


# Index

## A

Absolute 127, 349, 356  
 Aim 5–6, 17–18, 24, 33  
 alternate hypothesis 87–93, 106  
 analysis of variance (ANOVA) 181–182, 194–197, 233–235  
   complete randomised block design 227  
 critical values 366, 367  
 factorial 218–219, 225  
 fixed effects 229  
 $F_{\max}$  test prior to 197–199, 207–208  
 interaction 205–206, 219–225, 248, 261–262  
 Latin square design 228–229  
 Model I and Model II 196, 205, 230, 231  
 model, mixed 214, 230, 231  
 one-way, parametric 198–201, 226–227  
 one-way, non-parametric (general hypotheses) 241–246, 261–262  
 one-way, non-parametric (specific hypotheses) 246–248, 261–262  
 randomised block design 227  
 Scheirer–Ray–Hare 259–260, 261–262, 262  
 two-way parametric 205–210, 229–231  
 two-way parametric nested 212–218, 230  
 two-way parametric without replicates  212–218, 230  
 two-way non-parametric, general hypotheses 248–256, 261–262  
 two-way non-parametric, specific hypotheses 256–258, 261–262  
 three-way non-parametric 258–259, 262  
 three-way parametric with replicates 225–226, 231  
 three-way parametric without replicates 219–225, 231  
*a priori* 109–111, 111–113, 132–133  
 association 84–86, 109–111, 144–145

## B

bar chart 318–321  
 bimodal distribution 62  
 binomial distribution 54, 56–57

## C

calculated values 93–95  
 chi-squared 109–111, 139–143, 144–145, 356  
   critical values 360  
   goodness of fit test 111–119, 127–130  
   sample sizes 139–141  
   small numbers 137–139  
   test for association 38, 123–127, 130–133, 144–147  
   test for heterogeneity 120–123  
   Yates correction 127–133  
 coefficient  
   correlation 147–149  
   determination, of 157–158  
   regression 158–160  
   variation, of 74  
 confidence limits 75–76, 326  
 control 24–25, 140–141, 178–179, 227–232  
 continuous variables 51, 183, 315–316, 317–320  
 correlation 144–147, 147–149  
   coefficient 147–149  
   coefficient of determination 157–158  
   Pearson's product moment test 155–157  
   Pearson's product moment critical values 362  
   Spearman's rank test 149–154  
   Spearman's rank test critical values 361  
 critical values 95–106, 360–371

## D

data 1  
 data management 47–49

degrees of freedom 102–104  
 dependent and independent variables 149, 155, 160, 321–322  
 derived variables 53, 60–61, 76–78, 80–82  
 discrete variables 51, 109–111, 144–147, 315–316, 317–320

## E

error  
   sampling 19, 20, 25–27, 75, 88, 90–93, 161, 166, 172, 178–179, 190, 226–231  
   standard 75–76  
   Type I and Type II 99–100, 134, 232, 248  
 ethics 40–41, 292–298  
 expectation 109–111, 307–308  
 expected values, ratio 84–85, 109–111, 111–113, 127–130, 139–142  
 experimental design  
   assumptions and bias 34, 307–308, 326  
   chi-squared and G tests 139–142  
   completely randomised block design 229  
   controls 24–25, 140, 178–179, 226–231, 261  
   choosing a topic 338–340  
   correlations 178–179  
   faults 18–19, 326  
   influencing outcomes 33, 40–41, 295  
   Latin square 228–229  
   limitations 18–19, 326  
   non-parametric tests 260–262  
   parametric ANOVAs 226–231  
   randomised block design 226  
   regressions 178–179  
   repeatability 34–35  
   replicates 27–29, 29–32, 61, 140, 160, 194, 226–231, 261–262  
   sample sizes 29–32, 41–45, 137–139, 140, 178–179

experimental design (*cont.*)  
 strengths 18, 226–231  
*t* tests 226–227  
*z* tests 226–227  
 experimental investigation 3–5, 21  
 exponential distribution 54, 59–60

## F

F-tests  
 before a *t* or *z* test 181–182,  
 183–186, 187–188, 191–192, 363  
 $F_{\max}$  test before a parametric  
 ANOVA 181–182, 197–199  
 F test in an ANOVA 181–182,  
 366, 367  
 figures 177–178, 316–323, 326  
 focus groups 37  
 frequency tables 314–316

## G

G tests 109–111, 133, 139–143  
 critical values 360  
 goodness of fit 134–135  
 small numbers 137–139  
 test for association 135–137  
 general hypotheses 87, 181–182,  
 195, 231–232, 234, 243,  
 246–248, 256–258

## H

Harvard referencing 302–303, 328–334  
 health and safety 47–49, 267–278  
 histogram 54, 316–318  
 homogeneity, stand 10  
 hypothesis 6–7, 29–30, 33, 84  
 general 87, 181–182, 195,  
 231–232, 234, 241–246,  
 248–256  
 specific 87, 111–112, 181–182, 195,  
 231–232, 234, 246–248, 256–258  
 null and alternate 88–93, 106  
 testing 90–93

## I

interaction 205–206, 211, 218–219,  
 219–225, 226, 229–232, 248,  
 261–262  
 interpolation 105–106  
 interval scale 53, 54, 77–78, 80–82,  
 314, 316–318

interviews 37  
 item 7–8, 23, 178–179, 227

## K

Kruskal Wallis test 233–235,  
 261–262  
 critical values 360  
 test 242–247  
 kurtosis 66–69

## L

Latin square 228–229  
 law  
 access 278–280, 286–287  
 animals and other organisms 282–285,  
 287–288, 288–291, 298–300  
 health and safety 268–278, 298–300  
 humans 40, 47–49, 291–298, 298–300  
 international 265  
 national 265–266  
 plants 281, 284–287, 287–288,  
 298–300  
 sampling 278, 281, 298–300  
 line graph 316–323

## M

Mann Whitney U 233–235, 261–262  
 critical values 370  
 test 235–238  
 matched observations 190, 227–228,  
 238, 261  
 mean 63, 326, 355  
 Binomial distribution 65–66  
 Normal distribution 63–65  
 Poisson distribution 66  
 measurement, scales of 51–53  
 median 62–63  
 mode 62  
 Model I and II in regression 159,  
 178–179  
 Model I and II in parametric  
 ANOVA 196, 205

## N

nominal 52, 314, 316–318  
 non-parametric data 76–78  
 non-parametric statistics 76, 109–143,  
 144–179, 234–262  
 non-treatment variable 25–27, 34,  
 90–93, 226–232, 262

normal distribution 54, 54–56,  
 115–119, 357  
 null hypothesis 88–93, 106

## O

objective 6, 17–18, 23, 33  
 observations 7–8  
 observational investigation 2–3, 5, 21, 34  
 one-tailed test 101–102, 247, 258  
 ordnance survey co ordinates,  
 finding 309–310  
 ordinal scale 52, 80–82, 314, 316–318  
 orthogonal 205, 207, 249, 261–262

## P

parameter, population 11–12  
 parametric data 76–79  
 parametric statistics 181–232  
 Pearson's product moment  
 correlation 144–149, 178–179  
 critical values 362  
 test 155–157  
 Poisson distribution 54, 58  
 population 8, 23–24  
 pie chart 316, 323  
 plagiarism 302–303, 308, 328  
 power of a test 77, 80–81, 147, 155,  
 194, 233  
 principal major axis regression  
 144–147, 158–160, 178–179  
 test 166–171  
 probability 93, 95–100, 324–325

## Q

questionnaires 36–47  
 questions, open and closed 37–39, 44  
 qualitative and quantitative 36, 51

## R

random sampling 9–10, 23–24, 34,  
 35–36, 91, 137–139  
 randomising 27, 34, 35–36, 196, 213,  
 226–229, 229–231, 231, 262–263  
 randomised block design 227  
 range 70–71  
 interquartile 70  
 percentiles 70  
 ranged principal axis regression  
 144–147, 158–160, 178–179  
 test 172–177

- rank  
 scale 52  
 how to 79–80  
 ranking tests 233–234  
 referencing 302–303, 328–333  
 regression analysis 144–147,  
 158–160  
 lines 177–178, 316–323, 325  
 Model I and Model II 159, 178–179  
 principal axis regression  
 144–147, 166–171  
 ranged principal axis regression  
 144–147, 172–177  
 sample sizes 178–179  
 simple linear regression  
 144–147, 160–166  
 relationship 144  
 replication 27–29, 29–32, 60,  
 140–141, 160, 179, 194–195,  
 226–232, 261–262  
 research  
 choosing a topic 337–340  
 management 46–49, 265–300, 339
- S**
- sample 9–11, 23–24  
 representative 9  
 size 29–32, 41–45, 137–139, 179,  
 226–232, 261  
 statistics 11–12  
 sampling 9–11, 278–288  
 error 19–20, 25–27, 75–76, 88,  
 90–93, 161, 166, 172, 178–179,  
 190, 226–231  
 random 9–10, 23–24, 34, 35–36,  
 90, 137–139, 151  
 stratified and systematic 10  
 scales of measurement 51–53, 76–78  
 scatter plot 316–323  
 Scheirer–Ray–Hare 333–335, 262  
 critical values 360  
 test 258–260  
 significance, statistical 90–100, 106  
 simple linear regression 144–147,  
 178–179  
 test 158–160, 161–166  
 critical values 362  
 skew 66–69, 80–82  
 Spearman's rank correlation 144–147,  
 178–179  
 critical values 361  
 test 148–149, 149–158  
 specific hypotheses 87, 111–112,  
 181–182, 195, 231–232, 234,  
 246–248, 256–258  
 standard deviation 50, 60, 70–74, 74,  
 75–76, 76–79  
 standard error of the mean 75–76,  
 356  
 statistics 11–12  
 calculated value 94–95  
 choosing 29–32, 41–45, 341–347  
 critical value 95, 100–105  
 reporting 204, 311, 316–323,  
 323–326  
 symbols 348–358  
 sum of squares 72  
 stratified and systematic sampling 10
- T**
- tables 314–316  
 t tests, Student's 181–182, 226–228  
 critical values 62  
 matched pairs of data 190–193  
 unmatched data 184, 187–190  
 transforming data 80–82, 179  
 treatment 12–13  
 treatment variables 14, 25–27,  
 139–143, 178–179, 226–232,  
 260–262  
 Tukeys' test 181–182, 231–232  
 after a one-way ANOVA 201–205  
 after a nested ANOVA 218  
 after a three way ANOVA 224–225  
 after a two-way ANOVA 211–212  
 critical values 368  
 two-tailed test 100–102  
 Type I and Type II errors 99, 133, 232

**U**

- unmatched 182–183, 226–227,  
 234–235, 261  
 unimodal 55, 57, 62

**V**

- variance 69–70  
 binomial distribution 73  
 normal distribution 71–73  
 Poisson distribution 74  
 variation 13–15  
 variation, coefficient of 74  
 variable 13–15  
 dependent and independent 149,  
 155, 160, 321–322  
 non-treatment 25–27, 34, 90–93,  
 226–232, 262  
 treatment 14, 25–27, 139–143,  
 178–179, 226–232, 260–262

**W**

- Wilcoxon's matched pairs test 181–182,  
 226–228  
 critical values 371  
 test 239–241  
 Williams' correction  
 134–137

**Y**

- Yates' correction 127–133

**Z**

- z 181–183, 226–228  
 critical values 365  
 matched data 190–193  
 unmatched data 182–187