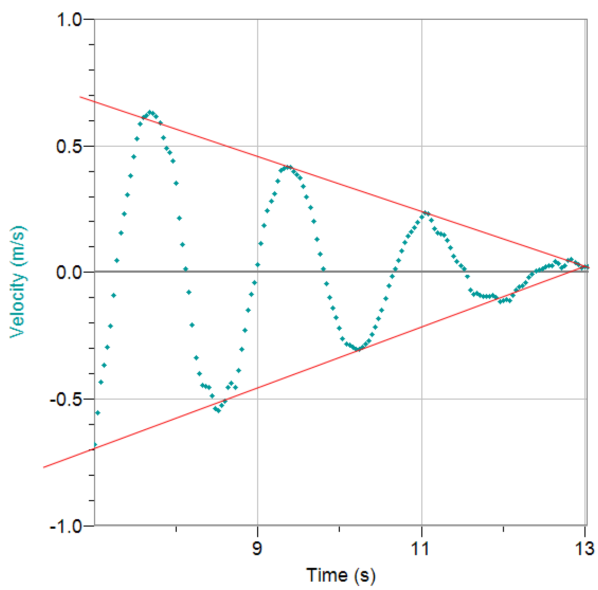
SHM damped by friction

A mass rubs on a plastic board as it oscillates on a spring. The near constant friction force that damps the simple harmonic motion is larger than small contributions from viscous drag and turbulence in air.

A motion detector (not shown) on the floor below the mass is connected to a computer running Logger Pro.

The velocity-time graph is a sine function that decreases in amplitude as energy of motion is converted to heat.



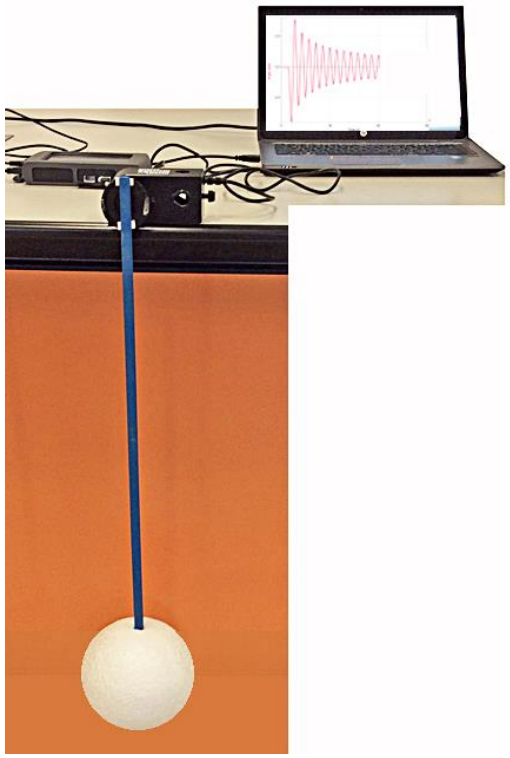
Lines have been added in red to show the almost identical reduction in velocity each cycle.

Explanation

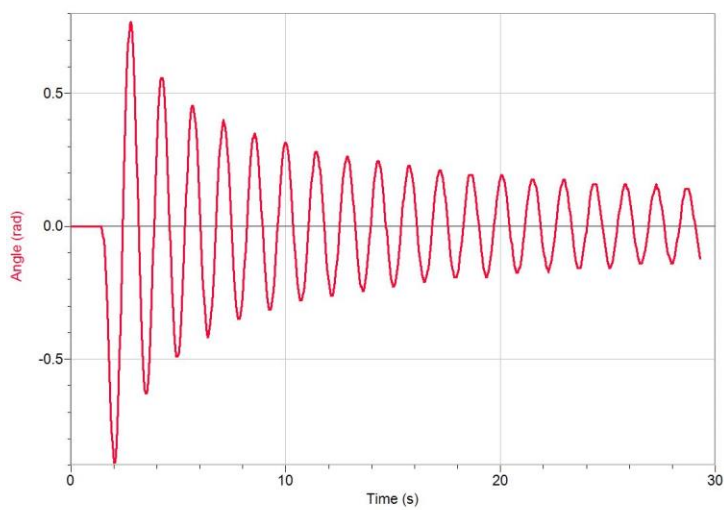
The friction force $-f$ and the period of the motion T can be taken as constant to within ±5%. The impulse applied to the mass each cycle $-fT$, is constant to within ±10%. The reduction in momentum $m(v_{(i+1)} - v_i)$ is almost the same from one cycle to the next and the amplitude of the v-t graph decays as an approximately linear function.

A second example

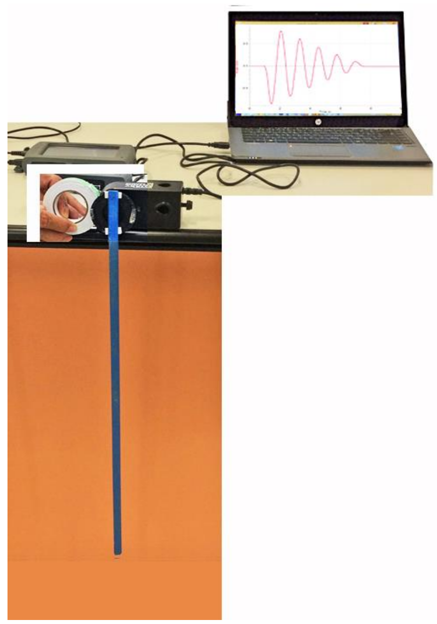
A rod and polystyrene ball are attached to a Vernier angular motion detector.



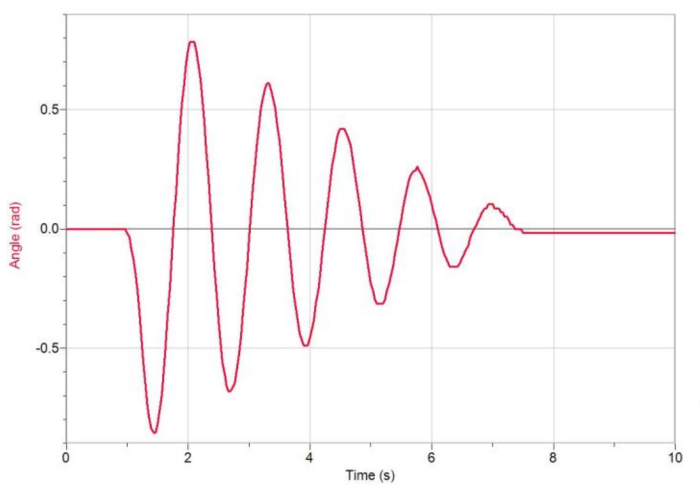
The dominant damping force is due to turbulence in air. The amplitude decays as shown below.



Removing the ball and pressing a smooth reel of tape gently against the rotating disc replaces the damping force in air with a near constant torque to oppose the motion.



The damping torque is constant and the amplitude decays by close to the same amount each cycle.



At small amplitudes and near constant angular frequency, maximum velocity is equal (for SHM) to $A\omega$ and the velocity again reduces by almost the same amount each cycle.

The damping torque can be found if the moment of inertia of the rod about the centre of rotation is known, *but that is another story*.