**Overview**: The following rubrics can be used to assess the individual project: the News Article. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on the Culminating Project Student Instructions. \*If student provides no assessable evidence (e.g., “I don’t know” or leaves answer blank), then that student response cannot be evaluated using the rubric and should be scored as a zero.

Below we provide an alignment table that details the dimensions assessed for each criterion.

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|  | **Student Criteria for Success** | **Disciplinary Core Idea** | **Science and Engineering Practice** | **Crosscutting Concept** |
| 1 | * Explain the problem of how *Etiam* is on a trajectory to hit the Earth.   + What are the criteria for success in solving this problem?   + What constraints exist that limit possible solutions? | **ETS1.A: Defining and Delimiting Engineering Problems**   * The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. | **Asking Questions and Defining Problems**   * Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. | N/A |
| 2 | * Cite data from the fossil record as evidence of past effects of asteroid collisions. | **LS4.A: Evidence of Common Ancestry and Diversity**   * The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. | **Analyzing and Interpreting Data**   * Analyze and interpret data to determine similarities and differences in findings. | **Patterns**   * Graphs, charts, and images can be used to identify patterns in data. |
| 3 | * The public is familiar with another recent asteroid collision from February 2013. An asteroid known as *Chelyabinsk*, hit Russia. Its mass was 10,000,000 or 1 x 107 kg and its speed was 60,000-69,000 km/hr. How can you compare the force of *Chelyabinsk’s* collision with the force of *Etiam*’s collision? Explain why the impact of one of these asteroids will be greater by describing the specific relationships between mass and kinetic energy and speed and kinetic energy. | **PS3.A: Definitions of Energy**   * Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. | N/A | **Scale, Proportion, and Quantity**   * Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. |
| 4 | * Describe and diagram all possible solutions for the public. These solutions must collectively use and explain all the following scientific concepts:   + Gravity and mass | **PS2.B: Types of Interactions**   * Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. | N/A | **Systems and System Models**   * Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. |
| 5 | * Describe and diagram all possible solutions for the public. These solutions must collectively use and explain all the following scientific concepts:   + Newton’s first law   + Newton’s second law   + Newton’s third law | **PS2.A: Forces and Motion**   * The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. * For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law). | [**Developing and Using Models**](http://www.nap.edu/openbook.php?record_id=13165&page=56)   * Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. | N/A |
| 6 | * Explain the investigation of solutions:   + Describe the experiment you ran to evaluate all the potential design solutions. Include: independent variable, dependent variable, controls, procedure, and data collected.   + Evaluate the different solutions: According to the test data, how well did each design meet the criteria of the problem? | **ETS1.B: Developing Possible Solutions**   * There are systematic processes for evaluating solutions with respect to how well they meet the criteria ~~and constraints~~ of a problem. * Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. * A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. * Models of all kinds are important for testing solutions. | **Planning and Carrying Out Investigations** Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Engaging in Argument From Evidence**   * Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. | N/A |
| 7 | * What is your final design solution to prevent a collision between *Etiam* and the Earth?   + How did you combine best characteristics of different designs to come up with the best possible design?   + Show diagram of final design solution (and any calculations, if applicable). | **ETS1.C: Optimizing the Design Solution** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. | **Designing Solutions** Apply scientific ideas or principles to design an object, tool, process or system. | N/A |

**Rubric 1**: Student defines the problem of an asteroid collision, including criteria of success and constraints that might limit possible solutions.

* Dimensions Assessed: DCI – ETS1.A: Defining and Delimiting Engineering Problems, SEP – Asking Questions and Defining Problems

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **does not** define the problem of an asteroid collision **and/or** includes **inaccurate or irrelevant** criteria of success and constraints that might limit possible solutions. | Student **accurately** defines the problem of an asteroid collision, including **accurate** criteria of success **OR** constraints that might limit possible solutions. | Student **accurately** defines the problem of an asteroid collision, including **accurate, but partial** criteria of success **and** constraints that might limit possible solutions. | Student **accurately** defines the problem of an asteroid collision, including **accurate and complete** criteria of success and constraints that might limit possible solutions. |
| **Look Fors:**   * Student leaves out an explanation of the problem. * And/or the student identifies criteria of success and constraints that are inaccurate or irrelevant. For example, they might identify a criterion of success as controlling the damage after the asteroid collision and a constraint as the ability to control the asteroid. | **Look Fors:**   * Student accurately explains that *Etiam’s* collision with Earth would likely cause a huge impact on Earth systems and biodiversity. * Student accurately defines at least one criteria for success OR at least one constraint. See right-hand columns for examples. | **Look Fors:**   * Student accurately explains that *Etiam’s* collision with Earth would likely cause a huge impact on Earth systems and biodiversity. * Student accurately defines a criterion for success. For example, completely preventing the collision. * Student also accurately defines one constraint. For example, limited amount of time before the asteroid will hit Earth. | **Look Fors:**   * Student accurately explains that *Etiam’s* collision with Earth would likely cause a huge impact on Earth systems and biodiversity. * Student accurately and completely defines the criteria for success. For example, completely preventing the collision or minimizing the impact in a way that reduces effects on Earth. * Student also accurately and completely defines any constraints. For example, limited amount and size of materials available, the technology available, limited amount of time available before the asteroid will hit Earth. |

**Rubric 2**: Student explains the importance of protecting Earth from an asteroid collision by citing similar patterns in the fossil record data as evidence.

* Dimensions Assessed: DCI – LS4.A: Evidence of Common Ancestry and Diversity, CCC – Patterns, SEP – Analyzing and Interpreting Data

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **irrelevantly** explains the importance of protecting Earth from an asteroid collision. | Student **accurately** explains the importance of protecting Earth from an asteroid collision but cites **no specific** patterns in the fossil record data as evidence. | Student **accurately** explains the importance of protecting Earth from an asteroid collision by citing **one** similar pattern in the fossil record data as evidence. | Student **accurately** explains the importance of protecting Earth from an asteroid collision by citing **multiple** similar patterns in the fossil record data as evidence. |
| **Look Fors:**   * Student provides an irrelevant explanation of why preventing an asteroid collision is important. For example, “It is important we prevent an asteroid collision because they are bad for the environment.” * Any fossil record evidence is thus not relevant to the claim. | **Look Fors:**   * Student provides a relevant explanation of importance. For example, “It is important we protect Earth from an asteroid collision because the past shows us that asteroid collisions can have large negative consequences for Earth and organisms.” * Student does not cite specific data from the fossil record. For example, “When this happened before, lots of plants and animals died.” | **Look Fors:**   * Student provides a relevant explanation of importance. For example, “It is important we protect Earth from an asteroid collision because the past shows us that asteroid collisions can have large negative consequences for Earth and organisms.” * Student provides one pattern in the fossil record from Task 1 as evidence. For example, “By observing the fossil record, scientists created a graph to show extinction rates. There have been several mass extinctions over time, one 65 million years ago that we know was caused by an asteroid collision. If we don’t want another mass extinction, we must prevent *Etiam’s* collision.” | **Look Fors:**   * Student provides a relevant explanation of importance. For example, “It is important we protect Earth from an asteroid collision because the past shows us that asteroid collisions can have large negative consequences for Earth and organisms.” * Student provides multiple patterns in the fossil record from Task 1 as evidence. For example, “A layer of iridium (component of asteroids) shows that an asteroid hit 65 million years ago. The same soil layer also has a lot of soot, suggesting massive fires all over the world. Another graph and model made from the fossil record shows a large decrease in the number of marine species, as well as a decrease in leaf diversity at this time. If we don’t want this all to happen to Earth again, we must prevent *Etiam’s* collision.” |

**Rubric 3**: Student describes the relationships between mass, kinetic energy, and speed, and uses these relationships to provide information about the potential magnitude of the *Etiam* collision.

* Dimensions Assessed: CCC – Scale, Proportion, and Quantity; DCI – PS3.A: Definitions of Energy

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student describes **no** relationships between mass, kinetic energy, and speed, **and/or** uses relationships to provide **inaccurate** information about the potential magnitude of the *Etiam* collision. | Student describes **partial** relationships between mass, kinetic energy, and speed, and uses this relationship to provide **accurate** information about the potential magnitude of the *Etiam* collision. | Student describes **complete but general** relationships between mass, kinetic energy, and speed, and uses these relationships to provide accurateinformation about the potential magnitude of the *Etiam* collision. | Student describes complete **and specific** relationships between mass, kinetic energy, and speed, and uses these relationships to provide accurateinformation about the potential magnitude of the *Etiam* collision. |
| **Look Fors:**   * Student does not describe any relationships between mass, speed, and kinetic energy between *Etiam* and *Chelyabinsk.* For example, no data or general comparisons are described. * And/or student compares the data for the asteroids *Etiam* and *Chelyabinsk* to form an inaccurate conclusion. For example, “*Etiam* will hit earth with about the same force as *Chelyabinsk.*” | **Look Fors:**   * Student accurately describes one of the relationships, but not both. See right-hand columns for accurate responses for each relationship. * Student makes comparisons between the *Etiam* and *Chelyabinsk* data that are accurate and use one of the relationships. For example, “The mass of *Etiam* is 6.89 x 1015 kg, which is a much larger mass than *Chelyabinsk* at 1 x 107 kg. Because the mass of *Etiam* is much larger, this means it will have much more kinetic energy andwill hit Earth with much more force, causing more damage than *Chelyabinsk.”* | **Look Fors:**   * Student accurately describes the relationships, but relationships are general: An object with more mass has more kinetic energy. An object moving at a greater speed will have more kinetic energy. * Student makes comparisons between the *Etiam* and *Chelyabinsk* data that are accurate and use the relationships above. For example, “The mass of *Etiam* is a much larger mass than *Chelyabinsk*. Because the mass of *Etiam* is much larger, this means it will have much more kinetic energy. This is shown by its greater speed. This helps us predict that *Etiam* will have much more kinetic energy to transfer to Earth, causing more damage than *Chelyabinsk.”* | **Look Fors:**   * Student accurately describes the specific relationships: Kinetic energy is proportional to the mass of the object and grows with the square of its speed. * Student makes comparisons between the *Etiam* and *Chelyabinsk* data that are accurate and use the relationships above. For example, “The mass of *Etiam* is 6.89 x 1015 kg, which is a much larger mass than *Chelyabinsk* at 1 x 107 kg. Because the mass of *Etiam* is much larger, this means it will proportionally have much more kinetic energy. This is also shown by its greater speed at 103,450 km/h, compared to *Chelyabinsk’s* speed of 60,000-69,000 km/hr. This helps us predict that *Etiam* will have much more kinetic energy to transfer to Earth, causing more damage than *Chelyabinsk.”* |

**Rubric 4**: Student draws a model to represent a potential deflection strategy and explains how mass and gravity could affect *Etiam*’s trajectory using this solution.

* Dimensions Assessed: CCC – Systems and System Models, DCI – PS2.B: Types of Interactions

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student draws an **irrelevant** model to represent a potential deflection strategy that **does not** use the effect of mass on gravitational attraction. | Student draws a **relevant** model to represent a potential deflection strategy but **does** **not accurately** explain how mass and gravity could affect *Etiam*’s trajectory using this solution. | Student draws a **relevant** model to represent a potential deflection strategy and **accurately, but partially** explains how mass and gravity could affect *Etiam*’s trajectory using this solution. | Student draws a **relevant** model to represent a potential deflection strategy and accurately **and completely** explains how mass and gravity could affect *Etiam*’s trajectory using this solution. |
| **Look Fors:**   * Student diagrams and/or explains an irrelevant solution that does not use the concepts of mass and gravity. For example, their solution is to catch *Etiam* with a soft surface. This solution is valid, but does not use concepts of mass and gravity. | **Look Fors:**   * Student’s solution is relevant (prevents or mitigates effects of an asteroid collision) and utilizes the relationship of mass and gravity. For example, using another large object to attract *Etiam* and divert it off its trajectory towards Earth. * Model uses arrows, but no captions to show the interactions and flow of energy and matter within this deflection system. * Student does not explain the diagram at all or does not accurately explain how it works in terms of mass and gravity. | **Look-Fors**   * Student’s solution is relevant (prevents or mitigates effects of an asteroid collision) and utilizes the relationship of mass and gravity. For example, using another large object to attract *Etiam* and divert it off its trajectory towards Earth. * Model uses arrows or captions to show the interactions and flow of energy and matter within this deflection system. * Student explains the solution in a way that is accurate but lacks detail, using the concepts of mass and gravity. For example, “This solution would use an object with large mass to attract *Etiam* with gravity and change its trajectory.” | **Look Fors:**   * Student’s solution is relevant (prevents or mitigates effects of an asteroid collision) and utilizes the relationship of mass and gravity. For example, using another large object to attract *Etiam* and divert it off its trajectory towards Earth. * Model uses arrows or captions to show the interactions and flow of energy and matter within this deflection system. * Student explains the solution, using the concepts of mass and gravity. For example, “This solution would use another large object to change *Etiam*’s trajectory. This works because the larger the mass of an object, the more gravitational pull it has on other objects. The object would have to be large, like the moon, in order to attract *Etiam* off its course to hit Earth.” |

**Rubric 5**: Student develops models of potential design solution(s) to prevent a collision and uses Newton’s laws to explain why the solution(s) work.

* Dimensions Assessed: DCI – PS2.A: Forces and Motion, SEP – Developing and Using Models

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student develops models of **irrelevant** potential solution(s) to prevent a collision that **does not** use Newton’s laws. | Student develops models of **relevant** potential design solution(s) to prevent a collision that uses Newton’s law(s) **but does not use** Newton’s laws to accuratelyexplain why the solution(s) work. | Student develops models of relevantpotential design solution(s) to prevent a collision **and uses** **some of** Newton’s laws to accuratelyexplain why the solution(s) work. | Student develops models of relevantpotential design solution(s) to prevent a collision and uses **all of** Newton’s laws to accuratelyexplain why the solution(s) work. |
| **Look Fors:**   * Student diagrams and/or explains irrelevant solution(s) that do not use the concepts of Newton’s three laws. For example, their solution is to divert *Etiam* from its trajectory by using the gravitational attraction of another object with a large mass. This solution is valid, but does not use concepts of Newton’s laws. | **Look Fors:**   * Student models solution(s) that use some or all of Newton’s laws. For example, student diagrams two solutions: 1) Blow up *Etiam* in space, so that smaller pieces will hit Earth. 2) Build a cushion on Earth for *Etiam* to bounce off of in order to prevent damage. * However, student either offers no explanation or does not explain how they work in terms of Newton’s laws. | **Look Fors:**   * Student models solution(s) that use some or all of Newton’s laws. For example, student diagrams one solution that uses two of Newton’s laws: 1) Blow up *Etiam* in space, so that smaller pieces will hit Earth. * Student explanations of the model(s) use concepts of some (one or two), but not all of Newton’s three laws to explain how the solution(s) work. For example, “This solution uses Newton’s first law, since *Etiam* will stay in motion in the same direction until the force of a missile acts on it, changing its speed and direction as it breaks it into pieces. This also uses Newton’s second law, which states that the pieces with less mass than the whole asteroid will hit Earth with less force.” | **Look Fors:**   * Student models solution(s) that use all of Newton’s laws. For example, student diagrams two solutions: 1) Blow up *Etiam* in space, so that smaller pieces will hit Earth. 2) Build a cushion on Earth for *Etiam* to bounce off of in order to prevent damage. * Student explanations of the model(s) use concepts of each of Newton’s three laws to explain how the solution(s) work. For example, “The first solution uses Newton’s first law, since *Etiam* will stay in motion in the same direction until the force of a missile acts on it, changing its speed and direction as it breaks it into pieces. This also uses Newton’s second law, which states that the pieces with less mass than the whole asteroid will hit Earth with less force. The second solution uses Newton’s third law as the cushion creates an equal and opposite reaction that reflects it back into space.” |

**Rubric 6**: Student describes the experiment conducted to test potential solutions and uses test data to evaluate how well each met the design criteria.

* Dimensions Assessed: DCI – ETS1.B: Developing Possible Solutions, SEP – Planning and Carrying Out Investigations, SEP – Engaging in Argument From Evidence

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student describes an **inaccurate or irrelevant** experiment conducted to evaluate potential solutions **and/or** **does not use** test data to evaluate how well each met the design criteria. | Student **generally** describes the experiment conducted to test potential solutions **and** uses test data to **incompletely** evaluate how well each met the design criteria. | Student **partially** describes the experiment conducted to test potential solutions **and/or** uses test data to **partially** evaluate how well each met the design criteria. | Student **completely** describes the experiment conducted to test potential solutions **and** uses test data to **completely** evaluate how well each met the design criteria. |
| **Look Fors:**   * Student’s experiment is not relevant to the project. For example, “We tested if a heavier ball would cause more pennies to fall over.” * And/or student does not use the test data or provide any reasoning for their evaluation of each solution. For example, “Solution 1 worked the best.” | **Look Fors:**   * Student describes the experiment they did to test all solutions, but description is very general and missing most components listed in the right-hand column. Experiments will vary. For example, “We did an experiment where we rolled a ball at the different solutions to see which ones prevented the most pennies from falling over.” * Student also only evaluates one solution, and does so without detail. For example, “We learned that a barrier is the best option because it prevents a collision.” | **Look Fors:**   * Student describes the experiment they did to test all solutions, identifying some, but not all components listed in the right-hand column. Experiments will vary. * And/or student evaluates some, but not all of the solutions in terms of criteria and constraints. For example, “Solution 2, a barrier, worked best because it succeeded in deflecting “*Etiam”* to not hit “Earth”, which meets the criteria of the problem.” Student writes a description like this for some of the other solutions. | **Look Fors:**   * Student describes the experiment they did to test all solutions, identifying independent variable, dependent variable, controls, materials, procedure, and data collection. Experiments will vary. * Student evaluates all of the solutions in terms of criteria and constraints. For example, “Solution 1, in which we placed diagonal Popsicle sticks right in front of Earth, succeeded in deflecting “*Etiam”* sideways away from “Earth”, but then the Popsicle sticks hit “Earth”, so this didn’t fully meet the criteria.” Student writes a description like this for all other solutions. |

**Rubric 7**: Student draws and describes a final design solution and explains how it combines best characteristics of different designs.

* Dimensions Assessed: DCI – ETS1.C: Optimizing the Design Solution, SEP – Designing Solutions

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student draws and describes a final design solution that **does not combine** best characteristics of different designs. | Student draws and describes a **relevant** final design solution but **does not** **explain** how it combines best characteristics of different designs. | Student draws and describes a **relevant** final design solution and **partially** explains how it combines best characteristics of different designs. | Student draws and describes a **relevant** final design solution and **completely** explains how it combines best characteristics of different designs. |
| **Look Fors:**   * Student drawing and description show a design solution that is either irrelevant to the forces and motion concepts of this unit OR does not combine best characteristics of different designs. | **Look Fors:**   * Student drawing and description show a design solution that is relevant to the forces and motion concepts of this unit and combines best characteristics of different designs. See example to right. * Student does not explain which characteristics were combined and why. | **Look Fors:**   * Student drawing and description show a design solution that is relevant to the forces and motion concepts of this unit and combines best characteristics of different designs. See example to right. * Student explains which best characteristics they incorporated from different designs, but does not explicitly explain why. For example, “We created a barrier that incorporated the soft foam material from Design Solution 1 and the farther placement from Earth from Design Solution 2.” | **Look Fors:**   * Student drawing and description show a design solution that is relevant to the forces and motion concepts of this unit and combines best characteristics of different designs. For example, a barrier made of soft material and placed farther away from Earth. * Student completely explains which best characteristics they incorporated from different designs and why. For example, “In one of the designs, we used popsicle sticks, but the ball bounced back a lot. In another design, we used a foam barrier, but it was too close to the pennies, so the ball pushed the barrier into the pennies. These results made us decide to create a soft barrier, like the foam, but place the barrier farther from Earth, like the popsicle sticks.” |