2023 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 20: Constructed-Response

Reporting Category: Motion, Forces, and Interactions
Practice Category: Mathematics and Data
Standard: HS.PHY.2.4 - Use mathematical representations of Newton's law of gravitation and Coulomb's law to both qualitatively and quantitatively describe and predict the effects of gravitational and electrostatic forces between objects.
Item Description: Identify the attractive force between objects, compare the magnitude of the force between different pairs of objects, and determine how the force would change if the mass of one object were reduced.

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Scoring Guide

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

Score*	Description
4A	The response demonstrates a thorough understanding of Newton's law of gravitation. The response correctly identifies the force that keeps planets in orbit around the Sun. The response correctly identifies that there is a stronger attractive force between Venus and Earth than between Mars and Earth and clearly explains the reasoning based on data. The response also correctly determines how much the attractive force between the Sun and the planets would change if the Sun were 30% less massive and clearly explains why.
4B	
3	The response demonstrates a general understanding of Newton's law of gravitation.
2	The response demonstrates a limited understanding of Newton's law of gravitation.
1	The response demonstrates a minimal understanding of Newton's law of gravitation.
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., 4A and 4B).

Score Point 4A

This question has three parts.

The table shows data for the first four planets in the solar system.

Planet	Ratio of Planet's Mass to Earth's Mass	Ratio of Planet's Distance from the Sun to Earth's Distance from the Sun
Mercury	0.06	0.39
Venus	0.82	0.72
Earth	1.00	1.00
Mars	0.11	1.52

Part A

Identify the force that keeps the planets in orbit around the Sun.

Gravity

Part B

Identify which force is stronger: the maximum attractive force between Venus and Earth or the maximum attractive force between Mars and Earth. Provide two reasons for your answer based on data in the table.

The maximum attractive force between Venus and Earth. This is because the mass of Venus is greater than that of Mars and the distance between Venus and Earth is lesser than the distance between Earth and Mars.

Part C

Suppose that the Sun had 30% less mass than it actually does.

How much would the attractive force between the Sun and the planets change? Explain your answer.

The mass between the Sun and the Planets would decrease by 30%. Gravity is directly proportional to the mass of the object, if the mass of the object is halved, gravity is halved, if it is quartered gravity is quartered, and if its reduced by 30%, gravity is reduced by 30%.

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Score Point 4B

This question has three parts.

The table shows data for the first four planets in the solar system.

Planet	Ratio of Planet's Mass to Earth's Mass	Ratio of Planet's Distance from the Sun to Earth's Distance from the Sun
Mercury	0.06	0.39
Venus	0.82	0.72
Earth	1.00	1.00
Mars	0.11	1.52

Part A

Identify the force that keeps the planets in orbit around the Sun.

gravity

Part B

Identify which force is stronger: the maximum attractive force between Venus and Earth or the maximum attractive force between Mars and Earth. Provide two reasons for your answer based on data in the table.

the force between venus and the earth, due to the fact that venus is closer and has more mass so it would have more gravitational attraction.

Part C

Suppose that the Sun had 30% less mass than it actually does.

How much would the attractive force between the Sun and the planets change? Explain your answer.

it would be 30% less as the formula for gravity is g = G*((m1*m2)/d^2) meaning that decreasing the mass of one object by 30% would effect gravity on everything by 30%

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Score Point 3

This question has three parts.

The table shows data for the first four planets in the solar system.

Planet	Ratio of Planet's Mass to Earth's Mass	Ratio of Planet's Distance from the Sun to Earth's Distance from the Sun
Mercury	0.06	0.39
Venus	0.82	0.72
Earth	1.00	1.00
Mars	0.11	1.52

Part A

Identify the force that keeps the planets in orbit around the Sun.

gravity

Part B

Identify which force is stronger: the maximum attractive force between Venus and Earth or the maximum attractive force between Mars and Earth. Provide two reasons for your answer based on data in the table.

The maximum attractive force between Venus and Earth is greater because Venus has a larger mass than Mars, so will have a stronger pull. And Venus is closer than Mars to the Sun so feels a stronger pull from the Sun.

Part C

Suppose that the Sun had 30% less mass than it actually does.

How much would the attractive force between the Sun and the planets change? Explain your answer.

The attractive force between the Sun and the planets would decrease by 30%.

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Score Point 2

This question has three parts.

The table shows data for the first four planets in the solar system.

Planet	Ratio of Planet's Mass to Earth's Mass	Ratio of Planet's Distance from the Sun to Earth's Distance from the Sun
Mercury	0.06	0.39
Venus	0.82	0.72
Earth	1.00	1.00
Mars	0.11	1.52

Part A

Identify the force that keeps the planets in orbit around the Sun.

gravity

Part B

Identify which force is stronger: the maximum attractive force between Venus and Earth or the maximum attractive force between Mars and Earth. Provide two reasons for your answer based on data in the table.

Venus and earth. They have larger masses which mean larger gravity force.

Part C

Suppose that the Sun had 30% less mass than it actually does.

How much would the attractive force between the Sun and the planets change? Explain your answer.

It would decrease 30 percent.

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Score Point 1

This question has three parts.

The table shows data for the first four planets in the solar system.

Planet	Ratio of Planet's Mass to Earth's Mass	Ratio of Planet's Distance from the Sun to Earth's Distance from the Sun
Mercury	0.06	0.39
Venus	0.82	0.72
Earth	1.00	1.00
Mars	0.11	1.52

Part A

Identify the force that keeps the planets in orbit around the Sun.

the force that identify is gravity

Part B

Identify which force is stronger: the maximum attractive force between Venus and Earth or the maximum attractive force between Mars and Earth. Provide two reasons for your answer based on data in the table.

venus and earth are the strongest

Part C

Suppose that the Sun had 30% less mass than it actually does.

How much would the attractive force between the Sun and the planets change? Explain your answer.

planets would move faster around the ecosytsem

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Score Point 0

This question has three parts.

The table shows data for the first four planets in the solar system.

Planet	Ratio of Planet's Mass to Earth's Mass	Ratio of Planet's Distance from the Sun to Earth's Distance from the Sun
Mercury	0.06	0.39
Venus	0.82	0.72
Earth	1.00	1.00
Mars	0.11	1.52

Part A

Identify the force that keeps the planets in orbit around the Sun.

Mercury would keep the planets around the sun. Because it is the lest to make the earth and planets mass

Part B

Identify which force is stronger: the maximum attractive force between Venus and Earth or the maximum attractive force between Mars and Earth. Provide two reasons for your answer based on data in the table.

noe of them they are equel to each other

Part C

Suppose that the Sun had 30% less mass than it actually does.

How much would the attractive force between the Sun and the planets change? Explain your answer.

with the heat of the sun to make it less percent each time

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