Beer Math w/John Palmer
The Session, 9/13/09

Page numbers are from How To Brew by John Palmer

1. Gravity Calcs p35

ppg = pts Gal/lbs = L °/kg
8.3454
ppg x mass = total gravity points
total gravity points/volume = specific gravity

2. Gravity Conversions (plato to OG) p196

Degrees Plato measures the amount of extract in wort as a weight percentage (solute to solution). IOW, wort that measures 10P has 10 grams of soluble extract (sugars, proteins, polyphenols) per 100 grams of wort. Commercial brewers use this unit more often that ppg to gauge their malt usage, because a) they are using refractometers, and b) they are more concerned with how much malt they are using rather than how much wort they are making.

The catch is that they still need to know what the specific gravity of the wort is to make the calculation of how much malt to use to get the extract target.
For gravities less than 13P /1.052 , the conversion factor is 4.

The second catch is that refractometers measure in Brix and the conversion between Brix and Plato is 96%. (Wort is mostly maltose, not pure sucrose) 12 => 11.5

An approximate conversion from P to SG is SG = 260 – (260/P)

3. Mash Efficiency p191

Mash efficiency is Your % compared to the Maximum Obtainable for the Malt (FGDB) (80%). So, if the maximum yield from a 2 Row base malt is 80% by weight, that means that for 10 pounds of malts you would expect 8 pounds of soluble extract. If he got 7 pounds of soluble extract from mashing 10 pounds that would be 70% Extract, but 87% Extract Efficiency (7/8).

Let's assume we consistently achieve 75% Efficiency. IOW, we get 75% of the max 80% by weight soluble extract. The gold standard is sucrose which yields 100% by weight as soluble extract. 1 pound dissolved into water to make 1 gallon of wort has a gravity of 1.046, or 46 points.

80% of 46 is 37 ppg or 310 Liter°/kg max
80% Eff of 37 is 30. For Liter°/kg is 250.
75% Eff is 28/ 235.
70% Eff is 26/220

4. Mash Water p170

Water to Grist Ratio: Quarts per Pound or Liters per Kilogram
(1 qt/lb = 2.086 L/kg)

Water retention coefficient (if you don't drain a lot) is half quart/pound or 1 liter per kilogram

Calculate how much water to use in the mash lbs x R = volume

Calculate mash volume p172 V = G (R + .32) or V = G (R + .667) quarts or liters

5. Calculating RA p161

RA as CaCO3 = Alk as CaCO3 – (Ca/1.4) – (Mg/1.7)

Or

RA as CaCO3 = Alk as CaCO3 – (Ttl H as CaCO3/2.78) *Approximation if Mg is 1/3 Ca*

Get nomograph and Spreadsheet at

http://www.howtobrew.com/section3/chapter15-3.html (bottom of page)

6. Calculating IBU's p56

The hop IBU equations are an oversimplification of a complicated model.

Alpha Acid is leached into the hot wort (like an oily rag in water).

The oil is sticking to everything else, the walls of the pot, the hops, the hot break.

Meanwhile, the oil slowwwly isomerizes during the boil, it becomes soluble, goes into solution, doesn't stick to anything anymore.

How do you get more alpha acids to dissolve into the wort? Well, same way you do it with an oily rag, you add detergent. Raising the pH of the wort/boil will increase the amount of alpha that isomerizes. But will also throw your beer pH off, which will hurt the flavor.

IBUs = AAU x Utilization / Volume in milligrams per liter (ppm)

to convert to ounces per gallon you multiply the equation by 75.

Utilization is the big black box encompassing how much of the original alpha acid is carried off by the hot break, the pot, the spoon, the trub, etc, balanced by how much goes into solution as a function of time, and how much iso-alpha degrades as a function of time.

Larger boilpots will have better utilization because of lower surface area to volume ratio.

Broadly, 60 minutes is 20-30%, 30 minutes 15-20%, 15 minutes is 8-12%.

7. SRM/MCU Color Calc p270

Lovibond is the traditional scale for measuring color. It is based on comparison of color samples.

The SRM scale is intended to reproduce the Lovibond color scale using transmitted light of a particular wavelength.

The traditional way of estimating a beers color is to use Malt Color Units, which are similar to IBUs. You multiply the Lovibond by the #lbs used and divide by the volume in gallons.

This SRM:MCU correlation works for pale beers up to about 12 SRM. From there, the MCUs head for the sky and SRM levels off.

Mosher = .3MCU + 4.7

Daniels = .2MCU + 8.4

Morey = 1.49MCU^.69

Palmer = 1.5MCU^.7

8. Priming Sugar p113
Grams/Liter of dextrose = (Vf-Vo) x 3.7 or (Vf-Vo) x .49 for oz/gal
Grams/Liter of sucrose = (Vf-Vo) x 3.5 or x .46 for oz/gal

9. ABV/ABW Calc p98
Per Miller ABV = (OG-FG)/.78
ABW = .789*ABV/FG

10. Calories
calories per 12 oz beer = $[(6.9 \times ABW) + 4(RE - 0.1)] \times FG \times 3.55$
$RE = (0.1808 \times °P_i) + (0.8192 \times °P_f)$

11. Forced carbonation
See Appendix D in BCS

12. BU to GU Ratio Calc
Typically .4 to .8
Double IPA 1 to 1.2