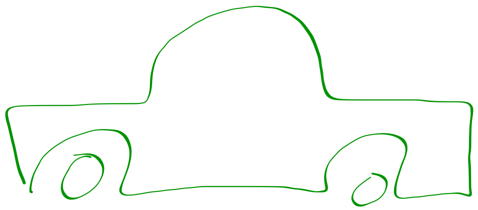
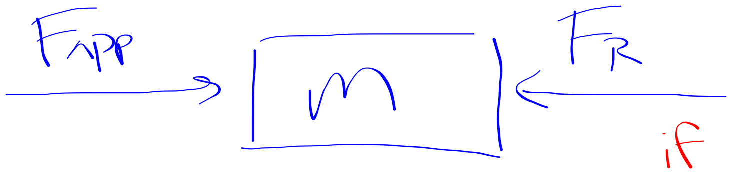
47. If a car generates 15 hp when traveling at a steady 80 km/h, what must be the average force exerted on the car due to friction and air resistance?

15 hp



$\rightarrow 80\ km/h = 22.2\ m/s$

$\xrightarrow{+}$



if constant

$\cancel{\Sigma F = ma}$

$\cancel{W = F \cdot d}$

$P = F \cdot v$

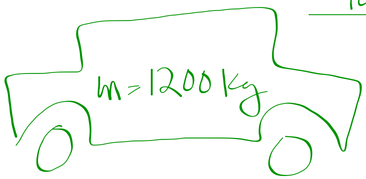
$\Sigma F = \cancel{ma} = 0$

$F_{app} - F_R = 0$

$F_{app} = \boxed{F_R}$

$F_{app} = P/v = \frac{(15)(750)}{22.2} = 506.8\ N$

51. A 1200-kg car slows down from 90 km/h to 70 km/h in about 5.0 seconds on the level when it is in neutral. Approximately what power (watts and hp) is needed to keep the car traveling at a constant 80 km/h?



90 km/hr $\rightarrow$ v_0

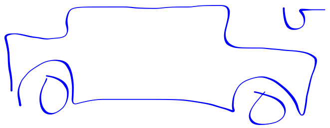
70 km/hr $\rightarrow$ v

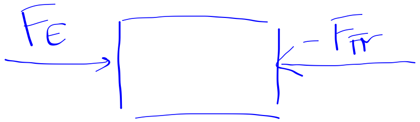
$\Delta t = 5s$

$$a = \frac{v - v_0}{\Delta t}$$

$\Sigma F = ma$ $\qquad -F_{Fr} = ma$ $\qquad \boxed{F_{Fr} = -ma}$

80 km/hr $\rightarrow$ v





$\Sigma F = \cancel{m}a = 0$

$F_E - F_{Fr} = 0$

$F_E = F_{Fr}$

$P = F \cdot v_c$ ← if constant

$= F_E \cdot v_c$

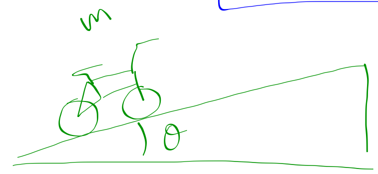
$= \left(-m\left(\frac{v - v_0}{\Delta t}\right)\right) \cdot v_c$

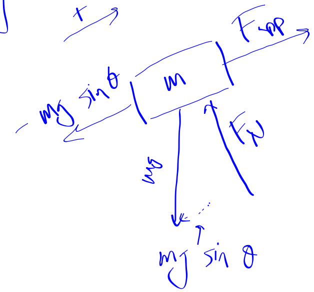
$= \left(-1200\left(\frac{19.4 - 25}{5}\right)\right) 22.2\ m/s$

$= \boxed{29{,}836.8\ W}$

55. How fast must a cyclist climb a 12.5° hill to maintain a power output of 0.23 hp? Ignore friction and assume the mass of the cyclist and bicycle is 85 kg.

$\cancel{P = \frac{W}{t}}$ $\boxed{P = F \cdot v}$





$\boxed{\Sigma F = ma} = 0$

$W = F \cdot d$

$W_{net} = F_{net} \cdot d$

$\boxed{W_{app} = F_{app} \cdot d}$

$\Sigma F = 0$

$-mg\sin\theta + F_{app} = 0$

$F_{app} = mg\sin\theta$

$P = F_{app} \cdot v$ if constant

$(0.23)(750) = (mg\sin\theta)\,v$

$$v = \frac{(0.23)(750)}{(85)(9.8)(\sin 12.5)}$$

$\boxed{= 0.96\ \frac{m}{s}}$

https://www.youtube.com/watch?v=PWhQwU_6w6E

1. When the dog jumps, what happens to the boat? Rotate & move backwards

2. How does the motion of the boat compare to the motion of the dog?

$F = m \cdot a$

same — boat larger ↑ — ↓ boat smaller

There is a term in physics for an object's "bashing power":

MOMENTUM

Momentum: $p = m \cdot v$

Units:

$\frac{kg \cdot m}{s}$ or $\frac{slug \cdot ft}{s}$

Objectives:

Students will understand and be able to describe what momentum is.

Students will be able to relate momentum to Newton's 2nd Law.

Students will understand Conservation of Momentum and be able to use it to solve problems.

Why is the concept of momentum helpful?

$$\sum F = ma \quad , \quad a = \frac{v - v_0}{t} \quad \text{SO:}$$

$$\Sigma F = m\left(\frac{v - v_0}{\Delta t}\right)$$

$$= \frac{mv - mv_0}{\Delta t}$$

change in momentum!

$$\boxed{\Sigma F = \frac{\Delta p}{\Delta t}}$$

Newton's 2nd Law as he thought about it -- in terms of **momentum**

$$\boxed{\sum F = \frac{\Delta p}{\Delta t}}$$ Why is this form useful?

1. What if mass changes? $\sum F = m \cdot a$ ← one mass...

$$\sum F = \frac{P - P_0}{\Delta t}$$ ← two masses...

2. Conservation of Momentum: a Thing (when there are $\boxed{\text{no external forces}}$ acting on a system): $\sum F = \frac{\Delta p}{\Delta t}$

$\boxed{\text{IF } \sum F = \emptyset}$

$$\emptyset = \frac{\Delta p}{\Delta t} \Rightarrow \Delta p = \emptyset$$

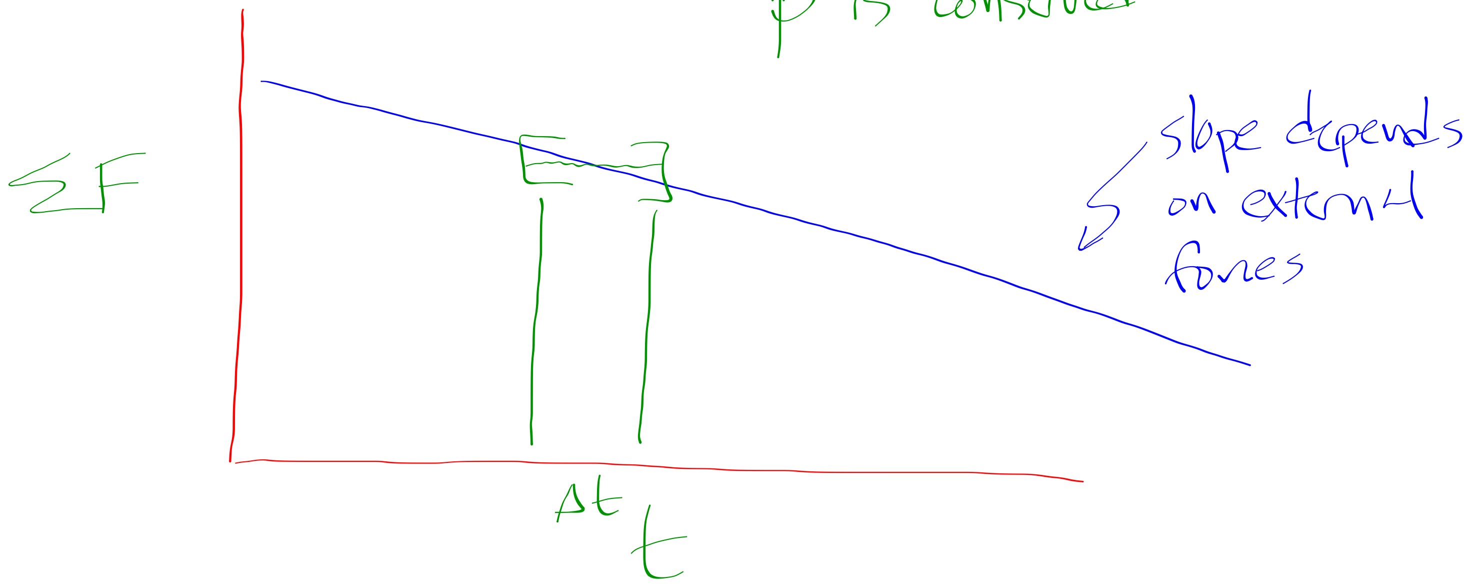
$$mv - mv_0 = \emptyset$$

$$\underbrace{m_1 v_1 + m_2 v_2 + \ldots}_{\text{INITIAL MOMENTUM OF THE SYSTEM}} = \underbrace{m_1' v_1' + m_2' v_2' + \ldots}_{\text{FINAL MOMENTUM OF THE SYSTEM}}$$

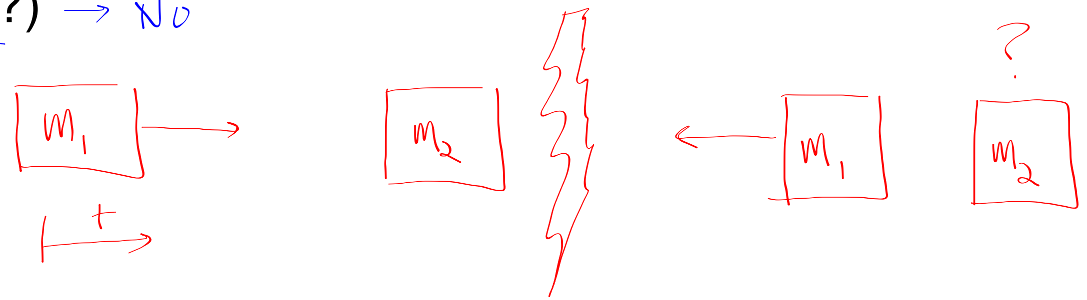
v_1' = FINAL VELOCITY OF OBJECT #1

v_2' = " " " " #2

Reality: if Δt is small,
p is conserved



EXAMPLE #1: A 30-g object gliding at 148 cm/sec across a frictionless surface strikes a 200-g object that is motionless. If the 1st object bounces off the 2nd object so that it is travelling at 80 cm/sec in the opposite direction of its original motion, what is the new velocity of the 2nd object? (Are there external forces?) → No



$$\Delta p = \emptyset$$

$$p_0 = p$$

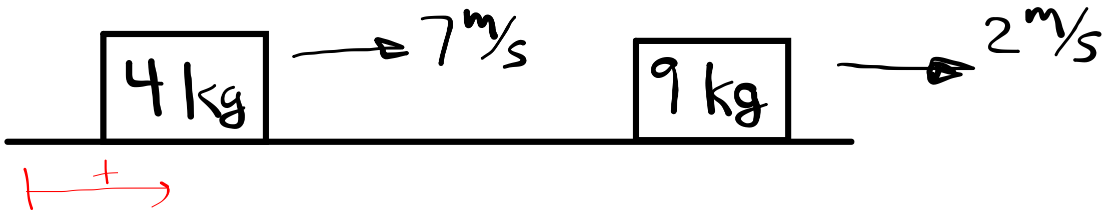
$$m_1 v_1 + \cancel{m_2 v_2} = m_1 v_1' + m_2 v_2'$$

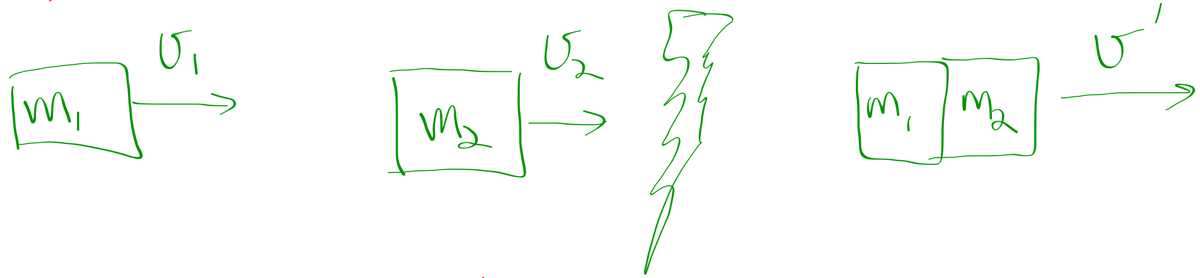
$$(30)(148) = (30)(-80) + (200) v_2'$$

$$v_2 = \frac{(30)(148) + (30)(80)}{200}$$

$$\boxed{v_2 = 34.2 \ \frac{cm}{s}}$$

EXAMPLE 2: These two objects collide and stick together, what is their final speed? (Are there external forces?)





$$\Delta p = 0$$

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v'$$

$$v' = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} = \frac{(4)(7) + (9)(2)}{(4+9)}$$

$$\boxed{v' = 3.54 \text{ m/s}}$$

EXAMPLE #3: The person and ship are initially motionless. If the person jumps off horizontally at 5 m/s to the right. What will the ship do? (Are there external forces?)

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

v_1 & v_2 both $\emptyset$!

$(1.8e7)(v_1') + (80)(5) = \emptyset$

$v_1' = -2.2e^{-5}$ m/s (negative - the boat will move in the opposite direction!)