

2023 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics

Question 37: Constructed-Response

Reporting Category: Motion, Forces, and Interactions

Practice Category: Evidence, Reasoning, and Modeling

Standard: [HS.PHY.2.1](#) - Analyze data to support the claim that Newton’s second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force.

Item Description: Analyze a model of two objects that are at rest and connected by a pulley to compare the net force on and mass of each object, and describe how mass being added to an object would affect the direction of the net force on the object.

[View item in MCAS Digital Item Library](#)

Scoring Guide

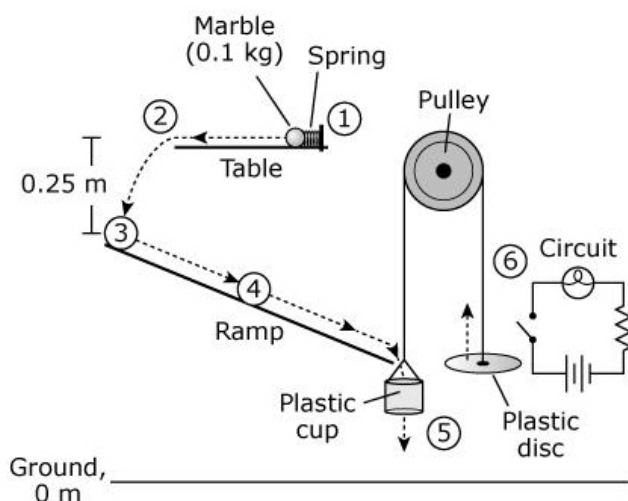
Select a score point in the table below to view the sample student response.

Score*	Description
3A	The response demonstrates a thorough understanding of how forces affect the motion of objects. The response correctly compares the net force on the cup with the net force on the disc and clearly explains the reasoning. The response correctly compares the mass of the cup with the mass of the disc and clearly explains the reasoning. The response also clearly describes how the direction of the net forces on the cup changed as the marble rolled into the cup and clearly explains the reasoning.
3B	
2	The response demonstrates a partial understanding of how forces affect the motion of objects.
1	The response demonstrates a minimal understanding of how forces affect the motion of objects.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

*Letters are used to distinguish between sample student responses that earned the same score (e.g., 3A and 3B).

Score Point 3A

A student designed a complex machine to turn on a light bulb. A diagram of the student's design is shown.



The circled numbers in the diagram refer to the steps that occurred when the student used the machine to turn on the light bulb. Several types of energy conversion took place during the steps.

Step 1: The student released a compressed spring, which pushed a 0.1 kg marble to the left on a table.

Step 2: The marble fell off the table.

Step 3: The marble landed on a ramp.

Step 4: The marble rolled down the ramp and into a plastic cup.

Step 5: The plastic cup moved downward, which caused a plastic disc to move upward.

Step 6: The plastic disc collided with a switch in an electric circuit, closing the circuit. The light bulb turned on.

This question has three parts.

Before the marble rolled into the plastic cup, the cup and the plastic disc were at rest.

Part A

Compare the magnitude of the net force on the cup with the magnitude of the net force on the disc when the cup and the disc were both at rest. Explain your reasoning.

The net force on both objects are zero because both objects aren't moving. That means all the forces on both objects should cancel out.

Part B

Compare the mass of the cup with the mass of the disc when the cup and the disc were both at rest. Explain your reasoning.

The mass of the cup and the mass of the disc are equal.

Both objects have a tension force (T) pulling upwards, and they are equal respective to the F_g of the object because they need to cancel out to have a F_{net} of 0. Those tension forces are equal, because it's one string. If the two tension forces are equal, then the two gravitational forces must be equal. Because the two gravitational forces are equal, the mass must be equal because everything else in the $F=mg$ equation is equal.

Part C

The marble rolled into the cup.

Describe how the direction of the net force on the cup changed as the marble rolled into the cup. Explain your reasoning.

The net force on the cup changed from 0 to pointing downwards.

This is because when the mass of the marble entered the cup, the mass of the cup is now increased which means it's F_g is larger. This new F_g is also larger than the F_g of the disc, breaking the earlier equilibrium. Now, the cup will be accelerating downwards and the disc will accelerate upwards.

[Back to Scoring Guide](#)

Score Point 3B

This question is part of a module with an introduction. The introduction can be seen in score point 3A.

This question has three parts.

Before the marble rolled into the plastic cup, the cup and the plastic disc were at rest.

Part A

Compare the magnitude of the net force on the cup with the magnitude of the net force on the disc when the cup and the disc were both at rest. Explain your reasoning.

The magnitude of the netforce of both the cup and the disc were equal because neither one of them were being pulled up or down, which means the total net force on both of them at rest is 0N.

Part B

Compare the mass of the cup with the mass of the disc when the cup and the disc were both at rest. Explain your reasoning.

Once again, both the cup's and the disc's masses at rest have the same mass because neither one of them were moving. If one had more mass it would have a bigger net force and pull the other one up, but since neither one moves, that means that both objects at rest have the same mass.

Part C

The marble rolled into the cup.

Describe how the direction of the net force on the cup changed as the marble rolled into the cup. Explain your reasoning.

The direction of the net force for the cup with the marble in it is down because when the marble goes into the cup, it creates more total mass than the disc, which means there would be more force going down than up because the force going up is from the disc, which now has less mass than the plastic cup, so the net froce goes down.

[Back to Scoring Guide](#)

Score Point 2

This question is part of a module with an introduction. The introduction can be seen in score point 3A.

This question has three parts.

Before the marble rolled into the plastic cup, the cup and the plastic disc were at rest.

Part A

Compare the magnitude of the net force on the cup with the magnitude of the net force on the disc when the cup and the disc were both at rest. Explain your reasoning.

The net force of both of them are the same because both of them are at rest meaning they aren't moving so the net force is equal to 0N.

Part B

Compare the mass of the cup with the mass of the disc when the cup and the disc were both at rest. Explain your reasoning.

They had similar masses because they had to have similar forces acting on both sides of the pulley. If one mass was much larger than the other they would not stay balanced on the pulley.

Part C

The marble rolled into the cup.

Describe how the direction of the net force on the cup changed as the marble rolled into the cup. Explain your reasoning.

When the marble entered the cup the cup's mass got larger and the force of gravity was stronger than the tension force from the pulley.

[Back to Scoring Guide](#)

Score Point 1

This question is part of a module with an introduction. The introduction can be seen in score point 3A.

This question has three parts.

Before the marble rolled into the plastic cup, the cup and the plastic disc were at rest.

Part A

Compare the magnitude of the net force on the cup with the magnitude of the net force on the disc when the cup and the disc were both at rest. Explain your reasoning.

the magnitude of the net force on the cup and the disc was the same because they were both at rest, and not in motion.

Part B

Compare the mass of the cup with the mass of the disc when the cup and the disc were both at rest. Explain your reasoning.

the mass of the cup was greater than the mass of the disc because the cup is lower than the disc, so it is holding it up which means the mass must be greater.

Part C

The marble rolled into the cup.

Describe how the direction of the net force on the cup changed as the marble rolled into the cup. Explain your reasoning.

the net force on the cup after the marble rolled into is has increased because the speed of the cup has increased.

[Back to Scoring Guide](#)

Score Point 0

This question is part of a module with an introduction. The introduction can be seen in score point 3A.

This question has three parts.

Before the marble rolled into the plastic cup, the cup and the plastic disc were at rest.

Part A

Compare the magnitude of the net force on the cup with the magnitude of the net force on the disc when the cup and the disc were both at rest. Explain your reasoning.

the magnitudes are different because the objects are to different shapes.

Part B

Compare the mass of the cup with the mass of the disc when the cup and the disc were both at rest. Explain your reasoning.

The mass's may also be different because of the fact they are two different shapes so the cup could possibly be holding the plate up.

Part C

The marble rolled into the cup.

Describe how the direction of the net force on the cup changed as the marble rolled into the cup. Explain your reasoning.

The direction of the net force changed because the marble has gone into a whole other object.

[Back to Scoring Guide](#)