# Introduction to Mechanics
# Dynamics
# Forces
# Applying Newton's Laws

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# Last time

- Newton's third law
- action-reaction pairs
- weight and gravity

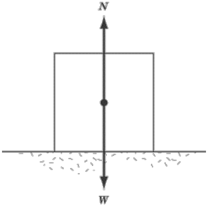
# Overview

- types of forces: normal force
    - elevators and acceleration

# Some types of forces

## The Normal Force

The normal force supports and object sitting on a surface. It acts in a direction **perpendicular to the surface**.




In this case, an object of weight $\vec{\mathbf{W}}$ sits on a level surface (that is not accelerating), and the *normal force*, $\vec{\mathbf{N}}$ is

$$\vec{\mathbf{N}} = -\vec{\mathbf{W}}$$

**Be careful! There are many cases in which the above equation is not true!**

[1]Figure from www.sparknotes.com

# The Normal Force

The normal force supports an object that sits on a surface, but its magnitude is different in different circumstances.

In general, one needs to work out what it will be in each problem.

Some cases where the normal force is different than the weight of an object are:

- there are other forces with components perpendicular to the surface.
- the object is in an accelerating elevator.
- the object sits on an incline.

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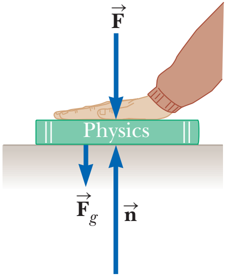
# Equilibrium Example

Consider a physics textbook pushed down on a table.




Does the book accelerate?

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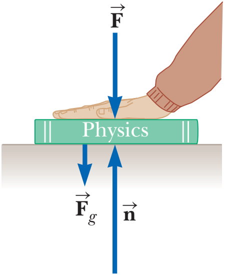


Does the book accelerate? No.

Then we know $\vec{\mathbf{F}}_{\text{net}} = 0$. Then we can conclude from the weight and the applied force what the normal force must be:

$$\vec{\mathbf{n}} + \vec{\mathbf{F}}_g + \vec{\mathbf{F}} = 0 \;\Rightarrow\; \vec{\mathbf{n}} = (F_g + F)\hat{\mathbf{j}}$$

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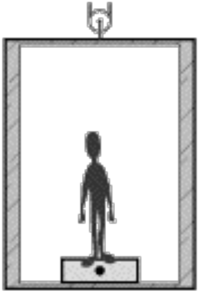
# Elevator Problems



$$\vec{\mathbf{a}} = 0$$

Elevator is at rest or moving with constant velocity. You feel the same as you normally do. Your weight and normal force are both of magnitude $mg$.

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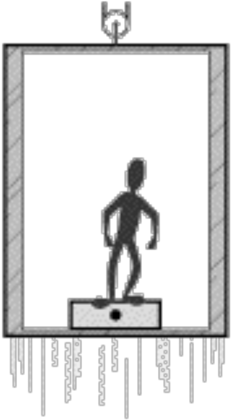
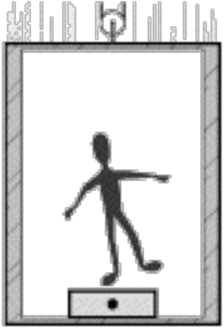


$\vec{\mathbf{a}} = +a\,\hat{\mathbf{j}}$ ($a$ is a positive number)

Elevator could be moving upward increasing speed **or** downward decreasing speed. You feel as if your weight has increased.

Your weight is $-mg\,\hat{\mathbf{j}}$, but the normal force is $\vec{\mathbf{n}} = m(g+a)\,\hat{\mathbf{j}}$.

# Elevator Problems



$\vec{\mathbf{a}} = -a\,\hat{\mathbf{j}}$  (*a* is a positive number)

Elevator could be moving upward and slowing down **or** moving downward increasing speed. You feel as if your weight has decreased.

Your weight is $-mg\,\hat{\mathbf{j}}$, but the normal force is $\vec{\mathbf{n}} = m(g - a)\,\hat{\mathbf{j}}$.

# Elevator Problem

When you lift a bowling ball with a force of 82 N, the ball accelerates upward with an acceleration $a$. If you lift with a force of 92 N, the ball's acceleration is $2a$. Find (a) the weight of the bowling ball, and (b) the acceleration $a$.

# Summary

- the normal force
- normal force: elevators

## Homework

Walker Physics:

- Ch 5, Problems: 40*, 41 (elevators)

*Ans: (a) upward, (b) 1.9 $m/s^2$, (c) we only know about the change in the velocity