Physics 1021

Spring 2012
Chapter 7

Announcements

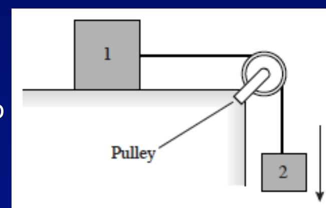
- This week's homework …. 2 parts
  last one due tonight
- Today's class:
  - Newton's third law
  - Pulleys
  - Tension
- Circular motion
- Quiz on Friday, Ch 5 and 6
- First exam Weds, Feb 22, Chs 1-8, 6 PM to 8 PM, Funger 108
  - Email me if there is a class conflict for you at the exam time

Kinetic constraints

When two or more objects are connected by strings, pulleys, or are rigidly connected, then they no longer move independently. The constraints between their positions, velocities and accelerations can be used to ease the solving of their motion.

For example in the picture below, all three types of constraints are in play:

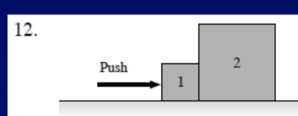
- Ropes: Masses 1 and 2 move and accelerate at the same rate
- Pulleys: The velocity of the masses is equal to the radius times the angular velocity of the pulley (as are the linear and angular accelerations

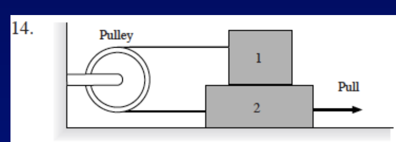


- Rigid body: All points at a given distance from the pulley center have the same acceleration.

Acceleration constraints

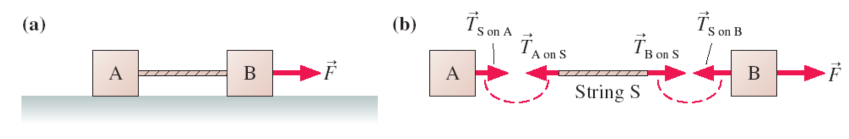
For each picture, write the acceleration constraint in terms of *components. For example, write $(a_1)_x = (a_2)_y$, if that is the appropriate answer, rather than $a_1 = a_2$*





The Massless String Approximation

FIGURE 7.22 The string's tension pulls forward on block A, backward on block B.



Often in physics and engineering problems the mass of the string or rope is much less than the masses of the objects that it connects. In such cases, we can adopt the following massless string approximation:

$$T_{\text{B on S}} = T_{\text{A on S}} \qquad \text{(massless string approximation)}$$

Third law: $T_{sonA} = T_{sonB}$

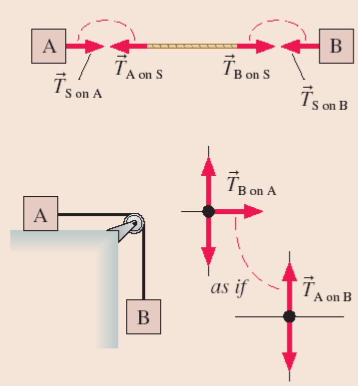
Applications

Strings and pulleys

The tension in a string or rope pulls in both directions. The tension is constant in a string if the string is:

- Massless, or
- In equilibrium

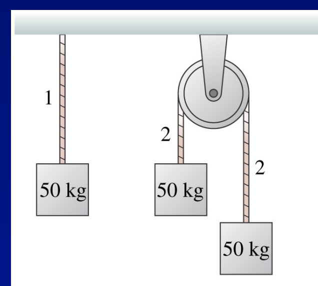
Objects connected by massless strings passing over massless, frictionless pulleys act *as if* they interact via an action/reaction pair of forces.



ConcepTest 7.5 Tension

All three 50 kg blocks are at rest. Is the tension in rope 2 greater than, less than, or equal to the tension in rope 1?

A. Equal to
B. Greater than
C. Less than

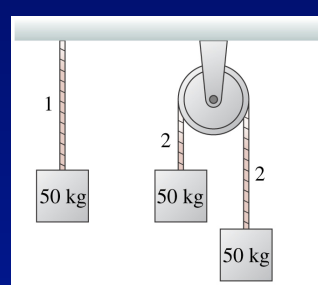


ConcepTest 7.5 Tension

All three 50 kg blocks are at rest. Is the tension in rope 2 greater than, less than, or equal to the tension in rope 1?

A. Equal to
B. Greater than
C. Less than

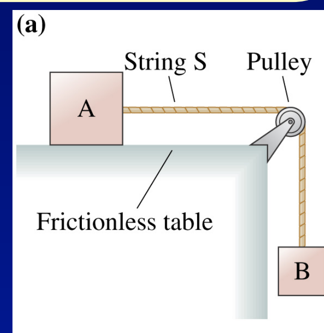
Each block feels an upward force of 490 N, which is provided by the tension. Therefore both ropes have the same tension.



ConcepTest 7.6 Tension II

In the figure, is the tension in the string greater than, less than, or equal to the weight of block B?

A. Equal to
B. Greater than
C. Less than

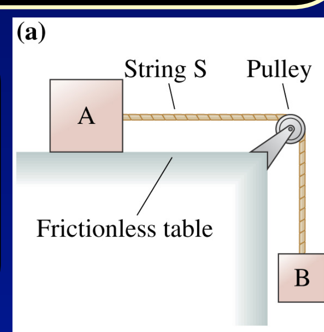


ConcepTest 7.6 Tension II

In the figure, is the tension in the string greater than, less than, or equal to the weight of block B?

A. Equal to
B. Greater than
C. Less than

The blocks are accelerating, since there is no force to hinder block A. This means that the net force on B {mg – T} is not zero and is downward. Thus mg > T



ConcepTest 7.7 Tension III

A 500 g weight is hung from a rubber band, which hangs from the hook on a spring scale? What is the measurement on the spring scale?

A. Less than 500g
B. equal to 500 g
C. more than 500 g

ConcepTest 7.7 Tension III

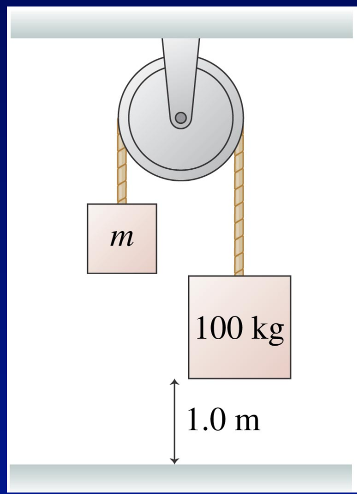
A 500 g weight is hung from a rubber band, which hangs from the hook on a spring scale? What is the measurement on the spring scale (ignore the weight of the rubber band)?

A. Less than 500g
B. equal to 500 g
C. more than 500 g

Neither the rubber band not the weight are accelerating. Therefore the net force on each is zero. Gravity pulls down of the weight and the rubber band pulls up with equal and opposite force. The weight pulls down on the rubber band with the same force, and in turn, the scale pulls up on the rubber band with the identical force, mg, (m = 0.5 kg

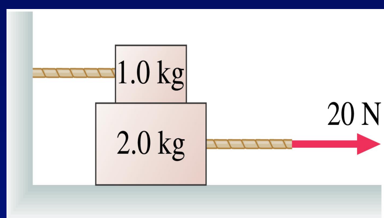
Atwood's machine

- An Atwood's machine is shown in the figure. The 100 kg block on the right side takes 6.0 s to reach the floor after it is released from rest.
- **What is the mass of the block on the left side?**



Ponderable: Sliding blocks

- A 1.0 kg block is tied to the wall with a rope. It sits on top of a 2.0 kg block. The lower block is pulled to the right with a tension force of 20 N. The coefficient of kinetic friction at both the lower and upper surfaces of the 2.0 kg block is $\mu_k = 0.40$



What is the tension in the rope attached to the 1.0 kg block?
What is the acceleration of the 2.0 kg block?

Tangible: Stretch it yourself

1. Take one rubber band and hang a heavy weight from it. Hang the other end from the spring scale. How far does it stretch? Call this length l_0. What is the reading of the scale?
2. Combine two rubber bands in a chain (end to end) and hang the same weight from the combination. How far does it stretch? Why?

For the questions below, answer only in integer numbers of rubber bands

3. About how many identical rubber bands must be combined (and how) to stretch by l_0 under the load of two heavy weights? Try this. Calculate the force on each rubber band? Draw the fbd for the mass. Draw the fbd for each rubber band.
4. About how many identical rubber bands must be combined (and how) to stretch by l_0 under the load of a mass smaller than the original one? Try this. Calculate the force on each rubber band? Draw the fbd for the mass.