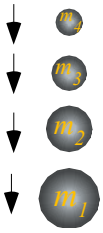
The first two problems appeared on the 2016 PhD physics qualifying exam
(...and I did not suggest them but I did vote for them.)

Superball tower IBM phenomena (Independent Bang Model with initial V_k=-1)



The 100% energy transfer limit

1.7.1 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)=_____?)*.

The towering limit

1.7.2 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 problem)

1.7.3 Assume the usual initial conditions for IBM. Find optimum mass m_2 in terms of masses m_1 and m_3 that will get the maximum final v_3 for mass m_3. Also, find that v_3 value.

The last problem was considered too difficult for the 2016 PhD qualifying exam