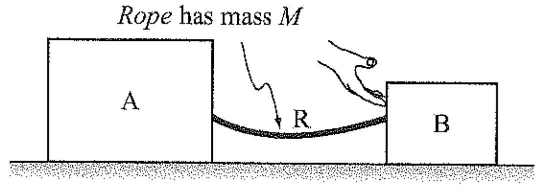
I. Blocks connected by a rope

Two blocks, A and B, are tied together with a rope of mass M. Block B is being pushed with a constant horizontal force as shown at right. Assume that there is no friction between the blocks and the table and that the blocks have already been moving for a while at the instant shown.



A. Describe the motions of block A, block B, and the rope.

B. On a large sheet of paper, draw a separate free-body diagram for each block and for the rope. Clearly label the forces.

Copy your free-body diagrams below after discussion.

Free-body diagram for block A	Free-body diagram for rope	Free-body diagram for block B

C. Identify all the *Newton's third law (action-reaction)* force pairs in your diagrams by placing one or more small "×" symbols through each member of the pair *(i.e.,* mark each member of the first pair as —×—▶, each member of the second pair as —××—▶, *etc.).*

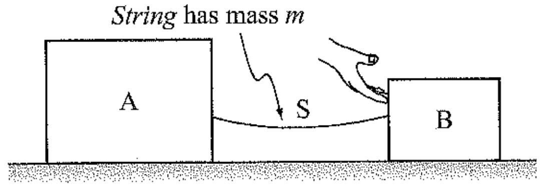
D. Rank, from largest to smallest, the magnitudes of the *horizontal components* of the forces on your diagrams. Explain your reasoning.

E. Consider the horizontal components of the forces exerted *on the rope* by blocks A and B. Is your answer above for the relative magnitudes of these components consistent with your knowledge of the net force on the rope?

➪ Check your reasoning with a tutorial instructor before proceeding.

II. Blocks connected by a very light string

The blocks in section I are now connected with a very light, flexible, and inextensible string of mass m $(m < M)$.



A. If the motion of the blocks is the same as in section I, how does the net force on the *string* compare to the net force on the *rope?*

1. Determine whether the net force on each of the following is *greater than, less than,* or *equal to* the net force on the corresponding object or system in section I. Explain.

   - block A

   - block B

   - the system composed of the blocks and the connecting string

2. Compare the horizontal components of the following pairs of forces:

   - the force on the string by block A and the force on the rope by block A. Explain.

   - the force on the string by block B and the force on the rope by block B. Explain.

B. Suppose the mass of the string that connects blocks A and B becomes smaller and smaller, but the motion remains the same as in section I. What happens to:

- the magnitude of the net force on that connecting string?

- the magnitudes of the forces exerted on that connecting string by blocks A and B?

C. A string exerts a force on each of the two objects to which it is attached. For a massless string, the magnitude of both forces is often referred to as "the tension in the string."

Justify the use of this approach, in which a *single value* is assumed for the magnitude of both forces.

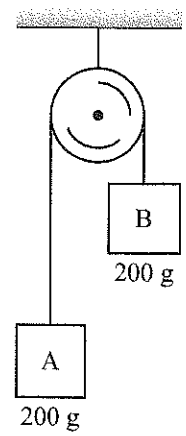
D. If you know that the net force on a massless string is zero, what, if anything, can you infer about its motion?

Is it possible to exert a non-zero force on a massless string? Is it possible for a massless string to have a non-zero *net* force? Explain.

➪ Discuss your answers above with a tutorial instructor before continuing.

III. The Atwood's machine

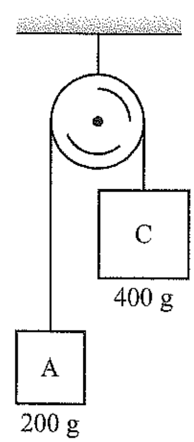
The Atwood's machine at right consists of two identical objects connected by a massless string that runs over an ideal pulley. Object B is initially held so that it is above object A and so that neither object can move.



A. Predict the subsequent motions of objects A and B after they are released. Explain the basis for your description. Do not use algebra.

B. Draw separate free-body diagrams for objects A and B. Are your free-body diagrams consistent with your prediction of the motion of the objects?

C. Object B is replaced by object C, of greater mass. Object C is initially held so that it is higher than object A and so that neither object can move.



Predict:

- what will happen to object C when it is released.

- how the motion of object C will compare to the motion of object A after they are released.

Explain the basis for your predictions. Do not use algebra.

D. Draw and label separate free-body diagrams for objects A and C *after* they are released. Indicate the relative magnitudes of the forces by the relative lengths of the force vectors.

Are the predictions you made in part C consistent with your free-body diagrams for objects A and C? If so, explain why they are consistent. If not, then resolve the inconsistency.

E. The weight of a 200 g mass has magnitude (0.2 kg)(9.8 m/s^2) ≈ 2 N. Similarly, the weight of a 400 g mass is approximately 4 N in magnitude.

1. How does the force exerted on object A by the string compare to these two weights?

2. How does the force exerted on object C by the string compare to these two weights?

   Explain your answers.

3. How does the net force on object A compare to the net force on object C? Explain.

F. Consider the following statement about the Atwood's machine made by a student.

"All strings can do is transmit forces from other objects. That means that the string in the Atwood's machine just transmits the weight of one block to the other. So the force upward on each block is equal to the weight of the other block."

Do you agree with this student? Explain your reasoning.

➪ Check your reasoning with a tutorial instructor.