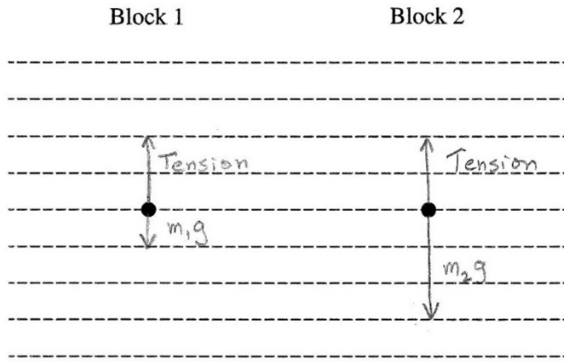
Question 1

7 points total | **Distribution of points**

(a) 2 points



For drawing two vectors starting on the dots that point upward, have the same length and are labeled as the tension force — 1 point

For drawing two vectors starting on the dots that point downward, where the vector for block 1 is smaller than the vector for block 2 and both are labeled as the gravitational force — 1 point

One earned point is deducted for drawing any extraneous vectors.

One earned point is deducted for vector lengths that do not allow the system to accelerate in the proper direction.

(b) 3 points

For writing an equation for Newton's second law for block 1 — 1 point

$m_1a = T - m_1g$

For writing an equation for Newton's second law for block 2 — 1 point

$m_2a = m_2g - T$

For eliminating T to obtain an equation that can be solved for the acceleration — 1 point

$T = m_1a + m_1g$

$m_2a = m_2g - m_1a - m_1g$

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

$a = (m_2 - m_1)g/(m_2 + m_1)$

Question 1 (continued)

		Distribution of points
(b)	(continued)	
	Alternate solution	*Alternate points*
	The system of two blocks must move as a unit, so the acceleration of the system is the acceleration of block 2.	
	For writing an equation showing that the net force acting on the system is the difference in masses times the acceleration of gravity	*1 point*
	$F_{net} = (m_2 - m_1)g$	
	For writing an equation that relates the net force to the sum of the masses and the acceleration of the system	*1 point*
	$F_{net} = (m_2 + m_1)a$	
	For writing an equation that can be solved for the acceleration in terms of the variables used in the summation of forces equations	*1 point*
	$(m_2 + m_1)a = (m_2 - m_1)g$	
	$a = (m_2 - m_1)g/(m_2 + m_1)$	
(c)	2 points	
	The acceleration of the new system, and thus of block 2, is smaller.	
	For indicating that the mass of the system is larger	1 point
	For a clear indication that the tension on block 2 is greater	1 point
	Alternate solution	*Alternate points*
	For indicating that the mass of the system is larger	*1 point*
	For indicating that the net force exerted on the system stays the same	*1 point*
	Notes: No points are earned for a correct prediction without a reasonable attempt at an explanation. No points are earned for an incorrect prediction, regardless of the explanation.	

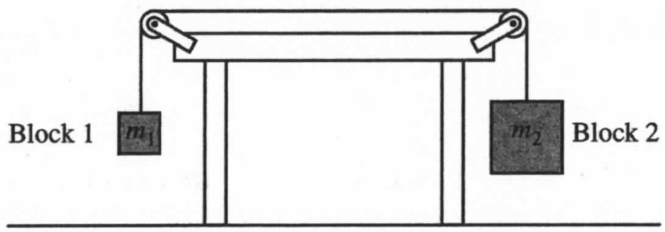
PHYSICS 1

Section II

5 Questions

Time—90 minutes

Directions: Questions 1, 4 and 5 are short free-response questions that require about 13 minutes each to answer and are worth 7 points each. Questions 2 and 3 are long free-response questions that require about 25 minutes each to answer and are worth 12 points each. Show your work for each part in the space provided after that part.



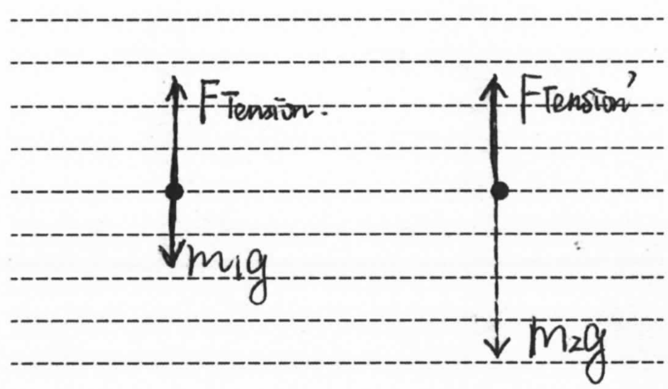
Note: Figure not drawn to scale.

1. (7 points, suggested time 13 minutes)

   Two blocks are connected by a string of negligible mass that passes over massless pulleys that turn with negligible friction, as shown in the figure above. The mass m_2 of block 2 is greater than the mass m_1 of block 1. The blocks are released from rest.

   (a) The dots below represent the two blocks. Draw free-body diagrams showing and labeling the forces (not components) exerted on each block. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces.

   Block 1 Block 2



(b) Derive the magnitude of the acceleration of block 2. Express your answer in terms of m_1, m_2, and g.

According to Newton's Second Law

For block 2: $m_2 g - F_T' = m_2 \cdot a$

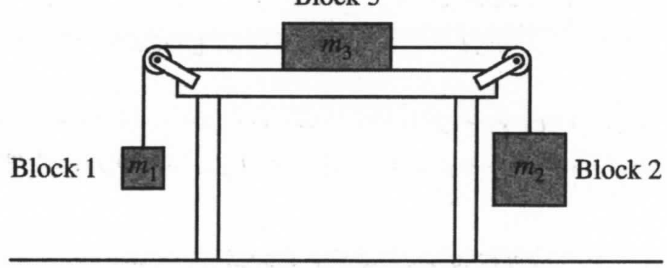
For block 1: $F_T - m_1 g = m_1 a$.

According to Newton's 3rd Law: $|F_T| = |F_T'|$

$\therefore$ $m_2 g - m_1 g = m_2 a + m_1 a$.

$\therefore$ $a_2 = \dfrac{(m_2 - m_1) g}{m_1 + m_2}$

Block 3 of mass m_3 is added to the system, as shown below. There is no friction between block 3 and the table.



Note: Figure not drawn to scale.

(c) Indicate whether the magnitude of the acceleration of block 2 is now larger, smaller, or the same as in the original two-block system. Explain how you arrived at your answer.

$a_2 = a_{system} = \dfrac{(m_2 - m_1) g}{m_1 + m_2 + m_3} < \dfrac{(m_2 - m_1) g}{m_1 + m_2} = a_2 \text{ original.}$

$\therefore$ the acceleration now is smaller than that before due to the increase in the total mass of the system.

PHYSICS 1

Section II

5 Questions

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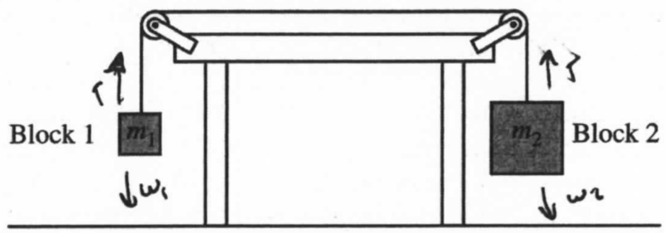


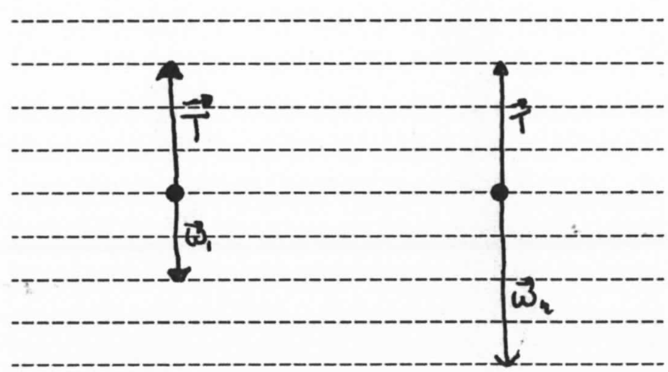
<u>Note:</u> Figure not drawn to scale.

1. (7 points, suggested time 13 minutes)

   Two blocks are connected by a string of negligible mass that passes over massless pulleys that turn with negligible friction, as shown in the figure above. The mass m_2 of block 2 is greater than the mass m_1 of block 1. The blocks are released from rest.

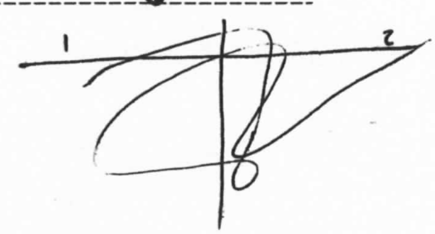
   (a) The dots below represent the two blocks. Draw free-body diagrams showing and labeling the forces (not components) exerted on each block. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces.

Block 1 Block 2



$\vec{w}_2 > \vec{w}_1$

$T = T$



(b) Derive the magnitude of the acceleration of block 2. Express your answer in terms of m_1, m_2, and g.

Block 1:

x: $F = ma$, $0 = ma$

y:

$F_{net} = m_1 a$

$T_1 - \omega_1 = m_1 a$

$(m_2 a) + \omega_2 - \omega_1 = m_1 a$

$a = \dfrac{m_2 a + \omega_2 - \omega_1}{m_1}$

$$\boxed{a_1 = \frac{m_2 a + m_2 g - m_1 g}{m_1}}$$

Block 2

x: $F = ma$, $0 = ma$

y:

$F_{net} = m_2 a$

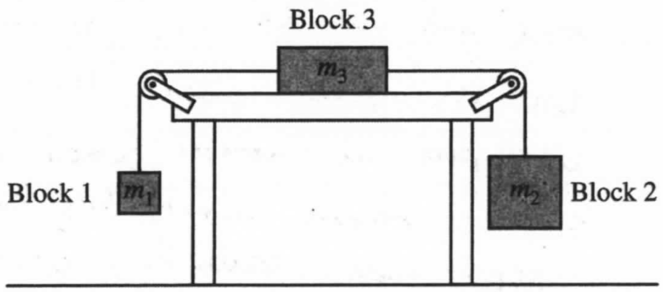
$T_1 - \omega_2 = m_2 a$

$T = (m_2 a_2) + \omega_2$

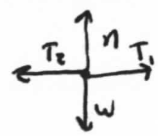
$a_1 = a_2$

$$\boxed{a = \frac{m_2 a + m_2 g - m_1 g}{m_1}}$$

Block 3 of mass m_3 is added to the system, as shown below. There is no friction between block 3 and the table.



Block 3



Note: Figure not drawn to scale.

(c) Indicate whether the magnitude of the acceleration of block 2 is now larger, smaller, or the same as in the original two-block system. Explain how you arrived at your answer.

The magnitude of Block 2's acceleration is less, because originally, the object's F_{net} was opposritely reacting with Block 1's F_{net}, such that the two were subtracting, and Block 2 would fall. But by adding Block 3 of a new mass means, assuming the same direction of motion, we must now add the F_{net} of Block 1 and Block 3 in order to calculate for the acceleration of Block 2, and the entire system. Logically, adding more weight to the object preventing acceleration (considering Block 1 and 3 as one object) will reduce acceleration.

GO ON TO THE NEXT PAGE.

PHYSICS 1

Section II

5 Questions

Time—90 minutes

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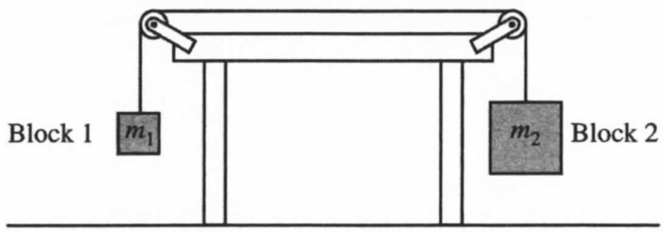
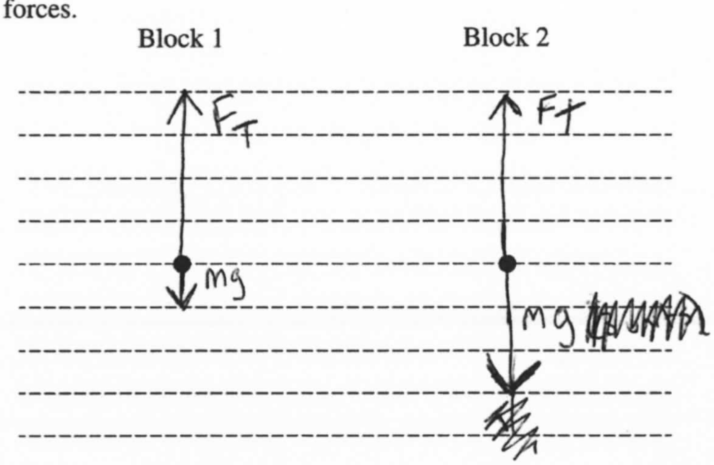


Note: Figure not drawn to scale.

1. (7 points, suggested time 13 minutes)

Two blocks are connected by a string of negligible mass that passes over massless pulleys that turn with negligible friction, as shown in the figure above. The mass m_2 of block 2 is greater than the mass m_1 of block 1. The blocks are released from rest.

(a) The dots below represent the two blocks. Draw free-body diagrams showing and labeling the forces (not components) exerted on each block. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces.



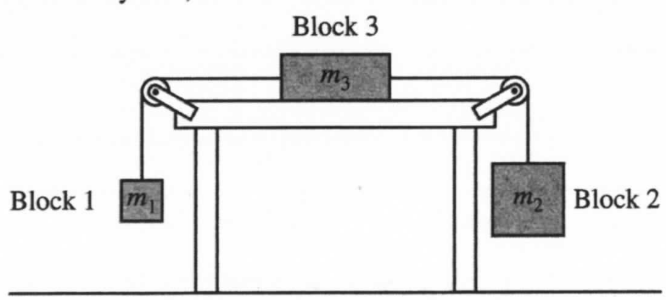
(b) Derive the magnitude of the acceleration of block 2. Express your answer in terms of m_1, m_2, and g.

$F = ma$ $\qquad a = \frac{F_{net}}{m_{net}}$

$$a = \frac{m_1 g + m_2 g}{m_1 + m_2}$$

$\cancel{a = m_0}$ $\qquad \cancel{a = \frac{g}{m_1 + m_2}}$

Block 3 of mass m_3 is added to the system, as shown below. There is no friction between block 3 and the table.



Note: Figure not drawn to scale.

(c) Indicate whether the magnitude of the acceleration of block 2 is now larger, smaller, or the same as in the original two-block system. Explain how you arrived at your answer.

This magnitude of block 2 is now smaller than the original system, this is because mass is inversly porportional to acceleration, $(a = \frac{F}{m})$, therefore, adding more mass to the system will lower the acceleration.

AP® PHYSICS 1
2015 SCORING COMMENTARY

Question 1

Overview

The intent of this question was application of Newton's second law to a modified Atwood's machine. The question requires a basic knowledge of free body diagrams and requires both quantitative and qualitative understanding of what affects the acceleration of the system.

Sample: P1Q1 A
Score: 7

Part (a) earned 2 points for full credit. The tension force on each block is labeled appropriately, with the same direction and relative lengths. The weight force on each block is labeled and both are drawn to appropriate lengths with respect to the tension force, with the weight of block 1 shorter than the tension and the weight of block 2 greater than the tension. Part (b) earned 3 points for full credit. Both Newton’s second law equations are written correctly, and the magnitudes of the tensions are clearly noted as being equal and then eliminated from the equations. Part (c) also earned 2 points for full credit. A smaller acceleration was predicted and the equation uses the fact that the net force on the system is the same.

Sample: P1Q1 B
Score: 5

Part (a) earned 2 points for full credit. Part (b) also earned 2 points. The student’s work for blocks 1 and 2 have an inconsistency in sign, so only one of the two Newton’s second law points was earned. These equations are correctly used to eliminate T. Part (c) earned 1 point for indicating that the acceleration decreases because the mass of the system increases by referring to ‘more weight’ in the last sentence.

Sample: P1Q1 C
Score: 3

Part (a) earned a net of 1 point. The tension forces and the weight forces each earned a point, but 1 point was deducted because the weight force on block 2 should be greater than the tension. Part (b) earned 1 point for writing an equation that relates the net force to the sum of the masses. Part (c) earned 1 point for indicating that the system has a larger mass, but no explicit understanding of an unchanged net force is demonstrated.