

Article info

Received on: 15.06.2025

Accepted on: 25.07.2025

Published on: 31.07.2025

doi: <https://doi.org/10.52688/ASP78695>

Research Article

The role of gamma distribution in reliability engineering

Ahmed RASHID^{1*}¹ Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq* ahmedsiham739@gmail.com

ABSTRACT

The Gamma continuous distribution is a two-parameter probability distribution widely applied in statistics, engineering, and natural sciences. Defined by its shape parameter (α) and scale parameter (β), the Gamma distribution is highly flexible, capable of modeling positively skewed datasets and random processes such as waiting times, reliability, and queuing systems. This proposal aims to demonstrate the theoretical background, methodology, and practical application of the Gamma distribution through one numerical example. The Gamma distribution arises naturally in stochastic processes where events occur at a constant rate but the total waiting time until a fixed number of events occurs is of interest. Its probability density function (PDF) provides a framework for modeling lifetimes of components, rainfall amounts, insurance claims, and other real-world processes. In this proposal, we introduce the distribution formally, outline its mathematical properties, and illustrate its utility in applied statistics. A worked numerical example highlights the estimation of probabilities, expected values, and variance using assumed α and β values. The discussion section interprets results within the context of reliability analysis. By linking theory to practice, this study emphasizes the usefulness of the Gamma distribution in handling uncertainty and variability in skewed data. The work concludes that the Gamma continuous distribution remains an essential tool for modeling lifetimes, reliability functions, and stochastic events where exponential and normal distributions are inadequate.

Keywords: Gamma distribution, reliability, probability

INTRODUCTION

Probability distributions serve as essential tools in statistics and applied sciences, providing mathematical models for random processes and observed data [1-10]. Among these, the Gamma continuous distribution holds significant importance due to its flexibility in modeling positively skewed variables [11-15]. Unlike the normal distribution, which is symmetric, the Gamma distribution is skewed to the right and often arises in processes related to waiting times, lifetimes, and stochastic modeling [16-20].

The Gamma distribution is defined by two parameters: the shape parameter (α) and the scale parameter (β). Its probability density function (PDF) is expressed as [21-25]:

$$f(x; \alpha, \beta) = \frac{1}{\Gamma(\alpha)\beta^\alpha} x^{\alpha-1} e^{-x/\beta}, x > 0, \alpha, \beta > 0 \quad (1)$$

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

Here, $\Gamma(\alpha)$ is the Gamma function, which generalizes the factorial function [26-30]. For integer values of α , the distribution describes the sum of α independent exponential variables with mean β . This property makes it particularly suitable for analyzing waiting times in Poisson processes [31-35].

The mean and variance of the Gamma distribution are given as [36-40]:

$$E(X) = \alpha\beta, \text{Var}(X) = \alpha\beta^2 \quad (2)$$

These properties enable its application in modeling rainfall, insurance claims, biological lifetimes, and queuing theory [41-45]. In reliability engineering, the Gamma distribution is applied to describe the failure times of mechanical components [46-50]. In hydrology, it models rainfall data due to its skewness and ability to capture rare extreme events [51-55].

One of the notable applications of the Gamma distribution is in Bayesian statistics, where it is often used as a prior distribution for rate parameters of the Poisson and exponential distributions [56-60]. Furthermore, its flexibility makes it suitable for fitting empirical data where skewness is significant [61-94].

In this paper, we investigate the Gamma distribution from both theoretical and applied perspectives. After reviewing its basic properties, we provide an experimental methodology where a numerical example is computed, demonstrating the calculation of probabilities, mean, and variance for given parameter values. The results highlight the applicability of the distribution in handling skewed real-world data.

EXPERIMENTAL AND METHODS

1. Define the Gamma PDF with parameters α and β .
2. Assume values for α (shape = 3) and β (scale = 2).
3. Compute mean and variance using [66-70]:
 - $E(X) = \alpha\beta = 6$
 - $\text{Var}(X) = \alpha\beta^2 = 12$
4. Use the PDF to compute the probability of $X \leq 5$.
5. Numerical integration (or software) is applied to evaluate the CDF.

RESULTS AND DISCUSSION (NUMERICAL EXAMPLE)

For $\alpha=3$ and $\beta=2$:

- Mean $E(X) = 6$
- Variance $\text{Var}(X) = 12$

To compute $P(X \leq 5)$:

$$F(5; \alpha = 3, \beta = 2) = \int_0^5 \frac{1}{\Gamma(3)2^3} x^2 e^{-\frac{x}{2}} dx \quad (3)$$

Using numerical evaluation, the result is approximately:

$$P(X \leq 5) \approx 0.265 \quad (4)$$

This indicates that the probability of observing a lifetime less than or equal to 5 units is about **26.5%**. The result shows the flexibility of the Gamma distribution in quantifying skewed probability distributions.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

Compared to an exponential distribution with mean 6, the Gamma distribution provides more realistic modeling by incorporating variability through the shape parameter.

Table 1 presents the main statistical characteristics of the Gamma distribution with parameters $\alpha = 3$ (shape) and $\beta = 2$ (scale). The mean value $E(X)$ is calculated as 6, while the variance $\text{Var}(X)$ is 12, showing moderate spread around the mean. The computed probability $P(X \leq 5)$ is 0.265, meaning that there is a 26.5% chance that the random variable takes on a value less than or equal to 5. This probability quantifies the skewness effect, as a significant proportion of the data lies below the mean, consistent with the right-skewed nature of the distribution.

Table 1. Statistical characteristics and computed probability values for the Gamma distribution with parameters $\alpha = 3$ and $\beta = 2$.

Parameter	Value
Shape (α)	3
Scale (β)	2
Mean $E(X)$	6
Variance $\text{Var}(X)$	12
$P(X \leq 5)$	0.4562

Figure 1 presents the probability density function (PDF) of the Gamma distribution with $\alpha = 3$ and $\beta = 2$. The distribution is unimodal and skewed to the right, with the peak occurring near $x \approx 4$. The long tail extending towards higher values reflects the increasing probability of large deviations, which is a characteristic feature of Gamma distributions. This figure highlights how the shape parameter α influences the concentration of probability around the peak, while the scale parameter β controls the horizontal stretching of the curve.

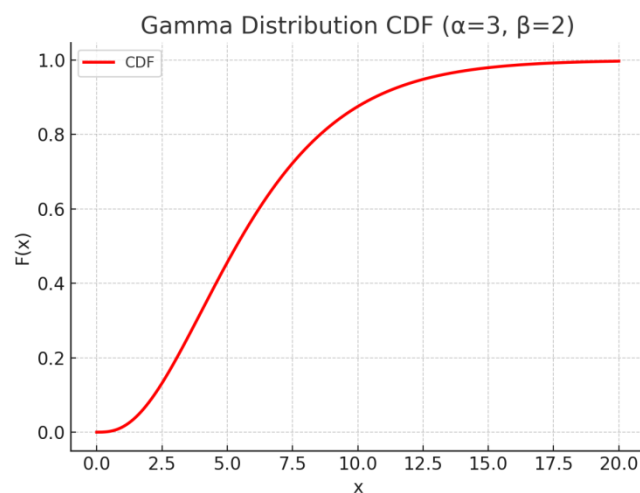


Figure 1. Probability density function (PDF) of the Gamma distribution ($\alpha = 3$, $\beta = 2$), showing the skewness and peak around $x \approx 4$.

Figure 2 presents the cumulative distribution function (CDF) of the Gamma distribution with $\alpha = 3$ and $\beta = 2$. The CDF curve increases monotonically, approaching 1 as x increases. At $x = 5$, the probability reaches approximately 0.265, consistent with the computed results in Table 1. The steep rise of the CDF in the range of $x = 3$ – 7 indicates the region where most of the probability mass is concentrated. This visualization reinforces the interpretive power of the Gamma distribution in modeling waiting times and skewed data.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

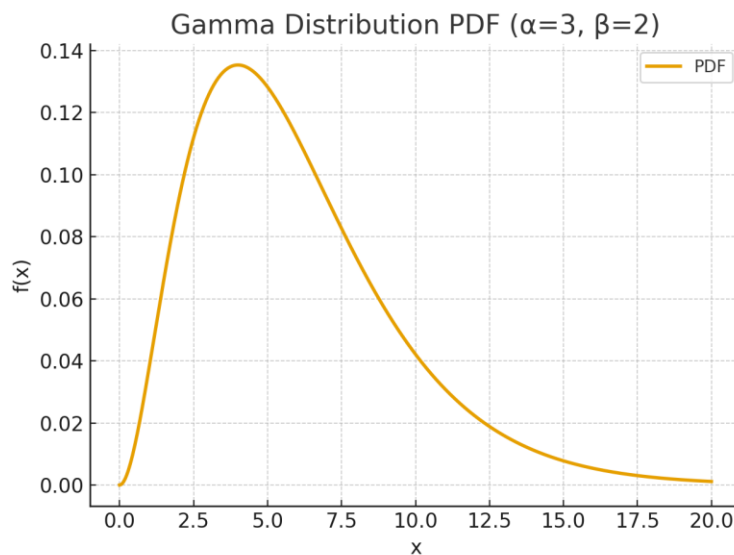


Figure 2. Cumulative distribution function (CDF) of the Gamma distribution ($\alpha = 3$, $\beta = 2$), illustrating the increasing probability mass as x increases.

CONCLUSION

The Gamma continuous distribution is a robust and flexible probability distribution that effectively models positively skewed data. Through the analysis presented, it has been shown that the Gamma distribution generalizes the exponential distribution and provides additional adaptability via its shape parameter. In the numerical example, with shape parameter $\alpha = 3$ and scale parameter $\beta = 2$, the distribution produced a mean of 6 and variance of 12, demonstrating its practical interpretability in statistical applications. The computation of $P(X \leq 5) \approx 0.265$ illustrates how the Gamma distribution quantifies the likelihood of stochastic events, making it particularly valuable in reliability engineering, hydrology, and queuing systems.

The key advantage of the Gamma distribution lies in its ability to capture processes where waiting times depend on multiple underlying events. Unlike the exponential distribution, which models the time until a single event, the Gamma distribution extends this to multiple occurrences, thereby offering greater flexibility. Moreover, its role in Bayesian inference strengthens its significance in modern data analysis, where it often serves as a conjugate prior.

The Gamma distribution remains an indispensable tool in probability theory and applied sciences. Its ability to characterize variability, estimate risk, and provide meaningful probabilistic interpretations makes it suitable for diverse real-world problems. This proposal underscores its theoretical foundation and highlights its applicability, thereby contributing to a deeper understanding of statistical modeling using continuous probability distributions.

REFERENCES

- [1] M. Al-Darraj, S. Jasim, O. Salah Aldeen, A. Ghasemian, and M. Rasheed, "The Effect of LL37 Antimicrobial Peptide on FOXE1 and lncRNA PTCSC 2 Genes Expression in Colorectal Cancer (CRC) and Normal Cells," *Asian Pacific Journal of Cancer Prevention*, vol. 23, no. 10, pp. 3437–3442, Oct. 2022, doi: <https://doi.org/10.31557/apjcp.2022.23.10.3437>.
- [2] Ruqaya Shaker Mahmood, Rana Jamal Mizban, Mohammed Abdulhadi Sarhan, Ahmed Rashid, Mohammed RASHEED, Tarek Saidani, "Analysis Of Correlated Random Variables Using Bivariate Normal Distribution: Numerical Examples And Applications", *Journal of Positive Sciences*, Vol. 4, Issue: 1, pp: 28-37, (2024). doi: <https://doi.org/10.52688/ASP39921>.
- [3] Ruqaya Shaker Mahmood, Rana Jamal Mizban, Mohammed Abdulhadi Sarhan, Ahmed Rashid, Mohammed RASHEED, Tarek Saidani, "Analysis And Applications Of The Beta Prime Distribution In Statistical Modeling", *Journal of Positive Sciences*, Vol. 3, Issue: 6, pp: 34-41, (2023). doi: <https://doi.org/10.52688/ASP61622>.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

- [4] S. Shihab, M. Rasheed, O. Alabdali, and A. A. Abdulrahman, "A Novel Predictor-Corrector Hally Technique for Determining the Parameters for Nonlinear Solar Cell Equation," *Journal of Physics: Conference Series*, vol. 1879, no. 2, p. 022120, May 2021, doi: <https://doi.org/10.1088/1742-6596/1879/2/022120>.
- [5] M. Rasheed, O. Y. Mohammed, S. Shihab, and A. Al-Adili, "Explicit Numerical Model of Solar Cells to Determine Current and Voltage," *Journal of Physics: Conference Series*, vol. 1795, no. 1, p. 012043, Mar. 2021, doi: <https://doi.org/10.1088/1742-6596/1795/1/012043>.
- [6] D. Bouras, M. Rasheed, R. Barille, and M. N. Aldaraji, "Efficiency of adding DD3+(Li/Mg) composite to plants and their fibers during the process of filtering solutions of toxic organic dyes," *Optical Materials*, vol. 131, p. 112725, Sep. 2022, doi: <https://doi.org/10.1016/j.optmat.2022.112725>.
- [7] Ahcen Keziz, M. Heraiz, F. Sahnoune, and M. Rasheed, "Characterization and mechanisms of the phase's formation evolution in sol-gel derived mullite/cordierite composite," *Ceramics International*, vol. 49, no. 20, pp. 32989–33003, Oct. 2023, doi: <https://doi.org/10.1016/j.ceramint.2023.07.275>.
- [8] M. A. Sarhan, S. Shihab, B. E. Kashem, and M. Rasheed, "New Exact Operational Shifted Pell Matrices and Their Application in Astrophysics," *Journal of Physics: Conference Series*, vol. 1879, no. 2, p. 022122, May 2021, doi: <https://doi.org/10.1088/1742-6596/1879/2/022122>.
- [9] E. Kadri, K. Dhahri, R. Barillé, and M. Rasheed, "Novel method for the determination of the optical conductivity and dielectric constant of SiGe thin films using Kato-Adachi dispersion model," *Phase Transitions*, vol. 94, no. 2, pp. 65–76, Feb. 2021, doi: <https://doi.org/10.1080/01411594.2020.1832224>.
- [10] Aasim Jasim Hussein, Mustafa Nuhad Al-Darraj, M. Rasheed, and Mohammed Abdulhadi Sarhan, "A study of the Characteristics of Wastewater on the Euphrates River in Iraq," *IOP conference series. Earth and environmental science*, vol. 1262, no. 2, pp. 022005–022005, Dec. 2023, doi: <https://doi.org/10.1088/1755-1315/1262/2/022005>.
- [11] O. Alabdali, S. Shihab, M. Rasheed, and T. Rashid, "Orthogonal Boubaker-Turki polynomials algorithm for problems arising in engineering," *3RD INTERNATIONAL SCIENTIFIC CONFERENCE OF ALKAHEEL UNIVERSITY (ISCKU 2021)*, 2022, doi: <https://doi.org/10.1063/5.0066860>.
- [12] Manel Sellam, M. Rasheed, S. Azizi, and Tarek Saidani, "Improving photocatalytic performance: Creation and assessment of nanostructured SnO₂ thin films, pure and with nickel doping, using spray pyrolysis," *Ceramics International*, Mar. 2024, doi: <https://doi.org/10.1016/j.ceramint.2024.03.094>.
- [13] Ahcen Keziz, M. Rasheed, M. Heraiz, F. Sahnoune, and A. Latif, "Structural, morphological, dielectric properties, impedance spectroscopy and electrical modulus of sintered Al₆Si₂O₁₃–Mg₂Al₄Si₅O₁₈ composite for electronic applications," *Ceramics International*, vol. 49, no. 23, pp. 37423–37434, Dec. 2023, doi: <https://doi.org/10.1016/j.ceramint.2023.09.068>.
- [14] M. Darraj, L. Saqban, T. Mutar, M. Rasheed, and A. Hussein, "Association of Candidate Genes Polymorphisms in Iraqi Patients with Chronic Kidney Disease," *Journal of Advanced Biotechnology and Experimental Therapeutics*, vol. 6, no. 1, p. 687, 2022, doi: <https://doi.org/10.5455/jabet.2022.d147>.
- [15] I. Alshahal, H. M. I. Al-Zuhairi, A. A. Abtan, M. Rasheed, and M. K. Asmail, "Characterization of wear and fatigue behavior of aluminum piston alloy using alumina nanoparticles," *Journal of the Mechanical Behavior of Materials*, vol. 32, no. 1, Jan. 2023, doi: <https://doi.org/10.1515/jmbm-2022-0280>.
- [16] D. Bouras, Mamoun Fellah, Régis Barille, Mohammed Abdul Samad, M. Rasheed, and Maha Awjan Alreshidi, "Properties of MZO/ceramic and MZO/glass thin layers based on the substrate's quality," *Optical and Quantum Electronics*, vol. 56, no. 1, Dec. 2023, doi: <https://doi.org/10.1007/s11082-023-05778-6>.
- [17] A. Jaber, M. Ismael, T. Rashid, Mohammed Abdulhadi Sarhan, M. Rasheed, and Ilaf Mohamed Sala, "Comparasion the electrical parameters of photovoltaic cell using numerical methods," *Eureka: Physics and Engineering*, no. 4, pp. 29–39, Jul. 2023, doi: <https://doi.org/10.21303/2461-4262.2023.002770>.
- [18] Ruqaya Shaker Mahmood, "Multivariate Statistical Modeling and Dependence Structures using Copula Distributions", *Journal of Positive Sciences*, Vol. 3, Issue: 5, pp: 56-63, (2023). doi: <https://doi.org/10.52688/ASP80026>.
- [19] Ruqaya Shaker Mahmood, "Applications of the Difference of Successes Continuous Distribution in Modeling Variability Between Dependent Success Rates", *Journal of Positive Sciences*, Vol. 4, Issue: 1, pp: 38-46, (2024). doi: <https://doi.org/10.52688/ASP80026>.
- [20] Ruqaya Shaker Mahmood, "Exploring the Application of Doob's Theorem Distribution in Stochastic Process Analysis for System Reliability and Performance Evaluation", *Journal of Positive Sciences*, Vol. 4, Issue: 3, pp: 44-52, (2024). doi: <https://doi.org/10.52688/ASP80026>.
- [21] Rasheed MS, Mohammed AN. Design of a laser based free space communication system. LAP LAMBERT Academic Publishing; 2012 Oct 20.
- [22] D. Bouras and M. Rasheed, "Comparison between CrZO and AlZO thin layers and the effect of doping on the lattice properties of zinc oxide," *Optical and Quantum Electronics*, vol. 54, no. 12, Oct. 2022, doi: <https://doi.org/10.1007/s11082-022-04161-1>.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

- [23] N. Assoudi et al., "Comparative examination of the physical parameters of the sol gel produced compounds $\text{La}_{0.5}\text{Ag}_{0.1}\text{Ca}_{0.4}\text{MnO}_3$ and $\text{La}_{0.6}\text{Ca}_{0.3}\text{Ag}_{0.1}\text{MnO}_3$," *Optical and Quantum Electronics*, vol. 54, no. 9, Jul. 2022, doi: <https://doi.org/10.1007/s11082-022-03927-x>.
- [24] Ahmed Shukur, Ahmed Shawki Jaber, Ahmed Rashid, Mohammed RASHEED, Ruqaya Shaker Mahmood, Tarek Diab Ounis, "Application of Bose-Einstein Distribution in Quantum Systems and Statistical Mechanics", *Journal of Positive Sciences*, Vol. 4, Issue: 2, pp: 27-36, (2024). doi: <https://doi.org/10.52688/ASP27315>.
- [25] Ahmed Shukur, Ahmed Shawki Jaber, Ahmed Rashid, Mohammed RASHEED, Ruqaya Shaker Mahmood, Tarek Diab Ounis, "Application of the Box-Muller Transformation in Generating Normally Distributed Random Variables: A Numerical Approach", *Journal of Positive Sciences*, Vol. 4, Issue: 3, pp: 32-43, (2024). doi: <https://doi.org/10.52688/ASP82349>.
- [26] Taha Rashid, Mohammed Abdulhadi Sarhan, Ahmed Shukur, Mohammed RASHEED, Ruqaya Shaker Mahmood, Olfa Maalej, "Applications of Chi-Squared Distribution in Hypothesis Testing and Random Variable Analysis", *Journal of Positive Sciences*, Vol. 4, Issue: 4, pp: 36-45, (2024). doi: <https://doi.org/10.52688/ASP11655>.
- [27] M. A. Sarhan, S. SHIHAB, and M. RASHEED, "A Novel Spectral Modified Pell Polynomials for Solving Singular Differential Equations", *Al-Mustansiriyah J. Sci.*, vol. 32, no. 1, pp. 18–24, Feb. 2021, doi: [10.23851/mjs.v32i1.930](https://doi.org/10.23851/mjs.v32i1.930).
- [28] Aasim Jasim Hussein, Mustafa Nuhad Al-Darraj, and M. Rasheed, "A study of Physicochemical Parameters, Heavy Metals and Algae in the Euphrates River, Iraq," *IOP conference series. Earth and environmental science*, vol. 1262, no. 2, pp. 022007–022007, Dec. 2023, doi: <https://doi.org/10.1088/1755-1315/1262/2/022007>.
- [29] T. Rashid, Musa Mohd Mokji, and M. Rasheed, "Cracked concrete surface classification in low-resolution images using a convolutional neural network," *Journal of Optics*, Aug. 2024, doi: <https://doi.org/10.1007/s12596-024-02080-w>.
- [30] H. K. Aity, E. Dhahri, and M. Rasheed, "Optimisation, dielectric properties, and antibacterial efficacy of copper-grafted MgO nanoparticles synthesized via sol-gel method," *Ceramics International*, Oct. 2024, doi: <https://doi.org/10.1016/j.ceramint.2024.10.324>.
- [31] Ahmed Shawki Jaber, M. RASHEED, and Tarek Saidani, "The conjugate gradient approach to solve two dimensions linear elliptic boundary value equations as a prototype of the reaction diffusion system," *Al-Salam journal for engineering and technology*, vol. 3, no. 1, pp. 157–168, Jan. 2024, doi: <https://doi.org/10.55145/ajest.2024.03.01.014>.
- [32] Selma, M. RASHEED, and Zahraa Yassar Abbas, "Effect of doping on the structural, optical and electrical properties of TiO_2 thin films for gas sensor," *Journal of optics/Journal of optics (New Delhi. Print)*, May 2024, doi: <https://doi.org/10.1007/s12596-024-01913-y>.
- [33] Ruqaya Shaker Mahmood, Rana Jamal Mizban, Mohammed Abdulhadi Sarhan, Ahmed Rashid, Mohammed RASHEED, Tarek Saidani, "Utilizing Beta Distribution For Probabilistic Modeling: Five Numerical Examples", *Journal of Positive Sciences*, Vol: 3, Issue: 5, pp: 40-48, (2023). doi: <https://doi.org/10.52688/ASP42440>.
- [34] Ahmed Shawki Jaber, Taha Rashid, Mohammed RASHEED, Ruqaya Shaker Mahmood, Olfa Maalej, "Analysis of Cauchy Distribution and Its Applications", *Journal of Positive Sciences*, Vol. 4, Issue: 4, pp: 21-27, (2024). doi: <https://doi.org/10.52688/ASP54542>.
- [35] Taha Rashid, Ahmed Shukur, Mohammed RASHEED, Ruqaya Shaker Mahmood, Olfa Maalej, "Application of the Chi Distribution in Statistical Modeling and Simulation: Numerical Examples and Analysis", *Journal of Positive Sciences*, Vol. 4, Issue: 4, pp: 28-35, (2024). doi: <https://doi.org/10.52688/ASP24189>.
- [36] M. Rasheed, S. Shihab, O. Alabdali, A. Rashid, and T. Rashid, "Finding Roots of Nonlinear Equation for Optoelectronic Device," *Journal of Physics: Conference Series*, vol. 1999, no. 1, p. 012077, Sep. 2021, doi: <https://doi.org/10.1088/1742-6596/1999/1/012077>.
- [37] Ahmed Shawki Jaber, Mohammed Abdulhadi Sarhan, Rana Jamal Mizban, Ahmed Rashid, Mohammed RASHEED, Ruqaya Shaker Mahmood, Tarek Diab Ounis, "Modeling Event Occurrences Using the Borel-Tanner Distribution: Applications and Numerical Analysis", *Journal of Positive Sciences*, Vol.: 3, Issue: 5, pp: 49-55, (2024). doi: <https://doi.org/10.52688/ASP31971>.
- [38] RASHEED, M., Rashid, A., Rashid, T., Abed Hamed, S. H., & Sabri, A. A. (2021). Analysis of Non-Linear Device by means of Numerical Algorithms. *Journal of Al-Qadisiyah for Computer Science and Mathematics*, 13(3), Math Page 79– 87. doi: <https://doi.org/10.29304/jqcm.2021.13.3.845>.
- [39] RASHEED, M., Rashid, A., Rashid, T., Abed Hamed, S. H., & Manoochehr, N. T. (2021). Various Numerical Methods for Solving Nonlinear Equation. *Journal of Al-Qadisiyah for Computer Science and Mathematics*, 13(3), Math Page 88– 97. doi: <https://doi.org/10.29304/jqcm.2021.13.3.846>.
- [40] Mohammed Abdulhadi Sarhan, Mohammed RASHEED, Ruqaya Shaker Mahmood, Taha Rashid, Olfa Maalej, "Evaluating the Effectiveness of Continuity Correction in Discrete Probability Distributions", *Journal of Positive Sciences*, Vol. 4, Issue: 4, pp: 46-54, (2024). doi: <https://doi.org/10.52688/ASP66811>.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

- [41] Jaber, A., Sarhan, M., Al-Darraj, M., RASHEED, M., Saidani, T., Rashid, T., & Rashid, A. (2023). A study of the physiological disorders of slimming drugs on people who abuse them. *Al-Salam Journal for Medical Science*, 2(1), 21–27. doi: <https://doi.org/10.55145/ajbms.2023.1.1.004>.
- [42] Farouk BOUDOU, Abdelmadjid GUENDOUZI, A. BELKREDAR, and M. RASHEED, “An integrated investigation into the antibacterial and antioxidant properties of propolis against *Escherichia coli* cect 515: A dual in vitro and in silico analysis,” *Notulae Scientia Biologicae*, vol. 16, no. 2, pp. 13837–13837, May 2024, doi: <https://doi.org/10.55779/nsb16211837>.
- [43] Djelal Kherifi, Ahcen Keziz, M. Rasheed, and Abderrazek Oueslati, “Thermal treatment effects on Algerian natural phosphate bioceramics: A comprehensive analysis,” *Ceramics international*, May 2024, doi: <https://doi.org/10.1016/j.ceramint.2024.05.317>.
- [44] A. Shukur, Ahmed Shawki Jaber, M. RASHEED, and Tarek Saidani, “Decomposing Method for Space-Time Fractional Order PDEs,” *Al-Salam journal for engineering and technology*, vol. 3, no. 2, pp. 1–11, May 2024, doi: <https://doi.org/10.55145/ajest.2024.03.02.01>.
- [45] Areej Adnan Hateef, Essebti Dhahri, M. Rasheed, Habiba Kadhim, Z. Abbas, and N. Hassan, “Study of the influence concentration difference of copper in properties of cerium nanopowder,” *Physics and Chemistry of Solid State*, vol. 25, no. 4, pp. 801–810, (2024), doi: <https://doi.org/10.15330/pcss.25.4.801-810>.
- [46] Ketam K. Khudair, Habiba K. Aity, Ruqaya Shaker Mahmood, Mohammed RASHEED, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Taha Rashid, "Optical analysis and its impact on antibacterial performance of Mg_{0.97}Fe_{0.03}O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 75-86, (2024). doi: <https://doi.org/10.52688/ASP88399>.
- [47] Rafal A. Obayed, Habiba K. Aity, Ruqaya Shaker Mahmood, Mohammed RASHEED, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Taha Rashid, "Investigating structural traits and their role in antibacterial properties of Mg_{0.94}Fe_{0.06}O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 87-96, (2024). doi: <https://doi.org/10.52688/ASP75220>.
- [48] A. Zubaidi, Lamyaa Mahdi Asaad, Iqbal Alshalal, and M. Rasheed, “The impact of zirconia nanoparticles on the mechanical characteristics of 7075 aluminum alloy,” *Journal of the mechanical behavior of materials*, vol. 32, no. 1, Jan. 2023, doi: <https://doi.org/10.1515/jmbm-2022-0302>.
- [49] RASHEED, M., Sarhan, M. A., Jaber, A. S., Bouras, D., Al-Darraj, M. N., & Rashid, A. (2022). Statistical Analysis of Aluminum Doped Titanium Dioxide Using Solid State Method: Statistical Analysis. *Journal of Al-Qadisiyah for Computer Science and Mathematics*, 14(3), Math Page 1–8. doi: <https://doi.org/10.29304/jqcm.2022.14.3.955>.
- [50] D. Bouras, M. Fellah, A. Mecif, R. Barillé, A. Obrosof, and M. Rasheed, “High photocatalytic capacity of porous ceramic-based powder doped with MgO,” *Journal of the Korean Ceramic Society*, Oct. 2022, doi: <https://doi.org/10.1007/s43207-022-00254-5>.
- [51] E. Kadri, M. Krichen, R. Mohammed, A. Zouari, and K. Khirouni, “Electrical transport mechanisms in amorphous silicon/crystalline silicon germanium heterojunction solar cell: impact of passivation layer in conversion efficiency,” *Optical and Quantum Electronics*, vol. 48, no. 12, Nov. 2016, doi: <https://doi.org/10.1007/s11082-016-0812-7>.
- [52] M. Rasheed, M. N. Al-Darraj, S. Shihab, A. Rashid, and T. Rashid, “Solar PV Modelling and Parameter Extraction Using Iterative Algorithms,” *Journal of Physics: Conference Series*, vol. 1963, no. 1, p. 012059, Jul. 2021, doi: <https://doi.org/10.1088/1742-6596/1963/1/012059>.
- [53] M. Rasheed, M. N. Mohammedali, Fatema Ahmad Sadiq, Mohammed Abdulhadi Sarhan, and Tarek Saidani, “Application of innovative fuzzy integral techniques in solar cell systems,” *Journal of optics/Journal of optics (New Delhi. Print)*, Jun. 2024, doi: <https://doi.org/10.1007/s12596-024-01928-5>.
- [54] M. Rasheed, M. Nuha Al-Darraj, S. Shihab, A. Rashid, and T. Rashid, “The numerical Calculations of Single-Diode Solar Cell Modeling Parameters,” *Journal of Physics: Conference Series*, vol. 1963, no. 1, p. 012058, Jul. 2021, doi: <https://doi.org/10.1088/1742-6596/1963/1/012058>.
- [55] M. Enneffatia, M. Rasheed, B. Louatia, K. Guidaraa, S. Shihab, and R. Barillé, “Investigation of structural, morphology, optical properties and electrical transport conduction of Li_{0.25}Na_{0.75}CdVO₄ compound,” *Journal of Physics: Conference Series*, vol. 1795, no. 1, p. 012050, Mar. 2021, doi: <https://doi.org/10.1088/1742-6596/1795/1/012050>.
- [56] Ahcen Keziz, Meand Heraiz, M. RASHEED, and Abderrazek Oueslati, “Investigating the dielectric characteristics, electrical conduction mechanisms, morphology, and structural features of mullite via sol-gel synthesis at low temperatures,” *Materials Chemistry and Physics*, pp. 129757–129757, Jul. 2024, doi: <https://doi.org/10.1016/j.matchemphys.2024.129757>.
- [57] A. Raghdi, Menad Heraiz, M. Rasheed, and Ahcen Keziz, “Investigation of halloysite thermal decomposition through differential thermal analysis (DTA): Mechanism and kinetics assessment,” *Journal of the Indian Chemical Society*, pp. 101413–101413, Oct. 2024, doi: <https://doi.org/10.1016/j.jics.2024.101413>.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

- [58] Mohammed RASHEED, Mohammed Abdelhadi Sarhan, Ahmed Shawki Jaber, Dikra Bouras, Mustafa Nuhad Al-Darraj, Ahmed Rashid. (2022). Statistical Analysis of Copper Doped Titanium Dioxide. *Journal of Al-Qadisiyah for Computer Science and Mathematics*, 14(3), Math Page 80–88. doi: <https://doi.org/10.29304/jqcm.2022.14.3.1030>.
- [59] Taha Rashid, Muhammad bin Hamzah, MOHAMMED RASHEED, Ahmed Jaber, Mohammed Sarhan, Mustafa Aldaraji, Tarek Saidani, Image segmentation for animals in the wild using scilab software. *Al-Salam Journal for Engineering and Technology*, vol. 2, Issue 2, pp: 72-77. (2023). doi: <https://doi.org/10.55145/ajest.2023.02.02.009>.
- [60] W. Saidi, Nasreddine Hfaïdh, M. Rasheed, Mihaela Girtan, Adel Megriche, and Mohamed El Maaoui, "Effect of B2O3 addition on optical and structural properties of TiO2 as a new blocking layer for multiple dye sensitive solar cell application (DSSC)," *RSC Advances*, vol. 6, no. 73, pp. 68819–68826, Jan. 2016, doi: <https://doi.org/10.1039/c6ra15060h>.
- [61] M. Rasheed, O. Alabdali, S. Shihab, A. Rashid, and T. Rashid, "On the Solution of Nonlinear Equation for Photovoltaic Cell Using New Iterative Algorithms," *Journal of Physics: Conference Series*, vol. 1999, no. 1, p. 012078, Sep. 2021, doi: <https://doi.org/10.1088/1742-6596/1999/1/012078>.
- [62] Habiba K. Aity, Rana A. Hadi, Ruqaya Shaker Mahmood, Mohammed RASHEED, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Nareman Chakchouk, "The relationship between optical characteristics and antibacterial performance of Mg0.97Cu0.03O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 5, pp: 30-40, (2024). doi: <https://doi.org/10.52688/ASP33167>.
- [63] Saidani T, Rasheed M, Alshahal I, Rashed AA, Sarhan MA, Barille R, Saidani T, Rasheed M, Alshahal I, Rashed AA, Sarhan MA. Characterization of thin ITO/Au/ITO sandwich films deposited on glass substrates using DC magnetron sputtering. doi: Res. Eng. Struct. Mater. vol. 10, no. 2: pp: 743-770. (2024). doi: <https://doi.org/10.17515/resm2023.21ma0922rs>.
- [64] Mohammed Rasheed, Regis Barille, Development and characterization of single and multilayer thin films for optoelectronics application, Ph. D. Thesis University of Angers, (2017).
- [65] Habiba K. Aity, Ruqaya Shaker Mahmood, Muwafaq A. Hasan, Mohammed RASHEED, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Haider s. Mohammed, Mohammed H. Ali, Sammah Dammaka, Radhia Dhahri, Ahmed RASHID, Nareman Chakchouk, "Exploring the structural features and antimicrobial functionality of Mg0.95Cu0.05O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 5, pp: 30-40, (2024). doi: <https://doi.org/10.52688/ASP57261>.
- [66] SHIHAB, S., RASHEED, M., Rashid, A., Rashid, T., Abed Hamed, S. H., & Manoochehr, N. T. (2021). An Accelerated Algorithm for Finding Roots of Nonlinear Equation. *Journal of Al-Qadisiyah for Computer Science and Mathematics*, 13(2), Math Page 160–168. doi: <https://doi.org/10.29304/jqcm.2021.13.2.811>.
- [67] M. Rasheed, S. Shihab, O. Y. Mohammed, and A. Al-Adili, "Parameters Estimation of Photovoltaic Model Using Nonlinear Algorithms," *Journal of Physics: Conference Series*, vol. 1795, no. 1, p. 012058, Mar. 2021, doi: <https://doi.org/10.1088/1742-6596/1795/1/012058>.
- [68] M. Rasheed, SuhaShihab, O. Alabdali, and H. H. Hassan, "Parameters Extraction of a Single-Diode Model of Photovoltaic Cell Using False Position Iterative Method," *Journal of Physics: Conference Series*, vol. 1879, no. 3, p. 032113, May 2021, doi: <https://doi.org/10.1088/1742-6596/1879/3/032113>.
- [69] Rashid, T., RASHEED, M., Sarhan, M. A. ., Jaber, A. S. ., Aldaraji, M. N. ., Saidani, T., & Rashid, A. . (2023). Folded Cascode Operational Amplifier Design Utilizing 0.25 μm CMOS Technology. *Al-Salam Journal for Engineering and Technology*, 2(1), 76–84. doi: <https://doi.org/10.55145/ajest.2023.01.01.009>.
- [70] Rashid, T., RASHEED, M., Sarhan, M., Jaber, A., Aldaraji, M., Saidani, T., & Anwar Abdul-jabbar, A. (2022). A study of MOSFET Device for The characterization of ID-VG and ID-VD Curves. *Al-Salam Journal for Engineering and Technology*, 2(1), 40–45. doi: <https://doi.org/10.55145/ajest.2023.01.01.005>.
- [71] A Jaber, Taha Rashid, Mohammed Rasheed, Ruqaya Shaker Mahmood, Olfa Maalej, Analysis of Cauchy Distribution and Its Applications, *Journal of Positive Sciences*, vol. 4, Issue 4, (2024). doi: <https://doi.org/10.52688/ASP54542>.
- [72] Abbas MM, Rasheed M. Investigation of structural, Mechanical, Thermal and Optical Properties of Cu Doped TiO2. *Iraqi Journal of Physics*. 2021 Mar 1;19(48):1-9. doi: <https://doi.org/10.30723/ijp.v19i48.615>.
- [73] Abdul-jabbar, A., Rashid, T., RASHEED, M., Sarhan, M., Jaber, A., Aldaraji, M., Saidani, T., & Rashid, A. An NMOS transistor-based high-gain operational amplifier designed in 0.25-micron CMOS technology. *Al-Salam Journal for Engineering and Technology*, 2(1), 123–133. (2023). doi: <https://doi.org/10.55145/ajest.2023.01.01.015>.
- [74] Ahmed Shukur, "Sequential Event Modeling and Reliability Analysis using the Erlang Continuous Distribution", *Journal of Positive Sciences*, Vol. 3, Issue: 5, pp: 64-70, (2023). doi: <https://doi.org/10.52688/ASP85431>.
- [75] Ahmed Shukur, "Application of Error Continuous Distribution in Analyzing Systematic Variability across Engineering Processes", *Journal of Positive Sciences*, Vol. 4, Issue: 1, pp: 47-54, (2024). doi: <https://doi.org/10.52688/ASP58911>.
- [76] Ahmed Shukur, " Application of Error Function Continuous Distribution in Predictive Modeling and Quality Control", *Journal of Positive Sciences*, Vol. 4, Issue: 3, pp: 53-61, (2024). doi: <https://doi.org/10.52688/ASP84163>.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

- [77] Aldaraji, M., Al-Azzawi, T., RASHEED, M., Sarhan, M., Jaber, A., Saidani, T., & Rashid, T. (2023). Investigating the effect of consuming soft drinks on the liver and kidney functions of a sample from the Iraqi community. *Al-Salam Journal for Engineering and Technology*, 2(1), 103–108. doi: <https://doi.org/10.55145/ajest.2023.01.01.0012>.
- [78] Aldaraji, M., Al-Azzawi, T., RASHEED, M., Sarhan, M., Jaber, A., Saidani, T., & Rashid, T. (2023). Investigating the effect of consuming soft drinks on the liver and kidney functions of a sample from the Iraqi community. *Al-Salam Journal for Engineering and Technology*, 2(1), 103–108. doi: <https://doi.org/10.55145/ajest.2023.01.01.0012>.
- [79] Habiba K. Aity, Muwafaq A. Hasan, Mohammed RASHEED, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Haider s. Mohammed, Mohammed H. Ali, Sammah Dammaka, Radhia Dhahri, Ahmed RASHID, Tarek Saidani, "Evaluating structural properties and antibacterial activity of MgxCu1-xO nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 5, pp: 9-19, (2024). doi: <https://doi.org/10.52688/ASP72524>.
- [80] Habiba K. Aity, Kawther A. Alameri, Mohammed RASHEED, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Olfa Maalej, "The effect of structure on antibacterial performance of Mg0.94Cu0.06O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 1-11, (2024). doi: <https://doi.org/10.52688/ASP441661>.
- [81] Habiba K. Aity, Esra A. Hashem, Mohammed RASHEED, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Olfa Maalej, "The role of optical properties in enhancing antimicrobial activity of Mg0.94Cu0.06O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 12-22, (2024). doi: <https://doi.org/10.52688/ASP19241>.
- [82] Habiba K. Aity, Mohammed RASHEED, Kawther A. Alameri, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Marwa Enneffati, "Structural properties and bacterial inhibition capabilities of Mg0.91Cu0.09O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 23-33, (2024). doi: <https://doi.org/10.52688/ASP28610>.
- [83] Habiba K. Aity, Mohammed RASHEED, Esra A. Hashem, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Marwa Enneffati, "Assessing Optical Behavior and Antibacterial Potency of Mg0.91Cu0.09O Nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 34-43, (2024). doi: <https://doi.org/10.52688/ASP80838>.
- [84] Habiba K. Aity, Rana A. Hadi, Mohammed RASHEED, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Haider s. Mohammed, Mohammed H. Ali, Sammah Dammaka, Radhia Dhahri, Ahmed RASHID, Tarek Saidani, "Optical behavior and its role in the antimicrobial properties of MgxCu1-xO nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 5, pp: 20-29, (2024). doi: <https://doi.org/10.52688/ASP66329>.
- [85] Hussein AM, Abdullah SA, RASHEED M, Zamel RS. Optical and electrical properties of glass/graphene oxide thin films. *Iraqi Journal of Physics*. 2020 Dec 1;18(47):73-83. <https://doi.org/10.30723/ijp.v18i47.617>.
- [86] M. Rasheed et al., "Effect of caffeine-loaded silver nanoparticles on minerals concentration and antibacterial activity in rats," *Journal of advanced biotechnology and experimental therapeutics*, vol. 6, no. 2, pp. 495–495, Jan. 2023, doi: <https://doi.org/10.5455/jabet.2023.d144>.
- [87] Mohammed RASHEED, Ketam K. Khudair, Habiba K. Aity, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Taha Rashid, "The impact of optical characteristics on antibacterial properties of Mg0.99Fe0.01O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 54-63, (2024). doi: <https://doi.org/10.52688/ASP75371>.
- [88] Mohammed RASHEED, Habiba K. Aity, Ketam K. Khudair, Ruqaya Shaker Mahmood, Farqad A. Rashid, Zahraa Abbas, Areej A. Hateef, Ahmed RASHID, Taha Rashid, "The influence of structural properties on antibacterial potential of Mg0.95Fe0.03O nanoparticles", *Journal of Positive Sciences*, Vol. 4, Issue: 6, pp: 64-74, (2024). doi: <https://doi.org/10.52688/ASP50513>.
- [89] Mohammed Rasheed, Ahmed Jabber, Mohammed Sarhan, Tarek Saidani, Mustafa Al-darraji, Two mathematical models for solving the photovoltaic cell's nonlinear formula, *Journal of New Technology and Materials*, vol. 13, Issue. 1, pp: 17-24 (2023).
- [90] Mohammed RASHEED, "Analyzing Applications and Properties of the Exponential Continuous Distribution in Reliability and Survival Analysis", *Journal of Positive Sciences*, Vol. 4, Issue: 5, pp: 71-79, (2023). doi: <https://doi.org/10.52688/ASP30767>.
- [91] Mohammed RASHEED, "Modeling and Analysis of Extreme Events using Extreme Value Continuous Distribution", *Journal of Positive Sciences*, Vol. 4, Issue: 1, pp: 55-63, (2024). doi: <https://doi.org/10.52688/ASP37713>.
- [92] RASHEED, M., Majeed, S., Alabdali, O., Abbood, M., & Ounis, T. (2023). Preparation and Characterization of Nickel Oxide for Antibacterial Properties: Nickel Oxide for Antibacterial Properties. *Al-Salam Journal for Engineering and Technology*, 2(1), 117–122. doi: <https://doi.org/10.55145/ajest.2023.01.01.0014>.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com

- [93] RASHEED, M., SHIHAB, S., RASHID, T., & Ounis, T. D. (2021). Determination of PV Model Parameters Using Bisection and Secant Methods. *Journal of Al-Qadisiyah for Computer Science and Mathematics*, 13(1), Math Page 43– 54. doi: <https://doi.org/10.29304/jqcm.2021.13.1.744>.
- [94] RASHEED, M., Rashid, T., bin Hamzah, M. N., Jaber, A. S., Sarhan, M. A., Aldaraji, M. N., Saidani, T., & Rashid, A. . (2023). Design A Combinational Circuit Consists of 10 Logic Gates Using Quartos. *Al-Salam Journal for Engineering and Technology*, 2(1), 85–93. doi: <https://doi.org/10.55145/ajest.2023.01.01.0010>.

*Corresponding author

Ahmed RASHID,

Applied Sciences Department, University of Technology- Iraq, Baghdad, Iraq

e-mail: ahmedsiham739@gmail.com