Read 4.7-4.9

2nd Law

$$\Sigma \vec{F} = m\vec{a}$$

net Force acting on object of mass m

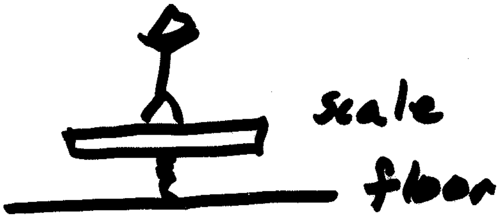
SI unit of Force

$ma = kg \cdot m/s^2$ Newton (N)

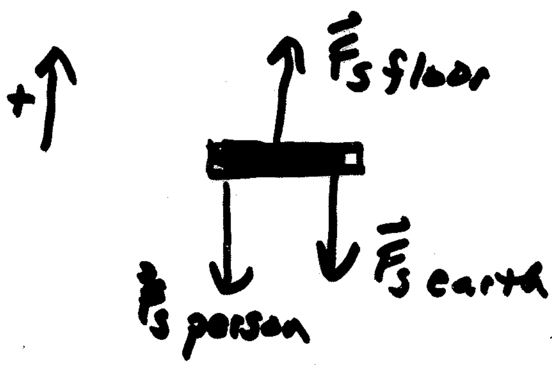
British unit of force: pound (lb)

Newton's 1st law is a special case when $\vec{a} = 0$

A person is standing on a scale. Identify the 3rd law partner for each force exerted on the scale



$\vec{F}_{AB}$: Force on A by B



$\vec{a} = 0$

$\vec{F}_{net} = m\vec{a} = 0$

$\vec{F}_{s\,floor} + \vec{F}_{s\,person} + \vec{F}_{s\,earth} = 0$

3rd law partners

$\vec{F}_{sF} \Rightarrow \vec{F}_{Fs}$

$\vec{F}_{sp} \Rightarrow \vec{F}_{ps}$

$\vec{F}_{se} \Rightarrow \vec{F}_{es}$

Interactive Question

- A book is resting on the surface of a table. Consider the following four forces that arise in this situation
  - 1) The force of the earth pulling on the book
  - 2) The force of the table pushing on the book
  - 3) The force of the book pushing on the table
  - 4) The force of the book pulling on the earth

- Which two forces form an "action-reaction" pair which obey Newton's third law?

A) 1 and 2
B) 1 and 3
C) 1 and 4
D) 2 and 4
E) 3 and 4

Interactive Question

- A book is resting on the surface of a table. Consider the following four forces that arise in this situation
  - 1) The force of the earth pulling on the book
  - 2) The force of the table pushing on the book
  - 3) The force of the book pushing on the table
  - 4) The force of the book pulling on the earth
- The book has zero acceleration. Which pair of forces excluding the "action-reaction" pairs, must be equal in magnitude and opposite in direction?

A) 1 and 2
B) 1 and 3
C) 1 and 4
D) 2 and 4
E) 3 and 4

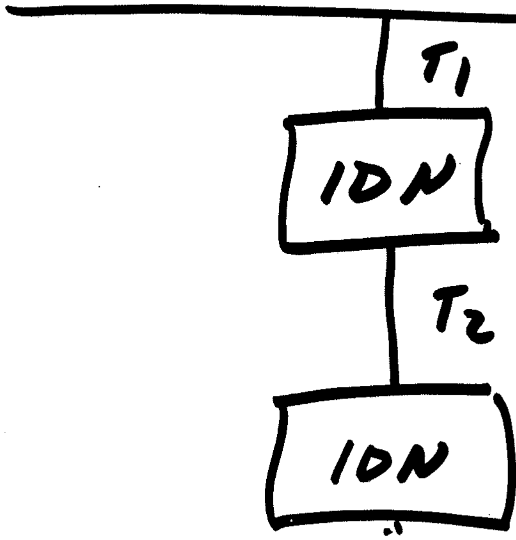
Force of Gravity

Consider an object that has only the force of gravity acting on it.

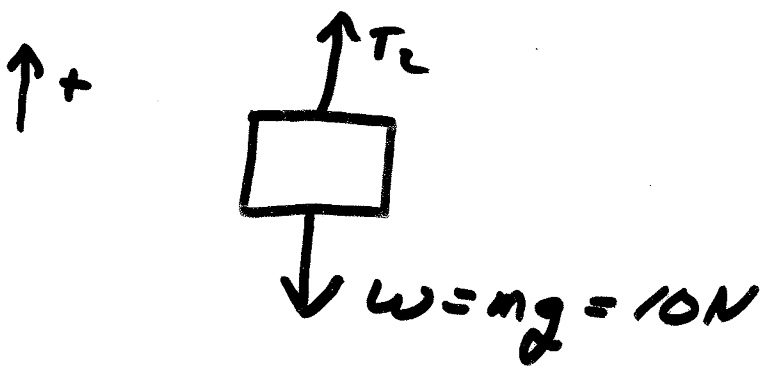
$$\vec{F}_g = m\vec{a} = m\vec{g}$$

This force is called the objects <u>weight</u>

Note mass does not depend on the force of gravity, but weight does.



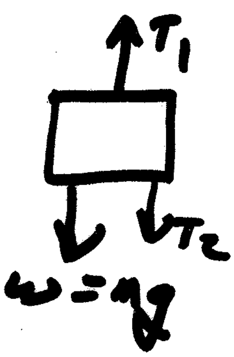
what are Tensions T_1 & T_2?



$$\vec{T}_2 + \vec{w} = 0$$

$$T_2 - w = 0$$

$$T_2 = w = \underline{10N}$$



$$\vec{T}_1 + \vec{T}_2 + \vec{w} = 0$$

$$T_1 - T_2 - w = 0$$

$$T_1 = T_2 + w$$

$$T_1 = 10N + 10N = \underline{20N}$$

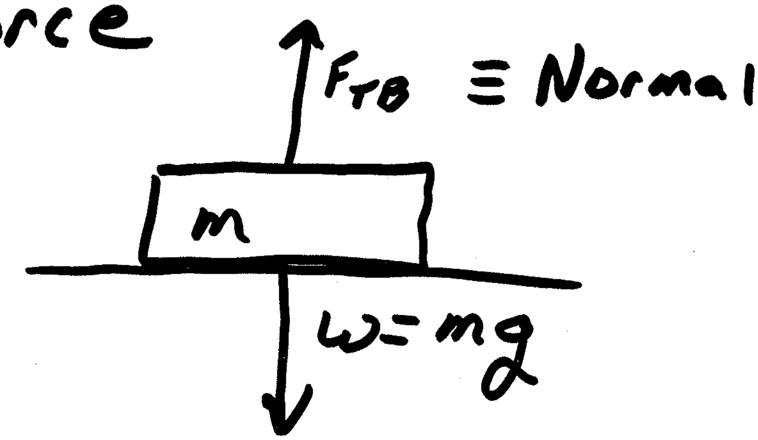
Interactive Question

A 2.0 kg projectile is fired at an angle of 20 degrees. What is the magnitude of the force on the projectile when it is at the highest position in its trajectory?

A) zero
B) 6.7 N
C) 9.8 N
D) 18.4 N
E) 19.6 N

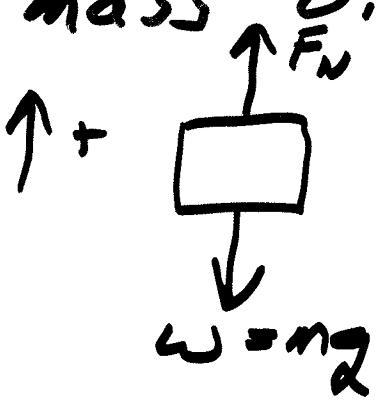
Normal force

Book on table



Normal force <u>always</u> perpendicular to contact surface

what is normal force for a book lying on a flat surface? Book has a mass 0.8 kg



$$\vec{F}_N + \vec{w} = 0$$

$$F_N - w = 0$$

$$F_N = w = mg$$

$$= (.8\,kg)(9.8\,m/s^2)$$

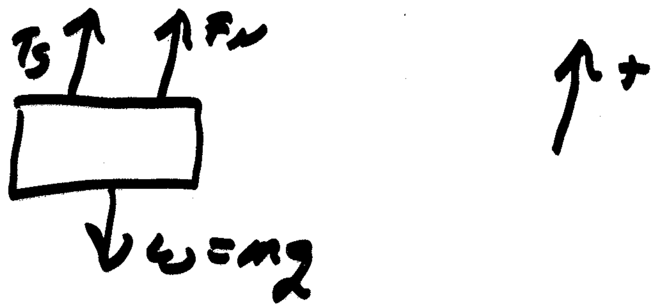
$$= \underline{7.84\,N}$$

A normal force of a book on a table is always

- A) Perpendicular to the surface of the table
- B) Parallel to the surface of the table
- C) Equal to the book’s weight
- D) A & C
- E) B & C

Tie a string on book and pull with a force of 5.0 N

What is the normal force?



$$\vec{T}_S + \vec{F}_N + \vec{w} = 0$$

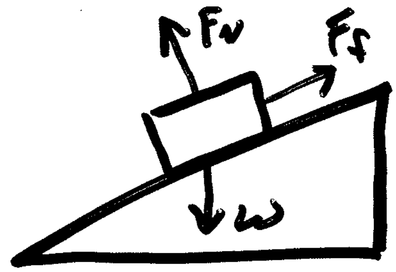
$$T_S + F_N - w = 0$$

$$F_N = w - T_S$$

$$= (8\,kg)(9.8\,m/s^2) - 5.0\,N$$

$$\boxed{F_N = 7.84\,N}$$

Block on an inclined plane



$\vec{F}_N + \vec{w} + \vec{F}_f = 0$

$\vec{F}_f$ = 2 types

object not moving : Static friction

$F_{max} = \mu_s F_N$ ← Normal Force

↑ coefficient of static friction

$F_s \leq \mu_s F_N$

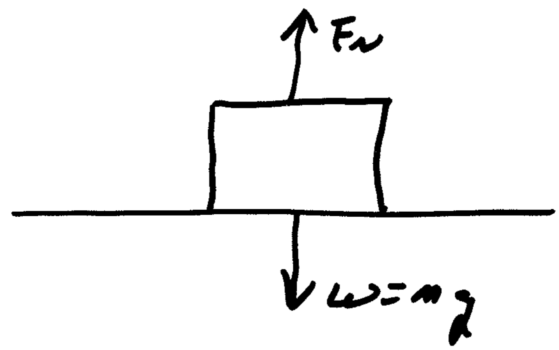
object moving: Kinetic friction

$F_k = \mu_k F_N$

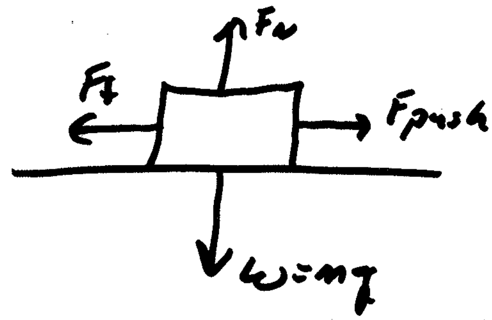
↑ coefficient of kinetic friction

μ_s, μ_k "mu" number between 0-1

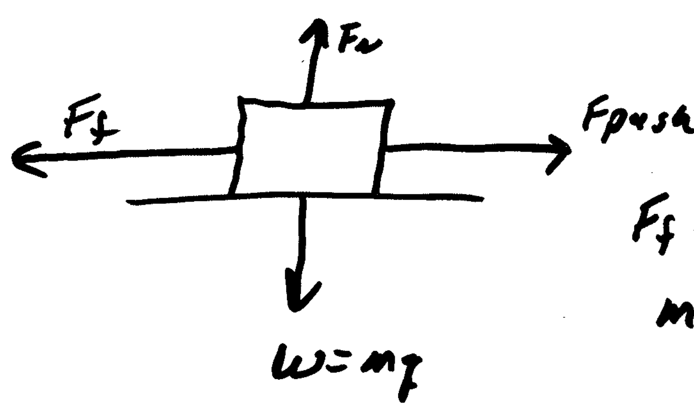
0 icy   1 sticky



$F_f = 0$



$F_f = F_{push}$ magnitude



$F_f = F_{push}$ magnitude

F_f gets larger as F_{push} gets larger until max friction force. Then object moves