Force and more force

- Notice:
  - If anyone wishes to take Physics 121, in Burnaby, during the summer, let me know.

Fan Cart Experiment

Experiment	*acceleration*	*mass*	*force*
Low speed, cart only	$a_{LC} = 0.28\ \text{m/s}^2$	m_C	F_L
Low speed, cart & bar	$a_{LCB} = 0.19\ \text{m/s}^2$	$m_C + m_B$	F_L
High speed, cart only	$a_{LC} = 0.46\ \text{m/s}^2$	m_C	F_H
High speed, cart only	$a_{HCB} = ?\ \text{m/s}^2$	$m_C + m_B$	F_H

Find mass of cart in terms of bar mass.

$$I: \quad F_L = m_C a_{LC}$$

$$II: \quad F_L = (m_C + m_B)\, a_{LCB}$$

therefore

$$m_C a_{LC} = (m_C + m_B)\, a_{LCB}$$

rearranging

$$m_C = \frac{m_B}{(a_{LC}/a_{LCB} - 1)} \quad .$$

Find mass of cart in terms of bar mass.

$$I:\quad F_{\mathrm{L}} = m_{\mathrm{C}}\, a_{\mathrm{LC}}$$

$$II:\quad F_{\mathrm{L}} = (m_{\mathrm{C}} + m_{\mathrm{B}})\, a_{\mathrm{LCB}}$$

therefore

$$m_{\mathrm{C}}\, a_{\mathrm{LC}} = (m_{\mathrm{C}} + m_{\mathrm{B}})\, a_{\mathrm{LCB}}$$

rearranging

$$m_{\mathrm{C}} = \frac{0.25\ \mathrm{kg}}{(0.28/0.19 - 1)}.$$

Find mass of cart in terms of bar mass.

$$F_L = m_C a_{LC}$$

$$F_L = (m_C + m_B)\, a_{LCB}$$

therefore

$$m_C a_{LC} = (m_C + m_B)\, a_{LCB}$$

rearranging

$$m_C = 0.52 \text{ kg} \qquad .$$

also

$$F_L = m_C a_{LC} = 0.52 \text{ kg } (0.28 \text{ m/s}^2) = 0.15 \text{ N}$$

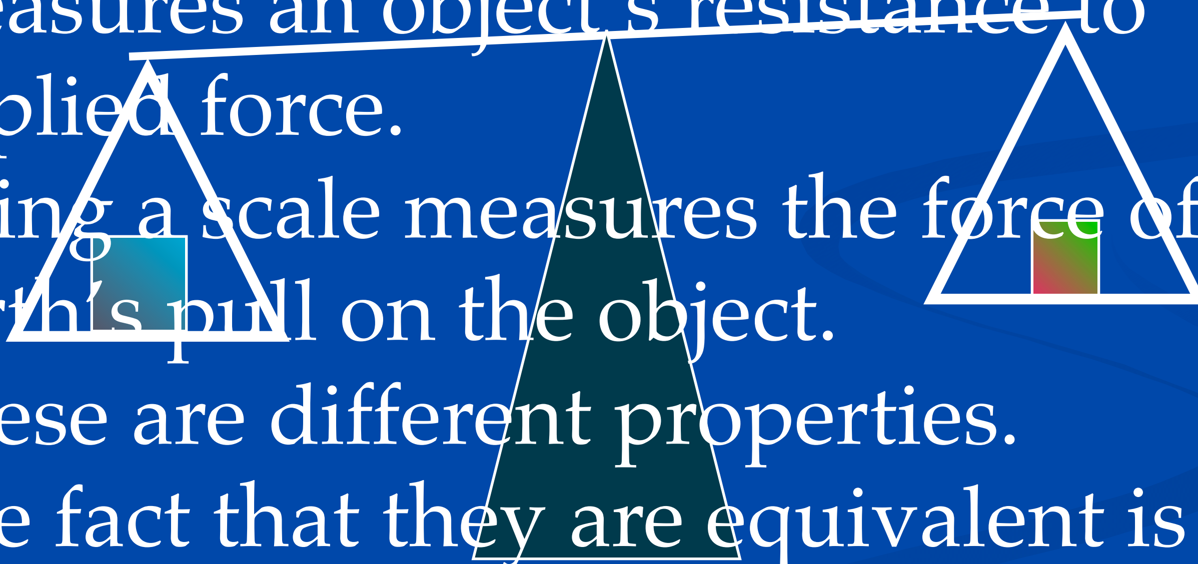
Fan Cart Experiment

Experiment	*acceleration*	*mass*	*force*
Low speed, cart only	$a_{LC} = 0.28\ m/s^2$	0.53 kg	0.15 N
Low speed, cart & bar	$a_{LCB} = 0.19\ m/s^2$	0.78 kg	0.15 N
High speed, cart only	$a_{HC} = 0.47\ m/s^2$	0.53 kg	0.25 N
High speed, cart& bar	$a_{HCB} = ?\ m/s^2$	0.78 kg	0.25 N

predict! $= 0.32\ m/s^2$

Gravitational Mass & Inertial Mass

- The fan cart measurement of mass measures an object's resistance to applied force.
- Using a scale measures the force of earth's pull on the object.
- These are different properties.
- The fact that they are equivalent is found experimentally & is surprising.



Inertial Frames of Reference

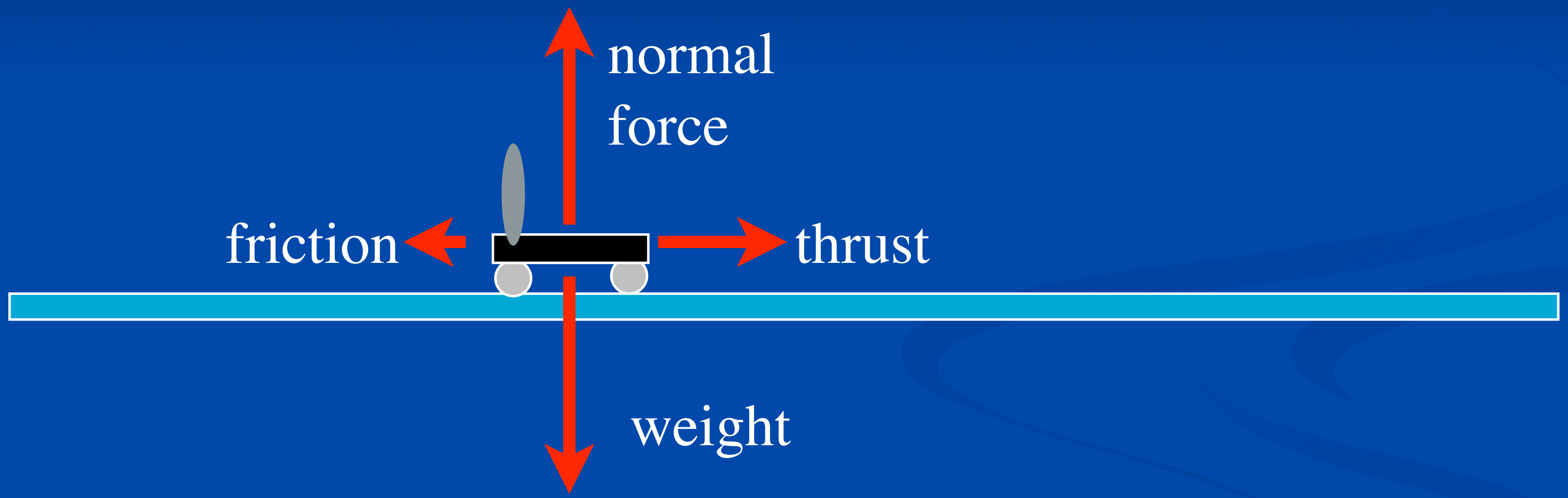
- In an inertial frame of reference…
  - Newton's 1st Law Holds
  - There are no *Fictitious* forces
  - The only force that is proportional to mass is gravity.

- So what? This is a circular argument!
  - If we're in an inertial f.o.r. then Newton 1 is true
  - If Newton 1 is true then we're in an inertial f.o.r.

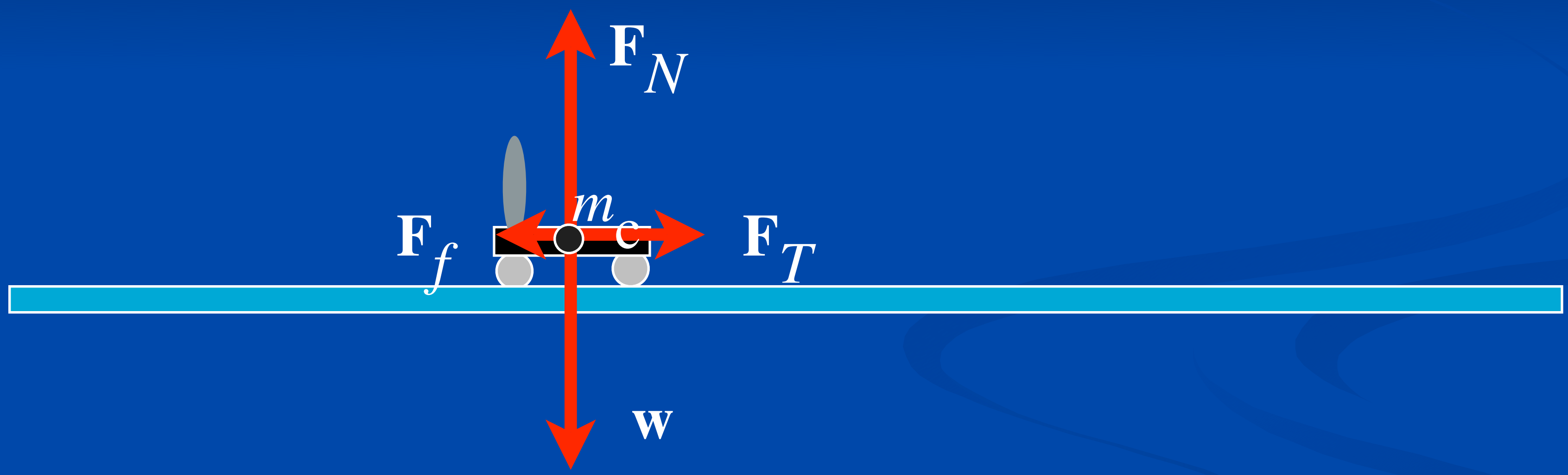
Inertial Frames of Reference

- We can say that Newton's 1st law assures us than inertial frames of reference do exist.
- That is, There are frames of reference where objects travel at uniform velocity if there are no external forces acting on them.

Free Body Diagrams



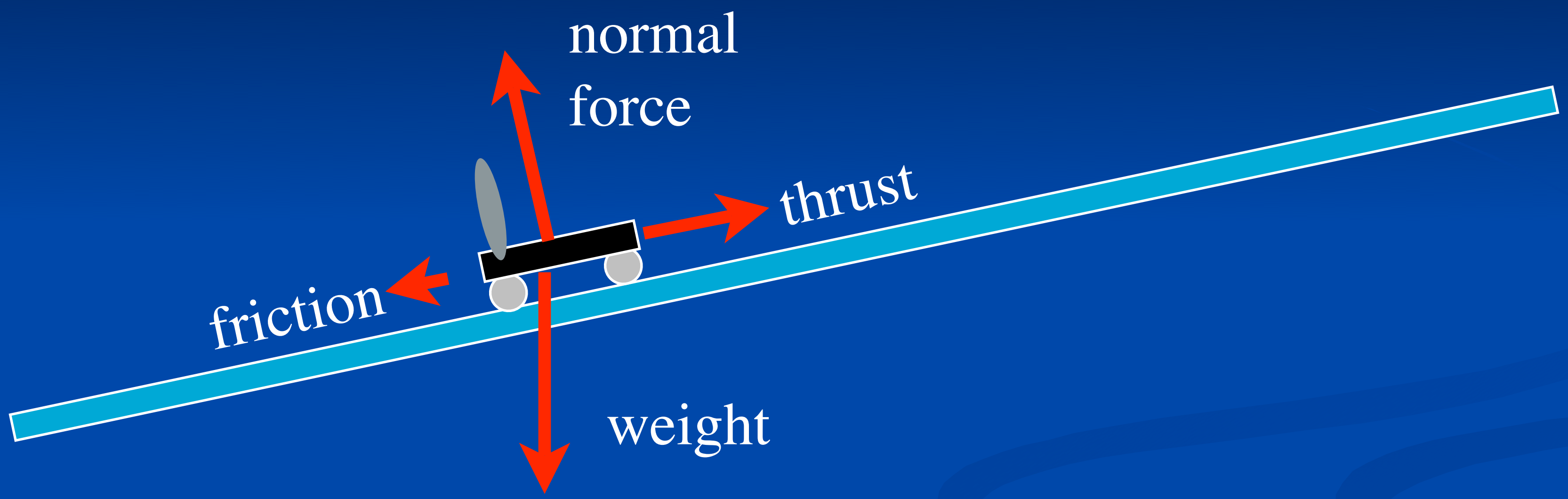
Free Body Diagrams



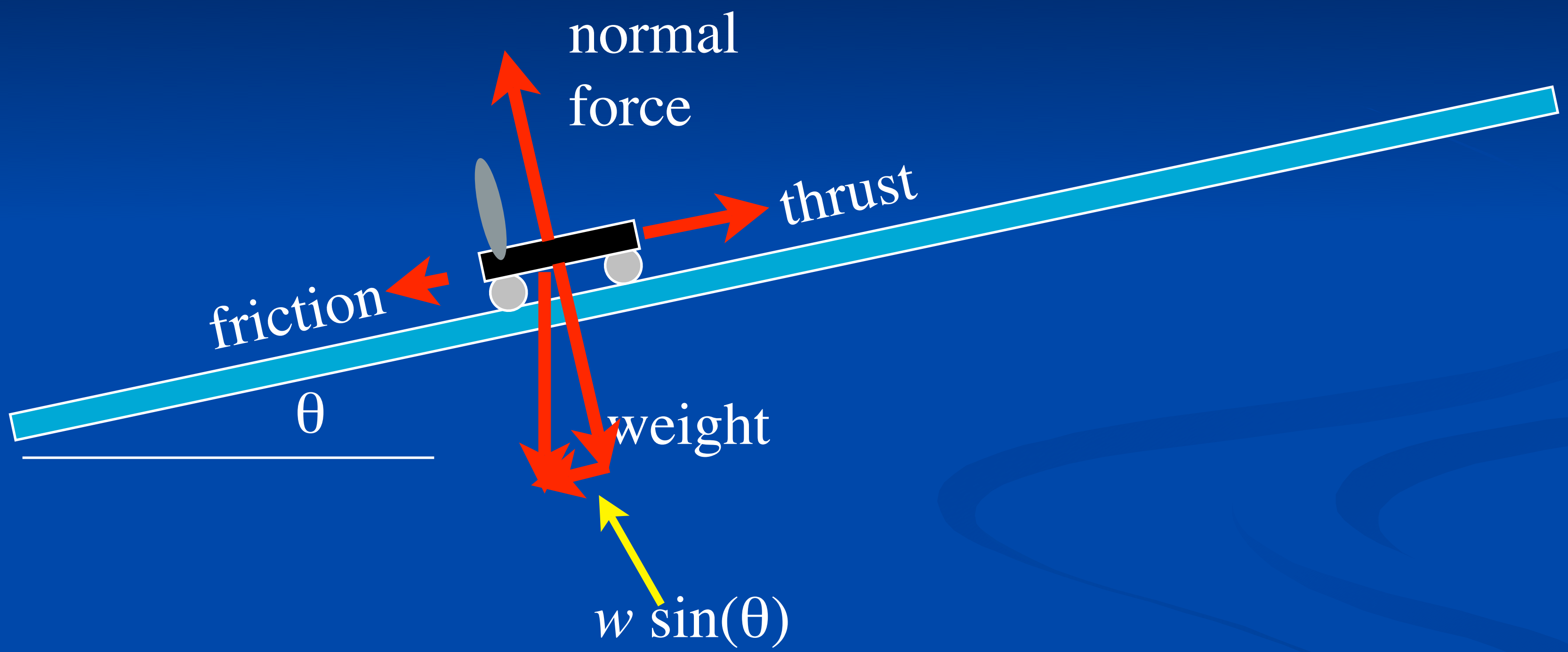
Free Body Diagrams

$$\mathbf{a}_c = \mathbf{F}_{net} / m_c$$

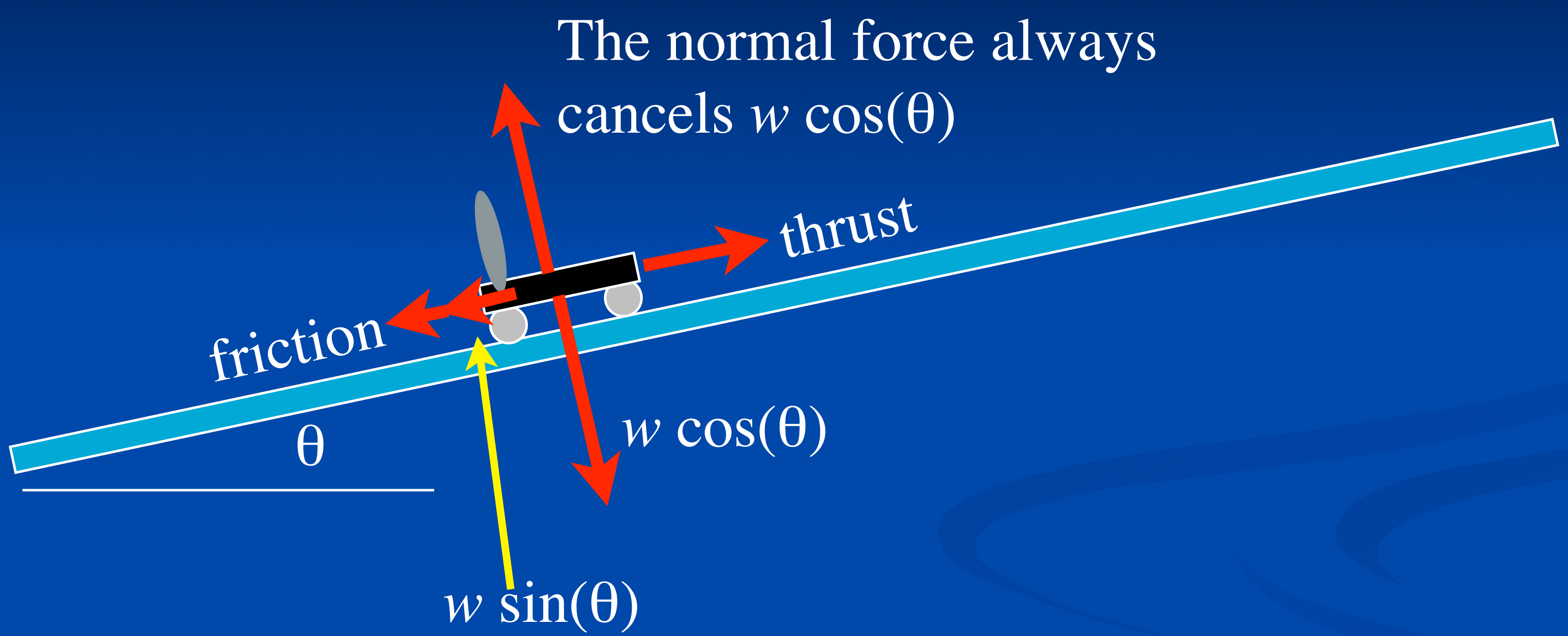
Free Body Diagrams



Free Body Diagrams



Free Body Diagrams



- What angle gives static equilibrium?
  - low speed & high speed
  - Assume friction = 0
  - Does friction cause θ to increase or decrease?

What angle gives equilibrium?

- Predictions
  - Low speed: 1.67°
  - High speed: 2.81°
- Measured
  - Low speed: 2.06°
  - High speed: 3.44°
- Why?
  - When accelerating friction is significant
  - At equilibrium , friction is negligible
    - Thrust was under-estimated.