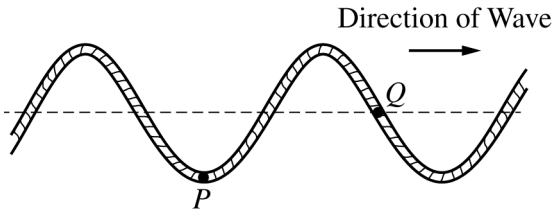
4. (7 points, suggested time 13 minutes)

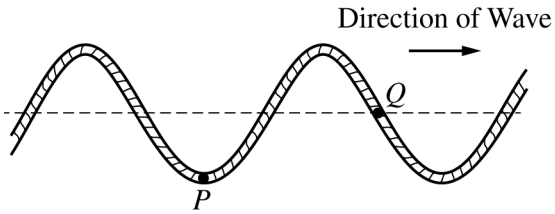
A transverse wave travels to the right along a string.

(a) Two dots have been painted on the string. In the diagrams below, those dots are labeled *P* and *Q*.

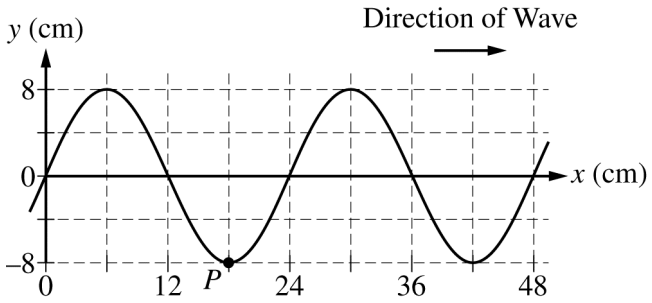
i. The figure below shows the string at an instant in time. At the instant shown, dot *P* has maximum displacement and dot *Q* has zero displacement from equilibrium. At each of the dots *P* and *Q*, draw an arrow indicating the direction of the instantaneous velocity of that dot. If either dot has zero velocity, write "$v = 0$" next to the dot.



ii. The figure below shows the string at the same instant as shown in part (a)i. At each of the dots *P* and *Q*, draw an arrow indicating the direction of the instantaneous acceleration of that dot. If either dot has zero acceleration, write "$a = 0$" next to the dot.



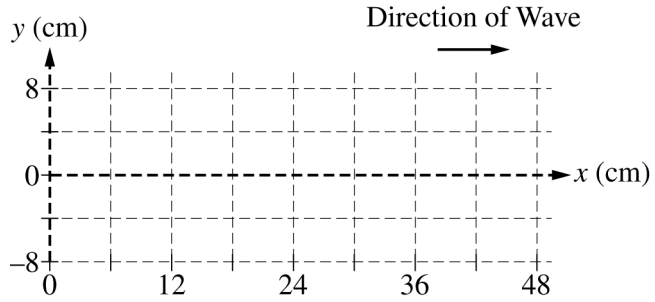
The figure below represents the string at time $t = 0$, the same instant as shown in part (a) when dot P is at its maximum displacement from equilibrium. For simplicity, dot Q is not shown.



(b)

i. On the grid below, draw the string at a later time $t = T/4$, where T is the period of the wave.

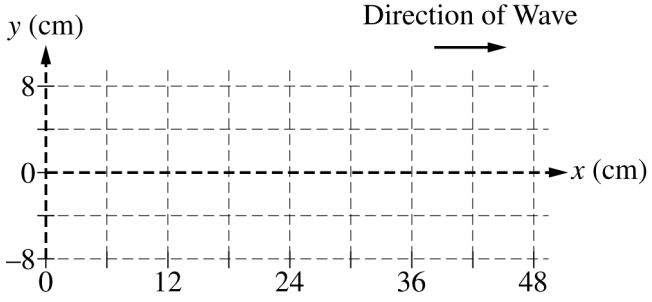
Note: Do any scratch (practice) work on the grid at the bottom of the page. Only the sketch made on the grid immediately below will be graded.



ii. On your drawing above, draw a dot to indicate the position of dot P on the string at time $t = T/4$ and clearly label the dot with the letter P.

(c) Now consider the wave at time $t = T$. Determine the distance traveled (not the displacement) by dot P between times $t = 0$ and $t = T$.

The grid below is provided for scratch work only. Sketches made below will not be graded.



AP® PHYSICS 1
2018 SCORING GUIDELINES

Question 4

7 points total **Distribution of points**

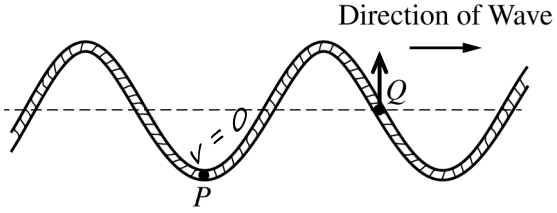
A transverse wave travels to the right along a string.

(a) LO / SP: 3.A.1.1 / 1.5; 6.A.1.2 / 1.2
4 points

Two dots have been painted on the string. In the diagrams below, those dots are labeled *P* and *Q*.

i. 2 points

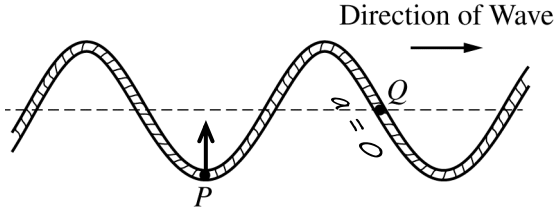
The figure below shows the string at an instant in time. At the instant shown, dot *P* has maximum displacement and dot *Q* has zero displacement from equilibrium. At each of the dots *P* and *Q*, draw an arrow indicating the direction of the instantaneous velocity of that dot. If either dot has zero velocity, write "$v = 0$" next to the dot.



For "$v = 0$" at point *P*		1 point
For an upward arrow at point *Q*		1 point

ii. 2 points

The figure below shows the string at the same instant as shown in part (a)(i). At each of the dots *P* and *Q*, draw an arrow indicating the direction of the instantaneous acceleration of that dot. If either dot has zero acceleration, write "$a = 0$" next to the dot.

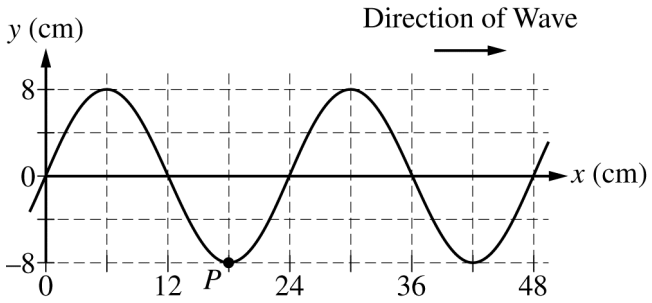


For an upward arrow at point *P*		1 point
For "$a = 0$" at point *Q*		1 point

Question 4 (continued)

Distribution of points

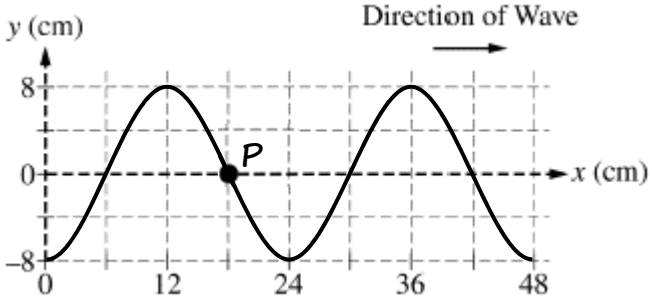
The figure below represents the string at time $t = 0$, the same instant as shown in part (a) when dot P is at its maximum displacement from equilibrium. For simplicity, dot Q is not shown.



(b) LO / SP: 3.A.1.1 / 1.5; 6.A.1.2 / 1.2
2 points

i. 1 point

On the grid below, draw the string at a later time $t = T/4$, where T is the period of the wave.
Note: Do any scratch (practice) work on the grid at the bottom of the page. Only the sketch made on the grid immediately below will be graded.



For a curve shifted to the right by 1/4 of a wavelength (1 gridline) with the same wavelength as the original wave (for example, as indicated by a negative minimum at $x = 0$)		1 point

ii. 1 point
On your drawing above, draw a dot to indicate the position of dot P on the string at time $t = T/4$ and clearly label the dot with the letter P.

For point P on the string and at the dot's original x position, 3/4 of a wavelength (3 grid units) to right of origin		1 point

Question 4 (continued)

Distribution of points

(c) LO / SP: 6.A.3.1 / 1.4
1 point

Now consider the wave at time $t = T$. Determine the distance traveled (not the displacement) by dot P between times $t = 0$ and $t = T$.

For the correct numerical answer: 32 cm		1 point

Learning Objectives (LO)

LO 3.A.1.1: The student is able to express the motion of an object using narrative, mathematical, and graphical representations. [See Science Practice 1.5]

LO 6.A.1.2: The student is able to describe representations of transverse and longitudinal waves. [See Science Practice 1.2]

LO 6.A.3.1: The student is able to use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. [See Science Practice 1.4]