We don't have to use the diameter of either wheel in the calculation, just the difference in circumference.

Phase and Time Delay

Back to the bicycle analogy. Supposing the bicycle is moving at a constant speed. The back wheel is slightly larger than the front one and we have managed to arrange that the frame and rear wheel do not change in size with distance covered. Two observers have to shout when the valves point vertically downwards, one observer for each wheel. At a time when both wheels appear to be in phase (could be any multiple of 360° phase change for the back wheel remember) both shout together. Then a curious thing happens. With each revolution of the front wheel the shout from the rear wheel observer gets later and later. A time delay appears between shouts of first observer and second observer which gets longer as the bike travels on. Eventually after 36 revolutions of the front wheel they both shout together again. But the rear observer would have shouted one less time than the front observer. If they were to count the revolutions and shout the number, the same numbers would get further and further apart in time. So a phase change is the same as a time delay in particular a constant phase change with frequency is equal to a fixed time delay. Note that the phase must be constantly and lineally increasing with respect to linear frequency.

So:

$$\text{Time} = \frac{\text{Rate of change of phase}}{\text{Rate of change of frequency}} = \frac{d\phi}{dw}$$

The relationship is really very simple. Figure 5 shows a graph of increasing phase change with frequency and the resulting associated time delay values.

The reverse is of course true and a time delay can be compensated for by introducing a network which shifts the phase a constant amount with frequency. If the amplitude response is unaffected then this circuit would be able to compensate for inherent time delay errors in loudspeakers, between drive units.

The Loudspeaker System

Consider the loudspeaker of figure 6 which is a conventional loudspeaker system with two drive units mounted on the front baffle. By measurement the acoustic sources of the HF and LF units are located at (1) and (4) respectively. The LF unit is fed through a low pass filter to control the acoustic response and reject high frequency signals which fall outside the designed pass band of the unit. It so happens that all low pass networks have inherent phase shifts which give rise to an apparent time delay. (high pass network do not have time delays). Indeed this explains why the LF unit source is behind the moving cone - because the LF unit on its own acts like a low pass filter. The lower the cut off point of the filter the greater is the associated time delay. So feeding the LF unit through a low pass electrical filter delays the signal more and the acoustic source is set back from position (4) in figure 6 to position (3). In the case of the Jupiter bass unit this represents a distance of 8 mm. So the point (3) is actually 70mm behind the front chassis surface when a crossover is applied.