Gas mileage = speed / fuel volume flow rate =
[(60 miles/hour)/(1.12 x 10^{-4} gal/s)] x (hour / 3600 s) = 148.8095238 miles/gallon

Why is this value of miles/gallon so high?

- The main problem is that conversion of fuel energy to engine output shaft work is about 20% efficient at highway cruise conditions, thus the gas mileage would be 148.8095238 x 0.2 = 29.76190476 mpg
- Also, besides air drag, there are other losses in the transmission, driveline, tires – at best the drivetrain is 80% efficient – so now we're down to 23.80952381 mpg
- Also – other loads on engine – air conditioning, generator, …

What else is wrong? There are too many significant figures; at most 2 or 3 are acceptable. When we state 23.80952381 mpg, that means we think that the miles per gallon is closer to 23.80952381 mpg than 23.80952380 mpg or 23.80952382 mpg. Of course we can't measure the miles per gallon to anywhere near this level of accuracy. 24 is probably ok, 23.8 is questionable and 23.81 is ridiculous. You will want to carry a few extra digits of precision through the calculations to avoid round-off errors, but then at the end, round off your calculation to a reasonable number of significant figures *based on the uncertainty of the most uncertain parameter*. That is, if I know the drag coefficient only to the first digit, i.e. I know that it's closer to 0.2 than 0.1 or 0.3, but not more precisely than that, there is no point in reporting the result to 3 significant figures.

Example 2. Scrutiny of a new formula

I calculated for the first time ever the rate of heat transfer (q) (in Watts) as a function of time t from an aluminum bar of radius r, length L, thermal conductivity k (units Watts/m˚C), thermal diffusivity α (units m^2/s), heat transfer coefficient h (units Watts/m^2˚C) and initial temperature T_{bar} conducting and radiating to surroundings at temperature T_∞ as

$$q = k(T_{bar} - T_\infty)e^{\alpha t/r^2} - hr^2(T_{bar} - T_\infty - 1) \qquad \text{(Equation 8)}$$

Using "engineering scrutiny," what "obvious" mistakes can you find with this formula? What is the likely "correct" formula?

1. The units are wrong in the first term (Watts/m, not Watts)

2. The units are wrong in the second term inside the parenthesis (can't add 1 and something with units of temperature)

3. The first term on the right side of the equation goes to infinity as the time (t) goes to infinity – probably there should be a negative sign in the exponent so that the whole term goes to zero as time goes to infinity.

4. The length of the bar (L) doesn't appear anywhere

5. The signs on ($T_{bar} - T_\infty$) are different in the two terms – but heat must ALWAYS be transferred from hot to cold, never the reverse, so the two terms cannot have different signs. One can, with equal validity, define heat transfer as being positive either to or from the bar,