

Table 3: Rubric for grading students' responses to the pre- and post-lesson content questions.

Content questions	Correct responses	Incorrect response
<i>The Mechanical Advantage</i>		
What is a pulley and what is the purpose of using a pulley?	Student mentions keywords pertaining to a simple machine or a wheel in which a rope or string passes around. Student mentions how pulleys are used to achieve mechanical advantage or to lift heavy objects. Both parts of the questions must be answered by student to receive full credit.	Student provides descriptions unrelated to those in the "Correct responses" column, including: "pulleys are used to pull things."
Draw the way pulleys can be installed on the given platform to help lift the weight shown below.	Student provides a diagram in which a rope or string goes over at least one upper pulley and under at least one lower pulley in the diagram.	Student provides a drawing unrelated to the description in the "Correct responses" column that fails to yield mechanical advantage.
What happens to the string when pulleys are added to them?	Student discusses that the strings feel looser or strings are not as stiff or tight as before.	Student gives an answer unrelated to the description in the "Correct responses" column, e.g., the strings become tighter and stiffer.
<i>Acceleration Due to Gravity</i>		
What is a force?	Student provides keywords pertaining to a pushing or pulling action, including making something move.	Student provides keywords or descriptions unrelated to those in the "Correct responses" column.
What is velocity?	Student provides keywords pertaining to the rate of change of position with respect to time. If the student uses the terms "fast" or "slow", they must be used together, such as how fast or slow something is going.	Student provides keywords or descriptions unrelated to those in the "Correct responses" column.
What is acceleration?	Student provides keywords pertaining to the rate of change of velocity with respect to time. If the student uses terms	Student provides keywords or descriptions unrelated to those in the "Correct responses"

such as “speeding up” or “slowing down”, they must be used together, such as when something speeds up or slows down.

column.

Fluid Flow Rate

What is flow rate?	Student provides keywords pertaining to the time required for a volume of liquid to enter (fill up) or exit (empty) a vessel.	Student provides keywords or descriptions unrelated to those in the “Correct responses” column, e.g., the rate at which something flows.
Which parameters affect flow rate?	Student provides keywords pertaining to the size and shape of the orifice (nozzle), the amount of liquid in the container, and additional forces used to push or pull the liquid out, such as a pump.	Student lists parameters that have no relationship with the flow rate, e.g., material of the nozzle or the setup.
Give a physical example of where regulating flow rate is important and how it is regulated in practice.	Student provides keywords pertaining to the movement of liquid, e.g., in a hose, a dam, a shower head, a river, etc. The student must give examples of how flow rate is regulated in order to receive full credit, such as regulating flow rate is important when taking shower, the flow rate is regulated by the shower head and faucet.	Student provides keywords, descriptions, or examples unrelated to those in the “Correct responses” column.

Measurements & Accuracy

Order the numbers from smallest to largest.	Student orders given numbers in increasing order.	Student orders given numbers in incorrect order, or leaves one or more numbers out.
Order the numbers from largest to smallest.	Student orders given numbers in decreasing order.	Student orders given numbers in incorrect order, or leaves one or more numbers out.
Using the ruler measure the height of an object in inches.	Student measures the object accurately and gives its length approximated to the nearest half-inch.	Student measures the length of the object incorrectly with the reported value being off by more than an inch.
What is the difference in height between the	Student determines heights of given objects to the nearest hundreds and subtracts them to find their difference to the	Student provides a difference in height of objects that deviates more than a hundred from the correct

tallest and shortest nearest hundreds.
objects?

answer.

Pi - What is it?

Simplify the ratio of circumference to area.	Student correctly write the ratio in terms of radius r and constant π and simplifies it to provide the final expression in terms of radius r .	Student incorrectly writes the ratio so that the simplified expression is incorrect, or incorrectly simplifies the expression, or writes numbers instead of an expression.
How many digits does number π have?	Student states that either the number is irrational or that the digits after the decimal go on forever and never end, etc.	Student gives a finite number of digits, such as three digits as in “3.14”, or states that π has one hundred digits, etc.
Calculate the area of the circle.	Student calculates the area correctly with an answer given exactly in terms of π or numerically approximated.	Student provides an answer that deviates greatly from the correct answer, especially by a factor, e.g., a multiple of 10.
What is an irrational number?	Student picks a number that cannot be turned into a fraction or ratio; states that an irrational number is made up of a non-terminating/never-ending decimal, e.g., π	Student provides an answer unrelated to those in the “Correct responses” column, refers to a number that is not irrational, e.g., -0.3.

Means, Modes and Medians

Calculate the mean.	Student correctly calculates the mean of a given set of numbers using a calculator, or gives answer in fractional format.	Student gives an answer that differs from actual numerical mean and performs calculation incorrectly.
Calculate the median.	Student correctly states or calculates the median of a given set of numbers.	Student provides an incorrect value of the median of a given set of numbers.
Calculate the mode	Student provides the correct value of the mode of a given set of numbers.	Student provides an incorrect value of the mode of a given set of numbers.
Solve a word problem with known average and missing data.	Student shows understanding of the problem, provides proper formula for finding the average, assigns a variable value to a unknown data in the set of values, and correctly solves for that unknown.	Student does not show an understanding of how to approach the problem.