PHY138 – Written Homework #3

This problem set is due by 5PM Monday, October 4 in the "Drop Boxes" in the basement of McLennan. We begin with a discussion of *Fermi Numbers*. This is followed by the homework assignment.

Fermi Numbers

ENRICO FERMI (1901-1954) was an Italian-born physicist best known for his contributions to nuclear physics and the development of quantum theory. In addition to his contributions to theory, he was also noted as an experimentalist. Fermi was awarded the Nobel Prize for his work on the nuclear process.

Fermi was famous for doing "back of the envelope" calculations in which the information given seems incomplete. Below I give you an example of solving a **Fermi Problem**. I then give you a list of other questions, and you will solve one of these.

An Example

The problem we will solve is: How many piano tuners are in Toronto? How might one figure out such a thing? Surely the number of piano tuners in some way depends on the number of pianos. The number of pianos must connect in some way to the number of people in the area.

Approximately how many people are in the Greater Toronto Area? 4,000,000

Does every individual own a piano? No

Would it be reasonable to assert that individuals don't tend to own pianos; households do? Yes

About how many households are there in Toronto? Perhaps 1,000,000

Does every household own a piano? No. Perhaps one out of every five does. That would mean there are about 200,000 pianos in Toronto.

Do all of these need tuning? No. Perhaps 1/2 of the pianos in Toronto are electronic and don't require tuning. Thus, there are about 100,000 pianos in Toronto that need tuning.

What about the pianos in the Conservatory of Music, Roy Thomson Hall, etc.? Probably negligible compared to the 100,000 pianos owned privately.

How many pianos are tuned every year? Some people never get around to tuning their piano; some people tune their piano every month. If we assume that "on the average" every piano gets tuned every two years, then there are 50,000 "piano tunings" every year.

How many piano tunings can one piano tuner do? Let's assume that the average piano tuner can tune three pianos a day. Also assume that there are 250 working days per year. That means that every tuner can tune about 750 pianos per year.

Finally, then how many piano tuners are needed in Toronto? The number of tuners needed is about 50,000/750 = 67. Assuming we have just enough tuners to satisfy the demand, there are therefore 67 piano tuners in Toronto.

Using different assumptions for various factors, it is unlikely that you can justify an answer greater than a factor of 10 or smaller than a factor of 10 from the number we just obtained; that is to say, there are probably not more than 670 tuners and surely no less than 7. Thus the answer obtained is probably good to within an "order of magnitude."

Checking the Answer

The Yellow Pages list 19 entries under **Pianos - Services, Supplies & Tuning**. Some of these are one-person operations, but other, like the *Canadian National Institute for the Blind* and *Paul Hahn & Co.* almost certainly have more than one person who tunes pianos. There are also certainly other tuners not listed in this section of the Yellow Pages; for example the *Piano Showcase* explicitly says that they tune pianos, but are only listed in the **Pianos** section of the Yellow Pages.

Supplementary Problem (25%)

Choose *one* of these problems and solve it. Explain all the steps in your reasoning.

1. How many hairs are on your head?
2. How many total hours did University of Toronto undergraduates wait for a PC to reboot since the beginning of the academic year?
3. Estimate the number of square meters of pizza eaten by University of Toronto undergraduate students since the beginning of the academic year.

From the Textbook (50%)

Chapter 4: Problem #44. Chapter 5: Problem #12.

From McDermott, Shaffer <u>Homework</u> Book (25%)

Questions 1 and 2 from the *Forces* section, pages 31 – 32. We recommend doing these after your tutorial