Today, we will:

- Do example problems – hypothesis test with two independent samples
- Review the pdf module: **Digital Data Acquisition**, and do some example problems

Example: Hypothesis testing

Given: [Continuation of previous example] We buy a gadget that is supposed to increase the gas mileage of our car. We take 6 trips *without* the gadget and 8 trips *with* the gadget. We do not attempt to pair up the tests. The results:

x_A (mpg without gadget)	x_B (mpg with gadget)
25.6	26.2
27.3	27.1
24.2	24.1
28.7	29.2
23.6	24.5
25.1	24.9
	26.5
	25.8

We ran 2 more tests with the gadget installed

To do: Determine if there is a statistically significant improvement (increase) in gas mileage.

Solution:

We did this problem "by hand" in the previous lecture. Today I will show you how to do it in Excel, using the built-in macro.

Summary of the "by hand" procedure– see previous lecture notes for details:

1. Calculate the critical t statistic using equation in notes. Get ***t* = -0.2941**.
2. Calculate df from **Welch's equation**. Get **df = 10**.
3. For these values of *t* and df, one tail, calculate or look up the *p*-value. Get ***p* = 0.3873**.
4. The final conclusion is that we are 61.3% confident that the gadget increases our gas mileage.
5. Since 61.3% < 95%, **we cannot accept the claim (to standard engineering confidence level) that this gadget increases our gas mileage**.

In practice, since these kinds of problems are very common, there is an Excel macro to do all the calculations for us. Click on: Data-Data Analysis-t-Test: Two-Sample Assuming Unequal Variances.

See Excel spreadsheet on website: **Two_samples_t_test_different_n.xls**

[I also do this problem in Matlab – see website for Matlab file.]

See *another* example Excel file, posted on course website (compare final scores in a course).

Example: Digital data acquisition

Given: The integer 18 (base 10).

To do: Write this integer in 8-bit binary format.

Solution:

VALUE / 2 = INTEGER + REMAINDER

$18/2 = 9 + 0/2 \rightarrow 9$

$9/2 = 4 + 1/2 \rightarrow 4$

$4/2 = 2 + 0/2 \rightarrow 2$

$2/2 = 1 + 0/2 \rightarrow 1$

$1/2 = 0 + 1/2 \rightarrow 0$

Stop @ 0

Remainders: 0, 1, 0, 0, 1

Read up from bottom

ANSWER: 1 0 0 1 0, but in 8-bit, add leading zeros:

128	64	32	16	8	4	2	1
0	0	0	1	0	0	1	0

ANSWER: 0001 0010

Verify: $16 + 2 = 18$ ✓

Example: Digital data acquisition

Given: The integer 0010 0110 (8-bit binary).

To do: Write this integer in base 10 format.

Solution:

128	64	32	16	8	4	2	1
0	0	1	0	0	1	1	0

Add: → $32 + 4 + 2 = 38$

38

Example: Digital data acquisition

Given: Two integers in 8-bit binary format: A = 0010 0110 and B = 1000 0100.

To do: Add $A + B$ and write the result in base 10 format and in binary format.

Solution:

$32 + 4 + 2 = 38$ $128 + 4 = 132$

- You can convert first, then add in base 10:

$A = 38$, $B = 132$ → $A + B = 170$ → convert to binary using above procedure.

Get **1010 1010**

- OR, stay in binary & add directly:

```
      +1
 0 0 1 0  0 1 1 0
 1 0 0 0  0 1 0 0
 ----------------
 1 0 1 0  1 0 1 0
```

= **1010 1010** ✓

Verify: $128 + 32 + 8 + 2 = 170$ ✓

Example: Digital data acquisition

Given: A voltage signal ranges from -1.2 to 1.4 volts. A digital data acquisition system is to be chosen – four choices are available:

(a) 12-bit A/D range = -10 to 10 V
(b) 8-bit A/D range = -2 to 2 V
(c) 10-bit A/D range = -5 to 5 V
(d) ✗ 14-bit A/D range = -1 to 1 V

To do: Determine which system is the best choice for this application, assuming that cost is irrelevant (all four are available in the lab).

Solution:

- Throw out (d) right off the bat – will clip!
  (-1 to 1 V is too limited of a range, since signal ranges from -1.2 to 1.4 volts → will clip)

- Calculate quantizing (or quantization) error for the other 3:

(a) quantization error $= \pm 0.5 \dfrac{V_{max} - V_{min}}{2^N} = \pm 0.5 \dfrac{10-(-10)\ V}{2^{12}}$

$= \pm 0.00244\ V$

(b) " " $= \pm 0.5 \dfrac{2-(-2)}{2^8} = \pm 0.00781\ V$

(c) " " $= \pm 0.5 \dfrac{5-(-5)}{2^{10}} = \pm 0.00488\ V$

Smallest quantizing error is best, provided there is no clipping. So, here, **DAQ system (a) is the best choice.**

Best resolution w/o clipping

[DAQ (d) has the best resolution, but it would clip]