Family Name, Given Name (Please print) | Student Number | Tutorial Leader's Name

PHY293 – Oscillations – Practice Midterm

Friday September 30, 2011

Duration - 50 minutes

PLEASE read carefully the following instructions.

Aids allowed: A non-programmable calculator without text storage.

Before starting, please **print** your name, tutorial group, and student number **at the top of this page and at the top of the answer sheet**.

There are four questions on this midterm test. Each question is worth one-quarter of the total grade.

Partial credit will be given for partially correct answers, so show any intermediate calculations that you do and write down, **in a clear fashion**, any relevant assumptions you are making along the way.

POSSIBLY USEFUL EQUATIONS:

	Amplitude	Velocity	Power
Peak Frequency	$\omega = \omega' = \omega_0\sqrt{1 - 1/(2Q^2)}$	$\omega = \omega_0$	$\omega = \omega_0$
Peak Value	$a_m = \frac{a_0 Q}{\sqrt{1-\frac{1}{4Q^2}}}$	$v_m = a_0\omega_0 Q$	$P_m = \frac{1}{2}ma_0^2\omega_0^3 Q$
General	$a(\omega) = \frac{a_0\omega_0^2}{\sqrt{(\omega_0^2-\omega^2)^2+(\gamma\omega)^2}}$	$v(\omega) = \frac{a_0\omega_0^2}{\sqrt{(\omega_0^2-\omega^2)^2/\omega^2+\gamma^2}}$	$< P(\omega) >= P_\mathrm{m}\frac{\gamma^2}{(\omega_0^2-\omega^2)^2/\omega^2+\gamma^2}$
	$\tan\delta = \frac{\omega\gamma}{(\omega_0^2-\omega^2)}$		$< P >= P_\mathrm{m}\frac{\gamma^2/4}{(\omega_0-\omega)^2+\gamma^2/4} \quad Q \gg 1$

Do no separate the two stapled sheets of the question paper. Hand in the question sheets with your exam booklet at the end of the test.

Good luck!

1. Explain succinctly (ie. in three sentences or less) the meaning *and* significance of each of the following, in the context of harmonic oscillations we've discussed in this class. Your answer should make clear not only what the term, or concept, *is*, but also put it in the context of this course and make it clear why it is *important*.

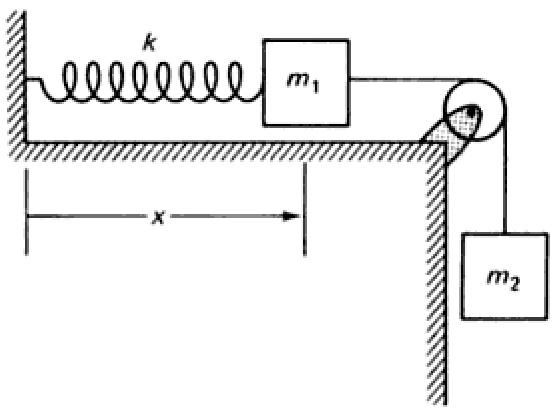
   (a) Velocity resonance;

   (b) Forced oscillations in the stiffness regime;

   (c) A high quality (Q) resonator;

   (d) Power absorption in a forced, damped oscillator.

2. Consider a mass m_1 attached to a spring (of un-stretched length d) and pulled by constant force F_2, $F_2 = m_2 g$ as shown in the following figure



   (a) Suppose that the system is in equilibrium when $x = L$. Is $L > d$ or is $L < d$? Justify your answer.

   (b) If L and d are known, what is the spring constant k?

   (c) If the system is at rest in the position $x = L$ and the mass m_2 is suddenly removed (for example, but cutting the string that connects m_1 and m_2), then what is the period and amplitude of the oscillations that m_1 will start to execute?

3. A block of mass m is connected to a spring, the other end of which is fixed. The block is immersed in viscous damping medium. The following observations have been made of the system:

   1. If the block is pushed horizontally with a force mg, the spring length is reduced by h;
   2. The viscous resistive force is equal to mg if the block moves with a certain speed: u.

   (a) For this complete system (spring and mass in damping medium), in the absence of any driving force, write down the differential equation governing horizontal oscillations of the mass in terms of m, g, h and u;

   Answer the following for the case $u = 3\sqrt{gh}$:

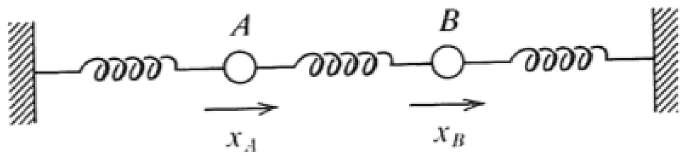
   (b) What is the angular frequency of the damped oscillations?

   (c) After what time, in multiples of $\sqrt{h/g}$, is the energy of the oscillator reduced by $1/e$?

   (d) What is the Q of this oscillator?

   (e) If the oscillator is driven with a force $mg\cos(\omega t)$, where $\omega = \sqrt{2g/h}$, what is the steady-state amplitude of the resulting oscillations of the mass?

4. Two equal masses, m, are on a frictionless surface, held between rigid supports by three identical, massless springs, with spring constant k, as shown in the figure. The displacements from equilibrium, along the line the springs are described by the coordinates x_A and x_B, as shown. If either of the masses is clamped, the period for one complete oscillation of the other mass (the one that is left free) is 3s (you can use $m = 1$kg if you feel this will help).



(a) If both masses are free, what are the periods of the two normal modes of the system?

(b) Sketch graphs of x_A and x_B versus t in each mode.

(c) At $t = 0$ mass A is held at its normal resting position and mass B is pulled aside a distance of 5 cm. The masses are released from rest at this instant.

(d) Write an equation for the subsequent positions of each mass as a function of time.

(e) What length of time (in s) characterises the periodic transfer of motion from B to A and back again? After one complete cycle, is the situation at $t = 0$ exactly re-produced?