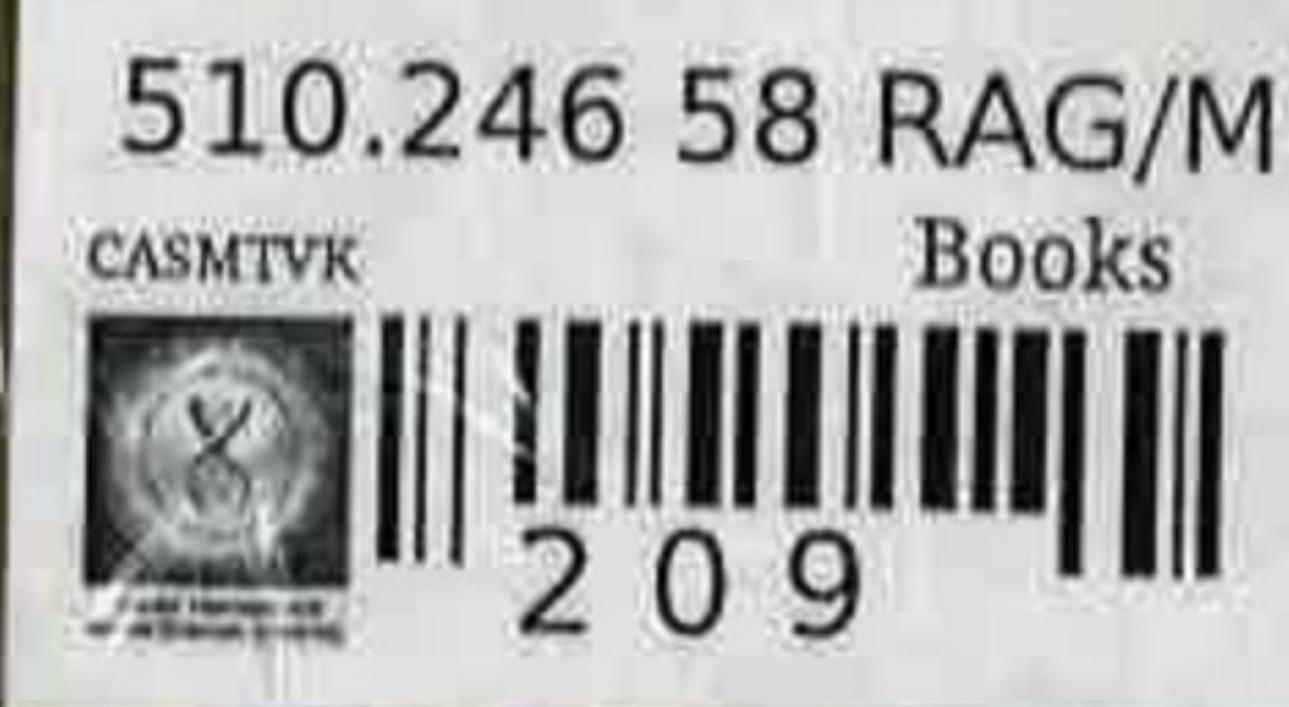


Mathematics
for
Management

An Introduction

M Raghavachari



Contents

1.1	Sets and Set Membership	1
1.2	Subsets and Set Equality	3
1.3	Set Operations	4
1.4	Fundamental Laws of Set Operation	6
1.5	Set Construction	8
1.6	Cartesian Product	10
1.7	Special Topics on Sets	11
1.8	Exercises	14
2.1	Functions	18
2.2	Construction of Functions	19
2.3	Linear and Quadratic Functions	22
2.4	Some Special Functions	25
2.5	Zeros of a Function	28
2.6	Exercises	34
3.1	Limit of a Function	37
3.2	Continuous Functions	40
3.3	Limit of a Sequence	42
3.4	Exercises	46
4.1	Derivative	48
4.2	Basic Laws of Derivative	51
4.3	Higher Order Derivatives	54
4.4	Applications and Further Topics	55
4.5	Exercises	58

Preface

Acknowledgements

1. Set Theory

1.1	Sets and Set Membership	1
1.2	Subsets and Set Equality	3
1.3	Set Operations	4
1.4	Fundamental Laws of Set Operation	6
1.5	Set Construction	8
1.6	Cartesian Product	10
1.7	Special Topics on Sets	11
1.8	Exercises	14

2. Functions and Their Applications

2.1	Functions	18
2.2	Construction of Functions	19
2.3	Linear and Quadratic Functions	22
2.4	Some Special Functions	25
2.5	Zeros of a Function	28
2.6	Exercises	34

3. Limits and Continuity

3.1	Limit of a Function	37
3.2	Continuous Functions	40
3.3	Limit of a Sequence	42
3.4	Exercises	46

4. Differentiation and Derivatives

4.1	Derivative	48
4.2	Basic Laws of Derivative	51
4.3	Higher Order Derivatives	54
4.4	Applications and Further Topics	55
4.5	Exercises	58

α alpha
γ, Γ gamma
ε epsilon
η eta
λ, Λ lambda
ρ rho
τ tau
χ chi
β beta
δ, Δ delta
ν nu
θ theta
μ mu
π pi
σ, Σ sigma
φ, Φ phi

GLOSSARY OF GREEK ALPHABETS

xii Mathematics for Management		
5. Maxima and Minima of Functions	60	
5.1 Maxima and Minima 60		10.12 Independent Trials 221
5.2 Applications 67		10.13 Poisson Approximation to Binomial 226
5.3 Discrete Optimization 72		10.14 Normal Approximation to Binomial 227
5.4 Exercises 76		10.15 Exercises 230
6. Integral	81	
6.1 Integral 81		11. Discrete Random Variables and Distributions 238
6.2 Integration by Parts 84		11.1 Random Variables 238
6.3 Applications 86		11.2 Probability Distribution of a Random Variable 240
6.4 Exercises 87		11.3 Expectation of a Random Variable 245
7. Progressions and Annuity	89	11.4 Variance of a Random Variable 250
7.1 Progressions 89		11.5 Distribution Function of a Random Variable 255
7.2 Geometric Series 95		11.6 Joint Distribution 259
7.3 Annuity 98		11.7 Correlation Coefficient 267
7.4 Investment Compounded Continuously 103		11.8 Distribution of Sum of Two Independent Poisson Variables 268
7.5 Exercises 105		11.9 Exercises 269
8. Vectors and Matrices	110	
8.1 Vectors 110		12. Continuous Random Variables and Distributions 275
8.2 Some Special Vectors 114		12.1 Continuous Random Variables 275
8.3 Geometrical and Physical Interpretation of Vectors 115		12.2 Some Important Continuous Distributions 283
8.4 Linear Dependence of Vectors 116		12.3 Exercises 303
8.5 Matrices 118		
8.6 Operations and Matrices 122		13. Data Analysis 308
8.7 Determinant of a Square Matrix 138		13.1 Measurement 308
8.8 Eigen Values and Eigen Vectors 142		13.2 Data Reduction 310
8.9 Inverse of a Square Matrix 144		13.3 Measures of Location or Central Tendency 316
8.10 Exercises 148		13.4 Measures of Dispersion 322
9. Linear Equations	154	13.5 Bivariate Data 329
9.1 System of Linear Equations 154		13.6 Sampling 332
9.2 Solution of a System of Linear Equations 156		13.7 Exercises 334
9.3 Linear Dependence of Vectors 160		
9.4 Solution by Inverse 161		14. Linear Programming 339
9.5 Rank of a Matrix 171		14.1 Examples of Linear Programming 339
9.6 Exercises 175		14.2 Solution of Linear Programming Problems 343
10. Basic Concepts of Probability	182	14.3 Marginal Analysis and Duality 346
10.1 Introduction 182		14.4 General Formulation and Results 351
10.2 Probability 183		14.5 The Transportation Problem 357
10.3 Definition of Probability 184		14.6 Exercises 370
10.4 Sample Space of Events 188		
10.5 Events and Relations Among Events 190		15. Extensions to Linear Programming 375
10.6 Definition of Probability and Rules of Probability 192		15.1 Linear Programming Extensions 375
10.7 Permutations and Combinations 196		15.2 Exercises 385
10.8 Applications of Permutations and Combinations to Probability Problems 203		
10.9 Conditional Probability 208		Appendix 391
10.10 Probability Networks or Probability Trees 214		References for Additional Reading 395
10.11 Index 216		Answers to Odd Numbered Exercises 397

Index

Index

Acceleration, 49, 115
Acceptance sampling, 236, 237, 270, 305
Acute angle, 61, 393
Additive property of, χ^2 , 298
Advertising, 21, 23, 55, 68, 69, 77
Algebra of events, 193
Annuity, 98, 99, 102
 amount of, 98
 formula for, 99
 present value of, 99
Antiderivative, 81
Arithmetic progression, 89, 91, 105
 common difference of, 89
 sum to n terms of, 91
Assignment problem, 72, 79, 373
Average rate of return, 270

Baggage handling, 387
Bar chart, 310
Bayes' formula, 211, 212, 213
Bayesian analysis, 300
Bernoulli trials, 221, 222, 224, 226, 238, 271
Beta function, 299
Binomial
 coefficient, 201, 202
 distribution, 241, 246, 252
 formula, 206, 222, 225, 235
 normal approximation to, 227, 262, 269
 Poisson approximation to, 226
 variable, 229
Birthday problem, 204
Bivariate data, 329
Book value, 24, 101, 106
Boole's inequality, 196
Bose-Einstein statistics, 185
Brand switching, 121, 128, 178
Break-even analysis, 32, 33, 35, 106

Canonical form, 159, 163
Capital budgeting, 182, 383
Cartesian product, 10
Central limit theorem, 291
Chain rule of differentiation, 53
Characteristic equation, 143
Characteristic polynomial, 143
Characteristic values, 143
Class interval, 312
Class width, 313
Coefficient of concordance, 338
Coefficient matrix, 386
Coefficient of variation, 254, 328
Cofactor, 138, 146
Combinations, 199, 203
Complementary slackness, 354, 368
Complete enumeration, 73
Complex numbers, 390
Composite depreciation method, 152
Composite function, 53
Composite life, 107
Conditional distribution, 260, 269, 273, 274
Confidence interval, 301, 302
Configuration, 295
 series, 295
 parallel, 295
Consistent equations, 174, 176, 178, 179
Consumer's surplus, 71, 72, 86, 88
Continuous random variable, 275, 310
Continuum, 275
Correlation
 coefficient, 267, 273, 329
 matrix, 268, 331
 rank correlation, 331, 337
Cost
 average, 70, 76
 fixed, 33

variable, 32
of understocking, 258
of overstocking, 258
Covariance, 263, 329
Cramer's Rule, 178
Critical activity, 386
Critical path, 385, 386
Critical path scheduling, 385
Cumulative frequencies, 316

Data analysis, 308
Degrees of freedom, 297
Demand function, 72
Dependent trials, 221
Depreciation fund, 24, 25, 92
Depreciation lapse schedule, 136, 137
Depreciation method
 composite depreciation, 152
 constant percentage of book value, 96, 106
 double declining balance, 93, 106
 sinking fund, 96, 100
 straight line, 24
 sum of the years' digits, 106
Derivative, 48, 49, 50
 basic laws of, 51
 chain rule of, 53
 geometric interpretation of, 50
 higher order, 54
 L'hospital's rule, 57
 non-existence of, 51
Discount, 98
Discrete maximization, 72, 268
Discrete random variables, 255, 272, 274, 310
Dispersion, 246
Distribution
 beta, 298
 Cauchy, 300
 chisquare, 298, 307
 compound Poisson, 244
 conditional, 259, 269, 273, 274
 discrete uniform, 241
 double exponential, 303
 Erlang, 296
 exponential, 279, 293, 296
 gamma, 296
 hypergeometric, 207, 243, 244
 inverse binomial or negative binomial, 242, 243
 joint, 259, 260, 274
 log normal, 295
 marginal, 259, 260, 273
 multinomial, 261

Fair game, 271
First derivative test, 64
First-in first-out (FIFO), 135
Fixed charge problem, 377
Force, 115
Fractile, 279, 285, 286, 307
Frequency distribution, 312, 313, 314
Frequency polygon, 314

normal, 286, 287, 304, 305, 307
pareto, 302
standard normal, 287
student's t, 302
triangular, 281
uniform or rectangular, 283
Weibull, 296, 297
Distribution function, 256
 properties of, 256
 distribution form, 256
Dummy destination, 367

Economic order quantity (EOQ), 68
Eigen values, 144, 152
Eigen vector, 144, 152
Elasticity of demand, 55
Elasticity of saturation, 59
Elementary row operation, 171
Equilibrium price, 31, 32
Equipment investment analysis, 104
Equilibrium state, 306
Estimated guarantee liability, 236
Estimation problem, 292
Events, 190, 191, 192
 algebra of, 193
 complementary, 191, 192, 204
 independent, 191, 217, 218, 219, 220, 234
 intersection of, 191
 mutual independence of, 219
 mutually exclusive, 191-196, 206, 210, 212, 214, 218, 219, 220
 null, 191, 192, 194
 pairwise independence of, 219
 simple, 189, 190
 union of, 192
Expectation, 246, 247, 248, 263, 282
 as centre of gravity, 247
 infinite, 247
 of a function, 247
 properties of, 248
Expected monetary value (EMV), 248, 249, 271
Expected opportunity loss (EOL), 250, 271
Expected value of perfect information (EVPI), 250, 271

Fair game, 271
First derivative test, 64
First-in first-out (FIFO), 135
Fixed charge problem, 377
Force, 115
Fractile, 279, 285, 286, 307
Frequency distribution, 312, 313, 314
Frequency polygon, 314

Frequency curve, 315
Function
 absolute value, 25
 composite, 53
 concave, 35
 continuity of, 40
 convex, 27, 28, 35, 57, 59, 69
 domain of, 18, 19, 46
 exponential, 43, 53
 inverse, 46, 47, 306
 limit of, 37
 logarithmic, 44, 53
 monotonic, 46, 47, 76
 piece-wise linear, 21
 polynomial, 23, 41
 profit, 20, 24, 65, 74, 258, 377
 quadratic, 23
 range of, 18, 19
 rate of change of, 48
 real valued, 19
 step, 58, 87
 strictly increasing, 44
 zeros of, 29

Gamma function, 296, 299
Gazinto chart, 167
Geometric progression, 89, 91, 95, 105
 sum to n terms, of, 91, 92
 common ratio of, 89
Geometric series, 94, 95
Global maxima, 62, 66, 76
Global minima, 62, 66, 76
Gompertz curve, 56
Graph, 21

Histogram, 314, 315
Hypotenuse, 393
Hypergeometric formula, 207

Independent trials, 221
Imaginary number, 390
Independent and identically distributed, 274
Independent random variables, 272
Inequalities, 392
Infinity, 394
Information retrieval, 388
Input-output Analysis, 165, 167, 177, 178, 179, 181
Instantaneous rate, 49
Instantaneous replenishment, 67
Integer programming
 fixed charge problem, 377
 mixed, 377

pure, 383
set-covering, 383
set-partitioning, 348, 350, 383
travelling salesman problem, 387
zero-one, 382
Integral, 81
 as area, 82
 definite, 81
 indefinite, 81
 lower limit of, 82
 properties of, 83
 upper limit of, 82
Integrand, 82
Integration
 as antiderivative, 81
 by parts, 84
Intercept, 23
Interest
 compound, 90, 107
 compounded continuously, 103
 simple, 89, 107
Internal rate of return, 106
Interval, 392
Inventory
 carrying cost of, 78
 control, 183
 EOQ formula, 68
 flow matrix, 134
 lead time, 183
 model, 67

Job sequencing, 73, 74, 79, 389
Johnson's rule for sequencing, 74
Joint distribution, 259, 260, 274

Lack of memory property, 294
Latent roots, 143
Learning curve, 86
Learning model, 233
LIFO (last-in first-out), 135
Limit
 left limit, 39
 limit of a function, 37
 limit of sequence, 42
 right limit, 39
Line chart, 310
Linear equations, 155, 176
 homogeneous system, 179
 inconsistent, 156, 157, 160
 matrix representation of, 155
 redundant, 156, 157, 159, 161
 row operation of, 173
 simultaneous, 142, 154
 solution of, 161

Linear programming
 complementary slackness, 354, 368, 372
 computer package for, 356
 constraints of, 339, 340
 critical path scheduling as, 386
 dual problem, 346, 347, 348, 349, 353
 dual variables, 349
 equality constraints in, 355
 extensions to, 375
 feasible solution, 343, 344, 354
 general formulation of, 351
 graphical method for, 343
 imputed values, 347
 marginal analysis and duality, 346
 matrix representation of, 352
 media allocation, 340
 objective function, 339, 340
 optimal solution, 343
 primal-dual relationships, 353, 354
 product mix, 339, 340
 shadow prices, 347
 simplex method, 343
 transportation problem, 342
 unrestricted in sign, 355, 356
 warehouse model, 371

Line segment, 27

Linear combination of vectors, 113

Linearly dependent, 160, 174

Linearly independent, 116, 117, 160, 171, 180

Local maxima, 62, 63, 64, 65, 76

Local minima, 62, 63, 64, 65, 76

Location of depots, 383

Logistic curve, 56

Makeham's formula, 107

Marginal cost, 49, 70, 71, 81, 84, 87

Marginal distribution, 260

Marginal revenue, 71

Market equilibrium, 30, 175

Market saturation, 59

Markov chain, 225

Markov trials, 225

Matching, 205

Mathematical induction, 150, 196

Mathematical programming problem, 388, 389

Matrix, 113
 addition, 122
 adjoint, 146, 162
 augmented, 158, 171
 columns of, 118
 determinant of, 138

diagonal elements of, 119
 difference, 123
 dimension of, 118
 distance, 120, 334
 doubly stochastic, 153, 180
 echelon, 171, 172, 173
 idempotent, 150
 identity, 132, 148, 163, 164
 inventory flow, 134, 135
 inverse of, 144, 145, 148, 151, 152, 162
 lower triangular, 133, 152
 multiplication, 123, 125, 126
 node-arc incidence, 121, 386
 non-singular, 146, 147, 150, 161, 173
 null, 124, 128
 orthogonal, 133, 148
 pay-off, 120
 permanent of, 153
 permutation, 149, 181
 post-multiplication of, 127
 precedence, 153
 pre-multiplication of, 127
 rank of, 171, 173, 181
 representation of equations by, 155
 rows of, 118
 scalar, 132
 singular, 141
 skew symmetric, 131, 150, 152
 sociogramme, 120, 125
 stochastic, 152
 square, 119, 142, 149
 symmetric, 131, 150, 268, 331
 totally unimodular, 151
 trace of, 119, 144
 transition, 122, 128, 129, 225
 transpose of, 130, 148
 transportation, 119
 upper triangular, 133, 152, 169
 variance-covariance, 266, 337

Mean 316, 320
 arithmetic, 317, 320, 335
 geometric, 318, 321, 335
 harmonic, 319, 321, 322, 335
 pooled, 327
 weighted arithmetic, 317
 weighted geometric, 319

Measures of dispersion, 322
 mean absolute deviation, 254, 324, 325
 pooled variance, 327
 range, 323
 standard deviation, 251, 323, 326, 327
 variance, 246, 250, 251, 323, 325

Median, 279, 287, 318, 320, 322, 325

Misclassification, 304

Mode, 287, 318, 321

Multinomial coefficients, 202

Net Present Value, 102

Net work, 121, 214, 215
 arcs of, 375
 capacity of arc of, 376
 conservation of flow, 376
 intermediate nodes of, 376
 maximal flow problem, 375, 376, 386
 nodes of, 121
 sink of, 375, 386
 source of, 121, 375, 384, 386
 transportation, 180

Newsboy problem, 259

Non-linear programming problem, 377

Normal distribution, 286
 properties of, 289
 2σ and 3σ rules, 292
 approximation to binomial, 227

North-west corner rule, 358

Obtuse angle, 61, 393

Opportunity cost, 361, 362, 365, 368, 369

Ordered pair, 10

Overtime budget, 305

PERT, 299

Permutations, 196, 198, 199, 203

Pictorial representation of data, 310
 pie diagram, 310
 histogram, 314, 315
 frequency polygon, 314
 frequency curve, 315, 316

Pie diagram, 310

Poisson
 approximation to binomial, 226
 distribution, 241
 compound, 244
 process, 242

Portfolio selection, 378

Present value, 97, 98, 99, 102, 106, 107
 net (NPV), 102

Present value of an annuity, 99

Present value under continuous compounding, 103

Principle of insufficient reason, 185

Probability,
 addition theorem of, 194, 196
 axioms of, 192
 Boole's inequality, 196
 conditional, 208-210
 probability integral transformation, 288
 probability trees, 214, 216

rules of, 193
unconditional, 208

Probability density function, 276
 properties of, 277

Producer's surplus, 87

Proper values, 143

Quadratic form, 149

Quadratic programming problem, 378, 379, 389

Quantity discounts and price breaks, 21

Quartiles, 279

Random experiment, 184

Random number tables, 333

Random variables, 239
 distribution of, 240
 independence, 262

Real number system, 391

Relative frequency, 186

Reliability, 294

Revenue, 17, 76

Sales decay constant, 44

Sample, 333

Sample space, 188-190

Sampling 332
 double, 235, 237
 random, 203
 with replacement, 203, 204, 205, 206, 209, 210, 222, 271
 without replacement, 198, 203, 205, 206, 209, 210, 271

simple random sampling, 333

Scale,
 interval, 309
 nominal, 308
 ordinal, 309
 ratio, 310

Scatter diagram, 337

Second derivative test, 65

Sequence, 42
 convergence of, 47
 finite, 43
 infinite, 43
 limit of, 42
 oscillation of, 43

Set of distinct representatives (SDR), 373

Sets, 1, 191
 associative law, 128
 cartesian product of, 10, 11
 complement of, 4, 192
 convex, 27, 59

De Morgan's law, 7, 220



- difference of, 5
- disjoint, 5, 192
- equality of, 3
- finite, 11
- infinite, 11
- identity law of, 6
- intersection of, 4
- laws of set operation, 6, 7
- null set (empty set), 3, 12
- number of elements in, 11
- number of subsets, 4, 17
- partition of, 13, 17
- subset, 3
- symmetric difference of, 12
- union of, 5
- universal, 3
- Sex prediction**, 223
- Shortest route problem**, 384
- Shortest path**, 385
- Single server queue**, 306
- Source**, 121, 386
- Stationarity**, 242
- Straight line graph**, 22

- Tangent**, 50
- Taxation paradox**, 175
- Test marketing**, 94
- Transitive relation**, 14
- Transportation problem**, 342, 357, 373, 379, 380, 381
 - feasible solution, 361, 362, 363, 364, 365
 - initial feasible solution, 358
 - north-west corner rule, 358
 - optimality test of, 361, 362, 363, 364, 365
- Vogel's method**, 359, 361

Transhipment problem, 379, 380, 381

Travelling salesman problem, 388

Trigonometry, 392, 393

Truck delivery problem, 388

Two person zero-sum game, 80, 373

Uncertain demand, 103

Variance, 246, 250, 251, 264, 282

- as moment of inertia, 253
- properties of, 251

Variance analysis, 133

Vectors, 110-134

- addition of, 111
- column, 110
- difference of, 112
- distance between, 114
- equality of, 111
- geometrical interpretation of, 115
- inequalities for, 113
- length of, 116
- linear combination of, 113
- linear-dependence of, 116-117
- multiplication of, 112
- null, 115
- orthogonal, 112
- parallelogram law for, 115
- row, 110
- scalar product of, 112
- sum, 115
- transpose of, 111
- unit, 114

Velocity, 49

Venn diagram, 5

Vogel's method, 359

Work stations, 153

Related Books from McGraw Hill Education

- | | |
|-------------------------------|--|
| Agarwal | : Organisation and Management |
| Bhole | : Financial Institutions and Markets, 2/e |
| Burton & Thakur | : Management Today |
| Chandra | : Fundamentals of Financial Management, 2/e |
| Chary | : Production and Operations Management |
| Gopalakrishnan | : Purchasing and Materials Management |
| Gupta | : Managerial Economics |
| Jawahar Lal | : Cost Accounting, 2/e |
| Kazmi Azhar | : Business Policy |
| Khan & Jain | : Management Accounting, 2/e |
| Khan & Jain | : Financial Management, 2/e |
| Khan & Jain | : Theory and Problems of Financial Management (MHE Outline Series) : |
| Mote, Paul & Gupta | : Managerial Economics |
| Tripathy & Reddy | : Principles of Management, 2/e |
| Venkataratnam | : Personnel Management & Human Resources |
| Vohra | : Quantitative Techniques in Management |

ISBN-13: 978-0-07-096570-6
ISBN-10: 0-07-096570-6

