

Index

A

Accumulation analysis, 512, 517
Activation energy, 183
Active factor(s), 188, 195, 200, 214, 233
 finding, 495
 performing the computations, program for, 197
 subspace, 195
Adaptation, different levels of, 269
Adjustment:
 feedback, 294
 periodic, 297
 repeated, 296
Alias, (*see also* Confounding), 51, 63
 matrix, 170
 strings, 202
Alphabetic optimality, 147, 248, 250
American Supplier Institute, 539
Analysis:
 accumulation, 510, 512
 Bayesian, 201, 209
 canonical, 161, 171, 278
 chi-square, 510
 eigenvalue, 182
 eigenvalue-eigenvector, 514
 of residuals, 136
 of variance, 47, 128, 160, 243
 of variance, rationale, 102
 of variance, split plot experiments, 473
 pick the winner, 76
 robust statistical, 480
 t-test, 510
 “what if”, 81

Animal survival study, 455
Appropriate training, 292
Approximate mechanisms, 181
Approximation, locally adequate, 247
Array:
 design, 466
 error, 465
Assumptions, tentatively entertained, 270
Average run lengths (ARLs), 291

B

Bad values, 95
Batch-to-batch variation, 189
Bayes-sampling theory controversy, 126, 132, 135, 145, 147
Bayes theorem, 268
 applied to model selection, 210
Bayesian analysis, 201
 to facilitate the identification of active factors, 211
Bearing:
 deep groove, 37
 used in a washing machine, 48
Berra, Yogi, 102
BH², 219
Bias:
 ignoring of, 255
 integrated squared, 260
 taking account of, 256
Binomial:
 model, 271
 significance test, 274

Black belts, 292
 Blitzkrieg, 173
 Block effect, 219, 221
 Blocking, 128, 263
 Budget, latent, 278
 Bureaucracy, 23

C

Canonical analysis, 161, 171, 278
 Capability indices, 294
 Catalyze investigation, 148
 Center for Quality and Productivity Improvement (CQPI), 18
 Change, motivating, 23
 Chart(s):
 bounded, 295
 control, 30
 fishbone, 6
 flow, 29
 Pareto, 16
 Shewhart, 6
 Check:
 model relevance, 170
 potentially interesting characteristics, 171
 sheets, 6, 16
 χ^2 (Chi-square):
 analysis, 512
 linear component of, 516
 statistic, 510
 Circuit, Wheatstone Bridge, 463
 Clutch:
 automobile, survival time, 455
 springs, 455
 Coating experiment, 478
 Coefficients, biased, 170
 Coherence, 145
 Columns:
 adding, 66
 dropping, 66
 Communication, 13
 Comparisons, 442
 Comparative experiments, 85
 Competition, 106
 Complication, 16
 Confidence:
 cones, 173
 ellipsoid, 245
 Confounding, 128
 complex, 229
 Consecutive reaction, 182
 Constrained optimization, 468
 Constraints:
 multiple, 185
 not known, 184

Contingency tables, 126
 Continuous design measure, 245
 Continuous improvement, 8
 Contour:
 diagram, 22
 overlays, 171
 plots, 171
 Correlation:
 between errors, 185
 between mean values, 185
 contemporaneous, 185
 Corrosion resistance of steel bars, 472
 Creativity, 5, 18
 Criteria (Criterion), 45, 524
 of aberration, 226
 MD, 227
 performance, 468, 524
 portmanteau, 485
 Critical runs, 81
 Criticism, 268, 270
 -estimation dichotomy, 277
 and estimation, iterative interplay
 between, 280
 Cross-functional deployment, 29
 Cube plot, 50
 Current region of interest, 250
 Cuscores, 291
 Cusums, 291
 Cut and try, 188

D

D-optimality, 245, 251
 Daniel plot, 91, 94
 Data, 14
 acquiring, 174
 analysis, 128, 173, 267
 transformation, 450
 Data acquisition:
 by observing the system, 176
 by running an experiment, 176
 by a visit to the library, 176
 Decision procedure
 optimal, 175
 Deduction, 144
 Degree:
 of approximating polynomial, 170
 of freedom, 102
 Departments:
 industrial engineering, 186
 quality engineering, 187
 statistics, 186
 Design(s):
 array, 445
 central composite, 187

- composite, 156, 187, 191
- defining relation, 226
- factorial, 8, 57, 62, 128
- factors, 496
 - identifying, 485
- first-order, 260
- fold over, 78, 170
- follow up, 214
- fractional factorial, 44, 50, 170, 191, 495
- geometric, 197
- MD-optimal, 225
- multi-factor, 214
- nested, 445
- non-geometric, 194, 197
- of a follow-up experiment, 218
- parameter, 469
- pick and try, 8
- Plackett-Burman, 187, 195, 201, 240
- response surface, 245
- robust, 43
- saturated two-level, 239
- screening, 43, 178, 188, 207
- second order, 260
- second order composite, 170
- sequential assembly of, 75
- Detective, 144
- Different routes, 149
- Different starting points, 149, 167
- Direction of ridges, 171
- Discovery inductive, 181
- Discriminate between rival models, 184
- Discussion with an engineer, 155
- Dispersion, 150
 - effects, 111, 151
 - non-transformable, 184
 - transformable, 184
 - interactions, 120
- Distributed lag models, 127, 243
- Distribution:
 - free tests, 481
 - noninformative prior, 230
 - predictive, 136, 273
- Distributional assumption, 481
- Division of the factors, 524

- E
- Effect(s):
 - block, 222, 224
 - curvature, 55
 - interaction, 57
 - sparsity, 241
- Efficient score statistics, 291
- Eigenvalue analysis, 182
- Eigenvalue-eigenvector analysis, 514

- Engineer, discussion with an, 155
- Environmental:
 - factors, 489
 - robustness, 498
- Error:
 - array, 465
 - percentage, 464
 - testing, 442
 - wrong estimate of, 440
- Estimation, 271, 276
 - iterative interplay between criticism and, 280
 - of error, 263
- Exchange algorithm, 222, 233
- Expectation, 17
- Experiment(s):
 - badly designed, 43
 - coating, 479
 - comparative, 85
 - follow-up, 214
 - injection molding, 215
 - lab scale, 188
 - for life testing, 453
 - lubricant, 228
 - one-shot factorial, 169
 - reactor, 221
 - split plot, 475, 487
- Experimental:
 - arrangement (*see also*, Design), 489
 - cost, 494
 - design, 9, 37, 128, 177
 - agricultural context, 175
 - effort, 487
 - factors, critical mix, 179
 - runs, misconducted, 283
 - space, iteratively evolving, 247
 - strategy, 76
- Experimentation:
 - agricultural, 175
 - management of, 48
 - one factor at a time, 8, 40, 189, 191
 - sequential approach, 45
 - valid, 44, 85
- Exponentially weighted moving average (EWMA), 290
- Extrapolation, informed, 482
- Extrapolative judgement, 484
- Extreme conditions, 494

- F
- F multiplier, 173
- Factorial designs, 8, 128
 - 2^3 , 37
 - 2^4 , 146
 - eight-run, 52, 61, 225

- Factorial designs (*continued*)
 sixteen-run, 60, 226
 twelve-run, 70
 32-run, 230
 dropping columns, 55
 projective properties, 179
 same or different machine, 177
- Factor(s):
 active, 189, 195, 198, 205, 214
 finding, 495
 design, 498
 division of the, 524
 environmental, 489
 robustness, 482
 sparsity, 196, 213
- Failure, rate of, 453
- Fear, 24
- Feedback:
 adjustment, 294
 corrective, 14
 empirical, 79
 scientific, 79, 173
- Feedforward, preemptive, 15
- Finding active factors, 495
- First degree model, 451
- First order steepest ascent, 170
- Fishbone charts, 6
- Fitted value, 92
- Flow charts, 6
- Fold-over, 78, 170
 fraction, 224
 for fractional factorial designs, 191
- Follow-up designs, 213
 to resolve confounding, 229
- Fractions obtained from group theory, 170
- Fractional designs, 8
 2_{IV}^{4-1} , 50
 2_{III}^{7-4} , 50
 2_{IV}^{5-1} , 62
 2_{IV}^{8-4} , 62, 148
 2_{III}^{15-11} , 62
 justifications, 64
 replication, 128
- Fractional factorials, 495
 $2^k - p$, 195
 fold-over, 170
 projective properties, 179
- F*-test, 102
- G**
- G*-optimality, 245, 251
 criterion, 253
- Geometric representation, 25
- Geometry, *n*-dimensional, 126
- Goody-ness, 185
- Graphical analysis, 146
- Graphs, 6
- Guesswork, 172
- Guinness's, 127, 131, 437, 482
- H**
- Helicopter, paper, 43, 146
- Human brain, 174
- Hypotheses, generating, 29, 144, 195
- I**
- ICI, Imperial Chemical Industries, 129
- IF, 12
- Immediacy, 169, 179
 of data acquisition, 143
- Improvement, continuous, 27
- Improving full-scale processes, 188
- Incompatibility of the data and the model, 272
- Indices, capability, 294
- Induction, 28, 144
- Inductive-deductive problem-solving, 27
- Inductive-deductive process, 27
- Industrial engineering departments, 186
- Inference, alternative methods of, 265
- Information function, 250, 254
- Informed extrapolation, 482
- Injection molding experiment, 218
- Input variable, 150
- Inquiry, exploratory, 173
- Integrated squared bias, 260
- Interactions, 45, 128
 three-factor, 207, 215
- Investigation, 146, 179
 experiencing the process, 192
 in the laboratory, 169
 iterative, 278
 the pilot plant, 169
 the full scale process, 188
 dynamic, 171
- Investigational team, 149
- Investigators, respected colleagues, 185
- Iterative, 28
 investigation, 279
- J**
- Judgement, 169
 extrapolative, 482
- K**
- Keep a notebook, 92

- Knowledge:
 fractionation, 30
 generating, 26
 specialist, 184
 Kullback-Leibler information, 231
- L**
- Lack of fit, 170, 262
 Lambda, 550
 Learning, 27, 174
 ability to catalyze, 186
 by chance, 28
 by scientific method, 28
 democratization of, 30
 scientific, 31
 Least squares, 126, 153
 generalization, 181
 Life test, 455
 Likelihood principle, abrogation of, 281
 Linear regression model, 153
 Location effects, 151
 Log transformation, 450
 Luck, 99
- M**
- Madison, Wisconsin, city of, 18
 Main effect(s), 52
 plans, 235
 Management:
 by disaster, 12
 by exception, 30
 by objectives, 30
 philosophy, 12
 strategy, 22
 style, 20
 systems, 23
 Managerial champions, 292
 Mantel's statistic, 511
 Manufacturing variation, 173, 464
 Marginal posterior probability, 197
 Mathematical:
 capability, 186
 French curve, 251
 one-shot paradigm, 175
 Maximum gradient, 165
 Maximum likelihood, 122
 Maximum, 163, 171, 191
 MD approach, 229
 MD criterion, 220
 Methods:
 cut and try, 188
 one factor at a time, 191
 two processing, 442
 two sampling, 442
 two testing, 442
 Minimax, 162, 171
 Minimum, 171, 191
 Minimization, of the determinant, 181
 Missing observations, 90
 MMSE: Minimum Mean Square Error
 need to modify, 181
 Mobility of executives, 23
 Model(s):
 ARIMA time series, 136
 binomial, 273
 discriminate between rival, 184
 discrimination, 209
 evolution, 278
 first degree, 451
 incredible, 283
 normal linear, 275
 second degree, 450
 statistical, 134, 279
 theoretical, 182
 Monday Night Beer Seminar, 182
 Morale, 17
 Motivation, 24
 Motivators, 24
 Multiple:
 constraints, 185
 correlation coefficient, 126
 responses, 185
 sources of variation, 444
 Murphy's Law, 6, 10
- N**
- Napoleon Bonaparte, 99
 Natural phenomena, 177
 Never-ending improvement, 150
 Neyman-Pearson theory, 168, 266
 Noise, white, 298
 Nonlinear:
 estimation, 181
 models, 129
 Nonparametric methods, 129
 Nonstationary disturbance, 83
 Nonstationary world, 86
 Normal linear model, 275
 Normal (Daniel) plot, 47, 178, 198
 Normal probability paper, 94
- O**
- Observation(s), 90
 outlying, 199

- One factor at a time experimentation, 8, 40, 191
- One-shot, 145, 169, 178
- Operability region, 246, 257
- Optimal design theory, 227
- Optimality, 147
 alphabetic, 141, 243, 248
D-, 248, 250
G-, 248, 250
- Optimization:
 constrained, 468
 mathematical, 27
- Optimum conditions, 55
- Orthogonal:
 arrangement, 128
 array, 8, 54, 241, 495
 20 × 20, 242
 block, 191
 polynomials, 127
- Outlying observations, 201
- Output variable, 150
- P**
- Paradigm:
 mathematical, 179
 scientific, 183
- Paper helicopter, 43, 146
- Parameter design, 470
 solution, sensitivity of, 470
- Pareto:
 diagrams, 6
 principle, 62
 situation, 44, 50
- Percentage error, 462
- Performance criterion, 468, 524
- Performance measure independent of adjustment (PerMIA), 524
- Permissible region, 245
- Pick and try, 8
- Plackett–Burman, 170, 187, 195, 201, 237, 240
 design, confounding structure, 201
 design, geometric, 196
 design, non-geometric, 196, 203
 projectivity *P*, 241
- Plots:
 Bayes, 195
 normal probability, 194
- Policy change, 22
- Portmanteau criteria, 485
- Practice, importance of, 125
- Predictive:
 density, 272
 distribution, 273
- Princeton, 289
- Principle of parsimony, 195, 485
- Probabilities
 marginal posterior, 205
 subjective, 279
- Probability paper, 45, 131
- Problems, truly novel, 185
- Process:
 drift, 294
 variation, 444
- Process workers, 185
- Projectivity, 45, 53
- Promotions to tenure, 186
- Properties:
 orthogonal arrays, 235
 projection, 237
 projective, 212
- Publicity, 18
- Q**
- Quadratic, 189
- Qualitative variables, 152
- Quality engineering, 36
 departments, 186
- Quality, management, 32
- R**
- R^2 , 173
- Rabbit breeding, 37
- Random
 arrangement, 487
 starts, 233
- Randomization, 128
- Rat cage, The, 190
- Rate of failure, 453
- Ratio, signal-to-noise (SN), 465, 524
- Reaction:
 consecutive, 182
 “orders” of, 183
- Reactor experiment, 223
- Reciprocal transformation, 455
- Region:
 of interest, current, 250
 of operability, 250
 permissible, 245
- Regression coefficients, 152
- Reparameterization, 156
- Replication, 128
- Residuals, 282
 subplot, 477
 whole plot, 477
- Resolution, 63

- Resolution, design, 52
 Resolution, highest possible, 55
 Response surface methods, 8, 145, 246, 498
 key ideas, 169
 Response, 45
 multiple, 185
 several, 171
 Rheologist, 185
 Ridge:
 analysis, 166
 estimators, 277
 gets stuck on, 191
 rising, 191
 some kind of, 191
 Robust statistical analysis, 482
 Robustness, environmental, 505
 Robustness factor, 482
 Rothamsted Agricultural Experimental Station,
 127
- S**
- Sampling variation, 444
 Scale(s):
 decibel, 448
 logarithmic, 448
 Richter, 448
 transformed, 450
 Scientific arbitrariness, 264
 Scientific method:
 democratization of, 26
 and the human brain, 267
 nature of, 133
 Screening:
 designs, 179
 of orthogonal arrays, ability, 181
 Second degree:
 equation, 163
 model, 451
 Second order composite design, 170
 Self-correcting, 149
 Sensitivity, 492
 of the parameter design solution, 469
 Sequence of experiments, 148
 Sequential assembly, 170, 191, 262
 Sequential experimentation, 146
 Sequential learning, 145, 148
 Sequentiality, 169
 Serendipity, 104
 Serial dependence, 185
 Seven tools, Ishikawa's, 16
 Several responses, 171
 Sexual reproduction, 177
 Shewhart charts, 6
 Shewhart's plan-do-check-act cycle, 28
 SHOULD, 11
 SHOULDN'T, 11
 Signal-to-noise ratio, 450, 524
 Simple data patterns, 263
 Simplification, 14
 Six sigma, 294
 initiative, 292
 SN ratio, 465, 524
 SN_L , 524
 SN_S , 524
 SN_T , 524
 Specialist knowledge, 184
 Split plot(s), 475, 493
 analysis of variance, 475
 arrangement, 87
 experiment(s), 473, 488
 Square region, 245
 Squared error loss, 503
 Standard deviation, logarithm of the sample,
 151
 Stationarity, 86
 Stationary approximation, 86
 Statistical:
 estimation and criticism, 266
 model, 135, 279, 281
 process control (SPC), 29
 significance, 45
 Statistical Techniques Research Group, Princeton,
 181
 Statistics departments, 186
 Steepest ascent, 189, 278
 direction of, 153, 191
 Strip block, 494
 Student's t , 441
 Studies:
 analytic, 120
 animal survival, 455
 enumerative, 86
 Subject matter knowledge, 17, 146, 155,
 179
 inspiring, 178
 led to physical understanding, 183
 Subjective probabilities, 278
 Subplot(s), 472
 residuals, 475
 Super-powerful tests, 130
 Survival time for automobile clutch, 455
 System, 10
- T**
- t -test analysis, 510
 Taguchi's "linear graph" method, 66

Teaching:
 modern, 30
 traditional, 12
Team approach, 8
Technical sophistication, 5
Testing, 175
 error, 445
 variation, 444
Theoretical:
 explanation, 40
 models, 182
 variance, 103
Theory-Practice iteration, 269
Theory of regression analysis, 243
THEY, 11
Tinkering, 14
Tracking down of a criminal, 172
Transformation(s), 550
 data, 450
 estimation, 263
 log, 450
 reciprocal, 455
 variance stabilizing, 454
Transformed scales, 448
Transmitted variation, 463, 465
Trench warfare, 173
Trial of the criminal, 172
Two processing methods, 442
Two sampling methods, 442
Two testing methods, 442
Two-way table, 54

U

Unexpected phenomenon, 185

V

Valid experimentation, 85
Validity, 42
Variance:
 analysis of, 243, 475
 components, 445, 447
 stabilizing transformations, 454
Variation, 41
 batch-to-batch, 189
 manufacturing, 464
 multiple sources of, 442
 process, 445
 sampling, 444
 testing, 444
 transmitted, 461, 466

W

Washing machine bearing, 50
Wheatstone Bridge, 463
Which way is up, 170, 189
Whole plot(s), 474
 residuals, 475
Working rule, 25%, 278
Wright Brothers, 28
Wrong estimate of error, 441