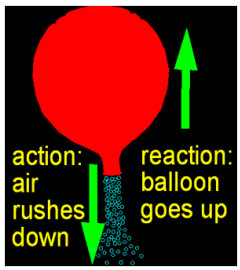
# 4.3 - Newton's 3rd Law

Include several force pairs that students can talk about.

Tidy up Workaround

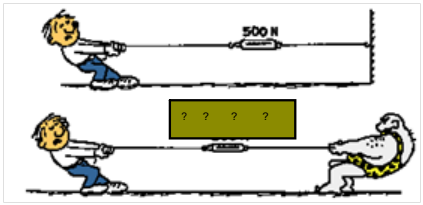



**Simplistic Portrayal of how a Balloon Moves.**

Finish up Example 7

# Newton's Third Law

All forces come in pairs that are equal in magnitude and opposite in direction.
Ergo: "For every action, there is an equal and opposite reaction."



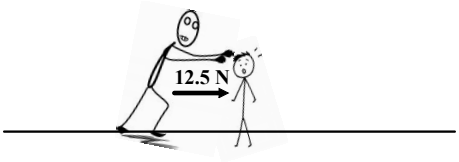

# Icy Examples

On an icy surface (no friction), a 71.3 kg dad pushes an 11.8 kg kid away from himself with a force of 12.5 N.

1. What is the force that the kid exerts on the father?

2. What acceleration does the dad have?

3. What acceleration does the kid have?




# 1: Force

What is the force that the kid exerts on the father?

This is a force pair: the force exerted by the dad (12.5 N) equals the force the kid exerts, but in the opposite direction.

# Acceleration

2. What acceleration does the dad have?

$$F = ma$$

$$a = \frac{F}{m} = \frac{12.5N}{71.3kg} = 0.175\,m/s^2$$

3. What acceleration does the kid have?

$$a = \frac{F}{m} = \frac{12.5N}{11.8kg} = 1.06\,m/s^2$$

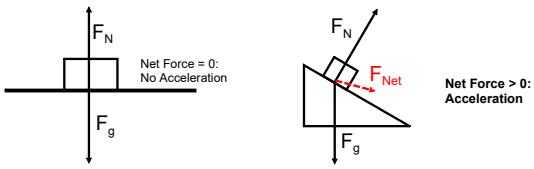
1.06 m/s$^2$ in the opposite direction.

# Normal Force: Part 2

The force that a surface exerts on objects.

Symbol = $F_N$. (Do not confuse with Newton)

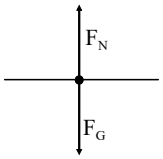
"Normal" means perpendicular to: normal force applies to any surface contacting at any angle.



## 4. Normal Force Example

What is the normal force acting on a 4.50 kg masson a level surface? Make an FBD to conceptualize this.

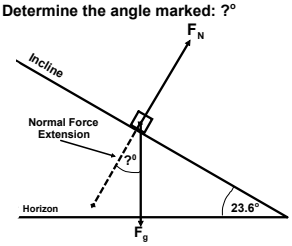
FBD:




$F_G = F_N = mg = (4.50\ kg)(9.81\ m/s^2) = 44.1\ N$

## 5. Geometry Challenge!

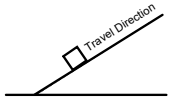
Determine the angle marked: ?°




?° = 23.6° : same as angle of incline.
If there were no friction, exactly what would be the direction of the object's travel?

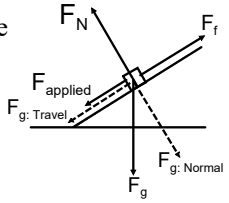
## Prelude to a Workaround

1st: Label the following forces: Gravitational, Normal, Friction, Applied (pulling the object down the slope).




2nd: Which forces are in line with the x and y axes? How would you find the x and y components of the other forces?

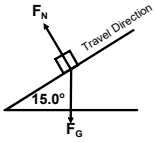
3rd: Which forces contribute to the motion of the object?
How do you find the net force in the direction of travel?
Add Applied, Friction, and Gravity w.r.t. direction of travel.



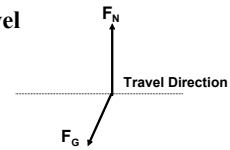

## Force Perspective Workaround

6. What $F_N$ acts on a 4.50 kg mass at a15.0° incline?

A: Make a sketch showing the incline, with $F_G$ and $F_N$.

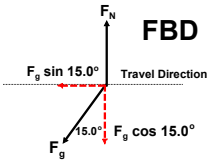



**B. Reorient the travel direction to make it horizontal.**




C. Decompose gravity ($F_g = m \cdot g$) into x and y components.
The y component opposes $F_N$.

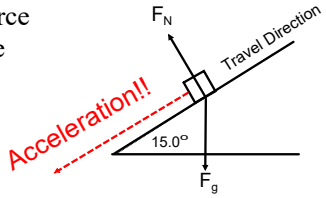
Note: angle is now between y-axis and the vector.




## Force Perspective Workaround

$F_g = mg = 4.50\ kg \cdot 9.81\ m/s^2 = 44.1\ N$
y component of gravity = $F_g \cos\theta$
$= 44.1N \cdot \cos 15^\circ = 42.6\ N$
Thus, the normal force is 42.6 N.

7. What is the acceleration of the box?
The x component of force can be used to calculate acceleration, using Newton's 2nd Law.




## Homework

Preview 4.4

4.3 Problems in your Booklet
Due: Next Class