Using F table (2 degrees of freedom numerator and 44 denominator), p-value is less than 0.01

Actual p-value = 0.0000 (to 4 decimal places)

Because p-value $\le \alpha = 0.05$, we reject the hypothesis that the treatment means are equal.

26 a.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Treatments	2	4 560	2280	9.87
Error	27	6 240	231.11	
Total	29	10 800		

b. Using F table (2 degrees of freedom numerator and 27 denominator), p-value is less than 0.01

Actual p-value = 0.0006

Because p-value $\le \alpha = 0.05$, we reject the null hypothesis that the means of the three assembly methods are equal.

28

	50°	60°	70°
Sample Mean	33	29	28
Sample Variance	32	17.5	9.5

$\bar{\bar{x}} = (33 + 29 + 28)/3 = 30$

SSTR = 70

MSTR = SSTR/(k − 1) = 70/2 = 35

SSE = 236

MSE = SSE/(n_T − k) = 236/(15 − 3) = 19.67

F = MSTR/MSE = 35/19.67 = 1.78

Using F table (2 degrees of freedom numerator and 12 denominator), p-value is greater than 0.10

Actual p-value = 0.2104

Because p-value $> \alpha = 0.05$, we cannot reject the null hypothesis that the mean yields for the three temperatures are equal.

30

	Paint 1	Paint 2	Paint 3	Paint 4
Sample Mean	13.3	139	136	144
Sample Variance	47.5	0.50	21	54.5

$\bar{\bar{x}} = (133 + 139 + 136 + 144)/3 = 138$

$$\text{SSTR} = \sum_{j=1}^{k} n_j(\bar{x}_j - \bar{\bar{x}})^2 = 5(133 - 138)^2$$
$$+ 5(139 - 138)^2 + 5(136 - 138)^2$$
$$+ 5(144 - 138)^2 = 338$$

MSTR = SSTR/(k − 1) = 330/3 = 110

$$\text{SSE} = \sum_{j=1}^{k}(n_j - 1)s_j^2 = 4(47.5) + 4(50)$$
$$+ 4(21) + 4(54.5) = 692$$

MSE = SSE/(n_T − k) = 692/(20 − 4) = 43.25

F = MSTR/MSE = 110/43.25 = 2.54

Using F table (3 degrees of freedom numerator and 16 denominator), p-value is between 0.05 and 0.10

Actual p-value = 0.0931

Because p-value $> \alpha = 0.05$, we cannot reject the null hypothesis that the mean drying times for the four paints are equal.

32 Note: degrees of freedom for $t_{\alpha/2}$ are 18

$$\text{LSD} = t_{\alpha/2}\sqrt{\text{MSE}\left(\frac{1}{n_i} + \frac{1}{n_j}\right)} = t_{0.025}\sqrt{5.09\left(\frac{1}{7} + \frac{1}{7}\right)}$$
$$= 2.101\sqrt{1.4543} = 2.53$$

$|\bar{x}_1 - \bar{x}_2| = |17.0 - 20.4| = 3.4 > 2.53$; significant difference

$|\bar{x}_1 - \bar{x}_3| = |17.0 - 25.0| = 8 > 2.53$; significant difference

$|\bar{x}_2 - \bar{x}_3| = |20.4 - 25| = 4.6 > 2.53$; significant difference

34 Treatment Means:

$\bar{x}_{.1} = 13.6$ $\bar{x}_{.2} = 11.0$ $\bar{x}_{.3} = 10.6$

Block Means:

$\bar{x}_{1.} = 9$ $\bar{x}_{2.} = 7.67$ $\bar{x}_{3.} = 15.67$ $\bar{x}_{4.} = 18.67$ $\bar{x}_{5.} = 7.67$

Overall Mean:

$\bar{\bar{x}} = 176/15 = 11.73$

Step 1

$$\text{SST} = \sum_i\sum_j (x_{ij} - \bar{\bar{x}})^2 = (10 - 11.73)^2 + (9 - 11.73)^2$$
$$+ \cdots + (8 - 11.73)^2 = 354.93$$

Step 2

$$\text{SSTR} = b\sum_{j=1} (\bar{x}_{.j} - \bar{\bar{x}})^2 = 5\,[(13.6 - 11.73)^2$$
$$+(11.0 - 11.73)^2 + (10.6 - 11.73)^2] = 26.53$$

Step 3

$$\text{SSBL} = k\sum_i (\bar{x}_{i.} - \bar{\bar{x}})^2 = 3\,[(9 - 11.73)^2$$
$$+ (7.67 - 11.73)^2 + (15.67 - 11.73)^2$$
$$+ (18.67 - 11.73)^2 + (7.67 - 11.73)^2]$$
$$= 312.32$$

Step 4

SSE = SST − SSTR − SSBL = 354.93 − 26.53 − 312.32 = 16.08

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Treatments	2	26.53	13.27	6.60
Blocks	4	312.32	78.08	
Error	8	16.08	2.01	
Total	14	354.93		

Using F table (2 degrees of freedom numerator and 8 denominator), p-value is between 0.01 and 0.025

Actual p-value = 0.0203

Because p-value $\le \alpha = 0.05$, we reject the null hypothesis that the means of the three treatments are equal.

36

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Treatments	3	900	300	12.60
Blocks	7	400	57.14	
Error	21	500	23.81	
Total	31	1800		

Using F table (3 degrees of freedom numerator and 21 denominator), p-value is less than 0.01

Actual p-value = 0.0001

Because p-value $\le \alpha = 0.05$, we reject the null hypothesis that the means of the treatments are equal.

38

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Cloth(block)	2	0.389	0.195	9.00
Silicone	4	16.103	4.026	
Error	8	3.577	0.447	
Total	14	20.069		

Using F table (4 degrees of freedom numerator and 8 denominator), p-value is less than 0.01

Actual p-value = 0.005

Because p-value $\le \alpha = 0.05$, we reject the null hypothesis that the mean indices corresponding to the five silicone solution strengths are equal. Note that the highest mean index is for the 15 per cent solution.

40

	Factor B			Factor A
	Level 1	Level 2	Level 3	Means
Factor A Level 1	$\bar{x}_{11} = 150$	$\bar{x}_{12} = 78$	$\bar{x}_{13} = 84$	$\bar{x}_{1.} = 104$
Factor A Level 2	$\bar{x}_{21} = 110$	$\bar{x}_{22} = 116$	$\bar{x}_{23} = 128$	$\bar{x}_{2.} = 118$
Factor B Means	$\bar{x}_{.1} = 130$	$\bar{x}_{.2} = 97$	$\bar{x}_{.3} = 106$	$\bar{\bar{x}} = 111$

Step 1

$$\text{SST}\ \sum_i\sum_j\sum_k (x_{ijk} - \bar{\bar{x}})^2$$
$$(135 - 111)^2 + (165 - 111)^2$$
$$+ .. + (136 - 111)^2 = 9028$$

Step 2

$$\text{SSA} = br\sum_i (\bar{x}_{i.} - \bar{\bar{x}})^2 = 3(2)[(104 - 111)^2$$
$$+ (118 - 111)^2] = 588$$

Step 3

$$\text{SSB} = ar\sum_j (\bar{x}_{.j} - \bar{\bar{x}})^2 = 2\,(2)[\,(130 - 111)^2$$
$$+ (97 - 111)^2 + (106 - 111)]$$
$$= 2328$$

Step 4

$$\text{SSAB} = r\sum_i\sum_j (\bar{x}_{ij} - \bar{x}_{i.} - \bar{x}_{.j} - \bar{\bar{x}})^2$$
$$= 2[(150 - 104 - 130 - 111)^2$$
$$+ (78 - 104 - 97 + 111)^2] +$$
$$+ (128 - 118 - 106 + 111)^2 = 4392$$

Step 5

$$\text{SSE} = \text{SST} - \text{SSA} - \text{SSB} - \text{SSAB} =$$
$$9028 - 588 - 2328 - 4392 = 1720$$

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Factor A	1	588	588	2.05
Factor B	2	2328	1164	4.06
Interaction	2	4392	2196	7.66
Error	6	1720	286.67	
Total	11	9028		

Factor A: F = 2.05

Using F table (1 degree of freedom numerator and 6 denominator), p-value is greater than 0.10

Actual p-value = 0.2022

Because p-value $> \alpha = 0.05$, Factor A is not significant

Factor B: F = 4.06

Using F table (2 degrees of freedom numerator and 6 denominator), p-value is between 0.05 and 0.10

Actual p-value = 0.0767

Because p-value $> \alpha = 0.05$, Factor B is not significant

Interaction: F = 7.66

Using F table (2 degrees of freedom numerator and 6 denominator), p-value is between 0.01 and 0.025

Actual p-value = 0.0223

Because p-value $\le \alpha = 0.05$, Interaction is significant

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