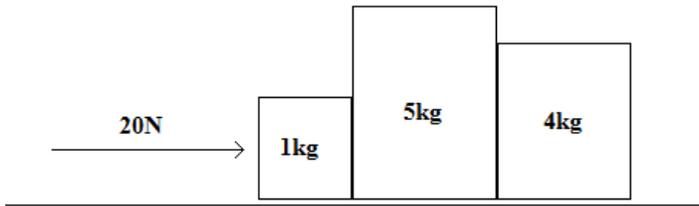


## Dynamics of systems

Suppose you have a set of three boxes sitting on a frictionless surface and you push on the 1kg box with a force of 20N to the right. What will be the forces of the 1kg box on the 5kg box and the 5kg box on the 4kg box?

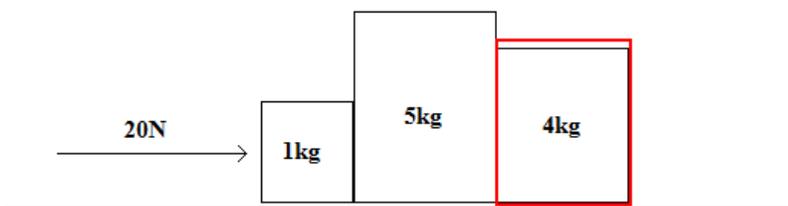


In situations like these, where multiple objects are accelerating together, it is best to determine first the acceleration of the system. You do this simply by applying  $F = m \cdot a$  to the entire system.



In the y-dimension, the force of gravity on the system is  $-98\text{N}$  and the normal force is  $+98\text{N}$ , so the net force is zero. In the x-dimension, the only force is the push, so the net force is  $20\text{N}$ . With a system mass of  $10\text{kg}$ , the acceleration of the system must be  $2\text{m/s}^2$ .

Now you can begin to focus on components of the system. For instance, focus of the 4kg box.



Vertically, gravity is  $-39.2\text{N}$  and the normal force is  $+39.2\text{N}$ . The net horizontal force is mass times acceleration and the acceleration was just found to be  $2\text{m/s}^2$ . So this is  $8\text{N}$ , which can only come from the 5kg box, as this is the only force acting horizontally on the 4kg box. It may be tempting to think that the  $20\text{N}$  push acts on all boxes, but it is only acting on the 1kg box.

Now focus on the combination of 5kg and 4kg boxes.



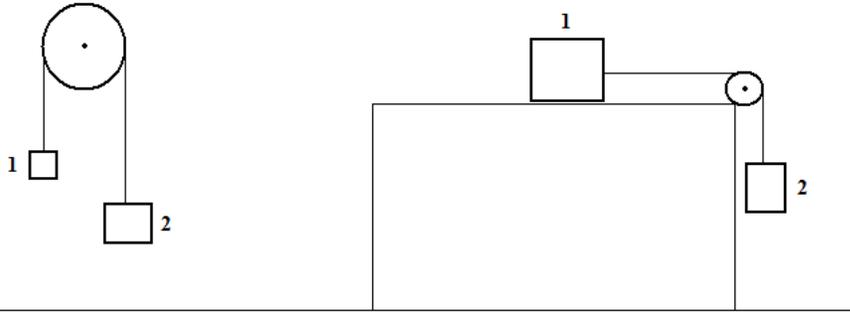
Again, the vertical net force will be zero. The mass of this combination is 9kg and the acceleration of the combination is  $2\text{m/s}^2$ , so the net horizontal force on the combination is 18N. This force can only come from the 1kg box, so the force of the 1kg box on the 5kg box is 18N.

By Newton's third law, the 5kg box pushes on the 1kg box with a force of -18N, making the net force on the 1kg box 2N, which matches its mass times its acceleration.

Answer Webassign Question 1

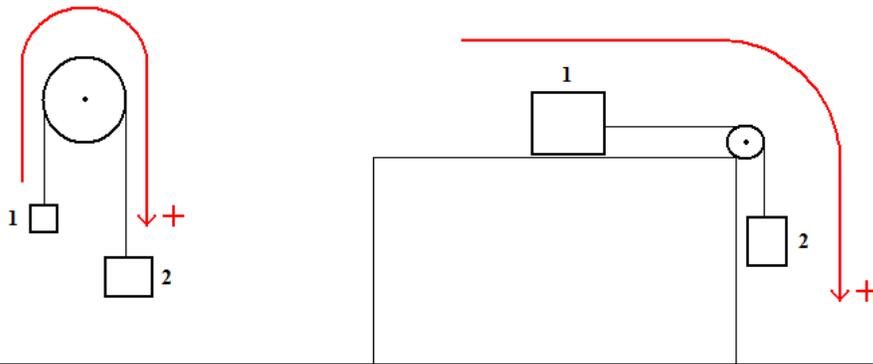
Answer Webassign Question 2

Answer Webassign Question 3



This idea of looking at systems first is useful for problems like the Atwood's machine on the left or the modified Atwood's machine on the right. On the left, block two will accelerate down as block one accelerates up. On the right, block two will accelerate down as block one accelerates right.

To avoid confusions with signs, it is best to imagine taking an axis and aligning it with the line of motion, even if that means making the axis curved.



In the left diagram, this means the force of gravity on block 1 will be negative, but the force of gravity on block two will be positive.

Answer Webassign Question 4

In the right diagram, this means the force of gravity on block 2 will be positive. If there is a force of friction to the left on block 1, it will be negative.

Answer Webassign Question 5

To review:

When multiple objects accelerate together, find the acceleration of the system. You can then focus on components of the system to determine the various internal forces involved.