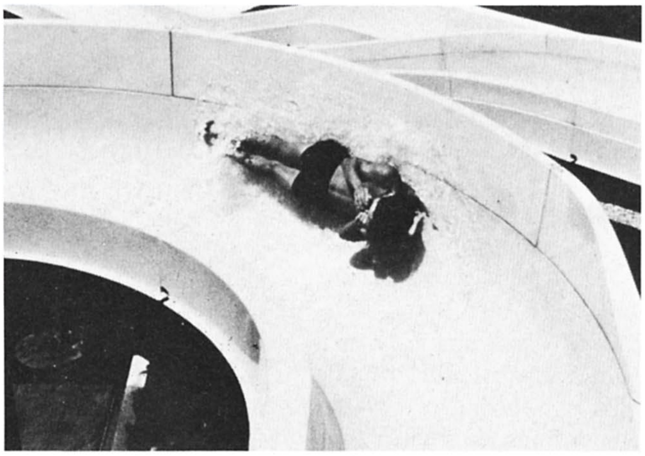

Fig. 9. A banked curve motion for one of the participants. Notice the additional wall height added to the curve.

Our field trip to Magic Waters was very useful in demonstrating how closely our theoretical analysis matched our experimental results. If one of these pools is within traveling range of your class, we encourage you to "catch the wave" and enjoy one of the best watery, if not concrete, experiences available. ♦

References

1. Francis W. Sears, Mark W. Zemansky, and Hugh D. Young, *University Physics* (Addison–Wesley, Reading, MA, 1982), p. 416.
2. Arthur N. Strahler, *The Earth Sciences* (Harper & Row, New York, 1971), p. 278.

How to Split Hairs on Fermi Questions

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How many molecules of oxygen are in each breath you breathe? How many liters of water are in the oceans of the world? These are typical "Fermi Questions." They are intended to be estimated to the nearest power of ten without using reference books or calculators. The Fermi Quiz is becoming a standard Physics Olympics event and is one of my favorites because of its broad educational value. It gives students a feeling for scale, encourages broad quantitative general knowledge, and builds boldness to wade into problems that at first seem impossible to timid minds.

I have made up several such quizzes in recent years. In working out the answer keys, I have usually taken for granted that answers of 5 or more should be rounded up and answers below 5 should be rounded down. This year, as I was working on the quiz, it occurred to me to question that assumption. I thought back to my slide-rule days. The middle of the C and D scales on a slide rule is not 5 but something close to pi, the square root of 10 to be exact. A moment's thought convinced me that the square root of 10 should be the dividing line in Fermi questions too. When we are talking about order of magnitude, we are really talking about a logarithmic scale. Halfway to log 10 is $\frac{1}{2}\log 10 = \log 10^{1/2} = 3.16$.

Now comes the real challenge: How do you explain all this to high-school-age contestants, most of whom have never seen a log scale? The concept can be expressed without logarithms. Note that 500 misses 100 by a factor of 5, but misses 1000 only by a factor of 2. Therefore, in terms of order of magnitude, 500 is not anywhere near the dividing line. It should be considered much closer to 1000. On the other hand, 300 is a factor of 3 over 100, and 333 is a factor of 3 under 1000. The dividing line should be somewhere in between, very close to 316 as a matter of fact. This line of reasoning can also be tied in with a discussion of arithmetic and geometric means.

My students followed this reasoning easily, but I also had success by simply pulling out the big yellow class-sized slide rule that has been gathering dust for years and introducing the class to log scales directly. Today's students see the slide rule as a curiosity. They want to know how to work it and how it works. The necessity for the slide rule has vanished, but the concepts behind it are still valid and useful for teaching.

I have gained insight into a number of problems in recent years because of my knowledge of the slide rule. No one will ever induce me to trade in my wonderful RPN calculator, but I can't help but feel something was lost in the digital revolution. Getting a log today is as easy as pushing a button, but you can't see the whole pattern that way. Perhaps increased use of log-log and semi-log graph paper in the classroom is advisable to help today's digital students visualize a log scale and develop an intuition for logarithmic relationships. In any case, I will be rounding more of my Fermi estimates upward. ♦