Today, we will:

- Do a review example problem – RSM
- Review the pdf module: **Hypothesis Testing and do some example problems**

Example: Response surface methodology

Given: We want to optimize the performance (maximum power *P* in units of horsepower) of a gasoline engine for a car. We vary three parameters simultaneously, and measure the engine's output power for each run with a dynamometer:

- *a* = spark plug gap (inches)
- *b* = spark timing (degrees before TDC – top dead center)
- *c* = fuel:air mixture (# of turns of the set screw that controls fuel:air mixture)

***a* (inches)**	***b* (degrees)**	***c* (# turns)**	***P* (hp)**
0.030	10	0	156
0.030	9	-0.25	160
0.029	9	0	162
0.029	11	0.25	159
0.031	11	-0.25	154
0.031	10	0.25	158

(a) To do: Calculate the coded variable x_b for the second row of data.

Solution:

(b) To do: Determine the direction of steepest ascent in terms of physical variables.

Solution: Solution done in Excel – see file on course website: **sample_car_engine_RSM.xls**.

Example: Response surface methodology

Given: We want to optimize the efficiency η (%) of a machine, where η depends on three parameters *a*, *b*, and *c*. We run several cases, varying *a*, *b*, and *c* simultaneously around the current operating point:

a	***b***	***c***	**η (%)**
15	4	0.2	71.5
16	6	0.5	80.6
15	5	0.3	74.4
14	6	0.4	67.7
16	5	0.2	80.3
14	4	0.5	64.6

To do: Determine the direction of steepest ascent. [I used Excel for convenience; file not on website – try it on your own for practice.]

Solution:

- Convert to coded variables x_1, x_2, and x_3.
- Use regression analysis to determine the direction of steepest ascent.

Answer: $\left(\frac{\partial y}{\partial x_1}, \frac{\partial y}{\partial x_2}, \frac{\partial y}{\partial x_3}\right) = (6.604,\ 1.576,\ -0.505)$.

- Pick *one* of the increments (Δx_1, Δx_2, or Δx_3), and then calculate the other two. I picked $\Delta x_2 = 0.5$.

Answer: $\Delta x_1 = 2.1 \qquad \Delta x_3 = -0.16$

- Convert these coded variable increments back to physical variables, Δa, Δb, and Δc.

Answer: $\Delta a = 2.1 \qquad \Delta b = 0.50 \qquad \Delta c = -0.024$

- Final step: You may round off (for convenience) and *march* in the direction of steepest ascent, varying *a*, *b*, and *c* *simultaneously*. [You cannot actually *do* this, since you don't have the experiment.]

Example: Hypothesis testing

Given: A manufacturer claims that a strut can hold at least 100 kg before failing. We perform 10 tests to failure, and record the load:

- $n = 10$ (number of data points in the sample)
- $\overline{x} = 101.4$ kg (sample mean)
- $S = 2.3$ kg (sample standard deviation)

To do: Determine if we should accept or reject the manufacturer's claim.

Solution:

- This is a (one-sided two-sided) *t*-test.
- The null hypothesis:
- The "side" of the null hypothesis:
- The alternative hypothesis:
- The critical *t* statistic:
- The *p*-value:
- Interpretation and conclusion: