

Note that the transverse velocity, $u_y(x, t)$ of a traveling harmonic wave is 90° out of phase with the transverse displacement, y(x,t) of the wave (*i.e.* ¹/₄ of a cycle). This is because the cosine and sine functions are related to each other by a phase angle of $\delta = 90^\circ$; $\cos \theta = sin(\theta + 90^\circ)$, and $sin \theta = cos(\theta - 90^\circ)$, where θ is an arbitrary angle. These relations can be derived from the *angle-addition formulae* for the sine and cosine functions:

 $sin(A \pm B) = sin A cos B \pm sin B cos A$ and: $cos(A \pm B) = cos A cos B \mp sin A sin B$.

Alternatively, we can show the transverse displacement, y(x,t) and the transverse velocity, $u_y(x, t)$ for the above sine-type harmonic traveling wave for fixed position, x = -5, 0 and +5 *meters*, as a function of time, *t*:



 $y(x,t) = A \sin[kx-wt] vs. t$

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