

Name:

## Criterion C - Processing & Evaluating

Criterion Benchmarks	Descriptors
0	The student does not reach a standard described by any of the descriptors below.
1 - 2	The student is able to: i. collect and present data in numerical and/or visual forms ii. accurately interpret data iii. state the validity of a hypothesis based on the outcome of a scientific investigation iv. state the validity of the method based on the outcome of a scientific investigation v. state improvements or extensions to the method.
3 - 4	The student is able to: i. correctly collect and present data in numerical and/or visual forms ii. accurately interpret data and explain results iii. outline the validity of a hypothesis based on the outcome of a scientific investigation iv. outline the validity of the method based on the outcome of a scientific investigation v. outline improvements or extensions to the method that would benefit the scientific investigation.
5 - 6	The student is able to: i. correctly collect, organize and present data in numerical and/or visual forms ii. accurately interpret data and explain results using scientific reasoning iii. discuss the validity of a hypothesis based on the outcome of a scientific investigation iv. discuss the validity of the method based on the outcome of a scientific investigation v. describe improvements or extensions to the method that would benefit the scientific investigation.
7 - 8	The student is able to: i. correctly collect, organize, transform and present data in numerical and/or visual forms ii. accurately interpret data and explain results using correct scientific reasoning iii. evaluate the validity of a hypothesis based on the outcome of a scientific investigation iv. evaluate the validity of the method based on the outcome of a scientific investigation v. explain improvements or extensions to the method that would benefit the scientific investigation.

SOI: Through identifying relationships of similarity and difference (identities and relationships), we understand how force and matter interact.



# Investigation

## Gravitational Force vs. distance

Go to the [PHET simulation](https://phet.colorado.edu/sims/html/gravity-force-lab-basics/latest/gravity-force-lab-basics_en.html) at [https://phet.colorado.edu/sims/html/gravity-force-lab-basics/latest/gravity-force-lab-basics\\_en.html](https://phet.colorado.edu/sims/html/gravity-force-lab-basics/latest/gravity-force-lab-basics_en.html) to collect gravitational force and distance values.

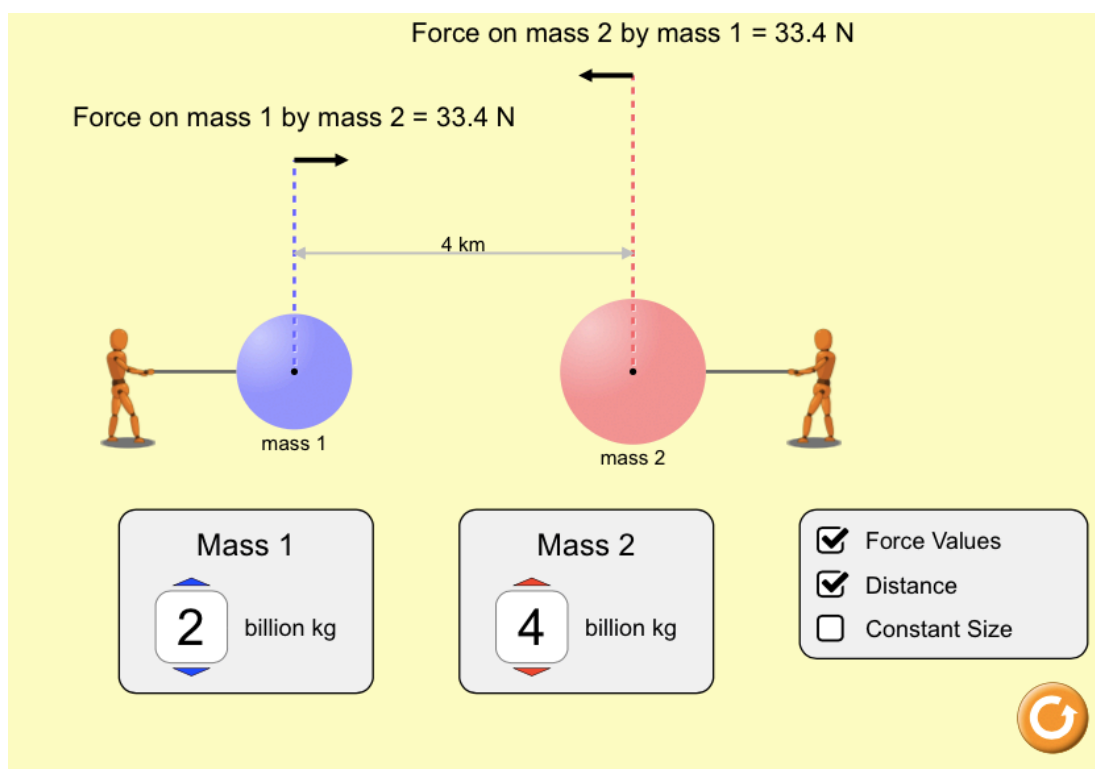


Figure 1

Procedure:

1. Set Mass 1 and Mass 2 value to 1 billion kg.
2. Tick all values on the right bottom corner.
3. Drag and move the masses to change the distance between the center of masses.
4. Record at least 5 set of force of gravity and distance values within the range of 1.3 km and 9.6 km.



# Processing

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This task addresses the key concept of **relationship** and focuses on Criteria C.

Question 1-3 focuses on strand i: present collected and transformed data.

1. Present your data in the form of a data table. In your data table include the values of;

- Gravitational Force (F)
- distance (d)
- 1/squared of distance ( $1/d^2$ )

2. Plot a graph of Gravitational force F (vertical axis) vs distance d (horizontal axis) graph. Label the axis names. Use scatter plot in your graphing software to produce the graph. Include a best-fit curve using the trendline option. Display the equation of the trendline. Copy and paste your graph below.

3. Plot a graph of F vs  $1/d^2$  graph. Use scatter plot in your graphing software to produce the graph. Include a best-fit line using the trendline option. Display the equation of the trendline. Copy and paste your graph below.



# Evaluating

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Question 4-5 focuses on strand ii: interpret data and explain results using scientific reasoning.

4. Based on your graphs which of the following statement is correct.

Statement	Place a tick.
Gravitational force $F$ is proportional to distance $d$ . $F \propto d$	
Gravitational force $F$ is proportional to distance squared. $F \propto d^2$	
$F \propto 1/d$	
$F \propto 1/d^2$	

5. Explain your answer to question 4 briefly.



Question 6 focuses on strand iii: evaluate the validity of a hypothesis based on the outcome of a scientific investigation.

6. According to Newton's Law of Universal Gravitation,

$$F_g = G \frac{m_1 m_2}{d^2}$$

where  $F_g$  is gravitational force;  $m_1$  is mass 1;  $m_2$  is mass 2;  $d^2$  is squared of distance between center of masses and G is gravitational constant which is equal to  $6.67 * 10^{-11} Nm^2 kg^{-2}$ .

- Using one set of data from your data table, calculate the gravitational constant in your experiment. Show your work clearly.
- Does the results of your experiment support Newton's Law of Universal Gravitation?
- Based on your answer to part a and the graphs you plotted in question 2 and 3, evaluate the validity of Newton's Law of Universal Gravitation.

*Hint: You should calculate G, gravitational constant using the slope of a graph you plotted to further support your statements.*



Question 7 focuses on strand iv: evaluate the validity of the method.

7. a. Based on the outcome of your investigation, state whether the method is valid or not.

b. Evaluate the validity of the method in detail.

*Hint: Consider strength and limitations of the method. Refer to your results to support your answers.*



Question 8-10 focuses on strand v: explain improvements or extensions to the method.

8. State improvements to the method or extensions to the data collection briefly.
9. Describe how would you proceed your improvement/extension to the method.
10. Explain how your suggestion would benefit the scientific investigation.

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