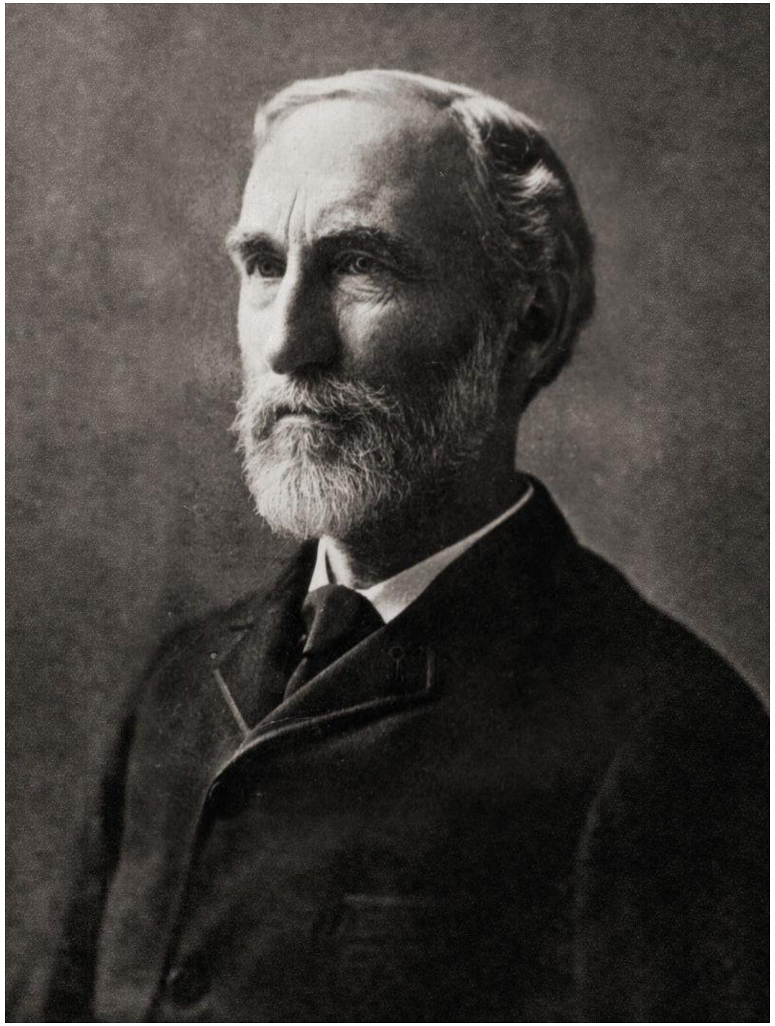
SQUARECAP

Discuss and Answer/Comment:

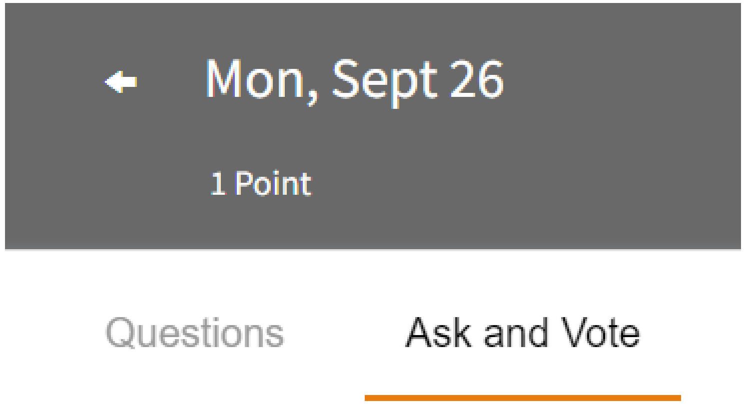
Who's a favorite scientist of yours, or one you identify with or are inspired by?

Josiah Willard Gibbs

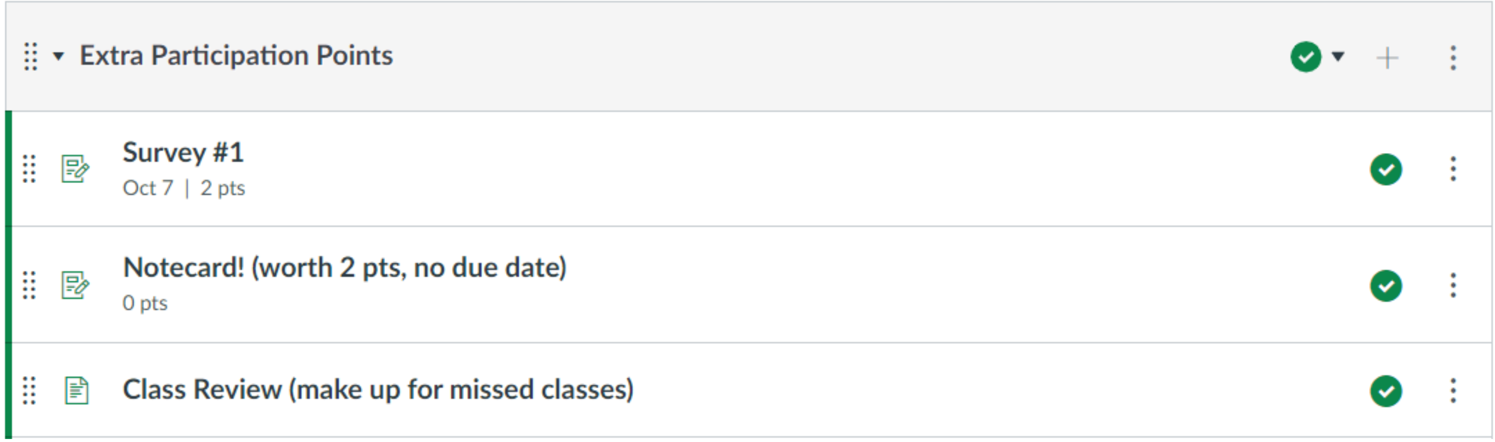
- First PhD in Engineering in America (Yale 1863)
- First paper at 34 years old
- Along with Boltzmann and Maxwell led the development of *statistical mechanics*
- A. Einstein: "*the greatest mind in American history*."
- Not proportionally well-known



Note: Ask and Vote

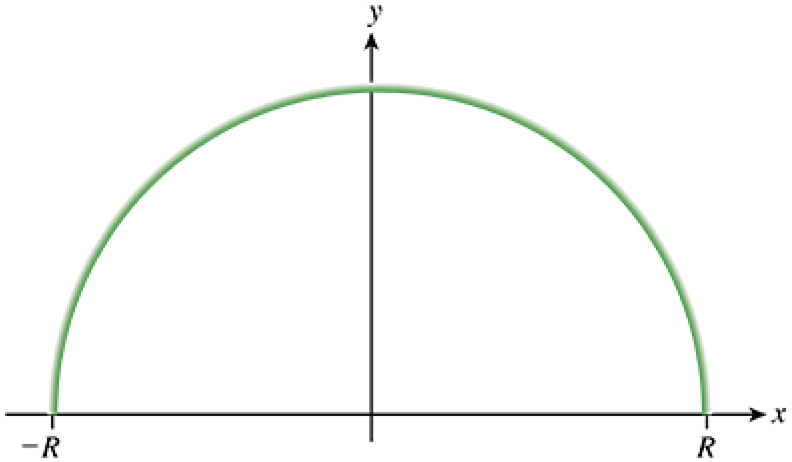


Participation Points: Survey #1 (Remember – 20% of grade!)



Homework Due Today – Drop-In Hours 4pm

Recap: Center of Mass



Statics, Friction, and Linear Elasticity

$x_{com} = \frac{1}{m}\int \rho dx$ $\qquad$ $\sigma_{stress} = F/A$

$\sum \vec{F} = 0$ $\qquad$ $\sum \vec{\tau} = 0$

$\tau = \vec{r} \times \vec{F}$ $\qquad$ $F_W = mg$ $\qquad$ $F_B = \rho g V$

$F_{static} \leq \mu_s N$ $\qquad$ $F = -k\Delta X$

$Y = \frac{F/A}{\Delta L/L}$ $\qquad$ $B = \frac{\Delta P}{\Delta V/V}$ $\qquad$ $S = \frac{F/A}{\Delta x/l}$

Problem 20: A thin wire is bent into a semicircle of radius *R*. As shown in the diagram, its center is at the origin and the two ends of the wire are on the *x* axis at $x = R$ and $x = -R$. Write an expression for the y coordinate of the center of mass of the wire.

$$\vec{x}_{cm} = \int \vec{x}\, dm = \int \vec{x} \rho\, dV$$

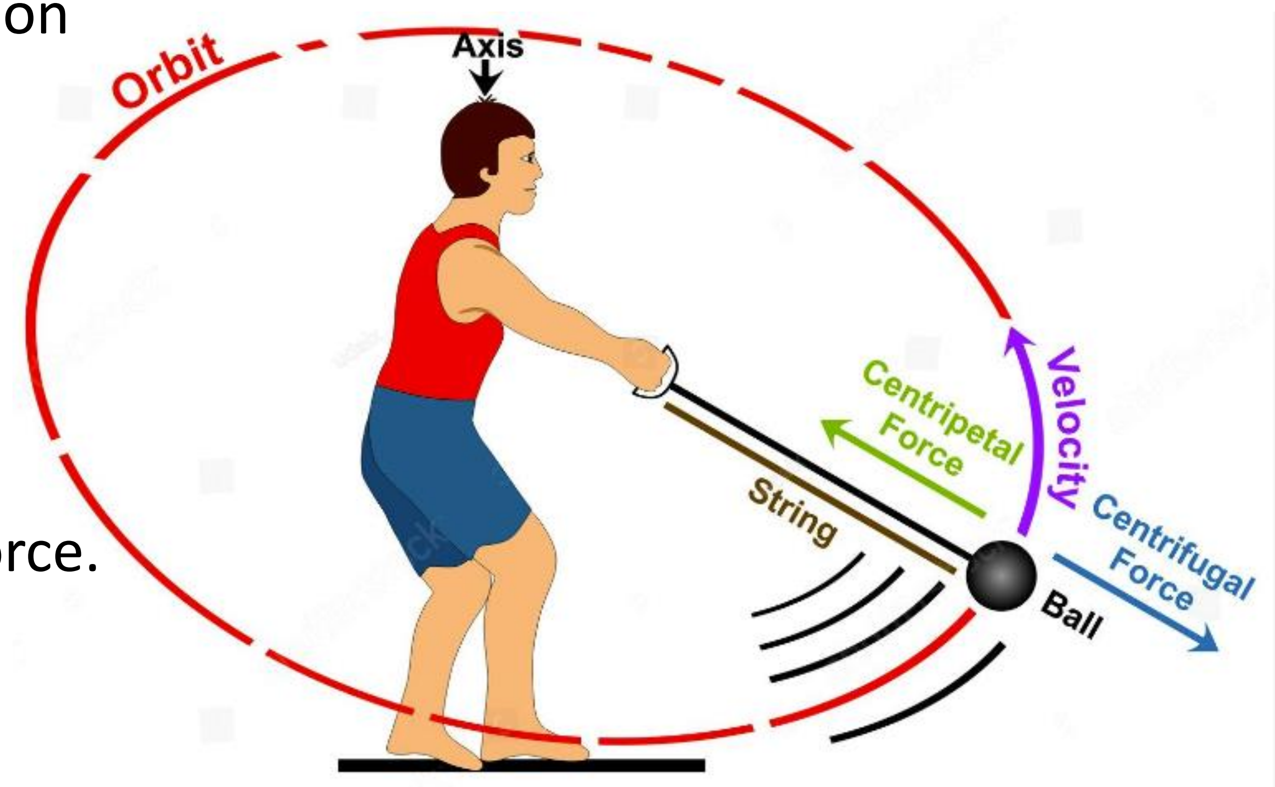
Recap: Non-Inertial Frames

A **fictitious force** is a force that appears to act on a mass whose motion is described using a non-inertial frame of reference, such as a linearly accelerating or rotating reference frame.[1] Fictitious forces are invoked to maintain the validity and thus use of Newton's second law of motion, in frames of reference which are *not* inertial.[2]

Inertial Frame Interpretation: The string tension provides a force which accelerates the ball.

$$F_{net} = ma_c$$

$$T = m\frac{v^2}{r}$$



Noninertial Frame Interpetation: The string tension balances the (fictitious) centrifugal force.

$$F_{net} = 0$$

$$F_T + F_{cg} = T - \frac{mv^2}{r} = 0$$

Recap: Complete(?): The Laws of Motion

Net external force $\vec{F}_{net}=\sum\vec{F}=\vec{F}_1+\vec{F}_2+\cdots$

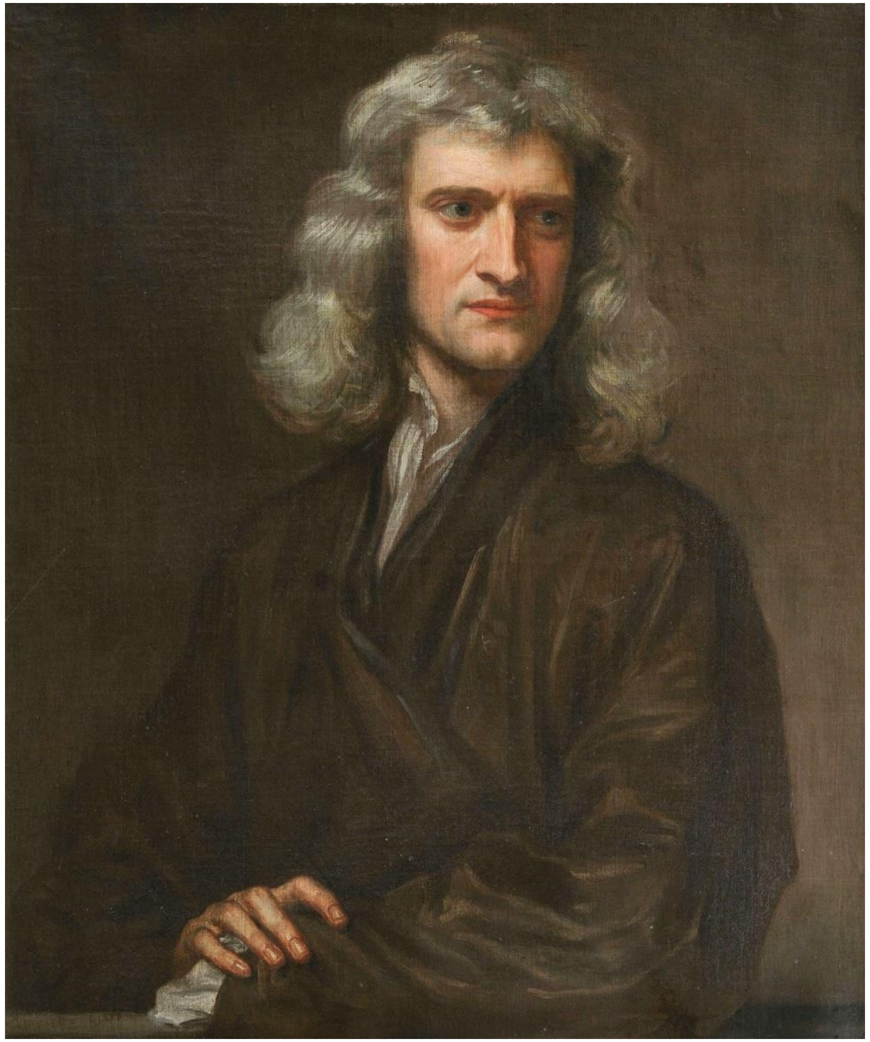
Newton's first law $\vec{v}=\text{constant when } \vec{F}_{net}=\vec{0}\,\text{N}$

Newton's second law, vector form $\vec{F}_{net}=\sum\vec{F}=m\vec{a}$

Definition of weight, vector form $\vec{w}=m\vec{g}$

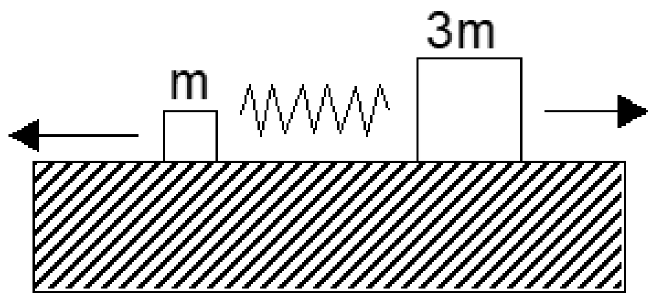
Newton's third law $\vec{F}_{AB}=-\vec{F}_{BA}$

We'll see…



Concept Check

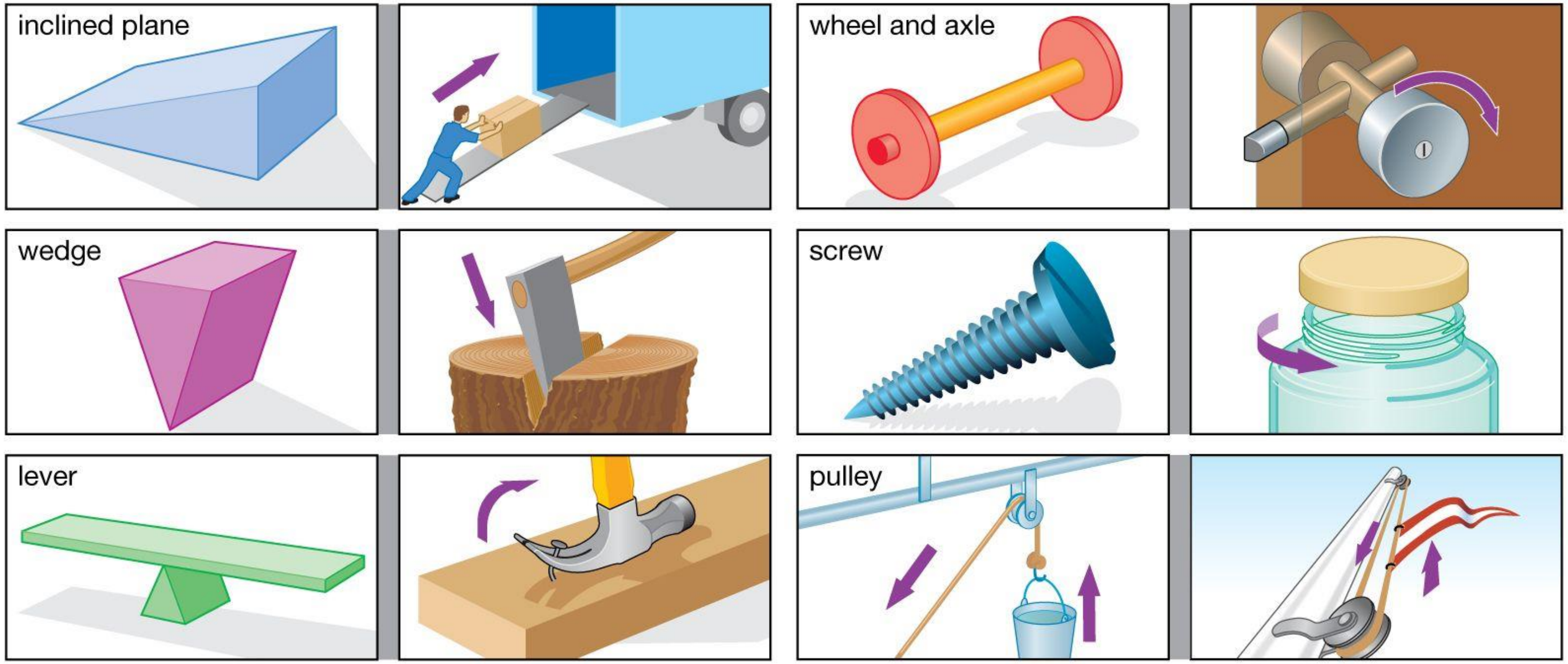
Two masses, of size m and 3m, are at rest on a frictionless surface. A compressed, massless spring between the masses is suddenly allowed to uncompress, pushing the masses apart.



What is the direction of the acceleration of the center-of-mass of the 2-mass system?

A) to the right
B) to the left
C) the acceleration is zero.

Prelecture Review: Work and Simple Machines

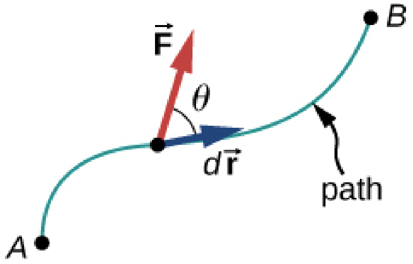


What are our questions and/or comments?

WORK DONE BY A FORCE

The work done by a force is the integral of the force with respect to displacement along the path of the displacement:

$$W_{AB} = \int_{\text{path } AB} \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}}.$$



Comments and Questions

- How does a machine that wedges an object differ than a machine that acts as a screw? How would you classify the mechanism of a shoulder joint that allows the arm to move in a 180 degree 3-D plane?
- I remember a documentary I was watching where a building crew were installing escalators into a new terminal of an airport. They didn't have room to use a big crane to set the escalators in place and instead used pulleys setting up very long chains and just raw manpower to slowly lift the escalators into place. How in the world is this possible? I've never understood how pulleys allow us to lift incredibly heavy objects like that.
- When thinking about forces, Newtons 3rd law, and work, I always struggle to quantify it in real world terms. When I go to the gym and lift weights, am I feeling the effects of a force or work? Are these concepts intuititve ideas, or are they more abstract? How should I think about them?
- What would be the challenges of calculating work in non-linear systems where forces vary with displacement?

My Comments and Questions

- Comment: The idea here is to understand machines through “analytic reasoning.” The modern point of view is very different than the “6 Simple Machines” Framework – Kinematic Pairs and Kinematic Chains. No exact # of fundamental pairs agreed upon.

linkage from Kinematics of Machinery, 1876

Classification of machines

The identification of simple machines arises from a desire for a systematic method to invent new machines. Therefore, an important concern is how simple machines are combined to make more complex machines. One approach is to attach simple machines in series to obtain compound machines.

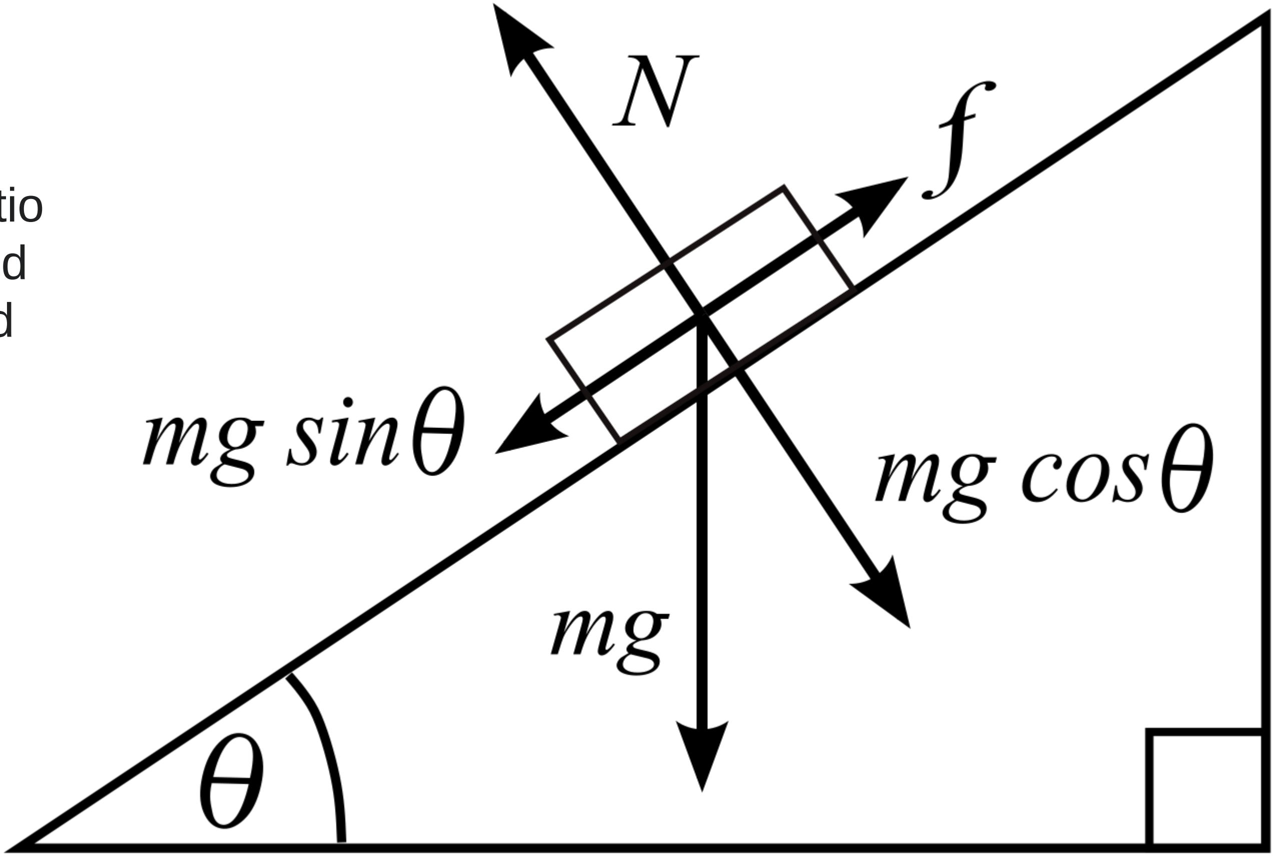
However, a more successful strategy was identified by Franz Reuleaux, who collected and studied over 800 elementary machines. He realized that a lever, pulley, and wheel and axle are in essence the same device: a body rotating about a hinge. Similarly, an inclined plane, wedge, and screw are a block sliding on a flat surface.[32]

This realization shows that it is the joints, or the connections that provide movement, that are the primary elements of a machine. Starting with four types of joints, the revolute joint, sliding joint, cam joint and gear joint, and related connections such as cables and belts, it is possible to understand a machine as an assembly of solid parts that connect these joints.[24]

Example: Mechanical Advantage of an Inclined Plane (Ramp)

The mechanical advantage of an inclined plane is the ratio of the weight of the load on the ramp to the force required to pull it up the ramp. If energy is not dissipated or stored in the movement of the load, then this mechanical advantage can be computed from the dimensions of the ramp.

$$MA = W/f$$



Concept Check