Chapter 4: Force and Motion
Thursday January 29th

- Review: Newton's 2nd law
  - Free body diagrams and net force
  - Normal/contact forces and weight
- Review: Newton's 3nd law
- Tension force as an example of the 3rd law
- Lots of example problems
- Introduction to friction (if time)

Reading: up to page 62 in the text book (Ch. 4)

Newton's second law

Newton's definition: *"The rate at which a body's momentum changes is equal to the net force acting on the body"*

The more familiar version:

$$\boxed{\vec{F}_{\text{net}} = m\vec{a}}$$

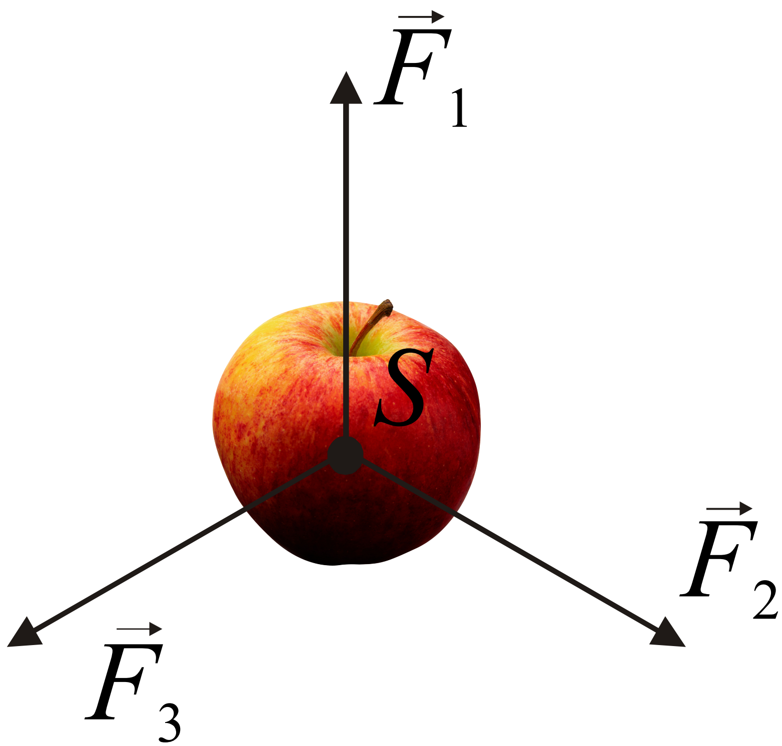
Note that Newton's 2nd law includes the 1st law as a special case ($F = 0$).

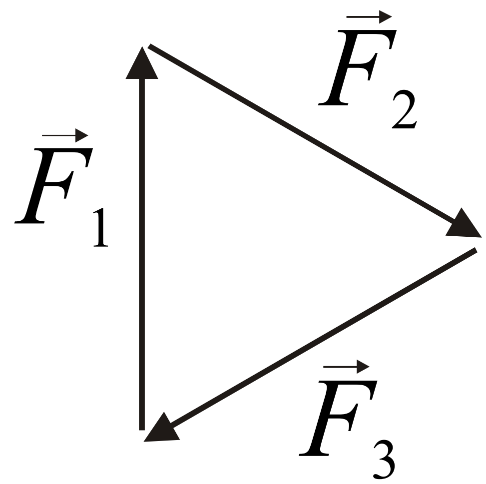
- We may treat the components separately.

$$F_{\text{net},x} = ma_x, \qquad F_{\text{net},y} = ma_y, \qquad F_{\text{net},z} = ma_z$$

- The mass, m, is a scalar quantity.
- $1\ \text{N} = (1\ \text{kg})(1\ \text{m.s}^{-2}) = 1\ \text{kg.m.s}^{-2}$

Free-body diagrams





$$\sum \vec{F} = 0 = \vec{a}$$

The 'net' force equals zero

- The forces shown above are what we call "external forces."
- They act on the "system" *S*.
- *S* may represent a single object, or a system of rigidly connected objects. We do not include the internal forces which make the system rigid in our free body diagram.

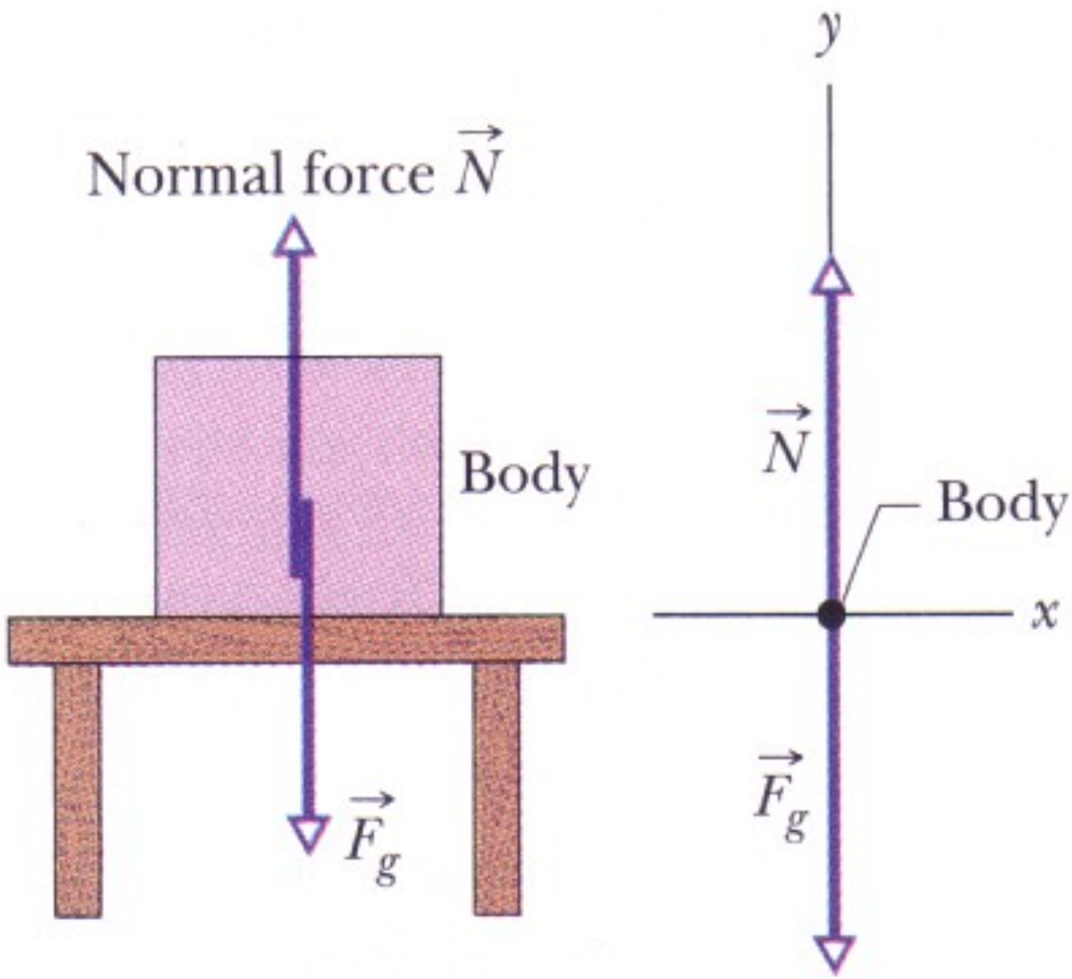
Gravitational Force

During free fall $$|\vec{a}| = g$$

$$\Rightarrow \qquad F = ma = mg$$ downward

- This is always true at the surface of the earth.
- Even when a mass is stationary, e.g., on the surface of a table, gravity still acts downwards with a magnitude equal to mg.
- This leads to the concepts of a **weight** ($= mg$) and **normal force**.

Weight and Normal Force



- The internal forces within the table supply a **normal force**, which is directed normal to the surface of the table, i.e., up.
- If the body remains stationary, then the normal force must be equal in magnitude (opposite in direction) to the **weight**.

Weight (a force!):

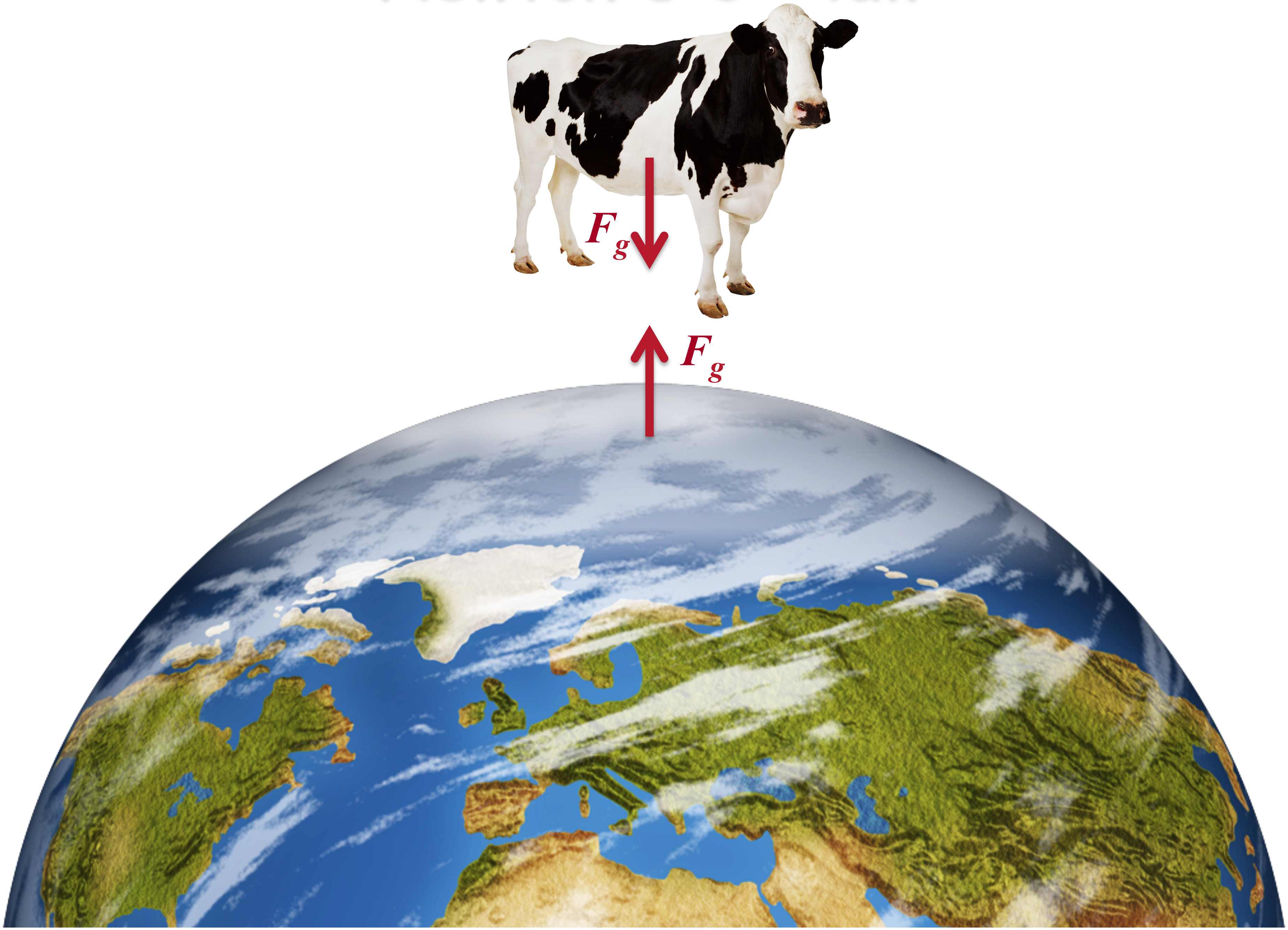
$$N = W = F_g = mg \text{ Newtons (N)}$$

Newton's 3rd law

If object **A** exerts a force on object **B**, then object **B** exerts an oppositely directed force of equal magnitude on object **A**.

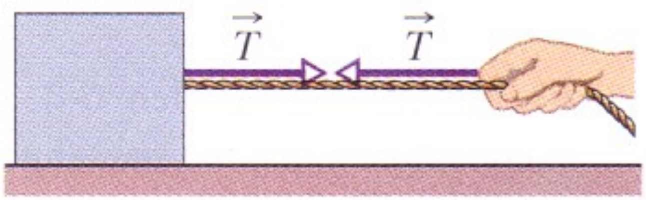
For every **"action"** force, there is always an equal and opposite **"reaction"** force; we call these a **"third-law force pair."**

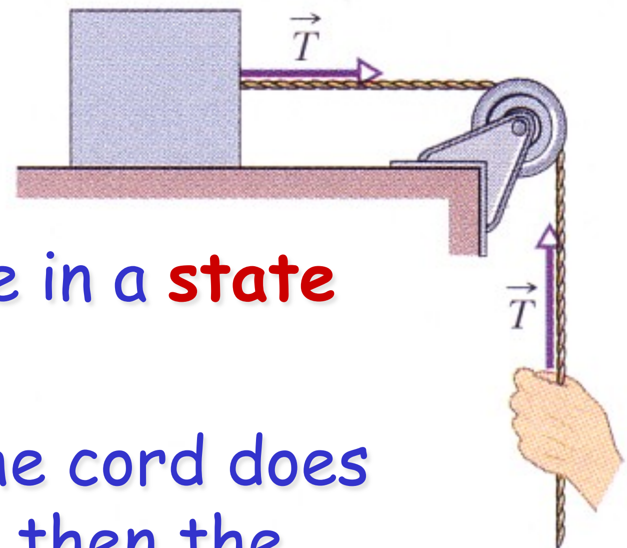
Newton's 3rd law

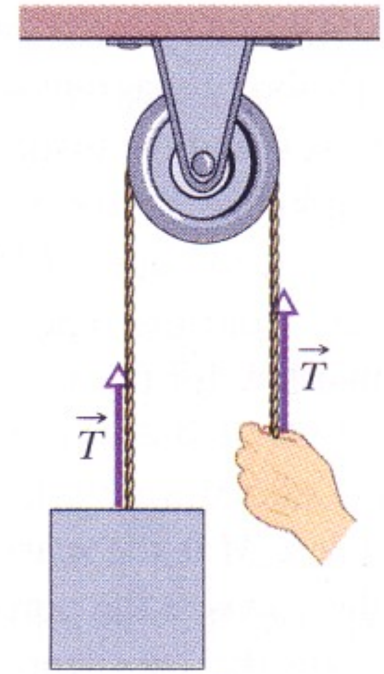


Newton's 3rd law

Tension



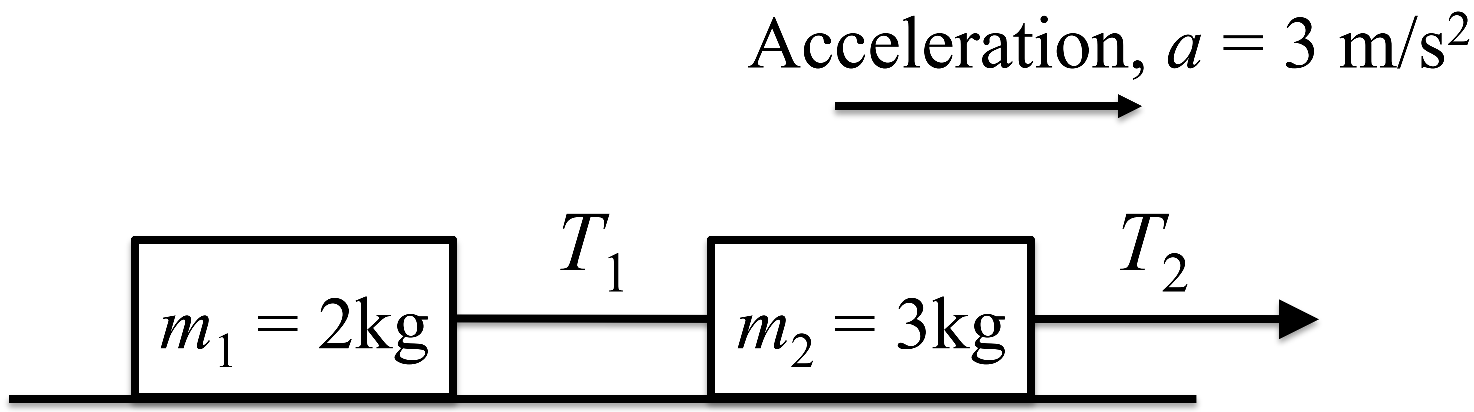




- A **taut cord** is said to be in a **state of tension**.
- If the body pulling on the cord does so with a force of 50 N, then the tension in the cord is 50 N.
- A taut cord pulls on objects at either end with equal and opposite force equal to the tension (Newton's 3rd law).
- Cords are massless, pulleys are massless and frictionless

Frictionless Horizontal Plane

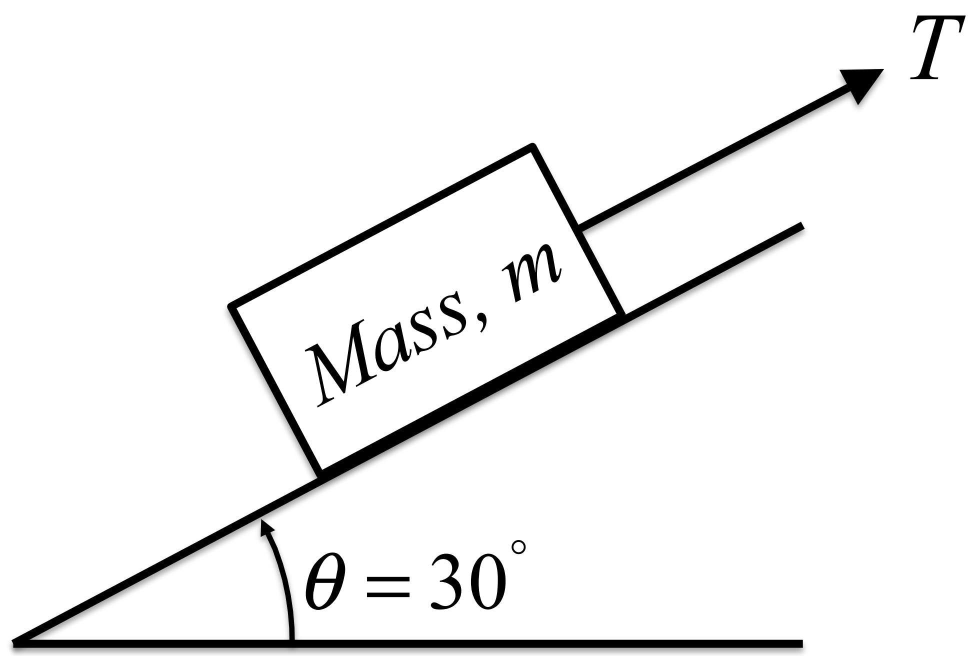
What are the tensions, T_1 and T_2?



We will deal with friction next week

Frictionless Inclined Plane

1. What is the tension, T, if the mass is static?
2. What is the acceleration if the tension, $T = 0$?



Frictionless Inclined Plane

1. What is the acceleration if $m = 5$ kg?
2. What is the acceleration if $m = 6$ kg?
3. What is the acceleration if $m = 4$ kg?