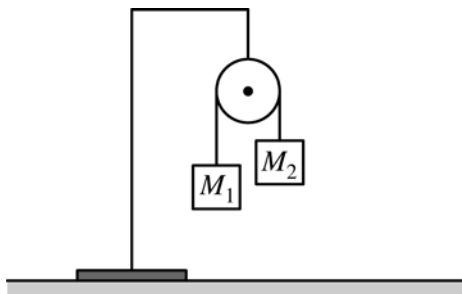
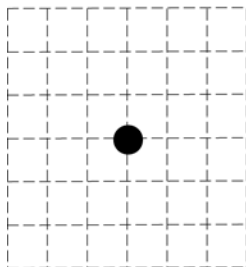
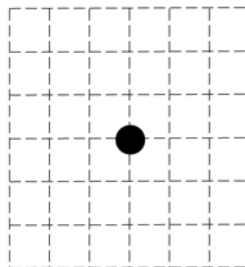


2017 AP[®] PHYSICS C: MECHANICS FREE-RESPONSE QUESTIONS**PHYSICS C: MECHANICS****SECTION II****Time—45 minutes****3 Questions**

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.



1. An Atwood's machine consists of two blocks connected by a light string that passes over a frictionless pulley of negligible mass, as shown in the figure above. The masses of the two blocks, M_1 and M_2 , can be varied. M_2 is always greater than M_1 .
- (a) On the dots below, which represent the blocks, draw and label the forces (not components) that act on the blocks. Each force must be represented by a distinct arrow starting on and pointing away from the appropriate dot. The relative lengths of the arrows should show the relative magnitudes of the forces.

Block of Mass M_1 Block of Mass M_2 

- (b) Using the forces in your diagrams above, write an equation applying Newton's second law to each block and use these two equations to derive the magnitude of the acceleration of the blocks and show that it is given by the equation:
- $$a = \frac{(M_2 - M_1)}{(M_1 + M_2)}g$$

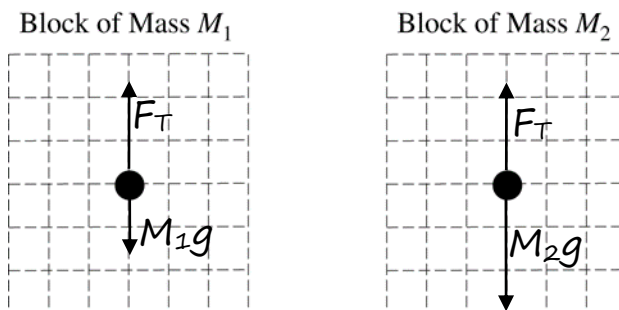
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Question 1

15 points total

**Distribution
of points**

(a) 3 points



For correctly drawing and labeling the vectors for the weight of the block and the tension for block M_1 with the tension larger than the weight

1 point

For correctly drawing and labeling the vectors for the weight of the block and the tension for block M_2 with the weight larger than the tension

1 point

For correctly drawing tension on the two blocks as equal in magnitude

1 point

Note: If any extraneous vectors are drawn, only a maximum of two points may be earned.

(b) 3 points

For correctly applying Newton's second law to block 1

1 point

$$F_T - M_1g = M_1a$$

For correctly applying Newton's second law to block 2

1 point

$$M_2g - F_T = M_2a$$

For combining the two equations above in such a way that will lead to the correct equation

1 point

$$M_2g - M_1g = (M_1 + M_2)a$$

$$a = \frac{(M_2 - M_1)}{(M_1 + M_2)}g$$

(c) 1 point

For indicating variables that will create a straight line whose slope can be used to determine g

1 point

Example: Vertical axis: a

$$\text{Horizontal axis: } \frac{(M_2 - M_1)}{(M_1 + M_2)}$$

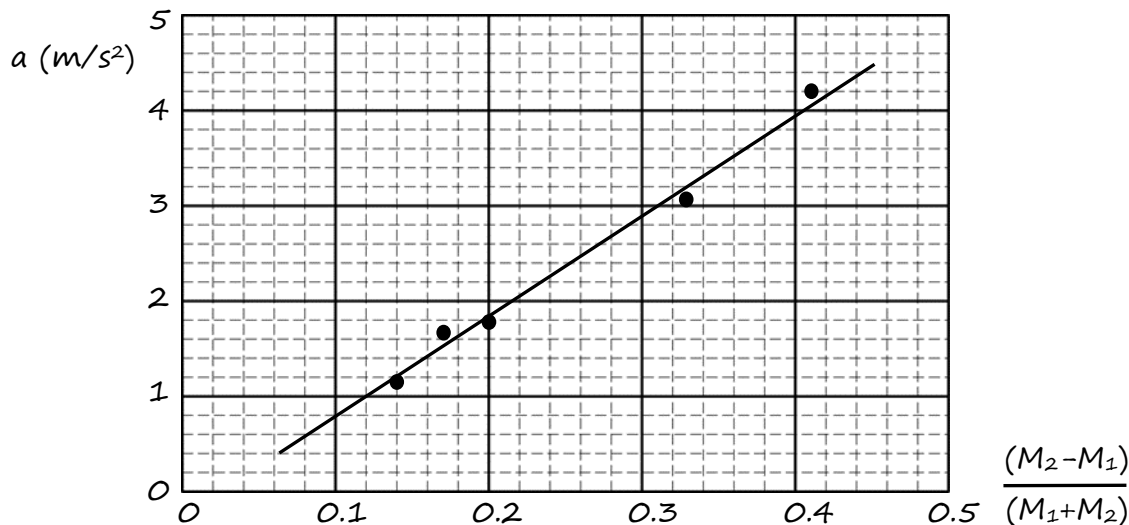
Note: Full credit is earned if axes are reversed, or if the student uses another acceptable combination.

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Question 1 (continued)

**Distribution
of points**

(d) 3 points



For using a correct scale that uses more than half the grid and for correctly labeling the axes, including units as appropriate

1 point

For correctly plotting the data

1 point

For drawing a straight best-fit line consistent with the plotted data

1 point

(e) 2 points

For correctly calculating the slope using the best-fit line and not the data points, unless the points fall on the best-fit line

1 point

(Note: Credit may be given for the linear regression only if the student states linear regression is used.)

$$\text{slope} = \frac{(y_2 - y_1)}{(x_2 - x_1)} = \frac{(3.0 - 1.0) \text{ m/s}^2}{(0.31 - 0.12)} = 10.5 \text{ m/s}^2$$

For correctly relating the slope to g

1 point

$$g = \text{slope} = 10.5 \text{ m/s}^2 \text{ (using linear regression yields } 10.1 \text{ m/s}^2 \text{)}$$

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Question 1 (continued)

**Distribution
of points**

(f) 2 points

Correct answer: “Lower”

For including a correct statement about the acceleration of the blocks

1 point

For including a correct statement about the forces on the blocks

1 point

Example: Because the block M_1 is on the table, the net force on the system increases, and therefore the acceleration increases. Because the acceleration of M_2 increases, the net force on M_2 must increase. Therefore, there must be a greater difference in the magnitude of the two forces on M_2 . Because the weight of block M_2 stays the same, the retarding force — the tension in the string — must decrease.

(g) 1 point

For a correct justification

1 point

Example: Block M_1 will experience friction with the table. The acceleration of the system will decrease and this will decrease the slope of the line; therefore, the value of g is determined by the experiment.