Flipping Physics Lecture Notes:

2019 #2 Free Response Question - AP Physics 1 - Exam Solution
http://www.flippingphysics.com/ap1-2019-frq2.html

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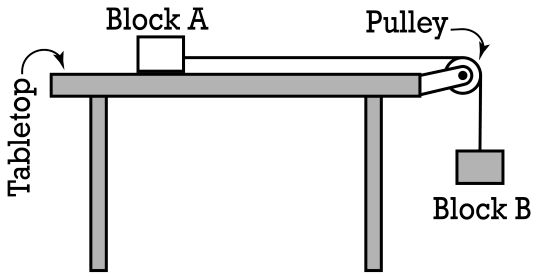
This Quantitative/Qualitative Translation question also works as a part of the AP Physics C: Mechanics curriculum.

This problem explores how the relative masses of two blocks affect the acceleration of the blocks. Block A, of mass m_A , rests on a horizontal tabletop. There is negligible friction between block A and the tabletop. Block B, of mass m_B , hangs from a light string that runs over a pulley and attaches to block A, as shown. The pulley has negligible mass and spins with negligible friction about its axle. The blocks are released from rest.



(a) i. Suppose the mass of block A is much greater than the mass of block B. Estimate the magnitude of the acceleration of the blocks after release.

The magnitude of the acceleration of block A after release is nearly zero.

Briefly explain your reasoning without deriving or using equations.

Block A is so massive that it has enough inertia to almost completely resist the relatively small tension force in the string which is caused by the relatively small force of gravity on block B.

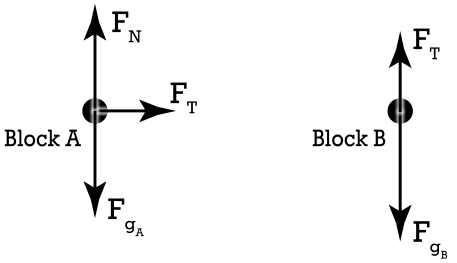
(a) ii. Now suppose the mass of block A is much less than the mass of block B. Estimate the magnitude of the acceleration of the blocks after release.

The magnitude of the acceleration of block A after release is nearly 9.81 m/s^2.

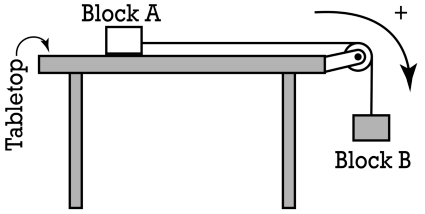
Briefly explain your reasoning without deriving or using equations.

In the absence of block A, block B would be in free fall and have an acceleration of 9.81 m/s^2 down. The relatively small mass of block A only causes a small tension force up on block B to decrease the magnitude of block B's acceleration slightly.

(b) Now suppose neither block's mass is much greater than the other, but that they are not necessarily equal. The dots below represent block A and block B, as indicated by the labels. On each dot, draw and label the forces (not components) exerted on that block after release. Represent each force by a distinct arrow starting on, and pointing away from, the dot.



(c) Derive an equation for the acceleration of the blocks after release in terms of m_A , m_B , and physical constants, as appropriate. If you need to draw anything other than what you have shown in part (b) to assist in your solution, use the space below. Do NOT add anything to the figure in part (b).



Define the positive direction as to the right on block A and down on block B. And then sum the forces on both blocks in that positive direction:

$$\sum_{\substack{\text{on both blocks}\\ \text{in+direction}}} F = F_{g_B} - F_T + F_T = m_t a \Rightarrow m_B g = \left(m_A + m_B\right) a \Rightarrow a = \left(\frac{m_B}{m_A + m_B}\right) g$$

(d) Consider the scenario from part (a)(ii), where the mass of block A is much less than the mass of block B. Does your equation for the acceleration of the blocks from part (c) agree with your reasoning in part (a)(ii) ? _X_ Yes ____ No

Briefly explain your reasoning by addressing why, according to your equation, the acceleration becomes (or approaches) a certain value when m_A is much less than m_B .

If m_A is much less than m_B then the quantity $\left(\frac{m_B}{m_A + m_B}\right)$ is nearly 1 and therefore the magnitude of the acceleration of both blocks is nearly equal to g or 9.81 m/s^2.

Grading Note: Part (d) is worth 1 point and you can get that 1 point with a "no" answer, as long as you give "valid reasoning that addresses the result in part (c) and the reasoning in part (a) double i"

(e) While the blocks are accelerating, the tension in the vertical portion of the string is T_1 . Next, the pulley of negligible mass is replaced with a second pulley whose mass is not negligible. When the blocks are accelerating in this scenario, the tension in the vertical portion of the string is T_2 . How do the two tensions compare to each other?

_X_ $T_2 > T_1$ ____ $T_2 = T_1$ ____ $T_2 < T_1$ Briefly explain your reasoning.

The addition of a pulley with non-negligible mass will increase the resistance of the system to change in velocity and therefore the new acceleration will be less than the original acceleration. We can sum the forces on block B to determine how this affects the tension force.

$$\sum_{\substack{\text{on block } B\\ \text{in + direction}}} F = F_{g_B} - F_T = m_B a \Rightarrow F_T = F_{g_B} - m_B a$$

Therefore, when acceleration is decreased the tension force is increased.

Note about grading: Part (e) is worth 2 points and you can get 1 point even if you mark the incorrect tension comparison, as long as the physics of your argument is sound. In other words, you can get the wrong answer and still get half the points. Please, answer every part of every question. You never know what will get you points, however, not answering the question is certain to get you zero points.