Flipping Physics Lecture Notes:

Free Response Question #1 - AP Physics 1 - 2015 Exam Solutions
http://www.flippingphysics.com/ap1-2015-frq1.html

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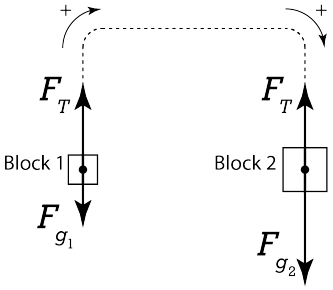
This Short Answer question also works as a part of the AP Physics C: Mechanics curriculum.

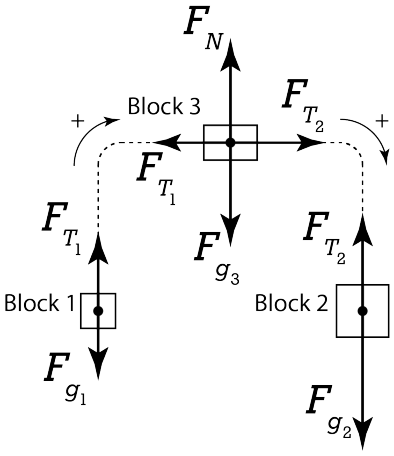
(a) First off, we know both blocks have a force of gravity acting downward on them. Let's label them F_{g_1} & F_{g_2}. We also know there is a force of tension upward on each block and, because there are no other objects attached to or pulling on the string between blocks 1 and 2, both forces of tension are the same. For the two tensions to be the same, it is also necessary that the string be massless and the pulleys be massless and frictionless, which they are. Let's label these forces of tension F_T. Now, about their magnitudes. Because block 2 has a greater mass than block 1, F_{g_2} should have a greater magnitude (or length) than F_{g_1}. This also tells us block 2 accelerates down and block 1 accelerates up. For this to happen, F_T on block 1 must be greater than F_{g_1} (to cause block 1 to accelerate upward) and F_T on block 2 must be less than F_{g_2} (to cause block 2 to accelerate downward).



Be careful with your free body diagrams! They are answers! They need to be clearly drawn and with lengths proportional to their relative magnitudes. You need to label each force. And do not break forces into components in your original free body diagram.

(b) We can sum the forces on both blocks simultaneously in the direction I have indicated in the free body diagram above (positive in the direction both blocks accelerate). Realize block 1 and 2 will have the same acceleration because they are attached to one another by the string.

$$\sum F_+ = F_{g_2} - F_T + F_T - F_{g_1} = m_t a \Rightarrow m_2 g - m_1 g = \left(m_1 + m_2\right) a \Rightarrow a = \frac{m_2 g - m_1 g}{m_1 + m_2} = \boxed{\frac{\left(m_2 - m_2\right) g}{m_1 + m_2}}$$



(c) Adding a block doesn't change the magnitude of the net force; it only increases the total mass. Therefore, using Newton's Second Law, $\sum \vec{F} = m\vec{a}$, if the net force stays the same and the mass increases, the acceleration must decrease. More specifically:

$$\sum F_+ = F_{g_2} - F_{T_2} + F_{T_2} - F_{T_1} + F_{T_1} - F_{g_1} = m_t a$$

$$\Rightarrow m_2 g - m_1 g = \left(m_1 + m_2 + m_3\right) a \Rightarrow a = \frac{m_2 g - m_1 g}{m_1 + m_2 + m_3}$$

which is less than the original acceleration from part (b).

Notice there are no numbers in this problem. YOU NEED TO LET GO OF YOUR NUMBERS DEPENDENCY and be able to solve problems with variables only. This will help you answer questions with no numbers like this one, which will most certainly come up again on the AP Physics 1 exams!