Introduction to Mechanics
Applying Newton's Laws
Pulleys
Objects Moving Together

Lana Sheridan

De Anza College

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Last time

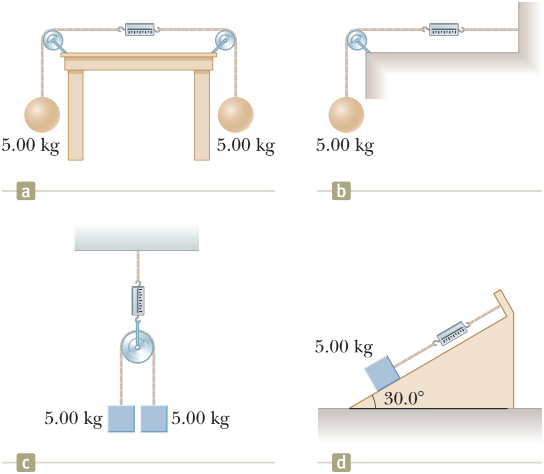
- static equilibrium
- tension and statics
- elevators again
- pulleys

Overview

- objects accelerated together
- introducing the Atwood machine

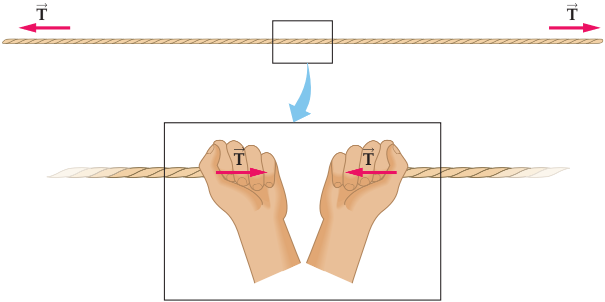
Tension and Force Meters

28. The systems shown in Figure P5.28 are in equilibrium.
W If the spring scales are calibrated in newtons, what do they read? Ignore the masses of the pulleys and strings and assume the pulleys and the incline in Figure P5.28d are frictionless.



Tension Reminder

The force exerted by a rope or chain to suspend or pull an object with mass.



[1] Figure from Walker, "Physics".

Tension and Force Meters

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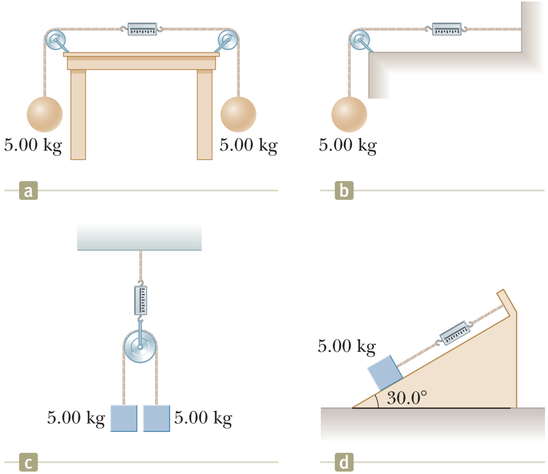
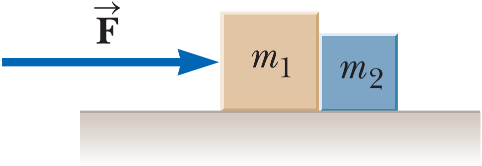


Answers: a) 49 N, b) 49 N, c) 98 N, d) 24.5 N

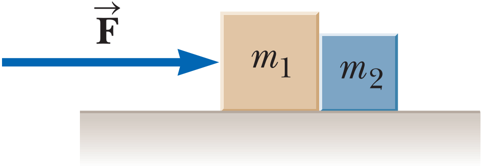
Separate Objects Pushed Together

Consider a force $\vec{\mathbf{F}}$ that acts on two objects, masses m_1 and m_2, free to slide on a frictionless surface:



Separate Objects Pushed Together

Question. What is the acceleration of object m_2?



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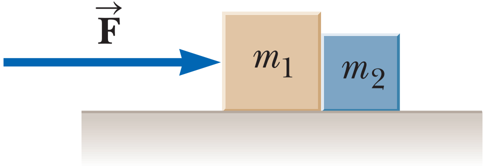

We could imagine that the two blocks are one large block of mass $(m_1 + m_2)$. This works because the two blocks will move together.

$$\vec{\mathbf{F}}_{\text{net}} = \vec{\mathbf{F}} + \vec{\mathbf{n}} + (m_1 + m_2)\vec{\mathbf{g}} = \vec{\mathbf{F}} = (m_1 + m_2)\vec{\mathbf{a}}$$

Then

$$\vec{\mathbf{a}} = \frac{\vec{\mathbf{F}}}{m_1 + m_2}$$

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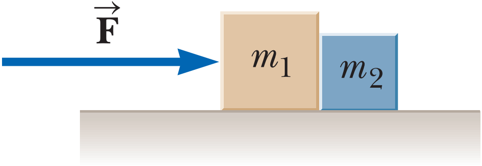

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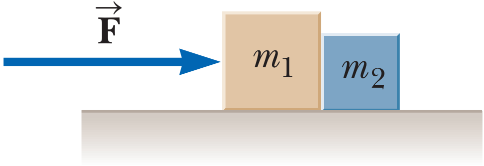

It is not $\vec{\mathbf{F}}$!

We can use Newton's second law again, but now our system will only be block 2.

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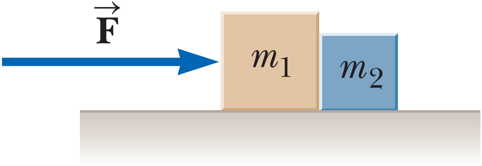

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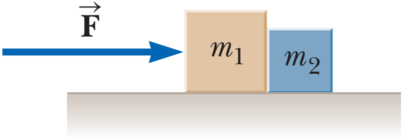
Using our expression for $\vec{\mathbf{a}}$:

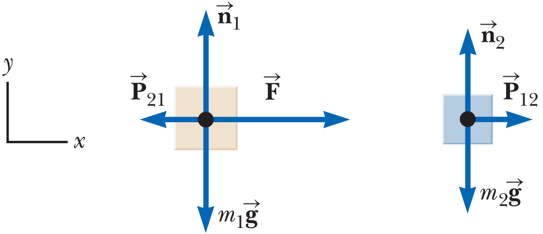
$$\vec{\mathbf{F}}_{\text{net},2} = \frac{m_2 \vec{\mathbf{F}}}{m_1 + m_2}$$

Separate Objects Pushed Together

Main Idea: if objects are pushed or pulled together, then they must all accelerate at the same rate.

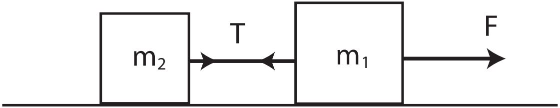


But if m_1 and m_2 are not equal, that means that the individual net forces on each must be different:



Separate Objects Pulled Along

Consider two blocks tied together and pulled along a frictionless surface.



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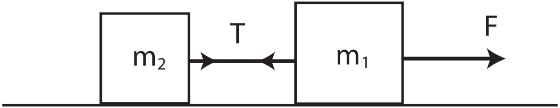

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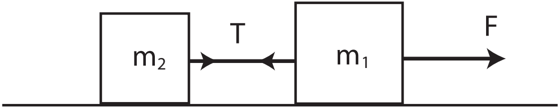

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The accelerations of the two blocks are the same.

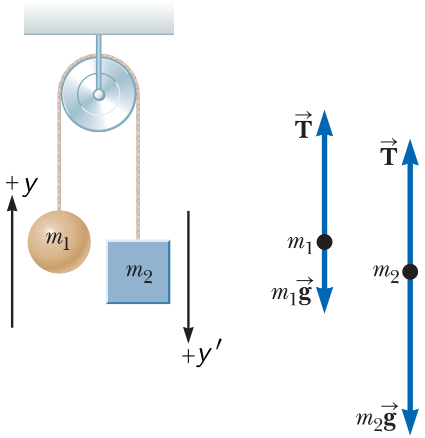
Imagining them as a single block gives the acceleration straight away:

$$\vec{\mathbf{a}} = \frac{\vec{\mathbf{F}}}{m_1 + m_2}$$

What is the tension in the rope connecting the blocks?

Pulleys and the Atwood Machine

The Atwood Machine can be used to make careful determinations of g, as well as explore the behavior of forces and accelerations.



[1] http://en.wikipedia.org/wiki/Atwood_machine

Summary

- objects accelerated together
- introducing the Atwood machine

Homework

Walker Physics:

- Ch 5, onwards from page 138. Problems: 21 (blocks moving together)
- Ch 6, Problems: 49 (blocks pulled along)