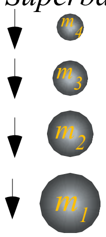
9/17/19 Assignment Set 4 - Read *Unit 1 Ch. 3* thru *Ch.8 Lect. 4-5* Due Wed. *9/25/19* Name______________

Some lesser known properties of parabolic PE functions

1.(a) Mechanics problems of atomic oscillators affected by electric fields is basic to spectroscopy. A useful model is potential $V^{atom}(x)=k\,x^2/2$ function of center x of charge Q with polarizability spring constant k. A uniform electric field E applies force $F=Q\cdot E$ to charge by adding potential $V^E(x)$ to $V^{atom}(x)$. (Give $V^E(x)=$______ and $F^E(x)=$_____) Consider the resulting potential $V^{total}(x)$ for an atom for unit constants $k=1$ and $Q=1$. Derive and plot the new values for equilibrium position $x^{equil}(E)$, energy $V^{equil}(E)$, dipole moment $p^{equil}(E)=Q\cdot x^{equil}$. Plot $V^{total}(x)$ for field values of $E=-3,-2,-1, 0, 1, 2,$ *and* 3. Does frequency $\omega^{equil}(E)$ vary with field E? What curve do $x^{equil}(E)$ points form?

(b) Follow the steps to construct to external and internal potential energy $V(r)$ and Force $F(r)$ plots of the Sophomore-Physics Earth model. (Lect, 6 p.39-41 and p,62-65.) Describe the 3 equally spaced energy levels.

Superball tower IBM model constructions (With initial $V_k=-1$*)* See Fig. 8.1(b) p.103 of *Text* Unit 1 or Lect. 5 p.60



The 100% energy transfer limit (IBM values are $v_1^{IN}=1$ and $-1=v_2^{IN}=v_3^{IN}=v_4^{IN}=\ldots$ *after 1st floor bang.)*

2. Suppose each m_k has just the right mass ratio m_k/m_{k+1} with the m_{k+1} above it to pass on all its energy to m_{k+1} so the top ball-N, a *1gm* pellet, goes off with the total energy. Construct velocity-velocity diagrams, indicate velocity at each stage, and derive the required intermediate mass values for (a) $N=2$, (b) $N=3$, (c) $N=4$.

(d) Give algebraic formula for this *Maximum Amplified Velocity* factor in terms of N *(MAV(N)=*____________*?).*

(e) Give algebraic formula neighbor-mass ratios $R=M_{N-1}/M_N$ in terms of N *(R(N)=*__________*?).*

N-Ball tower ∞-limits

3. Suppose each m_k is very much larger than m_{k+1} above it so that final v_{k+1} approaches its upper limit. Then top m_N goes off with nearly the highest velocity v_N attainable. Construct the velocity-velocity diagrams. Indicate each intermediate velocity limit value at each stage and the limiting top value for (a) $N=2$, (b) $N=3$, (c) $N=4$.

(d) Give algebraic formula for *Absolute Maximum Amplified Velocity* factor in terms of N *(AMAV(N)=*________*?).*

The optimal idler (An algebra/calculus vs. *geometry problem)*

4.(a) To get highest final v_3 of mass m_3 find optimum mass m_2 in terms of masses m_1 and m_3 that will do that.

(b) Consider this problem in Galileo-shifted frame with: $v_1^{IN}=2$ and $0=v_2^{IN}=v_3^{IN}$ (Algebra simplifies for this.)

(c) Do V-V plots for case $m_1=4$ and $m_3=1$ (where $m_2=$____?) …for non-optimal case $m_1=4$, $m_2=3$, $m_3=1$.

(d) Give formula for optimal top mass final velocity in terms of m_1, m_2, and m_3 and compare to result of 4(a). Plot that final velocity versus the idler mass $x=m_2=0$ to 4. How sensitive is the optimal final v_3 to x?

The backsides of exponentials

5. *Some lesser known properties of exponentials and logarithms*

(a) Do plots of exponential $y=e^x$ and $y=\log_e x$ functions on the same graph and draw any tangent-triangle whose hypotenuse is tangent to one of the curves and intercepts the x or y axis at integers -2, -1, 0, 1, 2,..

(b) As a roller-coaster car moves down a track $y=e^x$ it shines one laser beam along the track and another beam vertically down so both makes spots on baseline $y=0$. Find the distance between spots as function of x.