# Homework Set 12: Damped and Driven Harmonic Motion
## Due Wednesday, October 18, 2023

### Problems From TM5.

**1)** *3-2* Altered: Allow the motion of a *100 g* mass attached to a spring with a force constant of $k = 10^4$ *dyne/cm* initially displaced *3 cm* from the equilibrium point and released from rest, to take place in a resisting medium. After oscillating for 10 $T_S$ (10 system periods), the maximum amplitude decreases to half the initial value. Calculate

**a)** the damping parameter $\beta$, and

**b)** the frequency $\nu_S$ (compare with the undamped frequency $\nu_N$ (these are $f_S$ and $f_N$).

1 dyne = 1 g-cm/s$^2$ = $10^{-5}$ N but don't convert! **Stay in cgs!**

**2)** *3-11* Derive the expressions (*by hand … show the math*) for the energy and energy-loss curves shown in Figure 3-8 for the damped oscillator and reproduce them using your favorite plotting program.

[Make them look like those in the text! MATCH the algebraic expressions from TM5:

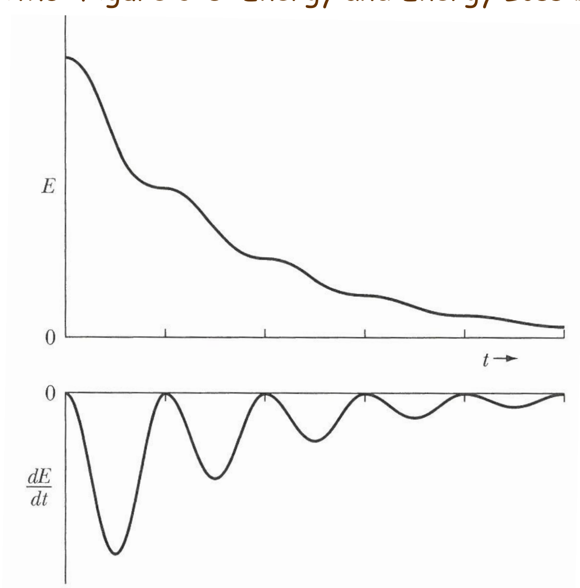
$$E(t) = \frac{mA^2}{2} e^{-2\beta t}\left\{\omega_N^2 + \beta^2 \cos 2(\omega_S t - \delta) + \beta\sqrt{\omega_N^2 - \beta^2}\sin 2(\omega_S t - \delta)\right\}$$

$$\frac{dE(t)}{dt} = mA^2 e^{-2\beta t}\left\{\beta(\omega_S^2 - \beta^2)\cos[2(\omega_S t - \delta)] - 2\beta^2\omega_S \sin[2(\omega_S t - \delta)] - \beta\omega_N^2\right\}$$

DON'T USE NUMBERED SUBSCRIPTS IN MATHEMATICA! Use $\omega_N$ for $\omega_0$ (for the natural frequency) and $\omega_S$ for $\omega_1$ (for the system frequency … $\omega_D$ will be for the driving frequency). The values I used for light damping were $\omega_N = 1$, $\beta = 0.1$, m = 2, A = 1, and $\delta = 0$.]

**3)** *3-16* Discuss the motion of a particle described by equation 3.34 in the event that b < 0 (i.e., the damping is negative).

TM5[1] Figure 3-8 Energy and Energy Loss by the Damped Harmonic Oscillator





[1] Thornton, T.T. and Marion, J. B., (2004). Classical Dynamics of Particles and Systems. 5th Ed. Belmont, CA: Brooks-Cole.