

**The University of Melbourne**  
**CVEN30008 Engineering Risk Analysis**

**Tutorial 8**

**Hypothesis Testing Part 1**

1. An ultralow particulate air filter is used to maintain uniform airflow in production areas in a clean room. A simple random sample of 58 filters from a certain vendor was tested. The sample mean velocity was 39.6 cm/s, with a standard deviation of 7 cm/s. Let  $\mu$  represent the mean air velocity obtained from filters supplied by this vendor.

- Can you conclude that the mean velocity is less than 40 cm/s? (Assume a significant level of 0.05)

- Use MATLAB to verify your results.

**Answer:**

$H_0: \mu \geq 40$  versus  $H_1: \mu < 40$

$\bar{X} = 39.6, \mu_0 = 40, \sigma = 7, n = 58$

Because the sample size is greater than 30, it is large-sample test (Z test).

$$Z = \frac{\bar{X} - \mu_0}{\sigma/\sqrt{n}} = \frac{39.6 - 40}{7/\sqrt{58}} = -0.44$$

P value obtained from Z table for  $Z < -0.44$ :

### Standard Normal Cumulative Probability Table



Cumulative probabilities for NEGATIVE z-values are shown in the following table:

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010

-0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

Hence,  $P(Z < -0.44) = 0.33$

Since the significant level  $\alpha = 0.05$  which is smaller than 0.33.

Because  $P > \alpha$ .

We do not reject  $H_0$ ,

Conclusion: we believe it is plausible that the mean velocity is at least 40 cm/s

### MATLAB

Left tail test

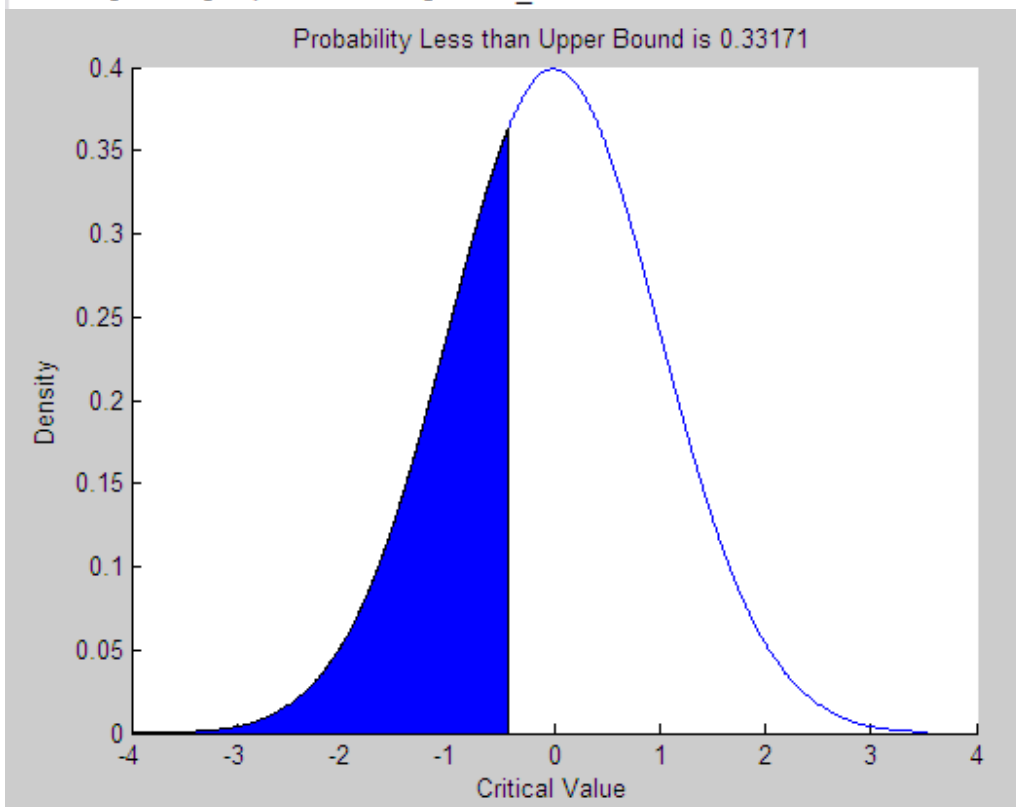
p =

0.3317

alpha =

0.0500

Since  $p > \alpha$ , Do not reject  $H_0$



2. A sample of 18 pieces of laminate had a mean warpage of 1.88 mm and a standard deviation of 0.21 mm. Can it be concluded that the mean warpage for this type of laminate is less than 2 mm (assume the significant level is 0.05)? Use MATLAB to verify your results.

**Answer:**

$H_0: \mu \geq 2$  versus  $H_1: \mu < 2$

$\bar{X} = 1.88$ ,  $\mu_0 = 2$ ,  $s = 0.21$ ,  $n = 18$ , degree of freedom =  $n - 1 = 17$

Because the sample size is smaller than 30, it is small-sample test ( $t$  test).

$$t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}} = \frac{1.88 - 2}{0.21/\sqrt{18}} = -2.424$$

Take the absolute value of  $t$ , P value estimated from  $t$  table:

Degrees of Freedom	Combined Area $\alpha$ in Two Tails					
	0.250	0.100	0.050	0.025	0.010	0.005
1	2.4142	6.3138	12.7062	25.4517	63.6567	127.3213
2	1.6036	2.9200	4.3027	6.2053	9.9248	14.0890
3	1.4226	2.3534	3.1824	4.1765	5.8409	7.4533
4	1.3444	2.1318	2.7764	3.4954	4.6041	5.5976
5	1.3009	2.0150	2.5706	3.1634	4.0321	4.7733
6	1.2733	1.9432	2.4469	2.9687	3.7074	4.3168
7	1.2543	1.8946	2.3646	2.8412	3.4995	4.0293
8	1.2403	1.8595	2.3060	2.7515	3.3554	3.8325
9	1.2297	1.8331	2.2622	2.6850	3.2498	3.6897
10	1.2213	1.8125	2.2281	2.6338	3.1693	3.5814
11	1.2145	1.7959	2.2010	2.5931	3.1058	3.4966
12	1.2089	1.7823	2.1788	2.5600	3.0545	3.4284
13	1.2041	1.7709	2.1604	2.5326	3.0123	3.3725
14	1.2001	1.7613	2.1448	2.5096	2.9768	3.3257
15	1.1967	1.7531	2.1314	2.4899	2.9467	3.2860
16	1.1937	1.7459	2.1199	2.4729	2.9208	3.2520
17	1.1910	1.7396	2.1098	2.4581	2.8982	3.2224
18	1.1887	1.7341	2.1009	2.4450	2.8784	3.1966
19	1.1866	1.7291	2.0930	2.4334	2.8609	3.1737
20	1.1848	1.7247	2.0860	2.4231	2.8453	3.1534

From the  $t$  table, for  $t = 2.1098$ ,  $P = \alpha/2 = 0.025$ ; for  $t = 2.4581$ ,  $P = \alpha/2 = 0.0125$ . (Because it is two-tailed  $t$  table, while the question is one-tailed test, we need to divide the  $\alpha$  value as shown in the second row by 2).

We know  $2.1098 < t = 2.424 < 2.4581$

Hence,  $0.025 > P(t > 2.424) > 0.0125$ .

Since  $P(t < -2.424) = P(t > 2.424)$ ,

$0.025 > P(t < -2.424) > 0.0125$

Because the significant level  $\alpha = 0.05$  which is greater than  $P(t < -2.424)$ .

$P < \alpha$

We reject  $H_0$ ,

We can conclude that the mean warpage for this type of laminate is less than 2 mm.

## MATLAB

```
Command Window
Left tail test

p =

    0.0134

alpha =

    0.0500

Since p <= alpha, Reject H_0
fx >>
```

**Note:** Matlab verified that  $P = 0.0134$ , which is between 0.0125 and 0.025 as stated above