Homework I: Areas of Physics, Units, Scales, and Philosophy

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You should read Chapters 1, 3 and 6 of Weinberg's *Dreams of a Final Theory* before the second afternoon section. You'll have a chance to discuss many of the philosophical ideas today and tomorrow, but feel free to bring an physics questions to class tomorrow.

Question 1 Areas of physics

Select one of the fields of physics described in Section 1 of today's notes. Briefly describe in your own words what physicists working on that topic study and list a few of the important problems they are working to solve. Why do you think this is an interesting or uninteresting are of physics?

Question 2 Size scales

a) Make a chart showing things you have learned about in the past, organized by size. Give the size quantitatively as orders of magnitude. How does the smallest thing on your chart compare to the smallest things that physicists are interested in? Make a similar comparison for the largest.

b) Come up with a few reasons why physicists often consider orders of magnitude to be more important than precise numbers.

Question 3 Dimensional analysis practice

Use dimensional analysis to estimate how long it takes a bowling ball to fall from the top of a building to the ground below. You must figure out which quantities are pertinent to the problem, and how to combine them make something with the units of time. **Hint:** The appropriate property of gravity to consider on Earth is $g = 9.8\text{m/s}^2$.

Question 4 Planck units

The natural units described in the notes are one possible choice of units, in that case primarily motivated by simplification of equations. Another choice are the Planck units. Using the following fundamental physical constant, derive quantities with dimensions of length (the *Planck length*), time (*Planck time*), mass (*Planck mass*) and temperature (*Planck temperature*). Give numerical values in SI units for each Planck unit. Why do you think these might be interesting?

Name of Constant	Symbol	Value in SI Units
Gravitational Constant	G	$6.67 \cdot 10^{-11}\mathrm{m}^3\mathrm{kg}^{-1}\mathrm{s}^{-2}$
Speed of Light in Vacuum	c	$3.00 \cdot 10^{8}\mathrm{ms}^{-1}$
Dirac Constant	$\hbar$	$1.05 \cdot 10^{-34}\mathrm{J{\cdot}s}$
Boltzmann Constant	k_B	$1.38 \cdot 10^{-23}\mathrm{J/K}$

Question 5 What makes a theory good?

Come up with a set of criteria which a physical theory should satisfy to be satisfactory. Do this for both a "fundamental" theory (one which seeks to describe how the universe works from the bottom up) and an "effective" theory, which describes something at a larger scale (like Newtonian mechanics).