Chap 4–1: Force

Strength and direction with which objects are being pulled (or pushed).

To measure force we can use a spring.

Example:

- **Bathroom scale: the force of gravity acting on us.**

We can represent any force by a vector with a direction and a magnitude.

Chap 4–2: Newton's First Law of Motion

Law of Inertia

Every body continues in its state of rest or constant velocity unless acted upon by a non–zero net force.

(constant velocity: uniform speed in a straight line)
Aristotle, Galileo.

The tendency of a body to maintain its state (that is both speed and direction) is called inertia.

This law holds only in reference frames that are not accelerating. In accelerating reference frames, the First Law does not hold. Non–accelerating frames are called Inertial Frames, while accelerating frames are called Non–inertial frames. We will deal exclusively with inertial frames.

Chap 4–3: Mass

Mass can be thought of simply as a quantity of matter.

A more precise definition:

A measure of the inertia of a body.

The more mass a body has, the harder it is to change its velocity (speed and / or direction).

A train has more mass than a tennis ball, therefore it is harder to change its direction or speed.

(which would you rather meet head on in a dark alley?)

The SI unit for mass is the kilogram (kg).

Mass is different than weight:

mass is universal
weight is local

Chap 4–4: Newton's Second Law of Motion

The acceleration of a body is directly proportional to the net force acting on it and is inversely proportional to its mass.

The direction of the acceleration is in the direction of the net force.

acceleration → $$\mathbf{a} = \frac{\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 + \cdots}{m} = \frac{\sum \mathbf{F}}{m}$$

← Net force ($\sum \mathbf{F}$)

← mass (m)

or

$$\sum \mathbf{F} = m\,\mathbf{a}$$

A relation between the description and the cause of motion.

Chap 4–4: Newton's Second Law of Motion

Force: An action capable of accelerating an object. Force and acceleration are vectors. The equation

$$\sum \mathbf{F} = m\,\mathbf{a}$$

Can be written in component form

$$\sum F_x = m\,a_x \qquad \sum F_y = m\,a_y \qquad \sum F_z = m\,a_z$$

The SI unit for force is called Newton (N).
Since F = m a where m is in kg and a is m/s^2,
then 1 N = 1 kg m/s^2.

Chap 4–4: Newton's Second Law of Motion

Find the net force needed to accelerate a 700 kg car to g.

$a = g = \mathbf{9.80 m/s^2.}$

$m = \mathbf{700\ kg}$

$\sum F = m\,a = \mathbf{(\ 700\ kg\ )(\ 9.80\ m/s^2\ ) = 6860\ N\ .}$

Chap 4–4: Newton's Second Law of Motion

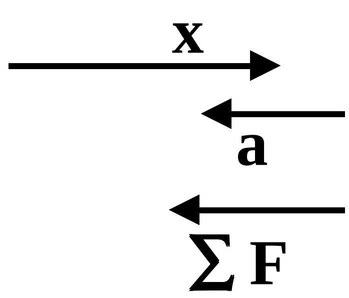
Find the net force needed to bring a 900 kg car to rest from a speed of 120 km/h in a distance of 100 m.

First find the acceleration.

(Convert to the right units: 120 km/h = 33.3 m/s)

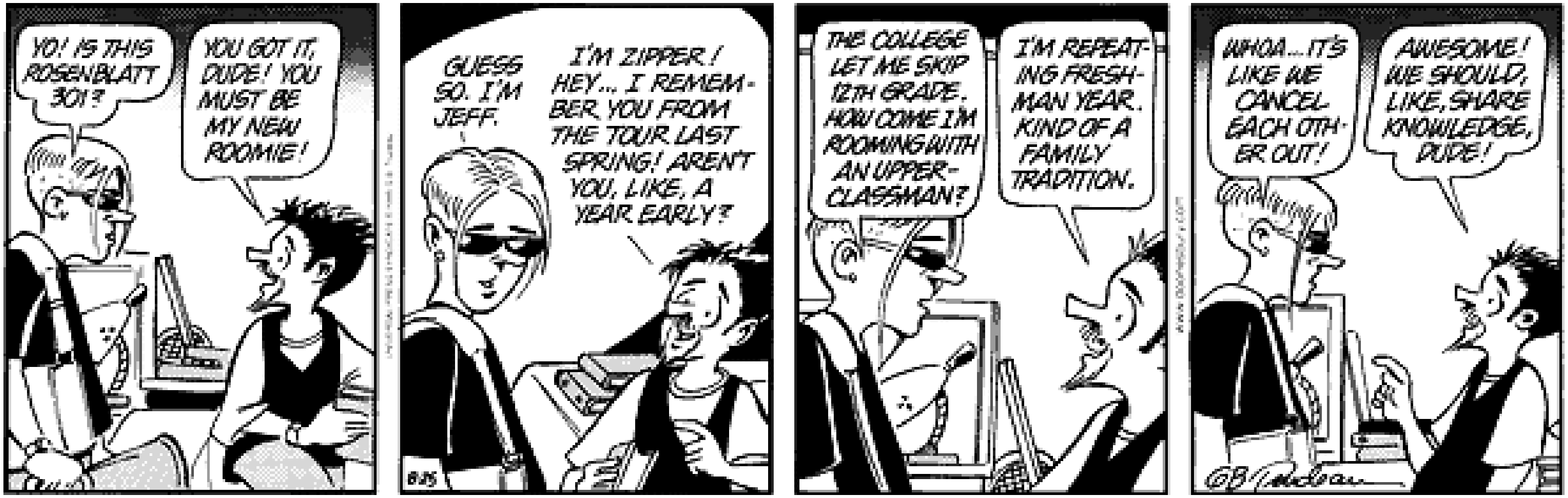
Use: $\cancel{v}^2 = v_0^2 + 2a(x - \cancel{x_0})$

$a = -v_0^2 / 2x = (33.3 \text{ m/s})^2 / 200 \text{ m} = -5.56 \text{ m/s}^2$

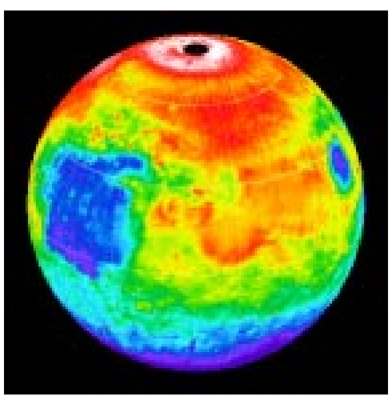


$m = 900 \text{ kg}$

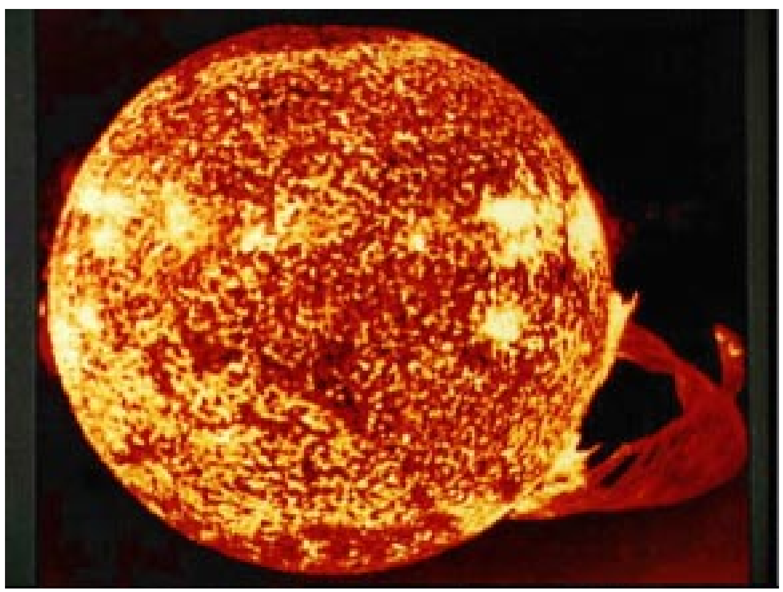
$\Sigma F = m a = (900 \text{ kg})(-5.56 \text{ m/s}^2) = -5004 \text{ N}$.



Mars



Sun



Venus