1. Reitze replaces Chan as lecturer for the next 7 lectures.
2. You can attend any of the lecturers' or TAs' office hours. You are not restricted to the current lecturer or your TA.
3. Clicker quizzes will start counting for your course grade next Tuesday (Jan 27)
   - You should have gotten an email with your clicker scores—if not, your clicker is not properly registered.
4. Yellow Book (copies of old exams and solutions) on sale at Target Copy for $16
5. Student Solution Manual – more copies will be available at the Reitz Union Book store (30 on Friday, 30 on Monday)
6. Exam 1
   - Feb 18, 8:20 – 10:10 pm
   - Room assignments will be posted
   - You are allowed one *handwritten* formula sheet (both sides)

Relative Position Vector

- Position of car A relative to car B is given by the vector subtraction equation
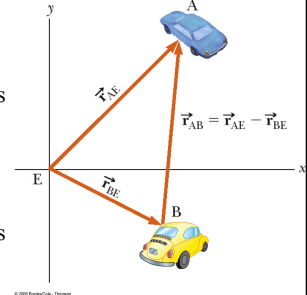
• $\vec{r}_{AE}$ is the position of car A as measured by E

• $\vec{r}_{BE}$ is the position of car B as measured by E

• $\vec{r}_{AB}$ is the position of car A as measured by car B

$$\vec{r}_{AB} = \vec{r}_{AE} - \vec{r}_{EB}$$

$$\vec{r}_{AB} = \vec{r}_{AE} - \vec{r}_{BE}$$

Relative Velocity Notation

- The pattern of subscripts can be useful in solving relative velocity problems
- Assume the following notation:
  - E is an observer, stationary with respect to the earth
  - A and B are two moving cars
- The rate of change of the displacements gives the relationship for the velocities

$$\vec{v}_{AB} = \vec{v}_{AE} - \vec{v}_{EB}$$

Relative Velocity
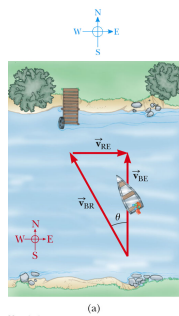
$$\vec{r}_{AB} = \vec{r}_{AE} - \vec{r}_{BE}$$

Take rate of change with time
$\Delta\mathbf{r}/\Delta t$

$$\vec{v}_{AB} = \vec{v}_{AE} - \vec{v}_{BE}$$

Example #3.12

A boat moves across a river with a speed of 10 km/hr **relative to the water**. The river has a velocity of 5 km/hr due east. If the skipper of the boat wants to **travel due north** across the river, what direction should she head? What is the speed of the boat relative to the shore?


(a)

Chapter 4

The Laws of Motion

Classical Mechanics

- Describes the relationship between the motion of objects in our everyday world and the forces acting on them
- Conditions when Classical Mechanics does not apply
  - very tiny objects (< atomic sizes)
    - 'Quantum Mechanics'
  - objects moving near the speed of light
    - 'Relativistic Mechanics' (special relativity)

Sir Isaac Newton

- 1642 – 1727
- Formulated basic concepts and laws of mechanics
- Universal Gravitation
- Calculus
- Light and optics

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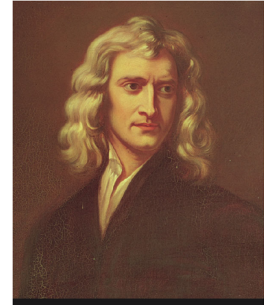
Newton's First Law

- An object moves with a velocity that is constant in magnitude and direction, unless acted on by a nonzero net force
  - The net force is defined as the vector sum of all the external forces exerted on the object

Inertia

- Is the tendency of an object to continue in its original motion

Mass

- A measure of the resistance of an object to changes in its motion due to a force
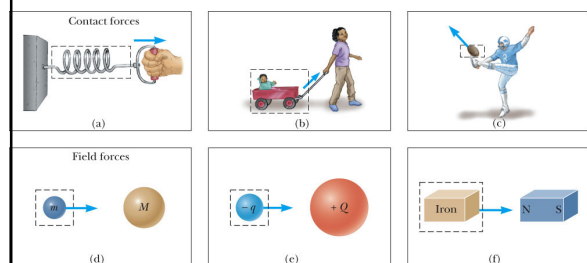- Scalar quantity
- SI units are kg

Newton's Second Law

- The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

$$\vec{\mathbf{a}} \; \alpha \; \frac{\sum \vec{\mathbf{F}}}{m} \; or \; \sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

  - F and a are both vectors

Contact and Field Forces

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Units of Force

- SI unit of force is a Newton (N)

$$1\,\text{N} \equiv 1\frac{\text{kg m}}{\text{s}^2}$$

- US Customary unit of force is a pound (lb)
  - 1 N = 0.225 lb

Gravitational Force

- Mutual force of attraction between any two objects
- Expressed by Newton's Law of Universal Gravitation:

$$F_g = G\frac{m_1 m_2}{r^2}$$

Weight

- The magnitude of the gravitational force acting on an object of mass m near the Earth's surface is called the weight w of the object
  - $w = m\,g$ is a special case of Newton's Second Law
    - g is the acceleration due to gravity
- g can also be found from the Law of Universal Gravitation

Example

A train has a mass of 5.22×10^6 kg and is moving at 90.0 km/h. The engineer applies the brakes, resulting in a net backward force of 1.87×10^6 N on the train. The brakes are held on for 30.0 s. (a) What is the final speed of the train? (b) How far does the train travel during this period?