a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Physics
Dynamics: Forces

Science and Mathematics
Education Research Group

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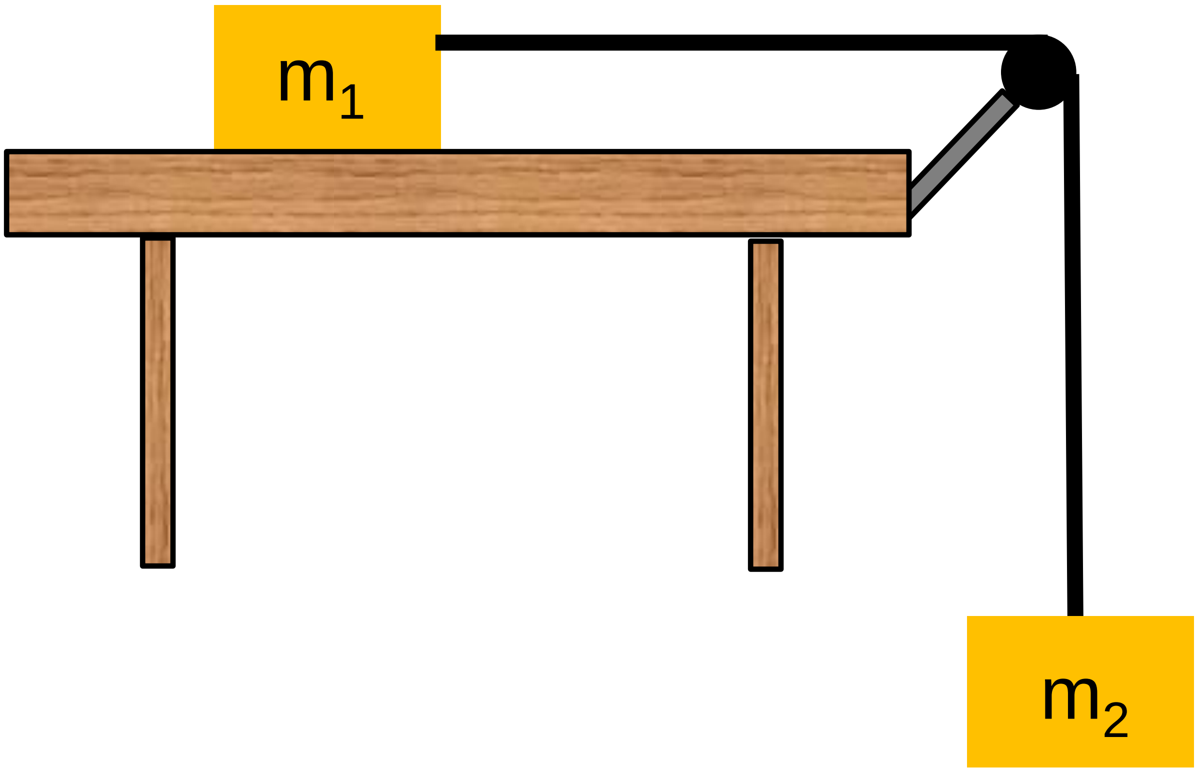
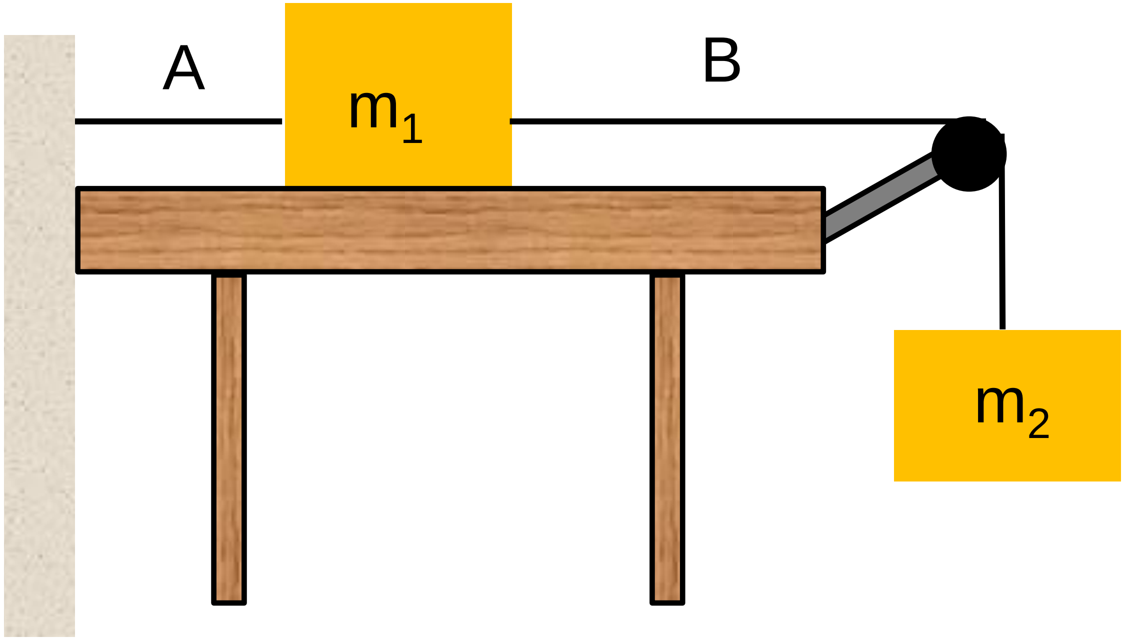
Blocks and a Pulley



Blocks and a Pulley I

Two blocks are connected via a pulley. The blocks are initially at rest as block m_1 is attached to a wall. If string B breaks, what will the accelerations of the blocks be? (Assume the strings don't stretch)



A. $a_1 = 0;\ a_2 = 0$

B. $a_1 = g;\ a_2 = g$

C. $a_1 = 0;\ a_2 = g$

D. $a_1 = g;\ a_2 = 0$

E. None of the above

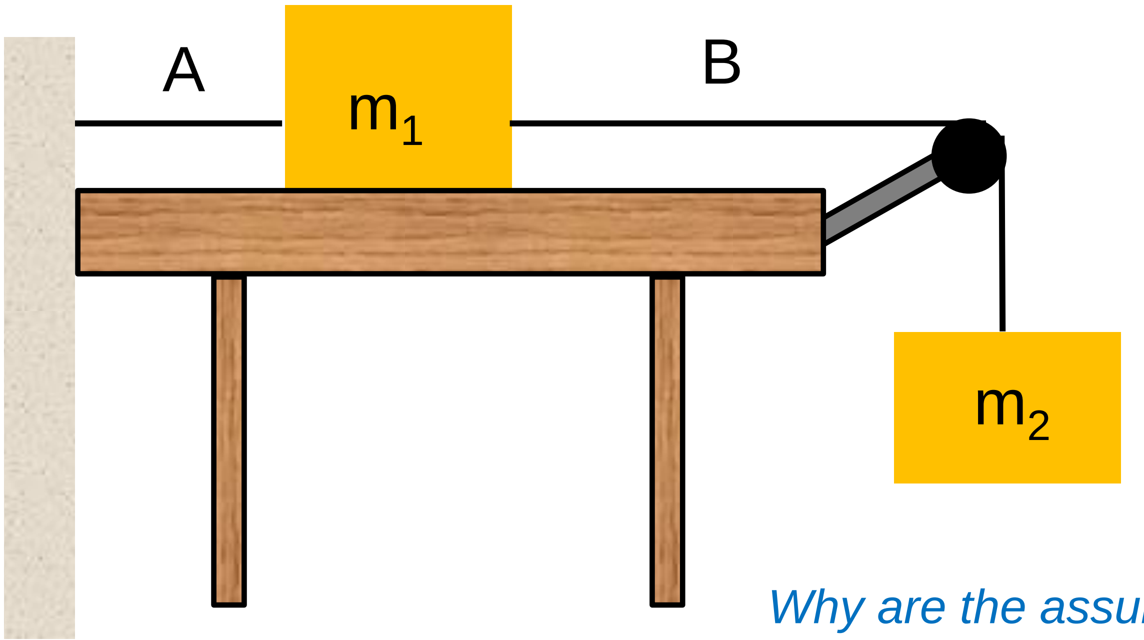
Solution

Answer: C

Justification: After string B is broken, the two blocks will no longer be attached to each other. Block 1 is still attached to the wall and will remain stationary on the table. An object at rest has no acceleration. Because block 2 is hanging off the table when the string breaks, it will then be in free fall. An object in free fall has acceleration g.

Blocks and a Pulley II

Two blocks are connected via a pulley. The blocks are initially at rest as block m_1 is attached to a wall. If string A breaks, what will the acceleration of the blocks be? (**Assume** friction is very small and strings don't stretch)



A. $a_1 = 0$; $a_2 = 0$
B. $a_1 = g$; $a_2 = g$
C. $a_1 = 0$; $a_2 = g$
D. $a_1 = g$; $a_2 = 0$
E. None of the above

Why are the assumptions above important?

Solution

Answer: E

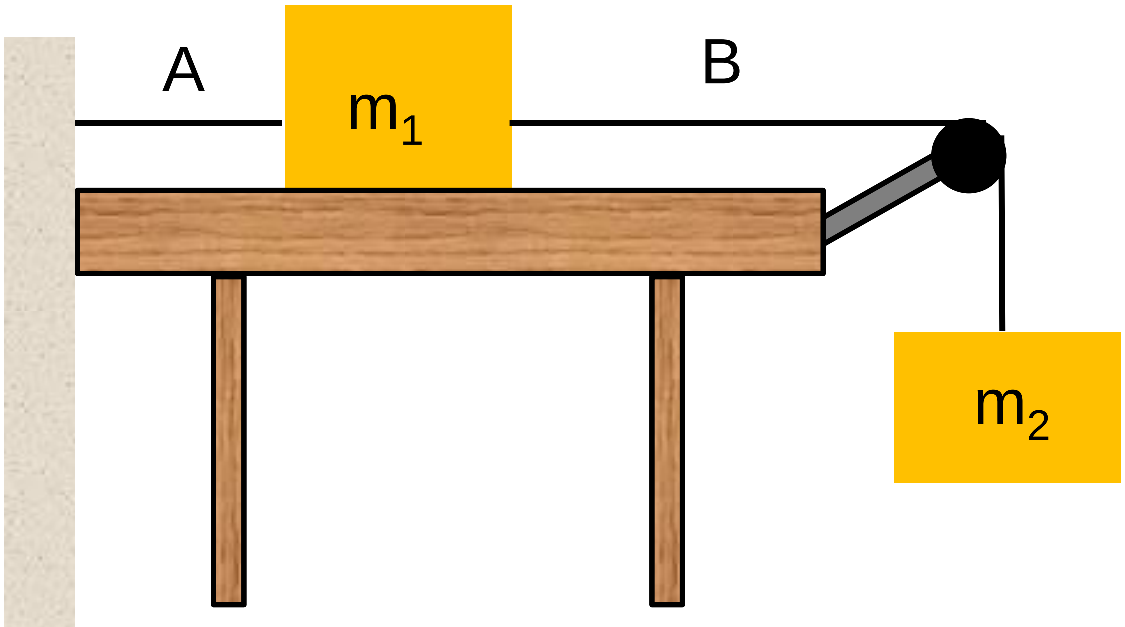
Justification: Since the string has been cut, block 2 will fall, and the both blocks will begin to move, meaning that acceleration cannot be 0 for either block. Consider two blocks as one system. Since they are attached, the blocks will be moving with the same velocity and acceleration. The system has a mass of (m_1+m_2), while the net force pulling the system down is m_2g. Thus the system is not in free fall. Therefore, applying Newton's second law, one can see that the acceleration of the system must be less than g:

$$F = ma \qquad m_2 g = (m_1 + m_2)a \qquad a = \frac{m_2 g}{(m_1 + m_2)} = \frac{m_2}{(m_1 + m_2)} g < g$$

Compare this question to the previous one.

Blocks and a Pulley III

Two blocks are connected via a pulley. The blocks are initially at rest as block m_1 is attached to a wall. If string A breaks, what will the accelerations of the blocks be? (**Assume** friction is very small and strings don't stretch)



A. $a_1 = a_2$

B. $a_1 > a_2$

C. $a_1 < a_2$

D. It depends on the block-table friction

Why are the assumptions above important?

Solution

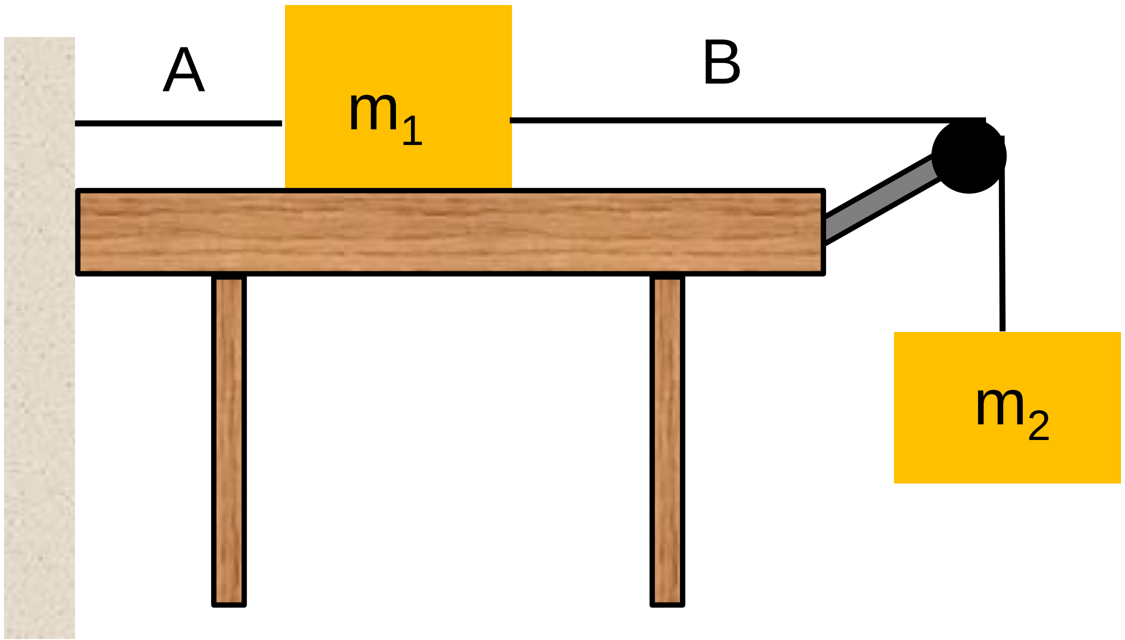
Answer: A

Justification: While attached by string B, the blocks are part of one system. The strings do not stretch, so the blocks will move as one – they will have the same acceleration. However, if the string was able to stretch, then the blocks could have different accelerations.

If friction was significant, the acceleration of the blocks would have been less than in the frictionless case, but the blocks would have the same acceleration!

Blocks and a Pulley IV

Two blocks are connected via a pulley. The blocks are initially at rest as block m_1 is attached to a wall. If string A breaks, what will the accelerations of the blocks be? (**Assume** no friction and strings don't stretch)



A. $a_1 = a_2 = 0$

B. $a_1 = a_2 = g$

C. $a_1 = a_2 = \frac{m_2 g}{(m_1 + m_2)}$

D. $a_1 = a_2 = \frac{m_1 g}{(m_1 + m_2)}$

E. $a_1 = a_2 = \frac{m_2}{(m_1 + m_2)}$

Solution

Answer: C

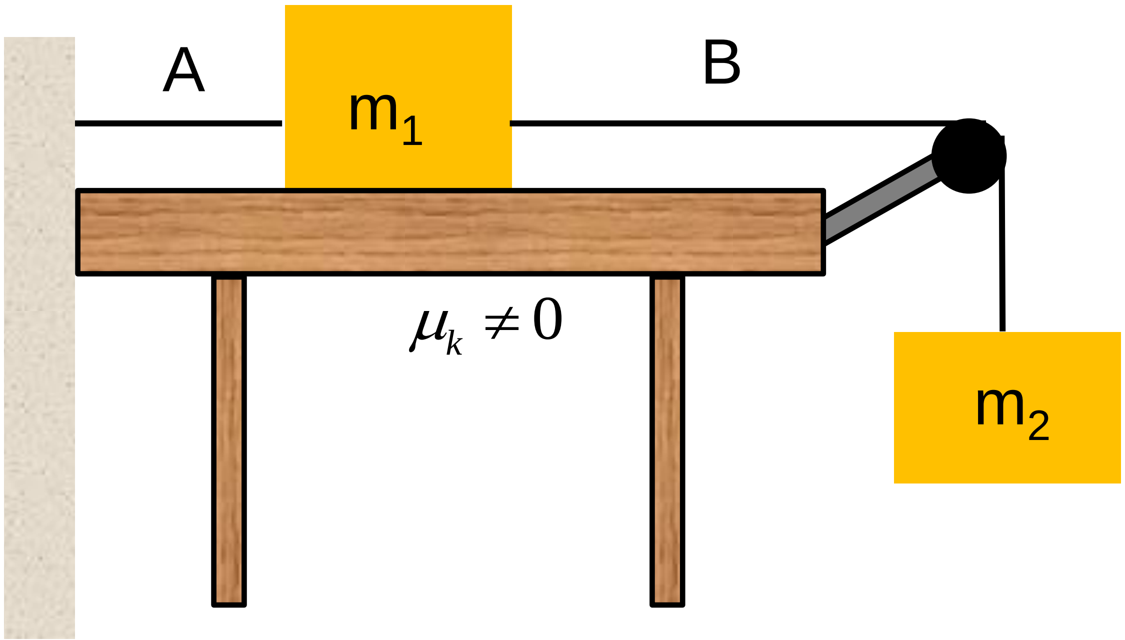
Justification: Answer A is incorrect as the blocks will accelerate (there is an unbalanced force acting on the two-block system). However, their acceleration will be less than g as discussed earlier: the downward force m_2g pulls two blocks (m_1 and m_2). Thus, answer B is incorrect as well. Answer E has dimensions wrong – the answer is a pure number and it has to have dimensions of acceleration: m/s^2. We have to decide between C and D. Applying Newton's second law we see that answer C is correct. The force pulling down on the two-block system that has a mass of (m_1 + m_2) is m_2g, thus:

$$\sum \vec{F} = m\vec{a} \Rightarrow a = \frac{m_2 g}{(m_1 + m_2)} = \frac{m_2}{(m_1 + m_2)} g < g$$

Limiting case analysis: if $m_1 \ll m_2$, the acceleration will be very close to g.

Blocks and a Pulley V

Two blocks are connected via a pulley. The blocks are initially at rest as block m_1 is attached to a wall. If string A attaching the blocks to the wall breaks. What will be the accelerations of the blocks? (**Assume:** strings don't stretch, but the coefficient of kinetic friction is $\mu \neq 0$)



A. $a_1 > a_2 = \dfrac{m_2 g}{(m_1 + m_2)}$

B. $a_1 = a_2 = \dfrac{m_2 g}{(m_1 + m_2)}$

C. $a_1 = a_2 = \dfrac{m_2 g - \mu m_1 g}{(m_1 + m_2)}$

D. $a_1 = a_2 = \dfrac{m_1 g - \mu m_2 g}{(m_1 + m_2)}$

E. $a_1 = a_2 = \dfrac{m_2 g + \mu m_1 g}{(m_1 + m_2)}$

Solution

Answer: C

Justification: In this case we reason exactly the same way as above with one difference: the force of friction is present, acting on block 1:

$$\sum \vec{F} = \overrightarrow{F_{\text{earth on 2}}} + \overrightarrow{F_{\text{friction on 1}}} = m\vec{a}$$

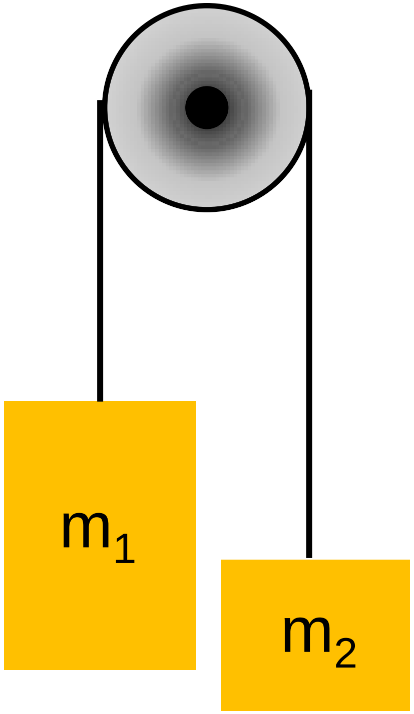
$$m_2 g - \mu m_1 g = (m_1 + m_2)a$$

$$a = \frac{m_2 g - \mu m_1 g}{(m_1 + m_2)} = \frac{m_2 - \mu m_1}{(m_1 + m_2)} g < g$$

Notice, the larger the friction, the less will be the acceleration of the system.

Blocks and a Pulley VI

Two blocks are connected via a pulley. The blocks are initially at rest. If the blocks are let go, what will be the magnitude of their acceleration? (**Assume:** the strings don't stretch and $m_1 > m_2$)



A. $a_1 = a_2 = \dfrac{m_2 g}{(m_1 + m_2)}$

B. $a_1 = a_2 = \dfrac{m_1 g}{(m_1 + m_2)}$

C. $a_1 = a_2 = \dfrac{(m_2 - m_1) g}{(m_1 + m_2)}$

D. $a_1 = a_2 = \dfrac{(m_1 - m_2) g}{(m_1 + m_2)}$

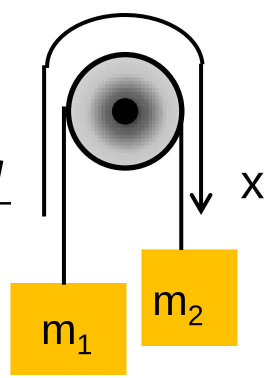
E. $a_1 = a_2 = \dfrac{m_2 g + m_1 g}{(m_1 + m_2)}$

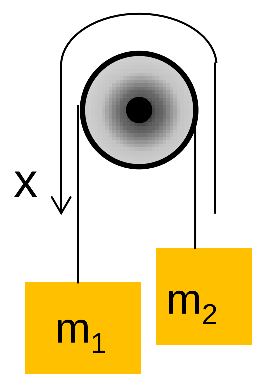
Solution

Answers: C and D

Justification: This problem is very similar to the problem above, with the only difference that the unbalanced force of gravity is acting on both blocks. Answers A and B do not recognize that both blocks are pulled down. Answer E gives final acceleration as g. Answer D will give positive acceleration while answer C will give a negative answer. The sign of acceleration has meaning depending on the coordinate axis. In both cases, the acceleration will be in the direction of the heavier falling mass m_1. So both answers can be a possibility:

$$\text{C. } a_1 = a_2 = \frac{(m_2 - m_1)g}{(m_1 + m_2)}$$





$$\text{D. } a_1 = a_2 = \frac{(m_1 - m_2)g}{(m_1 + m_2)}$$