


**Types of damped harmonic motion**

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# Types of damped harmonic motion

3 types of damped harmonic motion. What is damped simple harmonic motion. How to graph damped harmonic motion.

Remember that one of the points of the simple harmonic oscillator we spoke about last time that introduce a term of friction force that is proportional to the speed of mass to. We will examine this situation a little more closely today. A quick note: to understand all derivations (mathematically heavy) I recommend you to have experience with some basic differential equations and to have heard about linear independence. Our pattern for our mass to on a spring configuration is exactly the same as it was the last time we introduced the theme of simple harmonic oscillators and Hooke's Law. Image from Wikimedia Commons. The configuration is the same, except this time, we will introduce a fringe force term that is equal to  $-\gamma \frac{dx}{dt}$ . That is, this force is proportional to the speed of the object, so that  $\gamma$  is a constant. The negative sign shows that this force opposes the direction of movement. Physically, these types of donut strength terms really derive from our standard idea of friction between two solid surfaces. A frictional force proportional to speed typically derives from things like air resistance and other types of fluid resistance (for example, if the spring system has emerged in water). Our new strength diagram must account for this: Here we have indicated  $\vec{F}_f$  as the friction force. Once again, mass movement in the direction  $\hat{y}$  is irrelevant, as we intuitively don't expect the block to suddenly start jumping around. Newton's second law, 128; The second law in the sense

It is called the damped harmonic oscillator equation. We can see that this differential equation is reduced to the simple oscillating harmonic equation that we discussed last time when  $\gamma=0$ ; that is when there is no end of friction force. Let's solve the differential equation we found above for the move function  $x(t)$ , to understand exactly how the equation describes a damped harmonic oscillator. Taking into account that we discussed last week to use an approach involving complex exponential, we can make an assumption that the solution will appear something like  $e^{i(\omega t + \phi)}$  if we allow  $\omega$  to be potentially complex. Then I say we just need to include the first term on the right. You'll see why this is down here. For this, we can have  $e^{i(\omega t)}$  Now,  $\omega$  is potentially complex. Similar to simple harmonic oscillation, we still have to determine what  $\omega$  and  $\gamma$  are. The first two derivatives of  $x(t)$  are  $i\omega x(t)$  and  $-i\omega^2 x(t)$ .  $\frac{d^2x}{dt^2} = -\gamma \frac{dx}{dt} - \omega^2 x$  This is an extremely complicated expression, so let's break down as much as it's happening here.  $\omega$  is guaranteed to have an imaginary component of  $\frac{\gamma}{2m}$ . Also, there are actually two solutions allowed: one with the positive sign and one with the negative sign in front of the square root. Both are completely valid and so we should be able to distinguish between the two.  $\omega = \frac{\gamma}{2m} \pm i\sqrt{\omega_0^2 - \left(\frac{\gamma}{2m}\right)^2}$  The square root contribution is a bit more complicated, as depending on the relative sizes of  $\gamma$ ,  $m$ ,  $\omega_0$ , we don't know if the square root expression is real or imaginary. So, we have to deal with each of these cases separately. Consider the first case where  $\frac{\gamma}{2m} < \omega_0$ . In our expression for  $\omega$  from above, this means that the square root contribution is a real number (since the square root of a positive number is real). Simultaneously, we can relate  $\gamma$  and  $k$  through this inequality to get  $\gamma$

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