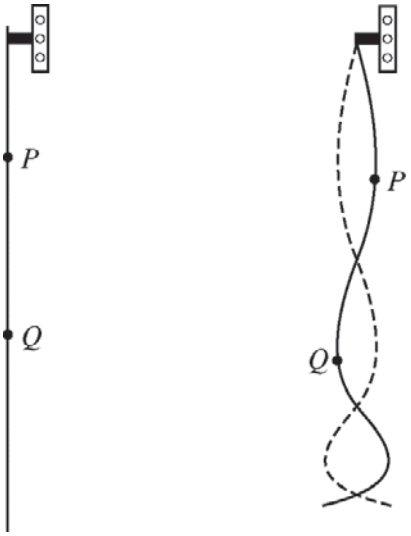

5. (7 points, suggested time 13 minutes)

The figure above on the left shows a uniformly thick rope hanging vertically from an oscillator that is turned off. When the oscillator is on and set at a certain frequency, the rope forms the standing wave shown above on the right. *P* and *Q* are two points on the rope.

(a) The tension at point *P* is greater than the tension at point *Q*. Briefly explain why.

(b) A student hypothesizes that increasing the tension in a rope increases the speed at which waves travel along the rope. In a clear, coherent paragraph-length response that may also contain figures and/or equations, explain why the standing wave shown above supports the student's hypothesis.

STOP

END OF EXAM

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Question 5

7 points total **Distribution of points**

(a) 2 points

For indicating that there is more rope or weight below one point than the other — 1 point
For indicating (explicitly or implicitly) that the tension at any point counteracts or supports the weight below that point — 1 point

Examples:

The rope at *P* supports more weight than the rope at *Q* so the tension must be higher at *P*.

The section of rope below *P* has an upward force from the rope above it and a downward gravitational force. The same goes for *Q*. Because the gravitational force is greater on the longer section (the section below *P*), the upward force — the tension — must be greater at *P*.

(b) 5 points

For indicating that the wavelength is longer near the top of the rope (or shorter near the bottom) — 1 point
For indicating (explicitly or implicitly) that the frequency is the same throughout the rope — 1 point
For using $v = \lambda f$ to conclude that wave speed is greater near the top of the rope (or less near the bottom), based on the difference in wavelength — 1 point
For indicating (explicitly or implicitly) that, as stated in part (a), tension is greater near the top of the rope (or less near the bottom) — 1 point
For a response that has sufficient paragraph structure, as described in the published requirements for the paragraph-length response — 1 point