4.2 – Newton's Second Law of Motion

Whole lotta mass to accelerate.

Finish Unit Analysis

Newton's Second Law:

"Acceleration of an object equals the net force on that object dividedby its mass."

AP Equation $a = \frac{F_{net}}{m}$	a = acceleration (m/s^2)
More Common: $F = ma$	F = force (Newtons: N)
	m = mass (kg)

Unit analysis:
Newton = $kg \cdot m/s^2$

Demo: 100 g mass ~ 1 N.

1. Toy Example

What force is required to make a 0.56 kg toy accelerate at 4.8 m/s^2?

$$F = ma$$
$$= 0.56\,kg \bullet 4.8\,m/s^2 = 2.7\,N$$

Truck Examples

2. 12,500 N is applied to a stationary 5520 kg truck. What acceleration does it have, disregarding friction?

$$F = ma$$
$$a = \frac{F}{m} = \frac{12{,}500\,N}{5520\,kg} = 2.26\,m/s^2$$

Truck Examples

3. How far will the truck go in 15.0 seconds? Its acceleration was 2.26 m/s^2

Kinematics!

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$x = 0m + 0m/s \bullet 15s + \frac{1}{2}2.26m/s^2 \bullet (15.0s)^2 = 254m$$

Weight: F_G, F_g, or F_w

How much do you weigh?
In physics this means something different than when someone asks you this insensitive question.

Acceleration due to gravity (g = 9.81 m/s^2) produces a force on objects against the ground, known as weight.

4. What is the weight (force) of a 15.0 kg mass against the ground?

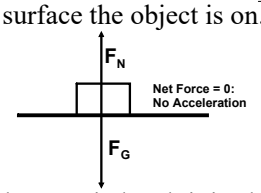
$$F_G = m \bullet g = 15.0\,kg \bullet 9.81\,m/s^2 = 147\,N$$

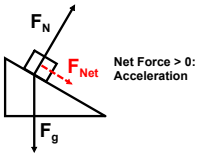
5. Bonus Question:

In the previous example, what is the magnitude of the force opposing the weight of the 15 kg object?

So that the object has no acceleration, a net force of 0 must exist: the force the ground is exerting is also 147 N, but in the opposite direction.

This is the Normal Force (F_N), and is perpendicular to the surface the object is on.





At the atomic level, it is electrostatic repulsion between electrons.

6. Normal Force Ex.

What is the normal force acting on a skateboard (5.0 kg) and its rider (75.0 kg) by the ground?

The normal force opposes the force of gravity.

Consider that the combined gravitational force of the rider plus the skateboard will equal the net force.

Total mass = 5.0 kg + 75.0 kg = 80.0 kg

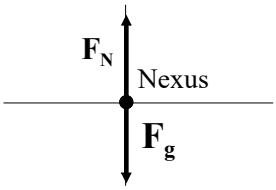
$$F_N = F_g$$
$$= m \bullet g$$
$$= 80 kg \bullet 9.81 = 785 N$$

Intro. to Free Body Diagrams (FBD's)

It is useful to show force vectors as proportional arrows on an x-y system: comparing x and y forces separately becomes easier.

Different from drawings, whichdepict forces from any location.

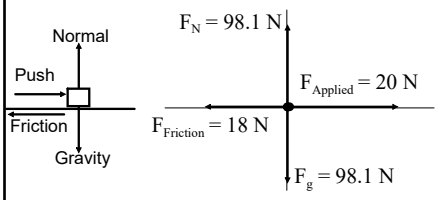
FBDs show all vectors (complete and decomposed) leaving one central "Nexus" point (the origin).



7. FBD Example

A guy pushes a 10 kg box along a level floor with a force of 20 N, experiencing a friction of 18 N.

A. Make a sketch of the situation with ALL forces.
B. Make an FBD of this with numeric values.
C. What net forces act on the box (x and y directions)?
D. What is the acceleration w.r.t x?



$\mathbf{F_{x\,Net} = 2\ N}$

$\mathbf{F_{y\,Net} = 0\ N}$

$$a = \frac{F_{Net}}{m}$$
$$= \frac{2\,N}{10\,kg} = 0.2\,m/s^2$$

Homework

Preview 4.3

4.2 Problems in your Booklet
Due: Next Class