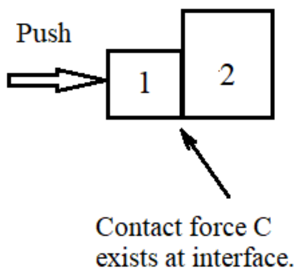
Physics 17   Part C2

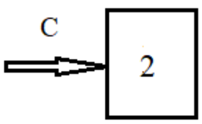
Contact Forces and Tension

The forces that objects exert on each other when they're pressed together are called "contact forces."

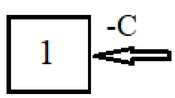
By Newton's 3rd Law, all forces come in pairs, including contact forces:

Whatever is the force one object exerts on a second one, the second one exerts the same force on the first one.





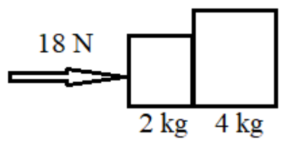
This is the force Block 1 exerts on Block 2.



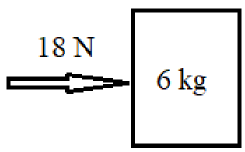
This is the force Block 2 exerts on Block 1.

Example A :

Find the contact force between the two blocks below.

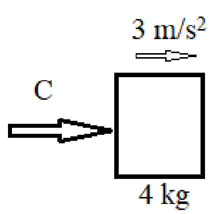


The acceleration of the pair of blocks above is the same as the acceleration of the block below:



$a = F/m$
$= 18/6$
$= 3\ m/s^2$

Each block in the pair has an acceleration of $3\ m/s^2$. Apply Newton's 2^{nd} Law to the 4-kg block alone:

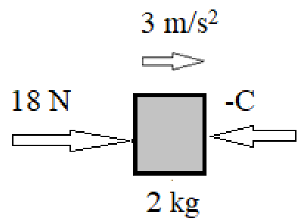


$F = ma$
$C = 4(3)$
$= 12\ N$

Example B:

Another way to find the contact force.

Apply Newton's 2^{nd} Law to the 2-kg block alone:



$F = ma$
$18 - C = 2\ (3)$
$C = 12\ N$

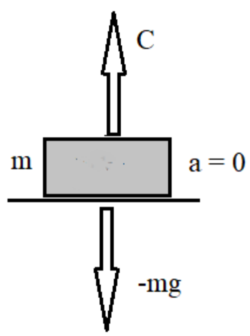
Same result.

Actual Weight versus Apparent Weight

The “apparent” weight of an object is not necessarily the actual weight, mg. The apparent weight of an object is whatever is the contact force exerted upward on it by whatever it is resting on, such as the floor.

<u>Example A</u>:

The object in the figure below is at rest (a = 0) on the floor.



Applying Newton’s Second Law (F = ma) to the object, we have

$$C - mg = 0$$
$$C = mg$$

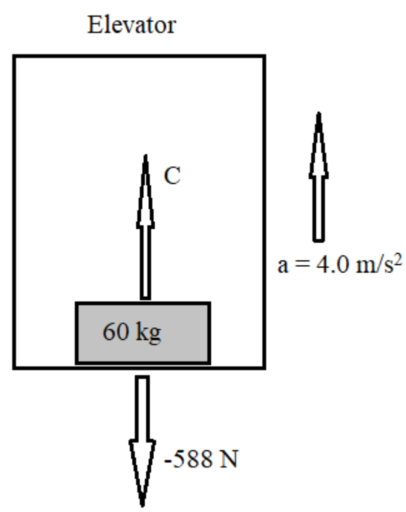
The apparent weight (C) is the same as the actual weight, mg.

In the example at the right, the apparent weight is not the same as the actual weight.

<u>Example B</u>:

(a) What is the actual weight of a 60-kg object accelerating at 4.0 m/s^2 in an elevator?

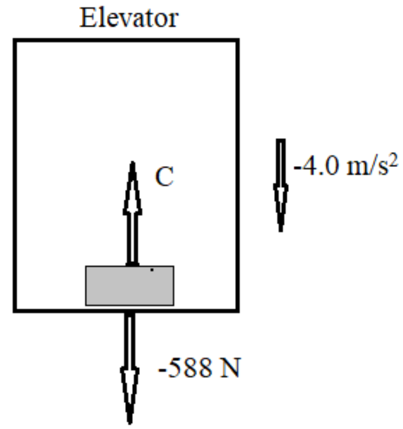
$$mg = 60\,(9.8)$$
$$= 588\text{ N}$$



(b) What is its apparent weight?

$$F = ma$$
$$C - mg = ma$$
$$C - 588\text{ N} = 60\,(4.0)$$
$$C = 828\text{ N}$$

Compare this to the block’s actual weight, which is 588 N. If instead of a block this were a person, she would feel 240 N heavier than she does when she is not accelerating.

<u>Example</u>: At the right, a 60-kg block is accelerating downward at -4.0 m/s² inside an elevator. What is its apparent weight? $F = ma$ $C - mg = ma$ $C - 588 = 60(-4.0)$ $C = 348\ \text{N}$ If this were a person, she would feel 240 N lighter than she does when she's at rest.	

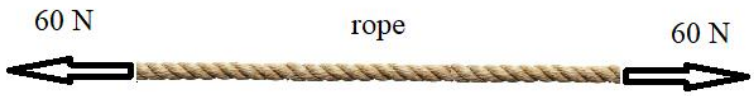
Tension

Ropes that pull on objects are said to be "under tension," or, to "have tension." Tension is a force quantity and therefore is measured in newtons (N).

The tension in a rope at rest is the pulling force applied to each end. These two forces will be the same if the rope is at rest ($a = 0$), i.e., not accelerating, because, according to Newton's 2nd Law, the net force on the rope is zero.

If the forces were not the same, there would be a net force acting on the rope, and therefore the rope would be accelerating, which contradicts our statement that the rope is at rest.

In the figure below, two persons each pull with a 60 N force on their end of a rope. The tension in the rope—by definition—is 60 N.

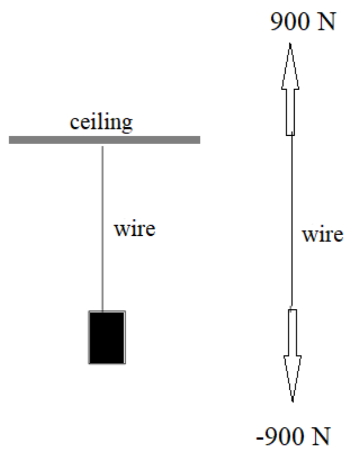


In the figure at the right, a wire is attached to the ceiling; at the other end hangs a 900-N block; we ignore the weight of the wire.

The block is not accelerating, so the ceiling's pull upward matches the Earth's pull downward pull.

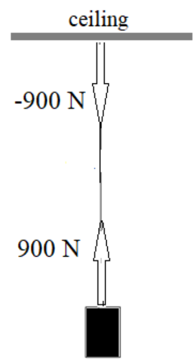
The tension in a wire equals whatever is the force applied to either end. In this case, 900-N pulls are applied to each end of the wire, so the tension in the wire is 900 N.

Note that the wire exerts a 900-N on the things at each end of the wire: . ceiling, and the block.



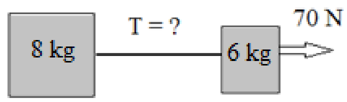
The example above shows what forces are applied to each end of the wire *by* the ceiling and the block. What about the forces exerted by the wire *on* the ceiling and block?

By Newton's Third Law, the forces on the ceiling and block are equal to the forces exerted by the ceiling and block. These forces are shown in the figure at the right:



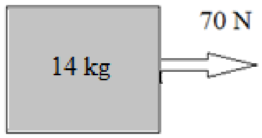
Example:

What is the tension in the wire connecting the two blocks below?



Solution:

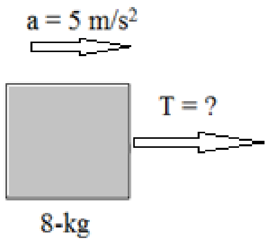
The acceleration of the pair of blocks is the same as would be the acceleration of the single block shown below, whose mass is the sum of the two masses.



$F = ma$
$70 = 14\,a$
$a = 5\ m/s^2$

Each block is accelerating at the rate: $a = 5\ m/s^2$.

Isolate the 8-kg block and apply Newton's 2nd Law to it:



$F = ma$
$T = 8\,(5)$
$= 40\ N$