2015.16 PH2a

QUIZ I

Your solutions are due on **TUESDAY OCTOBER 13, 2015, at the beginning of lecture (11:00am)**. Place the solutions in the locked section boxes outside 201 E. Bridge. Late quizzes **will not** be accepted, except in very special circumstances.

The quiz is **open book, open lecture notes, open section notes, open homework sets and solutions**.

Calculators may be used. Computers and smart devices, other than your brain are **not allowed**.

Please justify your answers and show all work.

Time Limit: **90 minutes**

**IMPORTANT:** PLEASE WRITE YOUR NAME, SECTION NUMBER AND YOUR T.A.’S NAME ON THE FRONT OF YOUR SOLUTION SHEET.

**THERE WILL BE A QUIZ REVIEW ON**

**SATURDAY OCTOBER 10, 2015**

**2:00PM TO 3:00PM**

**IN**

**201 E. BRIDGE**
Quiz 1 [all parts are 1 point]

Problem 1

1. It's Senior Ditch Day and you are forced to bungee jump off the top of Millikan Library, h=50 m. You are given an unlimited number of bungee cords (each one with Hooke's constant k=20 N/m, to be used in parallel!). Your goal is to jump off and get as close to the ground as possible without crashing. Assume a 100 kg frosh is the guinea pig leaping at t=0. Note that the bungee cords are tied above the roof in order that they begin to stretch as soon as the ends are lower than the roof.

a. Write down the differential equation for the motion of the student assuming y=0 is the top and the y-axis points downward.

b. What is the solution of the equation in a. given the boundary conditions? (The student falls from the top at t=0 with v(0)=0.)

c. What is the minimum number of cords to accomplish the goal?

d. When will the frosh return to the top assuming zero drag/air resistance? What is the maximum velocity of the frosh? What is the maximum acceleration in g's?

e. Use conservation of energy to determine the number of cords required and show you get the same answer as part b.

f. Now assume that air produces a drag force $F_d = -bv$ with coefficient $b = 3 \times 10^{-4}$ N/(m/s). How many oscillations will be observed before the motion is damped to 5 m? What will be the state of mind of the poor frosh?
Problem 2

A marble of 10 gm slides on a 2D track described by the function:

\[ z = z_0 \left[ 1 - \cos \left( \frac{x}{x_0} \right) \right] \]

Ignore marble spin (i.e., assume the marble slides without friction).

a. For \( x \ll x_0 \), show using a series expansion that the potential \( V(x) \) is like that of a spring.

b. For \( x \ll x_0 \) what is the effective spring constant \( k_{eff} \)?

c. For \( x \ll x_0 \) what is the equation of motion for the marble \( x(t) \) if \( x(0) = x_0 / 10 \) and \( v(0) = 0 \)?

d. A marble is dropped from a position \( x = x_0 / 10 \) in a bowl with \( z = \frac{1}{2} z_0 \left( \frac{x}{x_0} \right)^2 \) (for reference), and in the bowl of which has the profile of equation [1] up to the next highest term in \( \left( \frac{x}{x_0} \right) \). Use conservation of energy (or some other method) to determine whether the period is increased or decreased for the marble in the second case vs. the first.