Prof. Raghuveer Parthasarathy
University of Oregon; Fall 2007

Physics 351 – Vibrations and Waves

Problem Set 5

Due date: Thursday, Nov. 1, **noon**. (Turn in the assignment to the box outside my door.)
So that I can distribute the solutions immediately: **NO LATE HOMEWORK WILL BE ACCEPTED!**

Reading: French Chapter 4.

(1, 7 pts.**) The bouncing man.** The bouncing man, who we've seen in class, has a mass of 100 g. He hangs from an ideal massless spring whose other end I hold. When I attach him to the spring and he stops moving, I notice that the spring has been extended by 20 cm. I then move my hand up and down sinusoidally with an amplitude of 0.5 cm.
(a, 2 pts.**)** What is ω_0 for this system?
(b, 3 pts.**)** I notice that when my hand's driving frequency equals ω_0, the man bounces with amplitude 8 cm. What is the Q-factor of the system? (*Hint*: Think about the force my hand is applying.)
(c, 2 pts.**)** What power do I have to supply to maintain the forced oscillation at a frequency 5% greater than ω_0? (You can use the approximate relation derived in class: French Eq. 4-26.)

(2, 5 pts.**) Series RLC radio.** Mr. K decides to build a radio using a series RLC circuit (like we discussed in class) to pick up the campus radio station (f = 88.1 MHz – don't forget that $\omega = 2\pi f$!). He has a resistor of R = 100 Ω and a capacitor of C = 5 pF (i.e. 5×10^{-12} F).
(a, 1 pt.**)** What inductor does he need to complete the circuit?
(b, 4 pts.**)** Mr. K. builds the radio (he's surprisingly good at understanding frequency modulation), but it works horribly, picking up a mess of stations at once, and not amplifying the desired station well. What is wrong with his design? (You might find it helpful to plot A(f) for this circuit.)

(3, 5 pts**) Overdamped oscillator motion.** A door is built with a spring and a damper adjusted so the system is overdamped. Initially, the door is at its equilibrium (closed) position, i.e. $x(t=0) = 0$. Standing still with the tip of his nose at the "x=0" position, Mr. K suddenly kicks the door (i.e. $v(t=0) = v_0$). Does the door come back and hit him? (I.e. does x(t) cross zero?)

(4, 5 pts.**) Driven oscillator response.** Consider a driven, damped oscillator.
(a, 2 pts.**)** Prove that the amplitude of the response, $A(\omega)$, is a decreasing function of ω at $\omega=\omega_0$.
(b, 3 pts.**)** Prove that $d\delta/d\omega$ at $\omega=\omega_0$, where δ is the phase offset, is an increasing function of Q.
[*modified – RP Oct. 30, 2007*]

(5, 6pts.: 2 pts. for each part**) French, Problem 4-14 <u>parts a-c</u>.**