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Mathematics

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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Geometric structure generated by the metric and torsion tensors

[*Geometricheskaia struktura, sovmestno porozhdennaia metrikoi i krucheniem*]

N.I. Yaremenko

International Mathematical Centre of NAS of Ukraine (Ukraine)
Tereshchenkovskaya Str., 3, 01601, Kiev, Ukraine; e-mail: math.kiev@gmail.com

Abstract. This article discusses the geometry generated jointly and agreed by the metric and torsion tensor. The properties of the space described means of the metric and torsion. The introduction provides an overview of the problem of articles, the goal is to explore the geometric properties of the space, which is generated by the metric and torsion that is to build the geometry from two tensors – symmetric metric and skew-symmetric pair of covariant indices of the torsion tensor. In the main part of the paper it is shown that in such a space on the one hand all the properties of the geometry of an affine space retains, on the other hand there are many important features associated with the presence of a metric, and the structure of the curvature tensor has special features, the analog of Ricci–Jacobi identity for this tensor. Gap that occurs at the transition from the original to the image and, on the contrary, in the case of infinitely small contours was also evaluated. Examples are considered. The result of the space is the getting of the type of connectedness, the torsion tensor. The gap has also been estimated.

Keywords: metric tensor, connectedness, torsion tensor, bundle, covariant derivative, covariant tensor, Ricci–Jacobi identity, torsion, geodesic line.

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UDC 517.521.7+517.518.456

Estimation of the rate of summability through the rate of approximation by partial sums and Zygmund means

[*Otsenka skorosti summiruemosti cherez skorost' priblizheniia chastichnymi summami i srednimi Zigmunda*]

I.N. Brui

Baranovichi State University (Belarus)
Voikova Str., 21, 225404, Baranovichi, Belarus; e-mail: BarSU@brest.by

Abstract. The object of this article is numerical series. The purpose of this research is to establish the rate of summability of numerical series. The main result is to get the estimation of the rate of summability for a set of methods of summation of numerical series through the rate of approximation of these series of partial sums and Zygmund. This estimation is applied to the trigonometric Fourier series and concrete S.N. Bernstein and W. Rogosinski methods of summing them. The result can be used in theoretical research of summability with speed of numerical and functional series, as well as in special courses of approximation theory.

Keywords: numerical series, summability with speed, Zygmund means, Bernstein–Rogosinski means of trigonometric Fourier series.

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Trajectories of stereographically conjugated differential systems

[*Traektorii stereograficheski sopriazhennykh differentsial'nykh sistem*]

V.N. Gorbuzov

Yanka Kupala State University of Grodno(Belarus)
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: gorbuzov@grsu.by

Abstract. The object of the research is an ordinary autonomous of the differential system of the second order with polynomial right-hand parts. The basic notions, such as stereographic conjugate differential systems, regular point, equilibrium state, cycle, limit cycle and also the publications are given. In the main part the global qualitative investigation of behavior of trajectories for ordinary autonomous polynomial of the differential system of the second order on the compact manifold sphere is done. The purpose of the research is determined the relations between trajectories of stereographic conjugate of the autonomous differential of the second order systems. Invariants under stereographic projection of phase plane in the sets of regular points, equilibrium states, and closed trajectories are given. Existence of the open cycles (limit cycles) on the extended phase plane under stereographic projection is proved. The examples of differential systems, which have the open cycles (including the limit cycles) are given. Depending on infinitely remote equilibrium states on the projective phase plane the author has received forms of Bendixson's sectors of infinitely remote equilibrium state of extended phase plane. The stereographic atlases of trajectories for differential systems are constructed. The results we got can be applied in the qualitative theory of ordinary differential equations and in the theory of oscillations.

Keywords: differential equation, equilibrium state, limit cycle, Bendixson's sector, stereographic projection, projective plane.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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Toroidal atlas of trajectories of polynomial differential systems of the second order

[*Toroidalnyi atlas traektorii polinomial'nykh differentsial'nykh sistem vtorogo poriadka*]

V.V. Blashkevich [1],
V.Yu. Tyshchenko [2]

[1] *Yanka Kupala State University of Grodno(Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: blvv@mail.ru

[2] *Yanka Kupala State University of Grodno(Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: valentinet@mail.ru

Abstract. Global qualitative research of real autonomous polynomial systems of the second order by compactification of their phase plane with the use of torus is the aim of the given work. In the first paragraph of this article an object of this investigation is pointed as the real autonomous polynomial differential equations of the second order. In the second paragraph of the article the basic concepts are defined: a compactification of the phase plane by points at infinity to compact variety, homeomorphic to a two-dimensional torus and the toroidal atlas of trajectories of real autonomous polynomial differential systems of the second order. The approach of global qualitative research of behaviour of trajectories of real autonomous polynomial differential systems of the second order at a two-dimensional torus is stated further. The toroidal atlas of trajectories of real autonomous polynomial differential systems of the second order with instructions of correlations of a disposition of trajectories on torus development is constructed. The concept of the toroidal reduced real autonomous polynomial differential systems of the second order is introduced in the third paragraph. The group structure of diffeomorphisms between the toroidal reduced real autonomous polynomial differential systems of the second order is defined. Results can be applied in a qualitative theory of ordinary differential equations and in a theory of oscillations.

Keywords: differential equation, torus, toroidal atlas.

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Solvable cases in the problem of four bodies

[*Razreshimye sluchai v zadache chetyrekh tel*]

A.T. Sazonova

Yanka Kupala State University of Grodno(Belarus)
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: lozanna86@mail.ru

Abstract. A system consisting of *N* ordinary differential equations, which is a mathematical model of the motion of *N* bodies, is an object of the research. The basic concepts such as the movement of four bodies, the constant of the interparticle interaction, Painleve property, and meromorphic solution are mentioned. The purpose of this study is to establish the analytic properties of solutions of systems of nonlinear differential equations describing the motion of the four bodies. In the main part the system describing the motion of the four bodies is considered. The necessary and sufficient conditions for the Painleve property in the system under study are established. It was found six sets of constant values of the interparticle interactions in the problem of four bodies in the plane, for which the components of general solutions are meromorphic functions, as well as 112 sets, for which its appropriate systems do not have the Painleve property. The results can be used in analytic theory of differential equations, as well as in theory of celestial mechanics.

Keywords: movement of four bodies, interaction constant, Painleve property, meromorphic solution.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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Meromorphic property of solutions of a class of systems of differential equations

[*Meromorfnost' reshenii odnogo klassa sistem differentsial'nykh uravnenii*]

E.R. Bibilo [1],
I.P. Martynov [2]

[1] *Yanka Kupala State University of Grodno(Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: elena.bibilo@mail.ru

[2] *Yanka Kupala State University of Grodno(Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: i.martynov@grsu.by

Abstract. The object of the research is a class of system of two differential equations, each of which is an equation of the second order. The aim of the research is the study of analytical properties of differential systems of the given class solutions. The introduction contains the object of the study and a brief survey of the literary sources on the topic of the study. The first integrals of the system of differential equations, which is under consideration, have been constructed in the main part. The main part also describes the connection of the given system with the other system of two differential equations, each of which contains the derivative in the second degree with the rational right-hand member. The meromorphic property of the common solutions of the systems covered is also established in the main part of the research. The article also examines two differential equations of the fourth order, connected with the system under consideration and determines the meromorphic property of the common solutions of the given equations. Two-parameter rational solutions of the equations are constructed within the negative resonance. The results can be used in analytical theory of differential equations.

Keywords: system of differential equations, resonances, meromorphic functions, Schwarzian Derivative, regular singular point.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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The method of variables division for Maxwell's system of equations. II

[*Metod razdeleniia peremennykh dlia sistemy uravnenii Maksvella. II*]

I.E. Andrushkevich [1],
A.A. Vakulchik [2]

[1] *Polotsk State University (Belarus)*
Blokhina Str., 29, 211440, Novopolotsk, Belarus; e-mail: racursj@yandex.ru

[2] *Polotsk State University (Belarus)*
Blokhina Str., 29, 211440, Novopolotsk, Belarus; e-mail: racursj@yandex.ru

Abstract. In this paper on the example of heterogeneous spherical-symmetrical media the system of Maxwell's equations is being investigated with the purpose of variables division and accurate decisions modelling. In the introduction Maxwell's equations systems is noted down in the form of the bilinear matrix-functional equations. In the main body of the paper (paragraphs 1–3) on the basis of the application of the bilinear matrix-functional equations solution conditions, the synthesis of ideas and approaches used before in such methods as Fourier generalized method of variables division in special derivatives equations, and the algebraic method of variables division in Dirac equation, Maxwell's equations system, there have been compared its equivalent four systems of ordinary differential equations (variables are divided). Each of the obtained systems of ordinary differential equations defines the dependence of all the components of the electromagnetic field on the definite variable, which allows speaking about a principally new technology of electromagnetic fields calculation based on the application of the suggested approach to the division of variables. In the fourth part a brief comparative analysis of the special-frequency and spatial-time representation of the electromagnetic field have been carried out. There have been proven that the conclusion, that the approach suggested by the authors, allows to solve problems of applied electrodynamics in the spatial-time representation. As the illustration of the suggested method opportunities two new special solutions have been obtained.

Keywords: variables division, Maxwell's equations system, Fourier generalized method, algebraic method of variables division.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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The decision of optimal control problem with state constraint for one type of the second order equations

[*Reshenie zadachi optimal'nogo bystrodeistviia s fazovym ogranicheniem dlia odnogo tipa uravnenii vtorogo poriadka*]

M.N. Goncharova

Yanka Kupala State University of Grodno(Belarus)
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: m.gonchar@grsu.by

Abstract. The time optimal control problem with state constraints is designated in introduction. The place of a time optimal control problem among other problems of optimal control and the urgency of carried out research are shown. The aim of the work is construction of optimal control for the operated object which behaviour submits to the differential equation of the second order and satisfies to state constraints. State constraints are linear, that connected state object variable and its derivative. Own values of a matrix of the normal system equivalent to the considered equation, are valid and various. Movement can begin from any points that satisfy to state constraints. A final point is the coordinates beginning. In the main part problem is presented in terms of the differential equation and in terms of normal system of the differential equations. Conditions on problem parametres at which state constraint is essential for construction of admissible control are defined. Subsets of initial points are allocated on the basis of a kind of admissible control for object transfer in the coordinates beginning in the state constraint set. The trajectories that correspond to the control are constructed, and characteristics of the constructed process are defined. The optimality of offered process is proved by means of sufficient conditions of optimality. The received results can be used for the decision of the other specific optimal control problem, including problems with quality criteria that distinct from time.

Keywords: optimal control problem, state constraint, sufficient conditions of optimality.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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Modal control of linear systems of neutral type by feedback controller

[*Modal'noe upravlenie lineinymi sistemami neitral'nogo tipa posredstvom reguliatora po tipu obratnoi sviazi*]

A.T. Pavlovskaya

Yanka Kupala State University of Grodno(Belarus)
BLK, 5, 230009, Grodno, Belarus; e-mail: pavlovskay_at@grsu.by

Abstract. One of the major problems of automatic control theory is an analytical design of controllers defining required properties to a closed system. Existing design methods of difference-differential feedback controllers for modal control of feedback linear systems can be used for a class of systems specified by strict conditions of existence of such controller. The object of the research is to extend the class of modally controlled systems by means of feedback in the form of integro-differential controller. The paper presents a criterion of modal controllability using integral-differential feedback controller for linear systems of neutral type with many commensurate delays in state and without delay in control, during the proof of which the design method of controller is specified. The main idea of the method is to build controller which allows transforming the original system into the single-input system of delayed type to which the known methods of modal control are applied. The proposed method is an algebraic, though it is based on the theory of entire functions. Cases of continuous and absolutely continuous solutions are presented separately. Results of paper are applicable in the design of controllers in objects described by relevant systems of neutral type.

Keywords: systems of neutral type, modal controllability, feedback controller.

Physics

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
Seryia 2. Matematyka. Fizika. Infarmatyka, Vylichal'naia Tekhnika i Kiravanne"
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New methods of control of ecological state of soils and municipal wastewater

[*Novye metody kontrolia ekologicheskogo sostoianiia pochv i kommunal'nykh stochnykh vod*]

L.P. Loseva [1], T.K. Krupskaya [2], G.L. Ermolenko [3], S.S. Anufrik [4], N.A. Lysukho [5]

[1] *Yanka Kupala State University of Grodno(Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: spirulina1945@mail.ru

[2] *Yanka Kupala State University of Grodno(Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: krupskayatanyusha@mail.ru

[3] *Belarus State Economic University (Belarus)*
Partizanski Ave., 26, 220070, Minsk, Belarus; e-mail: kbez@bseu.by

[4] *Yanka Kupala State University of Grodno(Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: Anufrick@grsu.by

[5] *International Sakharov Environmental University (Belarus)*
Dolgobrodskaya, 23, 220070, Minsk, Belarus; e-mail: info@iseu.by

Abstract. The object of the research is dynamics of heavy metal pollution of soils and sewage. The main factors affecting the degree of air pollution, soil and water resources in highly populated areas are described. Some indicators of the ecological state of urban facilities are shown. The aim of this study is the application of new control methods based on x-ray fluorescence analysis to assess the anthropogenic changes of the soil environment and municipal wastewater. In the main part of the study the results of the research of soil and municipal wastewater by x-ray fluorescence analysis are given as a resalt of the research. It is shown that the degree of contamination of soils correlated with the degree of depletion of the species composition of microalgae. By examining the x-ray fluorescence spectra of the samples of aquatic plants it is established that high efficiency of wastewater treatment is happened by using algae. The author proposes a rapid method of monitoring the ecological state of soils and municipal wastewater on the basis of x-ray fluorescence analysis.

Keywords: x-ray fluorescence analysis, characteristic spectrum, herbal technology, heavy metals.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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Enumeration of a structural elements of nanosized object on the basis of the topological model

[*Perechislenie strukturnykh elementov nanorazmernogo ob''ekta na osnove topologicheskoi modeli*]

Yu.G. Tarasevich

Yanka Kupala State University of Grodno (Belarus)
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: grog@grsu.by

Abstract. A topological model for enumeration of structural units in the nano-sized object is presented. In the introduction the objects of interest are identified as nano-sized objects, especially three-dimensional. The existing experience of applying topology methods to the condensed state problems is outlined. The object of this research is formulation of the topological model usable in the thermodynamical problems of nano-state, e.g., in the practical applications of Hill's nanothermodynamics. In the main part firstly the topological entities definitions are introduced and the idealised condensed-state object is defined. Secondly, the expressions for enumeration of these entities are constructed. The expressions which are finally produced can be used in the range of the condensed state problems, including, but not limiting by the problems of thermodynamics of nano-sized objects, treated by the apparatus of Hill's nanothermodynamics.

Keywords: nanoparticles, thermodynamics, nanothermodynamics, topology, free energy.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
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Arithmetic classes of point symmetry groups of three-dimensional generalized regular lattices. II. Monoclinic and orthorhombic singonies

[*Arifmeticheskie klassy grupp tochechnoi simmetrii trekhmernykh obobshchennykh reguliarnykh reshetok. II. Monoklinnaia i rombicheskaia singonii*]

V.A. Liopo [1], A.V. Sabut [2]

[1] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: liopo@grsu.by

[2] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: sabutz@grsu.by

Abstract. A generalized regular lattice is pointed as an object of investigation of this article. The lattice was generated by an arbitrary basis over a numerical set $\Re$ in 3-d Euclidean space. The set $\Re$ is one from the Euclidean rings of $\mathbb{Z}$, $\mathbb{Z}[\sqrt{2}]$, $\mathbb{Z}[\sqrt{3}]$ and $\mathbb{Z}[\tau]$. The number $\tau = \frac{1+\sqrt{5}}{2}$ is the golden ratio. The article is a continuation of the work on the classification of point symmetry groups of 3-d generalized regular lattices. It was previously listed arithmetic classes of monoclinic point groups. The point groups representing these classes are written. It was determined infinite set of mmm-extensions for each arithmetic class of monoclinic point groups. The purpose of research is the determination of arithmetic classes of point symmetry groups of 3-d generalized regular lattices. In this article only the monoclinic and orthorhombic point groups are discussed. In the main part of the paper the previously obtained mmm-extensions of monoclinic point groups divided into arithmetic classes. It is established that the mmm-extensions of point groups from the $2/m_\alpha$-class divided into two arithmetic classes $m_\alpha m_\alpha m_\alpha$ and $m_\alpha m_\beta m_\beta$ for $\Re = \mathbb{Z}$ and $\Re = \mathbb{Z}[\tau]$, and the mmm-extensions of point groups from the $2/m_\alpha$-class divided into three arithmetic classes $m_\alpha m_\alpha m_\alpha$, $m_\alpha m_\beta m_\beta$ and $m_\alpha m_\gamma m_\gamma$ for $\Re = \mathbb{Z}[\sqrt{2}]$ and $\Re = \mathbb{Z}[\sqrt{3}]$, and the mmm-extensions of point groups from the $2/m_\beta$-class divided

into three arithmetic classes $m_\alpha m_\beta m_\beta$, ${}^* m_\beta m_\beta m_\beta$ and $m_\beta m_\beta m_\beta^*$ for $\Re = \mathbb{Z}$ and $\Re = \mathbb{Z}[\tau]$, and the mmm-extensions of point groups from the $2/m_\beta$-class divided into five arithmetic classes $m_\alpha m_\beta m_\beta$, ${}^* m_\beta m_\beta m_\beta$, $m_\beta m_\beta m_\beta^*$, ${}^* m_\beta m_\beta m_\gamma$ and $m_\beta m_\beta m_\gamma^*$ for $\Re = \mathbb{Z}[\sqrt{2}]$ and $\Re = \mathbb{Z}[\sqrt{3}]$, and the mmm-extensions of point groups from the $2/m_\gamma$-class divided into five arithmetic classes $m_\alpha m_\gamma m_\gamma$, ${}^* m_\beta m_\beta m_\gamma$, $m_\beta m_\beta m_\gamma^*$, ${}^* m_\gamma m_\gamma m_\gamma$ and $m_\gamma m_\gamma m_\gamma^*$ for $\Re = \mathbb{Z}[\sqrt{2}]$ and $\Re = \mathbb{Z}[\sqrt{3}]$. The complete lists of the arithmetic classes of point mmm-group are composed. In the next our article we will list the arithmetic classes of point $mm2$-group and 222-group, and we will give total classification of point symmetry groups of lower singonies of 3-d generalized regular lattices. The results of the article can be applied in physics of solid for describing the structure of materials withnon-crystallographic symmetry.

Keywords: regular lattice, point symmetry group, arithmetic class of point symmetry groups, crystal system, Bravais manifold.

Informatics, computer technology and its control

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Automated calculation of parameters of radio signals with quadrature amplitude modulation signals under a priori parametric uncertainty

[*Optimal'nye strategii upravleniia giperbolicheskim portfelem tsennykh bumag*]

A.A. Nagorniuk [1],
A.A. Pisarchuk [2]

[1] *Zhytomyr military institute named after S.P. Korolyov of State University of Telecommunication (Ukraine)*
Mira Ave., 22, 10004, Zhytomir, Ukraine; e-mail: paix77@mail.ru

[2] *Zhytomyr military institute named after S.P. Korolyov of State University of Telecommunication (Ukraine)*
Mira Ave., 22, 10004, Zhytomir, Ukraine; e-mail: dtn.pysarchuk@mail.ru

Abstract. In the introduction of the article the relevance of scientific task is designated, the objects of the research are the methods of automated parameters estimation of digital radio signals used in the software of radio control systems. The aim of the article is improvement in the method of parameters estimation of signals with quadrature amplitude modulation and evaluation of its effectiveness with respect to the signals with non-standard forms of signal constellations. The main part of the work describes an improved method based on the determination of the minimum cross-correlation function of symbol constellation. Reducing computational complexity of the approach is implemented by means of division of two-dimensional search on the two one-dimensional searches and using the dichotomy method. As a preliminary estimate of carrier frequency in the first one-dimensional search it was used the center frequency of the amplitude-frequency spectrum whose value is close to the carrier frequency due to the uniform distribution of energy in the spectrum. The effectiveness of the proposed approach was evaluated by computer simulation in MATLAB. The simulation results show that the relative error in the carrier frequency estimation is close to 10^{-5} for the signal-noise ratio greater than 25 dB. The smaller points are in the signal constellation, the frequency error calculation is smaller. Researches of the time of signal parameters estimation confirmed the theoretical calculations carried out. The practical significance of these results is that they can be used in software radio control systems for parameters estimation of the digital signals in real-time under a priori parametric uncertainty.

Keywords: automation, parameters estimation, frequency synchronization, phase constellation, radio signal, frequency objective function, method of dichotomy.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
Seryia 2. Matematyka. Fizika. Infarmatyka, Vylichal'naia Tekhnika i Kiravanne"
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Mathematical modeling of the documents flow in information systems of documents circulation. II

[*Matematicheskoe modelirovanie protsessov dvizheniia dokumentov v informatsionykh sistemakh dokumentooborota. II*]

M.A. Matalytski [1],
V.D. Monko [2]

[1] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: m.matalytski@gmail.com

[2] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: vasilii.manko@gmail.com

Abstract. In introduction the object of the research is a stochastic model for finding in stationary characteristics required for designing the architecture of document systems of organizations with hierarchical management structure. As models that adequately describe the basic functions of the designed document management systems, closed queueing network with the multiple types of messages applications were selected. The aim of this work is to find the time-probability characteristics of the above model. In the main part of the paper stationary probabilities of states and the average characteristics, the optimization problem considered and described their decision are found. The author also obtains approximate expressions for the characteristic data for a large number of different types of messages. The problem of minimizing the mean residence time of messages in systems in their service rate and the number of systems on the network is solved. The novelty of the results is that for the first time network with different applications as a model of information workflow system is used allowing them to find different characteristics for a large number of processed documents.

Keywords: information workflow systems, queueing network, different types of applications.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
Seryia 2. Matematyka. Fizika. Infarmatyka, Vylichal'naia Tekhnika i Kiravanne"
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Application of HM-network with impatient messages in modeling of request service in technological trade center and forecasting of its incomes

[*Primenenie HM-seti s neterpelivymi zaiavkami pri modelirovanii obrabotki zaprosov tekhnotorgovogo tsentra i prognozirovanii ego dokhodov*]

E.V. Kosareva [1],
T.T. Minash [2]

[1] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: koluzaeva@gmail.com

[2] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: tanushka.vatrushka@gmail.com

Abstract In introduction the organizational structure of technological trade center JSC "Garant" and the process of service of client's requests arriving in departments of the center are described. The stochastic model of functioning of technological trade center by means of open HM-network with impatient messages is proposed. The queueing systems (QS) in model correspond to

center departments, the service lines in systems correspond to the staff of departments, and messages correspond to requests of clients which enter to the technological trade center. The systems receive some income from processing of requests which generally are random variables with known distribution functions. In the main part of the article a system of inhomogeneous ordinary differential equations for finding of average number of messages in network systems and the relations for expected income of the network systems are received. The problem of finding of optimum number of employees in departments of the center that maximize the expected income from requests processing on the set interval of time is formulated. In case when the network is functioning so that all systems have messages in queues on the average the solution of the formulated problem is found. The model example is calculated for this case.

Keywords: HM-network, impatient messages, expected income, income optimization.

"Vesnik Hrodzenskaha Dziarzhaunaha Universiteta Imia Ianki Kupaly.
Seryia 2. Matematyka. Fizika. Infarmatyka, Vylichal'naia Tekhnika i Kiravanne"
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Investigation and application of G-networks
with incomes and signals with random time activation

[*Issledovanie i primenenie G-seti s dokhodami i signalami so sluchainym vremenem aktivizatsii*]

V.V. Naumenko [1],
M.A. Matalytski [2]

[1] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: victornn86@gmail.com

[2] *Yanka Kupala State University of Grodno (Belarus)*
Ozheshko Str., 22, 230023, Grodno, Belarus; e-mail: m.matalytski@gmail.com

Abstract. In the introduction the scope of G-queuing networks with signals and without them, as well as in the case of activation signals through a random time is given. The description of the application of synthetic of G-networks with signals with random delay and HM-networks with income is described. The object of this study is an open Markovian queuing network with income, positive and negative customers, as well as signals with a random delay. The aim of this study is to analyze and to study such a network in transition (non-stationary) mode. When the signal was sent to the system to activate it requires a random time. The model of an attack on a computer system (DDoS-attack), as well as the effect of the penetration of the virus in the information and telecommunications network is described. Case when the input rate of positive and negative customers and intensity of service requests are time dependent, and the income from the state transition network are random variables with given mean values is considered. In this case, all systems of service network are single-line. In the main part of the work a description of the test network, the possible transition probabilities and revenues from the state transition network is shown. The method of finding the expected income systems on the network, find expressions for the variance of income systems in the network is described. The example has been calculated.

Keywords: G-network, HM-network, virus, negative messages, transient behavior, signals with random delay, DDoS-attack, expected incomes.