CSUC
Department of Physics
301A Mechanics
Problem Set 5, due: Wednesday, November 14, 2018

I. READING

Read Chapter 5 in your class text completely and thoroughly. The topic of "Simple Harmonic Oscillation" is easily one of the two most important problems in all of physics (the other being gravity). We will progress from the simplest encounters already very familiar to you through a dazzling sequence of deep topics including causal Green's functions, Fourier analysis and Normal Mode decompositions (this later in the unit on chapter 11). Electrodynamics (one enormous set of *classical* simple harmonic oscillators!), Black Body Radiation and Quantum Field Theory (one enormous set of *quantum* simple harmonic oscillators!) are ultimate targets lurking in the backs of our minds. Along the journey you will come to appreciate the necessity of complex variables, canonical transformations and Hermiticity and the wily subtleties of unitarity. The richness of the problems provides a life-long never-ending feast. The problems below are just a tiny foretaste.

II. PROBLEMS

A. TEXT PROBLEMS. Please complete the following problems from *chapter 5* of our Class Text.

(1.) Page 207 problem *5-4* This problem is a "not-very-well-hidden" introduction to "Lagrange-like" problems. In it you will perform a sensitive small-angle approximation to the potential energy. Please include, as well, the parallel small angle approximation to the kinetic energy which will appear, then, as a function of ϕ and $\dot{\phi}$. Add the energy contributions together and set them equal to the (constant) total energy. Taking the time derivative of this equation yields your desired equation of motion. Discuss!

(2.) Page 207 problem *5-5* ... just a little practice ...

(3.) Page 209 problem *5-18* This is just an elementary multi-variable Taylor expansion such as we will perform very often. There are many way to perform it and we will discuss several of them. Think of it as an "expansion to consistent order in *small*".

(4.) Page 210 problem *5-26* This problem is very surprising and very characteristic. Also, if the path to your results is complicated - then you need to redo this ... . One big lesson to learn here is that once we introduce a new scale into a problem (in this case a small ratio which I recommend expressing as $\delta T / T_o$) - then ... this quantity will "propagate" through the entire calculation and show up *everywhere* - everything will be expressed in terms of it. *Good Algebra* matters. Once you do it right everything becomes clear. Enjoy this one!

(5.) Page 210 problem *5-29* This problem is very similar to the previous one. Make sure that your understanding of it coincides.

(6.) Page 211 problem *5-35* ... just a little practice ...

(7.) Page 212 problem *5-44* This is a really important problem and we will do it in class. Nonetheless, you should practice it until you can do it without difficulty. The patterns deduced are deep and universal and you will make use of them in "oh so many" disparate applications.

(8.) Page 212 problem *5-45* This problem introduces further important aspects of the previous problem. All those comments apply here as well.

(9.) Page 213 problem *5-48* ... just a little practice ...

(10.) Page 213 problem *5-51* This is the way you will ultimately do most of your work. Try to get used to it ... we will do it together in class.

B. CLASS PROBLEMS. Please complete the following problem from our class lectures.

(11.) *Causal Response* *Difficulty Index 2.0*

A damped S.H.O. of mass m sits at rest. Suddenly, at time t_o a constant force F_o is applied. What is the subsequent motion of the mass? You are to solve this problem two ways and show that the solutions agree. First, solve the ODE using a sum of the general homogeneous solution and a particular solution. Evaluate all constants by matching to the known initial conditions (it is initially at rest!) . Second, find the motion by using the formal Causal Green's function solution. Comment on the asymptotic behavior and its reasonableness. Suppose we had "turned on" the force slowly - what would we expect? What would we mean by "slowly" ?