

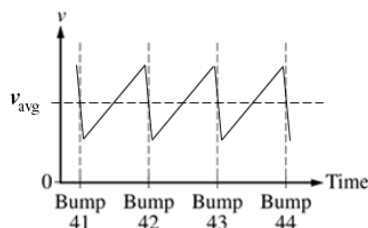
2016 SCORING GUIDELINES

Question 3

12 points total

Distribution
of points

(a)



i. 3 points

For having a constant upward slope in each segment between bumps

1 point

For having the velocity "reset" abruptly at each bump (i.e., as a sawtooth function, not a sinusoidal curve) to a minimum positive value that is the same for each bump

1 point

For having the same maximum value in each cycle that occurs near the bump times (This point can be earned for a sinusoidal curve with peaks at the bump times.)

1 point

ii. 1 point

For drawing a v_{avg} line that is horizontal and consistent with the graph drawn, even if that graph is wrong

1 point

(b) 2 points

Correct answer: Greater than

No points are earned if the correct answer is selected, but the explanation is completely incorrect or there is no explanation.

No points are earned if the wrong answer is selected.

For indicating that there is more time between bumps

1 point

For connecting that the cart has more time or more distance to accelerate between bumps

1 point

Example: The maximum speed is greater because the cart has more space (or time) to accelerate (build up speed) between bumps.

Alternate solution in terms of energy

Alternate points

For indicating that the potential energy difference increases due to increased height between successive bumps

1 point

For relating the increase in potential energy to an increase in kinetic energy

1 point

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Question 3 (continued)

Distribution
of points

(c) 2 points

Correct answer: Greater than

No points are earned if the correct answer is selected, but the explanation is completely incorrect or there is no explanation.

No points are earned if the wrong answer is selected.

For indicating that the acceleration is greater

1 point

For indicating that the component of the gravitational force increases

1 point

Alternate solution in terms of energy

Alternate points

For indicating that the potential energy difference increases due to increased height between successive bumps

1 point

For relating the increase in potential energy to an increase in kinetic energy

1 point

(d)

i. 2 points

Correct answer: No

No points are earned if the correct answer is selected, but the explanation is completely incorrect or there is no explanation.

For indicating that v_{avg} is not proportional to M

1 point

For connecting the equation to the data

1 point

Examples:

The y-intercept of the graph is not zero, but the equation indicates that it should be zero.

Doubling the mass from the graph does not double v_{avg} , but the equation indicates that it should double.If "yes" is selected, one point may be earned for explaining that v_{avg} increaseswith M or that v_{avg} looks (approximately) proportional to M for a limited portion of the data (e.g., the points at $M = 1.0$ kg and $M = 2.0$ kg).

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Question 3 (continued)

Distribution
of points

(d)

ii. 2 points

Correct answer: No

For indicating that the distance dependency is incorrect

1 point

For indicating that, according to the equation, greater d leads to a smaller v_{avg} , OR
 for stating or implying the contradiction between this inverse relation and the
 reasoning of part (b)

1 point

Credit is earned for any answer that is consistent with reasoning in part (b).

Example: According to the equation, a larger d corresponds to a smaller v_{avg} ,

because they are inversely proportional. But according to the reasoning of part
 (b), a bigger distance d between the bumps leads to a larger maximum average
 speed, showing that the equation is implausible.

If “yes” is selected, one point can be earned for indicating that an increase in the
 angle increases v_{avg} .