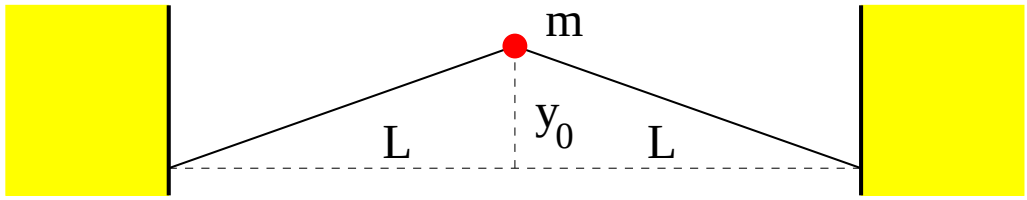
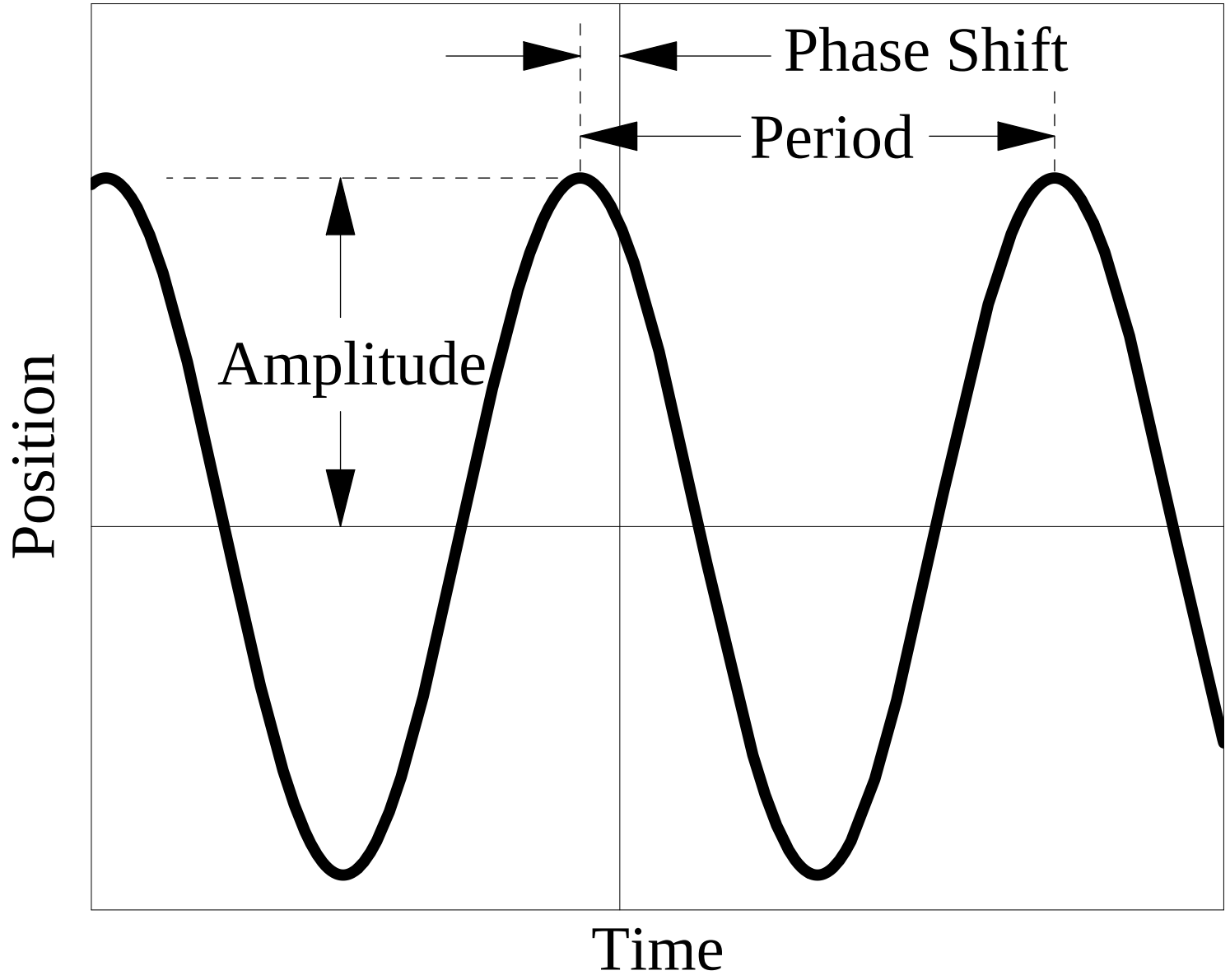
A Nanosized Biosensor

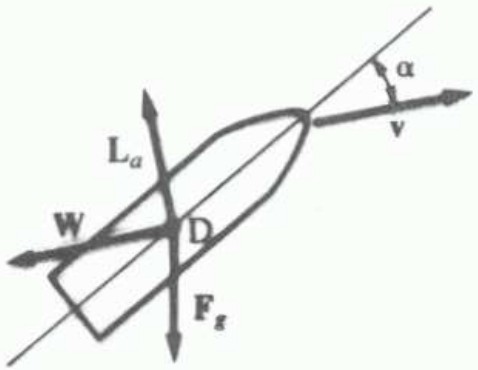
The figure below shows a possible design for a new biosensor. A large antibody (the red dot) that will bind to a protein marker for a specific disease is held in place in a narrow channel by two carbon nanotubes. Each nanotube has a length $L = 100\,nm$ and a tension $T = 1.3 \times 10^{-16}\,N$. The mass of the antibody is $m = 43\,kD$ where $1\,D = 1.66 \times 10^{-27}\,kg$. What is the force on the central mass due to the posts when it is displaced by a distance y from the equilibrium point? Ignore gravity. What is the equation for the displacement y of the central mass from equilibrium? How big is the damping? The mass is plucked so at $t = 0$, $y_0 = 2\,nm$ and $v_0 = 0$. The amplitude drops to one-half of its initial value in about $5.0\,s$. Note that $y_0 << L$.



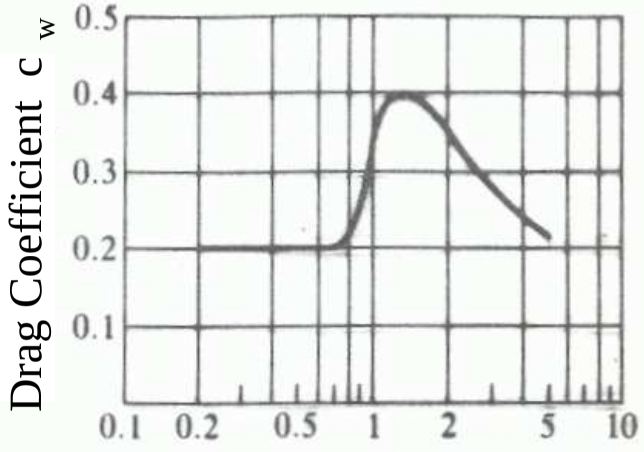
Harmonic Oscillator Waveform



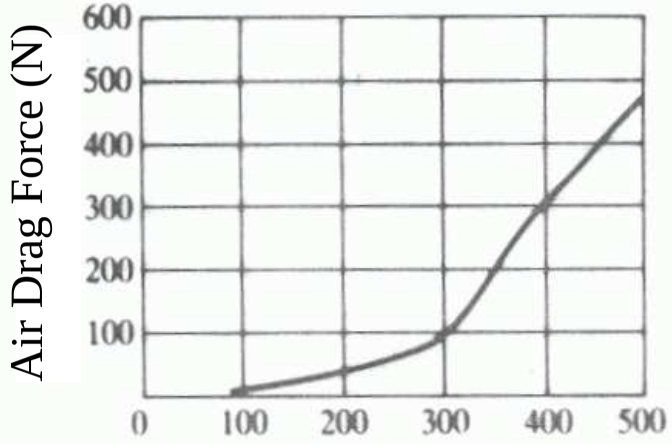
Aerodynamic Drag Forces

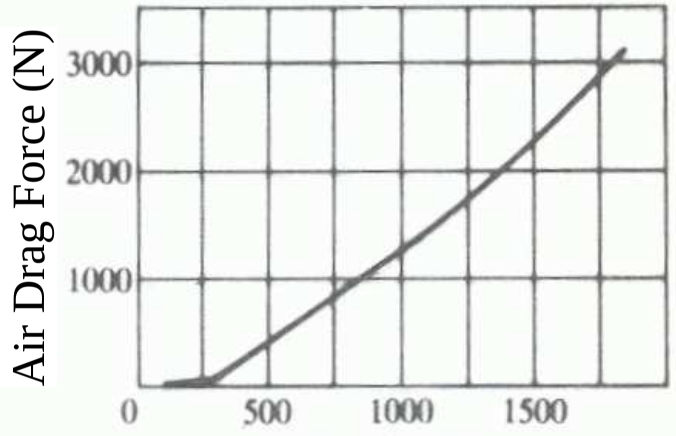


(a)

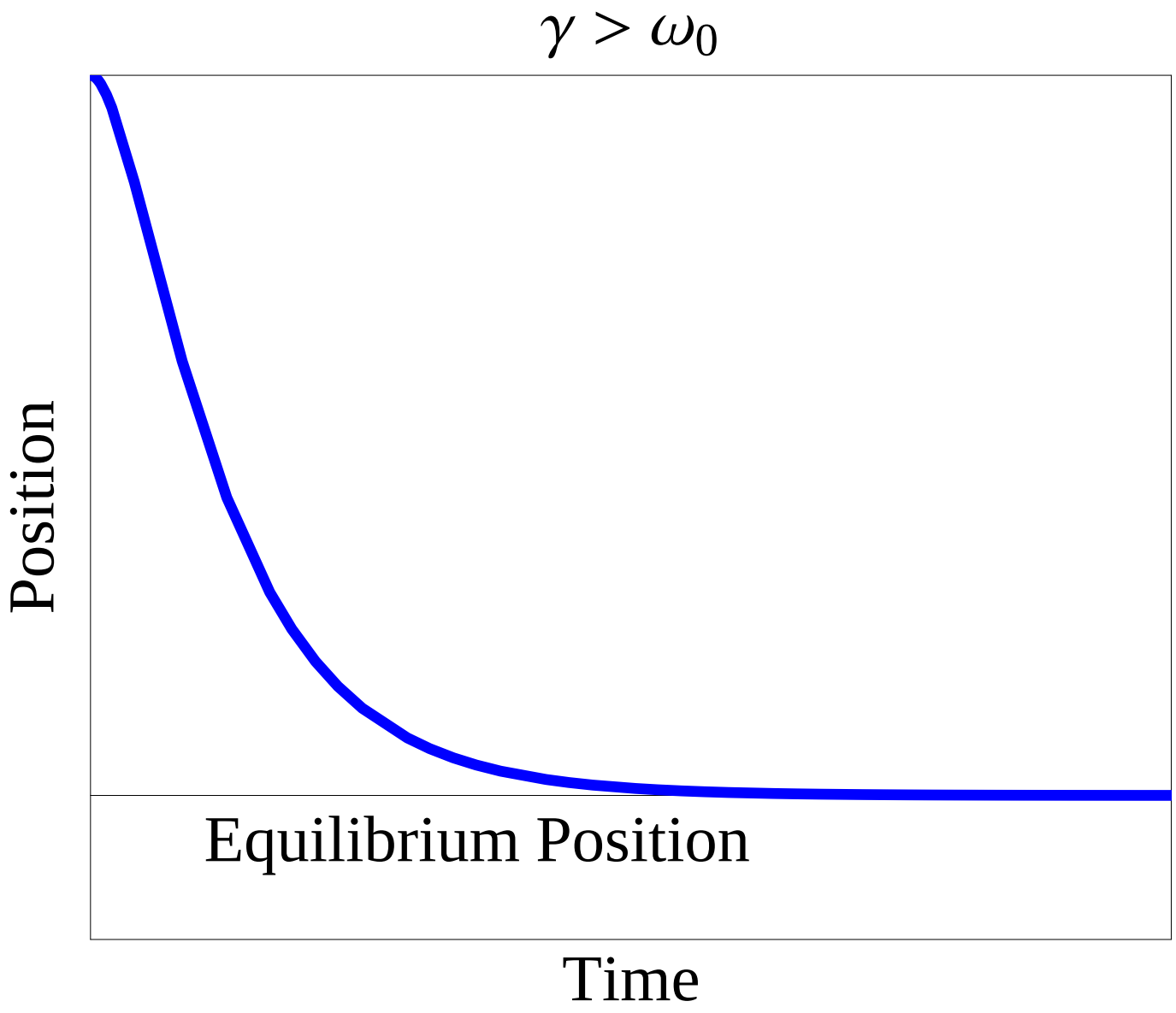


(b)





The $\gamma > \omega_0$ Result



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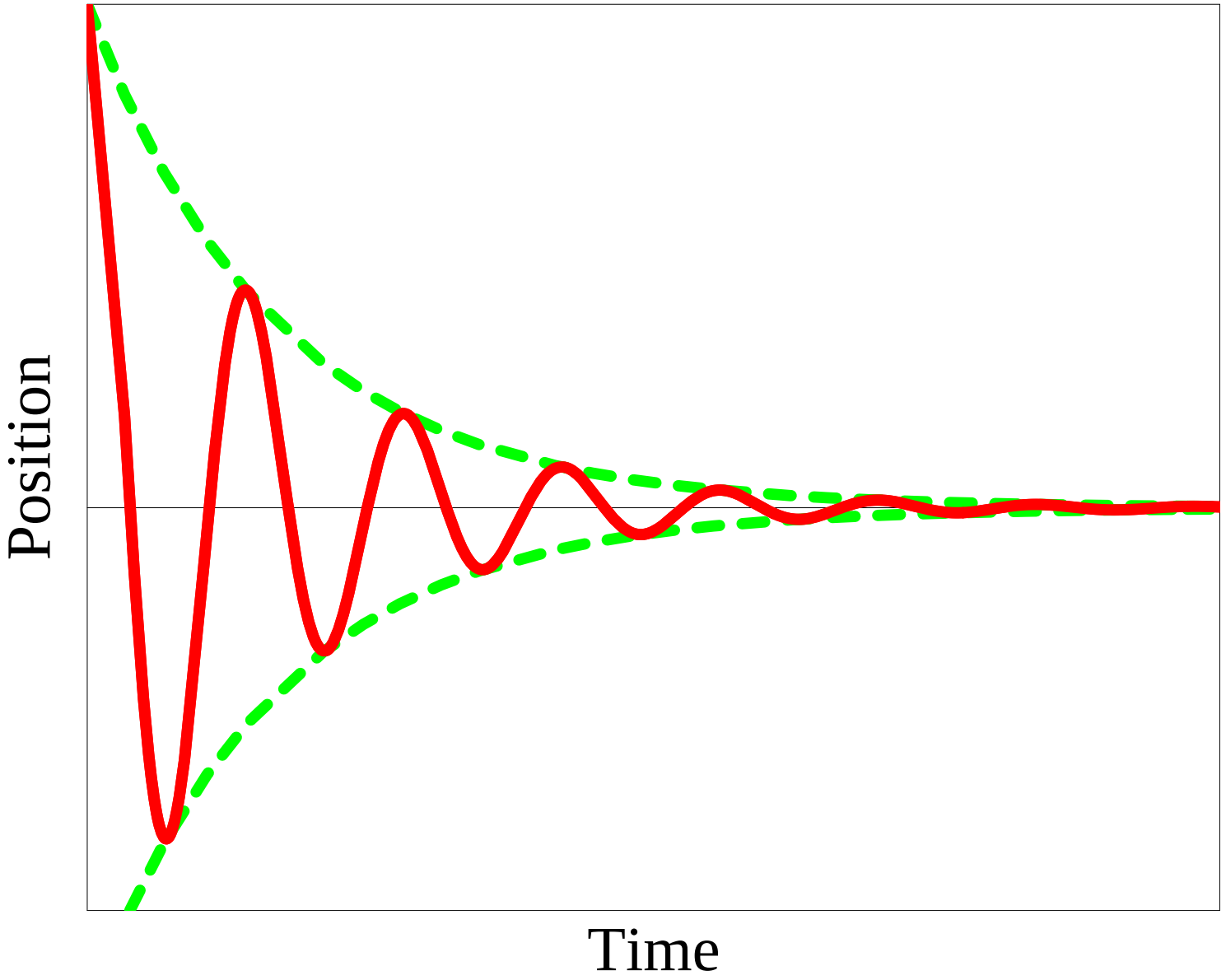

Comparison of Damping Factors

Object	Terminal Velocity (m/s)	b (kg/s)
Antibody	35	2×10^{-23}
Parachutist	5	5×10^{-3}
Basketball	20	4
Ping-Pong Ball	9	3×10^{2}
Raindrop	7	5×10^{4}

Decreasing ω_0 for fixed γ