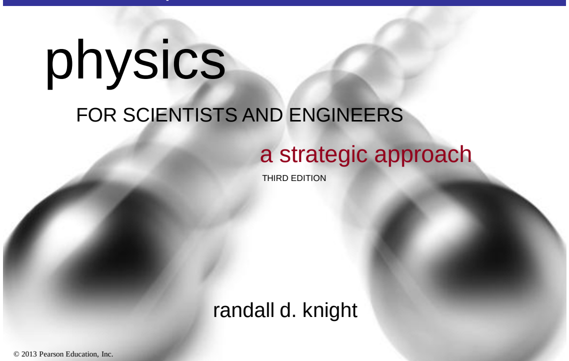
Class 2 - Chapter 1 Preclass Notes



physics

FOR SCIENTISTS AND ENGINEERS

a strategic approach

THIRD EDITION

randall d. knight

ALWAYS LEARNING PEARSON

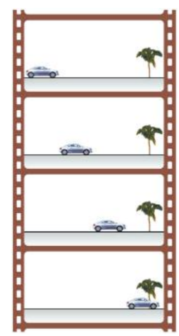
Chapter 1 Concepts of Motion

Chapter Goal: To introduce the fundamental concepts of motion.

Four basic types of motion

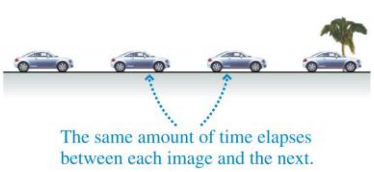
Making a Motion Diagram

- Consider an old-style movie of a moving object.
- Each separate photo is called a *frame.*
- The car is in a different position in each frame.



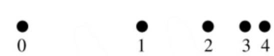
Making a Motion Diagram

- Imagine cutting individual frames of the filmstrip apart, and stacking them on top of each other.
- This composite photo shows an object's position at several *equally spaced instants of time.*
- This is called a **motion diagram**.



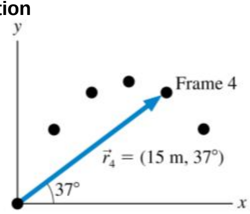
The Particle Model

- Often we can treat the object *as if* all its mass were concentrated into a single point.
- A mass at a single point in space is called a **particle**.
- Below is a motion diagram of a car stopping, using the **particle model**.

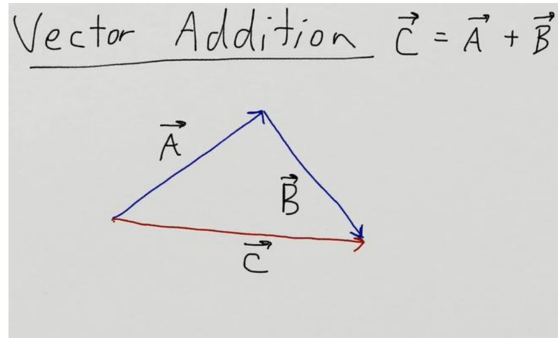


Position as a Vector

- Shown is the motion diagram of a basketball, with 0.5 s intervals between frames.
- One way to locate the ball is to draw an arrow from the origin to the point representing the ball.
- You can then specify the length and direction of the arrow.
- This arrow is called the **position vector** $\vec{r}$ of the object.
- The position vector $\vec{r}$ is an alternative form of specifying position.
- Another way of specifying position is to use coordinates (x, y).



Tactics: Vector Addition



Definition of Displacement

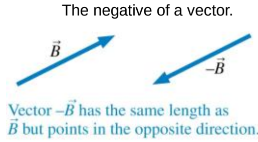
- The displacement $\Delta\vec{r}$ of an object as it moves from an initial position $\vec{r}_i$ to a final position $\vec{r}_f$ is

$$\Delta\vec{r} = \vec{r}_f - \vec{r}_i$$

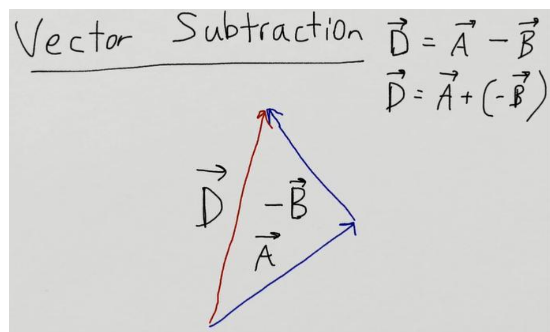
- The definition of $\Delta\vec{r}$ involves *vector subtraction*.
- With numbers, subtraction is the same as the addition of a negative number.
- Similarly, with vectors

$$\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$$

The negative of a vector.



Tactics: Vector Subtraction



Time Interval

A stopwatch is used to measure a time interval.

- It's useful to consider a *change* in time.
- An object may move from an initial position $\vec{r}_i$ at time t_i to a final position $\vec{r}_f$ at time t_f.
- The time interval is called Δt.

Average Speed, Average Velocity

The victory goes to the runner with the highest average speed.

To quantify an object's fastness or slowness, we define a ratio:

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time interval spent traveling}} = \frac{d}{\Delta t}$$

- Average speed is a *scalar* quantity (no direction information)
- The **average velocity** of an object during a time interval Δt, in which the object undergoes a displacement $\Delta\vec{r}$, is the vector:

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t}$$

Acceleration

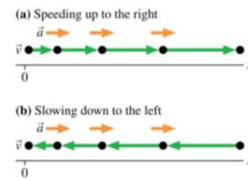
- Sometimes an object's velocity changes as it moves.
- Acceleration describes a *change* in velocity.
- Consider an object whose velocity changes from $\vec{v}_1$ to $\vec{v}_2$ during the time interval Δt.
- The quantity $\Delta\vec{v} = \vec{v}_2 - \vec{v}_1$ is the change in velocity.
- The *rate of change of velocity* is called the **average acceleration:**

$$a_{avg} = \frac{\Delta\vec{v}}{\Delta t}$$

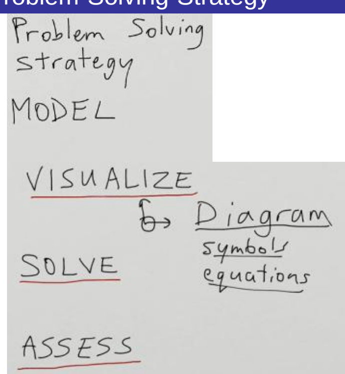
The Audi TT accelerates from 0 to 60 mph in 6 s.

Speeding Up or Slowing Down?

- When an object is speeding up, the acceleration and velocity vectors point in the *same direction*.
- When an object is slowing down, the acceleration and velocity vectors point in *opposite directions*.
- An object's velocity is constant if and only if its acceleration is zero.
- In the motion diagrams to the right, one object is speeding up and the other is slowing down, but they both have acceleration vectors toward the right.



General Problem-Solving Strategy



Units

- Science is based on experimental measurements, and measurements require units.
- The system of units in science is called *le Système Internationale d'unités* or **SI units**.
- The SI unit of time is the *second*, abbreviated s.

An atomic clock at the National Institute of Standards and Technology.

- The SI unit of length is the *meter*, abbreviated m.

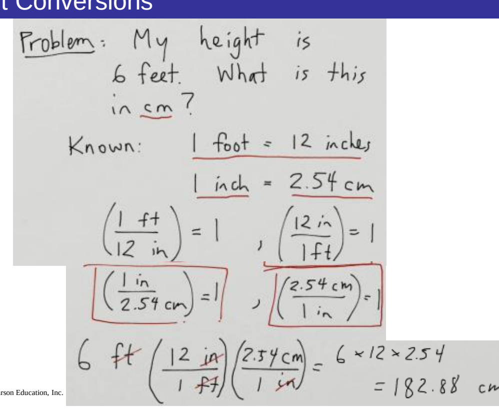
Units

- The SI unit of mass is the *kilogram*, abbreviated kg.
- Many lengths, times, and masses are either much less or much greater than the standards of 1 m, 1 s, and 1 kg.
- We use prefixes to denote various powers of 10, which make it easier to talk about quantities.

Common prefixes

Prefix	Power of 10	Abbreviation
giga-	10^9	G
mega-	10^6	M
kilo-	10^3	k
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ
nano-	10^{-9}	n

Unit Conversions



Significant Figures

- If you report a length as 6.2 m, you imply that the actual value is between 6.15 m and 6.25 m and has been rounded to 6.2.
- The number 6.2 has *two* significant figures.
- More precise measurement could give more significant figures.
- The appropriate number of significant figures is determined by the data provided.
- Calculations follow the “weakest link” rule: The input value with the smallest number of significant figures determines the number of significant figures to use in reporting the output value.