

---

## References

- J. Abate and H. Dubner (1968), A new method of generating power series expansions of functions, *SIAM J. Numer. Anal.*, **5**, 102–112.
- J. Abate, H. Dubner, and S. B. Weinberg (1968), Queueing analysis for the BIM 2314 disk storage facility, *J. Assoc. Comput. Mach.*, **15**, 577–589.
- J. Abate and W. Whitt (1992), The Fourier-series method for inverting transforms of probability distributions, *Queueing Systems*, **10**, 5–88.
- S. K. Acharya (1999), On normal approximation for maximum likelihood estimation from single server queues, *Queueing Systems*, **31**, 207–216.
- I. J. B. F. Adan, O. J. Boxma, and J. A. C. Resing (2001), Queueing models with multiple waiting lines, *Queueing Systems*, **37**, 65–98.
- A. S. Alfa (2003), Vacation models in discrete time, *Queueing Systems*, **44**, 5–30.
- A. O. Allen (1990), *Probability, Statistics, and Queueing Theory with Computer Science Applications*, 2nd ed., Academic Press, Boston.
- C. Armero (1994), Bayesian inference in Markovian queues, *Queueing Systems*, **15**, 419–426.
- C. Armero and D. Conesa (2000), Prediction in Markovian bulk arrival queues, *Queueing Systems*, **34**, 327–350.
- N. T. J. Bailey (1952), Study of queues and appointment systems in out-patient departments with special reference to waiting times, *J. Roy. Statist. Soc. B*, **14**, 185–199.
- N. T. J. Bailey (1954), A continuous time treatment of a simple queue using generating functions I, *J. Roy. Statist. Soc. B*, **16**, 288–291.
- N. T. J. Bailey (1964), *The Elements of Stochastic Processes with Applications to the Natural Sciences*, Wiley, New York.
- K. R. Balachandran (1973), Control policies for a single server system, *Management Sci.*, **19**, 1013–1018.
- I. V. Basawa, U. N. Bhat, and J. Zhou (2008), Parameter estimation in queueing systems using partial information, *Statist. Probab. Lett.*, to appear.

- I. V. Basawa and N. U. Prabhu (1981), Estimation in single server queues, *Nav. Res. Logist. Quart.*, **28**, 475–487.
- I. V. Basawa and N. U. Prabhu (1988), Large sample inference from single server queues, *Queueing Systems*, **3**, 289–304.
- F. Baskett, K. M. Chandy, R. R. Muntz, and F. G. Palacios (1975), Open, closed, and mixed networks of queues with different classes of customers, *J. Assoc. Comput. Mach.*, **22**, 248–260.
- M. Bäuerle (2002), Optimal control of queueing networks: An approach via fluid models, *Adv. Appl. Probab.*, **34**, 313–328.
- C. S. Beightler, L. G. Mitten, and G. L. Nemhauser (1961), A short table of Z-transforms and generating functions, *Oper. Res.*, **9**, 547–578.
- F. Benson and D. R. Cox (1951, 1952), The productivity of machines requiring attention at random intervals, *J. Roy. Statist. Soc. B*, **13**, 65–82; **14**, 200–210.
- U. N. Bhat (1968), *A Study of the Queueing Systems M/G/1 and GI/M/1*, Lecture Notes in Operations Research and Mathematical Economics, Vol. 2, Springer-Verlag, New York.
- U. N. Bhat (1969), Sixty years of queueing theory, *Management Sci.*, **15**, B280–B294.
- U. N. Bhat (1984), *Elements of Applied Stochastic Processes*, 2nd ed., Wiley, New York.
- U. N. Bhat (1987), A sequential technique for the control of traffic intensity in Markovian queues, *Ann. Oper. Res.*, **8**, 151–164.
- U. N. Bhat (2003), Parameter estimation in  $M/G/1$  and  $GI/M/1$  queues using queue length data, in S. K. Srinivasan and A. Vijayakumar, eds., *Stochastic Point Processes*, Narosa, New Delhi, 96–107.
- U. N. Bhat and I. V. Basawa (2002), Maximum likelihood estimation in queueing systems, in N. Balakrishnan, ed., *Advances on Methodological and Applied Aspects of Probability and Statistics*, Taylor and Francis, New York, 13–29.
- U. N. Bhat and K. M. Kavi (1987), Reliability models for computer systems: An overview including dataflow graphs, Part 1, *Sadhana*, **11**, 167–186; Part 2, in N. Viswanadham, ed., *Reliability and Fault-Tolerant Issues in Realtime Systems*, Indian Academy of Sciences, Bangalore, India.
- U. N. Bhat and G. K. Miller (2002), *Elements of Applied Stochastic Processes*, 3rd ed., Wiley, New York.
- U. N. Bhat, G. K. Miller, and S. S. Rao (1997), Statistical analysis of queueing systems, in J. H. Dshalalow, ed., *Frontiers in Queueing*, CRC Press, New York, Chapter 13, 351–393.
- U. N. Bhat, R. E. Nance, and R. R. Korfhage (1975), Information networks: A probabilistic model for hierarchical message transfer, *Inform. Sci.*, **9**, 169–184.
- U. N. Bhat, M. Shalaby, and M. J. Fischer (1979), Approximation techniques in the solution of queueing problems, *Nav. Res. Logist. Quart.*, **26**, 311–326.
- P. Billingsley (1961), *Statistical Inference for Markov Processes*, University of Chicago Press, Chicago.

- A. Birnbaum (1954), Statistical methods for Poisson processes and exponential populations, *J. Amer. Statist. Assoc.*, **49**, 254–266.
- G. Boole with J. F. Moulton, ed. (1970), *A Treatise on the Calculus of Finite Differences*, 5th ed., Chelsea, New York.
- O. J. Boxma and H. Takagi (1992), Editorial introduction, *Queueing Systems*, **11** (special issue on polling models), 1–5.
- G. Brigham (1955), On a congestion problem in an aircraft factory, *Oper. Res.*, **3**, 412–428.
- E. Brockmeyer, H. L. Halstrøm, and A. Jensen (1960), *The Life and Works of A. K. Erlang*, Applied Mathematics and Computing Machinery Series, Vol. 6, Acta Polytechnica Scandinavica, Copenhagen.
- P. J. Burke (1956), The output of a queueing system, *Oper. Res.*, **4**, 699–714.
- P. J. Burke (1976), Proof of a conjecture on the inter-arrival time distribution in an  $M/M/1$  queue with feedback, *IEEE Trans. Comm.*, **COM-24**, 575–576.
- J. A. Buzacott and J. G. Shanthikumar (1992), Editorial introduction, *Queueing Systems*, **12** (special issue on manufacturing systems), 1–2.
- J. A. Buzacott and J. G. Shanthikumar (1993), *Stochastic Models of Manufacturing Systems*, Prentice–Hall, Upper Saddle River, NJ.
- J. P. Buzen (1973), Computational algorithms for closed queueing networks with exponential servers, *Comm. Assoc. Comput. Mach.*, **16**, 527–531.
- K. M. Chandy (1972), The analysis and solutions for general queueing networks, in *Proceedings of the 6th Annual Princeton Conference on Information Science and Systems*, Princeton University, Princeton, NJ.
- M. L. Chaudhry (1992), Editorial introduction, *Queueing Systems*, **10** (special issue on numerical computations in queues), 1–3.
- M. L. Chaudhry, M. Agarwal, and J. G. C. Templeton (1992), Exact and approximate numerical solutions of steady-state distributions arising in the queue  $GI/G/1$ , *Queueing Systems*, **10**, 105–152.
- M. L. Chaudhry and J. G. C. Templeton (1983), *A First Course in Bulk Queues*, Wiley, New York.
- A. B. Clarke (1957), Maximum likelihood estimates in a simple queue, *Ann. Math. Statist.*, **28**, 1036–1040.
- A. Cobham (1954), Priority assignment in waiting line problems, *Oper. Res.*, **2**, 70–76; correction, *Oper. Res.*, **3**, 547.
- E. G. Coffman, Jr. and P. J. Denning (1973), *Operating Systems Theory*, Prentice–Hall, Englewood Cliffs, NJ.
- E. G. Coffman, Jr. and M. Hofri (1986), Queueing models of secondary storage devices, *Queueing Systems*, **1**, 129–168.
- E. G. Coffman, Jr. and L. Kleinrock (1968), Feedback queueing models for time shared systems, *J. Assoc. Comput. Mach.*, **15**, 549–576.

- J. W. Cohen (1969), *The Single Server Queue*, North-Holland, London.
- W. J. Conover (1971), *Practical Nonparametric Statistics*, Wiley, New York.
- R. W. Conway, W. L. Maxwell, and L. W. Miller (1967), *Theory of Scheduling*, Addison-Wesley, Reading, MA.
- R. B. Cooper (1981), *Introduction to Queueing Theory*, North-Holland, New York.
- P. J. Courtois (1977), *Decomposability: Queueing and Computer Science Applications*, Academic Press, New York.
- D. R. Cox (1955), The analysis of non-Markovian stochastic processes by the inclusion of supplementary variables, *Proc. Cambridge Philos. Soc.*, **51**, 433–441.
- D. R. Cox (1962), *Renewal Theory*, Methuen, London.
- D. R. Cox (1965), Some problems of statistical analysis connected with congestion, in W. L. Smith and W. B. Wilkinson, eds., *Proceedings of the Symposium on Congestion Theory*, University of North Carolina Press, Chapel Hill, NC, 289–316.
- D. R. Cox and P. A. W. Lewis (1966), *The Statistical Analysis of Series of Events*, Methuen, London.
- T. B. Crabill (1972), Optimal control of a service facility with variable exponential service times and constant arrival rate, *Management Sci.*, **18**, 560–566.
- T. B. Crabill, D. Gross, and M. J. Magazine (1977), A classified bibliography of research on optimal design and control of queues, *Oper. Res.*, **25**, 219–232.
- P. J. Denning and J. P. Buzen (1978), The operational analysis of queueing network models, *Comput. Surv.*, **10-3**, 225–261.
- R. L. Disney and P. C. Kiessler (1987), *Traffic Processes in Queueing Networks*, Johns Hopkins University Press, Baltimore.
- B. T. Doshi (1986), Queueing systems with vacations: A survey, *Queueing Systems*, **1**, 29–66.
- B. T. Doshi and D. Yao (1995), Editorial introduction, *Queueing Systems*, **20** (special issue on telecommunication systems), 1–5.
- J. H. Dshalalow (1997), Queueing systems with state dependent parameters, in J. H. Dshalalow, ed., *Frontiers in Queueing*, CRC Press, New York, Chapter 4, 61–116.
- H. Dubner and J. Abate (1968), Numerical inversion of Laplace transforms by relating them to the finite Fourier cosine transform, *J. Assoc. Comput. Mach.*, **15**, 115–123.
- L. C. Edie (1954), Traffic delays at toll booths, *J. Oper. Res. Soc. Amer.*, **2**, 107–138.
- A. K. Erlang (1917), Solution of some problems in the theory of probabilities of significance in automatic telephone exchanges, *Elektrotekniker*, **13**, 5.
- G. Falin (1990), A survey of retrial queues, *Queueing Systems*, **7**, 127–168.
- W. Feller (1968), *An Introduction to Probability Theory and its Applications*, Vol. 1, 3rd ed., Wiley, New York.
- T. C. Fry (1928), *Probability and Its Engineering Uses*, Van Nostrand, Princeton, NJ.

- S. H. Fuller (1980), Performance evaluation, in H. S. Stone, ed., *Introduction to Computer Architecture*, 2nd ed., Science Research Associates, Chicago, 527–590.
- D. P. Gaver, Jr. (1968), Diffusion approximations and models for certain congestion problems, *J. Appl. Probab.*, **5**, 607–623.
- E. Gelenbe and G. Pujolle (1998), *Introduction to Queueing Networks*, Wiley, New York.
- P. W. Glynn (1990), Diffusion approximations, in D. P. Heyman and M. J. Sobol, eds., *Stochastic Models*, Vol. 2, Elsevier Science, Amsterdam, Chapter 4, 145–198.
- W. J. Gordon and G. F. Newell (1967), Closed queueing systems with exponential servers, *Oper. Res.*, **15**, 254–265.
- T. L. Goyal and C. M. Harris (1972), Maximum likelihood estimation for queues with state dependent service, *Sankhya A*, **34**, 65–80.
- D. Gross and C. M. Harris (1998), *Fundamentals of Queueing Theory*, 3rd ed., Wiley, New York.
- F. A. Haight (1957), Queueing with balking, *Biometrika*, **44**, 360–369.
- F. A. Haight (1967), *Handbook of the Poisson Distribution*, Wiley, New York.
- G. Hardy (1949), *Divergent Series*, Oxford University Press, Oxford, UK.
- K. Harishchandra and S. S. Rao (1988), A note on the statistical inference on the traffic intensity parameter in  $M/E_k/1$  queue, *Sankhya*, **50**, 144–148.
- K. J. Hastings (2006), *Introduction to the Mathematics of Operations Research with Mathematica*, 2nd ed., Chapman and Hall, New York.
- D. P. Heyman (1968), Optimal operating policies for  $M/G/1$  queueing systems, *Oper. Res.*, **16**, 362–382.
- F. B. Hildebrand (1968), *Finite Difference Equations and Simulations*, Prentice–Hall, Englewood Cliffs, NJ.
- F. S. Hillier (1963), Economic models for industrial waiting line problems, *Management Sci.*, **10**, 119–130.
- F. S. Hillier and G. J. Lieberman (1986), *Introduction to Operations Research*, 4th ed., Holden-Day, Oakland, CA.
- T. Hirayama, S. J. Hong, and M. M. Krunz (2004), A new approach to analysis of polling systems, *Queueing Systems*, **48**, 135–158.
- D. L. Iglehart and W. Whitt (1970), Multiple channel queues in heavy traffic I, II, *Adv. Appl. Probab.*, **2**, 150–177, 355–369.
- J. R. Jackson (1957), Networks of waiting lines, *Oper. Res.*, **5**, 518–521.
- J. R. Jackson (1963), Jobshop-like queueing systems, *Management Sci.*, **10**, 131–142.
- R. R. P. Jackson (1954), Queueing processes with phase type service, *Oper. Res. Quart.*, **5**, 109–120.
- R. R. P. Jackson (1956), Random queueing processes with phase type service, *J. Roy. Statist. Soc. B*, **18**, 129–132.

- A. A. Jagers and E. A. van Doorn (1986), On the continued Erlang loss function, *Oper. Res. Lett.*, **5**, 43–46.
- R. Jain (1991), *The Art of Computer Systems Performance Analysis*, Wiley, New York.
- N. K. Jaiswal (1968), *Priority Queues*, Academic Press, New York.
- W. S. Jewell (1967), A simple proof of  $L = \lambda W$ , *Oper. Res.*, **15**, 1109–1116.
- N. L. Johnson and S. Kotz (1969), *Distributions in Statistics: Discrete Distributions*, Wiley, New York.
- L. Joseph, D. B. Wolfson, and C. Wolfson (1990), Is multiple sclerosis an infectious disease? Inference on an input process based on the output, *Biometrics*, **46**, 337–349.
- S. Karlin and H. M. Taylor (1975), *A First Course in Stochastic Processes*, 2nd ed., Academic Press, New York.
- F. P. Kelly (1979), *Reversibility and Stochastic Networks*, Wiley, New York.
- D. G. Kendall (1951), Some problems in the theory of queues, *J. Roy. Statist. Soc. B*, **13**, 151–185.
- D. G. Kendall (1953), Stochastic processes occurring in the theory of queues and their analysis by the method imbedded Markov chains, *Ann. Math. Statist.*, **24**, 338–354.
- J. F. C. Kingman (1962a), Some inequalities for the  $GI/G/1$  queue, *Biometrika*, **49**, 315–324.
- J. F. C. Kingman (1962b), On queues in heavy traffic, *J. Roy. Statist. Soc. B*, **24**, 383–392.
- J. F. C. Kingman (1965), The heavy traffic approximation in the theory of queues, in W. L. Smith and W. B. Wilkinson, eds., *Proceedings of the Symposium on Congestion Theory*, University of North Carolina Press, Chapel Hill, NC.
- J. F. C. Kingman (1969), Markov population processes, *J. Appl. Probab.*, **6**, 1–18.
- L. Kleinrock (1975), *Queueing Systems, Vol. I: Theory*, Wiley, New York.
- L. Kleinrock (1976), *Queueing Systems Vol. II: Computer Applications*, Wiley, New York.
- E. Koenigsberg (1958), Cyclic queues, *Oper. Res. Quart.*, **9**, 22–35.
- T. Konstantopoulos (1998), Editorial introduction, *Queueing Systems*, **28** (special issue on mathematical and probabilistic methods in communication networks), 1–5.
- J. A. Koziol and A. F. Nemeč (1979), On a Cramer–von Mises type statistic for testing bivariate independence, *Canad. J. Statist.*, **7**, 43–52.
- S. Krakowiak (1988), *Principles of Operating Systems*, MIT Press, Cambridge, MA (translated by D. Beeson).
- V. G. Kulkarni (1997), Fluid models for single buffer systems, in J. H. Dshalalow, ed., *Frontiers in Queueing*, CRC Press, New York, Chapter 11, 321–338.
- V. G. Kulkarni and H. M. Liang (1997), Retrial queues revisited, in J. H. Dshalalow, ed., *Frontiers in Queueing*, CRC Press, New York, Chapter 2, 19–34.
- S. S. Lavenberg, ed. (1983), *Computer Performance Modeling Handbook*, Academic Press, New York.

- A. M. Law and W. D. Kelton (1991), *Simulation Modeling and Analysis*, 2nd ed., McGraw-Hill, New York.
- W. Ledermann and G. E. Reuter (1956), Spectral theory for the differential equations of simple birth and death processes, *Philos. Trans. Roy. Soc. London Ser. A*, **246**, 321–369.
- P. A. W. Lewis (1972), *Stochastic Point Processes*, Wiley, New York, 1–54.
- H. W. Lilliefors (1966), Some confidence intervals for queues, *Oper. Res.*, **14**, 723–727.
- D. V. Lindley (1952), The theory of queues with a single server, *Proc. Cambridge Philos. Soc.* **48**, 277–289.
- J. D. C. Little (1961), A proof for the queueing formula:  $L = \lambda W$ , *Oper. Res.* **9**, 383–387.
- G. Luchak (1956), The solution of the single channel queueing equations characterized by a time-dependent Poisson distributed arrival rate and a general class of holding times, *Oper. Res.*, **4**, 711–732.
- J. McKinney (1969), Survey of analytical time sharing models, *Comput. Surv.*, **1**, 105–116.
- W. G. Marchal (1978), Some simpler bounds on the mean queueing time, *Oper. Res.*, **26**, 1083–1088.
- K. T. Marshall (1968), Some inequalities in queueing, *Oper. Res.*, **16**, 651–665.
- D. R. Miller (1981), Computation of steady state probabilities for  $M/M/1$  priority queues, *Oper. Res.*, **29**, 945–958.
- G. K. Miller (1996), *Estimation for Renewal Processes with Unobservable Interarrival Times*, doctoral dissertation, Southern Methodist University, Dallas; available through ProQuest/University Microfilms (<http://il.proquest.com/brand/umi.shtml>).
- G. K. Miller (1999), Maximum likelihood estimation for Erlang integer parameter, *Statist. Probab. Lett.*, **43**, 335–341.
- G. K. Miller and U. N. Bhat (1997), Estimation for renewal processes with unobservable gamma or Erlang interarrival times, *J. Statist. Planning Inference*, **61**, 355–372.
- G. K. Miller and U. N. Bhat (2002), Estimation of the coefficient of variation for unobservable service times in the  $M/G/1$  queue, *J. Math. Sci.*, **1**, 1–11.
- D. Mitra and I. Mitrani (1991), Editorial introduction, *Queueing Systems*, **9** (special issue on communication systems), 1–4.
- D. Mitra, I. Mitrani, K. G. Ramakrishnan, J. B. Seery, and A. Weiss (1991), A unified set of proposals for control and design of high speed data networks, *Queueing Systems*, **9**, 215–234.
- J. J. Moder and C. R. Phillips, Jr. (1962), Queueing with fixed and variable channels, *Oper. Res.*, **10**, 218–231.
- E. C. Molina (1927), Application of the theory of probability to telephone trunking problems, *Bell Systems Tech. J.*, **6**, 461–494.
- M. K. Molloy (1989), *Fundamentals of Performance Modeling*, Macmillan, New York.
- S. C. Moore (1975), Approximating the behavior of non-stationary single server queues, *Oper. Res.*, **23**, 1011–1032.

- P. M. Morse (1958), *Queues, Inventories, and Maintenance*, Wiley, New York.
- R. R. Muntz (1973), Poisson departure processes and queueing networks, in *Proceedings of the 7th Annual Princeton Conference on Information Science and Systems*, Princeton University Press, Princeton, NJ.
- M. F. Neuts (1966), The single server queue with Poisson input and semi-Markov service times, *J. Appl. Probab.*, **3**, 202–230.
- M. F. Neuts (1967), A general class of bulk queues with Poisson input, *Ann. Math. Statist.*, **68**, 759–770.
- M. F. Neuts (1975), Probability distributions of phase type, in *Liber Amicorum Professor Emeritus H. Florin*, Department of Mathematics, University of Louvain, Louvain, Belgium, 173–206.
- M. F. Neuts (1978), Markov chains with applications in queueing theory, which have a matrix geometric invariant probability vector, *Adv. Appl. Probab.*, **10**, 185–212.
- M. F. Neuts (1989), *Structured Stochastic Matrices of M/G/1 Type and Their Applications*, Marcel Dekker, New York.
- G. F. Newell (1968), Queues with time dependent arrival rates I, II, *J. Appl. Probab.*, **5**, 436–451, 579–606.
- G. F. Newell (1971), *Applications of Queueing Theory*, Chapman and Hall, London.
- C. Palm (1947), The distribution of repairmen in servicing automatic machines, *Industriidningen Norden*, **75**, 75–80, 90–94, 119–123 (in Swedish).
- R. D. Pedersen and J. C. Shah (1972), Multiserver queue storage requirements with unpacked messages, *IEEE Trans. Comm.*, June, 462–465.
- H. Perros (1994), *Queueing Networks with Blocking*, Oxford University Press, New York.
- S. M. Pitts (1994), Nonparametric estimation of the stationary waiting time distribution for the GI/G/1 queue, *Ann. Statist.*, **22**, 1428–1446.
- F. Pollaczek (1934), Über das Warteproblem, *Math. Z.*, **38**, 492–537.
- F. Pollaczek (1965), Concerning an analytical method for the treatment of queueing problems, in W. L. Smith and W. B. Wilkinson, eds., *Proceedings of the Symposium on Congestion Theory*, University of North Carolina Press, Chapel Hill, NC, 1–42.
- N. U. Prabhu (1960), Some results for the queue with Poisson arrivals, *J. Roy. Statist. Soc. B*, **22**, 104–107.
- N. U. Prabhu (1965a), *Queues and Inventories*, Wiley, New York.
- N. U. Prabhu (1965b), *Stochastic Processes*, Macmillan, New York.
- N. U. Prabhu (1987), A bibliography of books and survey papers on queueing systems: Theory and applications, *Queueing Systems*, **2**, 393–398.
- N. U. Prabhu (1997), *Foundations of Queueing Theory*, Kluwer Academic Publishers, Boston.
- N. U. Prabhu (1998), *Stochastic Storage Processes*, Springer-Verlag, New York.



- N. U. Prabhu and U. N. Bhat (1963a), Some first passage problems and their application to queues, *Sankhya A*, **25**, 281–292.
- N. U. Prabhu and U. N. Bhat (1963b), Further results for the queue with Poisson arrivals, *Oper. Res.*, **11**, 380–386.
- J. Putter (1955), The treatment of ties in some nonparametric tests, *Ann. Math. Statist.*, **26**, 368–386.
- V. Ramaswami (1990), From the matrix-geometric to the matrix-exponential, *Queueing Systems*, **6**, 229–260.
- V. Ramaswami (2001), The surprising reach of the matrix analytic approach, in A. Krishnamoorthy, N. Raju, and V. Ramaswami, eds., *Advances in Probability and Stochastic Processes*, Notable Publications, Neshanic Station, NJ, 167–177.
- R. H. Randles and D. A. Wolfe (1979), *Introduction to the Theory of Nonparametric Statistics*, Wiley, New York.
- S. S. Rao and U. N. Bhat (1991), A sequential test for a denumerable Markov chain and an application to queues, *J. Math. Phys. Sci.*, **25**, 521–527.
- S. S. Rao, U. N. Bhat, and K. Harishchandra (1984), Control of traffic intensity in a queue: A method based on SPRT, *Opsearch*, **21**, 63–80.
- E. Reich (1965), Departure processes, in W. L. Smith and W. B. Wilkinson, eds., *Proceedings of the Symposium on Congestion Theory*, University of North Carolina Press, Chapel Hill, NC, 439–457.
- M. Reiser and S. S. Lavenberg (1980), Mean-value analysis of closed multichain queueing networks, *J. Assoc. Comput. Mach.*, **27-2**, 313–322.
- W. Rudin (1964), *Principles of Mathematical Analysis*, McGraw–Hill, New York.
- T. L. Saaty (1961), *Elements of Queueing Theory and Applications*, McGraw–Hill, New York.
- T. L. Saaty (1966), Seven more years of queueing theory: A lament and a bibliography, *Nav. Res. Logist. Quart.*, **13**, 447–476.
- C. H. Sauer and K. M. Chandy (1981), *Computer Systems Performance Modeling*, Prentice–Hall, Englewood Cliffs, NJ.
- T. J. Schriber (1991), *Introduction to Simulation*, Wiley, New York.
- B. Sengupta (1989), Markov processes whose steady state distribution is matrix-exponential with an application to  $GI/PH/1$ , *Adv. Appl. Probab.*, **22**, 159–180.
- V. P. Singh (1970), Two-server Markovian queues with balking heterogeneous vs. homogeneous servers, *Oper. Res.*, **18**, 145–159.
- V. P. Singh (1971), Markovian queues with three heterogeneous servers, *AIIE Trans.*, **III-1** (March), 45–48.
- D. R. Smith and W. Whitt (1981), Resource sharing for efficiency in traffic systems, *Bell Systems Tech. J.*, **60**, 39–65.

- M. J. Sobel (1974), Optimal operation of queues, in A. B. Clarke, ed., *Mathematical Methods in Queueing Theory: Proceedings of a Conference at Western Michigan University*, Springer-Verlag, New York.
- W. J. Stewart (1994), *Introduction to the Numerical Solution of Markov Chains*, Princeton University Press, Princeton, NJ.
- S. Stidham, Jr. (1995), Editorial introduction, *Queueing Systems*, **21** (special issue on optimal design and control of queueing systems), 239–243.
- S. Stidham and N. U. Prabhu (1974), Optimal control of queueing systems, in A. B. Clarke, ed., *Mathematical Methods in Queueing Theory: Proceedings of a Conference at Western Michigan University*, Springer-Verlag, New York.
- T. Suzuki and Y. Yoshida (1970), Inequalities for many server queue and other queues, *J. Oper. Res. Soc. Japan*, **13**, 59–77.
- R. Syski (1960), *Introduction to Congestion Theory in Telephone Systems*, Oliver and Boyd, Edinburgh.
- L. Takács (1962), *Introduction to the Theory of Queues*, Oxford University Press, New York.
- L. Takács (1967), *Combinatorial Methods in the Theory of Stochastic Processes*, Wiley, New York.
- H. Takagi (1997), Queueing analysis of polling models: Progress in 1990–1994, in J. H. Dshalow, ed., *Frontiers in Queueing*, CRC Press, New York, Chapter 5, 119–146.
- T. R. Thiagarajan and C. M. Harris (1979), Statistical tests for exponential service from  $M/G/1$  waiting time data, *Nav. Res. Logist. Quart.*, **26**, 511–520.
- D. Thiruvaiyaru and I. V. Basawa (1996), Maximum likelihood estimation for queueing networks, in B. L. S. Prakasa Rao and B. R. Bhat, *Stochastic Processes and Statistical Inference*, New Age International Publications, New Delhi, 132–149.
- D. Thiruvaiyaru, I. V. Basawa, and U. N. Bhat (1991), Estimation for a class of simple queueing networks, *Queueing Systems*, **9**, 301–312.
- K. S. Trivedi (2002), *Probability and Statistics with Reliability, Queueing, and Computer Science Applications*, 2nd ed., Wiley, New York.
- W. N. Venables and B. D. Ripley (2002), *Modern Applied Statistics with S*, 4th ed., Springer-Verlag, New York.
- P. T. Whittaker and G. N. Watson (1962), *A Course of Modern Analysis*, 4th ed., Cambridge University Press, Cambridge, UK.
- W. Whitt (2000), An overview of Brownian and non-Brownian FCLTs for the single server queue, *Queueing Systems*, **36**, 39–70.
- P. Whittle (1967), Nonlinear migration processes, *Bull. Internat. Statist. Inst.*, **42**, 642–646.
- P. Whittle (1968), Equilibrium distributions for an open migration process, *J. Appl. Probab.*, **5**, 567–571.
- D. V. Widder (1946), *The Laplace Transform*, Princeton University Press, Princeton, NJ.

- R. W. Wolff (1965), Problems of statistical inference for birth and death queueing models, *Oper. Res.*, **13**, 343–357.
- R. W. Wolff (1982), Poisson arrivals see time averages, *Oper. Res.*, **30**, 223–231.
- T. Yang and J. G. C. Templeton (1987), A survey of retrial queues, *Queueing Systems*, **2**, 201–233.
- S. F. Yashkov (1987), Processor sharing queues: Some progress in analysis, *Queueing Systems* **2**, 1–17.



---

# Index

- Abel's theorem, 250, 251
- absorbing state, 38, 236, 242, 244
- accessible, 242
- approximation, 175
  - diffusion, 178
  - fluid, 180
- backward
  - Kolmogorov equation, 239
  - recurrence time, 165
- balking, 64
- behavioral problems, 3
- binomial distribution, 237
  - negative, 238
- birth-and-death process, 29, 187
- Brownian motion process, 180
- bulk queue, 115, 118, 123
- busy
  - cycle, 103
  - period, 3, 24, 38, 48, 88
- carried load, 57
- Chapman–Kolmogorov relation, 25
- closed network, 141
  - Jackson, 152
- coefficient of variation, 195
- collection of data, 18
- communicate, 242
- communication systems, 7
- completion time, 130
- compound Poisson process, 232
- computer systems, 7
- conditional likelihood function, 193
- confidence intervals, 197
- control of traffic intensity, 197
- convolution algorithm, 153, 211
- Coxian distribution, 235
- current life, 165
- cyclic queue, 154
- decision problems, 4, 201
  - control, 205
  - design, 202
  - performance measures, 202
- delayed renewal process, 161
- departure process, 40, 48
- design and control, 9
- deterministic distribution, 14
- diffusion process, 178
- distribution
  - binomial, 237
  - negative, 238
  - Coxian, 235
  - deterministic, 14
  - Engset, 62
  - Erlang, 14, 17, 120, 234, 245
    - generalized, 235, 243
    - mixed, 234
  - exponential, 14, 229
  - geometric, 237
  - hyperexponential (HE), 196, 233
  - limiting, 35, 79, 100
  - phase-type (PH), 235, 243
  - Poisson, 4, 14
  - uniform, 231
- earliest deadline first (EDF), 225
- effective output, 156

- Engset distribution, 62
- equilibrium, 3, 31
  - statistical, *see* statistical equilibrium
- equivalence class, 242
- ergodic, 186
- Erlang
  - delay formula, 45
  - distribution, 14, 17, 120, 234, 245
    - generalized, 235, 243
    - mixed, 234
  - first formula, 57
  - loss formula, 57
  - second formula, 45
  - unit of measure (Erlangs), 57
- excess life, 87, 165
- exponential distribution, 14, 229
  
- failure rate, 229
- finite
  - queue, 51
  - source
    - loss system, 61
    - queue, 59
- first-come first-served (FCFS), 36
- forced-flow law, 156
- forward
  - Kolmogorov equation, 28, 239
  - recurrence time, 87, 165
- fundamental matrix, 91, 143
  
- general response time law, 157
- generalized Erlang distribution, 235, 243
- generating function, 250
- generator, 27
- geometric distribution, 237
  
- hazard rate, 229
- hyperexponential (HE) distribution, 196, 233
- hypothesis testing, 197
  
- idle period, 24, 38, 171
- imbedded Markov chain, 75, 77, 123, 125, 191
- independence, tests for, 19
- infinite-server queue, 58
- infinitesimal transition rates, 27
- input process, 1
- interactive response time law, 157
- interarrival times, 13
  
- irreducible, 242
  - transient, 38
- Jackson network
  - closed, 152
  - open, 150
- key renewal theorem, 164
- Kolmogorov equation, 239
  - backward, 239
  - forward, 28, 239
  
- Laplace transform, 248
- Laplace–Stieltjes transform, 248
- last-come first-served (LCFS), 96
- limiting, 3
  - distribution, 35, 79, 100
- Little’s law, 38, 173
- local balance, 146
- long term, 3
- loss system, 57
  - finite-source, 61
  
- $M \rightarrow M$  property, 7, 146
- machine
  - interference problem, 59, 60
  - repair, 66
- manufacturing systems, 8
- marked point process, 24
- Markov
  - chain, 24, 236
    - imbedded, 75, 77, 123, 125, 191
  - process, 24, 239
    - renewal, 166
    - semi-, 166
- Markovian node network, 142
- Mathematica, 207
- MATLAB, 207, 215, 217
- matrix-analytic method, 6
- mean value analysis (MVA), 157, 207
- memoryless property, 16
- method of
  - isolation and aggregation, 158
  - maximum likelihood (m.l.), 186
  - moments, 186, 194
- mixed Erlang distribution, 234
- Monte Carlo simulations, 216
  
- negative binomial distribution, 238
- null recurrent, 242

- open network, 141
  - Jackson, 150
- operational laws, 155, 208
- ordinary renewal process, 161
- parameter
  - control, 198
  - space, 23, 242
- PASTA property, 83
- persistent, 242
- phase-type (PH) distribution, 235, 243
- point process, 23
  - marked, 24
- Poisson
  - arrivals see time averages, *see* PASTA
  - property
  - distribution, 4, 14
  - process, 14, 16, 229, 240
    - compound, 232
- Pollaczek–Khintchine formula, 84
- polling models, 8
- Polya process, 232
- positive recurrent, 242
- priority discipline, 127
  - head of the line, 127
  - nonpreemptive, 127
  - preemptive, 127
    - repeat, 127
      - different, 127
      - identical, 127
    - resume, 127
- QTS software, 207
- quantum, 93
- queue(s), 1
  - bulk, 115, 118, 123
  - cyclic, 154
  - discipline, 2
  - $E_k/G/1$ , 126
  - $E_k/M/1$ , 9, 120, 122
  - finite, 51
    - source, 59
  - $G/E_k/1$ , 126
  - $G/G/1$ , 169, 176, 193
  - $G/G/s$ , 177
  - $GI/G/1$ , 5, 9, 169
  - $GI/M/s$ , 5
  - $G^K/M/1$ , 123
  - $G/M/1$ , 98, 191, 197, 199
  - $G/M/1/K$ , 108
  - $G/M/s$ , 106
  - in series, 144
  - infinite-server, 58
  - length, 3
  - $M/D/s$ , 126
  - $M/E_k/1$ , 9, 120, 192
  - $M/G/1$ , 5, 76, 191, 194, 195, 197, 199, 221
  - $M/G/1/K$ , 90
  - $M/G/\infty$ , 221
  - $M/G^K/1$ , 123
  - $M_k/M/1$ , 121
  - $M/M/1$ , 5, 9, 10, 18, 34, 127, 187, 217, 218
  - $M/M/1/1$ , 62
  - $M/M/1/K$ , 54
  - $M/M/\infty$ , 58
  - $M/M_k/1$ , 122
  - $M/M/s$ , 7, 18, 43, 146
  - $M/M/s/K$ , 51
  - $M/M/s/s$ , 57
  - $M/M^{(X)}/1$ , 118
  - $M^{(X)}/M/1$ , 115
  - retrial, 8
  - tandem, 145
    - with blocking, 147
- queueing network, 7, 141
  - closed, 141
    - Jackson, 152
  - Markovian node, 142
  - open, 141
    - Jackson, 150
- random-number generator, 215
- recurrence time, 242
  - backward, 165
  - forward, 87, 165
- recurrent, 242
  - null, 242
  - positive, 242
- regenerative process, 24
- relative throughput, 142
- reliability, 144
- reneging, 66
- renewal
  - counting process, 24, 161
  - density, 162
  - equation, 164

- function, 162
- key theorem, 164
- period, 24, 161
- process, 24, 161
  - counting, *see* renewal counting process
  - delayed, 161
  - Markov, 166
  - ordinary, 161
- residence time, 130
- residual life, 165
- response time, 156
  - law
    - general, 157
    - interactive, 157
- retrial queues, 8
- Riemann–Stieltjes integral, 247
- Rouché’s theorem, 119
- round-robin (RR) service discipline, 12, 93
- routing matrix, 142
  
- sampling plan, 185
- semi-Markov process, 166
- sequential probability ratio test (SPRT), 198
- server sojourn time, 130
- service
  - mechanism, 2
  - times, 13
- shortest
  - job first (SJF), 226
  - processing time, 129
- simulation, 214, 215
  - Monte Carlo, 216
- sojourn time, 241
  - server, 130
- specialized models, 8
- state space, 23, 242
- stationarity, 80
  - tests for, 18
- stationary, 33
  
- statistical
  - analysis, 185
  - equilibrium, 4
  - inference, 9, 185
  - problems, 3
- steady state, 3, 31
- stochastic process, 3, 23, 242
- stopping rule, 193
- system
  - capacity, 2
  - time, 156
  
- tandem queues, 145
- Tauber’s theorem, 250, 251
- tests for
  - independence, 19
  - stationarity, 18
- throughput, 156, 214
  - time, 143
- time
  - dependent, 3
  - in system, 36
- traffic intensity, 35
  - control of, 197
- transform inversion, 6
- transient, 3, 242
  - irreducible, 38
- transition probability matrix, 26
  
- uniform distribution, 231
- upper bound, 172
- utilization, 156, 214
  - factor, 35
  
- vacation models, 8
- virtual waiting time process, 169
  
- waiting time, 3, 36, 47, 85, 103
  - process, virtual, 169
- Wiener process, 180