

Index

Numbers in *italics* indicate tables or figures without text on that page

Number followed by 'ap' are in the appendices

- additive independence, utility 202–3
- Aids example, Bayes' theorem 62
- aircraft arrival example, Poisson distribution 100
- aircraft safety 523
 - indicator lights 61
 - risk per flight 523
- ALARP* (as low as reasonably practicable) principle 547, 548
- analysis-of-variance (ANOVA) approach, regression analysis 596–7
- arctic shipping examples
 - conjugate prior distribution 416–17
 - random 'blows' 460–3
- 'arrival rates', rare extreme events 501–2, 504
- artificial variables 251
- as low as reasonably practicable (*ALARP*) principle 547, 548
- asymptotic distributions
 - about asymptotic distributions 479–82
 - convergence classes E1, E2 and E3 485–7
 - Generalized Extreme Value (GEV) distribution 481
 - relationships between types 480–3
 - stability postulate 484–5
 - type I, exponential type leading to Gumbel distribution 480, 481–2
 - type II, Cauchy type leading to Fréchet distribution 480, 481
 - type III, limited type leading to Weibull distribution 480
 - von Mises form combining version 481
 - see also* Fréchet distribution: type II; Gumbel (double exponential) distribution: type I; Weibull distribution: type III
- attributes
 - about attributes 162–4
 - cost and safety 163
 - deaths and injuries 192
 - increasing and decreasing 188–91
 - value of 163
 - measurement 184–8
 - interval scale 186
 - nominal scale 185
 - ordinal scale 185–6
 - ratio scale 186
 - money/utility as an attribute 172–8
 - preferences under certainty example 186–7
 - preferences under uncertainty example 187
 - quantitative analysis of 164
 - special dice, intransitive real-life choice example 187–8
 - transitivity 185–6
 - see also* basic reference lottery tickets (*BRLTs*); farmer's dilemma (utilities/attributes example); utility/utility theory
- autocorrelation coefficient 151
- autocorrelation function 151, 351–2
- autocovariance 151, 152
- automatic profit, and insurance 28
- 'Bald Soprano' example, conditional probability 45
- basic reference lottery tickets (*BRLTs*)
 - basic construction 175
 - certainty equivalent 176
 - expected monetary value (*EMV*) 176–7
 - and expected utilities 178, 180, 182
 - and π -values 178–82
 - risk premium 177
 - utility analysis 175–6
- basic risk 547
- bathub curve (hazard function) 478, 479
- Bayes' postulate
 - added 'scholium' 397, 398
 - and the beta distribution 393–4
 - historical note 396–7
 - and prior distributions 396, 398

- Bayes' theorem 48–63
 about Bayes' theorem using urns 48–9
 Aids example 62
 Bayes' calculation tree 51, 58, 59
 calibration and common sense 62
 coins, two headed/honest example 58
 communication system example 56–8
 and degree of belief 60
 and everyday life 58–61
 and exchangeability 383–4
 and exchangeable random quantities 401–2
 experimentation 203–6
 formal introduction 49–51
 and imperfect testing 61
 and inductive reasoning 63
 and inference 379–80, 389–90
 and mind changing/updating 56
 murder suspects example 58–61
 and rare disease testing 61
 Venn diagram for 50, 55
 welding flaws example 49–55
- Bayesian approach
 and the binomial distribution 391–2
 and classical estimation methods 418–19
 frequency and probability 12–13
see also inference
- Bayesian expected value, EMV example 130, 131
- Bayesian parameter and monte carlo
 methods 610
- Bayesian thought experiment, entropy 298–9
- Bernoulli, D., on utility 163
- Bernoulli distribution, property summary 621–3ap
- Bernoulli trials, and binomial distributions 92–3,
 94
- Bernstein, P. L., on uncertainty 14
- Bessel's correction 565
- best fit determination 601–3
- beta function/distribution 389–90
 and Bayes' postulate 393
 for estimating the binomial parameter 391, 392
 properties summary 622ap, 627–8ap
- beta-binomial distribution, properties summary 624ap
- betting
 and coherence/incoherence 29, 52, 53, 54
see also fair bet concept
- Beveridge and Schechter constraints example 237
- bias analysis, classical method and Bayesian fly in the ointment 433–4
- bimatrix payoff representation 229
- binomial distribution
 and Bernoulli trial 92–3, 94
 binomial random quantity 358–60
 estimation using the beta distribution 391, 392
 negative binomial distribution 95–6
 property summary 621ap, 623ap
 transition from binomial to normal distributions 360–4
see also Poisson distribution
- binomial formula, and Pascal's triangle 71–3
- binomial parameter 389–398
 and reference prior 424
- bins 569
- birthday problem 78–9
- blackbodies/blackbody radiation 299–301
 emission curves 302
- blue-eyed/brown-eyed people example 44–6
- Bolotin, V. V., maximum elastic strain failure criterion 497–8
- Boltzmann's formula/constant, entropy 291
- bookie operations 29
 Dutch books 29
- Boolean analysis/operations 31–2
 for risk analysis and management 544–5
 and set theory 36
- Bose–Einstein distribution/statistics 76–7, 301–10
- bosons 303
- bridge design example, optimization 229–31
- bridge elevation examples
 unknown mean of normal distribution 406–7
 unknown mean and variance of normal distribution 414
- bridge in Canada engineering, analogy to farmer's dilemma 165, 166
- Bridgman, P. W.
 on concepts 9–10
 operational definition of a concept 214
- BRLTs see* basic reference lottery tickets
- BSE, risk to the individual 525
- building extension example
 experimentation considerations (Bayes' theorem) 204–6
 normal form of analysis 206–10
- bundles concept for weakest link problems (Freudenthal) 501
- Calgary weather, and decision making 3–4
- calibration of instruments, and Bayes' theorem 62
- Canadian Standards Association safety classes 551–2
- canonical aspects, entropy 289–91
- canonical equations/form/stipulations, simplex method 246–8
- capacity and demand 453
- Cauchy distribution, properties summary 631–2ap
- cdf see* cumulative distribution functions (cdf), for discrete or continuous quantities

- Central Limit Theorem (model of sums)
 about Central Limit Theorem 356
 illustration 356–8
 non-identical independent random quantities 366
 normal approximation to the binomial 358–64
 proof 364–5
 second characteristic function and cumulants 365–6
 transition from binomial to normal distribution 360–4
 and unknown mean and variance of normal distribution 411
- centre of mass 134–5
 classical estimation methods 429
- certainty equivalent, *BRLTs* 176
- cfs* *see* characteristic functions (*of cfs*)
- chain, weakest link example 454
- characteristic (extreme/largest) values 472–4
- characteristic functions (*cfs*) 343–5, 620–36ap
 binomial distribution example 344–5
 gamma density example 347–8
 moment generation 349–50
 Poisson distribution example 345
 standard normal distribution example 345
 in two or more dimensions 354–6
- Chebyshev inequalities 367–9
 and laws of large numbers 370
 probability masses for 368
 ‘quadratic prevision’ example 369
- chi-square distribution 408, 414
 classical estimation method 432–3
 properties summary 622ap, 629–30ap
- chi-square goodness-of-fit test 578–80
- CJD/vCJD, risk to the individual 525
- classical estimation methods
 about classical methods 418–19, 444–6
 and Bayesian format/structure 418–19
 bias analysis and fly in the ointment 433–4
 binomial parameter 424–5
 centre of mass 429
 chi-square distribution 432–3
 confidence intervals and shortcomings 429–34
 and inference 418
 maximum likelihood 426–8
 parameters of scale 420–1
 point estimates 426, 428–9
 reference priors expressing indifference 418–26
 transformations to different powers 422
 unknown mean of normal distribution 419–20
 unknown mean and variance of normal distribution 423
 unknown variance of normal distribution 421–2
 variance 432
see also classical inference problems; hypothesis testing
- classical inference problems 438–43
 about classical methods 438–9
 common procedures 439–41
 offshore cable example 441–2
p-value 443
 paired observations 443
- codes of practice 556–7
- coefficient of kurtosis 140, 350, 567
- coefficient of skewness 139–40, 567
- coefficient of variation 132
- coherence/incoherence
 and assignment of probabilities 30–1
 and betting 29, 52, 53
 and conditional probability 52, 53
 definition 26–7, 28
 probabilistic incoherence 28
- coins
 biased example 66–7
 two headed/honest example, Bayes’ theorem 58
- combinatorial analysis 67–71
 binomial distribution 71–4
 birthday problem 78–9
 Bose–Einstein statistics 76–7
 and distinguishable/indistinguishable objects 68–9
 occupancy problems 76–7
 poker example 71
 Pólya’s urn 80–2
 random walk diagram 74–6
 replacement of objects 77–8
 urn model example 69–71
see also Pascal’s triangle
- compound Poisson process 146
- concavity of utility versus attribute given
 risk-averseness 189
- concrete acceptability decisions example 5–6, 7
- concrete specimen example, probability 21
- conditional expectation 138
- conditional preferences, utility/utility theory 200–1
- conditional probability 43–8
 ‘Bald Soprano’ example 45
 blue-eyed/brown-eyed people example 44–6
 and coherence/incoherence 52, 53
 and information 45
 and stochastic dependence 46
 urn model examples 46–7, 47–8
 wave height example 45–6
see also Bayes’ theorem
- conditional probability distributions, multi-dimensional problems 122–5
- confidence intervals
 classical estimation method and shortcomings 429–34
 linear regression 594–5

- conflict 220–1
 - animals in conflict 221
 - games against nature 220–1
 - ‘match-penny’ game 221
- congruential generating method for random numbers 605–6
- conjugate families of distributions
 - about conjugate families 390
 - and gamma distribution 412
 - likelihood function 404
 - unknown mean of normal distribution 403–7
 - bridge elevation examples 406–7
 - unknown mean and variance of normal distribution 410–15
 - unknown variance of normal distribution 408–10
- conjugate prior distribution
 - about conjugate prior distribution 402–3, 417–18
 - and exchangeable random quantities 508
 - Poisson distribution 415–17
 - arctic shipping example 416–17
- consequences, and decisions 4
- constituents, for finding partitions 32–3
- constraints
 - Beveridge and Schechter example 237
 - equality/inequality 236
- continuous distributions 113
 - properties summary 626–36ap
- continuous random quantities, multi-dimensional problems 117–20
- conventions 15–16
- convergence classes E1, E2 and E3 485–7
- convex/non-convex sets, linear optimization 239–41
- convolutions 336–40
 - electrical and mechanical systems 339
 - in engineering analysis 338–40
 - and linear transformations 345–8
 - and probability generating functions (*pgfs*) 341–2
 - Stieltjes notation 338
 - in terms of *cdfs* 337
- correlation
 - correlation coefficient 140–1, 597
 - and covariance 140–2
 - positive and negative 64
 - positive and negative coefficients 141
- cost coefficients, linear optimization 238
- cost/safety tradeoff 5, 546–7
- Coulomb–Mohr failure criteria 497
- counting processes 144–5
- covariance 140–3
 - and correlation 140–2
- critical quotient 486
- cumulative distribution functions (*cdf*) 620–36ap
 - continuous case 105
 - discrete case 93
 - characteristic (extreme/largest) values example 474
 - and coherence 117–20
 - and convolutions 337
 - notation 106
 - properties summary 112
 - and sampling from distributions 608–9
- dam spillway example of return period 471
- Darboux sums 637ap
- data reduction and curve fitting
 - about collection and use of data 561, 562, 563
 - Bessel’s correction 565
 - bridge elevation example 563, 564
 - chi-square goodness-of-fit test 578–80
 - data not normalised by location and scale parameters 574–7
 - degrees of freedom 565–6
 - dispersion 565–8
 - estimating model parameters 580
 - from data to probabilities 573, 577
 - geometric mean 564–5
 - goodness-of-fit tests 578–80
 - grouped data 568–9
 - histograms 568–9
 - kurtosis/coefficient of kurtosis 567
 - mean (average/arithmetical mean) 563–4
 - median 565
 - mode 565
 - ogives 570, 574, 576
 - probability plots 570–4
 - quantiles 566
 - range 565
 - sample coefficient of variation 566
 - sample variance 565
 - skewness/coefficient of skewness 567
 - standard deviation 565
 - tally charts 568–9
 - weighted mean 564
- data transmission service decision example 5, 6
- de Finetti, B.
 - and coherence 30–1
 - on exchangeability 384
 - and integration 640ap
 - and notation 15–16
 - and probability definition 429
- de Méré’s die tossing problem 455–7
- deaths and injuries, as attributes 192
- decision analysis 2, 383–5

- decision theory
 - decision trees 7
 - and risk management 542
 - and writing standards and rules 2
- decisions
 - about decisions and uncertainty 1–3
 - and Bayes' analysis and postulate 393–5
 - Calgary weather example 3–4
 - concrete acceptability example 5–6, 7
 - and consequences 4
 - data transmission service example 5, 6
 - design standards example 6–7
 - economic decision making 8
 - and inference 380–2
 - medical decision making 8–9
 - nature of a decision 3–9
 - oil wildcatter example 4–5
 - and prevision 4
 - and probabilities 4
 - rail route relocation example 5, 6
 - space probe example 394, 395
 - trees 3–8, 166, 172–3, 180–1, 183, 205, 228, 381, 395, 439, 516, 556
 - and utilities 4
- degrees of freedom 233, 565–6, 589–90
- demand and capacity 453
- demon's roulette, entropy 282–6
- dependence *see* stochastic dependence/independence
- design, and decision making 2
- design standards decisions 6–7, 556
- dice games
 - de Méré's two dice problem 170–1, 455–7
 - special dice, intransitive real-life choice example of attributes 187–8
- Dirac delta functions 113, 638–40ap
 - Dirac spike 353, 639ap
- discrete distributions, properties summary 620–5ap
- disjoint events 37
- disorder, and entropy 273–7
- dispersion 565–8
 - degrees of freedom 565–6
 - quantiles 566
 - sample coefficient of variation 566
 - sample variance 565
 - standard deviation 565
- distinguishable/indistinguishable objects, and combinatorial analysis 68–9
- distributions
 - infinitely divisible distributions 348
 - and moments 150–4
 - in more than one dimension 354
 - see also* probability distributions; transformation of distributions and random quantities
- domain of attraction, Gumbel type 467–9
- dominance, utility/utility theory 198
- double exponential distribution, class E2 468, 469
- duality (probability and utility) 212–14
 - dual linear problems/programs 253–7
 - duality theorem proof 255–7
 - primal problem 253–4
 - sets 83
- Dutch books 29
- emission curves 302
- EMV see* expected monetary value
- engineering analysis, convolutions in 338–40
- engineering design as a game against nature 223
- entropy
 - about entropy, disorder, chaos, certainty and uncertainty 272–3, 313–14
 - applications outside thermodynamics 310–13
 - Bayesian thought experiment 298–9
 - Boltzmann's formula/constant 291
 - canonical aspects 289–91
 - definition 273
 - demon's roulette 282–6
 - demon's urns 307–10
 - and disorder 273–7
 - Gibbs' ensemble of imagined copies 284–6
 - Gibbs' grand canonical ensemble 292–3
 - grand canonical ensemble 295–7
 - granular media example 311
 - and information 277–82
 - and Lagrangian/Lagrange multipliers 287–8, 292
 - maximizing with the entropy demon 274
 - maximizing leading to the Maxwell–Boltzmann distribution 286–91
 - maximum is absolute, proof 297–8
 - maximum-entropy probability distributions 291–7
 - exponential distribution example 293–4
 - normal distribution example 294
 - transition from discrete to continuous distributions 294–5
 - partition function 288, 290, 293
 - and Pascal's triangle 284
 - and prior probabilities 313
 - Schrödinger's nutshell 291
 - Shannon's theory 278–82
 - 'sum-over-states' (partition function) 290–1
 - transport example of entropy 311–13
 - Tribus presentation on entropy maximum 297–8
 - using Stirling's approximation 285
- equality/inequality constraints 236
- 'equally frangible rod', Lewis Carroll 103–6, 641–2ap
- ergodic chains/processes, Markov processes 149–50, 153–4

- estimation *see* classical estimation methods; failure probabilities estimation for systems and/or components
- estimation of failure *see* failure probabilities estimation for systems and/or components
- event trees, for risk analysis and management 542–3
- events
- equally likely 38
 - incompatible, mutually exclusive and disjoint 37
- excess variables and slack 236–7
- exchangeability
- about exchangeability 384–8, 444–5
 - and Bayes' theorem 383–4
 - exchangeable random quantities 399–402, 506–8
 - and *iid* assumptions 506–7
 - inference for 401–2
 - exchangeable sequences 384–8
 - and the hypergeometric distribution 99–100, 387
 - and independence 66–7
 - inference for exchangeable events 388–9
 - judgement of 388
 - and order of results 382–3, 384
 - partial exchangeability 443–4
 - and probability 38–9
 - and random/non-random data 383
 - and repeated trials 382
 - 'sufficient statistics' concept 384, 389
 - urn examples 385, 386
 - see also* inference
- exhaustive outcomes 28
- expectation, properties of 136–7
- expected monetary value (*EMV*) 130, 131, 170–2
- basic reference lottery tickets (*BRLTs*) 176–7
 - and Bayesian expected value example 130, 131
 - dice game example 170–1
 - money/utility as an attribute 172–8
 - oil wildcatter example 171–2
- expected utilities 180–3
- geometric representation 192–4
- expected values
- and decisions 130–2
 - see also* mean (expected value)
- exponential distribution 106–8, 348–9, 628ap
- of waiting times 107
- exponential parent distribution example 463–4
- exposure, to extremes 454
- extending the conversation (Myron Tribus) 55
- extremal-Fréchet type distribution, properties summary 635ap
- extremal-Gumbel type distribution properties summary 634–5ap
- extremal-Weibull type properties summary 635–6ap
- extreme voltage example of return period 471
- extremes
- about extremes and uncertainty 2, 453–5, 510–11
 - characteristic (extreme/largest) values 472–4
 - Gumbel distribution example 474
 - classes of parent
 - E1 Rayleigh distribution example 468, 469
 - E2 exponential distribution 468, 469
 - E3 lognormal distribution example 468, 469
 - and conjugate priors 508
 - demand and capacity 453
 - exchangeable random quantities 506–8
 - exponential parent distribution example 463–4
 - exposure considerations 454
 - exposure period variability 509
 - intensity and hazard function 478–9
 - and inter-period variation 509, 510
 - as a mixture 510
 - lognormal parent distribution 467
 - and maximum and minimum values 454
 - most probable largest values 475–7
 - parent probability distribution 462–3
 - random 'blows' arctic shipping example 460–3
 - return period of design loads 469–71
 - dam spillway example 471
 - extreme voltage example 471
 - stability postulate 484–5
 - system failure 453
 - time aspects 454
 - and uncertainty 508–9
 - waves example with a Rayleigh distribution of the amplitude of a Gaussian narrow band process 464–7
 - see also* asymptotic distributions; Poisson processes: rare extreme events; weakest link theories
- F*-distribution, properties summary 634ap
- factors of safety 551
- failure probabilities estimation for systems and/or components
- about failure estimation 526–7
 - demand and capacity 527–32
 - failure domain 532
 - failure rate/probabilities calculations 528–30, 539–41
 - failure rates 527
 - frequency of occurrences 538–41
 - generalization 531
 - human error 536–8
 - checking strategies 538
 - limit state function 529
 - margin of safety 529, 530
 - parallel systems 534–6, 537

- probability and frequency 538–41
- reliability 529
- series (weakest link) systems 533–6, 537
- systems of components 532–6
- fair bet concept 20–1, 26, 66–7, 618
 - historical note 17–18
- FAR* (fatality accident rate) 519, 521
- farmer's dilemma (utilities/attributes example)
 - about the farmer's dilemma 164–5
 - choice of crop 165, 166
 - in-betweenist solution 167–8
 - inconsistency problem 168–9
 - optimist's solution (maximax) 167
 - payoff matrix 165, 168
 - pessimist's solution (maximin) 165–7
 - regret matrix 168
 - regrettist's solution 168
 - tentative criterion/way out 169
- fatality accident rate (*FAR*) 519, 521
- fatigue study example, linear regression 585–6, 587
- fault trees, for risk analysis and management 543–4
- feasible space plot 232
- Feller, W., on occupancy with particle physics 76
- FMEA (failure modes and effects analysis) 549–50
- FMECA (failure mode, effect and criticality analysis) 550
- Fourier transforms
 - definition 350
 - and Laplace transforms 345
 - and spectral analysis 350–3
- Fréchet distribution: type II 480, 481, 492
 - properties summary 635ap
- frequency, and probability 12–15, 538–41, 568–70
 - and law of large numbers 370–1
- Freudenthal, A. M., on bundle concept 501
- gain floor and loss ceiling, games 258–9
- Galton, Francis, apparatus for bell-shaped distributions 573, 574
- games
 - antagonistic games 222
 - bimatrix payoff representation 229
 - and conflict 220–1
 - cooperative/non-cooperative games 223
 - definitions 222–5
 - engineering design as a game against nature 223
 - extensive/normal/matrix form 225–7
 - fair games 224
 - finite/infinite games 223
 - gain floor and loss ceiling 258–9
 - games against nature 220–1, 223
 - design 265–6
 - intelligent conflict 257–9
 - 'match-penny' game example 224–5, 228–9
 - matrix of payoffs 227–8
 - minimax solution 223
 - mixed strategies 225, 257–63
 - generalization 259–63
 - 'Nim' game example 225–8
 - 'odds and evens' game example 224
 - payoff matrix 222
 - perfect information games 225
 - pure conflict games 222
 - pure strategies 223–4
 - saddle points 224
 - value of a game 223
 - zero-sum games 222–3
 - see also* linear optimization; optimization
- gamma distribution
 - characteristic function example 347–8
 - and conjugate family 412
 - inverted, properties summary 630–1ap
 - MV Arctic ice ramming trials 574–7
 - properties summary 622ap, 629ap
 - standardized distribution example 326
- gamma function 374, 390
- Gaussian error curve 62
- Gaussian (normal) distribution *see* normal (Gaussian) distributions
- Generalized Extreme Value (GEV) distribution 481
- geometric distribution 96
 - properties summary 623–4ap
- geometric mean 564–5
- Gibbs' ensemble of imagined copies 284–6
- Gibbs' grand canonical ensemble, entropy 292–3
- goodness-of-fit tests 578–80
- grand canonical ensemble, entropy 295–7
- granular media example, entropy 311
- Gross National Product (GNP), risk and happiness issues 557–8
- Gumbel (double exponential) distribution: type I
 - about Gumbel distribution 467–9, 480, 481–2, 482–4
 - characteristic extreme value example 474
 - critical quotient 486
 - domain of attraction of Gumbel type 467–9
 - general derivation of 487–9
 - and the stability postulate 484–5
 - standardized Gumbel distributions 482, 483
- hazard function
 - bathtub curve 478, 479
 - and intensity 478–9
- hazardous occupations 523–4
- HAZOP (hazard and operability) studies 549
- Heaviside step functions 113, 638–40ap
- histograms 568–9

- historical note 16–19
- Holmes' lawn example, stochastic
dependence/independence 64
- homogeneous processes 146, 150
- human error 536–8
checking strategies 538
- human happiness and risk issues 557–8
- hypergeometric distribution 96–100, 116–17
and exchangeability 99–100, 387
Lotto example 98–9
properties summary 621ap, 624–5ap
urn examples 97–8
- hypothesis testing, classical method
about hypothesis testing 434–5
methodology 435–7, 439
type 1 and 2 errors 437–8
- ice under compression example, weakest link theories
500–1, 502
- icebergs
populations example of extremes 509–10
and the Titanic 40–4
- iid* *see* independent and identically distributed (*iid*)
random quantities
- imperfect testing, and Bayes' theorem 61
- importance sampling 611–12
- incoherence *see* coherence/incoherence
- incompatible events 37
- incompatible outcomes 28
- independence
additive utility independence 202–3
and exchangeability 66–7
logical independence 65–6
stochastic 46, 63–6
mutual utility independence 203
utility independence 201–3
see also stochastic dependence/independence
- independent and identically distributed (*iid*) random
quantities 143, 455
and the Central Limit Theorem 356–8, 455
de Méré's die tossing problem 455–7
and ordered random quantities 457–9
- independent random quantities 125–6
- indifference 11–12
- indifference surfaces, utility/utility theory 199
- inductive reasoning, and Bayes' theorem 63
- inference
about inference 378–82
and Bayes' theorem 379–80, 389–90, 401–2
and classical estimation methods 418
decision trees 381
and decisions 380–2
for exchangeable events 388–9
for exchangeable random quantities 399–402
with plenty/shortage of data 380
and 'population' 380
and 'preposterior' analysis 382
probabilistic inference 205
and probability theory 382
and variance 411
see also classical inference problems; conjugate
families of distributions; exchangeability
- inferred probabilities 38
- infinitely divisible distributions 348
- information, and entropy 277–82
- inhomogeneous stress states 495–9
see also weakest link theories
- injuries and deaths, as attributes 192
- insufficient reason principle 38
- insurance 27–8
and automatic profit 28
- integration for engineers/scientists/economists 640–1ap
- intelligent conflict, games 257–9
- intensity, and hazard function 478–9
- inverse transform technique in Monte Carlo simulation
610
- inverted gamma distribution, properties summary
630–1ap
- Jacobian matrix 327–9
for transformation of distributions 332–3
judgement of probability 10–11
- Kirchhoff's law of heat exchange 301
emission curves 302
- kurtosis (flatness), coefficient of kurtosis 140, 350, 567
- lagged Fibonacci generators (*lfgs*) 606
- Lagrange multipliers 231–5
degrees of freedom 233
with entropy 287–8
numerical example 234–5
stationary points of the constrained function 235
- Laplace (double-exponential) distribution, properties
summary 628–9ap
- Laplace transforms 345
- large numbers, laws of 370–1
probability and frequency aspects 370–1
and simulation 371
strong law 370
weak law 370
- least squares method *see* method of least squares
- Lebesgue integration 640–1ap
- Lewis Carroll's 'equally frangible rod' 103–6, 641–2ap
- liability risk 547
- lie detection 61

- likelihood/likelihood function 404
 - definition 56
- limit states
 - limit state function 529
 - structures 550
- Lindley, D. V., on unknown variances of normal distributions 410
- linear optimization/linear programming
 - about linear optimization 237–9
 - applications of linear programming 257
 - convex hull 240
 - convex/non-convex sets 239–41
 - cost coefficients 238
 - dual linear problems/programs 253–7
 - duality theorem proof 255–7
 - geometric aspects 239–41
 - graphical solution example 238–9
 - primal problem 253–4
 - segments 239
 - simplexes 240–1
 - stipulations 238
 - structural coefficients 238
 - vertex/extreme point 240
 - see also* games; simplex method, linear programming
- linear regression
 - about linear regression 580–93
 - analysis-of-variance (ANOVA) approach 596–7
 - confidence intervals 594–5
 - correlation coefficient 597
 - data pairs 582
 - degrees of freedom 589–90
 - fatigue study example 585–6, 587
 - future response 595–6
 - mean response 595
 - method of least squares 583–6
 - regression line estimation 583–6
 - sample coefficient of determination 597
 - sample correlation coefficient 597
 - uncertainty in mean response 591–3
 - uncertainty in model parameters 586–91
 - uncertainty regarding future response 593
 - uncertainty in X : Bayesian approach 598–9
 - see also* regression
- log-odds 425–6
- logic gate symbols 544
- logical independence 65–6
- logistic distribution 319
 - properties summary 631ap
- lognormal distribution
 - class E3 468, 469
 - properties summary 622ap, 633ap
- lognormal parent distribution, extremes/extreme conditions 467, 468
- loss ceiling and gain floor, games 258–9
- lottery 11, 12
 - and *BRLTs* 175–8
- Lotto example, hypergeometric distribution 98–9
- management of risk *see* risk analysis and management
- margin of safety 175, 529, 530
 - see also* failure probabilities estimation for systems and/or components
- marginal distributions, multi-dimensional problems 120–2
- marginal rate of substitution, utility/utility theory 200
- Markov processes 147–50
 - counting processes example 148
 - ergodic chains/processes 149–50, 153–4
 - queue examples 148–9, 149–50
 - and stationarity 149
- ‘match-penny’ game example 221, 224–5, 228–9
 - mixed strategy games 263–5
- MATLAB computer program example 607–8
- maximization and minimization 231
- maximum likelihood classical estimation method 426–8
- Maxwell–Boltzmann statistics/distribution 77, 286–91
- mean (data)
 - average/arithmetic mean 563–4
 - geometric mean 564–5
 - weighted mean 564
- mean (expected value) 127–9
 - conditional expectation 138
 - mathematical manipulation 135–7
 - and properties of expectation 136–7
 - urn and decisions 130–2
 - waiting times example 127–8
- median 565
- medical decision making 8–9
- method of least squares 583–6
 - ‘normal equations’ 584
 - ‘sums of the squares of the errors’ (*SSE*) 583–5
- mgfs see* moment generating functions
- mind changing/updating 56
- minimization and maximization 231
- mixed discrete and continuous distributions 113
- mixed strategies, games
 - about mixed strategies 225, 257–9
 - generalization 259–63
 - ‘match-penny’ example 263–5
- mode 128, 427, 565
- model uncertainty, structural systems 553
- models, about choice of probabilistic models 561–2

- moment generating functions (mgfs) 343–4
 - binomial distribution example 344–5
 - convolution example 347
 - moment generation 349–50
 - Poisson distribution example 345
 - standard normal distribution example 345
 - in two or more dimensions 354–6
- moments 138–40
 - central moments 138
 - coefficient of skewness and kurtosis 139–40, 350, 567
 - moments about the origin 138
 - practical interpretation 139
 - and moment generating functions (mgfs) and characteristic functions (cfs) 349–50
 - and probability generating functions (pgfs) 342–3
- Monte Carlo simulation
 - about Monte Carlo simulation 320, 603, 612
 - basis of method 603–4
 - Bayesian parameter 610
 - historical comments 603–5
 - hit-or-miss versus expected value methods 607–8
 - importance sampling 611–12
 - inverse transform technique 610
 - MATLAB computer program example 607–8
 - random numbers 605–7
 - sampling from distributions 608–10
 - variance reduction 611–12
 - see also* random numbers
- Morison's equation 317
- most probable largest values, extremes/extreme conditions 475–7
- multidimensional problems *see* two or more dimensional problems
- multidimensional normal distribution 636ap
- multinomial distributions 116–17
- multiplication principle 67–8, 97
 - permutations of objects 67–8
 - and random walk concept 75–6
- murder suspects example, Bayes' theorem 58–61
- mutual utility independence 203
- mutually exclusive events 28, 37
- MV Arctic dedicated ice ramming trials 460–3
 - gamma distribution for data 574–7
 - ogive for data 574, 576
- National Hockey League example, unfinished games and Pascal's triangle 73–4
- negation 11–12
- negative binomial distribution 95–6, 621ap
 - geometric distribution 96
 - property summary 621ap, 623–4ap
- Nessim *et al.*, on uncertainty 508–9
- 'Nim' game example 225–8
- non-linear regression and regression in several dimensions 599
- 'normal equations', method of least squares 584
- normal form of analysis 206–11
 - strategies listing 206–8
- normal (Gaussian) distributions 108–11
 - cumulative density function 108, 109
 - probability density function 108, 109
 - properties summary 109, 622ap, 632–3ap
 - standard normal distribution 110–11
 - strength of masonry example 111
 - unknown mean 403–7, 419–20
 - unknown mean and variance 410–15, 423–4
 - unknown variance 408–10
 - classical estimation method 421–2
- normalization of probabilities 29
- notations
 - convolutions, Stieltjes 338
 - cumulative distribution function (cdf) 106
 - integrals, Stieltjes 112–13
 - prevision 16
 - probability density function (pdf) 106
 - probability mass function (pmf) 106
 - random quantities 16
 - vector random quantities 331
- null events 37
- objective function 230
- objectivity 9
- occupancy problems 76–7
- odds, and probability 24–5
- 'odds and evens' game example 224
- offshore cable example, classical inference problem 441–2
- offshore industry
 - human factors and safety 537
 - WOAD (Worldwide Offshore Accident Databank) 524
 - work hazards 524
- ogives 570, 574, 576, 600
- oil wildcatter example, expected monetary value (EMV) 171–2
- oil wildcatters' dilemma 4–5
- optimal strategies 209–10
- optimization
 - bridge design example 229–31
 - constraints 230–1
 - degrees of freedom 233
 - engineering applications 229–31
 - entropy 286–7
 - equality/inequality constraints 236
 - Lagrange multipliers 231–5
 - minimization and maximization 231

- objective function 230
- product mix example 231, 232
- slack and excess variables 236–7
- transportation problem 250–3
 - see also* games; linear optimization/linear programming
- order relations 11
- ordered random quantities, and *iid* 457–9
- ordering of set of objects 67–8, 70

- p*-value, inference problems 443
- paired observations, inference problem 443
- pairwise preferential independence, utility theory 201
- parallel and series systems, failure probabilities 533–4
- parameters of scale, estimation methods 420–1
- parent probability distribution 462–3
 - exponential parent distribution example 463–4
- Pareto distribution, properties summary 632ap
- partial exchangeability 443–4
- partitions 28
 - finding using constituents 32–3
 - partition function, entropy 288, 290, 293
- Pascal distribution 96
- Pascal's triangle 71–4
 - and the binomial formula 71–3
 - and entropy 284
 - exchangeable sequences 73
 - National Hockey League unfinished game example 73–4
 - and random walks 71, 72
- Paulos, J. A., on rare disease testing 61
- payoff matrix 222, 260–3
 - farmer's dilemma example 165, 168
- pdf see* probability density function (*pdf*), for continuous quantities
- peak over threshold (POT) model 506
- perception of risk 525–6
 - circles of perception of risk 526
- permutations of objects 67–8
 - complete permutations 68
- pgfs see* probability generating functions (*pgfs*)
- phase-plane diagrams 153
- photons 303
- π -values 178–83
 - and *BRLTs* 178–82
- Planck's constant/equation 305, 306
- plotting positions 599–603
 - best fit determination 601–3
 - construction of the ogive 600–1
 - plotting position types summary 603
- pmf see* probability mass function (*pmf*), for discrete quantities
- point estimates, classical methods 426, 428–9
- point processes 145, 146
- Poisson distribution 100–3, 621ap
 - aircraft arrival example 100
 - communication examples 101–3
 - conjugate prior distribution for 415–17 and process 145–6
 - properties summary 621ap, 625ap
- Poisson process 145–6
- Poisson processes: rare extreme events 501–6
 - arrival rates 501–2, 504
 - simple scaling 505
 - waves in storms example 504
- Pólya's interpretation/urn, and prior distributions 397–8
- Pólya's urn 80–2
 - 'population', and inference 380
- positive linear transformations, utilities 183–4
- 'posterior' assessment 51
- POT (peak over threshold) model 506
- potential behaviour, historical note 17
- power spectral density (*psd*) 351–3
- PPHA (preliminary process hazard analysis) 549
- preferences 11–12, 162–202
 - conditional preferences 200–1
 - under certainty 186–7, 198–201
 - under uncertainty 187, 201–3
- preferential independence, utility theory 201
- 'preposterior' analysis 204
 - and inference 382
- prevision
 - and decisions 4
 - notation explained 16
 - 'quadratic prevision' example of Chebyshev inequalities 369
- prior distributions 383, 389, 396–8, 401–18
 - and Bayes' postulate 396
 - and conjugate families 445
 - Fisher and Pearson criticism 396
 - Pólya's interpretation/urn 397–8
 - reference priors expressing indifference 418–26
- prior of proportionality
 - and the binomial parameter 424–5
 - and log-odds 425–6
- prns* (pseudorandom numbers) 605–6, 607, 608
- probabilistic analysis, and regression 582–3
- probabilistic inference 205, 378–446
- probabilities of failure *see* failure probabilities
- probability density function (*pdf*), for continuous quantities 103–5
 - more than two random quantities 126–7
 - notation 106
 - properties summary 112

- probability distributions
- about probability distributions 90–1, 318, 371–2
 - Bernoulli trials 92–3, 94
 - binomial distribution 92–3, 94
 - conditional probability distributions 122–5
 - continuous distributions 113
 - properties summary 626–36ap
 - cumulative distribution functions (*cdfs*) 93
 - discrete distributions, 91–2
 - properties summary 620–5ap
 - exponential distribution 106–8
 - geometric distribution 96
 - hypergeometric distribution 96–100, 116–17
 - mixed discrete and continuous distributions 113
 - multinomial distributions 116
 - negative binomial distribution 95–6
 - normal (Gaussian) distribution 108–11
 - renormalization 113–14
 - truncation 113–14
 - uniform distribution 103–106
 - variance of 132–5
 - see also* asymptotic distributions; Poisson distribution; transformation of distributions; two or more dimensional problems
- probability and frequency, and law of large numbers 370–1
- probability generating functions (*pgfs*) 340–3
- and convolutions 341–2
 - and moments 342–3
 - Poisson distribution examples 341, 342–3
- probability integral transform 319–20, 609
- probability mass function (*pmf*), for discrete quantities 93, 620ap
- more than two random quantities 126–7
 - notation 106
 - properties summary 112
- probability/probability analysis 9–10
- about probability and uncertainty 618–19
 - about probability and utility (duality) 210–14
 - assessment of 37–43
 - assigning probabilities 20–5, 37–8, 39, 59
 - behavioural view 15
 - birthday problem 78–9
 - classical assignments 37–8
 - compound events 33–5
 - and decisions 4
 - definition 21–4, 26–7
 - evaluation 14, 22–3
 - exchangeability 38–9, 66–7
 - fair bet concept 20–1, 26, 66–7, 618
 - and frequency 12–15, 538–41
 - geometric 37–8, 157–8
 - historical note 16–19
 - judgement of 10, 44
 - as a linear operation 27
 - measurement of 24
 - necessary assignments 37–8
 - normalization of probabilities 29
 - occupancy problems 76–7
 - and odds 24–5
 - Pólya's urn 79–82
 - 'posterior' assessment 51
 - probabilistic incoherence 28
 - probability plots 570–4
 - rate of inflation example 14
 - and relative frequencies 38–9
 - rule for life 25
 - subjective nature of 1, 9, 20–31
 - theorem of total probabilities 29
 - urn example 23
 - see also* Bayes' theorem; coherence/incoherence; combinatorial analysis; conditional probability; Pascal's triangle; set theory; stochastic dependence/independence
- processes
- counting processes 144–5
 - discrete and continuous 144–5
 - homogeneous processes 146, 150
 - with independent increments 144–7
 - intensity of 146
 - Markov processes 147–50
 - point processes 145, 146
 - Poisson process 145
 - Wiener–Lévy process 147
 - see also* random processes
- product mix example, optimization 231, 232
- proportionality, and the binomial parameter 424
- psd* (power spectral density) 351–3
- pseudorandom numbers (*prms*) 605–6, 607, 608
- 'quadratic prevision' example of Chebyshev inequalities 369
- quantiles 566
- quasirandom numbers 606
- Raiffa, H.
- on expected utilities 181
 - on utility, and mean and standard deviation 174
- Raiffa's urns *see* urn model examples
- rail route relocation decisions 5, 6
- random 'blows' arctic shipping example 460–3
- random events 21
- random numbers 605–7
- congruential generating method 605–6
 - lagged Fibonacci generators (*lfgs*) 606
 - pseudorandom numbers (*prms*) 605–6, 607, 608

- quasirandom numbers 606
- statistical tests for 607
- see also* Monte Carlo simulation
- random processes (stochastic processes)
 - about random processes 144
 - discrete and continuous 144, 145
 - see also* distributions; Markov processes; processes
- random quantities
 - about random quantities 21, 90
 - continuous random quantities 90, 103
 - discrete random quantities 90
 - functions of 317
 - iid* (independent and identically distributed) 143–4, 455
 - linear functions of 142–4
 - notation explained 16
- random walk concept 71, 72, 74–6
- range 565
- ranked data 572
- rare disease testing, and Bayes' theorem 61
- rare extreme events *see* Poisson processes: rare extreme events
- rate of inflation probability example 14
- Rayleigh distribution
 - class E1 468, 469
 - from Gaussian process 330–1
 - properties summary 622ap, 630ap
- Rayleigh distribution of the amplitude of a Gaussian
 - nanor band process, wave example 464–7
- reference prior distributions 418–26
- regression
 - about regression and linear regression 580–3
 - modelling regression 581–2
 - origin of usage 581
 - and probabilistic analysis 582–3
 - see also* linear regression
- regression analysis *see* linear regression
- relative frequencies 38–9, 568–70
- see* frequency
- reliability
 - definition 529
 - see also* failure probabilities estimation for systems and/or components
- reliability index 175
 - structural systems 554–5
- reliability theory 526–36, 553–7
- renormalization and truncation 113–14
- repeated trials, for probability distributions 92
- replacement of objects 77–8
- return period of design loads 469–71
 - dam spillway example 471
 - extreme voltage example 471
- Riemann integral 637–8ap
- risk
 - about risk 1, 514–15, 516
 - about risk and engineering 2
 - aversion 162–9
 - codes of practice 556–7
 - decisions involving 516
 - economic issues 557–8
 - risk mitigation 542
 - risk premium, *BRLTs* 177
 - risk-prone problem 173, 190
 - risk-averse utility functions 192–4
 - risk-averseness, structural systems 554
 - risk-aversion 173, 188–92
 - measures of 195–7
 - small probabilities 517–18
 - and uncertainty 13–14
 - see also* failure probabilities estimation for systems and/or components; structural systems, risk and safety
- risk analysis and management 515, 541–50
 - ALARP* (as low as reasonably practicable) principle 547, 548
 - basic risk 547
 - and decision theory 514–15, 542
 - domain of 517
 - event symbols 544
 - with event trees 542–3
 - with fault trees 543–4
 - liability risk 547
 - reliability block diagrams 546
 - and risk mitigation 542
 - safety levels/target probabilities 545–7
 - safety/economy tradeoff 546–7
 - target risk values 548–9
 - voluntary risk 547
 - see also* failure probabilities estimation for systems and/or components; structural systems, risk and safety
- risk to the individual
 - about risk to the individual 518–19
 - aircraft safety 523
 - BSE 525
 - for Canadians as an example 518–19
 - circles of perception 526
 - CJD/vCJD 525
 - fatality accident rate (*FAR*) 519, 521
 - human happiness issues 557–8
 - perception of risk 525–6
 - probability per year 518
 - risk at work 523–5
 - smoking 519–20
 - traffic/road accidents 518, 520–2
 - annual death rate per vehicle 522
 - road accidents *see* traffic accidents

- saddle points, games 224
- safety
- about safety and engineering 2
 - aircraft safety 523
 - Canadian Standards Association safety classes 551–2
 - cost/safety tradeoff 5
 - factors of safety 551
 - and hazardous occupations 523–4
 - margin of safety/safety margin 175, 529, 530
 - safety index (*SI*) 515–17, 555
 - safety levels/target probabilities 545–7
 - safety/economy tradeoff 546–7
 - see also* risk to the individual; structural systems, risk and safety; work hazards
- sample coefficient of determination 597
- sample coefficient of variation 566
- sample correlation coefficient 597
- sample points, and set theory 35–6
- sample space, and set theory 35–6
- scale effects, weakest link theories 499–500
- scaling, simple scaling, rare extreme events 505
- Schrödinger's nutshell, entropy 291
- security blanket 380
- segments, linear optimization 239
- sensitivity analysis 619
- series and parallel systems, failure probabilities 533–4
- set theory 35–7
- and Boolean notation 36
 - and sample space, sample points and possibilities 35
- Shannon's theory, entropy 278–82
- SI* (safety index) 515–17, 555
- simple scaling, Poisson processes: rare extreme events 505
- simplex method, linear programming
- about the simplex method 241–2
 - artificial variables 251
 - basic solutions 244
 - basic variables 244
 - canonical equations/form/stipulations 246–8
 - feasible solutions 245
 - method description 243–5
 - multiple solutions 249
 - non-negativity 244
 - Phase I of simplex algorithm 249–53
 - Phase II of simplex algorithm 245–9
 - simplex tableau 248–9
 - standard linear programming form 242–3
 - transportation problem 250–3
- simulation
- about simulation 562
 - and law of large numbers 371
- skewness/coefficient of skewness 567
- slack and excess variables 236–7
- smoking, risk to the individual 519–20
- space probe example, decisions 394, 395
- spectral analysis, and Fourier transforms 350–3
- SSE* (sums of the squares of the errors) 583
- stability postulate 484–5
- standard deviation 132, 403, 565
- standard normal distribution 110–11
- standardized distributions 324–6
- example 325
- stationarity, and Markov processes 149
- Stieltjes integral 112–13, 637–8ap
- and mean 129
- Stieltjes notation, convolutions 338
- Stigler, S. M., on Bayes' postulate 397
- stipulations, linear optimization 238
- Stirling's approximation
- with entropy 285
- stochastic dependence/independence 63–7
- Holmes' lawn example 64
 - and judgement regarding probability 63–4
 - and positive/negative correlation 64–5
 - and truth (certainty) 63
- stochastic processes
- see* processes; random processes
- strategies
- for conflict 220–1
 - pure strategies 223–4
- structural coefficients, linear optimization 238
- structural systems, risk and safety 550–7
- Canadian Standards Association safety classes 551–2
 - factors of safety 551
 - iron bridges 551
 - limit states 550
 - model uncertainty 553
 - reliability index 554–5
 - and risk-averseness 554
 - stone arches 550
 - tail regions of load and demand curves 553
 - use of first and second moments only 553–4
 - with wood 551
- student's *t*-distribution, properties summary 622ap, 633–4ap
- subjectivity 9
- 'sufficient statistics', and exchangeability 384, 389
- 'sum-over-states' (partition function), entropy 290–1
- 'sums of the squares of the errors' (*SSE*) 583–5
- symmetry property 350
- system failure 453

- tally charts 568–9
- terminology 15
see also notations
- theorem of total probabilities 29
- theory of errors, and unknown mean of normal distribution 403
- thermodynamic models and urn equivalents 310
- time, and extreme values 454
- Titanic, collision probability 31–2, 39–43, 44
- traffic accidents 518, 520–2
 annual death rate per vehicle 522
 and perception of risk 525–6
- transformation of distributions and random quantities
 about transformation of random quantities 318, 371–2
 about transforming distributions 318
 Jacobian matrix 327–9
 linear transformations 345–8
 Rayleigh distribution from Gaussian process example 330–1
 and reliability theory 329–30
 several random quantities 331–6
 multidimensional normal distribution example 333–6
 using Jacobians 332–3
 vector notation 331
- single random quantities 319–24
 coin tossing example 322
 continuous distributions 320
 cumulative distribution functions 319
 increasing and decreasing quantities 323
 non-monotonic relationships 321
 probability integral transform example 319–20
 rectangular beam example 323–4
 standard logistic distribution example 319
- standardized distributions using location and scale parameters 324–6
 gamma distribution example 326
 for normal, exponential and Gumbel distributions examples 325
- two random quantities 326–31
see also characteristic functions (*cf*s); moment generating functions (*mgf*s); probability generating functions (*pgf*s); single random quantities
- transition to probability 577
- transitivity, attributes 185–6
- transport example of entropy 311–13
- transportation problem 250–3
- triangular distribution, properties summary 627ap
- Tribus presentation on entropy maximum 297–8
- truncation and renormalization 113–14
- two or more dimensional problems 114–27
 about multidimensional problems 114, 115
 coherence and *cdf*s 117–20
 conditional probability distributions 122–5
 continuous random quantities 117–20
 discrete random quantities 114–117
 hypergeometric distributions 116–17
 independent random quantities 125–6
 marginal distributions 120–2
 more than two random quantities 126–7
 multinomial distributions 116–17
 multidimensional normal distribution 294, 315, 333, 636ap
 properties summary, two dimensional distributions 120
- two or more dimensions, distributions in 354–6
- two-dimensional normal distribution, properties summary 622ap, 636ap
- uncertainty
 about uncertainty and decision making 1–9
 about uncertainty and probability 9, 14, 16, 20–5, 272, 618–19
 and extreme conditions 508–9
 from one-off events 13
 from repetitive experiment 12–13
 preferences under 201–3
 and risk 13–14
- uncertainty, with linear regression
 Bayesian approach 598–9
 in mean response 591–3
 in model parameters 586–96
 regarding future response 593
- undetermined multipliers 233
- uniform distribution, properties summary
 continuous 622ap, 626ap
 discrete 620–1ap
- unit step function 638–40ap
- updating probabilities/updating factor 56
- urn model examples
 with balls of many colours 79–80
 Bayes' theorem introduction 48–9
 betting 52, 53, 54
 combinatorial analysis 69–71
 conditional probability 46–8
 exchangeability 385, 386
 hypergeometric distribution 97–8
 mean (expected value) 132
 Pascal's triangle 71–2
 Pólya's urn 80–2
 probability 10–11, 23
 Raiffa's urns 47–9, 84–5, 130–2
 replacement of objects 77–8

- utility/utility theory
 - about utility and attributes 162–4
 - about utility and probability (duality) 210–14
 - additive independence 202–3
 - concavity of utility versus attribute given risk-averseness 189
 - conditional preferences 200–1
 - and decisions 4
 - dominance 198
 - expected utilities 180–3
 - geometric representation 192–4
 - experimentation considerations 203–6
 - historical note 17
 - increasing and decreasing attributes 188–91
 - indifference surfaces 199
 - marginal rate of substitution 200
 - mean and standard deviation as measure 173–4
 - money/utility as an attribute 172–8
 - multidimensional utility 197–203
 - mutual utility independence 203
 - non-linearity of 163–4
 - pairwise preferential independence 201
 - positive linear transformations 183–4
 - preferences under certainty 198–201
 - preferences under uncertainty 201–3
 - preferential independence 201
 - ranking of utilities 183
 - subjective nature of 1, 210
 - utility function and risk aversion 194–7
 - utility independence 201–3
 - and value function 198
 - see also* attributes; basic reference lottery tickets (*BRLTs*); expected monetary value (*EMV*); farmer's dilemma (utilities/attributes example); risk
- value function, and utility/utility theory 198
- variance of a probability distribution 132–5
 - and centre of mass 134–5
 - coefficient of variation 132
 - and inference 411
 - minimum variance: analogy to mechanics 133–4
 - and standard deviation 132
- variance reduction 611–12
- Venn diagrams 34
 - with Bayes' theorem 54, 55
- and probability of compound events 33–5
- with welding flaws 50
- voluntary risk 547
- von Mises form distributions 481
- von Neumann, J., on fair bets with biased coins 66–7
- waiting times example, mean 127–8
- waves
 - example with a Rayleigh distribution of the amplitude of a Gaussian narrow band process 464–7
 - height example, conditional probability 45–6
 - waves in storms example, Poisson processes: rare extreme events 504
- weakest link theories
 - about weakest links 494–5
 - applications 500–1
 - beam under bending moment example 498–9
 - bundles concept (Freudenthal) 501
 - chain example 454, 494–5
 - Coulomb–Mohr failure criteria 497
 - ice under compression example 500–1, 502
 - inhomogeneous stress states 495–9
 - elements in series example 496
 - maximum elastic strain failure criterion (Bolotin) 497–8
 - scale effects 499–500
 - and Weibull's theory 495, 496–7
 - see also* failure probabilities estimation for systems and/or components
- Weibull distribution: type III 480, 492–4
 - extremal-Weibull distribution, properties summary 635ap
- Weibull's theory, and weakest link theories 495, 496–7
- weighted mean 564
- weights of probability 25
- welding flaws example, Bayes' theorem 49–55
- Wiener–Lévy process 147
- WOAD (Worldwide Offshore Accident Databank) 524
- work hazards
 - hazardous occupations 523–4
 - lung disease 523
 - offshore industry 524
 - risk at work 523–5
- zero-sum games 222–3