Waterwheel Released Item Set
Constructed Response Anchor Papers

12 **Use evidence from the waterwheel prototype to explain how the performance of the prototype could be improved. Be sure to note any trade-offs in the suggested modifications.**

Type your answer in the space provided.

Score Level 0 Anchor Paper

The waterwheel prototype could be improved by placing it somewhere that has more rainfall/using more water to see if more energy is created.

This response demonstrates that the student has no understanding of the question. Changing the location of the wheel is not a design improvement to the prototype that would improve its performance (*by placing it somewhere that has more rainfall/using more water*). The response is irrelevant.

Score Level 0 Anchor Paper

you could increase the downspout rate to genetrate more power while increasing the downspout rate increase the flow to the light buble so the water could generate more watts so the ligh bulb is brighter, you could even increse the waterwheel capacity.

This response demonstrates that the student has no understanding of the question. The response gives no explanation for how flow rates or capacity could be increased in the prototype (*increase the downspout rate to genetrate more power while increasing the downspout rate*). The response also does not indicate how increasing these factors might achieve greater power generation in the prototype (*could even increse the waterwheel capacity*). The student response is too vague.

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Score Level 0 Anchor Paper

> The water wheel could have more of a technology aspect to it. There could be clearer enstructions to how it works and what it is supposed to do. whoever made this could tell use how the generator is being used and its purpose.

This response demonstrates that the student has no understanding of the question. The suggestions would have no impact on the design or function of the waterwheel (*There could be clearer enstructions to how it works and what it is supposed to do*). The student response is incorrect.

Score Level 1 Anchor Paper

> The waterwheel could be improved by extending the rain gutter. This could result in more rainwater being collected by the gutter.

This response demonstrates a minimal understanding and constructs a minimal explanation of the question. The explanation is minimally based on disciplinary core ideas when it states a possible modification (*extending the rain gutter…could result in more rainwater being collected*). The student demonstrates no integration of the science and engineering practices by not providing a tradeoff related to their proposed modification. The response reflects no synthesis of complex ideas or crosscutting concepts by not mentioning any changes in the energy of the system. The response has a very minimal understanding of one dimension.

Score Level 1 Anchor Paper

they could make the cups on the wheel smaller so that they fill up faster and therefor make the wheel spin faster and be able to create more electrical power

This response demonstrates a minimal understanding and constructs a minimal explanation of the question. The explanation is minimally based on disciplinary core ideas when it suggests a modification that could increase the amount of energy (*make the cups on the wheel smaller so that they fill up faster*). It is questionable whether smaller cups would achieve this result in all situations. The student demonstrates no integration of the science and engineering practices by not providing a tradeoff related to their proposed modification. The response reflects a little synthesis of crosscutting concepts related to the reasoning behind the energy transfer occurring as input of the system leads to more output of the system (*make the wheel spin faster and be able to create more electrical power*). The response has a minimal understanding of two dimensions.

Score Level 1 Anchor Paper

The downspout could be longer and steeper creating more gravitational energy and spinning the wheel faster. The faster the wheel spins the more kinetic energy is created and converted into electrical energy by the generator. This is one major modification that could be created would increase the energy output of the generator.

This response demonstrates a minimal understanding and constructs a minimal explanation of the question. The explanation is minimally based on disciplinary core ideas when it suggests a method to increase the spinning of the wheel (*downspout could be longer and steeper creating more gravitational energy and spinning the wheel faster*). The student demonstrates no integration of the science and engineering practices by not providing a tradeoff related to their proposed modification. The response reflects a little synthesis of crosscutting concepts related to the energy transfer occurring between the wheel, the input of the system, and the generator, output of the system (*The faster the wheel spins the more kinetic energy is created and converted into electrical energy by the generator*). The response has a minimal understanding of two dimensions.

Score Level 2 Anchor Paper

In order to improve the efficiency of the waterwheel, the students make several changes. They could increase the slant of the rain gutter, increases the gravitational energy, though this may cause some spillage. They coulnd also raise the rain gutter higher off the ground for a similar effect. If they increase the radius of the waterwheel, it cauld make the energy production more efficient.

This response demonstrates that the student has a general understanding and constructs a general explanation of the question. The explanation is mostly coherent based on disciplinary core ideas with three viable modifications (*increase the slant of the rain gutter, raise the rain gutter higher off the ground, increase the radius of the waterwheel*). The student response provides minimal rationale related to any of the modifications (*increases the gravitational energy*). The student demonstrates some integration of the science and engineering practices with mentioning a tradeoff with one of the modifications but lacks a clear rational about its impact (*though this may cause some spillage*). The response reflects some synthesis of understanding of complex ideas and crosscutting concepts by mentioning the relationship between efficiency in energy transfers and energy production (*cauld make the energy production more efficient)*. The response demonstrates a partial understanding of the three dimensions.

Score Level 2 Anchor Paper

The performance of the water wheel prototype could use minor modifications. These modifications could improve the energy output of the prototype and use a higher percentage of the rainfall. The containers placed on the wheel could be smaller in order to produce more energy, because the cups being lighter, would need less weight to be moved, resulting in a faster wheel, which can in turn result in a higher energy output. More cups could be attached to the wheel to minimize open space on the wheel, which would increase the amount of water able to land in the containers and create a greater speed of the wheel. The prototype other wise seems fine, there is a concentrated path for the water to travel and produce a decent amount of energy.

This response demonstrates that the student has a general understanding and constructs a general explanation of the question. The explanation is coherent based on disciplinary core ideas by indicating at least two modifications that would increase the speed of the wheel (*The containers placed on the wheel could be smaller, More cups could be attached to the wheel*). The response also does indicate some reasoning behind each of these modifications (*because*

the cups being lighter, would need less weight to be moved, to minimize open space on the wheel). The student demonstrates some integration of the science and engineering practices with the revisions and evaluation of the device but lacks a clear tradeoff with any of the modifications. The response reflects some synthesis of understanding of complex ideas and crosscutting concepts by describing how the increase in the input of the system, results in a higher output by the system (*resulting in a faster wheel, which can in turn result in a higher energy output*). The response demonstrates an understanding of some of the dimensions but only a partial understanding of all three dimensions.

Score Level 2 Anchor Paper

The prototype could be improved by using smaller containers on the water wheel. This would require less volume of water to quickly fill the cups and make the wheel turn faster, therefore creating more electricity. The trade off here would be that more rain water would be wasted as the fast spinning may cause splashing, but in turn you make more efficient use of the small amount of rainwater you have, since using cups that require so much volume is not efficient when dealing with low quantities of water.

This response demonstrates that the student has a general understanding and constructs a general explanation of the question. The explanation is mostly coherent based on disciplinary core ideas by suggesting a modification that could increase the speed of the wheel (*using smaller containers…require less volume of water to quickly fill the cups and make the wheel turn faster*). The modification would probably not achieve this result in all situations. The student demonstrates some integration of the science and engineering practices by mentioning a tradeoff to the modification (*that more rain water would be wasted as the fast spinning may cause splashing*). The student response seems to contradict their own modifications effectiveness in all situations (*more efficient use of the small amount of rainwater/not efficient when dealing with low quantities of water*). The response reflects some synthesis of understanding of complex ideas and crosscutting concepts by indicating how the modification could increase the output of electricity from the system (*make the wheel turn faster, therefore creating more electricity*). The response demonstrates a partial understanding of all three dimensions.

Score Level 3 Anchor Paper

A way to improve the prototype is to add multiple waterwheels to it. If you have larger cups and a wider funnel, more water could be put into the wheel causing it to spin faster and create more kinetic energy that would be converted to electrical energy by the generator. If more wheels are added, the efficiency of the waterwheel prototype would be a lot higher due to a more constant heavy flow of mechanical energy from the spinning of the wheel that can contain more water than its counterpart. A trade-off for the modification would be the higher expense and a larger amount of space that it would be occuping.

This response demonstrates that the student has a full and complete understanding and constructs a complete explanation of the question. The explanation is coherent based on disciplinary core ideas by indicating two possible modifications and their rationale (*have larger cups and a wider funnel, If more wheels are added*). The student demonstrates integration of the science and engineering practices by identifying tradeoffs for the modification of adding more wheels (*the higher expense and a larger amount of space that it would be occupying*). The response reflects a complete synthesis of understanding of complex ideas and crosscutting concepts by describing how the increase in input of water into the system results in an increase in the output of the system (*more water could be put into the wheel causing it to spin faster and create more kinetic energy that would be converted to electrical energy by the generator*). The response demonstrates an understanding of all three dimensions.

Score Level 3 Anchor Paper

The generator was not creating the necessary energy to fully light the light bulb, so my improvement would be ti get a larger funnel and place it higher. The larger funnel would allow more water to hit the wheel at once, adding more power and force. Also raising up the funnel higher puts more distance between the wheel and the water as it begins to fall. When the water begins to fall a a higher place it will have more potential and gravitational energy, which will chance to kinetic energy as it falls to hit the wheel. The only trade-off would be the accuracy of the water. with a longer distance between the wheel and the funnel there is more room for water to splash out and or miss the wheel, especially if there are other outside components such as wind.

This response demonstrates that the student has a full and complete understanding and constructs a complete explanation of the question. The explanation is coherent based on disciplinary core ideas by citing a modification and its effect (*get a larger funnel and place it*

higher. The larger funnel would allow more water to hit the wheel at once, adding more power and force.). The student demonstrates integration of the science and engineering practices by describing a valid tradeoff related to the modification (*the accuracy of the water. with a longer distance between the wheel and the funnel there is more room for water to splash out and or miss the wheel*). The response reflects a complete synthesis of understanding of complex ideas and crosscutting concepts by describing how the change in energy into the system would result in an increase in the energy of the system (*more potential and gravitational energy, which will chance to kinetic energy as it falls to hit the wheel*). The response demonstrates an understanding of all three dimensions.

Score Level 3 Anchor Paper

The performance of the waterwheel could be improved by enclosing the wheel and adding a basin at the bottom. Enclosing the wheel would make sure that no water could splash off and escape the wheel. This would maximize efficiency and produce a higher amount of energy. Adding a basin at the bottom would make it so that the students can measure how much water flowed through the generator so that they could estimate factors such as flow rate and efficiency and energy output more precisely. One trade off for the enclosure would be that the turbine would be harder to repair if broken and one trade off for the basin would be that it would have to be emptied after getting full because it wouldnt flow like a river.

This response demonstrates that the student has a full and complete understanding and constructs a complete explanation of the question. The explanation is coherent based on disciplinary core ideas by suggesting a viable modification that would increase efficiency (*Enclosing the wheel would make sure that no water could splash off and escape the wheel*). The student demonstrates integration of the science and engineering practices by refining the original design by citing a valid tradeoff based on the proposed modification (*that the turbine would be harder to repair if broken*). The response reflects a complete synthesis of understanding of complex ideas and crosscutting concepts by describing how the increase in input into the system results in an increase in the energy produced by the system (*This would maximize efficiency and produce a higher amount of energy*). The response demonstrates an understanding of all three dimensions. The basin at the bottom does not seem to address performance improvements and does not contribute to nor diminish from the score of the paper.