UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester 2, Sidang Akademik 1999/2000

Februari 2000

MSG 265 – Reka Bentuk dan Analisis Ujikaji

Masa: [3 jam]

ARAHAN KEPADA CALON:

Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA soalan di dalam SEMBILAN BELAS halaman bercetak dan EMPAT BELAS halaman Lampiran sebelum anda memulakan peperiksaan ini.

Jawab **SEMUA** soalan.

1.(a) Terangkan sebutan-sebutan berikut:

(i) kesan tetap (ii) kesan rawak

Berikan contoh-contoh untuk mengilustrasi.

(20/100)

(b) Sebuah kertas dalam *Journal of the Electrochemical Society* (Jilid 139, No.2, 1992, ms.524-532) menghuraikan suatu eksperimen untuk menyiasat "*low-pressure vapour deposition*" bagi polisilikon. Eksperimen itu dijalankan dalam sebuah reaktor kapasiti besar di Sematech di Austin, Texas. Reaktor itu mempunyai beberapa kedudukan wafer, dan empat dari kedudukan-kedudukan ini dipilih secara rawak. Pembolehubah sambutan ialah "*film thickness uniformity*". Tiga pereplikaan eksperimen dilarikan. Data dikutip ditunjuk di bawah:

Kedudukan Wafer	"*Uniformity*"			Jumlah
1	2.76	5.67	4.49	12.92
2	1.43	1.70	2.19	5.32
3	2.34	1.97	1.47	5.78
4	0.94	1.36	1.65	3.95

$\sum\sum y_{ij}^2 = 86.6307$

(i) Adakah terdapat perbezaan dalam kedudukan-kedudukan wafer? Gunakan $\alpha = .05$.

(ii) Anggarkan perubahan disebabkan oleh kedudukan wafer.

(iii) Nyatakan anggapan-anggapan yang digunakan.

(30/100)

(c) Cat primer kapal terbang diaplikasikan pada permukaan aluminium melalui dua kaedah: "*dipping*" dan "*spraying*". Tujuan primer itu ialah memperbaiki "*adhesion*" cat, dan sedikit bahagian boleh diprima dengan menggunakan sebarang dari dua kaedah aplikasi di atas. Kumpulan kejuruteraan proses yang bertanggungjawab bagi

...2/-

operasi ini berminat mengkaji sama ada tiga jenis primer berbeza dalam sifat "*adhesion*" mereka. Suatu eksperimen faktorial dijalankan untuk menyiasat kesan jenis primer cat dan kaedah aplikasi pada "*adhesion*" cat. Tiga spesimen dicat dengan setip primer dengan menggunakan setiap kaedah aplikasi, suatu cat "*finish*" diaplikasi, dan daya "*adhesion*" disukat.

Data diperoleh daripada eksperimen ditunjuk di bawah:

Jenis primer \ Kaedah aplikasi	"*Dipping*"		"*Spraying*"		Jumlah
1	4.0, 4.5, 4.3	12.8	5.4, 4.9, 5.6	15.9	28.7
2	5.6, 4.9, 5.4	15.9	5.8, 6.1, 6.3	18.2	34.1
3	3.8, 3.7, 4.0	11.5	5.5, 5.0, 5.0	15.5	27.0
Jumlah	40.2		49.6		89.8

$\sum\sum\sum y_{ijk}^2 = 458.72$

(i) Adakah wujudnya saling tindak yang bererti? Gunakan $\alpha = .05$.

(ii) Adakah wujudnya perbezaan yang bererti di antara aras-aras faktor "Jenis Primer"? Di antara aras-aras faktor "Kaedah Aplikasi"? Gunakan $\alpha = .05$.

(iii) Apakah gabungan rawatan yang paling baik di sini?

(iv) Nyatakan sebarang anggapan yang anda telah menggunakan.

(50/100)

2.(a) Seorang jurutera sedang mengkaji kesan kelajuan memotong terhadap kadar penanggalan logam dalam suatu operasi memesin. Walau bagaimanapun, kadar penanggalan logam ini juga terkandung dengan kekerasan spesimen ujian tersebut. Lima cerapan telah diambil pada setiap kelajuan memotong. Amaun logam yang ditanggalkan (y) dan kekerasan spesimen (x) dipamerkan dalam jadual berikut:

Kelajuan Memotong (rpm)

	800		1000		1200	
	y	x	y	x	y	x
	68	120	112	165	118	175
	90	140	94	140	82	132
	98	150	65	120	73	124
	77	125	74	125	92	141
	88	136	85	133	80	130
Jumlah	421	671	430	683	445	702

$\sum_i\sum_j y_{ij}^2 = 115{,}148$ $\sum_i\sum_j x_{ij}^2 = 285{,}366$ $\sum_i\sum_j x_{ij}\, y_{ij} = 180{,}946$

...3-

(i) Dirikan jadual analisisi kovarians bagi data di atas.
(ii) Dapatkan kesimpulan yang sesuai. Gunakan $\alpha = .05$.
(iii) Hitungkan min rawatan terlaras dan ralat piawainya bagi data di atas.

(50/100)

(b) Di bawah ialah hasil daripada suatu kajian yang menggunakan reka bentuk plot belahan. Empat jenis baja B_1, B_2, B_3 dan B_4, dan tiga persediaan tanah T_1, T_2 dan T_3 telah dijalankan bagi setiap plot tanah. Ujikaji telah dijalankan dalam dua blok dan data diperoleh ditunjuk di bawah:

Blok	Blok (*B*) (Plot Utama)	Persediaan Tanah (*T*) (subplot)		
		T_1	T_2	T_3
1	B_1	6	3	4
	B_2	8	5	7
	B_3	4	7	8
	B_4	5	6	5
2	B_1	2	6	5
	B_2	5	5	4
	B_3	1	3	3
	B_4	2	1	3

$\sum\sum\sum y_{ijk}^2 = 578$

Huraikan kesimpulan-kesimpulan yang anda boleh memperoleh daripada analisis data ini. Gunakan $\alpha = .05$.

(50/100)

3.(a) Dirasa empat faktor mempengaruhi "*taste*" sejenis minuman ringan: jenis pemanis (A), nisbah sirup dengan air (B), aras karbonasi (C), dan suhu (D). Setiap faktor boleh dilari pada dua aras, menghasilkan suatu reka bentuk 2^4. Pada setiap larian dalam reka bentuk, sampel-sampel minuman ringan diberi kepada suatu panel ujian yang terdiri daripada 20 orang. Setiap penguji menguntukkan suatu skor titik daripada 1 ke 10. Jumlah skor ialah pembolehubah sambutan, dan tujuan ialah mencari suatu rumusan yang memaksimumkan jumlah skor. Dua pereplikaan reka bentuk ini dilarikan, dan hasil ditunjuk di bawah:

Gabungan Rawatan	Replika		Gabungan Rawatan	Replika	
	I	II		I	II
(1)	159	163	*d*	164	159
a	168	175	*ad*	187	189
b	158	163	*bd*	163	159
ab	166	168	*abd*	185	191
c	175	178	*cd*	168	174
ac	179	183	*acd*	197	199
bc	173	168	*bcd*	170	174
abc	179	182	*abcd*	194	198

$\sum\sum\sum y_{ijk}^2 = 987{,}518$

(i) Cari anggaran-anggaran bagi semua kesan.
(ii) Ujikan, pada aras keertian $\alpha = .05$, kesan-kesan bagi eksperimen ini.

(60/100)

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(b) Pertimbangkan bahagian (a). Andaikan bahawa hanya replika I tersedia. Jika hanya pecahan satu per dua reka bentuk 2^4 itu dijalankan, bina reka bentuk ini dan tuliskan struktur alias yang lengkap. Berikan juga jadual analisis varians bagi kes ini.

(40/100)

4. Tuliskan nota-nota pendek mengenai topik-topik yang berikut:

(a) Polinomial Ortogon
(b) Pembauran
(c) Ujian-ujian Perbandingan Berganda

(100/100)

5. Soalan ini mengandungi 4 bahagian. Bagi setiap bahagian, huraikan kesimpulan-kesimpulan dan saranan anda.

(a) Suatu eksperimen dijalankan untuk menentukan kesan empat bahan kimia berbeza pada kekuatan fabrik. Bahan-bahan kimia ini digunakan sebagai sebahagian proses "*permanent press finishing*". Lima sampel fabrik dipilih, dan suatu reka bentuk blok rawakan lengkap dilari dengan menguji setiap jenis bahan kimia sekali dalam tertib rawak pada setiap sampel fabrik.

Data ditunjuk di bawah:

Jenis Bahan Kimia \ Sampel Fabrik	1	2	3	4	5
1	1.3	1.6	0.5	1.2	1.1
2	2.2	2.4	0.4	2.0	1.8
3	1.8	1.7	0.6	1.5	1.3
4	3.9	4.4	2.0	4.1	3.4

Data ini diproses melalui pakej statistik, SPSS, dengan menggunakan prosedur statistik, General Linear Model.

Output diperoleh ditunjuk di bawah:

General Linear Model

Between-Subjects Factors

		Value Label	N
FABRIK	1		4
	2		4
	3		4
	4		4
	5		4
Jenis Bahan Kimia	1		5
	2		5
	3		5
	4		5

...5/-

Tests of Between-Subjects Effects

Dependent Variable: KEKUATAN

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Model	101.569[b]	8	12.696	160.203	.000	1281.628	1.000
FABRIK	6.693	4	1.673	21.114	.000	84.454	1.000
KIMIA	18.044	3	6.015	75.895	.000	227.685	1.000
Error	.951	12	7.925E-02				
Total	102.520	20					

a. Computed using alpha = .05

b. R Squared = .991 (Adjusted R Squared = .985)

Post Hoc Tests

Jenis Bahan Kimia

Homogeneous Subsets

KEKUATAN

Duncan[a,b]

Jenis Bahan Kimia	N	Subset		
		1	2	3
1	5	1.1400		
3	5	1.3800	1.3800	
2	5		1.7600	
4	5			3.5600
Sig.		.203	.054	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 7.925E-02.

a. Uses Harmonic Mean Sample Size = 5.000.

b. Alpha = .05.

(b) Suatu eksperimen dijalankan untuk mengkaji kesan berbagai-bagai jenis muzik "*background*" pada produktiviti juruwang bank. Rawatan-rawatan ditakrif sebagai berbagai-bagai gabungan muzik tempo (perlahan, sederhana, cepat) dan gaya muzik (instrumental dan vokal, instrumental sahaja). Rawatan-rawatan dan huruf Latin yang dikaitkan ialah seperti berikut:

Rawatan	Huruf Latin	Tempo dan Gaya Muzik
1	A	Perlahan, instrumental dan vokal
2	B	Sederhana, instrumental dan vokal
3	C	Cepat, instrumental dan vokal
4	D	Sederhana, instrumental sahaja
5	E	Cepat, instrumental sahaja

...6/-

Data dikutip ditunjuk di bawah:

Minggu	Hari				
	I	S	R	K	J
1	18 (D)	17 (C)	14 (A)	21 (B)	17 (E)
2	13 (C)	34 (B)	21 (E)	16 (A)	15 (D)
3	7 (A)	29 (D)	32 (B)	27 (E)	13 (C)
4	17 (E)	13 (A)	24 (C)	31 (D)	25 (B)
5	21 (B)	26 (E)	26 (D)	31 (C)	7 (A)

Data ini diproses melalui pakej statistik, SPSS, dengan menggunakan prosedur statistik, General Linear Model.

Output diperoleh ditunjuk di bawah:

General Linear Model

Between-Subjects Factors

		Value Label	N
HARI	1	Isnin	5
	2	Selasa	5
	3	Rabu	5
	4	Khamis	5
	5	Jumaat	5
MINGGU	1		5
	2		5
	3		5
	4		5
	5		5
MUSIC	1	Slow, instrumen tal & Vocal	5
	2	Medium, instrumen tal & Vocal	5
	3	Fast, instrumen tal & Vocal	5
	4	Medium, instrumen tal only	5
	5	Fast, instrumen tal only	5

...7/-

Tests of Between-Subjects Effects

Dependent Variable: Produktiviti

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Model	11832.600[b]	13	910.200	57.975	.000	753.669	1.000
HARI	477.200	4	119.300	7.599	.003	30.395	.966
MINGGU	82.000	4	20.500	1.306	.323	5.223	.291
MUSIC	664.400	4	166.100	10.580	.001	42.318	.995
Error	188.400	12	15.700				
Total	12021.000	25					

a. Computed using alpha = .05

b. R Squared = .984 (Adjusted R Squared = .967)

Post Hoc Tests

MUSIC

Homogeneous Subsets

Produktiviti

Duncan[a,b]

MUSIC	N	Subset		
		1	2	3
Slow, instrumental & Vocal	5	11.4000		
Fast, instrumental & Vocal	5		19.6000	
Fast, instrumental only	5		21.6000	21.6000
Medium, instrumental only	5		23.8000	23.8000
Medium, instrumental & Vocal	5			26.6000
Sig.		1.000	.136	.081

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 15.700.

a. Uses Harmonic Mean Sample Size = 5.000.

b. Alpha = .05.

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(c) Jabatan kawalan kualiti di sebuah kilang fabrik sedang mengkaji kekesanan beberapa faktor pada pencelupan (*dyeing*) untuk kain "*blended cotton/synthetic*" digunakan untuk mengeluarkan baju. Tiga orang operator, tiga masa kitaran, dan dua suhu dipilih, dan tiga spesimen kecil kain dicelup di bawah setiap set keadaan. Kain yang dihasilkan dibandingkan dengan satu standard, dan satu skor berangka diberikan.

Hasil-hasil ditunjuk di bawah:

Masa kitaran	Suhu					
	250°			350°		
	Operator			Operator		
	A	B	C	A	B	C
30	22 25 24	28 29 27	32 33 27	24 23 28	38 36 35	34 36 39
50	36 35 36	34 38 39	33 34 35	37 39 35	34 38 36	34 36 31
70	28 24 27	35 35 34	26 27 25	26 29 25	36 37 34	28 26 34

Data ini diproses melalui pakej statistik, SPSS, dengan menggunakan prosedur statistik, General Linear Model.

Output diperoleh ditunjuk di bawah:

General Linear Model

Between-Subjects Factors

		Value Label	N
Masa Kitaran	1	30	18
	2	50	18
	3	70	18
OPERATOR	1	A	18
	2	B	18
	3	C	18
SUHU	1	250 Darjah Celsius	27
	2	350 Darjah Celcius	27

...9/-

Descriptive Statistics

	Masa Kitaran	OPERATOR	SUHU	Mean	Std. Deviation	N
SKOR	30	A	250 Darjah Celsius	23.6667	1.5275	3
			350 Darjah Celcius	25.0000	2.6458	3
			Total	24.3333	2.0656	6
		B	250 Darjah Celsius	28.0000	1.0000	3
			350 Darjah Celcius	36.3333	1.5275	3
			Total	32.1667	4.7081	6
		C	250 Darjah Celsius	30.6667	3.2146	3
			350 Darjah Celcius	36.3333	2.5166	3
			Total	33.5000	4.0373	6
		Total	250 Darjah Celsius	27.4444	3.5746	9
			350 Darjah Celcius	32.5556	6.0023	9
			Total	30.0000	5.4665	18
	50	A	250 Darjah Celsius	35.6667	.5774	3
			350 Darjah Celcius	37.0000	2.0000	3
			Total	36.3333	1.5055	6

...10/-

Descriptive Statistics

	Masa Kitaran	OPERATOR	SUHU	Mean	Std. Deviation	N
SKOR	50	B	250 Darjah Celsius	37.0000	2.6458	3
			350 Darjah Celcius	36.0000	2.0000	3
			Total	36.5000	2.1679	6
		C	250 Darjah Celsius	34.0000	1.0000	3
			350 Darjah Celcius	33.6667	2.5166	3
			Total	33.8333	1.7224	6
		Total	250 Darjah Celsius	35.5556	1.9437	9
			350 Darjah Celcius	35.5556	2.4037	9
			Total	35.5556	2.1205	18
	70	A	250 Darjah Celsius	26.3333	2.0817	3
			350 Darjah Celcius	26.6667	2.0817	3
			Total	26.5000	1.8708	6
		B	250 Darjah Celsius	34.6667	.5774	3
			350 Darjah Celcius	35.6667	1.5275	3
			Total	35.1667	1.1690	6
		C	250 Darjah Celsius	26.0000	1.0000	3
			350 Darjah Celcius	29.3333	4.1633	3
			Total	27.6667	3.2660	6
		Total	250 Darjah Celsius	29.0000	4.4159	9
			350 Darjah Celcius	30.5556	4.6934	9
			Total	29.7778	4.4926	18
	Total	A	250 Darjah Celsius	28.5556	5.6150	9
			350 Darjah Celcius	29.5556	5.9605	9
			Total	29.0556	5.6409	18

...11/-

Descriptive Statistics

	Masa Kitaran	OPERATOR	SUHU	Mean	Std. Deviation	N
SKOR	Total	B	250 Darjah Celsius	33.2222	4.2947	9
			350 Darjah Celcius	36.0000	1.5000	9
			Total	34.6111	3.4324	18
		C	250 Darjah Celsius	30.2222	3.8980	9
			350 Darjah Celcius	33.1111	4.1062	9
			Total	31.6667	4.1586	18
		Total	250 Darjah Celsius	30.6667	4.8911	27
			350 Darjah Celcius	32.8889	4.9016	27
			Total	31.7778	4.9779	54

Tests of Between-Subjects Effects

Dependent Variable: SKOR

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Model	55680.667[b]	18	3093.370	681.804	.000	12272.473	1.000
MASA	385.778	2	192.889	42.514	.000	85.029	1.000
OPERATOR	278.111	2	139.056	30.649	.000	61.298	1.000
SUHU	66.667	1	66.667	14.694	.000	14.694	.962
MASA * OPERATOR	308.444	4	77.111	16.996	.000	67.984	1.000
MASA * SUHU	61.778	2	30.889	6.808	.003	13.616	.896
OPERATOR * SUHU	10.111	2	5.056	1.114	.339	2.229	.230
MASA * OPERATOR * SUHU	39.111	4	9.778	2.155	.094	8.620	.578
Error	163.333	36	4.537				
Total	55844.000	54					

a. Computed using alpha = .05

b. R Squared = .997 (Adjusted R Squared = .996)

...12/-

Post Hoc Tests

Masa Kitaran

Homogeneous Subsets

SKOR

Duncan[a,b]

Masa Kitaran	N	Subset 1	Subset 2
70	18	29.7778	
30	18	30.0000	
50	18		35.5556
Sig.		.756	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 4.537.

a. Uses Harmonic Mean Sample Size = 18.000.

b. Alpha = .05.

OPERATOR

Homogeneous Subsets

SKOR

Duncan[a,b]

OPERATOR	N	Subset 1	Subset 2	Subset 3
A	18	29.0556		
C	18		31.6667	
B	18			34.6111
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 4.537.

a. Uses Harmonic Mean Sample Size = 18.000.

b. Alpha = .05.

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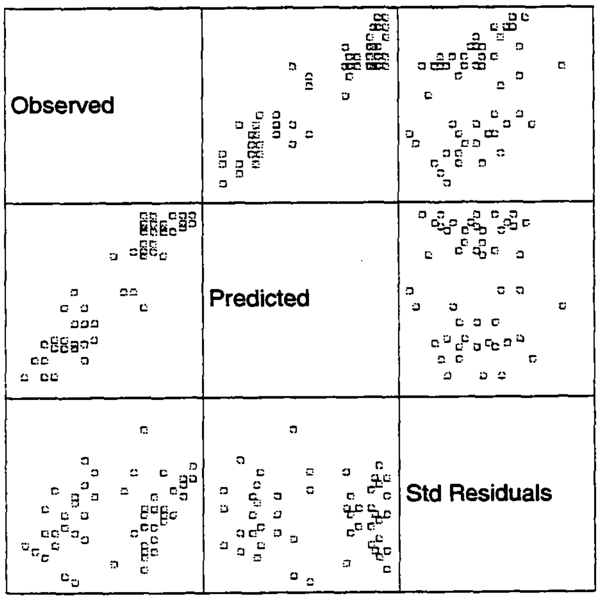
Dependent Variable: SKOR



Model:MASA + OPERATOR + SUHU + MASA*OPERATOR + MASA*SU

(d) Kekuatan tarik suatu bond dawai ialah suatu cirian penting. Jadual di bawah memberi maklumat untuk kekuatan tarik (y), tinggi die ($x1$), tinggi post ($x2$), tinggi lup ($x3$), panjang dawai ($x4$), lebar bond pada die ($x5$) dan lebar bond pada post ($x6$).

y	$x1$	$x2$	$x3$	$x4$	$x5$	$x6$
8.0	5.2	19.6	29.6	94.9	2.1	2.3
8.3	5.2	19.8	32.4	89.7	2.1	1.8
8.5	5.8	19.6	31.0	96.2	2.0	2.0
8.8	6.4	19.4	32.4	95.6	2.2	2.1
9.0	5.8	18.6	28.6	86.5	2.0	1.8
9.3	5.2	18.8	30.6	84.5	2.1	2.1
9.3	5.6	20.4	32.4	88.8	2.2	1.9
9.5	6.0	19.0	32.6	85.7	2.1	1.9
9.8	5.2	20.8	32.2	93.6	2.3	2.1
10.0	5.8	19.9	31.8	86.0	2.1	1.8
10.3	6.4	18.0	32.6	87.1	2.0	1.6
10.5	6.0	20.6	33.4	93.1	2.1	2.1
10.8	6.2	20.2	31.8	83.4	2.2	2.1
11.0	6.2	20.2	32.4	94.5	2.1	1.9
11.3	6.2	19.2	31.4	83.4	1.9	1.8
11.5	5.6	17.0	33.2	85.2	2.1	2.1
11.8	6.0	19.8	35.4	84.1	2.0	1.8
12.3	5.8	18.8	34.0	86.9	2.1	1.8
12.5	5.6	18.6	34.2	83.0	1.9	2.0

...14/-

Data di atas diproses melalui pakej statistik SPSS dengan menggunakan prosedur statistik, Regression dengan pilihan kaedah STEPWISE.

Output diperoleh ditunjuk di bawah:

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Pull Strength	10.1316	1.3585	19
Die Height	5.8000	.4000	19
Post Height	19.3842	.9500	19
Loop height	32.2105	1.5825	19
Wire Length	88.5368	4.6336	19
Bond Width on Die	2.0842	.1015	19
Bond Width on the Post	1.9474	.1712	19

...15/-

Correlations

		Pull Strength	Die Height	Post Height	Loop height	Wire Length	Bond Width on Die	Bond Width on the Post
Pearson Correlation	Pull Strength	1.000	.323	-.250	.691	-.557	-.335	-.248
	Die Height	.323	1.000	-.064	.235	-.069	-.219	-.389
	Post Height	-.250	-.064	1.000	.003	.446	.470	.193
	Loop height	.691	.235	.003	1.000	-.225	-.040	-.215
	Wire Length	-.557	-.069	.446	-.225	1.000	.401	.384
	Bond Width on Die	-.335	-.219	.470	-.040	.401	1.000	.429
	Bond Width on the Post	-.248	-.389	.193	-.215	.384	.429	1.000
Sig. (1-tailed)	Pull Strength	.	.089	.151	.001	.007	.081	.153
	Die Height	.089	.	.397	.166	.390	.184	.050
	Post Height	.151	.397	.	.495	.028	.021	.215
	Loop height	.001	.166	.495	.	.177	.435	.188
	Wire Length	.007	.390	.028	.177	.	.045	.052
	Bond Width on Die	.081	.184	.021	.435	.045	.	.033
	Bond Width on the Post	.153	.050	.215	.188	.052	.033	.
N	Pull Strength	19	19	19	19	19	19	19
	Die Height	19	19	19	19	19	19	19
	Post Height	19	19	19	19	19	19	19
	Loop height	19	19	19	19	19	19	19
	Wire Length	19	19	19	19	19	19	19
	Bond Width on Die	19	19	19	19	19	19	19
	Bond Width on the Post	19	19	19	19	19	19	19

...16/-

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Loop height	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Wire Length	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Pull Strength

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.691[a]	.477	.446	1.0107
2	.805[b]	.648	.604	.8554

a. Predictors: (Constant), Loop height

b. Predictors: (Constant), Loop height, Wire Length

c. Dependent Variable: Pull Strength

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.855	1	15.855	15.520	.001[a]
	Residual	17.366	17	1.022		
	Total	33.221	18			
2	Regression	21.513	2	10.757	14.700	.000[b]
	Residual	11.708	16	.732		
	Total	33.221	18			

a. Predictors: (Constant), Loop height

b. Predictors: (Constant), Loop height, Wire Length

c. Dependent Variable: Pull Strength

...17/-

Coefficients[a]

Model		Correlations		
		Zero-order	Partial	Part
1	(Constant)			
	Loop height	.691	.691	.691
2	(Constant)			
	Loop height	.691	.699	.580
	Wire Length	-.557	-.571	-.413

a. Dependent Variable: Pull Strength

Excluded Variables[c]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Die Height	.170[a]	.939	.362	.228	.945
	Post Height	-.252[a]	-1.486	.157	-.348	1.000
	Wire Length	-.424[a]	-2.781	.013	-.571	.949
	Bond Width on Die	-.307[a]	-1.877	.079	-.425	.998
	Bond Width on the Post	-.104[a]	-.569	.577	-.141	.954
2	Die Height	.163[b]	1.071	.301	.267	.944
	Post Height	-.079[b]	-.462	.651	-.118	.790
	Bond Width on Die	-.168[b]	-1.041	.314	-.260	.837
	Bond Width on the Post	.051[b]	.307	.763	.079	.835

a. Predictors in the Model: (Constant), Loop height

b. Predictors in the Model: (Constant), Loop height, Wire Length

c. Dependent Variable: Pull Strength

...18/-

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-8.971	4.854		-1.848	.082	-19.213	1.271
	Loop height	.593	.151	.691	3.940	.001	.275	.911
2	(Constant)	4.656	6.395		.728	.477	-8.900	18.213
	Loop height	.511	.131	.596	3.911	.001	.234	.789
	Wire Length	-.124	.045	-.424	-2.781	.013	-.219	-.030

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	8.0066	12.3134	10.1316	1.0932	19
Residual	-1.7840	1.5121	-4.58E-15	.8065	19
Std. Predicted Value	-1.944	1.996	.000	1.000	19
Std. Residual	-2.086	1.768	.000	.943	19

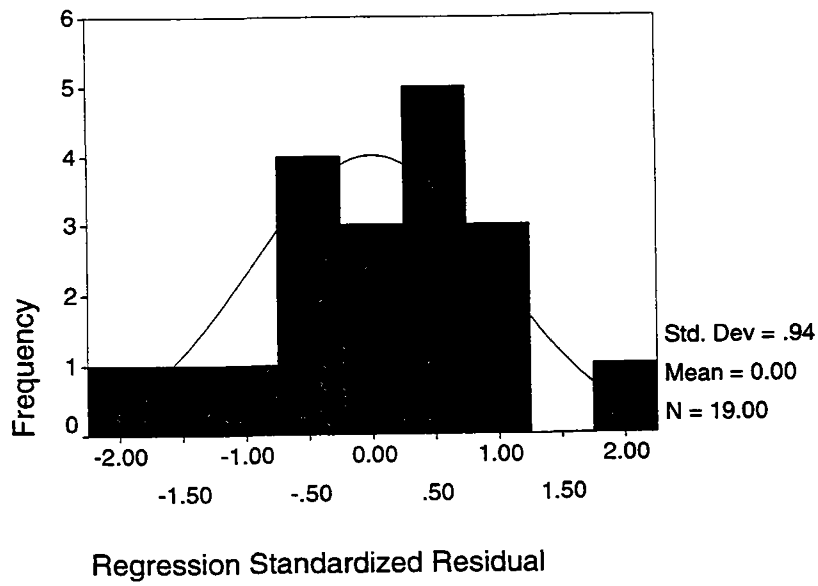
a. Dependent Variable: Pull Strength

...19/-

Charts

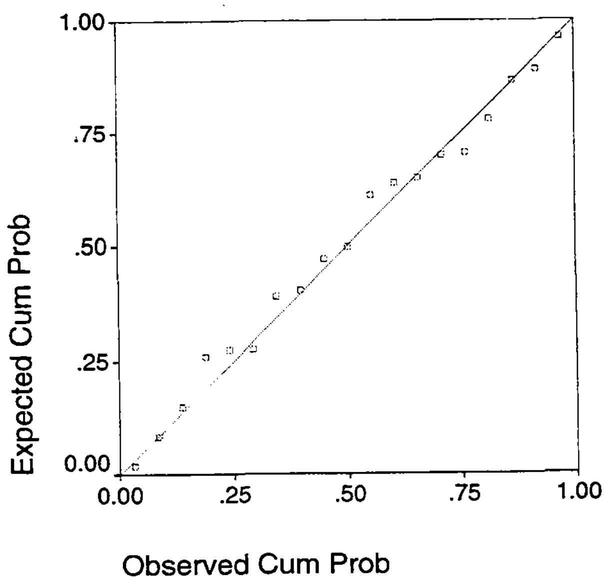
Histogram

Dependent Variable: Pull Strength



Normal P-P Plot of Regression Sta

Dependent Variable: Pull Strength



(100/100)

-oooOooo-

BERBAGAI RUMUS (Tatatanda seperti di dalam nota kuliah)

1. **Dua sampel tak bersandar** ($n_1 < 25$ atau $n_2 < 25$)

$$s_p^2 = \frac{\sum_i (x_i - \bar{x})^2 + \sum_j (y_j - \bar{y})^2}{n_1 + n_2 - 2}$$

$$= \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

2. **Sampel berpasangan**

$$s_d^2 = \frac{\sum_i (d_i - \bar{d})^2}{n - 1}$$

$$= \frac{\sum_i d_i^2 - \frac{(\sum d_i)^2}{n}}{n - 1}$$

3. **Analisis varian satu hala**

$$SST = \sum_i \sum_j y_{ij}^2 - \frac{y_{..}^2}{N}$$

$$SSA = \sum_i \frac{y_{i.}^2}{n_i} - \frac{y_{..}^2}{N}$$

$$SSE = SST - SSA$$

Bagi sebarang kontras $L = \sum_i c_i \, y_{i.}$,

$$SSL = (\sum_i c_i \, y_{i.})^2 / (n \sum_i c_i^2)$$

4. Rekabentuk blok rawakan

$$SST = \sum_i \sum_j y_{ij}^2 - \frac{y_{..}^2}{N}$$

$$SSA = \sum_i \frac{y_{i.}^2}{b} - \frac{y_{..}^2}{N}$$

$$SSB = \sum_j \frac{y_{.j}^2}{a} - \frac{y_{..}^2}{N}$$

$$SSE = SST - SSA - SSB$$

5. Rekabentuk segiempat sama Latin

$$SST = \sum_i \sum_j y_{ijk}^2 - \frac{y_{...}^2}{N}$$

$$SSR = \sum_i \frac{y_{i..}^2}{p} - \frac{y_{...}^2}{N}$$

$$SSC = \sum_k \frac{y_{..k}^2}{p} - \frac{y_{...}^2}{N}$$

$$SSA = \sum_j \frac{y_{.j.}^2}{p} - \frac{y_{...}^2}{N}$$

$$SSE = SST - SSR - SSC - SSA$$

6. Rekabentuk faktorial (dua faktor)

$$SST = \sum_i \sum_j \sum_k y_{ijk}^2 - \frac{y_{...}^2}{N}$$

$$SSA = \sum_i \frac{y_{i..}^2}{bn} - \frac{y_{...}^2}{N}$$

$$SSB = \sum_j \frac{y_{.j.}^2}{an} - \frac{y_{...}^2}{N}$$

$$SS_{sub-jumlah} = \sum_i \sum_j \frac{y_{ij.}^2}{n} - \frac{y_{...}^2}{N}$$

$$SSAB = SS_{sub-jumlah} - SSA - SSB$$

$$SSE = SST - SS_{sub-jumlah}$$

7. <u>Korelasi dan regresi linear mudah</u>

$$r^2 = \frac{\left(\sum_i x_i y_i - (\sum_i x_i)(\sum_i y_i)/n\right)^2}{[\sum_i x_i^2 - (\sum_i x_i)^2/n][\sum_i y_i^2 - (\sum_i y_i)^2/n]}$$

$$\hat{\beta}_1 = \frac{\sum_i x_i y_i - (\sum_i x_i)(\sum_i y_i)/n}{\sum_i x_i^2 - (\sum_i x_i)^2/n}$$

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x}$$

$$SSE = S_{yy} - \hat{\beta}_1^2 S_{xx}$$

$$= S_{yy} - \hat{\beta}_1 S_{xy}$$

$$S_{Y \cdot X}^2 = \frac{SSE}{n-2}$$

Anggaran ralat piawai bagi $\hat{\beta}_0$ ialah

$$\sqrt{MSE\left(\frac{1}{n} + \frac{\bar{x}^2}{S_{xx}}\right)}$$

Anggaran ralat piawai bagi $\hat{\beta}_1$ ialah

$$\sqrt{MSE/S_{xx}}$$

Selang peramalan 100(1 - α)% pada $x = x_0$:

$$\hat{y} \pm t_{\alpha/2}\sqrt{MSE\left(1 + \frac{1}{n} + \frac{(x_0 - \bar{x})^2}{S_{xx}}\right)}$$

Selang keyakinan 100(1 - α)% pada $x = x_0$ bagi $\mu_{Y \cdot x_0}$ ialah

$$\hat{y} \pm t_{\alpha/2}\sqrt{MSE\left(\frac{1}{n} + \frac{(x_0 - \bar{x})^2}{S_{xx}}\right)}$$

8. Regresi linear berganda

$$\underset{\sim}{y} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}, \quad \underset{\sim}{x} = \begin{pmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1k} \\ 1 & x_{21} & x_{22} & \cdots & x_{2k} \\ \vdots & \vdots & \vdots & & \vdots \\ 1 & x_{n1} & x_{n2} & \cdots & x_{nk} \end{pmatrix}$$

$$\underset{\sim}{\beta} = \begin{pmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{pmatrix}, \quad \underset{\sim}{\varepsilon} = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix}$$

$$\hat{\underset{\sim}{\beta}} = (\underset{\sim}{X}'\underset{\sim}{X})^{-1}\underset{\sim}{X}'\underset{\sim}{y}$$

$$SSE = \underset{\sim}{y}'\underset{\sim}{y} - \hat{\underset{\sim}{\beta}}'\underset{\sim}{X}'\underset{\sim}{y}$$

$$SSR = \hat{\underset{\sim}{\beta}}'\underset{\sim}{X}'\underset{\sim}{y} - (\Sigma y_i)^2/n$$

$$r^2_{12.3} = \frac{(r_{12} - r_{13}r_{23})^2}{(1 - r^2_{13})(1 - r^2_{23})}$$

$$MSE = \frac{SSE}{n-p}, \quad p = k+1 .$$

9. Polinomial ortogon

$$P_0(x) = 1$$

$$P_1(x) = \lambda_1 \left[\frac{x-\bar{x}}{d}\right]$$

$$P_2(x) = \lambda_2 \left[\left(\frac{x-\bar{x}}{d}\right)^2 - \left(\frac{n^2-1}{12}\right)\right]$$

$$P_3(x) = \lambda_3 \left[\left(\frac{x-\bar{x}}{d}\right)^3 - \left(\frac{x-\bar{x}}{d}\right)\left(\frac{3n^2-7}{20}\right)\right]$$

$$P_4(x) = \lambda_4 \left[\left(\frac{x-\bar{x}}{d}\right)^4 - \left(\frac{x-\bar{x}}{d}\right)^2\left(\frac{3n^2-13}{14}\right) + \frac{3(n^2-1)(n^2-9)}{560}\right]$$

$$\hat{a}_j = \frac{\sum_{i=1}^{n} P_j(x_i)y_i}{\sum_{i=1}^{n} P_j^2(x_i)}, \quad j = 0, 1, \ldots, k$$

$$SSR(\alpha_j) = \hat{a}_j \sum_{i=1}^{n} P_j(x_i)y_i$$

$$SSE(k) = S_{yy} - \sum_{j=1}^{k} \hat{a}_j \left[\sum_{i=1}^{n} P_j(x_i)y_i\right]$$

10. Pemilihan pembolehubah dan pembangunan model dalam regresi

$$R_p^2 = \frac{SSR(p)}{S_{yy}} = 1 - \frac{SSE(p)}{S_{yy}}$$

$$\overline{R_p^2} = 1 - \left(\frac{n-1}{n-p}\right)(1 - R_p^2)$$

$$MSE(p) = \frac{SSE(p)}{n-p}$$

$$C_p = \frac{SSE(p)}{\hat{\sigma}^2} - (n-2p), \quad \text{di mana } \hat{\sigma}^2 \text{ adalah suatu anggaran } \sigma^2 .$$

Rekabentuk Blok Tak Lengkap

$N = ar = bk$

$$\lambda = \frac{r(k-1)}{a-1}$$

$$SST = \sum_i \sum_j y_{ij}^2 - \frac{y_{..}^2}{N}$$

$$SS_{Blok} = \sum_j \frac{y_{.j}^2}{k} - \frac{y_{..}^2}{N}$$

$$Q_i = y_{i.} - \frac{1}{k} \sum_j n_{ij}\, y_{.j}\ , \quad i = 1, 2, \ldots, a$$

$$SS_{Rawatan\ (terlaras)} = \frac{k \sum_i Q_i^2}{\lambda a}$$

$$SSE = SST - SS_{Rawatan\ (terlaras)} - SS_{Blok}$$

Bagi Kontras $L = \sum_i c_i\, Q_i$,

$$SSL = k\, \frac{\left(\sum_i c_i\, Q_i\right)^2}{\lambda a \sum_i c_i^2}$$

Ralat piawai bagi suatu rawatan terlaras = $\sqrt{\dfrac{k\, MSE}{\lambda a}}$

$$Q_j' = y_{.j} - \frac{1}{r} \sum_i n_{ij}\, y_{i.}\ , \quad j = 1, 2, \ldots, b$$

$$SS_{Blok\ (terlaras)} = r\, \frac{\sum_j (Q_j')^2}{\lambda b}$$

Rekabentuk Faktorial (Tiga faktor)

$$SST = \sum_i \sum_j \sum_k \sum_l y_{ijkl}^2 - \frac{y_{....}^2}{abcn}$$

$$SSA = \sum_i \frac{y_{i...}^2}{bcn} - \frac{y_{....}^2}{abcn}$$

$$SSB = \sum_j \frac{y_{.j..}^2}{acn} - \frac{y_{....}^2}{abcn}$$

$$SSC = \sum_k \frac{y_{..k.}^2}{abn} - \frac{y_{....}^2}{abcn}$$

$$SS_{subjumlah\ (AB)} = \sum_i \sum_j \frac{y_{ij..}^2}{cn} - \frac{y_{....}^2}{abcn}$$

$$SS_{subjumlah\ (AC)} = \sum_i \sum_k \frac{y_{i.k.}^2}{bn} - \frac{y_{....}^2}{abcn}$$

$$SS_{subjumlah\ (BC)} = \sum_j \sum_k \frac{y_{.jk.}^2}{an} - \frac{y_{....}^2}{abcn}$$

$$SS_{subjumlah\ (ABC)} = \sum_i \sum_j \sum_k \frac{y_{ijk.}^2}{n} - \frac{y_{....}^2}{abcn}$$

$$SS_{A\times B} = SS_{subjumlah\ (AB)} - SS_A - SS_B$$

$$SS_{A\times C} = SS_{subjumlah\ (AC)} - SS_A - SS_C$$

$$SS_{B\times C} = SS_{subjumlah\ (BC)} - SS_B - SS_C$$

$$SS_{A\times B\times C} = SS_{subjumlah\ (ABC)} - SS_A - SS_B - SS_C$$

$$- SS_{A\times B} - SS_{A\times C} - SS_{B\times C}$$

$$SS_E = SS_T - SS_{subjumlah\ (ABC)}$$

Rekabentuk 2^k

$$Kontras_{AB\ldots K} = (a \pm 1)\ (b \pm 1) \ldots (k \pm 1)$$

$$AB \ldots K = \frac{2}{n2^k}\ (Kontras_{AB\ldots K})$$

$$SS_{AB\ldots K} = \frac{1}{n2^k}\ (Kontras_{AB\ldots K})^2$$

$$SS_{curvature} = \frac{n_F\, n_c\, (\overline{y_F} - \overline{y_C})^2}{n_F + n_C}$$

$$L = \alpha_1 x_1 + \alpha_2 x_2 + \ldots + \alpha_K x_K$$

Rekabentuk Tersarang

1. Dua Tahap

$$SST = \sum_i \sum_j \sum_k y_{ijk}^2 - \frac{y_{...}^2}{abn}$$

$$SS_A = \sum_i \frac{y_{i..}^2}{bn} - \frac{y_{...}^2}{abn}$$

$$SS_{B(A)} = \sum_i \sum_j \frac{y_{ij.}^2}{n} - \sum_i \frac{y_{i..}^2}{bn}$$

$$SS_E = SS_T - SS_A - SS_{B(A)}$$

2. Tiga Tahap

$$SS_T = \sum_i \sum_j \sum_k \sum_l y_{ijkl}^2 - \frac{y_{....}^2}{abcn}$$

$$SS_A = \sum_i \frac{y_{i...}^2}{bcn} - \frac{y_{....}^2}{abcn}$$

$$SS_{B(A)} = \sum_i \sum_j \frac{y_{ij..}^2}{cn} - \sum_i \frac{y_{i...}^2}{bcn}$$

$$SS_{C(B)} = \sum_i \sum_j \sum_k \frac{y_{ijk.}^2}{n} - \sum_i \sum_j \frac{y_{ij..}^2}{cn}$$

$$SS_E = SS_T - SS_A - SS_{B(A)} - SS_{C(B)}$$

Analisis Kovarians

$$S_{yy} = \sum_i \sum_j y_{ij}^2 - \frac{y_{..}^2}{an}$$

$$S_{xx} = \sum_i \sum_j x_{ij}^2 - \frac{x_{..}^2}{an}$$

$$S_{xy} = \sum_i \sum_j x_{ij}\, y_{ij} - \frac{(x_{..})\,(y_{..})}{an}$$

$$T_{xy} = \sum_i \frac{y_{i.}^2}{n} - \frac{y_{..}^2}{an}$$

$$T_{xx} = \sum_i \frac{x_{i.}^2}{n} - \frac{x_{..}^2}{an}$$

$$T_{xy} = \sum_i \frac{(x_{i.})\,(y_{i.})}{n} - \frac{(x_{..})\,(y_{..})}{an}$$

$$E_{yy} = S_{yy} - T_{yy}$$

$$E_{xx} = S_{xx} - T_{xx}$$

$$E_{xy} = S_{xy} - T_{xy}$$

$$\hat{\beta} = \frac{E_{xy}}{E_{xx}}$$

$$SS_E = E_{yy} - (E_{xy})^2 / E_{xx}$$

$$SS_E' = S_{yy} - (S_{xy})^2 / S_{xx}$$

$$MSE = \frac{SSE}{a(n - 1) - 1}$$

$$\bar{y}_{i.(terlaras)} = \bar{y}_{i.} - \hat{\beta}\,(\bar{x}_{i.} - \bar{x}_{..}),\ i = 1, 2, \ldots, a$$

$$S_{\bar{y}_{i.(terlaras)}} = \left[MSE \left(\frac{1}{n} + \frac{(\bar{x}_{i.} - \bar{x}_{..})^2}{E_{xx}} \right) \right]^{1/2}$$

X. Coefficients of Orthogonal Polynomials[a]

	n = 3		n = 4			n = 5				n = 6					n = 7					
X_j	P_1	P_2	P_1	P_2	P_3	P_1	P_2	P_3	P_4	P_1	P_2	P_3	P_4	P_5	P_1	P_2	P_3	P_4	P_5	P_6
1	−1	1	−3	1	−1	−2	2	−1	1	−5	5	−5	1	−1	−3	5	−1	3	−1	1
2	0	−2	−1	−1	3	−1	−1	2	−4	−3	−1	7	−3	5	−2	0	1	−7	4	−6
3	1	1	1	−1	−3	0	−2	0	6	−1	−4	4	2	−10	−1	−3	1	1	−5	15
4			3	1	1	1	−1	−2	−4	1	−4	−4	2	10	0	−4	0	6	0	−20
5						2	2	1	1	3	−1	−7	−3	−5	1	−3	−1	1	5	15
6										5	5	5	1	1	2	0	−1	−7	−4	−6
7															3	5	1	3	1	1
$\sum_{j=1}^{n} \{P_i(X_j)\}^2$	2	6	20	4	20	10	14	10	70	70	84	180	28	252	28	84	6	154	84	924
λ	1	3	8	1	$\frac{10}{3}$	1	1	$\frac{5}{6}$	$\frac{35}{12}$	2	$\frac{1}{2}$	$\frac{5}{3}$	$\frac{7}{12}$	$\frac{21}{10}$	1	1	$\frac{1}{6}$	$\frac{7}{12}$	$\frac{7}{20}$	$\frac{77}{60}$

	n = 8						n = 9						n = 10					
X_j	P_1	P_2	P_3	P_4	P_5	P_6	P_1	P_2	P_3	P_4	P_5	P_6	P_1	P_2	P_3	P_4	P_5	P_6
1	−7	7	−7	7	−7	1	−4	28	−14	14	−4	4	−9	6	−42	18	−6	3
2	−5	1	5	−13	23	−5	−3	7	7	−21	11	−17	−7	2	14	−22	14	−11
3	−3	−3	7	−3	−17	9	−2	−8	13	−11	−4	22	−5	−1	35	−17	−1	10
4	−1	−5	3	9	−15	−5	−1	−17	9	9	−9	1	−3	−3	31	3	−11	6
5	1	−5	−3	9	15	−5	0	−20	0	18	0	−20	−1	−4	12	18	−6	−8
6	3	−3	−7	−3	17	9	1	−17	−9	9	9	1	1	−4	−12	18	6	−8
7	5	1	−5	−13	−23	−5	2	−8	−13	−11	4	22	3	−3	−31	3	11	6
8	7	7	7	7	7	1	3	7	−7	−21	−11	−17	5	−1	−35	−17	1	10
9							4	28	14	14	4	4	7	2	−14	−22	−14	−11
10													9	6	42	18	6	3
$\sum_{j=1}^{n} \{P_i(X_j)\}^2$	168	168	264	616	2184	264	60	2772	990	2002	468	1980	330	132	8580	2860	780	660
λ	2	1	$\frac{2}{3}$	$\frac{7}{12}$	$\frac{7}{10}$	$\frac{11}{60}$	1	3	$\frac{5}{6}$	$\frac{7}{12}$	$\frac{3}{20}$	$\frac{11}{60}$	2	$\frac{1}{2}$	$\frac{5}{3}$	$\frac{5}{12}$	$\frac{1}{10}$	$\frac{11}{240}$

[a] Adapted with permission from *Biometrika Tables For Statisticians*, Vol. 1, 3rd edition by E. S. Pearson and H. O. Hartley, Cambridge University Press, Cambridge, 1966.

VII. Significant Ranges for Duncan's Multiple Range Test[a]

$r_{.01}(p, f)$

	p											
f	2	3	4	5	6	7	8	9	10	20	50	100
1	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
2	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
3	8.26	8.5	8.6	8.7	8.8	8.9	8.9	9.0	9.0	9.3	9.3	9.3
4	6.51	6.8	6.9	7.0	7.1	7.1	7.2	7.2	7.3	7.5	7.5	7.5
5	5.70	5.96	6.11	6.18	6.26	6.33	6.40	6.44	6.5	6.8	6.8	6.8
6	5.24	5.51	5.65	5.73	5.81	5.88	5.95	6.00	6.0	6.3	6.3	6.3
7	4.95	5.22	5.37	5.45	5.53	5.61	5.69	5.73	5.8	6.0	6.0	6.0
8	4.74	5.00	5.14	5.23	5.32	5.40	5.47	5.51	5.5	5.8	5.8	5.8
9	4.60	4.86	4.99	5.08	5.17	5.25	5.32	5.36	5.4	5.7	5.7	5.7
10	4.48	4.73	4.88	4.96	5.06	5.13	5.20	5.24	5.28	5.55	5.55	5.55
11	4.39	4.63	4.77	4.86	4.94	5.01	5.06	5.12	5.15	5.39	5.39	5.39
12	4.32	4.55	4.68	4.76	4.84	4.92	4.96	5.02	5.07	5.26	5.26	5.26
13	4.26	4.48	4.62	4.69	4.74	4.84	4.88	4.94	4.98	5.15	5.15	5.15
14	4.21	4.42	4.55	4.63	4.70	4.78	4.83	4.87	4.91	5.07	5.07	5.07
15	4.17	4.37	4.50	4.58	4.64	4.72	4.77	4.81	4.84	5.00	5.00	5.00
16	4.13	4.34	4.45	4.54	4.60	4.67	4.72	4.76	4.79	4.94	4.94	4.94
17	4.10	4.30	4.41	4.50	4.56	4.63	4.68	4.73	4.75	4.89	4.89	4.89
18	4.07	4.27	4.38	4.46	4.53	4.59	4.64	4.68	4.71	4.85	4.85	4.85
19	4.05	4.24	4.35	4.43	4.50	4.56	4.61	4.64	4.67	4.82	4.82	4.82
20	4.02	4.22	4.33	4.40	4.47	4.53	4.58	4.61	4.65	4.79	4.79	4.79
30	3.89	4.06	4.16	4.22	4.32	4.36	4.41	4.45	4.48	4.65	4.71	4.71
40	3.82	3.99	4.10	4.17	4.24	4.30	4.34	4.37	4.41	4.59	4.69	4.69
60	3.76	3.92	4.03	4.12	4.17	4.23	4.27	4.31	4.34	4.53	4.66	4.66
100	3.71	3.86	3.98	4.06	4.11	4.17	4.21	4.25	4.29	4.48	4.64	4.65
∞	3.64	3.80	3.90	3.98	4.04	4.09	4.14	4.17	4.20	4.41	4.60	4.68

f = degrees of freedom.

[a] Reproduced with permission from "Multiple Range and Multiple *F* Tests," by D. B. Duncan, *Biometrics*, Vol 1, No. 1, pp. 1–42, 1955

VII. Significant Ranges for Duncan's Multiple Range Test (*continued*)

$r_{.05}(p, f)$

f	*p* = 2	3	4	5	6	7	8	9	10	20	50	100
1	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09
3	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50
4	3.93	4.01	4.02	4.02	4.02	4.02	4.02	4.02	4.02	4.02	4.02	4.02
5	3.64	3.74	3.79	3.83	3.83	3.83	3.83	3.83	3.83	3.83	3.83	3.83
6	3.46	3.58	3.64	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68
7	3.35	3.47	3.54	3.58	3.60	3.61	3.61	3.61	3.61	3.61	3.61	3.61
8	3.26	3.39	3.47	3.52	3.55	3.56	3.56	3.56	3.56	3.56	3.56	3.56
9	3.20	3.34	3.41	3.47	3.50	3.52	3.52	3.52	3.52	3.52	3.52	3.52
10	3.15	3.30	3.37	3.43	3.46	3.47	3.47	3.47	3.47	3.48	3.48	3.48
11	3.11	3.27	3.35	3.39	3.43	3.44	3.45	3.46	3.46	3.48	3.48	3.48
12	3.08	3.23	3.33	3.36	3.40	3.42	3.44	3.44	3.46	3.48	3.48	3.48
13	3.06	3.21	3.30	3.35	3.38	3.41	3.42	3.44	3.45	3.47	3.47	3.47
14	3.03	3.18	3.27	3.33	3.37	3.39	3.41	3.42	3.44	3.47	3.47	3.47
15	3.01	3.16	3.25	3.31	3.36	3.38	3.40	3.42	3.43	3.47	3.47	3.47
16	3.00	3.15	3.23	3.30	3.34	3.37	3.39	3.41	3.43	3.47	3.47	3.47
17	2.98	3.13	3.22	3.28	3.33	3.36	3.38	3.40	3.42	3.47	3.47	3.47
18	2.97	3.12	3.21	3.27	3.32	3.35	3.37	3.39	3.41	3.47	3.47	3.47
19	2.96	3.11	3.19	3.26	3.31	3.35	3.37	3.39	3.41	3.47	3.47	3.47
20	2.95	3.10	3.18	3.25	3.30	3.34	3.36	3.38	3.40	3.47	3.47	3.47
30	2.89	3.04	3.12	3.20	3.25	3.29	3.32	3.35	3.37	3.47	3.47	3.47
40	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35	3.47	3.47	3.47
60	2.83	2.98	3.08	3.14	3.20	3.24	3.28	3.31	3.33	3.47	3.48	3.48
100	2.80	2.95	3.05	3.12	3.18	3.22	3.26	3.29	3.32	3.47	3.53	3.53
∞	2.77	2.92	3.02	3.09	3.15	3.19	3.23	3.26	3.29	3.47	3.61	3.67

f = degrees of freedom.