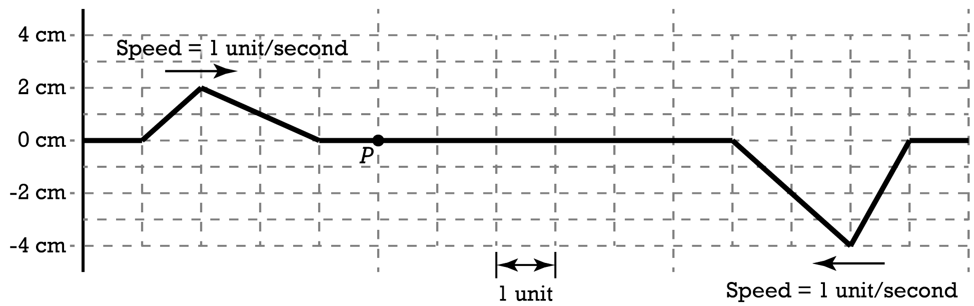
2017 #5 Free Response Question - AP Physics 1 - Exam Solution

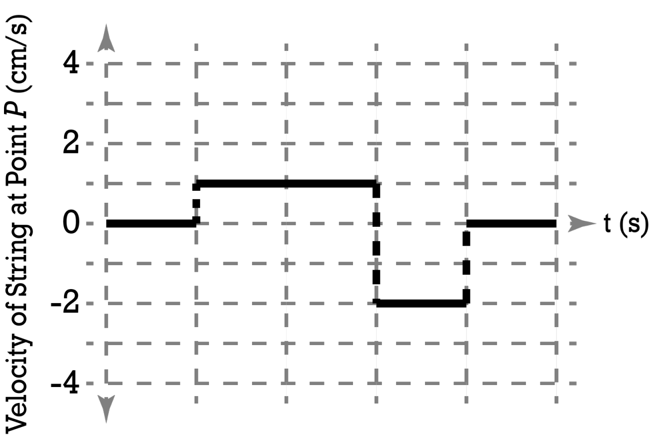
http://www.flippingphysics.com/ap1-2017-frq5.html

This is a Short Answer Question.



Two wave pulses are traveling in opposite directions on a string. The shape of the string at t = 0 is shown above. Each pulse is moving with a speed of one unit per second in the direction indicated.

(a) Between time t = 0 and t = 5 seconds, the entire left-hand pulse approaches and moves beyond point P on the string. On the coordinate axes below, plot the velocity of the piece of string located at point P as a function of time between t = 0 and t = 5 seconds.



The left-hand pulse is moving to the right at 1 unit per second, therefore, the pulse does not reach point P until t = 1 second. Therefore, the velocity of P until t = 1 second is zero. From t = 1 to 3 seconds, P moves up 2 cm. In other words, the velocity of P is:

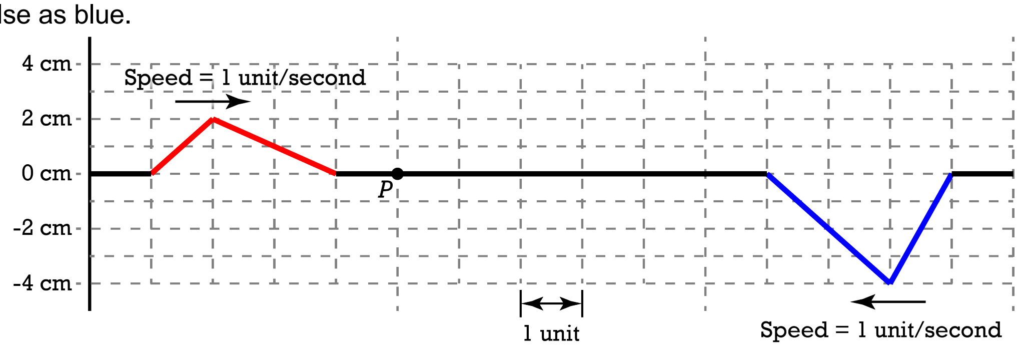
$V_{1\text{-}3} = \Delta x/\Delta t = (x_3 - x_1)/(t_3 - t_1) = (2\text{-}0)/(3\text{-}1) = 1$ *cm/sec.*

From t = 3 to 4 seconds, P moves down 2 cm:
$V_{3\text{-}4} = \Delta x/\Delta t = (x_4 - x_3)/(t_4 - t_3) = (0\text{-}2)/(4\text{-}3) = -2$ *cm/sec.*

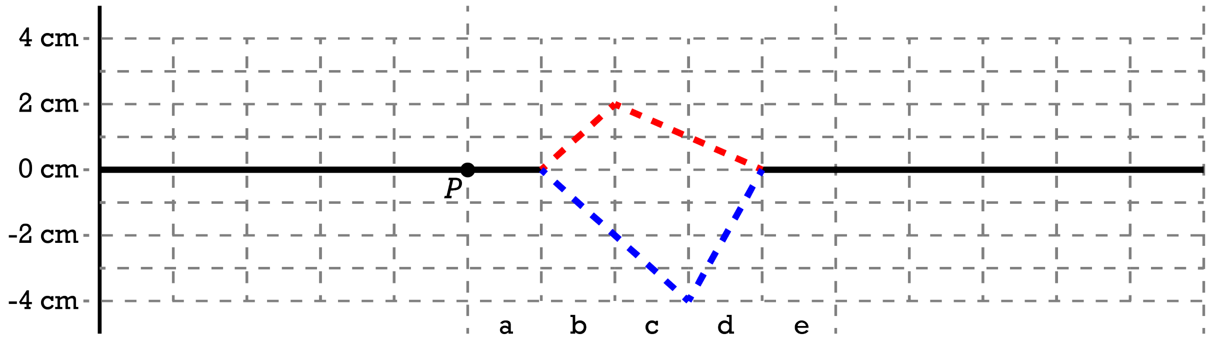
From t = 4 to 5 seconds, P does not move and velocity is zero.

(b) At t = 5 s, the pulses completely overlap. On the grid provided below, sketch the shape of the entire string at t = 5 s.

In order to better differentiate between the two pulses, let's draw the left-hand pulse as red and the right-hand pulse as blue.

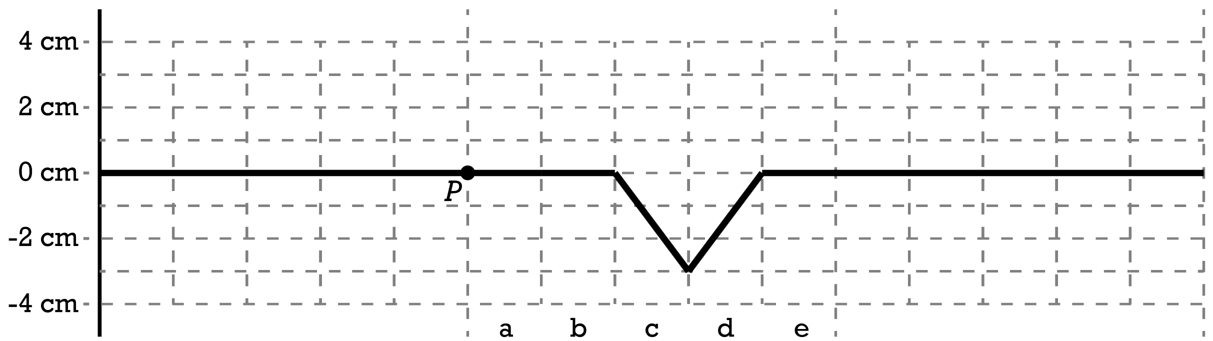


When the two pulses overlap, they will interfere with one another via wave superposition. Here is what the two original pulses look like at t = 5 seconds.



- In the two sections labeled “a” and “e”, both pulses have zero amplitude and add up to 0 cm.
- In section “b”, the red and the blue pulses are inverses of one another and therefore completely cancel one another out and the resultant wave has an amplitude of 0 cm.
- Section “c” starts with both pulses completely canceling one another out and a resultant wave of 0 cm amplitude. At the end of section “c” the red pulse is at +1 cm and the blue pulse is at -4 cm, which adds up to an amplitude of -3 cm. Both pulses are linear, so they will add up to a linear resultant pulse which, in section “c”, starts at 0 cm and ends at -3 cm.
- Section “d” will also be linear and starts at -3 cm and ends at 0 cm.

Therefore, resultant wave pulse at 5 seconds looks like this:



Please recognize that all 7 points for this problem are earned for your drawings. There is no explanation necessary. There are no equations used. Your *entire* answer is your drawings. Please, **draw carefully!!**

And, considering you earn 1 point in part (a) “For indicating zero velocity for 0 < t < 1 s and 4 s < t < 5 s” and 1 point in part (b) “for drawing a single pulse and zero elsewhere”, remember to draw horizontal lines at zero when necessary. … Sometimes my students do not draw lines when the value of the graph equals zero. You still have to draw horizontal lines at zero when the value is zero.