

Index

Only the first or most substantial use of R functions are indexed (under “R functions”). Where they occur in named files which spread over more than one page, the reference is to the first page.

- χ^2 , *see* chi-squared
- accuracy, 50, 126
- aircraft damage, 74
- Akaike information criterion, 246
- alternative hypothesis, 205, 208
- amoeba method, *see* simplex method
- autocorrelation function, 164
- autocorrelation length, 164
- base rate, 59
- basis function, 266
 - polynomial, 91
- Bayes factor, 58
- Bayes’ theorem, 8, 57, 62, 99
 - sequential application, 114
- Bayesian information criterion, 246
- beta function, 19, 228
- bias, 11, 37, 50, 96
- bias-variance decomposition, 95–97
- bias-variance trade-off, 96, 146, 242, 257
- binomial coefficient, 29
- birthday problem, 30
- black swan, 223
- bootstrap resampling, 282–287
- breast cancer, 58–60
- burn-in, 163
- central limit theorem (CLT), 39–43, 127
- centring, 188, 261
- chi-squared, 80, 86
- chi-squared test, 220–221
- clipping, 48
- coefficient of determination, *see* r^2
- combinations, 29
- conditional distribution, 27, 125
- conditional independence, 157, 180, 244
- conditional probability, 6, 27
- confidence interval, 122
 - equal-tailed, 123
 - frequentist, 212–215
 - highest density, *see* highest density interval
- conjugate distributions, 64, 103
- correlation coefficient, 25, 80
 - sample, 25
- cost/benefit, *see* utility
- covariance, 25
 - matrix, 25, 26, 52
 - sample, 25
- credible interval, 122
- cross-validation, 152, 243, 255–260
 - generalized, 262
- cross-validation likelihood, 243–245
- cumulative distribution function (CDF), 23
- curse of dimensionality, 66, 155, 158
- decision making, 66–67
- degrees of freedom, 84, 129, 220, 270
 - effective, 270
- density estimation, 145–153
- design matrix, 90, 261
- detailed balance, 161
- dinosaur, 113
- distributions
 - arcsine, 118
 - beta, 19–20, 102, 118
 - beta-binomial, 229
 - binomial, 13–15, 98, 118, 228
 - Cauchy, 22, 42–43, 175, 193
 - chi, 220
 - chi-squared, 219–222
 - exponential, 143
 - gamma, 21, 120
 - Gaussian, 20–21, 120–121, 238–239
 - Gaussian (multivariate), 25
 - Gaussian (standardized), 21
 - hypergeometric, 14
 - inverse gamma, 121, 131
 - Lorentz, *see* distributions, Cauchy
 - Maxwell–Boltzmann, 220
 - negative binomial, 249
 - normal, *see* distributions, Gaussian
 - Poisson, 16–19, 120
 - Rayleigh, 220
 - Student’s t , 129, 210–211
 - uniform, 20
- effective sample size, 164
- ellipse, 26
- empirical Bayes, 114, 188

- error
 - definition, 49
 - propagation, *see* uncertainty, propagation
 - random, 49
 - systematic, 49
- errors in variables, 94
- estimated risk, 153
- estimator, 36–37
 - bias, 11, 37
 - consistency, 37, 44
 - efficiency, 37
 - interval, 36
 - point, 36
- evidence, 65–66, 226, 227, 255
- exclusive or, 8
- exhaustive, 6
- expectation value, 10, 156
- expected utility, 67
- false negative, 58, 206
- false positive, 58, 206
- falsification, 223
- figurate numbers, 29
- firing missiles, 7–8
- Fisher information, 117
- Fourier series, 266
- frequency, 8, 61
- frequentist statistics, 204–206
- full-width at half-maximum (FWHM), 20
- gamma function, 21, 30
- goodness of fit, 79–80
- gradient ascent, 281, 283
- half-width at half-maximum (HWHM), 22
- hat matrix, 90
- Hessian matrix, 144, 281
- hierarchical Bayes, 114
- highest density interval (HDI), 123, 165
- highest density region, 123
- histogram, 145–147
- hyperparameters, 175
- hyperplane, 89
- hypershell, 221
- hypersphere, 221
- hypersurface, 29
- hypervolume, 158
- hypothesis testing, 110–111
 - χ^2 , *see* chi-squared test
 - one-sample, 206–215
 - one-sided, 210–212
 - problems with, 222–224
 - t test, *see* t test
 - two-sample, 215–217
 - two-sided, 212
 - z test, *see* z test
- importance sampling, 161
- improper distribution, 10
- information, *see also* Fisher information
 - matrix, 90
- integration
 - numerical, 65
- interquartile range (IQR), 23
- invariance
 - of density functions, 35, 86, 88, 178
 - of maximum likelihood, 85
 - of priors, 115–117
 - of quantiles, 35, 69
- inverse probability, 8
- inverse variance weighting, 53, 81, 83, 86
- iterative clipping, 48
- Jacobian, 33, 167
 - matrix, 34, 52
- joint probability, 6, 25
- kernel, 148, 273
 - Epanechnikov, 274
 - Gaussian, 149, 274
 - Nadaraya–Watson, 274
 - nearest neighbours, 149
 - rectangular, 148
 - regression, 273–276
 - tricubic, 275
- kernel density estimation, *see* density estimation
- kurtosis, 12
- L^1 distance, 29
- L^2 distance, 87
- L^2 risk function, 152
- Laplace’s rule of succession, 104
- law of large numbers, 11
- least squares, 76, 86
 - generalized, 90–91
 - ordinary, 90, 263
 - orthogonal, 95
 - total, 95
- likelihood, 56, 62–63, 109–110
 - choice of, 119
- linear congruential generator, 31
- linear model, 77, 83
- linear regression, 76–77, 83
- local maximum, 163, 280, 281
- loss function, 76, 87
- marginal distribution, 27, 125, 136, 156
- marginal likelihood, 65, 156, 227
- marginal probability, 7, 27
- marginalization, 27, 125
 - of sampled distributions, 159, 177, 180
- Markov chain, 161
- Markov Chain Monte Carlo (MCMC), 161–163
- maximum a posteriori (MAP), 87–89
- maximum entropy, 21, 114
- maximum likelihood, 84–89
 - for model selection, 239–240
 - ratio test, 240, 242

- mean, 10
 - minimizes L^2 loss, 87
 - sample, 11, 44
 - weighted, 53–54
- mean integrated squared error (MISE), 152
- median, 23
 - minimizes L^1 loss, 87
- median filter, 273
- Metropolis algorithm, 162–163
- Metropolis ratio, 162
- midrange, 45
- mixing factor, 194
- mixture model, 194
- mode, 19
- model, 55
 - forward, *see* model, generative
 - generative, 55, 63, 135, 173
 - measurement, 37–39, 47–49, 56, 62, 63, 173
 - noise, *see* model, measurement
- modulus operator, 31
- moment, 13
- monotonic, 23, 35, 69, 85
- Monte Carlo
 - integration, 157–159
 - sampling, 159–161
- Monty Hall problem, *see* three doors problem
- moving average, 149, 273
- multimodal, 123, 280
- multiple testing, 223
- mutually exclusive, 6
- Nelder–Mead method, *see* simplex method
- nested models, 231, 248
- neural network, 259
- Newton’s method, 281
- noise, 19, 38
- non-parametric model, 145, 273
- nonlinear model, 84
- normalization, 10
- null hypothesis, 205
- numerical optimization, 280–283
- numerical precision, 137, 140–141
- objective function, 76, 261, 269
- Occam factor, 241
- Occam’s razor, 241, 260
- odds ratio, *see* posterior odds ratio
- outliers, 47–49, 193
- overfitting, 219, 240, 256, 257
- p hacking, 223
- p value, 110–111, 205, 237
- parallax, 67, 282
- parent distribution, 36
- parent population, 36
- parsec, 68
- partition likelihood, 244
- Pascal’s triangle, 29
- permutations, 28
- planet orbit, 55
- Poisson process, 38
- posterior, 9, 62–64
 - as prior update, 64, 103, 189, 241
 - improper, 72, 116, 131, 176
 - normalization, 64
 - summary of, 121–124
- posterior odds ratio, 57, 226
- posterior predictive distribution, 156–157, 159, 178–181
- precision, 50, 126
- prediction, *see* posterior predictive distribution
- principle of indifference, 113
- principle of insufficient reason, 113
- principle of parsimony, 260
- prior, 9, 57, 63
 - choice of, 63, 73–74, 112–120
 - conjugate, 103, 118, 120–121, 131
 - improper, 71, 116
 - Jeffreys, 115–119, 129
 - on location parameter, 115
 - on scale parameter, 115
 - sampling, 232
 - subjectivity, 119–120
 - uninformative, 73
- probability density function (PDF), 9
- probability mass function (PMF), 9
- proposal distribution, 160
- pseudo random, 31
- quadratic approximation, 142–145
 - of evidence, 243
- quadrature, 52
- quantile function, 23
- quantiles, 165
- quartiles, 23
- r^2 (coefficient of determination), 80
 - adjusted, 80
- R functions
 - acf, 168
 - apply, 47
 - approxfun, 271
 - attributes, 82
 - attr, 263
 - bs, 271
 - choose, 31
 - colorRampPalette, 132
 - combinations, 31
 - contour, 135
 - cor, 25
 - cov, 25
 - cumsum, 24
 - dbeta, 19
 - dbinom, 14
 - dcauchy, 168
 - density, 150
 - diag, 182

- dmvnorm, 26
- dnbinom, 251
- dnorm, 24
- dpois, 16
- effectiveSize, 168
- expand.grid, 26
- expression, 182
- factorial, 30
- gamma, 21
- gradient.ascent, 285
- hist, 41
- HPDinterval, 165
- image.plot, 132
- integrate, 203
- kde2d, 151
- ksmooth, 274
- lm, 81
- locpoly, 274
- loess, 274
- matrix, 26
- metrop, 168, 170–172
- param.ridge, 264
- pbinom, 112
- pchisq, 220
- permutations, 31
- persp, 132
- plotCI, 47
- pnorm, 24
- polyeval, 257
- poly, 257
- pt, 212
- qnorm, 24
- qt, 214
- quantile, 24, 165
- rcauchy, 43
- rmvnorm, 168
- rnorm, 24
- rpois, 137
- runif, 41
- sample, 32
- scale, 263
- sd, 12
- set.seed, 32
- smooth.spline, 271
- splinefun, 271
- sreg, 277
- t.test, 212
- table, 18
- truehist, 146
- var, 12
- Vectorize, 46
- radioactive decay, 17
- random number seed, 31
- random numbers, 31–32
- random walk, 161
- rectangle method, 65, 158
- reduced chi-squared, 221
- regression, 76–77
 - local, 273
- regularization, 256, 260–261
 - probabilistic interpretation, 265–266
 - Tikhonov, 261
- rejection sampling, 160
- residual, 49, 218
- residual standard error (RSE), 80
- residual sum of squares (RSS), *see* sum of squares, residual
- ridge regression, 261–265
- Riemann sum, 65
- robust statistics, 48
- root mean square (RMS), 96, 256
- sampling, 31, 154–155
 - improper distributions, 176
 - Monte Carlo, *see* Monte Carlo, sampling
- sampling distribution, 205
- signal-to-noise ratio (SNR), 19, 107, 139
- simplex method, 281
- skew, 12
- smoother matrix, 270
- spline, 266–269
 - smoothing, 269–270
- standard deviation, 12
 - in the mean, 44, 129
 - sample, 12, 44
- standard error in the mean, *see* standard deviation, in the mean
- standardization, 260
- Stirling's approximation, 30
- stochastic process, 38
- stopping problem, 248–252
- sum of squared residuals, *see* sum of squares, residual
- sum of squares
 - explained, 79
 - regression, *see* sum of squares, explained
 - residual, 76, 87, 256
 - total, 80
- support, 9
- t test, 210–218, 237–238
 - Welch, 217
- Taylor expansion, 50, 52, 142
- telescope, 19
- test set, 256
- thinning, 165
- three doors problem, 4–5, 35
- training set, 256
- true negative, 58
- true positive, 58
- type I and II errors, 206
- uncertainty, 37
 - propagation, 50–54
- underdetermined, 187

unit normal distribution, *see* distributions, Gaussian
(standardized)

utility, 66

variance, 11, 50

sample, 12

z test, 206–209, 215–216