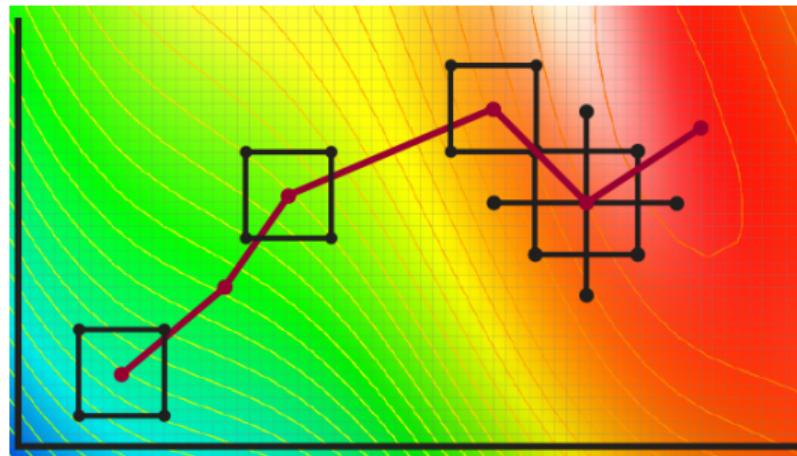


Experimentation for Improvement



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<http://learnche.org/>

Design and Analysis of Experiments

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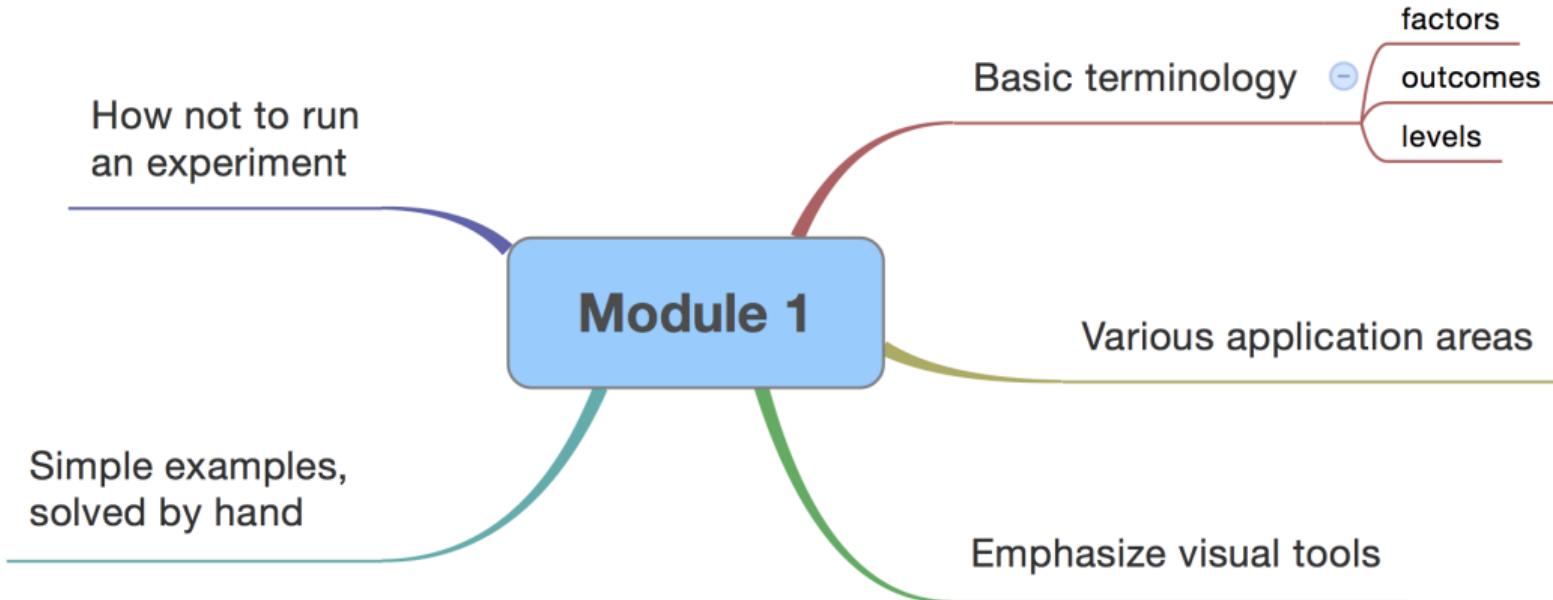


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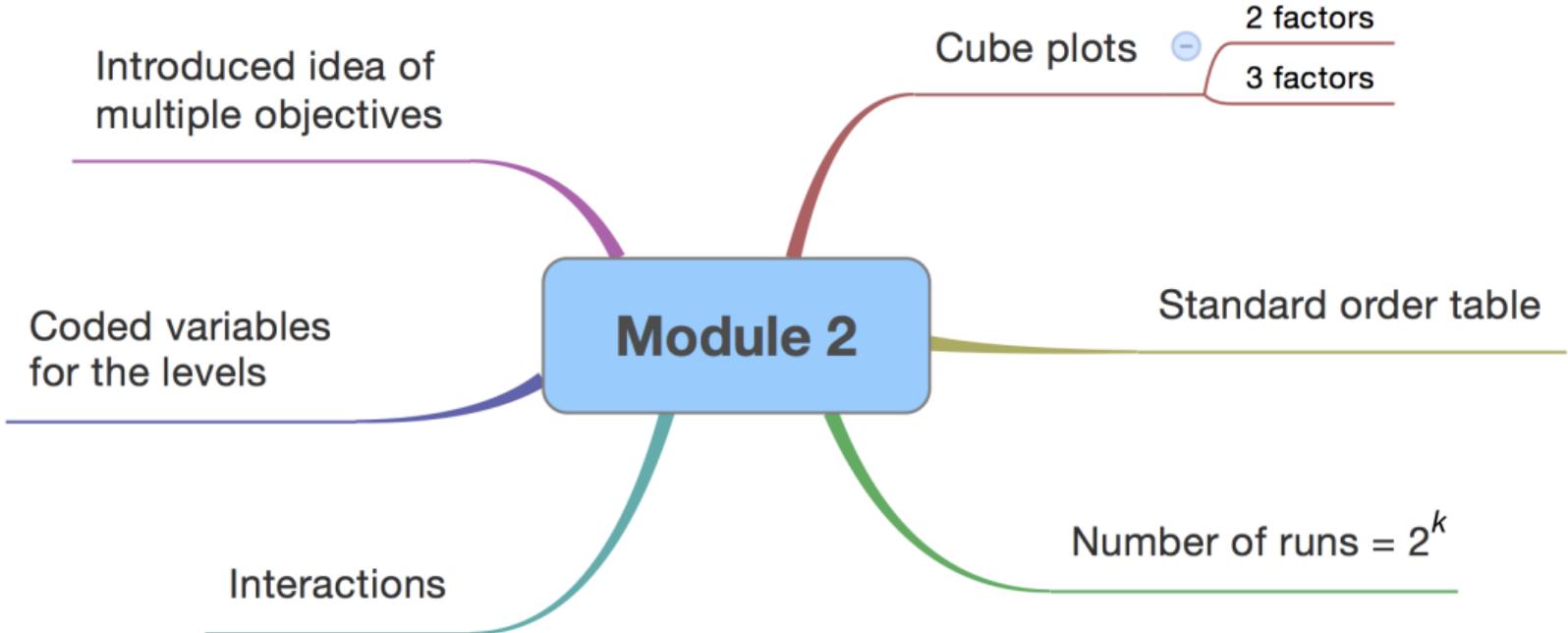
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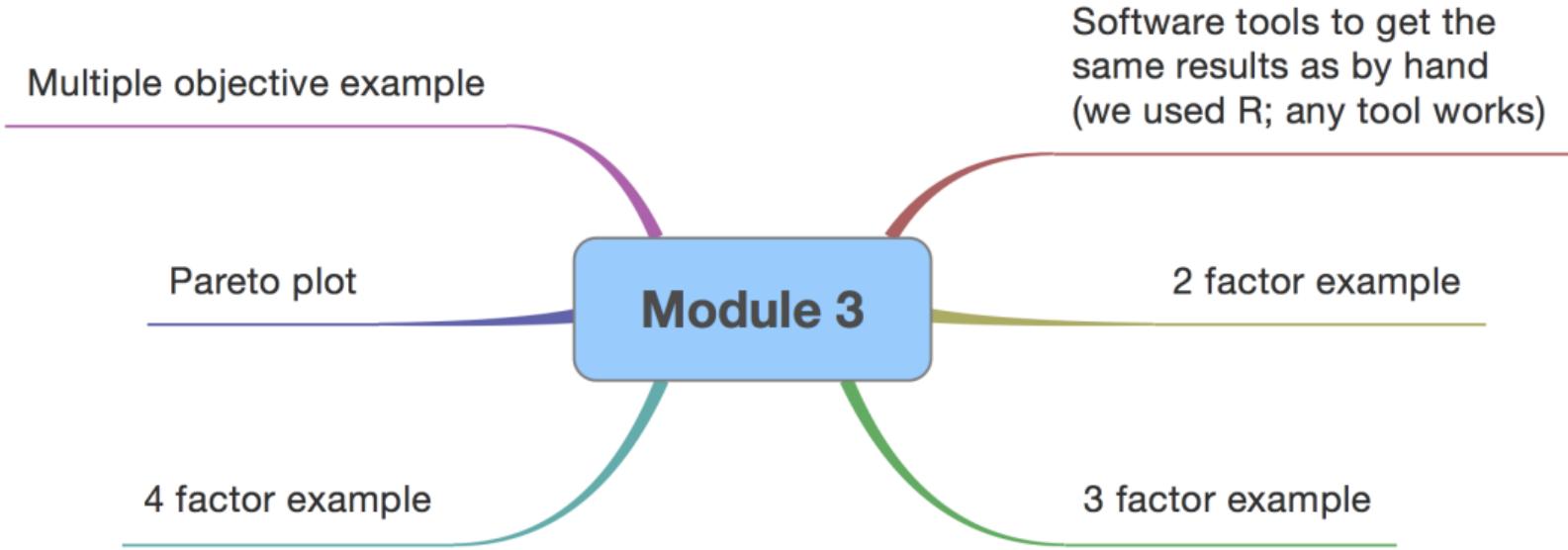
The course outline over the past five modules



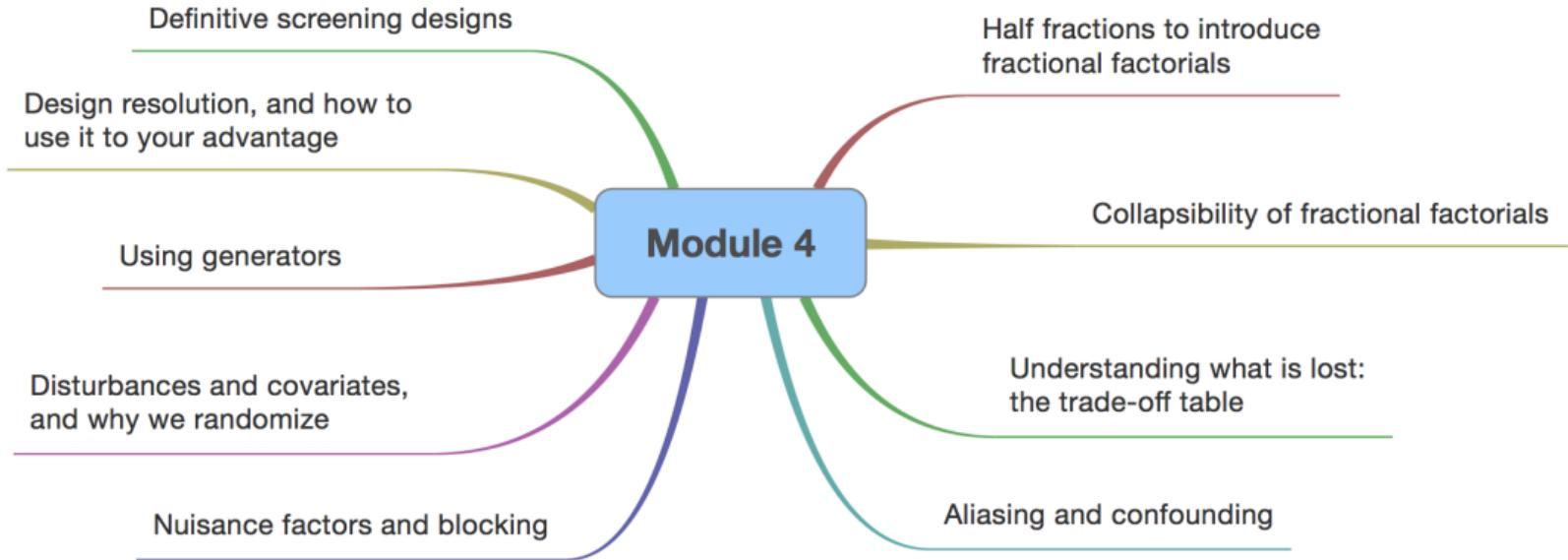
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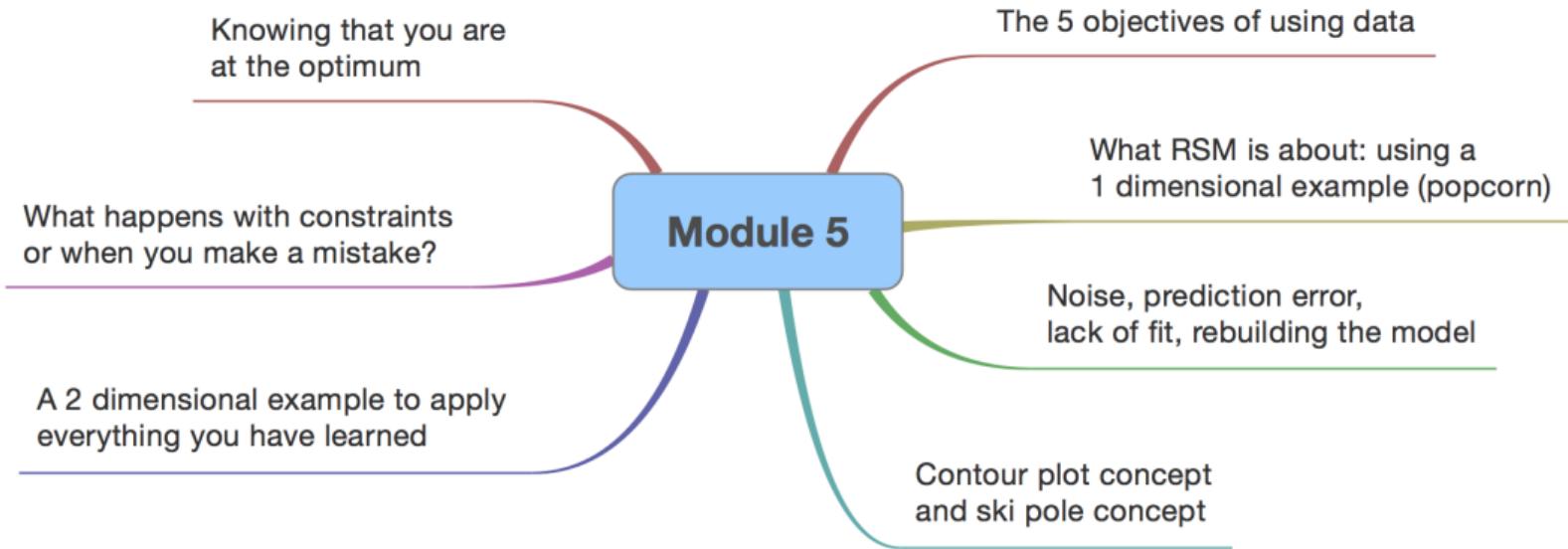
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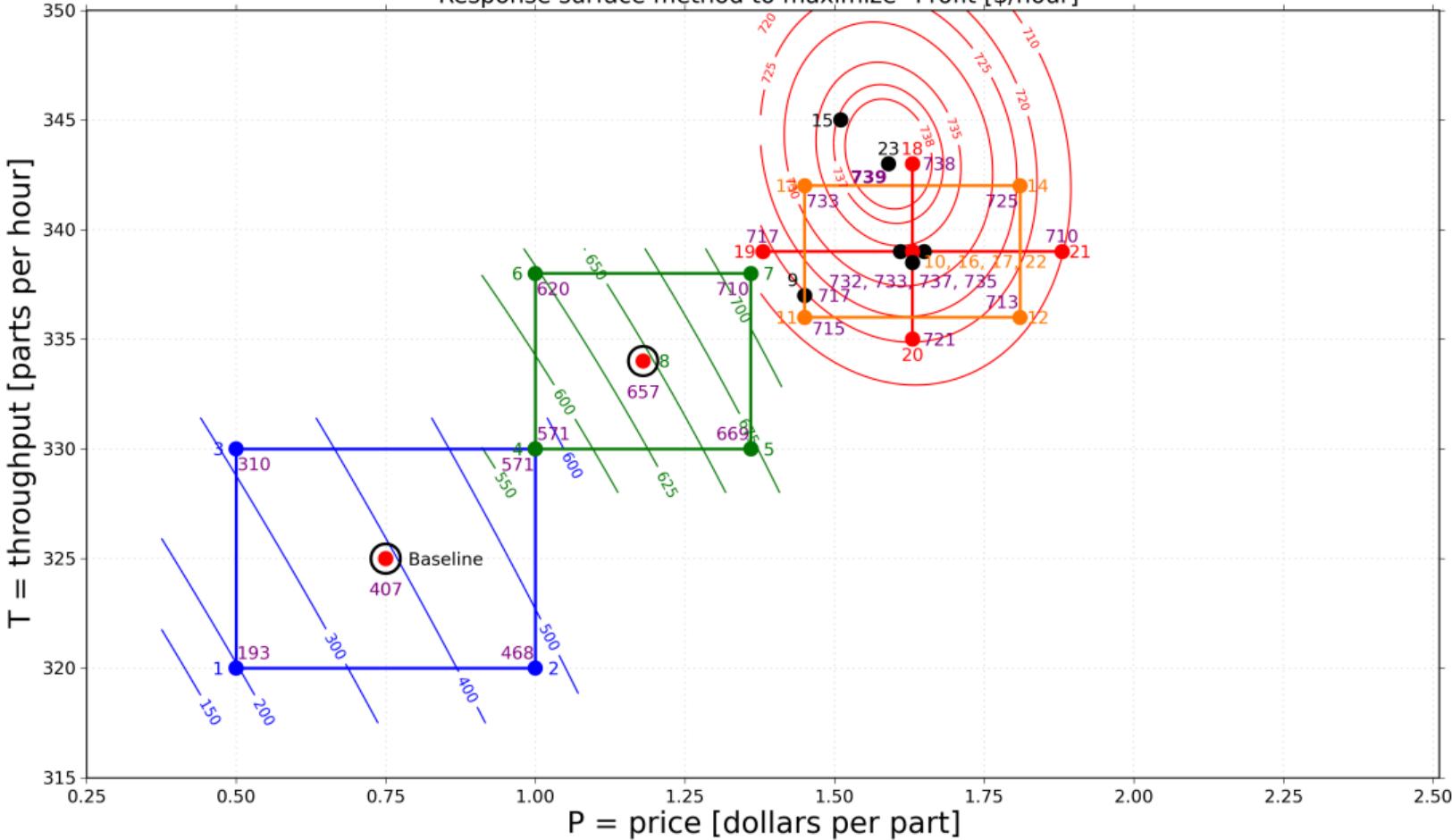
The course outline over the past five modules



The course outline over the past five modules



Response surface method to maximize "Profit [\$/hour]"



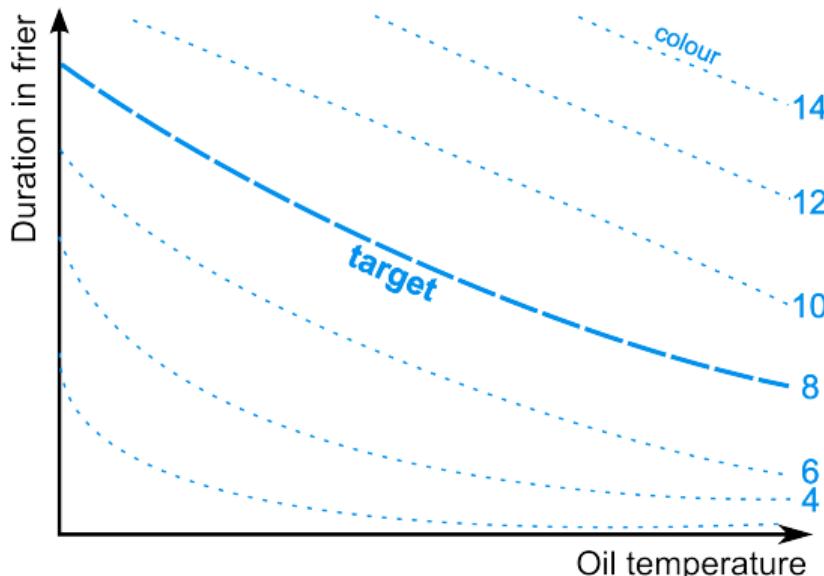
Dealing with multiple criteria in experiments

- The weighted sum = φ

$$\varphi = w_1(\text{colour}) + w_2(\text{breakability})$$

For example

$$\varphi = 0.3(\text{colour}) + 0.7(\text{breakability})$$



Optimizing the properties
of a snack food product
that is fried in oil

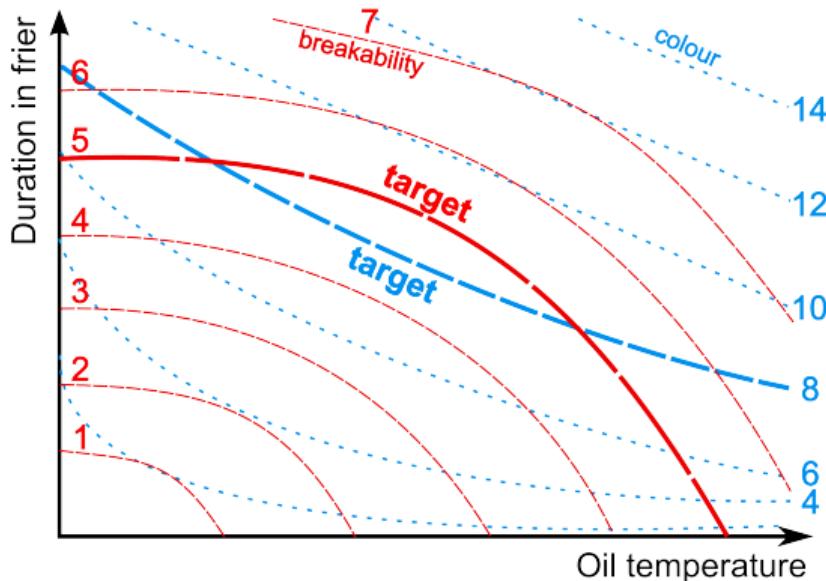


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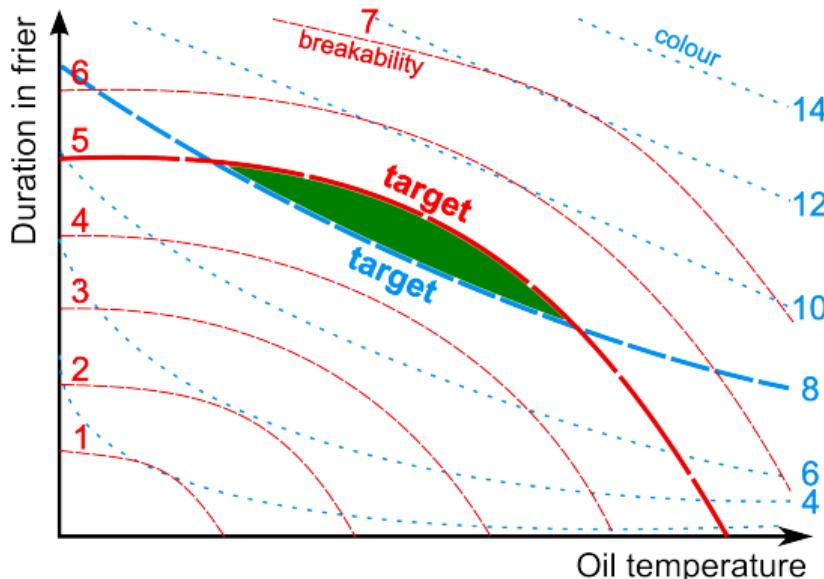


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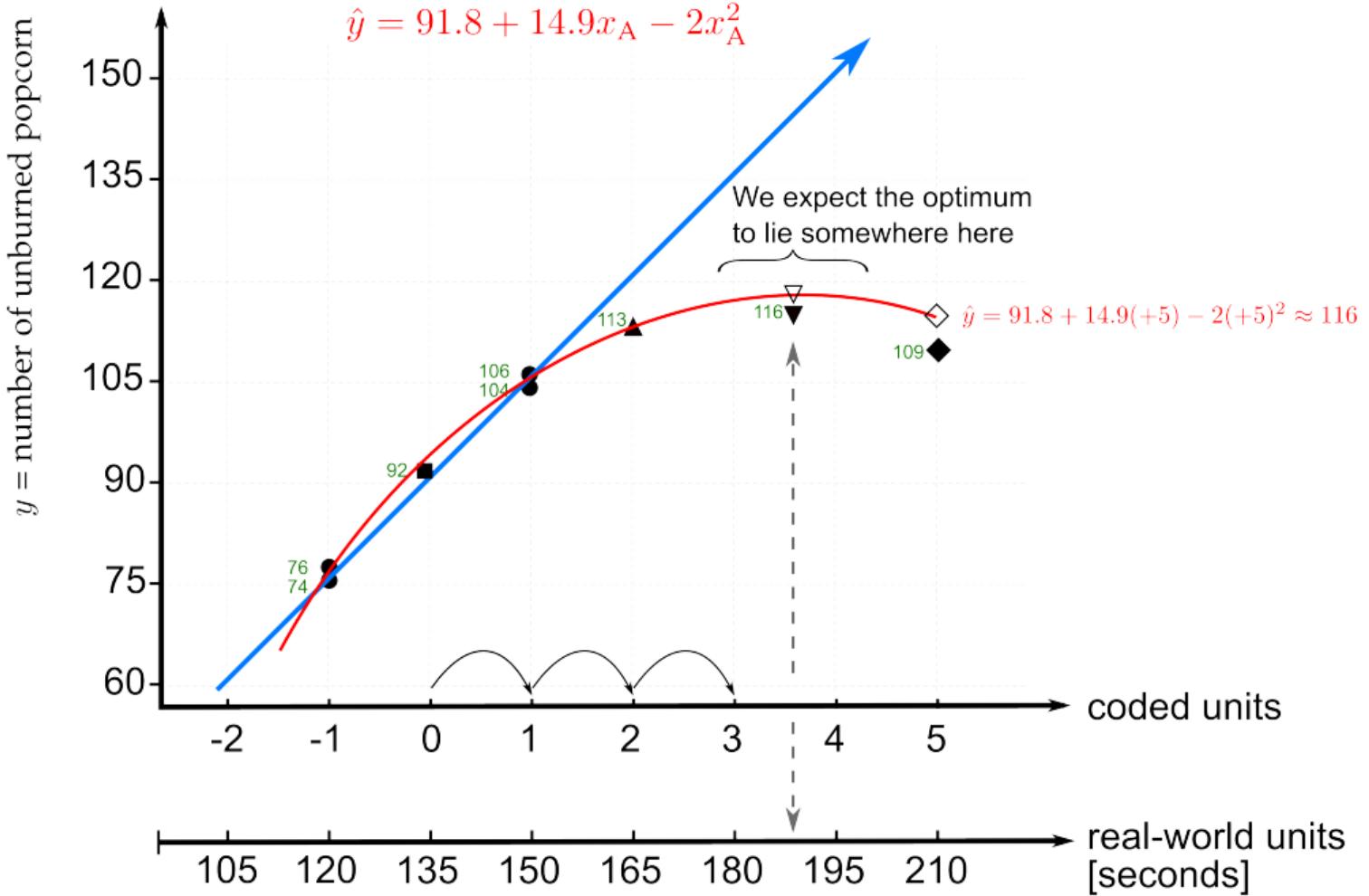
Number of factors, k						
increasing cost	3	4	5	6	7	8
4	2^{3-1}_{III} $\pm C=AB$					
8	2^3 <i>full</i>	2^{4-1}_{IV} $\pm D=ABC$	2^{5-2}_{III} $\pm D=AB$ $\pm E=AC$	2^{6-3}_{III} $\pm D=AB$ $\pm E=AC$ $\pm F=BC$	2^{7-4}_{III} $\pm D=AB$ $\pm E=AC$ $\pm F=BC$ $\pm G=ABC$	
16	2^3 <i>twice</i>	2^4 <i>full</i>	2^{5-1}_{V} $\pm E=ABCD$	2^{6-2}_{IV} $\pm E=ABC$ $\pm F=ABD$	2^{7-3}_{IV} $\pm E=ABC$ $\pm F=ABD$ $\pm G=ACD$	2^{8-4}_{IV} $\pm E=ABC$ $\pm F=ABD$ $\pm G=ACD$ $\pm H=BCD$
32	2^3 <i>4 times</i>	2^4 <i>twice</i>	2^5 <i>full</i>	2^{6-1}_{VI} $\pm F=ABCDE$	2^{7-2}_{IV} $\pm F=ABC$ $\pm G=ABDE$	2^{8-3}_{IV} $\pm F=ABC$ $\pm G=ABD$ $\pm H=ACDE$
64	2^3 <i>8 times</i>	2^4 <i>4 times</i>	2^5 <i>twice</i>	2^6 <i>full</i>	2^{7-1}_{VII} $\pm G=ABCDEF$	2^{8-2}_{V} $\pm G=ABCD$ $\pm H=ABEF$

increasing information
about additional factors

lower resolution
greater aliasing

The book by Goos and Jones: *Optimal Design of Experiments*

- ▶ A case-study based approach
- ▶ RSM with categorical factors
- ▶ Screening designs
- ▶ Mixture designs
- ▶ Blocking and covariates
- ▶ Split-plot designs (an important, practical topic)



Some additional advice on response surface methods

- ▶ RSM with multiple factors, e.g. **A**, **B**, **C**, and **D**. Pick a value for Δx_A , then:
 - ▶ $\Delta x_B = \frac{b_B}{b_A} \Delta x_A$
 - ▶ $\Delta x_C = \frac{b_C}{b_A} \Delta x_A$
 - ▶ $\Delta x_D = \frac{b_D}{b_A} \Delta x_A$
- ▶ Now with 4 factors, it does not make sense to run $2^4 = 16$ experiments in every factorial. Use fractional factorials.
- ▶ Unless, you are doing the experiments on a small scale, and they are cheap(er) than full-scale experiments.
- ▶ But watch the aliases when you approach the optimum. You will likely need to run a full CCD near the optimum to estimate curvature correctly.
- ▶ Check out the “**rsm**” package in R

Resources for Designed Experiments

The list is available here: <http://yint.org/resources>

Contact me to keep the list up-to-date: see the link on that webpage.