Chapter 1: introduction

<u>Dimensional analysis:</u> can be used to check equations
<u>Significant figures:</u> reliably known digit
<u>Units and conversions:</u> it is important to have consistent units. Use International System whenever possible

Dimensional analysis

TABLE 1.5 Dimensions and Some Units of Area, Volume, Velocity, and Acceleration

System	Area (L^2)	Volume (L^3)	Velocity (L/T)	Acceleration (L/T^2)
SI	m^2	m^3	m/s	m/s^2
cgs	cm^2	cm^3	cm/s	cm/s^2
U.S. customary	ft^2	ft^3	ft/s	ft/s^2

Which formula is dimensionally consistent with an Expression for velocity (v)? (a is acceleration)
a) v/t^2
b) $v\,x^2$
c) v^2/t
d) at

Chapter 2: Motion in 1D

displacement

$$\Delta x = x_f - x_i$$

velocity

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

$$\overline{speed} = \frac{|\Delta x|}{\Delta t} = \frac{|x_f - x_i|}{t_f - t_i}$$

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

acceleration

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

1-D motion with constant acceleration

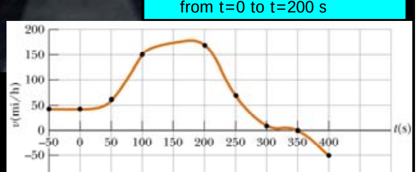
TABLE 2.3 Equations for Motion in a Straight Line Under Constant Acceleration

Equation	Information Given by Equation
$v = v_0 + at$	Velocity as a function of time
$\Delta x = \frac{1}{2}(v_0 + v)t$	Displacement as a function of velocity and time
$\Delta x = v_0 t + \frac{1}{2}at^2$	Displacement as a function of time
$v^2 = v_0^2 + 2a\,\Delta x$	Velocity as a function of displacement

Note: Motion is along the x axis. At $t = 0$, the velocity of the particle is v_0.

Constant acceleration: example

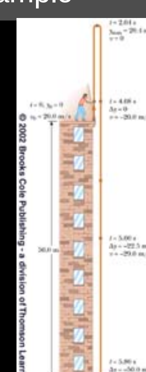
a) Find the peak of the acceleration as it speeds up from 45 to 170 mi/h
b) Find its average acceleration and displacement between t=200 and t=300 s
c) Find the train's displacement from t=0 to t=200 s



Freely falling objects: example

A stone is thrown from the top of a building with initial speed 20.0 m/s straight upward. The building is 50.0 m high, and the stone just misses the edge of the roof on its way down. (make a sketch)

Determine:
- time it takes for it to reach the maximum height
- maximum height
- time for the stone to return to the initial level
- velocity at that instant
- velocity and position for t=5.00 s



Chapter 3: Motion in 2D

displacement

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

Average velocity

$$\bar{\vec{v}} = \frac{\Delta\vec{r}}{\Delta t}$$

Instantaneous velocity

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta\vec{r}}{\Delta t}$$

Average acceleration

$$\bar{\vec{a}} = \frac{\Delta\vec{v}}{\Delta t}$$

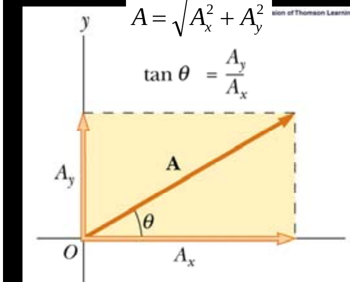
Instantaneous acceleration

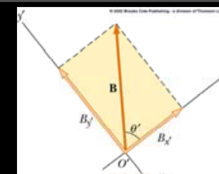
$$\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta\vec{v}}{\Delta t}$$

Components of a vector

$$A = \sqrt{A_x^2 + A_y^2}$$

$$\tan\theta = \frac{A_y}{A_x}$$





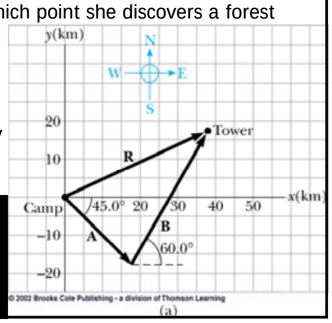
$$A_x = A\cos\theta$$

$$A_y = A\sin\theta$$

Vectors: example

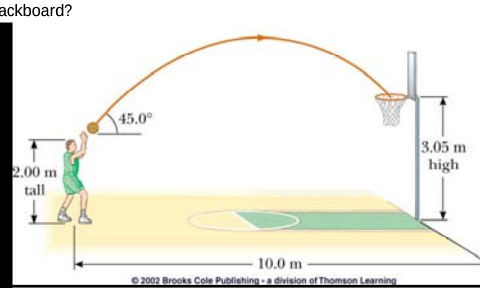
A hiker begins a trip by first walking 25.0 km southeast from her base camp. On the second day she walks 40.0 km in the direction 60.0 degrees northeast, at which point she discovers a forest ranger's tower.

a) Determine the component of the hiker's displacement on the 1st and 2nd day
b) Determine the total displacement



Projectile motion: example

A basketball player 2.0 m tall, wants to make a basket from a distance of 10.0 m. If he shoots the ball at 45.0 deg, at what initial speed must he throw the ball so that it goes through the hoop without striking the backboard?



Relative velocity

A passenger at the rear of a train traveling at 15 m/s relative to the Earth throws a baseball with a speed 15 m/s in the direction opposite to the motion of the train. What is the velocity of the baseball relative to the Earth?

$$\vec{v}_{ball-earth} = \vec{v}_{ball-train} + \vec{v}_{train-earth}$$

15 m/s   15 m/s

Chapter 4: Laws of motion

CONCEPT OF FORCE

$$1N \equiv 1Kg\,m/s^2$$

Net force: the sum of all external forces

$$\sum \vec{F}_i = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \ldots$$

Newton's Laws

1st: If the net force exerted on an object is zero, the object continues in its original state of motion:

- an object at rest, remains at rest;
- an object moving with some velocity continues with that same velocity.

Newton's second law

2^{nd}: The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass

$$\sum F_{ix} = ma_x$$
$$\sum F_{iy} = ma_y$$

Remember concepts of mass, inertia and weight!

3^{rd}: If two object interaction, the force F_{12} exerted by object 1 on object 2 is equal in magnitude and opposite direction to the force F_{21} exerted by object 2 on object 1.

Application of Laws of Newton

Equilibrium

$$\sum F_{ix} = 0$$
$$\sum F_{iy} = 0$$

Acceleration

$$\sum F_{ix} = ma_x$$
$$\sum F_{iy} = ma_y$$

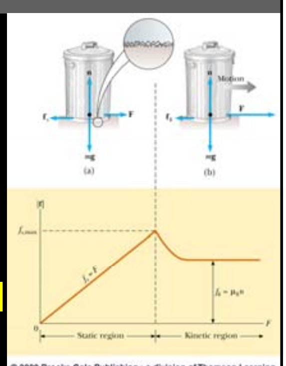
Plus friction...

Forces of friction: static and kinetic

Coefficient of static friction

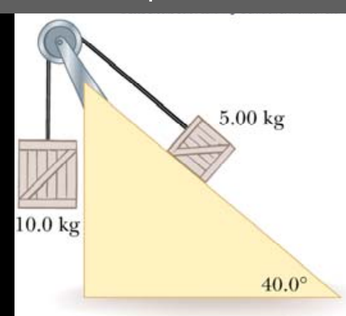
$$f_s \le \mu_s N$$
$$f_k = \mu_k N$$

Coefficient of kinetic friction



Newton's laws: more problems

Two packing crates of masses 10.0 kg and 5.0 kg are connected by a light string that passes over a frictionless pulley. The 5.00 kg crate lies on a smooth incline of angle 40.0°. Find the acceleration of the 5.00 kg crate and the tension in the string



Repeat the problem considering a friction coefficient of 0.2!

Chapter 5: Energy

Work $W = (F\cos\theta)\,\Delta x$ $\quad 1J \equiv 1Nm$

The kinetic energy $KE = \frac{1}{2}mv^2$

When work is done by a net force on an object and the only change in the object is its speed, the work done is equal to the change in the object's kinetic energy.

$$W_{net} = KE_f - KE_i = \Delta KE$$

Conservation of Mechanical Energy

In any isolated system of objects that interact only through conservative forces, the total mechanical energy of the system (the sum of the kinetic and potential energy) remains constant.

$$KE_f + PE_f = KE_i + PE_i$$

Spring Potential energy

$$PE = \frac{1}{2}kx^2$$

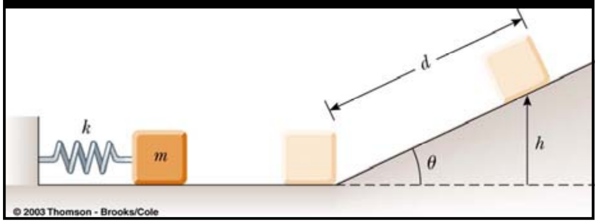
Gravitational Potential energy

$$PE = mgy$$

Energy conservation: example

A 0.50 Kg block rests on a horizontal, frictionless surface. The block is pressed against a light spring having k=80.0 N/m. The spring is compressed a distance of 2.0 cm to point A, and released.

a) Find the speed of the block when it is at the bottom of the incline B
b) Find the maximum distance d the block travels up the incline if the angle is 25^0.



Energy Balance

If there is a non-conservative force that is dissipative (friction, air resistance) its work is negative and the mechanical energy of the system will reduce.

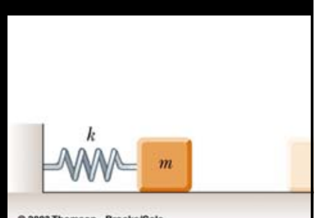
$$KE_f + PE_f = KE_i + PE_i - W_{diss}$$

If there is a non-conservative external force that is pumping energy into the system, its work is positive and the mechanical energy of the system will increase.

$$KE_f + PE_f = KE_i + PE_i + W_{Fext}$$

Energy balance: example

A 0.50 Kg block rests on a horizontal surface with coefficient of friction 0.1. The block is pressed against a light spring having k=80.0 N/m. The spring is compressed a distance of 2.0 cm to point A, and released. How far in does the block travel?



Power

Power is the time rate of energy transfer

$$\overline{P} \equiv \frac{W}{\Delta t}$$

SI Units: 1**W**=1 **J/s**

Conversion: 1**hp**=746 **W**

Prove that for a constant force over time: $\overline{P} = F\overline{v}$