Today, we will:

- Do a review example problem – experimental uncertainty analysis
- Review the pdf module: **Experimental Design**
- Do some example problems – experimental design (Taguchi design arrays)

Example: Experimental uncertainty analysis

Given: In fluid mechanics class, we learn that the change in pressure as you go down in a liquid (hydrostatic pressure change) is $\Delta P = \rho g h$, where

- ΔP = change in pressure (N/m^2, which is the same units as pascals, Pa)
- ρ = density $\rho = 1000.0\ kg/m^3 \pm 0.02\%$ (measured to 95% confidence)
- g = gravitational acceleration $g = 9.807\ m/s^2$ (a known constant)
- h = change in liquid depth $h = 3.45 \pm 0.03\ m$ (measured to 95% confidence)

To do: Write ΔP at these values of ρ, g, and h in standard engineering format.

Solution:

Example – Taguchi array

Given: Susan proposes this experimental design array for 3 parameters and 4 levels for each parameter, choosing to test each level of each parameter *twice*.

Run #	*a*	*b*	*c*	*X*
1	1	1	1	X_1
2	1	2	3	X_2
3	2	3	4	X_3
4	2	4	2	X_4
5	3	1	2	X_5
6	3	2	3	X_6
7	4	3	1	X_7
8	4	4	4	X_8

To do: Explain (be *specific*) why this array is *not* a proper (optimized) Taguchi array. **How would you fix it?**

Solution:

Example – Taguchi array

Given: Josh proposes this experimental design array for 3 parameters and 4 levels for each parameter, choosing to test each level of each parameter *twice*.

Run #	*a*	*b*	*c*	*X*
1	1	1	1	X_1
2	1	2	3	X_2
3	2	3	3	X_3
4	2	4	2	X_4
5	3	1	2	X_5
6	3	2	4	X_6
7	4	3	2	X_7
8	4	4	4	X_8

To do: Explain (be *specific*) why this array is *not* a proper (optimized) Taguchi array. **How would you fix it?**

Solution:

Example: Experimental design using Taguchi arrays

Given: Bryan uses a Taguchi design array with 3 parameters and 4 levels for each parameter, choosing to test each level of each parameter *twice*. The design array (a valid Taguchi array) is shown here, along with the experimental results of the test.

Taguchi, $P = 3, L = 4$				
Run #	***a***	***b***	***c***	***X***
1	1	1	1	*1.65*
2	1	2	4	*1.71*
3	2	3	3	*1.85*
4	2	4	2	*1.71*
5	3	1	2	*1.79*
6	3	2	3	*1.76*
7	4	3	1	*1.75*
8	4	4	4	*1.68*

To do: Calculate level average $\overline{X}_{b3}$ to three significant digits.

Solution:

Example: Experimental design using Taguchi arrays

Given: A toy gun that shoots Nerf bullets is being designed. The engineers want to maximize the distance traveled by the bullet. Three parameters are to be varied:

- a = spring constant
- b = weight of the bullet
- c = diameter of the bullet

The engineers decide to test 4 levels for each of these 3 parameters.

(*a*) To do: Calculate how many runs are required for a full-factorial analysis.

(*b*) To do: Design a Taguchi array such that each level of each parameter appears twice.