

**Homework: Damped oscillations: Energy loss
and the quality factor**

Name _____

1. An ideal (frictionless) simple harmonic oscillator is set into motion by releasing it from rest at $x = + 0.750$ m.

The oscillator is set into motion once again from $x = + 0.750$ m, except the oscillator now experiences a retarding force that is linear with respect to velocity. As a result, the oscillator does not return to its original starting position, but instead reaches $x = + 0.700$ m after one period.

- a. During the first full oscillation of motion, determine the fraction of the oscillator's total energy that was dissipated due to the retarding force. Explain.
 - b. Predict the maximum displacement of the oscillator upon completing its *fourth* full oscillation. Explain your reasoning.
 - c. Determine the quality factor of the oscillator. Show all work.
2. Consider two identical simple harmonic oscillators (1 and 2) to which are applied different damping forces. The two oscillators become underdamped, with the frequency of the first oscillator now greater than that of the second (*i.e.*, $\omega_{d,1} > \omega_{d,2}$).
- a. Which oscillator has the larger damping constant: *oscillator 1, oscillator 2, neither, or is there insufficient information to tell?* Explain your reasoning.
 - b. Which oscillator has the larger quality factor: *oscillator 1, oscillator 2, neither, or is there insufficient information to tell?* Explain your reasoning.
3. Consider a weakly damped oscillator that is released from rest at $t = 0$ and whose amplitude is smaller by a factor of e after undergoing N full oscillations.
- a. Write an expression for the period of oscillation T_d in terms of N and the damping constant g . Explain your reasoning and show all work. (*Hint:* Recall from tutorial how you interpreted the quantity e^{-gT_d} .)
 - b. Do you think that the quality factor Q of this oscillator would be *increases with N , decreases with N , or neither?* Explain *without* performing any calculations.
 - c. Verify your answer in part b above determining an expression for Q in terms of N . Show all work.

