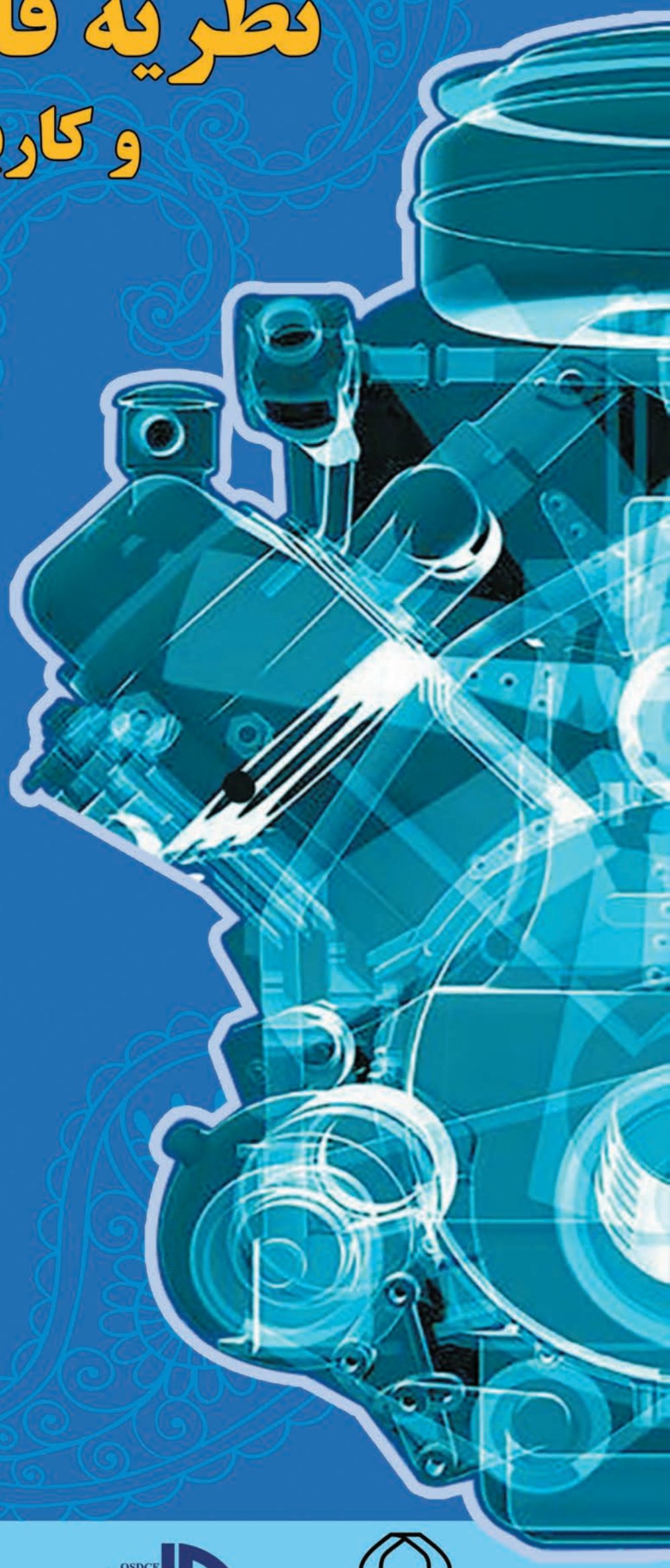
کتابچه راهنما و خلاصه مقالات

پنجمین سمینار تخصصی

# نظریه قابلیت اعتماد
## و کاربردهای آن



۲۸ و ۲۹ فروردین ۱۳۹۸
دانشکده علوم ریاضی
دانشگاه یزد

# Abstracts of

# The 5th Seminar on Reliability Theory and its Applications

**Department of Statistics**
**Yazd University,**
**Yazd, Iran**

**17-18 April, 2019**

# Preface

Following the series of workshops on “Reliability Theory and its Applications” in Ferdowsi University of Mashhad and three seminars in University of Isfahan (2015), University of Tehran (2016) and Ferdowsi University of Mashhad (2017) we are pleased to organize the 5th Seminar on **“Reliability Theory and its Applications”** during 17-18 April, 2019 at the Department of Statistics, Yazd University. On behalf of the organizing and scientic committees, we would like to extend a very warm welcome to all participants, hoping that their stay in Yazd will be happy and fruitful. Hope that this seminar provides an environment of useful discussions and would also exchange scientic ideas through opinions. We wish to express our gratitude to the numerous individuals that have contributed to the success of this seminar, in which around 70 colleagues, researchers, and postgraduate students from universities and organizations have participated.

Finally, we would like to extend our sincere gratitude to the Research Council of Yazd University, the administration of College of Sciences, the Ordered and Spatial Data Center of Excellence, the Islamic World Science Citation Center, the Fars Science and Technology Park, the Iranian Statistical Society, the Scientic Committee, the Organizing Committee, the referees, and the students and staff of the Department of Statistics at Yazd University for their kind cooperation.

Eisa Mahmoudi (Chair)

April, 2019

## Topics

The aim of the seminar is to provide a forum for presentation and discussion of scientic works covering theories and methods in the field of reliability and its application in a wide range of areas:

- Accelerated life testing
- Bayesian methods in reliability systems
- Case studies in reliability analysis
- Computational algorithms in reliability
- Data mining in reliability
- Degradation models
- Lifetime data analysis
- Lifetime distributions theory
- Maintenance modeling and analysis
- Networks reliability
- Optimization methods in reliability
- Reliability of coherent
- Safety and risk assessment
- Software reliability
- Stochastic aging
- Stochastic dependence in reliability
- Stochastic orderings in reliability
- Stochastic processes in reliability
- Stress-strength modeling
- Survival analysis

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# Estimation of $P(Y < X)$ for Two-Parameter Lindley Logarithmic Distribution

**Somayeh Abolhosseini**[1], **Mahna Imani and Mohammad Khorashadizadeh**

**Department of Statistics, University of Birjand, Birjand, Iran**

**Abstract:** In this paper we consider the estimation of the stress-strength parameter $R = P(X < Y)$, when $X$ and $Y$ are independent and both are two-parameter Lindley Logarithmic (LL) distributions. In this paper, we consider the computation of $R$, as well as its maximum likelihood estimator. Furthermore a simulation study has presented.

**Keywords** Lindley Logarithmic Distribution, Stress-Strength model, Maximum Likelihood Estimator.

**Mathematics Subject Classification (2010) :** 47A55, 39B52, 34K20, 39B82.

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# A New Bathtub Shaped Extension of the Weibull Distribution with Analysis to Reliability Data

**Zubair Ahmad**[1], **Eisa Mahmoudi, GholamHossein Hamedani**[2]

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**Abstract:** In this article, a new flexible extension of the Weibull distribution is proposed which is capable of modeling lifetime data with bathtub-shaped hazard rate function. The new model is introduced by considering a system of two logarithms of cumulative hazard rate functions. The proposed distribution will be named as a new flexible extended Weibull distribution. Some mathematical properties and characterizations along with the estimation of the model parameters through maximum likelihood method are discussed. Finally, to illustrate the importance of the proposed distribution, two real life applications with bathtub-shaped hazard functions are analyzed demonstrating that the new model provides adequate fits in comparison with the other modified forms of the Weibull model including the exponentiated Weibull, Marshall-Olkin Weibull, Additive Weibull, new modified Weibull and additive Perks-Weibull distributions.

**Keywords** Bathtub-shaped hazard rate function, Modeling reliability data, Characterizations, Maximum likelihood estimates, Weibull distribution.

**Mathematics Subject Classification (2010):** 60E05, 62F10.

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# Optimal Inspection and Repair Strategy for a Repairable System

**Jafar Ahmadi**[1], **Fatemeh Safaei**

**Department of Statistics, Ferdowsi University of Mashhad, P. O. Box 1159, Mashhad 91775, Iran**

**Abstract:** It is known that a system can be considered as a collection of components which are connected in some fashion for a specific purpose. The main feature of a system is its activation and operation. Therefore, when an operating system is active, its maintenance is important, the problem is: how can we maintain a system to increase its activation time? Also, when a system fails, the question is: does the system need to be repaired, or not? These problems have received considerable attention from many researchers. In this talk, we are going to address these issues and explore some new strategies.

**Keywords** Cost of replacement, Minimal repair, Perfect repair, Repairable system.

**Mathematics Subject Classification (2010) :** 62N05, 90B25, 60K10.

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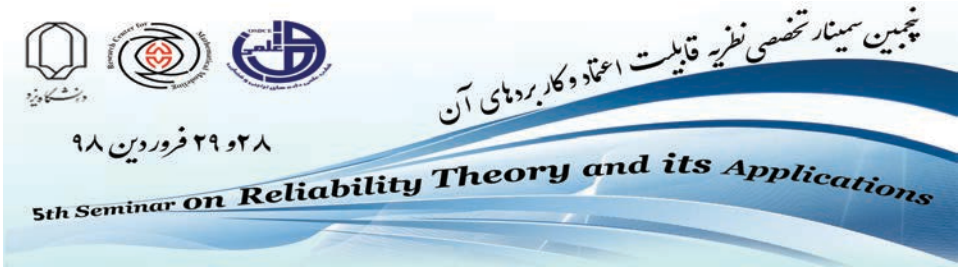


# An New Lifetime Performance Index

**Adel Ahmadi Nadi**[1], **Bahram Sadeghpour Gildeh, Robab Afshari**

**Department of Statistics, Ferdowsi University of Mashhad, Mashhad, Iran**

**Abstract:** In this paper, we consider a generalization of the lifetime performance index $C_L$ introduced by Montgomery [9], for processes with multiple quality characteristics. The new index is appropriate for mutually independent and exponentially distributed characteristics. The relationship between the extended index and overall lifetime-conforming rate is also established.

**Keywords** Lifetime Performance Index, Process Capability Indices, Exponential Distribution.

**Mathematics Subject Classification (2010) :** 62P30.

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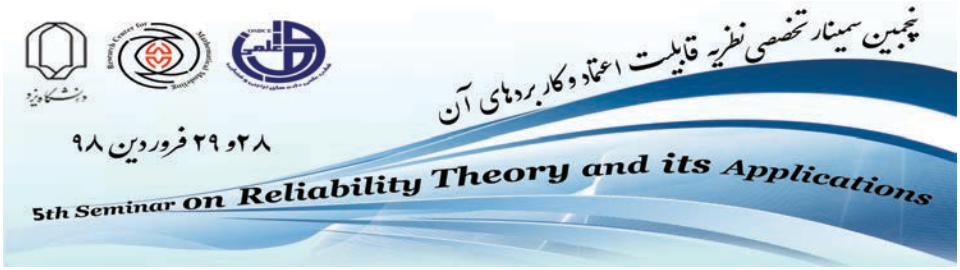


# Stochastic Properties of Generalize Finite Mixture Models with Dependent Components

**Ebrahim Amini-Seresht**[1]

**Department of Statistics, Bu-Ali Sina University, Hamedan, Iran**

**Abstract:** The purpose of this talk is to present some stochastic ordering results for the lifetimes of two classical finite mixture models with dependent components in the sense of the hazard rate order and the reversed hazard rate order.

**Keywords** Stochastic orders, Mixture model, Coherent system, Copula function.

**Mathematics Subject Classification (2010) :** 60E15, 60K10.

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# Measuring the Complexity of the Multi-State Networks Based on Jensen-Shannon Information

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**Abstract:** Nowadays, the networks have extensive applications in many domains of science and technology. The performance of the networks in good order conditions is a key issue for the users. Hence, the optimal design of the networks is a crucial task for engineers and network designers. This paper proposes a network complexity (NC) index for measuring the complexity of the structures of multi-state networks based on the Jensen-Shannon divergence. For this purpose, we utilize the signature-based reliability representation of the multi-state networks. We show that the NC index is free of the underlying distribution function of component lifetimes of the network, and depends only on the network structure. The NC, which lies between (0,1), can be used to rank the multi-state networks in terms of their complexity, in comparison to $k$-out-of-$n$-type networks. Some important properties of the NC index are investigated. Several examples of real networks are presented and, under different conditions, their NC indices are computed. As

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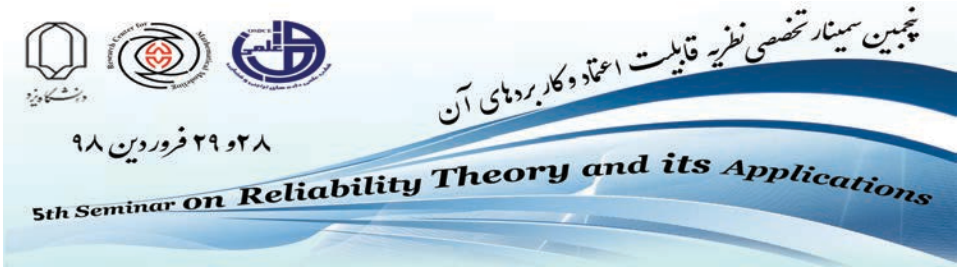
the computation of the signature matrix for large networks is an important issue in evaluating the NC index, we propose an efficient algorithm to assess the signature matrix of multi-state networks of any order.

**Keywords** Signature matrix, Kullback-Liebler information, Mutual information, Shannon entropy.




# Prediction for a Simple Step-stress Model under Type-II Censoring

**Akbar Asgharzadeh**[1], **S. Nouri Joybari**

**Department of Statistics, Faculty of Mathematical Sciences,**

**University of Mazandaran, Babolsar, Iran**

**Abstract:** With conventional life-testing experiments, it is almost impossible to obtain adequate information about the failure-time distribution and its associated parameters. Accelerated life testing (ALTs) of products are designed in order to obtain information more rapidly than under normal operating conditions. Products are tested at higher than normal levels stress such as presure, high temperature and voltage to induce early failure. Data obtained from ALTs are then analyzed and used to obtain information about the failure-time distribution and its associated parameters. In this talk, prediction methods for a simple step-stress model are discussed under Type-II censoring scheme Some numerical examples are used to illustrate the prediction methods.

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# A Graphical Method to Determine the Maximum Likelihood Estimation of Parameters of the New Pareto-Type Distribution: Complete and Censored Data

**Akbar Asgharzadeh, Ali Saadatinik**[1]

**Department of Statistics, Faculty of Mathematical Sciences,**

**University of Mazandaran, Babolsar, Iran**

**Abstract:** In this paper, a graphical method is used to determine the maximum likelihood estimation of parameters of the new Pareto-Type distribution based on complete and censored data. Using this graphical method, we will also discuss the existence and uniqueness of the maximum likelihood estimates.

**Keywords** New Pareto-Type distribution, Maximum Likelihood Estimation, Graphical Method, Censored Data.

**Mathematics Subject Classification (2010) :** 62F10, 62N01, 62N02.

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# Preventive Maintenance Model for Systems Subject to Marshal-Olkin Type Shock Models

**Somayeh Ashrafi**[1], **Razieh Rostami, Majid Asadi**

**Department of Statistics, University of Isfahan, Isfahan 81744, Iran**

**Abstract:** In this paper, we consider a binary system that is subject to Marshall-Olkin type shocks. We study an age-based preventive maintenance model for this system. The optimal preventive maintenance time that minimizes the mean cost per unit of time is investigated. The efficiency of the proposed model is computed. some examples are illustrated as the applications of the proposed model.

**Keywords** Reliability, Optimal PM time, Emergency repair.

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# Stochastic Comparisons of Series and Parallel Systems From Heterogeneous Log-logistic Random Variables with Archimedean Copula

**Ghobad Barmalzan**[1]

**Department of Statistics, University of Zabol, Zabol, Iran**

**Abstract:** This paper studies the usual stochastic, star, convex transform and dispersive orders of both series and parallel systems comprised of heterogeneous (and dependent) Log-logistic components. We establish that, without any restriction on the parameters, the lifetime of a parallel or series systems with dependent heterogeneous components is smaller than that with dependent homogeneous components in the sense of the dispersive orders. Sufficient conditions are established for the star ordering between the lifetimes of series and parallel systems consisting of dependent components having multiple-outlier Log-logistic model. Under certain conditions on Archimedean copula and the parameter, we also discuss convex transform order between the series and parallel systems. These results generalize some corresponding ones in the literature to the case of dependent scenarios or general settings of components lifetime distributions.

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# Measures of Income Inequality Based Quantile

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**Abstract:** Quantile functions are equivalent alternatives to distribution functions in analysis and modelling of statistical data. Curves that measure inequality in incomes have been a topic of immense interest for more than a century ever since the work of Lorenz in 1905. A measure of income inequality is designed to provide an index that can abridge the variations prevailing in income among the individuals in a group. In the present paper, we study more aspects on the income inequality measures using quantile function approach. Aging concepts such as IFR, IFRA, NBU, HNBUE, ... have an important role in reliability. The inequality curves and indices and some links with reliability aging using quantile function approach are concentrated in this talk. We will focus on income inequality, quantile function and aging consepts and their links. We look into possible functional relationships between the income inequality measures and quantile function. We examine the possible relationships of the inequality measures as well as reliability concepts like mean residual life function and reversed mean residual life function. Then functional relationships enable us to establish characterization results for probability distributions.

**Keywords** Quantile function, Order statistics, Lorenz order, Income inequality measures.

**Mathematics Subject Classification (2010) :** 62P20, 91B82, 91B70.

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# Some Aging Properties of a Repairable Coherent System

**Majid Chahkandi**[1]

**Department of Statistics, University of Birjand, Birjand, Iran**

**Abstract:** We consider a repairable system with $n$ independent and identically distributed components which begins to operate at time 0. If the system fails, then it undergoes minimal repair and begins to operate again. We find a general representation of the failure rate of the system based on its components failure rate. The reliability, aging and stochastic properties of the system lifetime are also investigated.

**Keywords** Aging properties, Minimal repair, Repairable system, Stochastic ordering.

**Mathematics Subject Classification (2010) :** 47A55, 39B52, 34K20, 39B82.

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# Measures of Inaccuracy for Concomitants of Generalized Order Statistics

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[1] **Faculty of Mathematics, Shahrood University of Technology,Iran**

[2] **Department of Statistics, Persian Gulf University, Bushehr, Iran**

**Abstract:** In this paper, we obtain a measure of inaccuracy between rth concomitant of generalized order statistic and the parent random variable in Morgenstern family. Applications of this result are given for concomitants of order statistics and record values. We also study some results of cumulative past inaccuracy between the distribution function of rth concomitant of order statistic (record value) and the distribution function of parent random variable.

**Keywords** Measure of inaccuracy, Cumulative inaccuracy, Concomitants, Generalized order statistics.

**Mathematics Subject Classification (2010) :** 62B10, 62G30.

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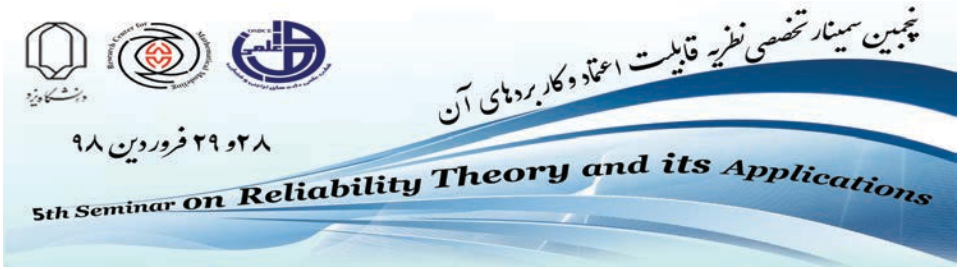


# Aspects of Convexity and Concavity for Multivariate Copulas

**Ali Dolati**[1]

**Department of Statistics, Yazd University, 89195–741, Yazd, Iran;**

**Abstract:** In this talk we review recent results on different types of convexity and concavity of multivariate copulas and the relationships among them.

**Keywords** Componentwise concavity, Copula, Quasi-concavity, Schur-concavity.

**Mathematics Subject Classification (2010) :** 60E05, 62H20.

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# Survival Function Estimation in Length-Biased and Right Censored Data

**Vahid Fakoor**[1], **Mahboubeh Akbari**

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**Abstract:** This article concerns an almost sure representation with rate for a new estimator of a survival function in the setting of length-biased and right-censored data. This representation will be the key to obtain the asymptotic properties including normality and the uniform consistency with rate of convergence for the kernel density estimator. Simulation study are drawn to illustrate the results and to show how the kernel estimator behaves for finite samples.

**Keywords** Asymptotic normality, Density estimation, Kernel method, Length-biased and right-censored data, Strong representation.

**Mathematics Subject Classification (2010):** 62G05, 62G20.

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# The Odd Generalized Half-Normal Power Series Distribution

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**Abstract:** In this paper, a new four-parameter model called the odd generalized half-normal power series (OGHNPS) distribution is defined and studied, which is obtained by compounding odd generalized half-normal (OGHN) and power series distributions. The new distribution has several desired properties and nice physical interpretations. We derive the reliability functions, the moments, and the moment generating function of the new distribution. The method of maximum likelihood is used for estimating parameters. Two particular cases of this distribution are introduced and studied in a real example.

**Keywords** Compound distribution, Odd log-logistic family of distributions, Generalized half-normal distribution, Power series distribution.

**Mathematics Subject Classification (2010) :** 62E15, 62E10, 62N99.

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# Goodness of Fit Tests for Rayleigh Distribution Based on Progressively Type II Right Censored via a New Divergence

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**Abstract:** In this paper, we define first a new measure of distance between two distributions based on their cumulative distribution function that is similar to Tsallis divergence. Then based on a progressively type II right censored sample, we construct goodness-of-fit tests for testing Rayleighity. Monte Carlo simulations for the power of the proposed tests are carried out under different alternatives. Finally, an illustrative example for use of the proposed tests is presented.

**Keywords** Goodness of fit test, Rayleigh distribution, Progressively type II right censored sample.

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# Condition-based-maintenance for a System Under Shocks and Degradation

**Firouzeh Haghighi**[1]

**School of Mathematics, Statistics and Computer Science, College of Science, University of Tehran, Tehran, Iran**

**Abstract:** In this work, a model for the systems subjected to deterioration and random shocks is developed where the shocks arrive according to a counting process. A shock could cause immediate system failure or increase the *virtual age* of system . A general degradation path model based on the *virtual age* and random effect of system is used to model the degradation of system. When the degradation level of system exceeds a critical level, the soft failure occurs. Some stochastic properties of the model have been studied. Then, an optimal maintenance policy for the systems is obtained. The maintenance action is performed based on the observed condition information. At each inspection time the system is checked. If the system has been failed it replace with new one. Otherwise the level of degradation of the system is checked. If it exceeds a pre-specified level, the system replace with new one. Regarding to the cost of corrective and preventive maintenance acts, the objective is to determine the inspection schedule and degradation threshold for preventive maintenance.

**Keywords** Counting process, Degradation-shock model, $k-$fold convolution, Maintenance.

**Mathematics Subject Classification (2010) :** 62N05, 90B25.

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# Comparison between Constant-Stress and Step-Stress Tests under Time and Cost Constraint Data from Weibull Distribution

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**Abstract:** To collect the information about the lifetime distribution of a product, a standard life testing method at normal working conditions is impractical when the product has a long lifetime. Accelerated life testing quickly yields information on product life. Test units are run at high stress and fail sooner than at design stress. The lifetime at design stress is estimated by extrapolation using a regression model. Due to constrained resources in practice, test time must be determined carefully at the design stage in order to run an accelerated life test efficiently. Test time directly affect the experimental cost as well as the estimate precision of the parameters of interest. This article investigates optimal test time based on two optimality criteria under the constraint that the total experimental cost does not exceed a pre-specified budget. The purpose is to quantify the advantage of using step-stress testing in comparison to constant-stress testing.

**Keywords** Accelerated life testing, Constant-stress testing, Maximum likelihood estimation, Optimal allocation, Step-stress testing.

**Mathematics Subject Classification (2010) :** 62N05, 62N01, 90C31.

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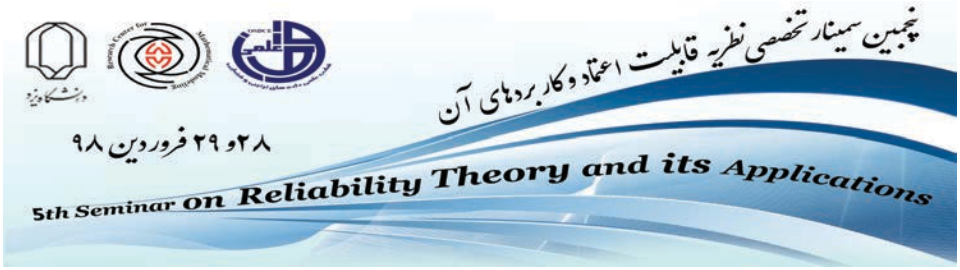


# Some Maintenance Policies for Coherent Systems

**Marziyeh Hashemi**[1], **Majid Asadi**

**Department of Statistics, University of Isfahan, Isfahan 81744, Iran**

**Abstract:** The optimal strategies to maintain the technical systems in good working condition are of important goals in reliability engineering. In this talk, some optimal maintenance policies for $n$-component coherent systems under some partial information on the component failures of the system are proposed. We introduce two criteria to compute the probability of the number of failed components in the system. Also, by imposing some cost functions, we introduce two new approaches to the optimal *corrective and preventive* maintenance of a coherent system based on the proposed criteria.

**Keywords** Preventive maintenance, Corrective maintenance, Minimal repair, Signature, Survival signature.

**Mathematics Subject Classification (2010) :** 90B25, 60K10.

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# Condition-based Maintenance Strategy Based on the Inverse Gaussian Degradation Process

**Samaneh Heydari**[1], **Soudabeh Shemehsavar, Elham Mosayebi Omshi**

**School of Mathematics, Statistics and Computer Sciences, University of Tehran, Iran**

**Abstract:** In this study a condition based maintenance (CBM) considering for a single unit system with two competing causes, degradation-based failure and shock-based failure. Inverse Gaussian process (IG) utilized to describe the degradation behavior of this system and External shocks arriving at random times according Non-homogeneous poisson processes (NHPP). To increasing the life time of the system, an imperfect maintenance performed. The main objective of this study is to minimize the expected cost per unit time by consider a relationship between the degradation level after imperfect maintenance and the cost of this action. This relationship can be linear and non-linear. Finally a numerical example introduced to describe the proposed maintenance policy.

**Keywords** Inverse Gaussian process, External shocks, Condition-based maintenance, imperfect maintenance.

**Mathematics Subject Classification (2010) :** 90B25.

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# On Estimation of Stress-Strength Parameter for Discrete Weibull Distribution

**Mahna Imani**[1], **Mohammad Khorashadizadeh**

**Department of Statistics, University of Birjand, Birjand, Iran**

**Abstract:** In this paper, statistical inference for the reliability of stress-strength models when stress and strength are independent discrete Weibull random variables is discussed. The so called proportion method estimator of model is studied and is compared with maximum likelihood (ML) estimator. Also, based on simulation, the root mean square error (RMSE) and the relative bias (RB) of the estimator of $R = P(X < Y)$ and its variance are computed and compared. Furthermore, we have provied a confidence interval for $R$ as well as its coverage rate.

**Keywords** Discrete Weibull distribution, Stress-Strength model, Maximum likelihood estimator.

**Mathematics Subject Classification (2010) :** 62F10, 62F12, 62F15, 62N01, 62N05.

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# A Confidence Interval for Stress-Strength Reliability in Gamma Model

**Ali Akbar Jafari, Javad Shaabani**[1]

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**Abstract:** In this paper we consider to construct confidence interval for the stress-strength reliability parameter under the gamma distribution. A generalized pivotal quantity is proposed for this parameter and a Monte Carlo simulation approach is given to obtain a generalized confidence interval. This approach is illustrated using a real data set.

**Keywords** CornishFisher expansion, Gamma distribution, generalized confidence interval.

**Mathematics Subject Classification (2010) :** 62F40, 62F25.

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# Allocating Two Redundancies in Series Systems with Dependent Component Lifetimes

**Hamideh Jeddi, Mahdi Doostparast**[1]

**Department of Statistics, Ferdowsi University of Mashhad, P. O. Box 1159, Mashhad 91775, Iran**

**Abstract:** This article deals with the problem of allocating redundancies for improving engineering system performances where component lifetimes are dependent and heterogeneous and an active policy is possible. Stochastic orders are implemented for comparing allocation policies. Allocations are derived under general conditions and hold for arbitrary dependency structures among lifetimes. Various examples are also given.

**Keywords** Dependence, Redundancy, Reliability, Stochastic orders.

**Mathematics Subject Classification (2010) :** 90B25, 60E15.

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# Bayesian Conditional Estimation of Weibull Distributions Under Type-II Censored Order Statistics

**Jaber Kazempoor**[1], **Arezo Habibirad**

**Department of Statistics, Ferdowsi University of Mashhad, P. O. Box 1159 Mashhad 91775, Islamic Republic of Iran**

**Abstract:** Two methods of estimation of parameters in Weibull distribution under type-II censored order statistics have been considered. It is because of the complex behavior in the calculation of the likelihood function of the presented scheme in this situation without loss of generality, this problem fixed with Gumbel model. The one to one transformation between these models and its satisfying in their parameters able us for the use of this alternative model. Moreover, some statistical inferences of a new strategy of estimating based on The Bayesian conditional method has provided and the numerical results of these strategies are compared.

**Keywords** Bayes, Conditional, Gumbel, Maximum Likelihood Estimators, Weibull.

**Mathematics Subject Classification (2010) :** 62E17, 62H12.

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# Allocation Policy of Redundancies in Two-Parallel-Series System with Randomized Components

**Maryam Kelkinnama**[1]

**Department of Mathematical Sciences, Isfahan University of Technology, Esfahan 81744, Iran**

**Abstract:** In this paper, we consider two-parallel-series system consisting two types of components chosen from two batches of $n$ independent components. Suppose that the number of components from the first batch (say $K$) is chosen randomly according to a probability distribution. We purpose to compare the systems when $K$ is distributed by two probability distributions such that they stochastically ordered.

**Keywords** Coherent system, Redundancy, Stochastic orders, Randomized components.

**Mathematics Subject Classification (2010) :** 60E15, 62N05.

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# A Probabilistic Model for Structure Functions of Coherent Systems

**Mohammad Khanjari Sadegh**[1]

**Department of Statistics, University of Birjand**

**Abstract:** Recently Coolen and Coolen-Maturi (2016) suggested the probabilistic idea for structure function of a coherent system. They did not give any specific model for their suggestion. In this paper we tried to make the preliminaries for this model. The author welcomes the interest readers and participants of the Seminar for their collaborations that are crucial for further progress of the present work.

**Keywords** Coherent systems, Probabilistic structure function, Survival signature.

**Mathematics Subject Classification (2010) :** 62N05, 60E15.

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# A New Two-Sided Class of Lifetime Distributions

**Omid Kharazmi, Mansour Zargar[1], Masoud Ajami**

**Department of Statistics, Vali-e-Asr University of Rafsanjan, P. O. Box 518, Rafsanjan, Iran**

**Abstract:** In the present paper, we introduce a new class of change point lifetime distributions. Some statistical and reliability characteristics are presented for the proposed model. In addition, we look at a real example of the data, and it can be seen that in practice the new model has a superiority over some of the statistical models.

**Keywords** Hazard rate function,Order statistics, Maximum likelihood estimator, Transmutation map,odd Transmuted two-sided distribution.

**Mathematics Subject Classification (2010) :** 62E10, 62F10.

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# Hazard Rate and Reversed Hazard Rate of $k$-out-of-$n$:$F$ Systems in a Single Outlier Model

**Bahare Khatib Astane**[1]

**Department of Mathematics, University of Neyshabur**

**Abstract:** The hazard rate function of a $k$-out-of-$n$:$F$ system is studied in the situation in which all observations except one have the same distribution. Such model is known as a single outlier model. The sensitivity of the hazard rate function with respect to the outlier is investigated in some different cases. Analogously, the reversed hazard rate function is computed. Moreover, the aging behavior of series and parallel systems are of interest in this paper.

**Keywords** Reliability function, Series system, Parallel system, Proportional (reversed) hazard rate model, Order statistics.

**Mathematics Subject Classification (2010) :** 62N05.

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# Some Results on Stress-Strength Model in General Form of Discrete Lifetime Distribution

**Mohammad Khorashadizadeh**[1]

**Department of Statistics, University of Birjand, Birjand, Iran**

**Abstract:** Stress-Strength interference (SSI) model is a concept that has a special place in reliability engineering and many other applied fields. The variety of articles published in this area, especially on the basis of continuous lifetime distributions, indicates the importance of this issue. On the other hand, discrete lifetime distributions and their application in real-life situations greatly increase the importance of studying the concepts of reliability for this case.

In this talk, after a brief review of existing works on SSI model based on discrete lifetime distribution, we introduce a technique for estimating of the stress-strength parameter in different models and situations in general form of discrete distributions. Based on some real examples, we compare those methods in literatures. Other important issues related to this topic are the estimation of the variance of the estimator. In this regard, we also discuss the improvement of approximation problem of the estimator's variance via Bhattacharyya lower bounds in replace of Cramer-Rao lower bound.

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# Bayesian Inference on Stress-Strength Parameter in Burr type XII Distribution under Hybrid Progressive Censoring Samples

**Akram Kohansal**[1]

**Department of Statistics, Imam Khomeini International University, Qazvin, Iran**

**Abstract:** In this paper, the Bayesian inference of stress-strength parameter for Burr type XII distribution under the Type-II hybrid progressive censored samples is considered. The problem is solved in three cases. In first case, assuming that stress and strength have the unknown common first shape parameter and different second shape parameters, the Bayes estimate of stress-strength parameter is derived by two approximation method: Lindley's approximation and MCMC method. In second case, assuming that stress and strength have the known common first shape parameter and unknown different second shape parameters, the exact Bayes estimate of stress-strength parameter is derived. In third case, assuming that all parameters are different and unknown, the Bayesian inference of stress-strength parameter is derived by MCMC method. We use one Monte Carlo simulation study to compare the performance of different methods.

**Keywords** Type-II hybrid progressive censored sample, Stress-strength model, Burr type XII distribution, Bayesian inference.

**Mathematics Subject Classification (2010) :** 62N05**,** 62F15**,** 62F10**.**

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# A Class of Mean Residual Regression Models Under Case-Cohort Design

**Zahra Mansourvar**[1]

**Department of Statistics, University of Isfahan, Isfahan 81744, Iran**

**Abstract:** A general class of mean residual life models is studied for analysing survival data under the case-cohort design. Martingale estimating equations are proposed for estimation of the regression parameters and the baseline mean residual life function. It is shown that the resulting regression estimators are asymptotically normal, with variance-covariance matrix that has a closed form.

**Keywords** Censored data, Estimating equation, Mean residual life, Case-cohort design.

**Mathematics Subject Classification (2010) :** 62N01, 62N02.

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# Reliability of Weighted-$k$-out-of-$n$ Systems Consisting $m$ Types of Components with Randomly Chosen Components in Each Types

**RahmatSadat Meshkat**[1], **Eisa Mahmoudi**

**Department of Statistics, Yazd University, 89175-741, Yazd, Iran;**

**Abstract:** In this paper, we consider weighted-$k$-out-of-$n$ system in which $m \geq 2$ type of components each with its own positive integer-valued weight $\omega_i$, $(i = 1, \cdots, m)$. The random lifetimes of components are from two cases: (1) the identically distributed and dependent random lifetimes of components, (2) the exchangeable and dependent random lifetimes of components in the same type with independent classes (i.e. the product copula is used). It was assumed that the random numbers $N_i, N_i = 0, 1, \cdots, n_i$ of components are chosen from class $C_i$ for type $i (i = 1, \cdots, m)$. The structure of dependency of the system component lifetimes is modelled by copula function. The reliability of the system is obtained as a mixture of the reliability of weighted-$k$-out-of-$n$ systems consisting $m$ types of components with fixed number of them in terms of the probability mass function of the random vector $(N_1, \cdots, N_{m-1})$.

**Keywords** Copulas, Reliability, Weighted-$(k_1, k_2, \cdots, k_m)$-out-of-$n$ system.

**Mathematics Subject Classification (2010) :** 62N05, 90B25.

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# Bayesian Analysis of Masked Data with Non-ignorable Missing Mechanism

**Hasan Misaii**[1], **Firouzeh Haghighi and Samaneh Eftekhary Mahabadi**

**Department of Statistics, University of Tehran, Tehran, Iran**

**Abstract:** The problem of estimation lifetime parameters in the presence of masked data is considered for a series system. Maximum Likelihood Estimations are derived and compared under missing not at random (MNAR) and missing at random (MAR) mechanisms. The results show superior performance of our approach when non-ignorable missing mechanism is occurred. Morevere, the Bayesian approach is expanded for estimation of model parameters. Bayesian analysis led to less biasness for parameters estimation than classical analysis. The proposed method is illustrated through a real example.

**Keywords** Masked Data, Non-ignorable Missing Data, Markov chain Monte Carlo Method.

**Mathematics Subject Classification (2010) :** 62M05, 49N30, 65C40.

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# A Historical View on Progress of Operational Research and Reliability with Their Role in World War

**GholamReza Mohtashami Borzadaran**[1]

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**Abstract:** Operational Research (OR) is an interdisciplinary branch of applied mathematics and science that used methods such as mathematical modelling, statistics, algorithm, to arrive the optimal or suitable solution of a copmlex problem. It leads to managements of large systems includes men, machines, fuctories, industry, economics, money in industry, material and so on.

Quality control is the activity of checking that products are of an acceptable standard and it is extendable to other feilds also.

Reliability can be expressed as the probability that given system will perform it required function under specified condition for a distinct period of time.

It is clear that a significance connection can be exist between these criteria, and sometimes are necessary to each other. So links of them is noticeable.

The operational research has a long story in the solving the life problems. It is wellknown that OR first came into using in UK during world war I and in world war II about 200 operational research scientists worked as analysis engineer for solving several problems related to management radar and bombing and so on.

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From 1960 military became known and continues service to the military and non-military areas in UK. Then it became popular in USA and had progressed there and in the world repidly. In the world war II sciences like OR, reliability and quality control had critical role and importance in managing of the war.

Note that the reliability in 1939 by Swedish engineer and mathematician W. Weibull proposed a useful distribution which is popular in reliability Gnedenko(1943) found three models where Wiebull's was one of them. Also, the application of statistical methods to quality control firstly used in 1930.

In world war II , these criterias was very basically helpful in management of the war.

After war, the progress and applications of them extended to other branch of the life style of the peoples.

In here, besides a historical view and their connections, also we will discuss on the trend of the reliability, OR and quality control up to now and what will happen in future.

**Keywords** Operation research, Quality control, Reliability History, World War.

**Mathematics Subject Classification (2010) :** 01A05**,** 01A99**,** 01A61**.**

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# On the Properties of a Reliability Dependent Model

**Vahideh Mohtashami-Borzadaran**[1], **Mohammad Amini, Jafar Ahmadi**

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**Abstract:** In this paper, a model for two dependent series-parallel systems with random number of sub-systems were introduced and the dependence structure of the proposed model was studied. Moreover, the dependency measures, such as the Kendall's tau and Spearman's rho are investigated. Furthermore, some of the bivariate reliability indexes such as the bivariate mean residual life and the bivariate reversed hazard rate were calculated.

**Keywords** Kendall's tau, Spearman's rho, Bivariate reversed hazard rate, mean reversed residual lives.

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# A Dynamic Predictive Maintenance Policy for Inverse Gaussian Process

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**Abstract:** Condition based maintenance (CBM) is a practical and effective way to guarantee the product availability. The optimization strategy of CBM is widely studied. Despite the gamma process, the inverse Gaussian (IG) process is new in this concept. Here, we deal with a dynamic condition-based maintenance of single-unit systems where the deterioration is governed by an IG process. To be more realistic, the parameters of the model are considered to be unknown. We employ the Bayes method to use the available information of degradation paths and update the information about parameters during the time.

**Keywords** Condition-based maintenance, Remaining useful life, Inverse Gaussian process, Bayesian update.

**Mathematics Subject Classification (2010) :** 90B25.

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5th Seminar on Reliability Theory and its Applications

# A Review on Degradation Data and Their Applications

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**Abstract:** Reliability analysis based on degradation modeling is a convenient and effective method for some highly reliable components or systems when observations of failures are rare. In other words, for systems with high reliability, it is difficult to assess reliability based only on lifetime data; because failures dont occur during short time at normal conditions. In such cases, degradation data contain more information than lifetime data about system reliability, which records the accumulation of damage over time. In this talk, first of all, the concept and some applications of degradation data are stated. An application of degradation modeling to estimate the time to failure of a component is illustrated. Then, some different modeling approaches are discussed to analyze the degradation data and failure times. Further, the reliability of a k-out-of-n:F system is proposed based on the amount of deteriorations of consisting components. The effect of a cold standby component on reliability of such a system is also investigated.

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# The Stochastic Properties of General Conditional Random Variables of the Dependent Components in the $(n-m+1)$-out-of-$n$ Systems

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**Abstract:** In this paper, the general conditional residual lifetime and inactivity time of the $(n-m+1)$-out-of-$n$ systems with arbitrary dependent components are considered. Also, we investigate some stochastic properties of the general conditional residual lifetime and inactivity time of the system when the components are exchangeable.

**Keywords** Residual lifetime, Inactivity time, Exchangeability, Multivariate totally positive, Reliability.

**Mathematics Subject Classification (2010) :** 62N05, 60E15, 60E05.

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# Optimal Design for Step-Stress Accelerated Degradation Tests Under Inverse Gaussian Process

**Soudabeh Shemehsavar**[1], **Samaneh Heydari, Elham Mosaebi omshi**

**School of Mathematics, Statistics and Computer Sciences, University of Tehran, Iran**

**Abstract:** In this study a step-stress accelerated degradation test (SSADT) is considered when the degradation follows an Inverse Gaussian process (IG). Under constraint that the total experimental cost does not exceed a pre-specified budget the optimal setting such as sample size, measurement frequency and number of measurement at each stress level are obtained. Finally an example is presented to illustrate the proposed method.

**Keywords** Inverse Gaussian process, step-stress accelerated degradation test, mean-time-to-failure.

**Mathematics Subject Classification (2010) :** 90B25, 97K60.

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# On a New Bivariate Survival Model for the Analysis of Dependent Lives and Its Generalization

**Shirin Shoaee**[1]

**Department of Statistics, Faculty of Mathematical Sciences,**

**Shahid Beheshti University, Tehran, Iran.**

**Abstract:** In this paper, a new bivariate model based on the model of dependent lives is introduced. This new bivariate distribution has natural interpretations, and it can be applied in fatal shock models or in competing risks models. Then, the proposed bivariate model is generalized. We call these new distributions as the bivariate Gompertz (BGP) distribution and bivariate Gompertz-geometric (BGPG) distribution, respectively. Then, we present various properties of the new bivariate models. Also, the ageing properties and the bivariate hazard gradient are discussed. We propose to use the EM algorithm to compute the maximum likelihood estimators of the unknown parameters, and it is computationally quite tractable. Finally, we analyze one real data set for illustrative purposes.

**Keywords** Bivariate model, Competing risks model, Expectation-Maximization algorithm, Gompertz distribution, Shock model.

**Mathematics Subject Classification (2010) :** 62H10, 62H12, 62E15.

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# Defining Stochastic Orderings and Ageing Classes of Life Distributions: A Unified Approach

**Mahdi Tavangar**[1]

**Department of Statistics, University of Isfahan, Isfahan 81744, Iran**

**Abstract:** In this talk, we present some new characterizations of the well-known reliability classes of life distributions such as IFR, DFR, NBU, HNBUE, NBUC, etc. For this purpose, a unified approach based on a weighted average of the failure rate of the equilibrium distribution is utilized. Different properties of the proposed measure are also considered.

**Keywords** Equilibrium distribution, Failure rate, Stochastic orders.

**Mathematics Subject Classification (2010) :** 62N05, 60K10.

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# Dynamic Measure of Importance

**Hamzeh Torabi**[1]

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**Abstract:** Measuring the total contribution of the components in a system is useful for various purposes. Ranking the components according to their importance measure which assesses the change in system reliability relating to the change in the reliability of that component, helps the engineer in evaluation of reliabilities of systems at various stages such as design, improvement, and control.

In this talk, a dynamic version of the Birnbaums reliability importance measure which can evaluate the importance of components at each time, is introduced and for some important types of systems are obtained.

**Keywords** Birnbaums reliability Importance measure, $k$-out-of-$n$ system, Parallel system, Series system, Signature of system.

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# Survival Function of Generalized $\delta$-Shock Model Based on Polya Process

**Hamzeh Torabi, Marjan Entezari**[1]

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**Abstract:** The shock models have attracted great deal of attention because of their important role in the engineering systems. A shock model is called when a system fails if the interval time between two consecutive shocks is less than a fixed threshold $\delta$. In this paper, the generalized $\delta$-shock model by assuming that the system is subject to two types of shocks under a Polya process of shock arrival which has dependent interarrival times is studied. The survival function of the system are obtained and also, the illustrative examples is presented.

**Keywords** $\delta$-shock model, Interarrival times, Polya process, Survival function.

**Mathematics Subject Classification (2010) :** 62N05, 90B25.

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# A Study on Methods for Estimating the Parametersa of the Exponentiated Weibull Distribution Under Randomly Right Censored Data Based on Misspesification of Model

**Parisa Torkaman**[1]

**Department of Statistics, Faculty of Mathematics and Statistics, University of Malayer, Malayer, Iran**

**Abstract:** Exponentiated Weibull distribution introduced as an extention of the weibull distribution is derived usefull applicationa in reliability and survival studies. In this paper, we compared the maximum likelihood estimator(MLE), the approximate maximum likelihood estimator(AMLE) and the approximate maximum likelihood Jackniffe estimator(AMLJE) of the parameters of the exponentited weibull distribution in case of the randomly right censored data. The performance of the MLE,AMLE and AMLJE are copmared by the simulation stydy. Simulation study show that, AMLE and AMLJE be have better than MLE when the proposed model is misspecified and thay are not better when not so.

**Keywords** Exponentiated Weibull distribution, approximate maximum likelihood , Right censord data.

**Mathematics Subject Classification (2010) :** 62N02, 62N01.

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# Recent Developments on Preventive Maintenance with Applications to Complex Networks

**Somayeh Zarezadeh**[1]

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**Abstract:** In the applications of reliability engineering, an important problem is provide the optimized strategies for maintenance and repair of networks (systems) in order to keep them in optimal working conditions. Usually the optimal criteria are proposed based on cost functions and availability of the network in long-run operation. In recent years, a substantial number of maintenance policies for systems composed of several components are proposed by authors under different conditions. In this talk, we first review some of the existing results on the maintenance of the complex systems. Then, we give different preventive maintenance (PM) models based on the concept of survival signature and its variants to get the optimal times of the PM of network under different scenarios. The proposed models are on the basis of some imposed cost functions and also based on availability criterion. The results are illustrated using several examples networks.

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