Force diagrams (review) draw only forces on isolated object (i.e., not the pairs which act on the other object)

Vertical: \( W = N_R + N_F \) (Net \( = 0 \))

Horizontal: \( F_R + F_f = F_{air} \) Friction propels car forward!

(Fr and \( F_f \) are not friction force, rolling resistance reduces them a bit.)

Gravity = "action at a distance" (Newton)

Most forces we deal with are "contact forces"
Momentum

Newton's full law of motion actually can accommodate change of mass (rocket!)

\[ F = ma = m \frac{\Delta v}{\Delta t} = \Delta (mv) = \frac{\Delta p}{\Delta t} \]

Momentum \( p = mv \) is a thing that force changes

\[ \rightarrow \text{if net force} \rightarrow \text{net momentum is constant} \]

Examples

- Rock
- Part \( \rightarrow \) Prove

\[ p = 0 \]

\[ \text{Part} + \text{Prove} = 0 \]

\[ \text{Part} = - \text{Prove} \]

equals and opposite

Recall

- Rocket
- Bullet

Fuel

Rockets throw momentum out the nozzle \( \rightarrow \) ship

\[ \text{Fuel} = m v \]

\[ \text{High weight reaction opposite} \]
Centripetal Force & Acceleration

If object in circular motion
=> direction changes
=> velocity changes
=> force present

Formula: \( a = \frac{v^2}{r} \)

radial of circular orbit

\( F = ma = \frac{mv^2}{r} \)

(circular motion)

(rotational speed) \( \omega = \frac{v}{r} \) radians/second

\( a = r\omega^2 \)

\( F = m r \omega^2 \) double speed

by quadrupling force!

Typical forces?

- string (tether)
- strut or chair (carnival ride)
- seat belt/chair/door (car turn)
- friction (car wheels)
- gravity (planets, satellites)

Angular Momentum