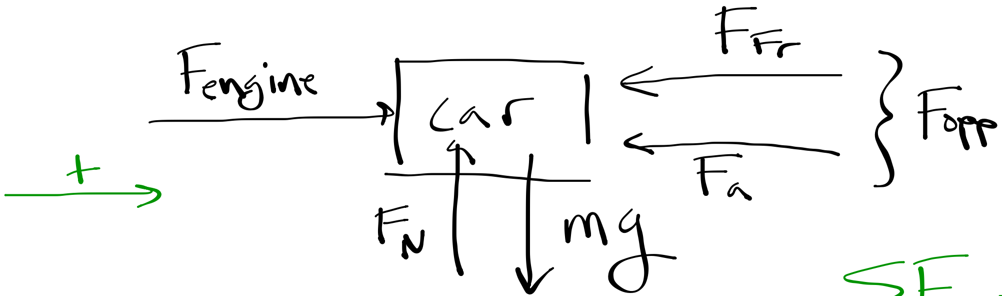
47. If a car generates 15 hp when traveling at a steady 80 km/h, what must be the average force exerted on the car due to friction and air resistance?

$$P = 15\,hp \cdot \frac{750\,W}{hp} = 11{,}250\,W$$

$$80\,\frac{km}{hr} \cdot \frac{1000\,m}{km} \cdot \frac{hr}{3600\,s} = 22.2\,m/s$$



$$\sum F_x = m\cancel{a}^{\,0}$$

$$\sum F_x = F_{opp} + F_{engine} = 0$$

$$P_{engine} = \frac{W}{t} = \frac{F \cdot d}{t}$$

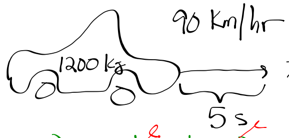
$$11250 = F \cdot v = F \cdot 22.2$$

$$F_{engine} = 507\ N$$

$$F_{opp} + 507\,N = 0$$

$$\boxed{F_{opp} = -507\,N}$$

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?



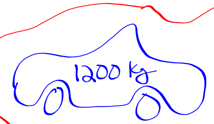
$90\ \text{km/hr} \cdot \frac{1000\ \text{m}}{\text{km}} \cdot \frac{1\ \text{hr}}{3600\ \text{s}} = 25\ \text{m/s}$

$70\ \frac{\text{km}}{\text{hr}} = 19.4\ \text{m/s}$

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

$$\frac{1}{2}(1200)(25)^2 + W_{NC} = \frac{1}{2}(1200)(19.4)^2$$

$$W_{Fr} = W_{NC} = -149{,}184\ \text{J}$$



$\frac{80\ \text{km}}{\text{hr}} = 22.2\ \text{m/s}$

$W_{NC} = 0\ \text{J}$

$F_{eng} \rightarrow \boxed{1200\ \text{kg}} \leftarrow F_{Fr}$

$\Sigma F_x = m\cancel{a}^{0} = 0$

$$F_{eng} = -F_{Fr}$$

$$F_{eng} \cdot d = -F_{Fr} \cdot d$$

$$\frac{F_{eng} \cdot d}{t} = -\boxed{\frac{F_{Fr} \cdot d}{t}}$$

$$\frac{W_{Fr}}{t} = \frac{-150{,}000\ \text{J}}{t} = \frac{F_{Fr} \cdot d}{t}$$

$$P_{Fr} = \frac{-150{,}000\ \text{J}}{5\ \text{s}} = -30{,}000\ \text{W} = \boxed{\frac{F_{Fr} \cdot d}{t}}$$

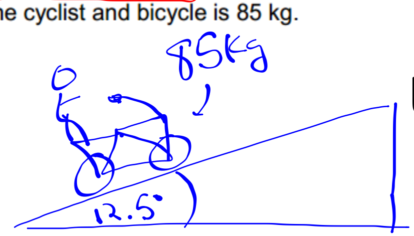
$\frac{F_{eng} \cdot \boxed{d}}{\boxed{t}} = \frac{F_{eng} \cdot v}{} = 30{,}000\ \text{W}$, $\frac{d}{t} = v$ (if v = constant)

$$P_{eng} = F_{eng} \cdot v = \boxed{30{,}000\ \text{W}}$$

$$F_{eng} \cdot 22.2\ \text{m/s} = 30{,}000\ \text{W}$$

$$F_{eng} = 1351\ \text{N}$$

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.

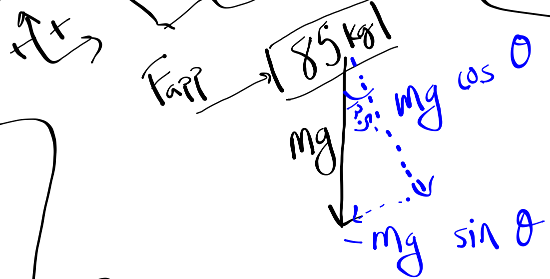


$$P = 0.23\,hp \cdot \frac{750\,W}{hp} = 172.5\,W$$

→ if v is constant

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

$$\boxed{P = F \cdot v}$$



$$\Sigma F_x = m a_x = 0$$

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

$$F_{app} = (85)(9.8)(\sin 12.5) = 180.3\,N$$

$$172.5\,W = 180.3\,N \cdot v$$

$$\boxed{v = 0.96\,m/s}$$

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

MOMENTUM

Momentum: $\vec{p} = m\vec{v}$ $\left(kg \cdot \frac{m}{s}\right)$ OR $\left(SLUG \frac{ft}{s}\right)$

momentum K.E.

mv $\frac{1}{2}mv^2$

Why is the concept of momentum helpful?

$$\Sigma F = ma$$

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

So $\Sigma F = m\left(\frac{v - v_0}{\Delta t}\right) = \frac{mv - mv_0}{\Delta t} = \frac{p - p_0}{\Delta t}$

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

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

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

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

1. Cases of changing mass can be considered. (F = ma is not helpful if mass is changing ...)

2. Momentum is conserved ($p_o = p_f$) when the sum of all forces acting on an object/system is zero. This gives us a new equation to use to find masses and/or velocities.

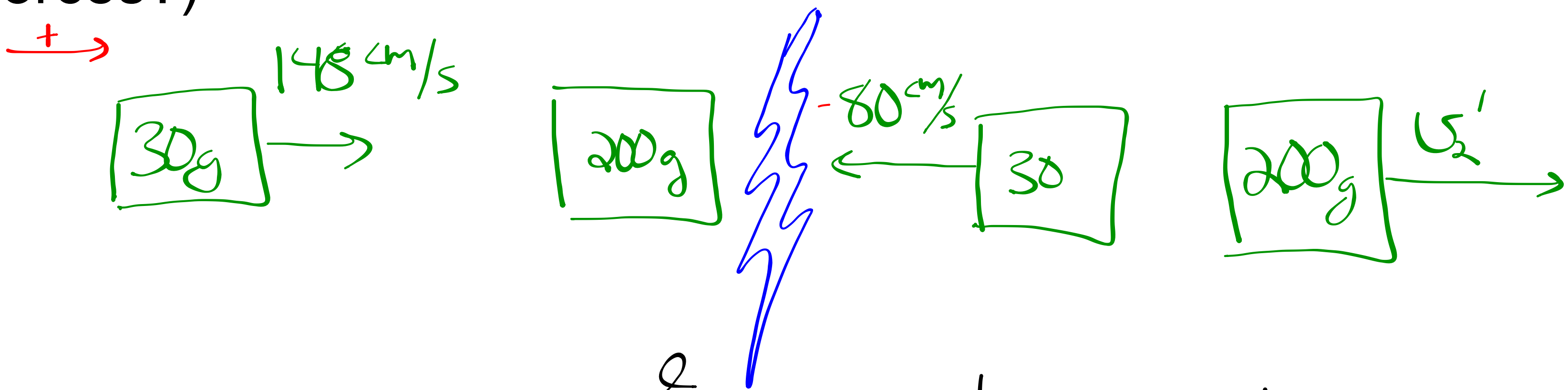
WHEN $\Sigma F = 0$ then $\frac{\Delta p}{\Delta t} = 0$ $\Delta p = 0$

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

v_1' = FINAL VELOCITY OF OBJECT #1

v_2' = " " " " #2

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?)



$$m_1 v_1 + \cancel{m_2 v_2}^{\,0} = m_1 v_1' + m_2 v_2'$$

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

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

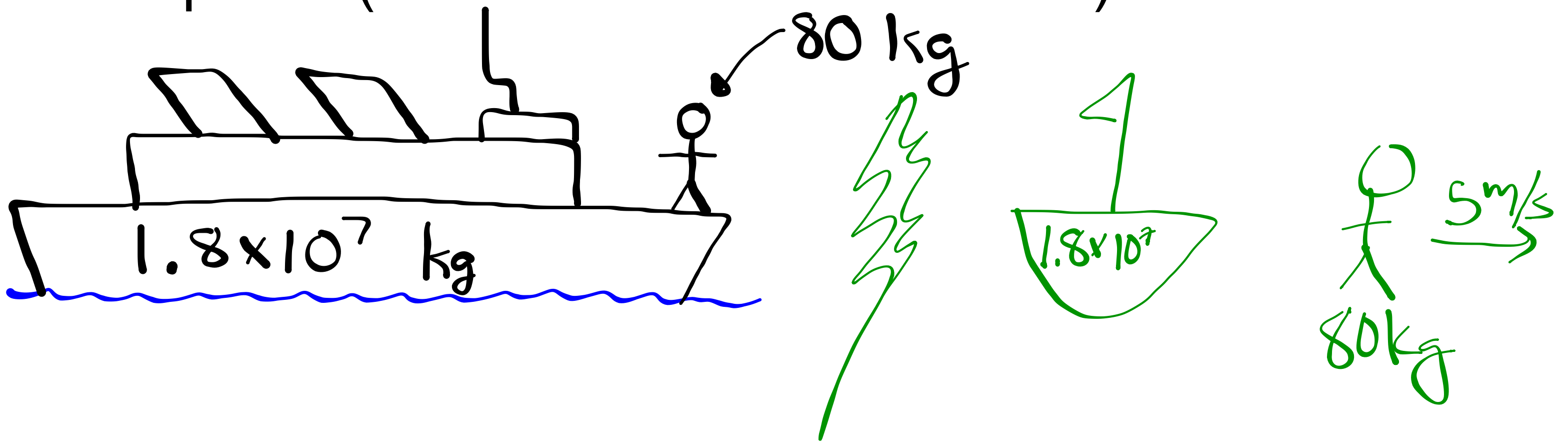
EXAMPLE 2: These two objects collide and stick together, what is their final speed? (Are there external forces?)

$$m_1v_1 + m_2v_2 = m'v'$$

$$(4)(7) + (9)(2) = (13)v'$$

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

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?)



$$mv = m_1 v_1' + m_2 v_2'$$

$$0 = (1.8\times10^7)v_1' + (80)(5)$$

$$v_1' = 2.2\times10^{-5} \text{ m/s}$$