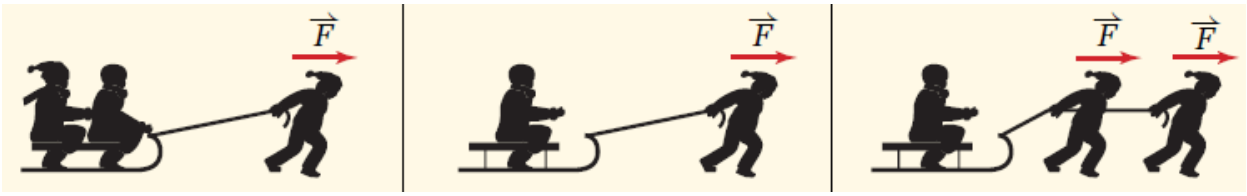
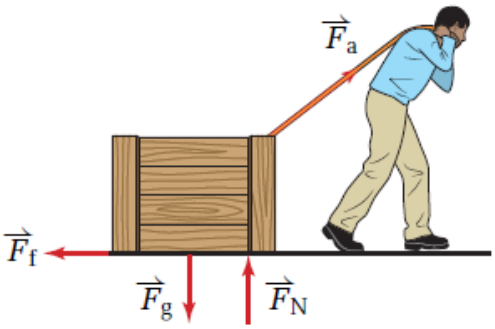
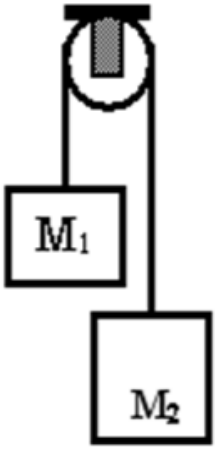
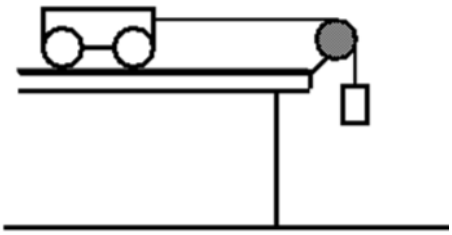
# 5.2 Motion and Newton's Second Law



# 5.2 Motion and Newton's Second Law

## NEWTON'S SECOND LAW

Force is the product of mass and acceleration, or, acceleration is the quotient of the force and the mass.

$$\vec{F} = m\vec{a} \quad \text{or} \quad \vec{a} = \frac{\vec{F}}{m}$$

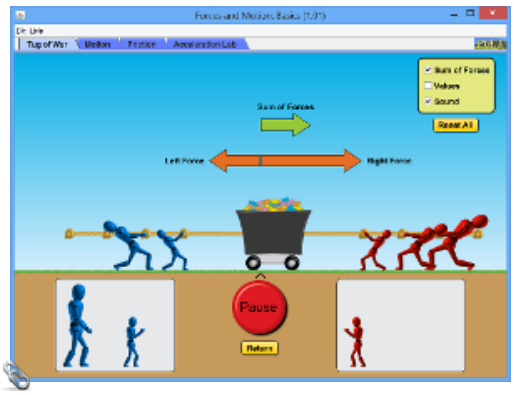
| Quantity | Symbol | SI unit |
|---|---|---|
| acceleration | $\vec{a}$ | $\frac{\text{m}}{\text{s}^2}$ (metre per second squared) |
| force | $\vec{F}$ | N (newton) |
| mass | $m$ | kg (kilogram) |

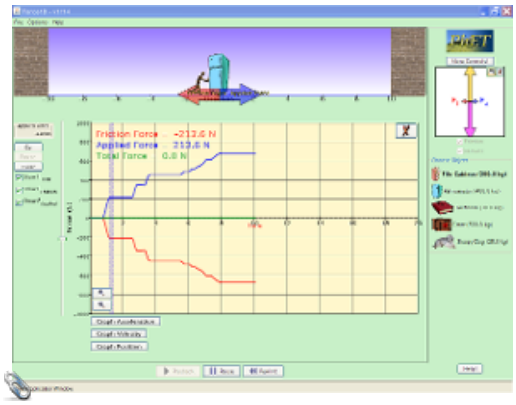
**Unit Analysis**

$$\text{(mass) (acceleration)} = \text{kg}\,\frac{\text{m}}{\text{s}^2} = \text{N}$$

**Note:** The $\vec{F}$ in Newton's second law always represents the vector sum of all the forces, or the net force, acting on the mass. (or average force)

## PhET Demos



# Mathematical Practice

1. What is the acceleration of a 12 kg cart under a constant force of 88 N?

$a = ?$

$m = 12\,kg$

$F_{net} = 88\,N$

$F_{net} = ma$

$88 = 12a$

$7.3\,m/s^2 = a$

2. An average force of 1200 N accelerates an object at 21 m/s$^2$. What is the mass of the object?

$F_{net} = 1200\,N$

$a = 21\,m/s^2$

$m = ?$

$F_{net} = ma$

$1200 = m(21)$

$57\,kg = m$

3. What average (net) force is required to accelerate a 33 kg mass at 4.6 m/s$^2$?

# Newton's 2nd Law Basics Review

Grade:11

Subject:Physics 112

Date:2014

1 A massive box sits on a frictionless surface. Will a force of 0.0001 N cause an acceleration?

Yes

No

2 A car is acted upon by a net force of 1000 N. Suddenly that force is tripled (must be a Toyota), by what factor did the acceleration change?

A x 3

B x 1/3

C no change

3 Calculate the resulting acceleration of an 25 kg mass under a net force of 142 N.

A 0.18 N

B 5.7 N

C 3550 N

$142 = 25a$

$\frac{142}{25} = a$

# Fire Up Your Neurons!

Take 3 minutes and write a few detailed sentences about how Newton's 2nd Law applies to rockets from launch to orbit.

# Combining Dynamics and Kinematics

We will now be mathematically solving problems that could require one or more of a large selection of equations (review handbook).

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

Involve problems we've done previously with common forces like applied force, gravity and friction.

Involve concepts from kinematics incorporating displacement, velocity, and acceleration.

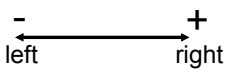
This section takes practice. Review problem solving strategies. You will have many mathematical problems to solve, but unlike your math class, you will need to determine what equations apply to the problem first.

*very important difference

Let's do some examples

# Combining Dynamics and Kinematics

An applied force of 50 N is used to accelerate an object to the right across a frictional surface. The object encounters 10 N of friction. The weight of the object is 80 N.




1. Calculate the net force. (40 N)
2. Calculate the acceleration. ($4.9\ m/s^2$)
3. From the initial push, calculate how far the object will travel if the constant force was applied for 12 seconds. (353 m)
4. Calculate the instantaneous velocity after 5 seconds. (24.5 m/s)

1. $F_{net} = ?$

$F_a = 50N$

$F_f = -10N$

$F_{net} = \sum Forces$ ✓

~~$F_{net} = ma$~~ not enough info given

$F_{net} = F_a + F_f$

$= 50 + (-10)$

$= 40N$

2. $a = ?$

$F_{net} = 40N$

$m \leftarrow$ get using $F_g = mg$ ($9.81\ m/s^2$)

$80 = m(9.81)$

$8.2 = m$

$F_{net} = ma$

$40 = (8.2)a$

$4.9\ m/s^2 = a$

3. $d_f = ?$

$t = 12s$

$v_0 = 0\ m/s$

$d_0 = 0\ m/s$

$d_f = d_0 + v_0 t + \frac{1}{2}at^2$ ($d_0 \to 0$, $v_0 \to 0$)

$d_f = \frac{1}{2}(4.9)(12)^2$

$= \frac{1}{2}(4.9)(144)$

$d_f = 353m$

## Attachments

forces-and-motion-basics_all.jar

forces-1d_all.jar