The Embedded Muse 2

Editor: Jack Ganssle (jack@ganssle.com) July 2, 1997

The Engineering Mind

Comics mock us. Spouses get frustrated with us. Yet most of us take great pride in the way we approach problems (yeah, and even life). Engineering is all about problem solving, and we engineers tend to excel at finding ways to make things work.

Non-engineers are often baffled when presented with a problem, especially one involving numbers, having little clue where to start looking for a solution. Engineers, though, seem to have an innate sense of the right way to go about finding a solution. Problem solving is a **process**, one which engineers have mastered more so than most other folks.

Two recent incidents brought this to mind. The first occurred recently while watching a class of 10 year olds listening to the story of Apollo 11. The lecturer asked the class if they knew how long it took the astronauts to fly from the earth to the moon. “14 years”, “6 months”, and a dozen other baseless answers came back from the youngsters. One, though, said “well, they left July 16 and arrived July 20, so I guess it was 4 days.”

Hearing this I sat bolt upright. That’s what it’s all about! This youngster somehow had that instinctual ability to assimilate data, to solve a math problem, and come up with a reasonable answer. That’s exactly what we engineers do all day. Once I thought we were trained to think this way. Now, hearing this wisdom from a 10 year old, I can’t help but wonder if it’s in our makeup. Do we gravitate to an engineering career because of the way we think? Is it nature or nuture?

The second incident was a response made by Bill Swan to an earlier issue of this newsletter where I made an off-hand remark about the number of angels that can dance on the head of a pin. His remarks use the engineering method to shed a bit of quantitative light on this pressing subject. Here is his analysis (and, I’m humbled by his analytical treatment of this subject):

Sorry, but this one turns out to be an estimable quantity given the
original form, which was how many angels could _dance_ on the head of a pin. The maximum number is easily worked out.

Given that the angels are _dancing_ upon it, it's clear that it must present something like a danceable surface. So, just to put us into the ballpark let us posit that the pin manufacturer is able to produce pinheads even to one atom's variation. The pinhead surface is thus uneven to approximately the size of an iron atom (I presume pins are generally still made of steel). Quantum mechanics doesn't allow us to assume a surface of smaller size...

For simplicity's sake, let us assume that angels are versatile dancers and can deal with an unevenness in the floor roughly approximate to their own size. (Me, I have trouble with even perfectly smooth floors...) This factor can conceivably vary widely with the skill of the dancer and the style of the dancing: the Highland Fling can be performed on surfaces that would be impossible for ballroom dancers. The style of dancing also determines "angel-packing" factor, but we'll assume they're not attempting a space-consuming Irish-style Riverdance stage stepdance. All of this is rough, but it should put us within an order of magnitude or so.

So... A pinhead (I just went and measured one) is roughly 0.1" in diameter. According to my _Reference Data for Radio Engineers_ (1972), the radius of an iron atom is 1.17 angstroms.

Applying the conversion: 1 in = 2.54 cm, we find that the area of the pinhead is roughly 3.14 * (0.05*2.54)^2 = 0.05 cm^2, or 0.05*(10^-4) m^2, or 5*(10^-6) m^2 or simply 5E-6 m^2 -- I happen to like the simpler notation. (And if there are errors here, well, I'm having my Pentium do the calculations... :-)

Using the conversion: 1 angstrom = 0.1 nm, we find that the "area" of the pinhead covered by an iron atom is roughly (0.117E-9)^2 m^2 = 1.37E-20 m^2. (I am assuming a rectangular lattice of iron atoms here; even if that is wrong we are still in the ballpark.)

Therefore, the maximum number of angels able to dance upon the head of this pin is in the neighborhood of 5E-6/1.4E-20 = 3.6E14 or 360 million million angels. (I am avoiding any use of "billion" because that term has different values dependent upon one's nationality.)

If one knows in what fashion our angels are tripping the light fantastic, and if one knows something about their surefootedness, this number can be refined. But in any event we can at long last estimate the number of angels which can dance upon the head of a pin.

Thought for the Week

Since it's always a bad idea to take ourselves too seriously, let me end this with a joke that makes fun of us:

A group of engineers celebrating in a bar kept shouting "94 days!". The bartender pulled one aside and said "This is quite a celebration you're having. What did you do in 94 days?" The engineer said "We put the puzzle together." The bartender said "That must have been quite a challenge".

"It sure was", the engineer boasted, "On the end of the box it said '5 to 7 years' ".

About The Embedded Muse

The Embedded Muse is an occasional newsletter sent via email by Jack Ganssle. Send complaints, comments, and contributions to him at jack@ganssle.com.

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