ME 488: Design of Experiments

One Way Table Construction Practice

William 'Ike' Eisenhauer

Department of Mechanical and Materials Engineering
Portland State University
Portland, Oregon 97223

wde@pdx.edu

Fall 2013

Introduction

Purpose

This file contains a number of ANOVA table construction practice problems, the objective are to:

1. Understand the mechanics of an ANOVA table
2. Understand the relationship of the entries in ANOVA tables

Rights to Use

- This file is free and print to use for academic purposes
- Please retain citation at bottom of each page
- You may NOT incorporate this into a commerical product without additional written permission

If you find these useful, (or if you discover errors) please let me know at **wde@pdx.edu**. Enjoy!

ANOVA Table

The One Way Table

Source	df	SS	MS	F
Treatment	$df_{treatment}$	$SS_{treatment}$	$MS_{treatment}$	F
Error	df_{error}	SS_{error}	MS_{error}	
Total	df_{total}	SS_{total}		

ANOVA Table: Problem 1

The One Way Table

Source	df	SS	MS	F
Treatment	a	7417	239.26	b
Error	86	3788	44.05	
Total	117	11205		

1. a =
2. b =

ANOVA Table: Problem 2

The One Way Table

Source	df	SS	MS	F
Treatment	10	1025	102.5	c
Error	a	b	7.32	
Total	105	1720		

1. a =
2. b =
3. c =

ANOVA Table: Problem 3

The One Way Table

Source	df	SS	MS	F
Treatment	28	a	b	4.51
Error	91	5553	61.02	
Total	c	13261		

1. a =
2. b =
3. c =

ANOVA Table: Problem 4

The One Way Table

Source	df	SS	MS	F
Treatment	91	3517	c	d
Error	a	7725	79.64	
Total	b	11242		

1. a =
2. b =
3. c =
4. d =

ANOVA Table: Problem 5

The One Way Table

Source	df	SS	MS	F
Treatment	99	9803	a	d
Error	8	8755	c	
Total	107	b		

1. a =
2. b =
3. c =
4. d =

ANOVA Table: Problem 6

The One Way Table

Source	df	SS	MS	F
Treatment	a	b	c	d
Error	8	2086	260.75	
Total	28	11863		

1. a =
2. b =
3. c =
4. d =

ANOVA Table: Problem 7

The One Way Table

Source	df	SS	MS	F
Treatment	a	9661	345.04	1.58
Error	b	8105	c	
Total	65	d		

1. a =
2. b =
3. c =
4. d =

ANOVA Table: Problem 8

The One Way Table

Source	df	SS	MS	F
Treatment	a	3143	71.43	d
Error	b	4286	1071.5	
Total	c	7429		

1. a =
2. b =
3. c =
4. d =

ANOVA Table: Problem 9

The One Way Table

Source	df	SS	MS	F
Treatment	36	a	b	0.49
Error	41	c	198.83	
Total	77	11629		

1. a =
2. b =
3. c =

ANOVA Table: Problem 10

The One Way Table

Source	df	SS	MS	F
Treatment	a	c	173.04	d
Error	b	4414	50.16	
Total	133	12201		

1. a =
2. b =
3. c =
4. d =

ANOVA Table: Problem 11

The One Way Table

Source	df	SS	MS	F
Treatment	55	9538	c	2.42
Error	99	7086	71.58	
Total	a	b		

1. a =
2. b =
3. c =

ANOVA Table: Problem 12

The One Way Table

Source	df	SS	MS	F
Treatment	31	5412	a	c
Error	49	4516	b	
Total	80	9928		

1. a =
2. b =
3. c =

ANOVA Table: Problem 13

The One Way Table

Source	df	SS	MS	F
Treatment	53	3955	c	e
Error	a	b	d	
Total	86	6844		

1. a =
2. b =
3. c =
4. d =
5. e =

ANOVA Table: Problem 14

The One Way Table

Source	df	SS	MS	F
Treatment	38	8395	c	d
Error	49	b	144.78	
Total	a	15489		

1. a =
2. b =
3. c =
4. d =

ANOVA Table: Problem 15

The One Way Table

Source	df	SS	MS	F
Treatment	a	c	e	0.54
Error	b	d	122.83	
Total	133	11804		

1. a =
2. b =
3. c =
4. d =
5. e =

ANOVA Table:Solution to Problem 1

The One Way Table

Source	df	SS	MS	F
Treatment	a	7417	239.26	b
Error	86	3788	44.05	
Total	117	11205		

1. $a = 117 - 86 = 31$
2. $b = \frac{239.26}{44.05} = 5.43$

ANOVA Table:Solution to Problem 2

The One Way Table

Source	df	SS	MS	F
Treatment	10	1025	102.5	c
Error	a	b	7.32	
Total	105	1720		

1. $a = 105 - 10 = 95$
2. $b = 7.32(a) = 7.32(95) = 695$
3. $c = \frac{102.5}{7.32} = 14.0$

ANOVA Table:Solution to Problem 3

The One Way Table

Source	df	SS	MS	F
Treatment	28	a	b	4.51
Error	91	5553	61.02	
Total	c	13261		

1. $a = 13261 - 5553 = 7708$
2. $b = (4.51)(61.02) = 275.29$
3. $c = 28 + 91 = 119$

ANOVA Table:Solution to Problem 4

The One Way Table

Source	df	SS	MS	F
Treatment	91	3517	38.65	d
Error	a	7725	79.64	
Total	b	11242		

1. $a = \frac{7725}{79.64} = 97$
2. $b = 91 + a = 91 + 97 = 188$
3. $c = 3517/91 = 38.65$
4. $d = \frac{c}{79.64} = \frac{38.65}{79.64} = 0.49$

ANOVA Table:Solution to Problem 5

The One Way Table

Source	df	SS	MS	F
Treatment	99	9803	a	d
Error	8	8755	c	
Total	107	b		

1. $a = \frac{9803}{99} = 99.02$
2. $b = 9803 + 8755 = 18558$
3. $c = \frac{8755}{8} = 1094.38$
4. $d = \frac{a}{c} = \frac{99.02}{1094.38} = 0.09$

ANOVA Table:Solution to Problem 6

The One Way Table

Source	df	SS	MS	F
Treatment	a	b	c	d
Error	8	2086	260.75	
Total	28	11863		

1. $a = 28 - 8 = 20$
2. $b = 11863 - 2086 = 9777$
3. $c = \frac{b}{a} = \frac{9777}{20} = 488.85$
4. $d = \frac{c}{260.75} = \frac{488.85}{260.75} = 1.87$

ANOVA Table:Solution to Problem 7

The One Way Table

Source	df	SS	MS	F
Treatment	a	9661	345.04	1.58
Error	b	8105	c	
Total	65	d		

1. $a = \frac{9661}{345.04} = 28$
2. $b = 65 - a = 65 - 28 = 37$
3. $c = \frac{8105}{b} = \frac{8105}{37} = 219.05$
4. $d = 9661 + 8105 = 17766$

ANOVA Table:Solution to Problem 8

The One Way Table

Source	df	SS	MS	F
Treatment	a	3143	71.43	d
Error	b	4286	1071.5	
Total	c	7429		

1. $a = \frac{3143}{71.43} = 44$
2. $b = \frac{4286}{1071.5} = 4$
3. $c = a + b = 44 + 4 = 48$
4. $d = \frac{71.43}{1071.5} = 0.07$

ANOVA Table:Solution to Problem 9

The One Way Table

Source	df	SS	MS	F
Treatment	36	a	b	0.49
Error	41	c	198.83	
Total	77	11629		

1. $a = 11629 - c = 11629 - 8152 = 3477$
2. $b = (198.83)(0.49) = 96.58$
3. $c = (198.883)(41) = 8152$

ANOVA Table:Solution to Problem 10

The One Way Table

Source	df	SS	MS	F
Treatment	a	c	173.04	d
Error	b	4414	50.16	
Total	133	12201		

1. $a = 133 - b = 133 - 88 = 45$
2. $b = \frac{4414}{50.16} = 88$
3. $c = 173.04(a) = 173.04(88) = 7787$
4. $d = \frac{173.04}{50.16} = 3.45$

ANOVA Table:Solution to Problem 11

The One Way Table

Source	df	SS	MS	F
Treatment	55	9538	c	2.42
Error	99	7086	71.58	
Total	a	b		

1. $a = 55 + 99 = 154$
2. $b = 9538 + 7086 = 16624$
3. $c = \frac{9538}{55} = 173.42$

ANOVA Table:Solution to Problem 12

The One Way Table

Source	df	SS	MS	F
Treatment	31	5412	a	c
Error	49	4516	b	
Total	80	9928		

1. $a = \frac{5412}{31} = 174.58$
2. $b = \frac{4516}{49} = 92.16$
3. $c = \frac{a}{b} = \frac{174.58}{92.16} = 1.89$

ANOVA Table:Solution to Problem 13

The One Way Table

Source	df	SS	MS	F
Treatment	53	3955	c	e
Error	a	b	d	
Total	86	6844		

1. $a = 86 - 53 = 33$
2. $b = 6844 - 3955 = 2889$
3. $c = \frac{3955}{53} = 74.62$
4. $d = \frac{b}{a} = \frac{2889}{33} = 87.55$
5. $e = \frac{c}{d} = \frac{74.62}{87.55} = 0.85$

ANOVA Table:Solution to Problem 14

The One Way Table

Source	df	SS	MS	F
Treatment	38	8395	220.92	1.53
Error	49	7094	144.78	
Total	87	15489		

1. $a = 38 + 49 = 87$
2. $b = 15489 - 8395 = 7094$
3. $c = \frac{8395}{38} = 220.92$
4. $d = \frac{c}{144.78} = \frac{220.92}{144.78} = 1.53$

ANOVA Table:Solution to Problem 15

The One Way Table

Source	df	SS	MS	F
Treatment	a	c	e	0.54
Error	b	d	122.83	
Total	133	11804		

This one is tricky, follow along on the next page!

ANOVA Table:Solution to Problem 15 Part II

Solving the Equations

- $a + b = 133$; $c + d = 11804$
- $\frac{c}{a} = e = (122.83)(0.54) = 66.33$; $\frac{d}{b} = 122.83$
- $66.33(a) + 122.83(b) = 11804$
- $66.33(133 - b) + 122.83(b) = 11804$
- $8821.89 - 66.33b + 122.83b = 11804$
- $56.50b = 2982.11 \rightarrow b = 52.78 \rightarrow b = 53$
- a $= 133 - b = 133 - 53 = 80$
- b $= 53$
- c $= (a)(e) = (80)(66.33) = 5306.4$
- d $= 11804 - c = 11804 - 5306.4 = 6497.6$
- e $= 66.33$