Hints for Problem Set 2: Tackling physics problems

1. **Drag Dimensions:** This problem boils down to solving the equation:
   $$\text{kg ms}^{-2} = (\text{m})^x (\text{kg m}^{-1}\text{s}^{-1})^y (\text{ms}^{-1})^z$$
   Remember that $(ab)^x = a^x b^x$ and note that there is only one kilogram term on either side of the equals sign.

2. **Radioactive Decay:** There are two factors of two in the question: there are twice as many atoms of A than B, so and the half-life of B is twice that of A.
   Use $N = N_0 e^{-\lambda t}$ and remember that you are looking for the situation to be reversed, i.e. $N_A = \frac{N_B}{2}$.
   Given the numbers are particularly nice, maybe trial and error would be a quick, but unsatisfactory, approach.

3. **Infinite resistors Part II: I**t's the same approach as before but without nice numbers given you'll have to find an algebraic expression to link the resistance of the chain to the previous one.
   Because the chain is infinite you can say that $R_{n+1} = R_n$

4. **Resistor networks Part II:** You've already calculated A-D, so that's only 6 left you need to do, or do you? Won't A-B, A-H and A-F be the same by symmetry?

5. **Maximum range Part II:** A clear diagram is always important, more so for tricky problems like this. A stepping stone along the way will be this equation:
   $$\frac{1}{2}gt^2 - u\sin\theta\, t - R\tan\phi\ = 0.$$
   You'll find it helpful here to know that: $\cos 2x\ \equiv 1 - x$

6. **Maximum range Part III:** Sorry – there's no clever shortcut here, you're going to have to differentiate!
   You'll find it helpful here to know that: $\cot\phi\ = \tan\left(\frac{\pi}{2} - \phi\right)$
   Your final expression should be reassuringly simple, and it must resemble what you should have found in part 1 when $\phi = 0$.

7. **Motion graphs Part II:** Split the motion into sections.... Free fall / drag starts to grow / terminal velocity / bouncing / free fall again. Start with acceleration-time and work through to velocity then displacement.

8. **Realistic Sand Ramp:**

   a) I found it useful to break the cross-section into three parts, one of which you've already done the work for. Using symmetry you only really need to work out the volume of one side of the sloped ramp. I then set up an integral over the length of the ramp, but is there an easier way?

   b) Since the ramp is wider than the pyramid, we can simply subtract half the area of the pyramid. This is a first approximation, now since a large volume of the ramp is being supported by the solid structure of the pyramid, you can imagine that the side ramps could be made steeper, thus decreasing their volume further.

   c) Sorry, you're on your own for this one – break it down into as many manageable chunks as you can.

9. **Spiral Ramp:** I first turned this 3D problem into a 2D problem by rotating the face about its base edge until the apex was vertical. However, will this change the value of theta? Once you've done that, find an expression for the length of the ramp using Pythagoras' theorem, and then use trigonometry and lots of right angled triangles to find ugly expressions for these side lengths.

10. **Total length:** When I first solved this I was very pleased to recognise that there was a convergent infinite geometric series here, due to the symmetric nature of the problem. On reflection, I now realise that there is a much quicker way when I unwrap the problem properly.