text{ N}}$

35. A meteor whose mass was about 10^8 kg struck the earth (m = 6.0×10^{24} kg) with a speed of about 15 km/s and came to rest in the earth.

a) What was the earth's recoil speed?

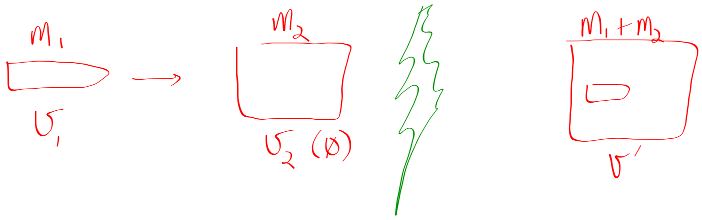
meteor earth same

$$m_1 v_1 + \cancel{m_2 v_2} = m_1 v_1' + m_2 v_2'$$

$$(1e8)(15\,\tfrac{km}{s}) = (m_1 + m_2)v'$$

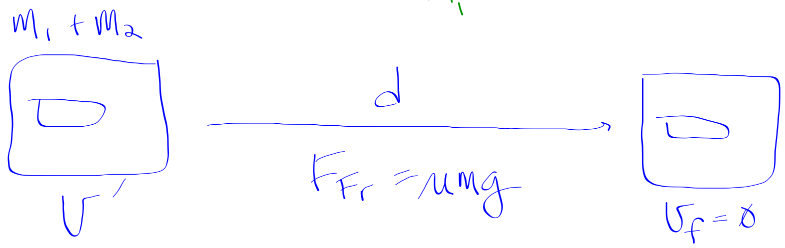
$$v' = \frac{(1e8)15}{(1e8 + 6e24)} = 2.5e^{-16}\,\tfrac{km}{s}$$

7. A 44-g bullet strikes and becomes embedded in a 1.54-kg block of wood placed on a horizontal surface just in front of the gun. If the coefficient of kinetic friction between the block and the surface is 0.28, and the impact drives the block a distance of 18.0 meters before it comes to rest, what was the muzzle speed of the bullet? (Hint: this requires both CLEE and conservation of momentum.)



$$m_1 v_1 + \cancel{m_2 v_2}^{0} = (m_1 + m_2) v'$$

$$v_1 = \frac{(m_1 + m_2)}{m_1} v'$$



$$\frac{1}{2}mv_0^2 + \cancel{mgh_0} + \cancel{\frac{1}{2}kx_0^2} + W_{NC} = \cancel{\frac{1}{2}mv^2} + \cancel{mgh} + \cancel{\frac{1}{2}kx^2}$$

$$\frac{1}{2}mv_0^2 + W_{NC} = 0$$

$$W_{Fr} = -\mu mg \cdot d$$

$$\frac{1}{2}mv_0^2 + -\mu mgd = 0$$

$$\frac{1}{2}(m_1 + m_2)(v')^2 + -\mu(m_1 + m_2)g \cdot d = 0$$

$$v' = \sqrt{\frac{2(+\mu\cancel{(m_1 + m_2)}g \cdot d)}{\cancel{m_1 + m_2}}}$$

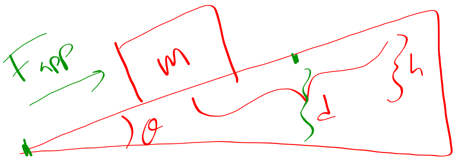
$$v' = \sqrt{2(0.28)(9.8)(18)} = 9.94 \text{ m/s}$$

$$v_1 = \frac{(m_1 + m_2)}{m_1} v'$$

$$= \frac{(0.044 + 1.54)}{(0.044)}(9.94)$$

$$= 357.84 \text{ m/s}$$

2. How much work is required to slide a 4.0 kg block 6.0 m up a 31-degree incline whose coefficient of friction is 0.1? [141 J]



$h = d \sin\theta$

$F_{fr} = \mu mg \cos\theta$

$W_{NC} = mgh$

$[F_{app} \cdot d]$

$W_{app} + {}^{-}\mu mg \cos\theta \cdot d = mgh$