A demonstration of constructive interference using an ultrasonic rangefinder

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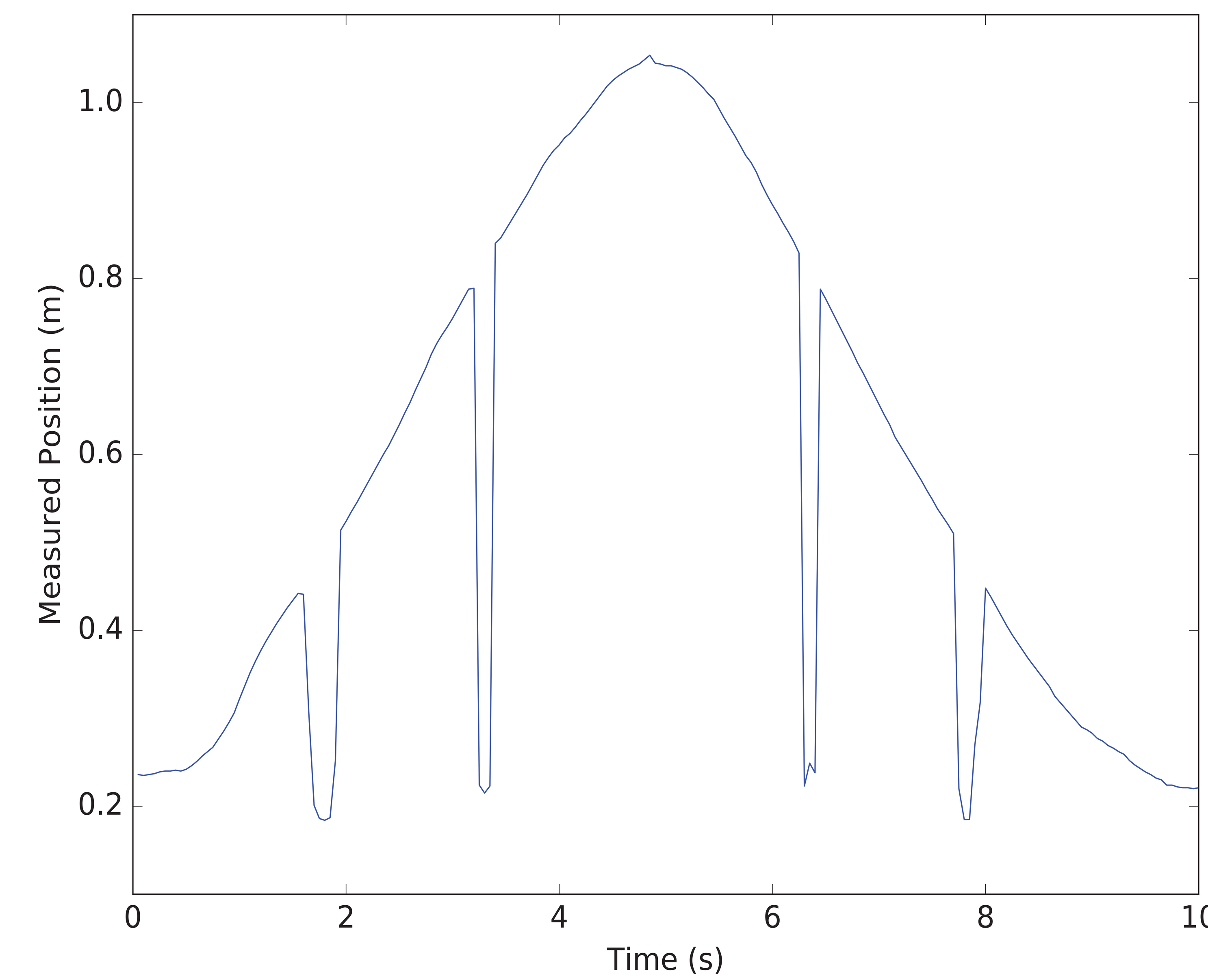
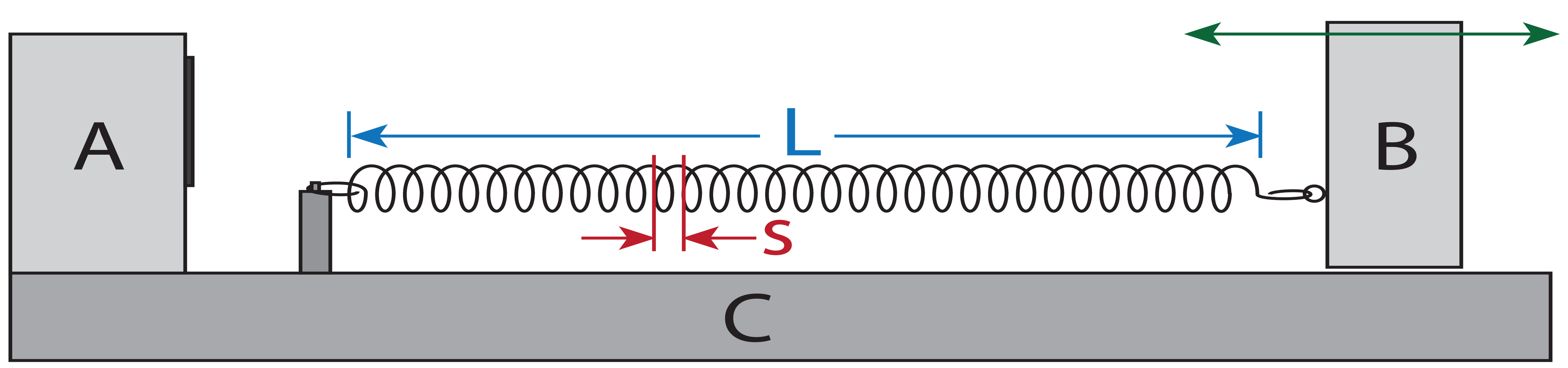
When a spring is uniformly stretched in the reflection region of a rangefinder, there are lengths of string stretch for which the spring coil spacing is an integer half-wavelength of the rangefinder's ultrasonic carrier wavelength. Reflections from successive coils then add constructively, creating an erroneous distance measurement which can be used to determine the wavelength of the ultrasonic signal.

Our first indication that something strange was happening occurred when we were measuring the position of a cart attached to a spring, as part of an introductory physics lab. As you can see in this graph, there are certain positions at which the position measurement goes bad. This data was taken by just moving the cart back and forth by hand.

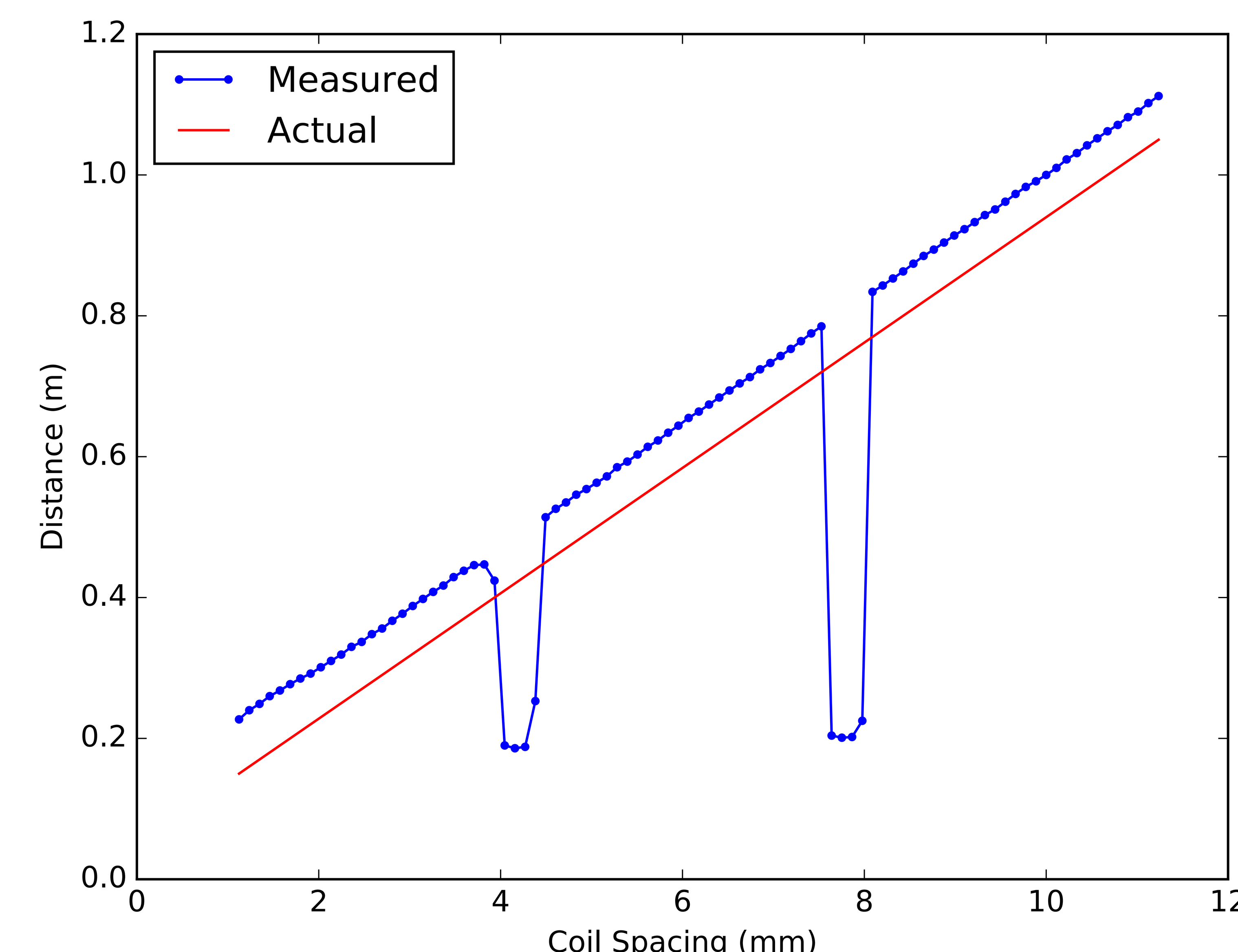


Here's what's happening. As the spring stretches, the spacing between the coils increases. At certain critical lengths *L*, the coil spacing *s* is an integer half-wavelength of the ultrasonic pulse wavelength λ. Sequential reflections from each loop of the coil have then each travelled one wavelength further, and the reflections arrive at the transducer (A) in phase with each other. These in-phase reflections form a very strong signal from the spring, instead of the desired reflection from the object (B) being measured.

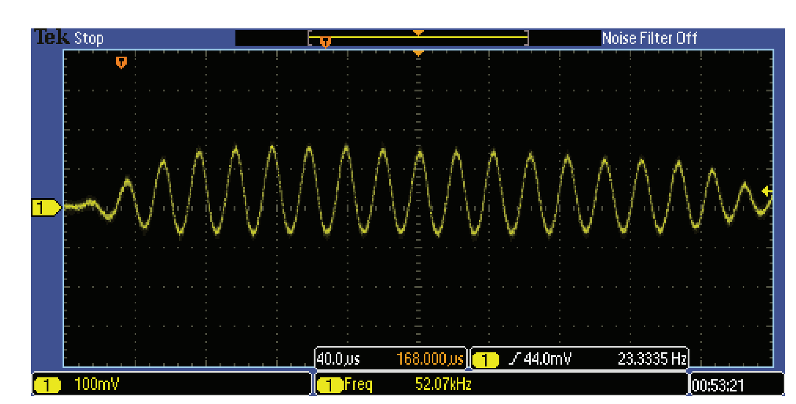


Careful measurements of position give the results you see here. There are dips in the measured distance at $\lambda/2$ and at λ, and from the coil spacings at these dips we can measure the wavelength —and thus the frequency— of the ultrasonic pulse. Based on this data, the frequency was 47±3 kHz.

There is a shift between the actual and measured distance because we measured the actual distance from the front of the ultrasonic transducer case rather than from the transducer membrane.



Finally, we used a second ultrasonic transducer to view the actual pulses with an oscilloscope. The frequency measured with the 'scope was 52 kHz, which is consistent with the interference measurement.



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