NAUČNI RADOVI
Prof. dr Katice Hedrih
(sa bibliografijom)

Priredili: Dr Slaviša Milisavljević
Dr Žarko Mijajlović

Beograd, 2014

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(A Short Survay)

KATICA (Stevanović) HEDRIH

Full professor-Scientific Research Full Professor – Project Leader of Project ON144002 in Mathematical Institute SANU Belgrade (2009-)
Full professor *and the* ***Head of the Chair for Mechanics*** (1977-1979, 1981-1983, 1986-2004)
Head of Centre of Nonlinear Dynamics and Active Structure (2005-2009)
at the Mechanical Engineering Faculty of the University of Niš

Academician of Ukrainian Higher Education Academy of Sciences
Member of Serbian Scientific Society
Academician of the Academy of Nonlinear Sciences
Scientific Secretary of the Yugoslav Section of Academy of Nonlinear Sciences (1997-2010)
Member of American Academy of Mechanics

Katica (Stevanović) HEDRIH, Doctor of Technical Sciences, ***Scientific Research Full Professor in Mathematical Institute SANU-Belgrade,*** University Professor, Bachelor Mechanical Engineer, Full Professor and the Head of the Chair for Mechanics at the Mechanical Engineering Faculty of the University of Niš (1977-1979, 1981-1983, 1986-2004) and a Full Professor of the Mechanical Engineering Faculty, University of Priština, Project Leader of republic scientific projects: Subproject – Current problems of mechanics with applications (1995-2000), Project 1616 - Real Problems on Mechanics (2001-2004) at the Mathematical Institute of SASA in Belgrade, Project 1828 –Dynamics and Control of Active Structure (2001-2004) at Faculty of Mechanical Engineering Niš, current Project ON144002 Theoretical and Applied Mechanics of the Rigid and Solid Bodies. Mechanics of Materials (2006-2010) an academician of the ***Higher Education Academy of Sciences of Ukraine*** (since 1996), a ***member of Serbian Scientific Society*** (starting from 2008) and an academician of the ***International Academy of Nonlinear Sciences ANS. – Moscow*** (since 1997), Editor-in-chief of the University of Niš scientific journal "**FACTA UNIVERSITATIS**" (1989-2004) and Editor-in-Chief of the Series Mechanics, Automatic Control and Robotics (1990-2011), member of Editorial Board of ***Int. Journal Nonlinear Sciences and Numerical Simulations, Freund Publishing House LTD*** (1999-), and ***J. Mathematical Problems in Engineering***, Hindawi Publishing Corp.http://www.hindawi.com/ (2004-), a member of GAMM and Tensor Society, member of International ASME, American Academy of Mechanics and a European Society for Mechanics Member. She is also reviewer and referee of the numerous university scientific publications and papers published by Elsevier, Springer, Hindawi Press, Freund Publishing House and other. Referee of *Zentralblatt* (with more than 100 reviews). She is the author of the monographs: *Vectors of the Mass Moments (1998), Analytical Dynamics of Discrete Hereditary Systems (co-author O.A. Goroshko,* 2001). and *The Vector Method of the Heavy Rotor Kinetic Parameters Analysis and Nonlinear Dynamics* (2001). She was the chief and project-leader of a number of scientific projects in areas of mechanics and mechanical engineering. She is one of co-authors of the research project and SASA edition-publication - The Life and Work of Serbian Scientists with four published bibliographies. She is the author of a number of scientific papers, and of university study books and textbooks in the area of Oscillations Theory, Theory of Elasticity, Strength of Materials, Mechanics, Mathematical Physics, Philosophy of Natural Sciences, History of Mechanics. She was a supervisor of a number of magisterium of sciences (10) and doctoral dissertations (8) in the area of technical sciences – nonlinear and deformable body mechanics and member of numerous commission for evaluation of the dissertations. Her papers and books were cited many times and two paper were cited by *Yu. A. Mitropolskiy and B.I.Moseenkov in Monograph*: *Asimptotičeskie rešenia uravneniy v časnih proizvodnih,* Kiev 1976, (Listed under No. 138 and 139). Her first doctors of technical sciences are now university professors and Project leader and supervisor of new generation of the Ph. D. students.

Katica R. (Stevanović) HEDRIH was born on August 28^{th} 1944 in Bobovište. As a member of the first Yugoslav competition team she was a contestant of the Fifth Mathematical Olympics in Vroclav. Poland, in 1963. She graduated mechanical engineering, the first in generation, as the best graduated student of the faculty and the University of Niš in 1966/67. She carried the "štafeta mladosti" in 1969. She got a Magisterium of Science degree in the area of mechanics (1972) and became a Doctor of the Technical Sciences (1975) at the Mechanical Engineering Faculty of University in Niš, and she also took and passed the candidate minimum (1971) in Mathematical Physics, the area of Nonlinear Oscillations and Nonlinear Differential Equations at the Mathematical Institute of the Ukrainian National Academy of Science in Kiev evaluated by commission headed be academician Y. A. Mitropolskiy. She is a University full professor since 1986.

She was the organizer of two Yugoslav congresses on theoretical and Applied Mechanics (YUCTAM Niš-1995 and Vrnjačka Banja 1997), as well as of a number of minisymposia of international rank ((YUSNP Niš 1991 and YUSNM Niš 2000, ISNM NSA Niš 2003, Integrity of Dynamical Systems at IFNA WCNA, Orlando, 2004; Integrity of Dynamical Systems –European Fracture Conference E FC16-Greece 2006 and APM Saint Petersburg 2007; MS – Analytical Mechanics at Nonlinear Dynamic Shanghai 2007, MS – Kinetic Control and Vibrorheology at ESMC Lisbon 2009 and ICDVC Hangzhou 2010m and other.).

She is the author of a number (10) of university study books and textbooks in the area of Oscillations Theory, Theory of Elasticity, Strength of Materials, Mechanics, Partial Differential Equations and Integral Equations with Application in Engineering, Philosophy of Natural Sciences, History of Mechanics.

She attended, with invited lectures or as invited participant, numerous University Mechanics Seminars or Scientific Meetings in the area of nonlinear mechanics (University of Rochester Seminar 1989, USA; University of Waterloo Seminar on Mechanics 1989., Canada; Rochester Institute of Technology, 1989.; IUTAM Symposium-Nonlinearity and Chaos in Engineering Dynamics, UCL 1993.; Inter. Conf.: *Stability, Control and Rigid Bodies Dynamics - ICSCD 96*, Donetsk – Mariupol; Seminar on *National Technical University of Athens, 1986.; SANU - Serbian Greek Symposium on Solid Mechanics 1997.; Greek-Germany-Polish–Serbian Symposium on Mechanics - Recent Advances in Mechanics, Xanthi, 1998, Democritus University of Thrace*; Third International Symposium on Classical and Celestial Mechanics, Velikie Luki, Russia, 1998; *Parallel General Lecture-Third International Conference on Nonlinear Mechanics ICNM 1998, Shanghai, China; 5th National Congress on Mechanics, Ioannina, 1998. Patras 2007; Int. IEEE-Conference Control Oscillations and Chaos COC 2000 Saint Petersburg, Russia; ISUMEL Lvov 2001,2003,2005,2007,2009 Ukraine*; Int. Symposium *Dynamical Systems and Applications*-Lodz 2001, 2010. Poland; Int. Conf. *Differential Geometry and it's Applications*, Tensor Society Tsukuba, Japan 2002.and Sapporo 2007; Int. Symposium *Analysis, Manifolds and Mechanics*, Calcutta, 2003, Universiity of Kalyani, India, 2003 and 2007, IUTAM Symposium Chaotic Dynamics and Control of Systems and Processes in Mechanics , Roma 2003. …..Workshops IFAC FDA Bordeaux 2004, Porto 2006, Ankara 2008, ENOC Moscow 2002, Eidhoven 2005, DINCON Brasil 2010, Nonlinear Vibrations Virginia Tech 2010, ICVDC Hangzhou 2010, and other) and contribution papers, of a large number of leading international congresses and scientific meetings, as well as of university scientific seminars (Ukraine, Canada, USA, Germany, Byelorussia, Greece, Israel, Austria, Bulgaria, Chesz, China, England, Denmark, Russia, Poland, Japan, Romania, Turkey, Portugal, France, India, Australia, Brazil, ...) in the area of mechanics and Nonlinear Dynamics and she is the author of over 400 bibliographical units in areas of mechanics, technical sciences and mathematics. Her papers were referenced in well-known reference journals. She is the author of the monographies: *Vectors of the Mass Moments (1998), Analytical Dynamics of Discrete Hereditary Systems (co-author O.A. Goroshko, Ukraine* 2001). and *The Vector Method of the Heavy Rotor Kinetic Parameters Analysis and Nonlinear Dynamics* (2001). She was the chief and project-leader of a number of scientific projects in areas of mechanics and mechanical engineering starting from the 1977. Shi is founder and chair of two Scientific Seminars; Theoretical and Applied Mechanics at Mechanical Engineering Faculty University of Niš (1976-2004) and Nonlinear Dynamics – Milutin Mulanković (staring from 2005). Katica (Stevanović) HEDRIH is, also, a member of numerous International Scientific Meeting held in Ukraine, Yugoslavia, Poland, China, Turket, Makedonia, Serbia, India and other.

She was, as a student a member of the first University Council in Niš (1975), and as a full professor a member of the first Educational-scientific Council of the University in Niš (1987-1988), and a member of the governing board (1994) of the Mathematical Institute SASA in Belgrade.

Books:

Vectors of the Mass Moments (Topics from Mathematics and Mechanics), *Selected Chapters of Nonlinear Oscillation Theory, Selected Chapters of Elasticity Theory, Collections of solved exams problems of Elasticity Theory, Collections of solved exams problems of Oscillation Theory, Collections of* *solved exams problems of Oscillation Theory (co-autor P. Kozić), Collections of solved exams problems of Strength of Materials (co-author M.Maksić), Natural Sciences today (co-authors M. Antić and D. Djordjević), Ljubomir Klerić (SASA Life and work of Serbian Scientists – First volume), Kosta Alković (SASA Life and work of Serbian Scientists – Third volume), Tatomir P. Andjelić (SASA Life and work of Serbian Scientists – Sixth volume) and Danilo P. Rašković (SASA Life and work of Serbian Scientists – Tenth volume) and Tatomir P. Andjelić (CD – 125 anniversary of Mathematical Institute Belgrade), Partial Differential and Integral Equations with Applications (co-authors S. Janković and P. Protić), Analytical Dynamics of Discrete Hereditary Systems (co-author O.A. Goroshko), The Vector Method of the Heavy Rotor Kinetic Parameters Analysis and Nonlinear Dynamics, and other.*

Editor in Chief of the Following Journals: *Facta Universitatis* (1990-2001), *Facta Universitatis Series Mechanics, Automatic Control and Robotics*, University of Niš (1991- 2009), and Editor of a number of Scientific Proceedings and ANN Monograph Advances in Nonlinear Sciences (Vol. 2, 2008)..

Member of Editorial Board of the following Journals: *International Journal of Nonlinear Sciences and Numerical Simulations*, Freund Publishing House LTD (od 1999-), *Facta Universitatis Series Living and Working Environmental Protection*, University of Niš (2001-), *Nauka Tehnika Bezbednost* (Science Technique Security), Institut bezbednosti, Beograd (2001- 2005) , ***J***. *Mathematical Problems in Engineering*, Hindawi Press (2004-), *Journal of Non-Linear Modeling in Science and Engineering*, http://www.demon.co.uk/cambsci/ijnms.html, Scientific Technical Review SA (2006-) and other.

Referee of *Zentralblatt fur Mathematik und ihre Grenzgebiete Berlin* (more than 100 reviews) and Journals *Theoretical and Applied Mechanics*, JDM, Beograd.(1975-1997, 2003-*), Facta Universitatis Series Mechanics, Automatic Control and Robotics*, University of Niš (1990-), *Facta Universitatis Series Living and Working Environmental Protection*, University of Niš (1995-), *Facta Universitatis Series Mechanical Engineering, University of Niš* (1993-), Neurosciences letters, Elsevier, Journal of Sound and Vibrations, Elsevier, European Polymer Journal,Elsevier, FME Transaction, Faculty of Mechanical Engineering University of Belgrade, Material Letters, Elsevier, Journal Nonlinear Analysis - Theory, Methods and Applications, Series B: Real-world Applications, Pergamon Press, Acta Mechanica Sinica, JVS, Journal of Solid and Structures, Nonlinear Dynamics, J. Of Nonlinear Mechanics, The Proceedings of Shanghai International Symposium on Nonlinear Science & Applicaions'03, as a special issue of International Journal of Bifurcation & Chaos published by World Scientific Co**.,** Archive of Applied Mechanics - Manuscript Central Account Info (SY-23)-Springer, Workshop Preprints/Proceedings No 2004-1 IFAC workshop on Fractional Differentiation and its Applications FDA 04, ENSEIRB, Bordeaux France, July 19-21, 2004. Signal Processing, Elsevier, ENOC 2005, EuroMech, and other.

Professors*: Draginja Nikolić, professor of Mathematics, Professor Dr Ing. Math. Danilo P. Rašković, Academician Yuriy Alekseevich Mitropoljskiy, Academician Tatomir P. Andjelić, Professor dr Dragoslav Mitrinović, Profesasor dr Jurij Korobov and other.*

Subject Reference**:** *Mechanics, Nonlinear Machanics, Theory of Oscillations, Theory of Elasticity, Elastodynamcs, Photoelasticity, Piezoelectrucity, Ultrasonics, Electromechanical Systems, Mechanical Engineering, Applied Mathematics, Physical Mathematics; Strength of Materials, Machine Dynamics, Computational Mechanics, Control Motions and Nonlinear Dynamical Systems, Analytical Dynamics, Damage and Fracture Dynamics, Active Structure Dynamical Systems, History and Philosophy of Sciences.*

Honours and Awards:

Best graduate student of 1966/67 at Faculty of Mechanical Engineering, and Best graduate student of 1966/67 at University of Niš.

Best Thesis of Bachelor's (Master) degree at Yugoslav Faculties of Engineering, 1967.

Fact: *For period of 33 years (from 1960 to 1993) between students at Mechanical Engineering Faculty University of Niš K. (Stevanović) Hedrih is student whit best examine evaluations (9,67) and all exams in first examination term.*

Member of the Olympic Team of Yugoslavia at International Mathematical Olympiad in Vroclav Poland (1963)

"***Štafeta mladosti"*** in 1969 and **Gold Watch Prize-present of Yugoslav President** with Signature Tito, 1969.

Medallion (Plague)***"Archimed"*** and Charter 2007 of Scientific-Technical Institute of Serbian Army for scientific work.

Prize ***Saint Volodimir (Nagrada Svatoga Volodimira)*** for 2010 of Ukrainian Higher Education Academy of Sciences

Medallion (Plague) and Charter 2008 of Cankaya University, Ankara, Turkey for Scientific advances in ***IFAC FDA Workshop Fractional differentiation and Applications.***

Medallion (Plague) and Charter 2010 of Cankaya University, Ankara, Turkey for Scientific advances in ***International Conference Nonlinear Sciences and Complexity – NSC 2010.***

Gold Medallion of Faculty of Mechanical Engineering of Niš.1985,
Medallion of Faculty of Mechanical Engineering of Niš for First Postgraduate Student – First Magistar.of Technical Science (Mechanics) 1995.

Prize of Local Editorial Zentralblatt Belgrade 1999;

First Prize of the Yugoslav Association of Pedagogues for Pedagogical Critique 2000;

Short lectures at Scientific Congresses and Symposiums approximately 200; Invited Scientific Lectures at Scientific Congresses and Symposiums, and Seminars: approximately 50. Invited Plenary and Keynote Lectures more then 20.

Supervisor of Doctor of Technical Sciences Theses 8; Supervisor of Magister of Technical Sciences Theses 10; Member of scientific commissions for evaluations of scientific levels and defense of Doctor of Technical Sciences Theses 26 and of Magister of Technical Sciences Theses 27; Supervisor of graduated student (equivalent to Master degree now) works 10 and member of commissions for defense more then 100.

Scientific Project Leader 7 in area of basic sciences (Mechanics) and each with duration of 5 years and Scientific Sub Project Leader 3 supported by Ministry of Science; Researcher at Projects of Technology 5; Professional Projects in Mechanical Engineering (Project Leader (4) or Research (3)).
Scientific Papers in International and National Journals and Chapters in Books: approximately 90, and total approximately more then 300.

Scientific Visits and participation in the Seminars or international Scientific Meetings : multiple visits to Ukraine-Kiev, Lvov and Kharkov (1969, 1970,.1996, 1998, 2001, 2003), Russia-Moscow State University and Institute on Mechanics as well as Institute of Control and Institute of Mechanical Engineering Problems in Russia (1995, 97, 98, 2000, 2002, 2005, 2007, 2008), Poland- University of Cracow, Warsaw and Poznanj and Lodz (1963, ….. 1999, 2001, 2003, 2005, 2007, 2009), Germany GAMM …., England (1993, 2003), Byelorussia, University of Waterloo, (1989), Canada, Institute of Technology Rochester (1989), Cornell University (1989) USA., Israel Institute of Technology (1992), Technical University of Athens (1997), Shanghai University China (1998, 2002), Poland Technical University Lodz (2000), Technical University of Denmark, Lyngby, Copenhagen Denmark (1977, 1999), Tsukuba University and Tensor Society .Japan (2002), M.C. Chaki Centre for Mathematics and Mathematical Sciences, Calcutta, India, 2003, University of Kalyani, India, 2003., University La Sapienza Roma IUTAM (2003), Romania Politechnika Timisoara (2002), Technical University of Wien (2003), Greece Aristotelian University Tessaloniki (2003), Tianjin University China 2004, University of Ljubljana (2002), ENSEIRB Bordeaux 2004, WCNA Orlando 2004, University of Luisiana, Lafayette USA 2006, University Otto von Geuricke 2004., Politechnika Warsaw 2004, University of Luxembourg 2005, ….... ICTAM Adelaide, Australia 2009, Porto 2008, Lisabon Portugal 2009, Brasil 2010, Virginia Tech 2010, University in Hagzhou 2010,)

Prof. Dr K. (Stevanović) Hedrih has been further honored with inclusion in Who's Who in Serbia and as a fellow of the American Biographical Institute Research Association. The American Biographical Institute also named her "Woman of the Year" for 1997, with biographical listings in Five Thousand Personalities of the World and the International Directory of Distinguished Leadership. International Directory of Distinguished Leadership (by the Editorial Board ABI)- Eighth Edition 1998. Member of the ABI's Research Board of Advisors -RBA 1998. Distinguished biography of the MILLENNIUM HALL OF FAME 1998- ABI. (Hall of Fame Testimonial Plaque). 2000 Millennium MEDAL OF HONOR - ABI 1998. ABI - American Biographical Institute - Research Fellow Recognition 1996 - 24K gold-plated coin engraved ABI Research Fellow. K. Hedrih is listed in the Directory of the European Research and Development and the Who's Who in European Research and Development 2003. 2000 Outstanding People if the 20th Century - Incorporating the Outstanding Achievement Awards, International Biographical Center Cambridge, CB2 3QP, England.(1998)
IBC

Professional Career:

Assistant, Faculty of Mechanical Engineering, University of Niš, (1968-1975)
Assistant Professor, Faculty of Mechanical Engineering, University of Niš, (1975-1981)
Associate Professor, Faculty of Mechanical Engineering, University of Niš, (1981-1985)
Full Professor, Faculty of Mechanical Engineering, University of Niš, (1986-....)
Full Professor – Scientific Research Full Professor at Mathematical Institute SANU Belgrade (2009-..)
Full Professor on Mechanics at Technical Faculty in Bor University of Belgrade (1986-1989)
Full Professor on Theory of Vibrations Mechanical Engineering University of Priština (1994-)
Elected for Full Professor on Mechanics at Faculty of Technical Academy of Yugoslav National Army (1998)
***Head of the Chair for Mechanics* (1977-1979, 1981-1983, 1986-2004)**
Vice-dean of Faculty of Mechanical Engineering University of Niš (1978-1980).

Seminar Leader: Theoretical and Applied Mechanics at Faculty of Mechanical Engineering University of Niš (1976-2005) and Seminar Nonlinear Dynamics – Milutin Milanković (2005-2009).
No
Project Leader in area of Mechanics at Mathematical Institute SANU - Belgrade (1990 - …..);
Project leader in area of Mechanical Engineering and Mechanics at Faculty of Mechanical Engineering University of Niš (1976 – 1995, 2001-2005, 2006-2010);
Expert of Yugoslav Ministry of Sciences, Technology and Development in area 1111 Mathematics, 1113 Physics and 1223 Mechanical Engineering.
President of Organizing Committee and Member of Scientific Committee of XXI Yugoslav Congress of Theoretical and Applied Mechanics Niš 1995 and XXII Yugoslav Congress of Theoretical and Applied Mechanics Vrnjačka Banja 1997; Symposium of Serbian Society of Mechanics "Nonlinear Problems in Mechanics" Arandjelovac 1983; "YUGOSLAV CONFERENCE ON NONLINEAR DETERMINISTIC AND ATOCHSTIC PROCESES IN DYNAMICAL SYSTEMS WITH APPLICATIONS" Niš 1991;; Minisymposium"Nonlinearity and Chaos in Engineering Dynamics" Niš 1995., The Fifth Symposium on Nonlinear Mechanics – The Nonlinear Sciences at the Threshold of Third Millennium Niš 2000.
Member of Governing Board of Mathematical Institute SANU Beograd (1994).

SPISAK RADOVA
Katice R. (Stevanovic) Hedrih
u periodu 2005-2010
(List of Selected Papers – Period 2005-2010)

I. Radovi publikovani u časopisima za period 2005-2010 godina
(sa ISSN brojevima, kao i sa i bez impact faktora)
I. List of Papers published in Scientific Journals with chategorization)

2010.

1* Hedrih (Stevanović) K., Optimal control in nonlinear system with no ideal constraints, Commun Nonlinear Sci Numer Simulat, journal homepage: www.elsevier.com/locate/cnsns, CNSNS 1579 No. of Pages 13, Model 3G
Optimal control in nonlinear system with no ideal constraints, *Communications in Nonlinear Science and Numerical Simulation*, *In Press, Accepted Manuscript*, *Available online 6 May 2010*,
Katica R. (Stevanović) Hedrih
Preview PDF (574 K) | Related Articles (Science Direct)
(Stevanovic´) Hedrih KR. Optimal control in nonlinear system with no ideal constraints. Commun Nonlinear Sci Numer Simulat (2010), doi:10.1016/j.cnsns.2010.04.053
ISSN 1007-5704 M23=3

2* Hedrih (Stevanović) K., Simonovic´ J. D. , *Non-linear dynamics of the sandwich double circular plate system*, Int. J. Non-Linear Mech. (2010), doi:10.1016/j.ijnonlinmec.2009.12.007
International Journal of Non-Linear Mechanics 2009. 12 . 007.
Non-linear dynamics of the sandwich double circular plate system,
International Journal of Non-Linear Mechanics, ***In Press, Corrected Proof***, *Available online 4 January 2010*
Katica R. (Stevanović) **Hedrih**, Julijana D. Simonović
Preview PDF (1676 K) | Related Articles (Science Direct)
K.R.(Stevanovic´) Hedrih, J.D.Simonovic´ , Non-linear dynamics of the sandwich double circular platesystem, Int. J.Non-Linear Mech. (2010), doi:10.1016/j.ijnonlinmec.2009.12.007
ISSN 0020-7462 M21=8 IF= 1.716

3* Katica R. (Stevanovic) Hedrih and Vera Nikolic-Stanojevic, **A MODEL OF GEAR TRANSMISSION: FRACTIONAL ORDER SYSTEM DYNAMICS, (Research Article),** Mathematical

Problems in Engineering, Received 24 January 2010; Revised 2 March 2010; Accepted 6 May 2010.
(http://www.hindawi.com/journals/mpe/aip.972873.html)
http://www.hindawi.com/journals/mpe/aip.6.html
ISSN 1024-123x M23=3 IF =0.553

4* Hedrih (Stevanović) K., Vibrations of a Heavy Mass Particle Moving along a Rough Line with Friction of Coulomb Type, ©Freund Publishing House Ltd., International Journal of Nonlinear Sciences & Numerical Simulation 10(11): 1705-1712, 2009
http://www.freundpublishing.com/International_Journal_Nonlinear_Sciences_Numerical%20Simulation/MathPrev.htm
K.R. (Stevanović) Hedrih, Vibrations of a Heavy Mass Particle Moving along a Rough Line with Friction of Coulomb Type, International Journal of Nonlinear Sciences and Numerical Simulation, Vol. 11, No.3 March 2010, pp. 203-210.
ISSN 1565-1339 M21=8 IF= 8.479
http://www.reference-global.com/toc/ijnsns/11/3

5* Hedrih (Stevanović) K., Hedrih A. N., Eigen modes of the double DNA chain helix vibrations has benn qualified for publication in Journal of Theoretical and Applied Mechanics (JTAM), no. 1, vol. 48, 2010., pp. 219-231
ISSN 1429-2955 M23=3

6* Hedrih (Stevanović K., Tensor equations of discrete dynamically defined and undefined systems with hereditary and creep light elements, Analele Stiintieice Ale Universitatii "Alexandru Ioan Cuza" Din (ASI (S.N) Matematica -Scientific Annals of "Al.I. Cuza" University of Iasi, Matematica, Tom XCI, 2010, f. 1, pp. 131-149.
ISSN 1221-8421 M23=3

7* Hedrih (Stevanović) K., Raičević V., Jović S., Vibro-impact of a Heavy Mass Particle Moving along a Rough Circle with Two Impact Limiters, ©Freund Publishing House Ltd., International Journal of Nonlinear Sciences & Numerical Simulation 10(11): 1713-1726, 2009
http://www.freundpublishing.com/International_Journal_Nonlinear_Sciences_Numerical%20Simulation/MathPrev.htm
K.R. (Stevanović) Hedrih, V. Raičević, S. Jović , Vibro-impact of a Heavy Mass Particle Moving along a Rough Circle with Two Impact Limiters, International Journal of Nonlinear Sciences and Numerical Simulation, Vol. 11, No.3 March 2010, pp. 211-223.
ISSN 1565-1339 M21=8 IF= 8.479

8* Camelia Frigioiu, Katica (Stevanovic) Hedrih - On the Geometrization of the Rheonomic Lagrangian Mechanical Systems Analele Universit_at_ii Oradea, Fasc. Matematica, Tom XVII (2010), Issue No. 1, 89-97
ISSN 1221 – 1265 M24=3

2009

9* Hedrih (Stevanovi´c) K., Energy transfer in the hybrid system dynamics (energy transfer in the axially moving double belt system), Special Issue, **ARCHIVE OF APPLIED MECHANICS**, DOI 10.1007/s00419-008-0285-7. Archive of Applied Mechanics, (2009) vol.79, No.6-7 pp. 529-540.
http://www.springerlink.com.nainfo.nbs.bg.ac.yu:2048/content/2081u5426316886m/
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ISSN 0939-1533 M23=3 IF= 0.993

10* Hedrih (Stevanović K., Main chains and eigen modes of the fractional order hybrid multipendulum system dynamics, **IOP PUBLISHING PHYSICA SCRIPTA**, vol. T136, Phys. Scr. 78 (2008) 000000 (12pp) doi:10.1088/0031-8949/78/8/000000
http://www.iop.org/EJ/journal/1402-489
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11* Hedrih (Stevanović) K., Jović S., Models of Technological Processes on the Basis of Vibro-impact Dynamics, Scientific Technical Review, Vol.LIX,No.2,2009,pp.51-72.
YU ISSN 1820-0206 M51=2

2008

12* Hedrih (Stevanović K., Energy analysis in a nonlinear hybrid system containing linear and nonlinear subsystems coupled by hereditary element (Article), **NONLINEAR DYNAMICS** , (2008) vol.51 br.1-2 str. 127 - 140. DOI 10.1007/s11071-007-9197-2
ISSN 0924-090X (Print) 1573-269X , (Online), Volume 51, Numbers 1-2 / January, 2008, pp. 127-140. DOI 10.1007/s11071-007-9197-2, SpringerLink Date, Tuesday, January 30, 2007.
http://www.springerlink.com.nainfo.nbs.bg.ac.yu:2048/content/rg2302474v1ru044/ž
http://nainfo.nbs.bg.ac.yu.nainfo.nbs.bg.ac.yu:2048/Kobson/service/jcr.aspx?ISSN=0924-090X
ISSN 0924-090X M21=8 IF = 1.758
ISSN 0924-090X (Print) 1573-269X , (Online)

13* Hedrih (Stevanović K., Transversal forced vibrations of an axially moving sandwich belt system, Archive of Applied Mechanics, Springer, (2008) vol.78 br.9 str. 725-735
http://www.springerlink.com.nainfo.nbs.bg.ac.yu:2048/content/2081u5426316886m/
http://nainfo.nbs.bg.ac.yu.nainfo.nbs.bg.ac.yu:2048/Kobson/service/jcr.aspx?ISSN=0939-1533
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14* Hedrih (Stevanović K. and Simonović J., Transversal Vibrations of a Double Circular Plate System with Visco-elastic Layer Excited by a Random Temperature Field, *International Journal of Nonlinear Sciences and Numerical Simulation, 2008,* Vol. 9, No.1, pp.47-50. http://www.ijnsns.com/2008/TOC9.1.doc

http://nainfo.nbs.bg.ac.yu.nainfo.nbs.bg.ac.yu:2048/Kobson/service/jcr.aspx?ISSN=1565-1339
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15* Katica (Stevanović) Hedrih, (2008), Energy transfer in double plate system dynamics, **Acta Mechanica Sinica**, Volume 24, Number 3 / June, 2008, pp. 331-344, DOI 10.1007/s10409-007-0124-z, Springer Berlin / Heidelberg, ISSN (567-7718 (Print) 1614-3116 (Online),
http://www.springerlink.com.nainfo.nbs.bg.ac.yu:2048/content/rg2302474v1ru044/
http://www.springerlink.com.nainfo.nbs.bg.ac.yu:2048/content/248380442p246217/
ISSN 0567-7718 M22=5 IF=0.939

16* Katica (Stevanović) Hedrih, (2008), Energy interaction between linear and nonlinear oscillators (Energy transient through the subsystems in the hybrid system), *ISSN 1027-3190. Ukr. mat. Ωurn., 2008, t. 60, # 6, pp. 796-814.*
http://springerlink.com/content/5717572370176j67/
http://nainfo.nbs.bg.ac.yu.nainfo.nbs.bg.ac.yu:2048/Kobson/service/ElecasDet.aspx?ID=34971&ISSN=0041-5995
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ISSN 1027-3190

17* Hedrih (Stevanović K., Vibration Modes of a axially moving double belt system with creep layer ,Journal of Vibration and Control, (2008), 14(10-Sep): 1333-1347.
http://nainfo.nbs.bg.ac.yu.nainfo.nbs.bg.ac.yu:2048/Kobson/service/jcr.aspx?ISSN=1077-5463
ISSN 1077-5463 M23=3 IF= 0.863

18* Hedtrih (Stevanović) K., (2008), *Dynamics of multipendulum systems with fractional order creep elements, Special Issue Vibration and Chaos,* Journal of Theoretical and Applied Mechanics, Quaterly, (Warsaw, Poland) No.3 Vol. 46, pp. 483-509.
http://nainfo.nbs.bg.ac.yu.nainfo.nbs.bg.ac.yu:2048/Kobson/service/jcr.aspx?ISSN=1429-2955
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Kongres Internacionalne unije teorijske i primenjene mehanike **IUTAM ICTAM** se održava jednom u četiri godina i selekcija radova je veoma stroga. Oko 50% se odbija, a mali broj dobije priliku da usmeno predstavi svoje rezultate, u većini su to posteri sa 3 minuta prikaza.

U okviru **IUTAM ICTAM** Adelaide 2008, *Katica R. (Stevanović) Hedrih* održala je **''Session Lecture''** u trajanju od 20 minuta uključujući i diskusiju, u okviru sekcije Oscilacije struktura - SM19 :: Structural vibrations , kojom su predsedavali Co-chairs: *Marian Wiercigroch* (UK) and *Pedro Ribeiro* (Portugal).

Kategirizacija učešća u ICTAM sa orlnim kratkim predavanjem može se smatrati velikim priznanjem naučne rezultate, posebno, kada istražač dolazi iz male zemlje, koja nije velesila u nauci, kakva je Srbije.

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Hedrih (Stevanović), K. (2006), ***Transversal forced vibration of an axially moving sandwich double belt system***, The Sixth European Solid Mechanics Conference ESMC Budapest 2006. EuroMech Main Conference., prededava u zasedanju sekcije Multibody Dynanucs.

Hedrih (Stevanović), K. (2006), DYNAMICS OF THE AXIALLY MOVING SANDWICH MULTI BELT SYSTEM, International Conference "Actual Problems of Applied Mathematics and Mechanics", devoted 80-anniversary from birthday Ac. Rvachev V.L, on October 23-26,2006 in Kharkov., Član naučnog odbora konferencije i sa radom.

Katica R. (Stevanović) Hedrih, DYNAMICS OF SANDWICH STRUCTURES (DINAMIKA SENDVIČ STRUKTURA), Invited Plenary Lecture, Medjunarodne konferencije Savremeni problemi u građevinarstvu - Current Problems in Civil Engineering, Gradjevinski fakultet u Subotici, Univerziteta u Novom Sadu, 2 i 3. jun 2006. Abstracts and CD Full paper.

2005.

Katica (Stevanović) Hedrih, ***Transversal vibrations of the axially moving sandwich belts , Invited Lecture – 40 minutes, ISRAMES December 2-4, 2005. Kalyani, West Bengal, India.****The* ***International Symposium on "Recent Advances in Mathematical Sciences and Earth Sciences"*** *2nd to 4th December 2005. Department of Mathematics, University of Kalyani.*

Katica (Stevanović) Hedrih: Measurements of dynamical systems integrity and fracture mechanics, Invited plenary lecture, ISUMEL 2005 Lviv, Ukraine, 7-й МІЖНАРОДНИЙ СИМПОЗІУМ УКРАЇНСЬКИХ ІНЖЕНЕРІВ-МЕХАНІКІВ У ЛЬВОВІ, **(МСУІМЛ — 7), 18 — 20 травня 2005 р., Присвячений 160-річчю Національного університету „Львівська політехніка”**

VII* Plenarna prefavanja ili predavanja po pozivu na naucnim skupovima štampani u apstraktu ili u celini

(Plenary Lecture, Invited Lecture or Keynote Lecture presented at scientific meetings and published as Abstract of paper or full paper)

2010.

Hedrih (Stevanović) K., (2010), Discontinuity of kinetic parameter properties in nonlinear dynamics of mechanical systems, **Keynote Invited Lecture**, 9th Brazilian Conference on Dynamics, Control and Their Applications - 9º Congresso Temático de Dinâmica, Controle e Aplicaçõesm, June 07-11, 2010. UneSP, Sao Paolo (Serra negra), Brazil, Technical Program and Booklet of Abstracts, DINCON 2010, FUNUNeSP, Chair: pp. 14, Abstrac pp. 26
http://www.rc.unesp.br/igce/demac/dincon2010/instrucao.php

2009.

9th Internationa Symposium Ukrainian Mechanical Engineers Lvov 2009 – ISUMEL 2009

Član Naučnog odbora i učesnik sa plenarnim predavanjem.

Održana predavanja

Invited Plenary Lecture (45 minuta)- plenarno predavanje po pozivu u ’’Aktavom zalu’’ Lvovske politehnike.

1* *Katica (StevanovIć) HEDRIH, (2009), Main chains and eigen modes of the hybrid homogeneous fractional order multichain system, Invited Plenary Lecture (45 minuta),* Proceedings of 9th International Symposium Ukrainian Mechanical Engineers Lvov 2009 – ISUMEL 2009, Ministarstvo obrazovanza i nauke Ukraine, Lvov Polztechnique, Naukoviz žurnal ’’Mashonoznanstvo’’**,** ISBN 078-966-06-8, pp. 6-8.

Minisymposium Keynote Lecture:

Katica (Stevanović) Hedrih, Free and forced vibration of the heavy material particle along line with friction: Direct and inverse task of the theory of vibrorheology, 7th EUROMECH Solid Mechanics Conference, J. Ambrósio et.al. (eds.), Lisbon, Portugal, September 7-11, 2009, ESMC 2009 Book of Abstracts ‘ Mini’Symposia, iydanje Instituto Superior Tecnico, Lisbon, APMTAC, 2009, pp. 597-598, ISBN 9789899 626423

Katica (Stevanović) Hedrih, Free and forced vibration of the heavy material particle along line with friction: Direct and inverse task of the theory of vibrorheology, Booklet of Abstracts - ESMC

Lisbon 2009, Minisymposium Keynote Lecture, Minisymposium MS-24-Kinetics, Control and Vibrorheology - KINCONVIB – 2009, Faculty of Mechanical Engineering University of Niš, pp. 51-52.
ISBN 978-86-80587-94-3 COBISS.SR – ID 169182988 BarCod 9-788680-58794-3

2008.

Katica (StevanovIć) HEDRIH, (2208), Dynamically determined and undetermined hereditary discrete systems (External and internal degrees of freedom in the hybrid hereditary dynamics), *Invited Lecture-Key note Lecture*,The Euromech Colloquium 498 Nonlinear Dynamics of Composite and Smart Structure (NDCS) -Nonlinear Dynamics and Chaos of Composite and Smart Structures (NDCS), May 21-23, 2008, Kazimierz Dolny, POLAND. Lublin 2008, pp. 29-39.

Katica (Stevanović) Hedrih, Mathematical analogy between hybrid system dynamics, 45 minutes Invited Plenary Lecture, Book of Extended Abstracts, Edited by Alexander M. Kovalev (IAMM NASU, kovalev@iamm.ac.donetsk.ua), 10th International Conference "Stability, Control and Rigid Bodies Dynamics" Donetsk (Ukraine), June 2008, pp. 125-127.

2007.

Hedrih (Stevanović), K., (2007), *Hybrid Systems and Hybrid Dynamics: Theory and Applications,* ***Invited Plernary*** **Lecture,** 8th HSTAM International Congress on Mechanics, Patras, 12 – 14 July, 2007, Greece, Proceedings, Edited by N. Bazwos, D.L. Karabalis, D. Polyzos, , D.E. Beskos and J. T. Katsikadelis, Volume I, pp. 77-86.

Hedrih (Stevanović), K., *Hybrid System Dynamics,* Proceedings, Invited Lecture, First International Congress of Serbian Society of Mechanics, Editors: D. Šumarac and D. Kuzmanović, Srpsko društvo za mehaniku, 10-13, April, 2007, pp. 79-84. http://www.ssm.org.yu/congress2007/authors.html

Goroško O. A. and Hedrih (Stevanović) K.**,,** Advances in development of the analytical dynamics of the hereditary discrete systems, Key Note Lecture, Minisymposium, Booklet of Abstracts - IDND 2007 – Analytical Dynamics of Discrete Heresitary System, pp**.*27-34.***

Goroshko O.A. and Hedrih (Stevanović), K., (2007), Construction of the Lagrange mechanics of the hereditary systems, Minisymposium Oppening Minisymposa Lecture of the International Summer School APM – Advanced Problem in Mechanics- Integrity of Dynamicsal SDystems, Saint Petersburg 2007., in Booklet of Abstracts - IDND 2007 – Analytical Dynamics of Discrete Heresitary System, Shanghai 2097, pp. 63-84.

Hedrih (Stevanović), K., (2007), *Tensor equations of the dynamics of the discrete systems with hereditary and creep light elements,* Conference on Differential Geometry.Lagrange and Hamilton Spaces. Dedicated to Acad. Radu Miron at his 80th anniversary, 2007, *A.I.Cuya, University, Faculty of Mathematics, Iasi, Romania.*. Book of Abvstracts, pp. 18'22.

Hedrih (Stevanović), K., Hybrid System Dynamics, Proceedings, First International Congress of Serbian Society of Mechanics, Editors: D. Šumarac and D. Kuzmanović, Srpsko društvo za mehaniku, 10-13, April, 2007, pp. 79-84.

Hedrih (Stevanović), K., (2007), *Energy Transfer in Hybrid System Dynamics*, Invited Participation, 6th Recent German-Greek-Polish Symposium, Recent Advances in Mechanics, September 17-21 2007, Alexandroupolis, Greece , Book of Abvstracts, pp. 7-8.

2006.

Hedrih (Stevanović), K. (2006), DYNAMICS OF THE AXIALLY MOVING SANDWICH MULTI BELT SYSTEM, International Conference "Actual Problems of Applied Mathematics and Mechanics", devoted 80-

anniversary from birthday Ac. Rvachev V.L, on October 23-26,2006 in Kharkov., Član naučnog odbora konferencije i sa radom.

Hedrih (Stevanović), K. (2006), TENSOR EQUATIONS OF THE DYNAMICS OF THE DISCRETE SYSTEMS WITH HEREDITARY AND CREEP LIGHT ELEMENTS, 9th International Conf. of TENSOR 2006., THE 9th INTERNATIONAL CONFERENCE OF TENSOR SOCIETY ON DIFFERENTIAL GEOMETRY, FUNCTIONAL&COMPLEX, INFORMATICS AND THEIR APPLICATIONS, *Japan, Sept. 4-8, 2006.Tensor Society. 30.minutno predavanje po pozivu.*

Katica R. (Stevanović) Hedrih, DYNAMICS OF SANDWICH STRUCTURES (DINAMIKA SENDVIČ STRUKTURA), Invited Plenary Lecture, Medjunarodne konferencije Savremeni problemi u građevinarstvu - Current Problems in Civil Engineering, Gradjevinski fakultet u Subotici, Univerziteta u Novom Sadu, 2 i 3. jun 2006. Abstracts and CD Full paper.

Katica R. (Stevanović) Hedrih, ENERGY OSCILLATIONS IN THE SUBSYSTEM DYNAMICS OF THE HYBRID SYSTEM (OSCILACIJE ENERGIJE U DINAMICI PODSISTEMA HIBRIDNOG SISTEMA), *To the Memory of my Professors Tatomir P. Andjelic and Danilo P. Raskovic First Heads of the Department of Mechanics at Mathematical Institute SASA , Jubilarni seminar . ''60 godina Matematičkog instituta SANU''* a *40-to minutno predavanje po pozivu, publikovan Apstrakt.*

Katica R. (Stevanović) Hedrih, *Theoretical and Applied Mechanics of the Rigid and Solid Bodies. Mechanics of Materials (2006-2010) (Teorijska i primenjena mehanika krutih i čvrstih tela. Mehanika materijala.), savremeni problemi, prikaz rezultata projekta ON144002 i Matematički institut SANU, Jubilarni seminar -''60 godina Matematičkog instituta SANU''* a 3*0-to minutno predavanje po pozivu, publikovan Apstrakt*.

2005.

Katica (Stevanović) Hedrih, ***Transversal vibrations of the axially moving sandwich belts , Invited Lecture – 40 minutes, ISRAMES December 2-4, 2005. Kalyani, West Bengal, India.****The* ***International Symposium on "Recent Advances in Mathematical Sciences and Earth Sciences"*** *2nd to 4th December 2005. Department of Mathematics, University of Kalyani.*

Katica (Stevanović) Hedrih: Measurements of dynamical systems integrity and fracture mechanics, Invited plenary lecture, ISUMEL 2005 Lviv, Ukraine, 7-й МІЖНАРОДНИЙ СИМПОЗІУМ УКРАЇНСЬКИХ ІНЖЕНЕРІВ-МЕХАНІКІВ У ЛЬВОВІ, **(МСУІМЛ — 7), 18 — 20 травня 2005 р., Присвячений 160-річчю Національного університету „Львівська політехніка"**

VIII* Član naučnog odbora internacionalnih aucnih skupova ili organizatoor minisimpozijuma

(Member of Scientific Commitee of interantional scientific meetings and organizer of Minisymposia included in the Program of interantional scientific meetings)

2010.

***** M11-Minisymposia Kinetics, Control and Vibrorheology at ICDVC-2010- The Third International Conference on Dynamics, Vibration and Control, 12-14 May 2010, Hangzhou,, China, Chinese Society of Theoretical and Applied Mechanics, 2010. http://saa.zju.edu.cn/icdvc2010/

Član Naučnog odbora i organizator Minisimpozijuma

Member of Scientific Commitee of interantional scientific meeting and organizer of Minisymposia included in the Program.

***The 3rd INTERNATIONAL CONFERENCE "NONLINEAR DYNAMICS - 2010",** *at the* **NATIONAL TECHNICAL UNIVERSITY, "KHARKOV POLYTECHNICAL INSTITUTE", KHARKOV, UKRAINE,** the 3rd ND-KhPI 2010 , the Nonlinear Dynamics Conference, from **21** until **24 September, 2010**

Član Naučnog odbora.

Member of Scientific Commitee of interantional scientific meeting.

* "3rd Conference on Nonlinear Science and Complexity" (NSC10), Cankaya University, Ankara, Turkey in the period of 26 - 29 July, 2010.
http://nsc10.cankaya.edu.tr/index.php

Član Naučnog odbora.

Member of Scientific Commitee of interantional scientific meeting.

2009.

*** 

9th International Symposium Ukrainian Mechanical Engineers Lvov 2009 – ISUMEL 2009, Ministarstvo obrazovanza i nauke Ukraine, Lvov Polztechnique, Naukoviz žurnal ''Mashonoznanstvo''**,** ISBN 078-966-06-8.

Član Naučnog odbora i učesnik sa plenarnim predavanjem.

Member of Scientific Commitee of interantional scientific meeting and Plenary Lecturer.

*10th Conference on Dynamical Systems – Theory and Applications, Proceedings, DSTA Lodz 2009, Lodz, December 7-10, 2009, Poland, Department for Automatic and Biomechanics, Lodz, (see Proceedings - ISBN 978-83-929120-4-0, Vol. I and II).

Član Naučnog odbora.

Member of Scientific Commitee of interantional scientific meeting.

* Minisymposium MS-24-Kinetics, Control and Vibrorheology - KINCONVIB – 2009, European Society of Mechanics, Instituto Superior Tecnico – Lisbon and Mechanical Engineering Faculty in Niš - Project ON144002 - Seminar Nonlinear Dynamics - Milutin Milanković and MATHEMATICAL INSTITUTE SANU, Project ON144002, 2009.

ISBN 978-86-80587-94-3 COBISS.SR – ID 169182988 BarCod 9-788680-58794-3

Organizator minisimpozijuma.

Organizer of Minisymposia included in the Program.

2008.

*The Euromech Colloquium 498 Nonlinear Dynamics of Composite and Smart Structure (NDCS) - Nonlinear Dynamics and Chaos of Composite and Smart Structures (NDCS), May 21-23, 2008, Kazimierz Dolny, POLAND. Lublin 2008, pp. 29-39.

Član Naučnog odbora i plenarno predavanje po pozivu.

Member of Scientific Commitee of interantional scientific meeting and Invited Lecture-Key note Lecture.

2007.

***** **APM** Saint Petersburg 2007 pp.**,** Minisymposium, The International Summer School APM – Advanced Problem in Mechanics, Saint Petersburg 2007., pp. 133-156.

APM 2007 – *Minisymposium Integrity of Dynamical Systems – organized by Katica (Stevanović) Hedrih, Summer School.* APM 2007 Advanced Problems in Mechanics, Russia, St. Petersburg June 20 - 28, 2007**.** *Institute for Problems in Mechanical Engineering of the Russian Academy of Sciences, Izdavač Mašinski fakultet u Nišu, p. 379.* ISBN 86-80587-67-2 COD 9 7886 80587677, BarCod 9 7886 80587677

ISBN 86-80587-67-2 COD 9 7886 80587677, BarCod 9 7886 80587677

Organizator minisimpozijuma po pozivu.

Invited organizer of Minisymposia included in the Program.

***** First International Congress of Serbian Society of Mechanics, Editors: D. Šumarac and D. Kuzmanović, Srpsko društvo za mehaniku, 10-13, April, 2007, pp. 79-84. http://www.ssm.org.yu/congress2007/authors.html

Član Naučnog odbora i plenarno predavanje po pozivu.

Member of Scientific Commitee of interantional scientific meeting and Invited Lecture-Key note Lecture.

***** IDND 2007 – *Analytical Dynamics of Discrete Heresitary Systems – Organized by Katica (Stevanović) Hedrih, Izdavač Mašinski fakultet u Nišu zam -* Minisymposia - Analytical mechanics of the hereditary discrete systems

Second International Symposium on Nonlinear Dynamics, 27-30 Oct.,2007, Shanghai, Donhua University, China,p-198. ISBN 978 – 86 – 80587 – 72 – 1 COBISS.SR – ID 144265740. BarCod 9 788680 56772 1

http://www.2007isnd.com/

ISBN 978 – 86 – 80587 – 72 – 1 COBISS.SR – ID 144265740. BarCod 9 788680 56772 1

Organizator minisimpozijuma po pozivu.

Invited organizer of Minisymposia included in the Program.

***** *Minisymposium - Integrity of Dynamical Systems- ECF16, Organized by* Katica (Stevanović) Hedrih, invited organizer of Minisymposia ***IDS-ECF - the 16th European Conference of Fracture***, Greece 2006, Centre for Nonlinear Dynamics and Active Structures, Faculty of Mechanical Engineering University of Niš and Democritus University of Thrace, Xanthi, Greece, 2006. p. 324. ISBN 86-80587-57-5. BarCod 9 788680 587578. COBIS. SR - ID 130756620. UDK 531:01 /048); 530:182(048); 530:42 (048); 53:005.745 (100).

ISBN 86-80587-57-5.

BarCod 9 788680 587578. COBIS. SR - ID 130756620

Organizator minisimpozijuma po pozivu.

Invited organizer of Minisymposia included in the Program.

2006.

Hedrih (Stevanović), K. (2006), DYNAMICS OF THE AXIALLY MOVING SANDWICH MULTI BELT SYSTEM, International Conference "Actual Problems of Applied Mathematics and Mechanics", devoted 80-anniversary from birthday Ac. Rvachev V.L, on October 23-26,2006 in Kharkov.,

Član Naučnog odbora.

Member of Scientific Commitee of interantional scientific meeting.

2005.

Katica (Stevanović) Hedrih, ***Transversal vibrations of the axially moving sandwich belts , Invited Lecture – 40 minutes, ISRAMES December 2-4, 2005. Kalyani, West Bengal, India.****The* ***International Symposium on "Recent Advances in Mathematical Sciences and Earth Sciences"*** *2nd to 4th December 2005. Department of Mathematics, University of Kalyani.*

Član Naučnog odbora.

Member of Scientific Commitee of interantional scientific meeting.

***Katica (Stevanović) Hedrih: Measurements of dynamical systems integrity and fracture mechanics, Invited plenary lecture, ISUMEL 2005 Lviv, Ukraine, 7-й МІЖНАРОДНИЙ СИМПОЗІУМ УКРАЇНСЬКИХ ІНЖЕНЕРІВ-МЕХАНІКІВ У ЛЬВОВІ,* (МСУІМЛ — 7), 18 — 20 травня 2005 р., Присвячений 160-річчю Національного університету „Львівська політехніка"**

Član Naučnog odbora.

Member of Scientific Commitee of interantional scientific meeting.

IX. Učešće u vodećem naučnom kongresu IUTAM ICTAM u oblasti teorijske i primenjene mehanike u svetu (period 2005-2010)

Kongres Internacionalne unije teorijske i primenjene mehanike **IUTAM ICTAM** se održava jednom u četiri godina i selekcija radova je veoma stroga. Oko 50% se odbija, a mali broj dobije priliku da usmeno predstavi svoje rezultate, u većini su to posteri sa 3 minuta prikaza.

U okviru **IUTAM ICTAM** Adelaide 2008, *Katica R. (Stevanović) Hedrih* održala je **''Session Lecture''** u trajanju od 20 minuta uključujući i diskusiju, u okviru sekcije Oscilacije struktura - **SM19 :: Structural vibrations** , kojom su predsedavali Co-chairs: *Marian Wiercigroch* (UK) and *Pedro Ribeiro* (Portugal).

Kategirizacija učešća u ICTAM sa orlnim kratkim predavanjem može se smatrati velikim priznanjem naučne rezultate, posebno, kada istražač dolazi iz male zemlje, koja nije velesila u nauci, kakva je Srbije.

Naziv predavanja je:

Katica R. (Stevanović) Hedrih (August 29, 2008, **Fri 11:20 B)**

Phenomenological mapping method and mathematical analogy of hybrid system dynamics, XXII International Congress of Theoretical and Applied Mechanics Abstracts Book, Edited by J. Dernier, M.D. Fim and T. Mattner, Adelaide 2008,p. 317, **ISSN 978-0-9805142-0-9, p. 317, and CD-ROM ISSN 978-0-9805142-1-6, pp. 10135, 1-2..**

(vidi WEB ictam2008.adelaide.edu.au).

X* U okviru projekta ON144002 radi seminar Nonlinear Dynamics - Milutin Milankovic na Mašinskom fakultetu. Vidi seroju publikaciju: Booklet of Abstracts - Minisymposium and WEB http://www.mi.sanu.ac.rs/seminars/seminar16.htm

XI* Rukovodilac projekata u periodu 2000-2010:
Project Leader Katica (Stevanović) Hedrih

**** ON1616 Realni problemi mehanike (2001-2005)***
**** ON1616 Real Problem of Mechanics (2001-2005)***

Institution Coordinator: ***Mathematical Institute Serbian Academy of Sciences and Arts.***
Project Leader: ***Katica (Stevanović) Hedrih***
Researchers: ***41.***
Researcher months: ***approximately 98 months***.

Deo doktorske teze uradio Ljubiša Perić a radion na doktorskoj tezi mr Dragan Jovanović.

**** ON1828 Dinamika i upravljanje aktivnih konstrukcija (2001-2005)***
**** ON1828 Dynamics and Control of active Structures (2001-2005)***

Institution Coordinator: ***Faculty of Mechanical Engineering University of Niš***
Project Leader: ***Katica (Stevanović) Hedrih***
Researchers: 21

Researcher months: ***approximately months***.
Deo doktorske teze ***uradio Ljubiša Perić*** a ***doktorsku teyu radio mr Dragan Jovanović***.

**** Projekt ON144002 Teorijska i primenjena mehanika krutih i čvrstih tela. Mehanika materijala.***
* ***Project ON144002 -Theoretical and Applied Mechanics of the Rigid and Solid Bodies. Mechanics of Materials (2006-2010)***
Support: ***Ministry of Sciences and Environmental Protection of Republic of Serbia***
Institution Coordinator: ***Mathematical Institute Serbian Academy of Sciences and Arts.***
Project Leader: ***Katica (Stevanović) Hedrih***
Researchers: 38**.**
Researcher months: ***approximately 136 months***.
U okviru istra\ivanja na projektu doktorsku disertaciju završ i odbranio mr Dragan Jovanović. Magistarske teze uradili i odbranili Julijana Simonović i Srdjan Jović. Sada rade istra\ivanja za izradu doktorata mr Julijana Simonović, mr Ljiljana Veljović i mr Srdjan Jović (mentor prof dr Vladimir Raičević).

XIII* Mentor odbranjenih doktorskih disertacija i magistarskih teza u periodu 2005-2010.

Mentor doktorske disertacije d*r Dragan Jovanović:*
Jovanović D., *(2009), Potencijalna energija i stanje napona u materijalu sa prslinom, (Potential energy and stress state in material with crack)* , Doktorska disertacija, (odbrana 10 novembra 1009), Mašinski fakultet u Nišu, str.237.

Mentor magistarske teze *Mr Julijane Simonovic*
Simonović J., (2008), *Dinamika mehaničkih sistema složenih struktura,* magistarski rad odbranjen 8 maj 2008. Mašinski fakultet u Nišu, str. 249.

Serija konsultacije u izradi magistarske teze istračivaču na projektu ON144002 mr Srdjanu Joviću:
Јовић С., (2009). ***Енергијска анализа динамике виброударних система***, магистарски рад, одбрањен 06. Новембра 2009. Факултет техничких наука у Косовској Митровици Универзитета у Приштини, стр. 239.
u saradnji sa mentorom magistarske teze ***prof dr Vladimirom Raičevićem***,

XIVI* Članstvo u redakcijama časopisa, uredništvima, naučnim društvima

Editorial of Journals:

1* Editor in Chief *of the Following Journals*:
Facta Universitatis (1990-2001) with 13 Series .
http://facta.junis.ni.ac.rs/
Facta Universitatis Series Mechanics, Automatic Control and Robotics, University of Niš (1991- 2008)
http://facta.junis.ni.ac.rs/macar/macar.html
ISSN 0354 – 2009 M24=3 IF =0,371

2 **Associate Editor** (2004-)*
Mathematical Problems in Engineering, Hindawi Publishing Corp. http://www.hindawi.com/
(http://www.hindawi.com/journals/mpe/aip.972873.html)
http://www.hindawi.com/journals/mpe/aip.6.html
http://www.hindawi.com/journals/mpe/editors.html
http://www.hindawi.com/13168039.html
ISSN 1024-123x M23=3 IF =0.553

3 **Member of Editorial Board** of the Following Journals*:

International Journal of Nonlinear Sciences and Numerical Simulations, ©Freund Publishing House Ltd., (2000-)
http://www.cs.uky.edu/~jzhang/nsns.html
http://www.ijnsns.com/
http://www.freundpublishing.com/International_Journal_Nonlinear_Sciences_Numerical%20Simulation/Math.htm
ISSN 1565-1339 M21=8 IF= 8.479

Scientific Technical Review, Vojske Srbije, (2005-) YU ISSN 1820-0206
http://www.vti.mod.gov.yu/ntp/index.htm
YU ISSN 1820-0206 M51=2 IF =0,040

Journal of the Serbian Society for Computational Mechanics (2006-)
www.sscm.kg.ac.rs/jsscm/

4* Referee of Following Journals and Information Data-Base:

Archive of Applied Mechanics - Manuscript Central Account Info (SY-23)-Springer, (4 recenzije samo u 2006)
Nonlinear Dynamics, Springer više recenyija
Workshop Preprints/Proceedings No 2006-2 IFAC workshop on Fractional Differentiation and its Applications FDA 06, Porto (desetak recenyija)
The European Union Control Association (32 recenzija u 2006)
ESIS Euroepean Conference of fracture 2006 (31 recenziju u 2006)
Zentralblatt fur Mathematik und ihre Grenzgebiete Berlin (desetak recenzija u 2006)
Facta Universitatis Series Mechanics, Automatic Control and Robotics, University of Niš (1990-)
Mathematical Problems in Engineering, Hindawi Publishing Corp. http://www.hindawi.com/
Neurosciences letters, Elsevier, Journal of Sound and Vibrations, Elsevier,
European Polymer Journal, Elsevier,
FME Transaction, Faculty of Mechanical Engineering Universitz of Belgrade,
Material Letters, Elsevier,
Journal Nonlinear Analysis - Theory, Methods and Applications, Series B: Real-world Applications, Pergamon Press,
Signal Processing, Elsevier,
Journal of Porous Materials, Springer
ENOC 2005, EuroMech
Journal of Nonlinear Mechanics
Nonlinear Dynamics

and other.

XV* Članstvo u akademijama nauka i naučnim društvima u kojima se obavlja izbor članova tajnim glasanje na osnovu naučnih rezultata
Member of Academy of Sciences and Scientific Societies with elections on the nasic of scientific results:

*** Ukrainian Higher Education Academy of Sciences - Akademija nauka visokih skola i univerziteta Ukrajine (od 1996-)**

www.anvsu.org.ua

*** Naučno društvo Srbije - Serbian Scientific Society (2008-)**

http://www.rcub.bg.ac.rs/~nds/ http://www.rcub.bg.ac.rs/~nds/indexe.html

*** Akademija nelinearnih nauka – Academy of Nonlinear Sciences - Mosckow (1997-)**

*** Južnoslovenska akademija nelinearnih nauka u Srbiji JANN - SouthSlavian Academy of Nonlinear Sciences – SANS Belgrade (1997-)**

http://www.masfak.ni.ac.rs/sitegenius/topic.php?id=786

*** Naučni sekretar JANN – Scientific Secretary of SANS (1998-20010)**

XVI* Member of Professional-Scientific Societies:

American Academy of Mechanics AAM
Member of GAMM – Germany (since 1972)
Member of Tensor Society - Japan
Member of International ASME – International American Society of Mechanical Engineers USA (od 2000 -)
Member of European Society for Mechanics – EuroMech
Member of M.C.Chaki Centre for Mathematics and Mathematical Sciences – Calcutta, India
Member of SSM-JDM
Member of Serbian Society of Computational Mechanics
www.sscm.kg.ac.rs/jsscm/
Member of Society of Nonlinear dynamics in Human Factors – Adelaide , Australia.

XVII*Citati (Subject: Citation) (2005-2010)

Najmanje dvadesetak citata, u periodu 2006-2010, u časopisima sa ISI liste, a više od 150 u radovima publikovanim u domaćim člasopisima i doktoraskim i magistarskim disertacijama autora iz Srbije.

*** Citati u časopisima sa ISI liste (izbor)**

Na primer:

* Hedrih (Stevanović) K., Filipovski A., (2002), *Longitudinal Vibration of a Fractional Derivative Order Rheological Rod with Variable Cross Section*, Facta Universitatis, Series Mechanics, Automatic Control and Robotics, Vol. 3 No. 12, 2002. pp.327-350. YU ISSN 0534-2009.
http://facta.junis.ni.ac.yu/facta/macar/macar2002/macar2002-02.html

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Jakšić N., Boltežar M., (2005), Viscously damped transverse vibrations of a moving string, Journal of Mechanical Engineering – Strojniški vestnik, vol.51. No.9/05Iassue 485, pp. 560-569. ISSN 0039-2480.. **ISI List**

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Hedrih (Stevanovic′) K.: Interpretation of the transfer of energy from high-frequency to low-frequency modes by averaging asymptotic method Krilov-Bogolybov-Mitropolsky. In.: Proc. of the Second International Conference "Asymptotics in Mechanics", pp. 97-104. Saint-Petersberg State Marine Technological University, Saint-Petersberg (1997)

Hedrih (Stevanovic′) K.: Multifrequency forced vibrations of thin elastic shells. In: CD Proc. of the Fifth EUROMECH Nonlinear Dynamics Conference, pp. 2417-2426. Eindhoven University of Technology (2005)

Cited (quoted) in:

Kozmin A., Mikhlin Yu. and C. Pierre, Transient in a two DOF nonlinear Systems, Nonlinear Dynamics, 2006; Nonlinear Dynamics, Volume 51, Numbers 1-2 / January, 2008 , DOI: 10.1007/s11071-007-9198-1

*** Citati na moje radove nalaze se i u sledećim publikovanim radovima:**

Q. Li and Y. H. Chen, Why traction-free? Piezoelectric crack and Coulombic traction, Journal Article , *Archive of Applied Mechanics, Volume 78, Number 7 / July, 2008* DOI: 10.1007/s00419-007-0180-7

Pei-Wei Zhang, Zhen-Gong Zhou and Lin-Zhi Wu, Coupled field state around three parallel non-symmetric cracks in a piezoelectric/piezomagnetic material plane, Journal Article. *Archive of Applied Mechanics, Volume 79, Number 10 / October, 2009* , DOI: 10.1007/s00419-008-0270-1

Yufeng Xing and Bo Liu, Closed form solutions for free vibrations of rectangular Mindlin plates, Journal Article, *Acta Mechanica Sinica, Volume 25, Number 5 / October, 2009* , DOI: 10.1007/s10409-009-0253-7

Yufeng Xing and Bo Liu, New exact solutions for free vibrations of rectangular thin plates by symplectic dual method, Journal Article*, Acta Mechanica Sinica, Volume 25, Number 2 / April, 2009,* DOI: 10.1007/s10409-008-0208-4
Journal Article

Q. Li and Y. H. Chen, Why traction-free? Piezoelectric crack and Coulombic traction, *Archive of Applied Mechanics, Volume 78, Number 7 / July, 2008,*
DOI: 10.1007/s00419-007-0180-7

*** Citati u delima domaćih autora:**

Veliki broj citata u sledećim disertacijama:

Jovanović D., *(2009), Potencijalna energija i stanje napona u materijalu sa prslinom, (Potential energy and stress state in material with crack)* , (odbrana 10 novembra 1009), Doktorska disertacija, Mašinski fakultet u Nišu, str.237.

Simonović J., (2008), *Dinamika mehaničkih sistema složenih struktura*, magistarski rad odbranjen 8 maj 2008. Mašinski fakultet u Nišu, str. 249.

Јовић С., (2009). ***Енергијска анализа динамике виброударних система***, магистарски рад, одбрањен 06. Новембра 2009. Факултет техничких наука у Косовској Митровици Универзитета у Приштини, стр. 239.

Mirko Blagojević (2008), Naponsko i deformaviono stanje elemenata cikloreduktora pri dinami;kom opterećenju, Mašinski fakultet u Kragujevcu, str.224..

*** Jedan broj citata na moje radove se može naći u radovima publikovanim u sledećim časopisima:**

* Scientific Technical Review, Vojske Srbije, (2005-) YU ISSN 1820-0206
http://www.vti.mod.gov.yu/ntp/index.htm
YU ISSN 1820-0206 M51=2 IF =0,040

***** *Facta Universitatis Series Mechanics, Automatic Control and Robotics*, University of Niš (1991- 2008). http://facta.junis.ni.ac.rs/macar/macar.html
ISSN 0354 – 2009 M24=3 IF =0,371

* FME Transactions - Scientific Journal published by Faculty of Mechanical Engineering. Faculty of Mechanical Engineering, University of Belgrade
http://www.mas.bg.ac.rs/transactions/index.html
YU ISSN 1451-2092 M51=2

XVIII* Nagrade i priznanja u periodu 2005-2010

Medallion (Plague)***"Archimed"*** and Charter 2007 of Scientific-Technical Institute of Serbian Army for scientific work.

Medallion (Plague) and Charter 2008 of Cankaya University, Ankara, Turkey for Scientific advances in IFAC FDA Workshop.

XIX* Recenzije za inostrane fondacije i ministarstva nauke (Referee for aboard foundation of sciences and Ministry of Sciences other countries)

Recenzija sdržaja projekta registrovanog pod oznakom:
Project proposal No. 101/09/1481 submitted in the current round of GA CR Call for Proposals.
iz osnovnih nauka na poziv Češke fondacije za nauku (CSF - GACR - application for 2009 - 101/09/1481, Subject: CSF - Czech Science Foundation, "CSF - Czech Science Foundation" <info@gacr.cas.cz>) prema pozivu d 3 jula 2008 godine.
U potpisu poyiva je:
Hana Jirmanova
Head of Department of Technical Sciences
Email: hana.jirmanova@gacr.cas.cz
On behalf of the **Czech Science Foundation (GA CR)**, the major funding body in the Czech Republic that supports all scientific areas of basic research including the international projects, to ask you whether you would be prepared to evaluate a project proposal No. 101/09/1481 submitted in the current round of GA CR Call for Proposals.

XX* Predavanja na sminarima u Matematičkom institutu SANU u periodu 2005-2010.

1* Mechanics Colloquium - Odelenje za mehaniku Matematickog institute SANU

SREDA, 17. mart 2010. u 18 sati:
Katica (Stevanovic) Hedrih, Matematicki institut SANU Beograd
TRIGGER OF COUPLED SINGULARITIES IN NONLINEAR DYNAMICS OF A HEAVY MASS PARTICLE ALONG ROTATE ROUGH CIRCLE

SREDA, 14. oktobar 2009. u 18 sati:
Katica R. (Stevanovic) Hedrih, Masinski fakultet, Nis
VISIBILITY OF NONLINEARITY

UTORAK, 14. oktobar 2008. u 14 sati:
Prof. Katica (Stevanović) Hedrih, Mašinski fakultet Niš
PHENOMENOLOGICAL MAPPING METHOD AND MATHEMATICAL ANALOGY OF HYBRID SYSTEM DYNAMICS

SREDA, 5. decembar 2007. u 18 sati:
Katica (Stevanović) Hedrih, Mašinski fakultet, Niš
PREDSTAVLjANjE REZULTATA PROJEKTA ON 144002
Projekt ON144002 Teorijska i primenjena mehanika krutih i cvrstih tela. Mehanika materijala. (2006-2010)

SREDA, 17. oktobar 2007. u 18 sati:
Katica (Stevanovic) Hedrih, Masinski fakultet, Nis
Pojmovi nelinearne dinamike i Aleksandr Mikhailovich Lyapunov (1857 ~V 1918) A.M.Lyapunov

SREDA, 16. maj 2007. u 18 sati:
Katica (Stevanovic') Hedrih, Ma~Zinski fakultet, Ni~Z
Novi prikazi klasicne dinamike rotora (ili Novi pogled u Kinetiku rotora)

SREDA, 17. maj 2006. u 18 sati:
Katica (Stevanovic) Hedrih, Julijana D. Simonovic (Masinski fakultet, Nis)
SLOBODNE TRANSVERZALNE OSCILACIJE ELASTICNO SPREGNUTIH KRUNIH PLO?A

SREDA, 12. april 2006. u 18 sati:
K. S. Hedrih

Transversal vibrations of the axially moving sandwich band and string (Transverzalne oscilacije aksijalno pokretne sendvic trake i strune)

SREDA, 01. mart 2006. u 18 sati:
Katica (Stevanovic) Hedrih
Nelinearna dinamika - Interdisciplinarni pristup

SREDA, 26. oktobar 2005. u 18 sati:
Katica (Stevanović) Hedrih
Transversal Vibration of a Parametrically Excited Beam: Influence of Rotatory Inertia and Transverse Shear on Stochastic Stability of Deformable Forms and Processes

SREDA, 21. septembar 2005. u 18 sati:
Katica (Stevanović) Hedrih
Dostignuća Nelinearne dinamike

SREDA, 08. jun 2005. u 18 sati:
Katica Stevanovic-Hedrih,
Memorijalno predavanje povodom 20. godina od smrti prof. Danila Raskovica
Prof. dr ing dipl. math. Danilo P. Raskovic (1910-1985), upravnik Odeljenja za mehaniku Matematickog instituta SANU u 1962. godini.

SREDA, 25. maj 2005.:
16:00-16:40, Katica Stevanovic-Hedrih,
Mere integriteta dinamickih sistema.

SREDA, 02. mart 2005. u 18 sati:
Katica Stevanovic Hedrih
VISEFREKVENTNE NELINEARNE OSCILACIJE TANKE ELASTICNE LjUSKE SA POZITIVNOM GAUSS-OVOM KRIVINOM I KONACNIM DEFORMACIJAMA
(Predavanje je posveceno secanju na profesora dr Ing. dipl. Math. Danila P. Raskovica (10. septembar 1910-29. januar 1985), jednog od Upravnika Odeljenja za mehaniku Matematickog instituta SANU (1962), a povodom 20. godina od smrti.)

SREDA, 01. decembar 2004. u 18 sati:
Katica Stevanovic Hedrih, Spasoje Gadzic
O JEDNOM MODELU DINAMIKE KRUTIH TELA VELIKIH BRZINA

2* Seminar Nonlinear dynamics - Milutin Milankovic - Project ON144002

Cetvrtak, 8. oktovar 2009. u 11,00 h na Masinskom fakultetu u Nisu, u svecanoj sali 401.
Katica R. (Stevanovic) Hedrih
Vibrations, Energy and Powers of Force Works of a Material Particle Motion along Rough Line with Friction of Coulomb Type

Cetvrtak, 15. oktobar 2009, u 11,00 h na Masinskom fakultetu u Nisu, u svecanoj sali 401.
Katica R. (Stevanovic) Hedrih
Vibro-impact system dynamics: Heavy material particle oscillations along rough circle with radial two side impact limiter of the elongations

Cetvrtak, 22, oktobar 2009. u 11,00 h na Masinskom fakultetu u Nisu, u svecanoj sali 401.
Katica R. (Stevanovic) Hedrih
Considering Transfer of Signals through Hybrid Fractional Order Homogeneous Structure

Cetvrtak, 29. oktobar 2009 u 11,00 h na Masinskom fakultetu u Nisu, u svecanoj sali 401.
Katica R. (Stevanovic) Hedrih

Optimal Control in Engineering systems with trigger of coupled singularities

Četvrtak, 12. februar 2009, u 12,00 h na Mašinskom fakultetu u Nišu, u Laboratoriji L 307.
Katica R. (Stevanović) Hedrih
„Beseda o MEHANICI, mojim profesorima, kolegama i studentima“
Nastavak besede i diskusija.

Četvrtak, 5. februar 2009, u 12,00 h na Mašinskom fakultetu u Nišu, u Laboratoriji L 307.
Katica R. (Stevanovic) Hedrih
„Beseda o MEHANICI, mojim profesorima, kolegama i studentima“
(„Onn Mechanics, as well as on my Professors, Colleagues and Students“)
povodom 445 godina od rodjenja Galileo Galilei (15 February 1564 – 8 January 1642) i 130 godina od rodjenja Milutina Milankovića (1879 - 1958), posvećeno profesorima Draginji Nikolić, Danilu Raskoviću, Tatomiru Andjeliću i Yuriju Mitropoljskom.

Sreda, 3. decembar 2008. u 18,00 h
Katica R. (Stevanović) Hedrih
MAIN CHAINS AND EIGEN MODES OF THE FRACTIONAL ORDER HYBRID MULTI PENDULUM SYSTEM DYNAMICS

ČETVRTAK, 6. DECEMBRA 2007. godine sa početkom u 11,00 časova
Katica (Stevanović) Hedrih
Mehanika krutog tela i Leonhard EULER
Rigid body dynamics and Leonhard Euler (1707-1783)

ČETVRTAK, 5. APRILA 2007. godine sa početkom u 13,00 časova
Katica (Stevanović) Hedrih
Hibridni sistemi i hibridne dinamike: Teorija i primene
Hybrid Systems and Hybrid Dynamics: Theory and Applications

3* Seminar for Geometry, education and visualization with applications

ČETVRTAK, 06.05.2010. u 17 sati, sala 301f, MI
Katica Stevanovic Hedrih
Vektori polozaja materijalnih tacaka reonomnog sistema i njihovi tangentni triedri i N-jedri vektorskih baza u razlicitim sistemima krivolinijskih koordinata

ČETVRTAK, 12.11.2009. u 17 h Matematicki fakultet u Beogradu
Katica (Stevanović) Hedrih
Coriolis-ova sila inercije u dinamici mehanickog sistema i trensformacije koordinata iz Descartes-ovog u generalisani sistem ortogonalnih krivolinijskih koordinata
(predavanje je posveceno akademiku Milevi Prvanovic, povodom 80-tog rodjendana)

4* Seminar for the History and Philosophy of Mathematics and Mechanics

UTORAK, 06. april 2010. u 12:15 sati
Prof. Dr Katica R. Stevanovic-Hedrih, Matematicki institut SANU, Beograd
KOORDINATNI SISTEMI I KOORDINATE VEKTORA I SILE INERCIJE

UTORAK, 16. mart 2010. u 12:15 sati
Prof. Dr Katica R. Stevanović-Hedrih, Matematički institut SANU, Beograd
POVODOM: VEKTOR, ŠTA JE TO?

UTORAK, 20. pktobar 2009. u 12:15 sati
Prof. Dr Katica Stevanović-Hedrih, Mašinski fakultet, Univerzitet u Nišu

FORMALIZAM TRANSFORMACIJE KOORDINATA, DINAMIČKI (MEHANIČKI) SISTEMI I SILE INERCIJE

UTORAK, 18. novembar 2008. u 12:15 sati
Prof. dr Katica Stevanović-Hedrih, Mašinski fakultet, Univerzitet u Nišu
MEHANIKA KRUTOG TELA I LEONARD OJLER

UTORAK, 24. mart 2009. u 12:15 sati
Prof. Dr Katica Stevanović-Hedrih, Mašinski fakultet, Univerzitet u Nišu
GALILEO GALILEI I KINETIKA

5* Seminar on Applied Mathematics

Utorak, 24.11.2009. u 14:15, sala 301f, MI SANU:
Katica R. (Stevanović) Hedrih
THE OPTIMAL CONTROL IN ENGINEERING NONLINEAR SYSTEMS WITH TRIGGER OF COUPLED SINGULARITIES

Utorak, 17.02.2009. u 14:15, sala 305, MI BG:
Katica (Stevanović) Hedrih, Mašinski fakultet, Niš
MAIN CHAINS AND EIGEN MODES OF THE FRACTIONAL ORDER HYBRID SYSTEM VIBRATIONS

XX* Gostovanje na nasim seminarima inostranih profesora po pozivu na inicijativu K. Hedrih u periodu 2006-2010.:

March 28, 2009 at 11,30h
Valery V. Kozlov, Real member and vice-president of Russian Academy of Science, Steklov Mathematical Institute RAS, Moscow, Russia
Opening Lecture Seminar Nonlinear Dynamics – Milutin Milankovic
В.В. Козлов: **СПЕКТРАЛЬНЫЕ СВОЙСТВА КОНЕЧНОМЕРНЫХ ОПЕРАТОРОВ И ЗАДАЧА О ГИРОСКОПИЧЕСКОЙ СТАБИЛИЗАЦИИ**
Valery V. Kozlov: **Spektralna svojstva konačnodimenzionalih operatora i zadatak giroskopske stabilizacije**

SREDA, 11. novembar 2009. u 18 sati:
E.E. Gdoutos, *Office of Theoretical and Applied Mechanics of the Academy of Athens School of Engineering, Democritus University of Thrace, GR-671 00 Xanthi, Greece E-mail: egdoutos@civil.duth.gr*
FAILURE MECHANISMS OF COMPOSITE SANDWICH STRUCTURES

SREDA, 7. maj 2008. u 18 sati:
Prof. ***Giuseppe Rega,*** *Dipartimento di Ingegneria Strutturale e Geotecnica, Sapienza Universitŕ di Roma*
CONTROL OF BIFURCATION, CHAOS AND BASIN INTEGRITY: THEORETICAL ISSUES AND APPLICATION

PETAK, 23. NOVIMBRA 2007. godine sa početkom u 11,00 časova
Academician ***Radu Miron,*** *Faculty of Mathematics, University "Al.I.Cuza" Iasi, Iasi, Romania*
UNIVERSITATEA „ALEXANDRU IOAN CUZA",FACULTATEA DE MATEMATICĂ
Bulevardul Carol I, nr. 11 / 700506 – Iaşi, R O M Â N I A, E-mail: radu.miron@uaic.ro
održaće predavanje pod nazivom

Lagrangian and Finslerian Mechanics of Nonconservative Mechanical Systems

U PETAK, 23. NOVIMBRA 2007. godine sa početkom u 12,00 časova
Camellia Frigioiu, University "Dunarea de Jos", Department of Mathematics
Str. Domneasca nr 47, Galati - 800008, ROMANIA, Camelia.Frigioiu@ugal.ro
The Dynamical Systems of Rheonomic Finslerian Mechanical Systems

U UTORAK, 12. DECEMBRA 2006. godine sa početkom u 14,00 časova
Alexander P. Seyranian D.Sc, Ph.D, Leading Research Fellow,Institute of Mechanics, Moscow State Lomonosov University, održaće predavanje pod nazivom

MULTIPARAMETER STABILITY THEORY WITH MECHANICAL APPLICATIONS

U CETVRTAK, 1. JUNA 2006. godine sa pocetkom u 12,00 casova
J.T. Katsikadelis, Academy of Athens, Office of Theoretical and Applied Mechanics & School of Civil Engineering, National Technical University of Athens, Greece.
The BEM for Nonlinear Vibrations of Plates with Variable Stiffness and Mass Properties

ON174001 - Dynamics of hybrid systems with complex structures. Mechanics of materials. (2011-2014)
ON174001 – Dinamika hibridnih sistema složenih struktura. Mehanika materijala . (2011-2014)
Support: *Ministry of Education, Sciences and Technology of Republic of Serbia*
Institution Coordinator: *Mathematical Institute Serbian Academy of Sciences and Arts.*
Project Leader: *Katica (Stevanović) Hedrih*
Researchers: 38.

Report – Research Results in 2011 and 2012.

List of References – Researchers:

List of References in 2011
Katica R. (Stevanovic) Hedrih

1* Hedrih (Stevanović) R. Katica, (2010), Ceo život posvećen mehanici, inženjerstvu i matematici, Danilo P. Rašković(28 avgust 1910-29 januar 1985), Povodom 100 godina od rodjenjazaslužnog Užičanina, časopis Istorijskog arhiva Užica, Istorijska baština, 2010, br 10, str. 155-192.
Istorijski arhiv Užica, Istorijska baština

2* Hedrih (Stevanović) K., Optimal control in nonlinear system with no ideal constraints, Commun Nonlinear Sci Numer Simulat, journal homepage: www.elsevier.com/locate/cnsns, CNSNS 1579 No. of Pages 13, Model 3G
Optimal control in nonlinear system with no ideal constraints, *Communications in Nonlinear Science and Numerical Simulation, In Press, Accepted Manuscript, Available online 6 May 2010,*
Katica R. (Stevanović) Hedrih

Preview PDF (574 K) | Related Articles (Science Direct)
(Stevanovic´) Hedrih KR. Optimal control in nonlinear system with no ideal constraints. Commun Nonlinear Sci Numer Simulat (2010), doi:10.1016/j.cnsns.2010.04.053
ISSN 1007-5704
http://www.sciencedirect.com/science/article/pii/S1007570410002650

Hedrih (Stevanović) K R. Optimal control in nonlinear system with no ideal constraints. Commun Nonlinear Sci Numer Simulat (2010), doi:10.1016/j.cnsns.2010.04.053, Journal Comunications in Nonlinear Sciences and Numerical Simulation, 2011 16 (5):2289-2300.
www.elsevier.com/locate/cnsns, CNSNS 1579 No. of Pages 13, Model 3G

ISSN 1007-5704

http://www.sciencedirect.com/science/article/pii/S1007570410002650

COMMUNICATIONS IN NONLINEAR SCIENCE AND NUMERICAL SIMULATION 2011 16 (5):2289-2300
ISSN 1007-5704

http://www.sciencedirect.com/science/article/pii/S1007570410002650
M21=8
Volume 16, Issue 5, May 2011, Pages 2289– 2300

3* Camelia Frigioiu, Katica (Stevanovic) Hedrih, and Iulian Gabriel Bˆırsan, Lagrangian geometrical model of the rheonomic mechanical systems, World Academy of Science, Engineering and Technology 73 2011
M23=3

.
Frigioiu C, Hedrih (Stevanovic) K, Birsan I G (2011), Lagrangian geometrical model of the rheonomic mechanical systems, *Proceedings of World Academy of Science*, *Engineering and Technology*, 73, pp.1178-1184, M23=3
http://www.scopus.com/record/display.url?eid=2-s2.0-79953006306&origin=inward&txGid=38F76A400992B9C0EEC574F93BAF155A.y7ESLndDIsN8cE7qwvy6w%3a4

World Academy of Science, Engineering and Technology
Volume 73, January 2011, Pages 352-358

Lagrangian geometrical model of the rheonomic mechanical systems

Frigioiu, C.[a] , Hedrih, K.[b] , Bîrsan, I.G.[c]
[a] Department of Mathematics, Faculty of Sciences, Dunărea de Jos University of Galați, 111 Domneasca, 800201 Galați, Romania
[b] Faculty of Mechanical Engineering, University of Nis, Serbia
[c] Faculty of Mechanical Engineering, Dunărea de Jos University of Galați, 111 Domneasca, 800201 Galați, Romania

4* Hedrih (Stevanović) R. Katica **and Ivančević Tijana, (2011), Rigorous Kinetic Analysis of the Racket Flick-Motion in Tennis for Generating Topspin and Backspin, Volume 20 Issue 2 (International Journal of Mathematics, Game Theory and Algebra)**
https://www.novapublishers.com/catalog/product_info.php?products_id=22625,
https://www.novapublishers.com/catalog/product_info.php?products_id=23060

Volume 20 Issue 2 (International Journal of Mathematics, Game Theory and Algebra)
https://www.novapublishers.com/catalog/product_info.php?products_id=22625

Katica (Stevanović) Hedrih and Tijana Ivancevic, RIGOROUS KINETIC ANALYSIS OF THE RACKET FLICK-MOTION IN TENNIS FOR GENERATING TOPSPIN AND BACKSPIN, In: International Journal of Mathematics, Game Theory and Algebra , Volume 20, Issue 2, pp. 1–26 © 2011 Nova Science Publishers, Inc., ISSN: 1060-9881
https://www.novapublishers.com/catalog/product_info.php?products_id=22625,
https://www.novapublishers.com/catalog/product_info.php?products_id=23060
M23=3

Chapter 5
In: Horizons in World Physics – Volume 276 ISBN 978-1-61324-654-2
Editor: Albert Reimer 2011 Nova Science Publishers, Inc.

5* Hedrih (Stevanović) K R. and Simonović J., Multi-frequency analysis of the double circular plate system non-linear dynamics", Nonlinear Dynamics, Springer, NODY1915R2, (has been accepted for publication)
DOI: 10.1007/s11071-011-0147-7

- Article title: Multi-frequency analysis of the double circular plate system non-linear dynamics
- DOI: 10.1007/s11071-011-0147-7

ISSN 0924-090X

M21=8

6* Hedrih (Stevanović) K R., 2010, Kinetic Impulses - Impacts On Rotating Rigid Rotor Bearings, Scientific Technical Review, 2010, Vol.60,No.3-4, pp.54-66, UDK: 531.38:514.732.4,62-253, COSATI: 12-01, 20-11, 13-07.
http://www.vti.mod.gov.rs/ntp/entp.htm, ISSN 1820-0206

M51=1,5

7* Hedrih (Stevanović) K R., Raičević V. and Jović S., Phase Trajectory Portrait of the Vibro-impact Forced Dynamics of Two Heavy Mass Particles Motions along Rough Circle,

Communications in Nonlinear Science and Numerical Simulations, 2011 16 (12):4745-4755,

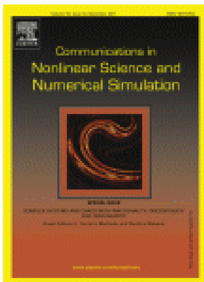
DOI 10.1016/j.cnsns.2011.05.027, Volume 16, Issue 12, December 2011, Pages 4745– 4755

http://www.sciencedirect.com/science/article/pii/S1007570411002735
http://www.sciencedirect.com/science/article/pii/S1007570411002735

Communications in Nonlinear Science and Numerical Simulation

Volume 16, Issue 12, December 2011, Pages 4745– 4755

SI:Complex Systems and Chaos with Fractionality, Discontinuity, and Nonlinearity



Hedrih (Stevanović) K R., Raičević V. and Jović S., Phase Trajectory Portrait of the Vibro-impact Forced Dynamics of Two Heavy Mass Particles Motions along Rough Circle, **Communications in Nonlinear Science and Numerical Simulations,**
Ms. Ref. No.: CNSNS-D-10-01646R2, accepted for publishing, to appear

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Albert C.J. C. J. Luo, José António Tenreiro António Tenreiro Machado and Dumitru Baleanu

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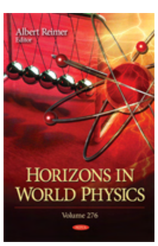
Chapter 5

In: Horizons in World Physics – Volume 276 ISBN 978-1-61324-654-2
Editor: Albert Reimer 2011 Nova Science Publishers, Inc.



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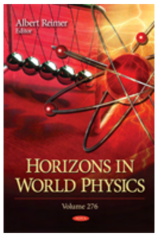

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III*

Serbian Scientific Society

Symposium Nonlinear Dynamics – Milutin Milanković

http://afrodita.rcub.bg.ac.rs/~nds/indexe.html

Multidisciplinary and Interdisciplinary Applications
(SNDMIA 2012), Belgrade, October 1-5, 2012.
(Eigth Serbian Symposium in area of Non-linear Sciences)

supported by Project ON174001 (2011-2014)
coordinated through
Department of Mechanics at Mathematical Institute SANU

Co-organizers scientists from

Serbian Society of Mechanics,
Institute „Mihajilo Pupin“ Belgrade,
Institute „Vincha“,
The Society of Physical Chemists of Serbia

Faculty of Physical Chemistry University of Belgrade and
Faculty of Technical Sciences Kosovska Mitrovica, University of Pristina with allocated place in Kosovska Mitrovica.

У оквиру овог скупа одржала сам једну беседу на отварању, као један од два главна организарора, једни пленарно предавање и јесно саопштење. Беседа је најављена под називом:

***Address to Participant of Symposium**: Hedrih (Stevanović) K. SYMPOSIUMS ON NONLINEAR MECHANICS IN SERBIA, ICNO AND ENOC*

док је пленарно предавање одежано у следећем термину:

October 5, 2012 at 12,00h-12,40h, Plenary Lecture

Chairs: H. Yabuno, Pavel Krasilnikov and Marina V. Shitikova

PL-13. ID-81. PHENOMENOLOGICAL MAPPING AND MATHEMATICAL ANALOGY IN NONLINEAR DYNAMICAL SYSTEMS, K. (Stevanović) Hedrih [1,] [1] Mathematical Institute SANU, Department of Mechanics, and Faculty of Mechanical Engineering University of Niš, Serbia,

Прво једноауторско саопштење сам представила самаЧ

October 4, 2012 at 13,40h-15,00h, Contributed Lectures

CL-36. ID-80. STOCHASTIC PARAMETRICALLY EXCITED HEREDITARY SANDWICH MULTI BEAM DYNAMICAL SYSTEMS, K. (Stevanović) Hedrih' Mathematical Institute SANU, Department of Mechanics, and Faculty of Mechanical Engineering University of Niš, Serbia.

Док је коауторско саопштење под називом:

CL-37. ID-79. HYBRID SYSTEM DYNAMICS ON LAYER WITH NONLINEAR ELASTIC AND INERTIA PROPERTIES, K. (Stevanović) Hedrih [1]**, M. Stamenković** [2]**, N. Nešić** [2]**,** [1] Mathematical Institute SANU, Department of Mechanics, and Faculty of Mechanical Engineering University of Niš, Serbia,[2] Mathematical Institute SANU, Department of Mechanics, Kneza Mihaila 36/III, Serbia,

успешно сапштла деуги коаутор **Марија Stamenković.**

Двостранични апстракти радова су публиковани у публикацији Симпозијума и преглед са одговарајућим библиографским падацима је дат у следећем приказу истих:

Hedrih (Stevanović) K., (2012), PHENOMENOLOGICAL MAPPING AND MATHEMATICAL ANALOGY IN NONLINEAR DYNAMICAL SYSTEMS, **Plenary Lecture**, Booklet of Abstracts of Symposium Nonlinear Dynamics – Milutin Milanković, Multidisciplinary and Interdisciplinary Applications (SNDMIA 2012), Belgrade, October 1-5, 2012. (Eigth Serbian Symposium in area of Non-linear Sciences), Editors: Katica R. (Stevanović) HEDRIH andf Žarko Mijajlović, Serbian Scientific Society, 2012, pp. 38-39. (http://afrodita.rcub.bg.ac.rs/~nds/indexe.html)

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(http://afrodita.rcub.bg.ac.rs/~nds/indexe.html)

K. (Stevanović) Hedrih, M. Stamenković , N. Nešić (2012), HYBRID SYSTEM DYNAMICS ON LAYER WITH NONLINEAR ELASTIC AND INERTIA PROPERTIES, Contributed Lecture, Booklet of Abstracts of Symposium Nonlinear Dynamics – Milutin Milanković, Multidisciplinary and Interdisciplinary Applications (SNDMIA 2012), Belgrade, October 1-5, 2012. (Eigth Serbian Symposium in area of Non-linear Sciences), Editors: Katica R. (Stevanović) HEDRIH and Žarko Mijajlović, Serbian Scientific Society, 2012, pp. 139-140. (http://afrodita.rcub.bg.ac.rs/~nds/indexe.html)

Била сам модератор Округлог стола на тему Етика научника, који се одржао веома успешно по оцени и домаћих и иностраних учесника.

October 4, 2012 at 13,00h-13,40h, Round Table

Invitataion for Chairs and Contribytion Discussions: Albert Luo, Hiroshi Yabuno, Pavel Krasilnikov, Mihai Zakr\evski, Marina V. Shitikova**,** , Ljiljana Kolar Ani’, Slobodan Ani’, |eqko :upi’, Žarko Mijajlović, K. (Stevanović) Hedrih I drugi.

Round Table: "Ethic of Scientists and Evaluation of Scientific Research Results".

*** Kratak opis realizacije naucnog programa Simpozijuma** (u prilogu realizovani naucni program Simpozijuma)

Naucni program Simpozijuma Nonlinear Dynamics – Milutin Milankovic je uspesno realizaovan u toku od svih pet dana pocevsi od 1 oktobra (od 8,30h do 19h svakog dana) i zakljucno sa programom 5 oktobra 2012, koji se zavrsio sa programom zatvaranja i naucnom diskusijom prisutnih ucesnika. Mesto odrzavanja velika sala Matematickog instituta SANU.

Odrzano je 11 plenarnih predavanja iz razlicitih oblasti nelinearne dinamike i jedno specijalno o kulturnoj bastini Srbije. Sedam plenarnih predavaca je bilo iz iinostranstva (po jedan iz Japana, U.S.A., dva iz Rusije, Izraela, Nemacke, Litvanije). Odrzan je uspesno Okrugli sto o Etici naucnika i jedna panel diskusija o Nelinearnoj dinamici na zatvaranju Simpozijuma. Odrzane su tri specijalne sekcije iz oblasti nelinearne dinamike iz Fizike, Fizicke hemije i Dinamike mehanickih sistema, kao i 11 predavanja po pozivu iz oblasti nelinearne dinamike bio sistema, mehanike fluida, analiticke mehanike i dr. Saopstenja su takodje odrzavana po programu.
Autori 88 dvostranicnih apstrakta radova, koji su ukljuceni u Booklet of Abstracts su iz Srbije, Rusije, Japana, U.S.A., Izraela, Nemacke, Litvanije, Ukrajine, Kine, Spanije, Indije, Kine, Katara.

Opsta ocena ucesnika je da je Simpozijum izuzetno uspesano realizovan. Ucesnici su se izuzetno povljno izjasnili o visokom nau;nom nivou realizovanog naucnog programa simpozijuma, a posebno o naucnoj atmosferi stvorenoj diskusijama i naucnim komunikacijama medju ucesnicima po odrzanim plenarnim predavanjima, predavanjima po pozivu, kao i saopstenjima. Ocena je da je Okrugli sto pravi izbor i sadrzajno veoma uspesno realizovan.

Ocena je da bi trebalo nastaviti sa organizacijom i narednih Smpozijuma iz ovog ciklusa Nonlinear Dynamics interdisciplinarnog i mulitidisciplinarnog sadrzaja i sa ucesnicima po pozivu iz inostranstva. Koncepcija naucnog programa je takodje uspesno osmisljenja i uspesno realizovana.

Publikovan je Booklet of Abstracts – Symposium **Nonlinear Dynamics – Milutin Milankovic** koji sadrzi dvostranicne apstakte plenarnih predavanja, predavanja po pozivu i saopstenja., ukupno 88 apstrakata i priloge. Publikacija je katalogizirana i CIOP Narodne bibluioteke Srbije i nasi sledece identifikacione brojeve:

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Planirana je postsimpozijumska publikacija radi publikovanja celih radova koji dobiju pozitivne recenzije, kao i apstrakta diskusija na okruglom stolu ”Etika naucnika”. http://afrodita.rcub.bg.ac.rs/~nds/indexe.html

ISBN 978-86-7746-344-1, COBISS.SR – ID 193221132,Barcod 978-86-7746-344-1: http://www.mi.sanu.ac.rs/projects/booklet_of_abstracts.pdf

October 5, 2012 at 12,00h-12,40h, Plenary Lecture

Chairs: H. Yabuno, Pavel Krasilnikov and Marina V. Shitikova

PL-13. ID-81. PHENOMENOLOGICAL MAPPING AND MATHEMATICAL ANALOGY IN NONLINEAR DYNAMICAL SYSTEMS, K. (Stevanović) Hedrih [1, 1] Mathematical Institute SANU, Department of Mechanics, and Faculty of Mechanical Engineering University of Niš, Serbia,

Booklet of Abstracts - **Symposium Nonlinear Dynamics – Milutin Milanković,** Multidisciplinary and Interdisciplinary Applications, (SNDMIA 2012), Belgrade, October 1-5, 2012., (Eigth Serbian Symposium in area of Non-linear Sciences), Serbian Scientific Society. Str. 38-39. http://afrodita.rcub.bg.ac.rs/~nds/indexe.html, **ISBN 978-86-7746-344-1, COBISS.SR – ID 193221132,Barcod 978-86-7746-344-1:** http://www.mi.sanu.ac.rs/projects/booklet_of_abstracts.pdf

First Editoer’inChief of Booklet of Abstracts - **Symposium Nonlinear Dynamics – Milutin Milanković,** Multidisciplinary and Interdisciplinary Applications, (SNDMIA 2012), Belgrade, October 1-5, 2012., (Eigth Serbian Symposium in area of Non-linear Sciences), Serbian Scientific Society. Str. 1-193. http://afrodita.rcub.bg.ac.rs/~nds/indexe.html, **ISBN 978-86-7746-344-1, COBISS.SR – ID 193221132,Barcod 978-86-7746-344-1:** http://www.mi.sanu.ac.rs/projects/booklet_of_abstracts.pdf

Циклус предавања Одељења природно-математичких наука Научног друштва Србије

НАУЧНИ ХОРИЗОНТИ
ПРИРОДНОМАТЕМАТИЧКЕ НАУКЕ - ЈУЧЕ, ДАНАС И СУТРА

Предацање под насловом: Хедрих (Стевановић) К., (2012), О ТАНГЕНТНИМ ПРОСТОРИМА ВЕКТОРА ПОЛОЖАЈА МАТЕРИЈАЛНИХ ТАЧАКА РЕОНОМНОГ СИСТЕМА И ЊИХОВИМ КИНЕТИЧКИМ ДЕФОРМАЦИЈАМА, предавање, **НАУЧНИ ХОРИЗОНТИ - ПРИРОДНОМАТЕМАТИЧКЕ НАУКЕ - ЈУЧЕ, ДАНАС И СУТРА,** Циклус предавања Одељења природно-математичких наука Научног друштва Србије, Понедељак, 30. април 2012. године. http://afrodita.rcub.bg.ac.rs/~nds/indexe.html

Семинари Математичког интитута САНУ

Семинар механике Оцдљења за механику Математичког интитута САНУ

http://www.mi.sanu.ac.rs/seminars/seminar12.htm
http://www.mi.sanu.ac.rs/colloquiums/mechcoll.htm

SREDA, 11. april 2012. u 18 sati:
Проф. др Катица Р. (Стевановић) Хедрих, руководилац пројекта ОИ 174001 и управник Одељења за механику

Предацање под насловом: Хедрих (Стевановић) К., (2012), Вектори момената маса, вектори ротатори и њихова примена на системе више спрегнутих тела који изводе спрегнуте ротације, предавање, ,Семинар механике Одељења за механику Математичког института САНУ, среда 11 април 2012 у 18 часва (замена предавања због одсутности предавача, који није најавио спреченост да одржи предавање, види Записник Семинара механике Одељења за механику) .

http://www.mi.sanu.ac.rs/colloquiums/mechcoll.htm

Предавање одржано на основу садржаја и резултата из публикованих радова:

Hedrih (Stevanović K., (2012), Mass moment vectors and vector rotators and their applications to the rigid body multi-coupled rotations, **(**realized as Plenary Lecture, Certificate**),** Selected papers, CCMECH-7, 7th INTERNATIONAL SYMPOSIUM ON CLASSICAL AND CELESTIAL MECHANICS (CCMECH'2011), October 23 – 28, 2011, Edited by Leszek Gadomski, Pavel Krasilnikov and Alexander Prokopenya. The Russian Academy of Sciences, A. A. Dorodnicyn Computing Centre of RAS, Moscow State University, Moscow State Aviation Institute, and Collegium Mazovia in Siedlce (Poland), pp. 44-62. ISBN 978-83-63169-20-6.

Hedrih (Stevanović) Katica, (2012 ili 13), Vector method based on mass moment vectors and vector rotators applied to rigid-body multi-coupled rotations around no intersecting axes, invited and accepted by guset Editor Jan Awrejcevicz and submitted for possible publishing in specual Issue of International Journal of Structural Stability and Dynamic, (wait Editorial drcission of Editor in Chief of Journasl). ISSN 0219-4554

Sreda, 09. maj 2012. u 18 sati:
Проф. др Катица Р. (Стевановић) Хедрих, *Математички институт САНУ Београд и Машински факултет Универзитета у Нишу (Пројекат ON174001)*

Предацање под насловом: Хедрих (Стевановић) К., (2012), Линеаризације и апроксимације са применама у механици: Методе, претпоставке, прве аналитичке апроксимације и грешке (Linearizations and approximations with applications in mechanics: Methods, assumptions, first analytic approximations and errors), предавање, Семинар механике Одељења за механику Математичког института САНУ, среда 9 маја 2012 у 18 часва (замена предавања због одсутности предавача, који је најавио спреченост да одржи предавање, види Записник Семинара механике Одељења за механику) .

http://www.mi.sanu.ac.rs/colloquiums/mechcoll.htm

Семинари Математичког интитута САНУ
Семинар за философију и историју математике, механике и астрономје

http://www.mi.sanu.ac.rs/seminars/seminar12.htm

<u>UTORAK, 22. maj 2012. u 12:15 sati</u>

Prof. Dr Katica R. (Stevanović) Hedrih, matematički institut SANU, Beograd

FASCINANTNA NELINEARNA DINAMIKA TEŠKE MATERIJALNE TAČKE; APSTRAKCIJA REALNIH SISTEMA I OŽIVLjAVANJE MATEMATIKE

Предацање под насловом: Хедрих (Стевановић) К., (2012), FASCINANTNA NELINEARNA DINAMIKA TEŠKE MATERIJALNE TAČKE; APSTRAKCIJA REALNIH SISTEMA I OŽIVLjAVANJE MATEMATIKE, предавање, Семинар за филозофију и историју математике, механике и астрономје, Математичког института САНУ, уторак, 22 мај 2012 у 12 часва. http://www.mi.sanu.ac.rs/seminars/programs/seminar12.maj2012.htm

Predavanje povodom 15 godina članstva u akademiji nauka visokih škola i univerziteta ukrajine (od 1996)

Rezime: Predavanjem se prikazuju fenomeni fascinantne nelinearne dinamike teške materjalne tačke koja se kreše po rotirajućoj krivoj liniji - krugu (paraboli, cikloidi, elipsi). Zavisno od međusobnog položaja mimoilaznih osa oko kojih se izvode spregnute rotacije prikazuju se nelinearne diferencijalne jednačine i odgovarajući fazni portreti. Kroz analizu svojstava i značenja stacionarnih tačaka i trigera spregnutih singulariteta, kao i bifurkacija stacionarnih tačaka varijacijom parametara sistema prikazuje se oživl.avanje matematematičkih metoda i diferencijalnih jednačina do tzv. "žive matematike".

Fenomenološkim preslikavanjem i matematičkom analogijom, po ugledu na ideje Mihajla Petrovića, pokazuje se da nekoliko nelinearnih diferencijalnih jednačina, kojima se opisuje fascinantna nelinearna dinamika teške materijalne tačke, predstavljaju matematičku apstrakciju opisa dinamike rotora sa spregnutim debalansima, žirorotora, ili krutih tela koja izvode spregnute rotacije. ukazuje se na pojam konzervativnog i nekonzervativnog sistema i sistema sa trenjem njihovih zajedničkih trigera spregnutih singulariteta. Za sisteme sa trenjem ukazuje se na bifurkaciju singulariteta iz trigera spregnutih singulariteta i pojavu jednostranih singulariteta.

<u>UTORAK, 23. oktobar 2012. u 12:15 sati</u>

Katica R. (Stevanovic) Hedrih, Matematicki institut SANU, Beograd

JUBILEJ "OPŠTE TEORIJE STABILNOSTI" A. M. LJAPUNOVA

Предацање под насловом: Хедрих (Стевановић) К., (2012), JUBILEJ "OP
TE TEORIJE STABILNOSTI" A. M. LJAPUNOVA, предавање, Семинар за филозофију и историју математике, механике и астрономје, Математичког института САНУ, уторак, 23 октобра 2012 у 12 часва. http://www.mi.sanu.ac.rs/seminars/programs/seminar12.oct2012.htm

Rezime: Proteklo je 120 godina od prvog objavljivanja, 1892. godine, "Opste teorije stabilnosti" Aleksandra Mihailovi Ljapunova (6. jun 1857 - 3. novembar 1918). Povodom tog jubileja predavanje je usmeren. na osnovne postavke "Opste teorije stabilnosti" Ljapunova, osnovne pojmove i njihove definicije, kao i na njihovu interdiscilinarnu i multidisciplinarnu primenu, u skoro svim oblastima nauka, a posebno u razvoju oblasti nelinearne dinamike. Za mnogobrojne kljucne reci, kao to su

Ljapunovljeva stabilnost, Ljapunovljeve funkcije prvog i drugog reda, Ljapunovljev funkcional, Ljapunovljev eksponent, Ljapunovljeva centrala granicna teorema, Ljapunovljeva jednacina, Ljapunovljev fraktal, Ljapunovljevo vreme i Ljapunov-Malkinova teorema, biti prikazane osnovne definicije i primene i biti ukazano na njihov znacaj u savremenim naucnim istrazivanjima u raznim oblastima nauka.

Семинари Математичког интитута САНУ

Семинар Математичке методе механике

http://www.mi.sanu.ac.rs/mmm/

Предацање под насловом: Хедрих (Стевановић) К., (2012), О ТАНГЕНТНИМ ПРОСТОРИМА ВЕКТОРА ПОЛОЖАЈА МАТЕРИЈАЛНИХ ТАЧАКА РЕОНОМНОГ СИСТЕМА И ЊИХОВИМ КИНЕТИЧКИМ ДЕФОРМАЦИЈАМА, предавање, Семинар Математичке методе механике, Математички институт САНУ, Понедељак, 30. април 2012. године. http://www.mi.sanu.ac.rs/mmm/srpski/indexs.html

******

Семинари Математичког интитута САНУ

Семинар **''Математичке методе механике у примени''.**

Mathematical Methods of Mechanics and Applications and Project OI 174001
Matematicke metode mehanike u primeni
Projekat OI 174001 Dinamika hibridnih sistema slozenih struktura (2011-2014)
Serija predavanja za istrazivace pripravnike i doktorante iz oblasti Kinetike, Elastodinamike, Analiticke mehanike, Primene tenzorskog racuna u mehanici, Teorije oscilacija i Nelinearne dinamike
Одржаван сваке среде у току 2011 и 2012 године.
http://www.mi.sanu.ac.rs/colloquiums/program.htm

Хедрих (Стевановић) К., (2011 и 2012), Serija predavanja za istrazivace pripravnike i doktorante iz oblasti Kinetike, Elastodinamike, Analiticke mehanike, Primene tenzorskog racuna u mehanici, Teorije oscilacija i Nelinearne dinamike, Одржаван сваке среде у току 2011 и 2012 годинe и одржано висе од 25'0 цасова предаванја доторских курсева и консултација са истраsивачима са пројекта ОН174001. Предавач ниједан час није наплатио, апредавања је одржао са поседбним надахнућем и радопћу преношења знања на младе истраживаче..

http://www.mi.sanu.ac.rs/colloquiums/program.htm

Spisak referenci u 2013
Katica (Stevanoviċ) R. Hedrih

Renumeracija TAM

Hedrih (Stevanoviċ) R. Katica, (2012/2013), ADVANCES IN CLASSICAL AND ANALYTICAL MECHANICS: A REVIEWS OF AUTHOR'S RESULTS,
* CITATION DATA FOR TAM 40 (S1), 2012: THEORET. APPL. MECH., VOL.40, NO.S1, PP. 293-383, BELGRADE 2012, DOI : 10.2298/TAM12S1293H
* CITATION DATA FOR TAM 40 (1-2), 2013: THEORET. APPL. MECH., VOL.40, NO.1-2, PP. 293-383, BELGRADE 2013, DOI:10.2298/TAM1302293H,
Math.Subj.Class.: 70-02; 70E55; 70F40; 70G10; 70G45; 70J50; 70K50; 70K28; 44A05; 45J05; 45K05; 45L05; 45M05;34A38

Katica (Stevanovic) Hedrih
Rukovodilac projekta ON174001 (period 2011-2014 godina) MPN RS koordiniranog u MI SANU po clanu 24 AKT-a Ministarstva prosvete, nauke I tehnoloskog razvoja Republike Srbije

Hedrih (Stevanoviċ) R. Katica, (2013), Vector method based on mass moment vectors and vector rotators applied to rigid-body multi-coupled rotations around no intersecting axes, International Journal of Structural Stability and Dynamics, WORLD SCIENTIFIC PUBLISHING COMPANY PTE LTD, 5 Toh Tuck Link, Singapore 596224, Fax: (65) 6467 7667

Hedrih (Stevanoviċ) R. Katica, (2013), Vector method based on mass moment vectors and vector rotators applied to rigid-body multi-coupled rotations around no intersecting axes, International Journal of Structural Stability and Dynamics, Vol. 13, No. 7 (2013) 1340007 (20 pages), # c World Scientificc Publishing Company, **ISSN: 0219-4554**, DOI: 10.1142/S0219455413400075
http://dk.doi.org/10.1142/S0219455413400075

May 6, 2013, 11:18:35am, WSPC/165-IJSSD, 1340007 ISSN: 0219-4554, DOI: 10.1142/S0219455413400075

VECTOR METHOD BASED ON MASS MOMENT VECTORS AND VECTOR ROTATORS APPLIED TO RIGID-BODY MULTI-COUPLED ROTATIONS AROUND NON INTERSECTING AXES

International Journal of Structural Stability and Dynamics
Vol. 13, No. 7 (2013) 1340007 (20 pages)
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DOI: 10.1142/S0219455413400075

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VECTOR METHOD BASED ON MASS MOMENT VECTORS AND VECTOR ROTATORS APPLIED TO RIGID-BODY MULTI-COUPLED ROTATIONS AROUND NON INTERSECTING AXES

KATICA R. (STEVANOVIĆ) HEDRIH
Department for Mechanics
Mathematical Institute of Serbian Academy of Science and Arts (SANU)
Belgrade and Faculty of Mechanical Engineering
University of Niš, Serbia
khedrih@eunet.rs
katicahedrih@gmail.com

http://dk.doi.org/10.1142/S0219455413400075

Hedrih, A., Hedrih(Stevanovvić) K. , Modeling Double DNA Helix Main Chains of the Free and Forced Fractional Order Vibrations, Chapter in Book **Advanced topics on modeling, system stability and control applications of fractional calculus,** Editor M. Lazarević, (in press)

I would like to inform you that the title ***"Advanced Topics on Modeling, System Stability and Control Applications of Fractional Calculus"*** has been evaluated by the reviewers which advised that the title is accepted for publication.

WSEAS Editing Department
www.wseas.org

Hedrih, N. A., Hedrih(Stevanovvić) K. , **(2013),** Modeling Double DNA Helix Main Chains of the Free and Forced Fractional Order Vibrations, Chapter in Book **Advanced topics on fractional calculus on control problem, modeling, system stability and modeling,** Editor M. Lazarević, **(2013),** pp. **145-183 and Appendix pp. 192-200.** . WORLD SCIENTIFIC PUBLISHING COMPANY PTE LTD

ADVANCED TOPICS ON APPLICATIONS OF FRACTIONAL CALCULUS ON CONTROL PROBLEMS, SYSTEM STABILITY AND MODELING

I. Introduction to Fractional Calculus with Brief Historical Background 1
Control and Stability Issues
II. Direct and Indirect Method for Discretization of Linear Fractional Systems 15
III. Finite -Time Stability of Fractional Time Delay System 37
IV. Stability of Discrete-Time Fractional Order Systems considered: An Approach Based on Stability of Discrete-Time Integer Order Time-Delay Systems 59
Modeling
V. Modeling of Human Skin Using Distributed Order Fractional Derivative Model-Frequency Domain 79
VI. A Thermodynamically Consistent Rheological Model for Engineering Applications 98
VII. Modeling Double DNA Helix Main Chains of the Free and Forced Fractional Order Vibrations 125
VIII. Appendix

Hedrih (Stevanović) K., (213), Метода аналитичке функције комплексне промењиве у Теорији еластичности и Механици флуида, Abstract, Program, IV Simpozijum Matematika I primene 24 i 25 maj 2013, Matematički fakultet Univerziteta u Beogradu, str. 5
http://alas.matf.bg.ac.rs/~konferencija/

Hedrih (Stevanović) K., (213), **LINEAR AND NONLINEAR DYANAMICS OF HYBRID SYSTEM,** *Invited Plenary Lecture, (To memory of my Serbian professors:* ***Draginja Nikolić, Danilo P. Rašković and Tatomir P. Andjelić*** *and to academicians supported my international scientific acctivity in nonlinear dynamics:* ***Yuri Alekseevich Mitropolskiy, Vladimir Metodievich Matrosov*** *and* ***Valentin Vitalevich Rumяantsev*** *and President of IFNA Professor dr* ***V. Lakshminatham*** *),* Proceedings of Fourth Serbian (29th Yu) Congress on Theoretical and Applied Mechanics, Vrnjačka Banja, Serbia, 4-7 June 2013, pp. 43-58. ISBN 978-86-909973-5-0
ISBN 978-86-909973-5-0. COBISS.SR-ID 198308876

Hedrih (Stevanović) K., (213), Fractional order differential equations of dynamics of two mass particles, constrained by a fractional order element, 8th INTERNATIONAL SYMPOSIUM
ON CLASSICAL AND CELESTIAL MECHANICS (CCMECH'8), September 25 – 29, 2013, Siedlce, Poland, (The Russian Academy of Sciences, A. A. Dorodnicyn Computing Centre of RAS, Moscow State University, Moscow State Aviation Institute, Warsaw University of Life Sciences, and Collegium Mazovia in Siedlce (Poland) will hold the Eighth International Symposium on Classical and Celestial Mechanics (CCMECH'2013) at Collegium Mazovia in Siedlce, Poland) pp.
http://agora.guru.ru/display.php?conf=CCMECH7

Hedrih (Stevanović) K., (213), Fractional order hybrid system dynamics, Proceedings in Applied Mathematics and Mechanics (PAMM) 24 May 2013, GAMM 2013, 84th Annual Meeting of the International Association of Applied Mathematics and Mechanics Novi Sad, Serbia, March 18-22, 2013. http://gamm2013.cats-host.com/cms/

GAMM (Gesellschaft für Angewandte Mathematik und Mechanik), Novi Sad, Serbia, March 18-22, 2013, Contributed section-Biomechanics S2.4. **PAMM · Proc. Appl. Math. Mech. 13, (2013) /** http://onlinelibrary.wiley.com/doi/10.1002/pamm.v13.1/issuetoc

Katica R. (Stevanović) Hedrih, (201`3), Fractional order hybrid system dynamics, PAMM, Proc. Appl. Math. Mech. 13, 25 – 26 (2013) / DOI 10.1002/pamm.201310008
http://onlinelibrary.wiley.com/doi/10.1002/pamm.v13.1/issuetoc
GAMM (Gesellschaft für Angewandte Mathematik und Mechanik)

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Katica R. Stevanovic Hedrih and Ljiljana Veljović
Special Issue on Applied Mathematics
Guest Editors: Aurél Galántai and Péter T. Nagy

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* 8th INTERNATIONAL SYMPOSIUM ON CLASSICAL AND CELESTIAL MECHANICS (CCMECH'8), September 25 – 29, 2013, Siedlce, Poland, (The Russian Academy of Sciences, A. A. Dorodnicyn Computing Centre of RAS, Moscow State University, Moscow State Aviation Institute, Warsaw University of Life Sciences, and Collegium Mazovia in Siedlce (Poland) will hold the Eighth International Symposium on Classical and Celestial Mechanics (CCMECH'2013) at Collegium Mazovia in Siedlce, Poland).
http://agora.guru.ru/display.php?conf=CCMECH7, http://www.msz.gov.pl/en

*** 4th International Conference on Nonlinear Dynamics,** Sevastopol, Ukraine, 19-22 June, 2013, **http://kpispu.org.ua/en/ND2013_conference**

* 12TH CONFERENCE on DYNAMICAL SYSTEMS THEORY AND APPLICATIONS, December 2-5, 2013. Łódź, Poland.www.wydawnictwa.p.lodz.pl,**http://www.dys-ta.com/**

* **Fourth Serbian Congress of Theoretical and Applied Mechanics**
(http://www.ssm.org.rs/Congress2013/authors.html)

* Mini Symposium **Nonlinear Dynamics – Milutin Milankovic**
Interdisciplinary and multidisciplinary sciences
4th -7th of June 2013, Hotel BREZA- Vrnjačka Banja, Serbia
Organizer: Katica R. (Stevanovic) Hedrih
(http://www.ssm.org.rs/Congress2013/authors.html)

Plenary Lectures and Semi-Plenary Lectures and Invited Participant.

* 8th INTERNATIONAL SYMPOSIUM ON CLASSICAL AND CELESTIAL MECHANICS (CCMECH'8), September 25 – 29, 2013, Siedlce, Poland, (The Russian Academy of Sciences, A. A. Dorodnicyn Computing Centre of RAS, Moscow State University, Moscow State Aviation Institute, Warsaw University of Life Sciences, and Collegium Mazovia in Siedlce (Poland) will hold the Eighth International Symposium on Classical and Celestial Mechanics (CCMECH'2013) at Collegium Mazovia in Siedlce, Poland).
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* THE 13TH INTERNATIONAL CONFERENCE OF TENSOR SOCIETY ON DIFFERENTIAL GEOMETRY AND ITS APPLICATIONS, AND INFORMATICS BESIDES., ***The 86th Anniversary of Radu MIRON'S Birth.*** September 3rd (Tuesday) to September 7th (Saturday) in 2013. Faculty of Mathematics, Alexandru Ioan Cuza University and Mathematical Institute "O.Mayer" in Iaşi Romania And Tensor Society, Japan,
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Cairman of the Sessions

* **4th International Conference on Nonlinear Dynamics,** Sevastopol, Ukraine, 19-22 June, 2013, **http://kpispu.org.ua/en/ND2013_conference**

* 12TH CONFERENCE on DYNAMICAL SYSTEMS THEORY AND APPLICATIONS, December 2-5, 2013. Łódź, Poland.

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Interdisciplinary and multidisciplinary sciences
4th -7th of June 2013, Hotel BREZA- Vrnjačka Banja, Serbia
Organizer: Katica R. (Stevanovic) Hedrih

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Guest Editors:
Katica R. (Stevanović) Hedrih and Žarko Mijajlović

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* Academician of Ukrainian Higher Education Academy of Sciences
Akademik Akademije nauka visokih skola I univerziteta Ukrajine (od 1996)
http://www.anvsu.org.ua/

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* Tensor Society (Tokyo).
c/o Kawaguchi Inst. of Math. Soc. Sengen 1-13-33, Tsukuba,
Japan.
E-mail: tensor-ns@nifty.ne.jp,kawaguchi_tom@ybb.ne.jp

* Calan **GAMM (1962)**
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* Int. ASME (American Society of Mechanical Engineers (od 2000)(.
https://my.asme.org/

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Recenzije
Nonlinear Dynamics
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Comunication in Nnlinear Science and Numerical Simulations
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Matematicki institut SANU
Odeljenje za mehaniku
PLAN RADA ZA OKTOBAR 2013.

Sreda 9.10.2013. 18 casova, sala 301f
Katica R. (Stevanovic) Hedrih, Matematicki institut SANU Beograd i Masinski fakultet Univerziteta u Nisu
DISCRETE FRACTIONAL ORDER SYSTEM DYNAMICS

Abstract: A theory of free vibrations of discrete fractional order system with finite number of degrees of freedom is founded in matrix form. Fractional order system wih finite number of degrees of freedom is defined by three matrices: matrix of mass inertia coefficients, matrix of system rigidity coefficients, matrix of the fractional order properties elements. By using matrix method a mathematical description of fractional order discrete system free vibrations is determined in form of coupled fractional order differential equataions. Corresponding solutions in analytical form for special case of the matrix of fractional order properties elements are determined in forms of polinomial series along time. For that case eigen characteristic numbers and corresponding system of eigen main coordinates as well as independent eigen fractional order modes are determined. Some graphical ilustrations of these eigen mail fractional order modes are presented on the basis of numerical data.
A function of visoelastic creep fractional order dissipation of system energy and generalized forces of system with no ideal visoelastic creep fractional order dissipaion of system energy for generalized coordinates are introduced and deffined. Extended Lagrange differential equations second order for fractional order system dynamics in matrix formal form are introduced. A theorem is formulated.
By use presented matrix method , as specal cases of the fractional order chain system are considered. Also, for a fractional order double DNA helix chain, the two coresponding main eiden chains as well as eigen modes are presented.

Matematički institut SANU
Seminar za istoriju i filozofiju matematike, mehanike i astronomije

УТОРАК, 8. октобар 2013. у 12:15 сати

Проф. Др Катица (Стевановић) Хедрих, Математички институт САНУ

ЗАКОНИ, ПРИНЦИПИ И ТЕОРЕМЕ ДИНАМИКЕ. ФИЗИЧКИ И МАТЕМАТИЧКИ ОСНОВИ

Резиме: Приказују се основни закони, принципи и теореме динамике. указује се на физичке и математичке основе једначина динамике. Приказује се извођење Lagrange-ових једначина друге врсте различитим принципима и даје уопштење истих за различите механичке системе. Анализира се математички формализам који се често јавља, а нема утемељење у реалним механичким системима. Дају се примери извођења једначина осцилација деформабилних тела варијационим принципом и принципом динамичке

UTORAK, 5. novembar 2013. u 12:15 sati
Prof. Dr Katica (Stevanović) Hedrih, Matematički institut SANU

BESEDA O MIHAILU PETROVIĆU, ELEMENTIMA MATEMATIČKE FENOMENOLOGIJE I NELINEARNOJ DINAMICI

Rezime: U ovom radu se predstavlja sadržaj besede o Mihailu Petroviću i nelinearnoj dinamici, održane na Univerzitetu u Beogradu u okviru "*Majskih dana matematike*" pod nazivom "Srpski matematičari", a u organizaciji Rektorata Univerziteta u Beogradu i Srpske akademije nauka i umetnosti. Ključna ideja predavanja je da se prikažu ideje Mihaila Petrovića u savremenoj nauci, usmeravajući pažnju na njegovo, po oceni Milutina Milankovića, najznačajnije delo "*Matematička fenomenologija*", kao i njen značaj i vidljivost kroz savremene naučne tokove sadržane u rezultatima otkrića kompleksnih fenomena nelinearne dinamike. Takođe, u sadržaju besede se našao i prikaz materijalizacije njegovih ideja i matematičkog znanja kroz patente koje nam je ostavio u nasleđe. Slavljen od matematičara, promovisani su samo njegovi rezultati iz matematike, a nepravedno zapostavljeni njegovi rezultati primene i multidisciplinarnosti. U ovoj besedi, načinjen je još jedan pokušaj da se savremenicima i mladim generacijama obrati pažnja i na Mihajla Petrovića, fizičara, inženjera inovatora i praktičara, a pre svega vizionara integracije naučnih saznanja iz različitih naučnih oblasti redukcijom broja modela dinamika. Ideje o fenomenološkom preslikavanju su svakako najznačajnije. I danas se nalaze u savremenim naučnim istraživanjima, a po mišljenju predavača imaju isti značaj za dalji razvoj i integraciju različitih naučnih znanja, samerljiv sa značajem koju ima teorija stabilnosti Ljapunova..

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VECTOR METHOD: KINETIC PARAMETERS ANALYSIS AND IMPACTS TO BEARINGS OF THE COUPLED ROTOR DYNAMICS

dedicated in memory of Academician Konstantin Vasiljevich Frolov (1932-2007)

Katica R. (Stevanovic) HEDRIH

Faculty of Mechanical Engineering University of Niš Mathematical Institute SANU Serbia, Niš

Katica R. (Stevanovic) HEDRIH, VECTOR METHOD: KINETIC PARAMETERS ANALYSIS AND IMPACTS TO BEARINGS OF THE COUPLED ROTOR DYNAMICS. *dedicated in memory of Academician Konstantin Vasiljevich Frolov (1932-2007),* Вестник научно-технического развития, Национальная Технологическая Группа, № 9 (25), 2009 г. pp. 42 -59. www.vntr.ru , www.ntgcom.com, www.vntr.ru www.ntgcom.com

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Katica (Stevanovic) Hedrih

Rukovodilac projekta ON174001 (period 2011-2014 godina) MPN RS koordiniranog u MI SANU po clanu 24 AKT-a Ministarstva prosvete, nauke I tehnoloskog razvoja Republike Srbije

(u zvanju redovni professor Masinskog fakulteta Univerziteta u Nisu, sa 44 gorine radnog staza, ostvarenog na Masinskom fakultetu u Nisu (1967-2009) I Matematickom institutu SANU (2009-2011))

Clan Naucnog drustva Srbije (2008)

Akademik Akademije nauka visokih skola I univerziteta Ukrajine (od 1996)

Akadenik Akademije nelinearnih nauka Moskva (od 1997)

Laureat nagrade "Sveti Volodimir" za naucni rad (2010)

Laureat nadrade “Arhimed” VTI VS RS za naucni rad (2007)
Laureat dve plakete Cankaya Univerziteta iz Ankare u oblasti primene izvoda necelog reda (2008) I oblasti nelinearne dinamike (2010)
Mentor veceg beoja unikatnih diplomskih radova iz oblasti mehanike, veceg beoja mgistarskih I veceg beoja doktorskih disertacija uspesno odbranjenih!
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Prof. dr Katica R. (Stevanović) Hedrih,
Doctor of Technical Sciences
Scientific Research Professor - Full Professor of University
Priject Leader OI174001 (2011-2014)
Department of Mechanics
Mathematical Institute SANU Belgrade
http://www.mi.sanu.ac.rs/
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Office Address:
Prof. dr Katica R. (Stevanović) Hedrih,
Priject Leader OI174001 (2011-2014)
Head of Department of Mechanics (2010-2012)
Mathematical Institute SANU Belgrade
http://www.mi.sanu.ac.rs/colloquiums/mechcoll.htm
ul. Knez Mihailova 36/III
11009 - Belgrade, Serbia
Phone: 381 18 42 41 663/ 381 11 2 630 170 / Cell: 381 (0) 63 8 75 75 99
khedrih@eunet.rs

Full Professor of Mechanical Engineering University of Niš (1967 - 2009)
http://www.masfak.ni.ac.rs/sitegenius/topic.php?id=409
Member of Serbian Scientific Society and Secretary of Department of Natural Sciences and Mathematics of Serbian Scientific Society
http://afrodita.rcub.bg.ac.rs/~nds/
http://afrodita.rcub.bg.ac.rs/~nds/indexe.html
Academician of Ukrainian Higher Education Academy of Sciences
http://www.anvsu.org.ua/

or

Private address:
Prof. dr Katica R. (Stevanović) Hedrih,
18 000- Nis, ul. Vojvode Tankosica 3/22, Serbia
Phone/Fax: 381 18 42 41 663/ Cell: 381 (0) 63 8 75 75 99
khedrih@eunet.rs,khedrih@sbb.rs
http://www.masfak.ni.ac.rs/sitegenius/topic.php?id=409

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VECTOR METHOD: KINETIC PARAMETERS ANALYSIS AND IMPACTS TO BEARINGS OF THE COUPLED ROTOR DYNAMICS
dedicated in memory of Academician Konstantin Vasiljevich Frolov (1932-2007)

Katica R. (Stevanovic) HEDRIH
Faculty of Mechanical Engineering University of Niš Mathematical Institute SANU
Serbia, Niš

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HEDRIH (STEVANOVIĆ), K.

Some Vectorial Interpretations of the Kinetic Parameters of Solid Material Lines

MSC (1980): 73B20, 53A17, 53A45, 70C10, 73A05

This paper introduces the vector $\boldsymbol{J}_n^{(N)}$ of the material line mass inertia moment at the point N for the axis oriented by the unit vector $\boldsymbol{n}$; the vector is used for interpretation of the material line kinetic characteristics. The change of the vector of the material line mass inertia moment is determined in the transition from one space point to another when the axis retains its orientation which represents the Huygens-Steiner theorem translated for the defined material line mass inertia moment vector. Then the change of the vector of the material line mass inertia moment is defined at the given point in the case of the axis changing its orientation in the way analogous to the Cauchy equations in the elasticity theory. Then the interpretation of the main inertia directions are derived as well as of the main inertia asymmetry are defined. The relation between the axis deviation load vector by the material line mass inertia moment for the octahedron axis and the inertia asymmetry axis is analysed.

Further interpretation of the kinetic characteristics of the material line by means of the material line mass inertia moment vector and by means of the material line mass static (linear) moment vector for the axis and the point refers to the description of the motion quantity moment (angular momentum) and kinetic energy as the function of the vectors and the momentary annular velocity and the referential point velocity. Special cases of the material line rotation around the fixed axis and the fixed point are extra analysed. The deviation part of the material line mass inertia moment vector for the fixed bearings is specially analysed as well as for the rotation axis in view of the appearance of the dynamic pressure upon the bearings. The kinetic vector rotator is introduced.

The conditions for dynamic balancing by means of the static moment vector and of the deviation load vector of the rotation axis by the material line mass inertia moment are shown. This paper also introduces the notations of vectors of linear and square sector moment of material lines for pole and axis and sector pole.

New notations

Notations of the vectors of zero, linear and square moment mass of material lines for pole and axis are pointed out in this paper as well as the notations of vectors of linear and square sector moment mass of material lines for pole and axis and sector pole:

$$\boldsymbol{M}_n^{(A)} = \int_L \boldsymbol{n}\,\mathrm{d}m = L\boldsymbol{n}\sigma\,, \qquad \boldsymbol{S}_n^{(A)} = \int_L [\boldsymbol{n}, \boldsymbol{\varrho}]\,\mathrm{d}m = \int_L [\boldsymbol{n}, \boldsymbol{\varrho}]\,\sigma(s,t)\,\mathrm{d}s\,,$$

$$\boldsymbol{J}_n^{(A)} = \iiint_V [\boldsymbol{\varrho}, [\boldsymbol{n}, \boldsymbol{\varrho}]]\,\mathrm{d}m = \int_L [\boldsymbol{\varrho}, [\boldsymbol{n}, \boldsymbol{\varrho}]]\,\sigma(s,t)\,\mathrm{d}s\,,$$

$$\boldsymbol{L}_n^{\boldsymbol{\Omega}_B} = \sigma \int_L [\boldsymbol{n}, \boldsymbol{\Omega}_B]\,\mathrm{d}s = [\boldsymbol{n}, \boldsymbol{R}^{\boldsymbol{\Omega}_B}]\,, \qquad \boldsymbol{K}_n^{\boldsymbol{\Omega}_B} = \sigma \int_L [\boldsymbol{\Omega}_B, [\boldsymbol{n}, \boldsymbol{\Omega}_B]]\,\mathrm{d}s\,,$$

$$\boldsymbol{L}_n^{(A)\boldsymbol{\Omega}_B} = \sigma \int_L [\boldsymbol{\varrho}, [\boldsymbol{n}, \boldsymbol{\Omega}_B]]\,\mathrm{d}s\,, \qquad \boldsymbol{L}_n^{\boldsymbol{\Omega}_B(A)} = \sigma \int_L [\boldsymbol{\Omega}_B, [\boldsymbol{n}, \boldsymbol{\varrho}]]\,\mathrm{d}s\,.$$

Material line mass zero moment vector, mass linear moment vector and material line mass inertia moment vector at the point for the axis

The set of material points forms the material system. When the mass is continuously distributed in a certain part of the line, then there is an infinite number of material points and the system forms a continuous material line. The line region filled with the continuously distributed mass represents a material line.

In order to study the dynamics of the rigid and solid material line the geometry of mass plays an important part. In the references there is a conclusion that it is not necessary to know all the details about the mass distribution and the internal structure of the masses in order to study the material line motion under the action of the force and the properties necessary for the study of the rigid material line motion as a material system are the dynamic properties of the rigid material line. The values determining the dynamic properties are called the dynamic parameters of the rigid material line. According to the given references these parameters are taken to be: Mass M of the rigid material line; the position vector $\boldsymbol{\varrho}_C$

of the mass center of the material line, the point C with respect to a certain point 0 and $\mathbb{J}^{(C)}$ the inertia tensor of the material line for the point C which is determined by six scalar dynamic parameters. In this way in the general case for the dynamic rigid material line characteristic ten independent scalar dynamic parameters are required.

Since our aim is to consider a possibility of the interpretation of the dynamic parameters of the rigid and solid material line in a modified shape we are going to set as a reference the pole 0 as well as the axis oriented by the unit vector $\boldsymbol{n}$. Considering that in the general case the line motion of the rigid material can be represented by one rotation around the momentary axis, that is, by the translation of the center velocity and the rotation around the axis through the given center we are led to the idea to define the line dynamic parameters of the rigid material by means of the pole 0 as the referential point through the position on the axis parallel to the momentary rotation axis.

Therefore we define:

1° The vector $\boldsymbol{M}_n^{(A)}$ of the material line mass for the point A and the axis oriented by the unit vector $\boldsymbol{n}$:

$$\boldsymbol{M}_n^{(A)} = \int_L \boldsymbol{n}\, \mathrm{d}m = L\boldsymbol{n}\sigma\,, \tag{1}$$

which does not depend on the mass distribution in the material line, that is, on the density σ. For all the space points and parallel axes it has the same value and it changes only with the axis orientation change. It is determined only by the mass quantity and the axis orientation.

2° The vector $\boldsymbol{S}_n^{(A)}$ of the linear moment of the material line mass for the point A and the axis throught this point oriented by the unit vector $\boldsymbol{n}$ in the form

$$\boldsymbol{S}_n^{(A)} = \int_L [\boldsymbol{n}, \boldsymbol{\varrho}]\, \mathrm{d}m = \int_L [\boldsymbol{n}, \boldsymbol{\varrho}]\, \sigma(s, t)\, \mathrm{d}s\,, \tag{2}$$

where $\boldsymbol{\varrho}$ is the position vector of the elementary material line mass $\mathrm{d}m$ with respect to the pole A, $\boldsymbol{n}$ is the unit orientation axis vector through the pole A. The vector $\boldsymbol{S}_n^{(A)}$ can be considered as the static moment of the material line mass for the axis oriented by the unit vector $\boldsymbol{n}$ for the point A. If we denote the position vector of the material line mass center by ϱ_C with respect to the pole then it is valid for the vector $\boldsymbol{S}_n^{(A)}$ of the linear moment for the point A and the axis oriented by the unit vector $\boldsymbol{n}$:

$$\boldsymbol{S}_n^{(A)} = M[\boldsymbol{n}, \boldsymbol{\varrho}_c] = [\boldsymbol{n}, \mathbf{M}^{(A)}]\,. \tag{3}$$

3° The vector $\boldsymbol{J}_n^{(A)}$ of the material line mass inertia moment at the point A for the axis oriented by the unit vector $\boldsymbol{n}$ in the form

$$\boldsymbol{J}_n^{(A)} = \iiint_V [\boldsymbol{\varrho}, [\boldsymbol{n}, \boldsymbol{\varrho}]]\, \mathrm{d}m = \int_L [\boldsymbol{\varrho}, [\boldsymbol{n}, \boldsymbol{\varrho}]]\, \sigma(s, t)\, \mathrm{d}s \tag{4}$$

can also be considered as the material line mass square moment vector at the pole A for the axis through the pole oriented by the vector $\boldsymbol{n}$. The vector $\boldsymbol{J}_n^{(A)}$ of the material line mass inertia moment at the point A for the axis oriented by the unit vector $\boldsymbol{n}$ can be decomposed into three components: the one collinear with the axis, $J_n^{(A)}$, and the two other ones $D_{nv}^{(A)}$ and $D_{nu}^{(A)}$ in the directions normal to the orientation axis $\boldsymbol{n}$. The collinear component represents the axial moment of the material line mass inertia for the axis oriented by the unit vector $\boldsymbol{n}$ through the pole A. The other two components represent the deviational moments of the material line mass for a couple of normal axes $\boldsymbol{n}$ and $\boldsymbol{u}$, that is, $\boldsymbol{n}$ and $\boldsymbol{v}$:

$$\boldsymbol{J}_n^{(A)} = J_n\boldsymbol{n} + D_{nv}\boldsymbol{v} + D_{nu}\boldsymbol{u}\,. \tag{5}$$

This definition, expression for the material line mass inertia moment vector at the point A for the axis oriented by the unit vector $\boldsymbol{n}$, can be obtained starting from the expression for the axial moment of the material line mass inertia for the axis oriented by the vector $\boldsymbol{n}$ drawn throught the point A and for the deviational moments of the material line mass for the couples of the orthogonal axes $(\boldsymbol{n}, \boldsymbol{v})$ and $(\boldsymbol{n}, \boldsymbol{u})$ according to ref. [1].

The rigid material line mass deviation moment vector at the point A for the axis $\boldsymbol{n}$ is

$$\boldsymbol{D}_n^{(A)} = -\int_L \boldsymbol{T}(\boldsymbol{T}, \boldsymbol{\varrho})\, (\boldsymbol{n}, \boldsymbol{\varrho})\, \sigma\, \mathrm{d}s = \boldsymbol{T} \int_L ([\boldsymbol{T}, \boldsymbol{\varrho}], [\boldsymbol{n}, \boldsymbol{\varrho}])\, \sigma\, \mathrm{d}s\,. \tag{6}$$

Interpretation of the Papos-Guldin theorems

Let us define the vector $\boldsymbol{R}_n^{(0)}$ of the rotation of the vector $\boldsymbol{S}_n^{(0)}$ of the linear moment of the material line mass for the point 0 and the axis through this point oriented by the vector $\boldsymbol{n}$ around the same axis as

$$\boldsymbol{R}_n^{(0)} = 2\pi \boldsymbol{S}_n^{(0)}\,. \tag{7}$$

In this definition we have defined the rotation vector $\boldsymbol{R}_n^{(0)}$ as the "circle circumference" of the diameter equal to the vector $\boldsymbol{S}_n^{(0)}$ of the linear moment of the material line mass for the same axis. Now by definition the vector $\boldsymbol{S}_n^{(0)}$ of the linear moment of the body mass for the point 0 and the axis oriented by the unit vector $\boldsymbol{n}$ of the form (2) it is easy to interprete both Papos-Guldin theorems from the expression (7):

1° Interpretation of the first Papos-Guldin's theorem:

$$\boldsymbol{R}_n^{(0)L} = 2\pi[\boldsymbol{n}, \varrho_C]\, L = P\boldsymbol{n}_c\,. \tag{8}$$

2° Interpretation of the second Papos-Guldin's theorem:

$$\boldsymbol{R}_n^{(0)A} = 2\pi[\boldsymbol{n}, \varrho_C]\, A = V\boldsymbol{n}_c\,. \tag{9}$$

The Huygens-Steiner theorem generalized to the material line mass inertia moment vector for the axis through the referential point

The Figure 1 shows the material line and two referential points-poles 0 and A and two parallel axes through them oriented by the unit vector $\boldsymbol{n}$. The same Figure also shows the elementary mass denoted by dm at the point N of the rigid material line and ϱ and $\boldsymbol{r}$, the position vectors of that point with respect to the pole 0, that is, A, as well as the position vector ϱ_A of the pole A with respect to 0.

Now it is necessary to determine the change of the material line mass inertia vector $\boldsymbol{J}_n^{(0)}$ for the point 0 and the axis oriented by the unit vector $\boldsymbol{n}$ and its relation to the vector $\boldsymbol{J}_n^{(A)}$ of the material line mass inertia moment for the point A and the axis oriented by the same unit vector $\boldsymbol{n}$.

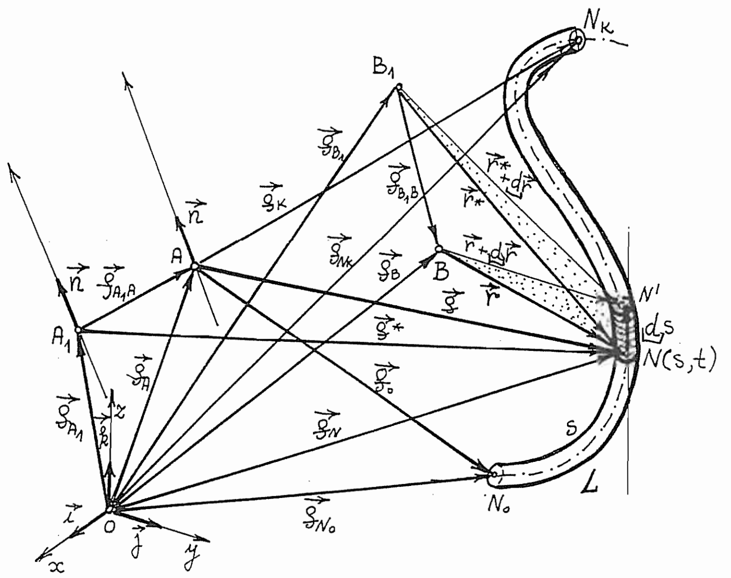

Fig. 1

This means we are interested in the change of the material line mass inertia moment vector to a certain axis which moves from one point to another retaining its orientation. By using the expression (4) defining the inertia moment vector for a certain point and axis we can write

$$\boldsymbol{J}_n^{(0)} = \boldsymbol{J}_n^{(A)} + [\varrho_A, \boldsymbol{S}_n^{(A)}] + [\mathbf{M}_C^{(A)}, [\boldsymbol{n}, \varrho_A]] + [\varrho_A, [\boldsymbol{n}, \varrho_A]]\, M\,. \tag{10}$$

We see that all the members in the last expression have the same structure. In the last expression the vector $\boldsymbol{r}_C$ is the position vector of the mass center with respect to the pole A.

In the case when the pole A is the center C of the material line mass the vector $\boldsymbol{r}_C$ is equal to zero, whereas the vector ϱ_A turns into ϱ_C so that the last expression (10) can be written in the form

$$\boldsymbol{J}_n^{(0)} = \boldsymbol{J}_n^{(C)} + [\varrho_C, [\boldsymbol{n}, \varrho_C]]\, M\,. \tag{11}$$

This expression represents the generalized Huygens-Steiner theorem with respect to the vector $\boldsymbol{J}_n^{(0)}$ of the material line mass inertia moment for the axes oriented by the unit vector $\boldsymbol{n}$ passing through the mass center and any other point.

The part $[\varrho_C, [\boldsymbol{n}, \varrho_C]]\, M$ from the expression (11) represents the position part and we are going to call it the inertia position moment vector for the point 0 and the axis oriented by the unit vector $\boldsymbol{n}$.

The change of the material line mass inertia moment for the point and the axis at the axis orientation change through the referential point

The material line mass inertia moment vector $\boldsymbol{J}_n^{(0)}$ for the point 0 and the axis passing through it oriented by the unit vector $\boldsymbol{n}$ is equal to

$$\boldsymbol{J}_n^{(0)} = \boldsymbol{J}_x^{(0)} \cos \alpha + \boldsymbol{J}_y^{(0)} \cos \beta + \boldsymbol{J}_z^{(0)} \cos \gamma . \tag{12}$$

The last expression is analogous to the equation, which is known as the Cauchy equation in the elasticity theory.

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Address: Prof. Dr. Katica (Stevanović) Hedrih, 18000-Niš, ul. Vojvode Tankosića 3/22, Srbija, Yugoslavia.

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Hu, R.; Müller, P. C.

Ein modellgestütztes Verfahren zur Fehlererkennung bei mechanischen Komponenten von Industrierobotern

MSC (1980): 62N05, 70F10, 73-05, 70B15

Die Erkennung von Fehlern in den mechanischen Komponenten ist eine der wichtigen Aufgaben der Roboterdiagnose. Außer der Methode der Signalanalyse besteht noch die Möglichkeit, Fehler mit Hilfe der Modellkenntnisse der Roboter-Mechanik durch regelungstechnische Schätzverfahren zu detektieren. Es wird hier ein modellgestütztes Verfahren vorgestellt. Dieses Verfahren basiert auf einem dynamischen Mehrkörpermodell des Roboters mit Berücksichtigung des Reibungseffektes und der Elastizität in den Antriebsstängen. Die Kenngrößen, deren Änderungen das Fehlverhalten des Roboters kennzeichnen, werden u. a. durch den an jeder Roboterachse implementierten Nichtlinearitäten-Beobachter ermittelt. Durch den Vergleich zwischen den aus dem Modell berechneten idealen und den aktuell geschätzten Zuständen des Roboters werden dann die möglichen Fehler erkannt.

Auswahl der Kenngrößen aus dynamischen Modellen

Es werden Roboter mit rotatorischen Freiheitsgraden betrachtet. Jede Achse des Roboters wird hierbei von einem Gleichstrom-Motor über ein einstufiges Getriebe mit der Übersetzung n_i angetrieben, dessen Nachgiebigkeit als lineare Drehfeder k_i modelliert wird, siehe Bild 1. Wird der auf die Getriebeübersetzung bezogene Motorwinkel mit p_i ($p_i = \theta_i/n_i$) und die Lagekoordinate des Roboterauslegers mit q_i bezeichnet, so läßt sich das dynamische Modell [1] des Roboters beschreiben als

$$\boldsymbol{M}(\boldsymbol{q})\,\ddot{\boldsymbol{q}} + \boldsymbol{h}(\boldsymbol{q}, \dot{\boldsymbol{q}}) + \boldsymbol{K}(\boldsymbol{q} - \boldsymbol{p}) = \boldsymbol{0}\,, \tag{1}$$

$$\boldsymbol{J}\ddot{\boldsymbol{p}} + \boldsymbol{f} - \boldsymbol{K}(\boldsymbol{q} - \boldsymbol{p}) = \boldsymbol{\tau}\,, \tag{2}$$

wobei $\boldsymbol{J}$ und $\boldsymbol{M}(\boldsymbol{q})$ jeweils die Massenmatrizen der Motoren und der Ausleger bezeichnen. In $\boldsymbol{h}(\boldsymbol{q}, \dot{\boldsymbol{q}})$ sind die Zentrifugal- und Corioliskräfte sowie die Gewichte der Ausleger zusammengefaßt. Die Antriebsmomente $\boldsymbol{\tau}$ werden an den Motorachsen

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THE ANALOGY BETWEEN THE STRESS STATE MODEL, THE STRAIN STATE MODEL AND THE MASS INERTIA MOMENT STATE MODEL

Katica (Stevanović) Hedrih

Mechanical Engineering Faculty University of Niš
Institute of Mathematics-Belgrade
Yugoslavia

Abstract. *The paper introduces the notation of the total specific deformation vector $\vec{\delta}_n^{(N)}$ for the line element drawn from the point N of the deformable body in natural configuration in the direction of the unit vector $\vec{n}$ and the notation of the mass inertia moment vector $\vec{\mathcal{J}}_n^{(N)}$ for the axis oriented by the unit vector $\vec{n}$ and for the pole N.*

The paper introduces the notation of the total specific deformation vector $\vec{\delta}_n^{(N)}$ for the line element drawn from the point N of the deformable body in natural configuration in the direction of the unit vector $\vec{n}$ and the notation of the mass inertia moment vector $\vec{\mathcal{J}}_n^{(N)}$ for the axis oriented by the unit vector $\vec{n}$ and for the pole N.

A comparative analogy is drawn between the total stress vector $\vec{p}_n^{(N)}$ at the point N of the deformable body for the plane with the normal $\vec{n}$ and the vector $\vec{\delta}_n^{(N)}$ of the total specific deformation (strain) for the line element in the direction of the unit vector $\vec{n}$ drawn from the point N, as well as the vector $\vec{\mathcal{J}}_n^{(N)}$ of the mass inertia moment of the body for the axis oriented by the unit vector $\vec{n}$ through the point N. The analogy between the following notions is pointed out: the stress state model and the strain state model in the Theory of Elasticity as well as the mass inertia moment state model of the rigid body in the given point.

The paper further also points out the identity of the mathematical models for the determination of the principal stresses directions, principal strain directions and principal inertia axes as well as an analogy between the plane of the shearing

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stresses extreme values, the line elements directions between which the extreme values of the sliding deformation and the inertial asymmetry for which the greatest values of the centrifugal moments of the rigid body mass occur.

This paper defines the kinetic vector fixed to a certain point N and axis passing through the given rigid body point. This vector is: the vector $\vec{\mathcal{J}}_n^{(N)}$ of the body mass inertia moment for the point N and the axis oriented by the unit vector $\vec{n}$. The change of the vector of the body mass inertia moment in the transition from one rigid body point to another is not determined in this paper.

1.THE DEFINITION FOR THE BODY MASS INERTIA MOMENT VECTOR

Since our aim is to consider a possibility of the interpretation of the rigid body mass kinetic parameters in a modified shape we are going to set as a reference the pole N as well as the axis oriented by the unit vector $\vec{n}$. Considering that in the general case the rigid body motion can be represented by the translation of the mass center velocity and the rotation around the axis through the given center we are led to the idea to define the rigid body dynamic parameters by means of the pole N as the referential point through which we put an axis parallel to the momentary rotation axis.

There fore we define the following vector $\vec{\mathcal{J}}_n^{(N)}$ of the body mass inertia moment at the point N for the axis oriented by the unit vector $\vec{n}$ in the form:

$$\vec{\mathcal{J}}_n^{(N)} \iiint\limits_V [\vec{\rho}, [\vec{n}, \vec{\rho}]]\, dm \tag{1}$$

where $\vec{\rho}$ is the position vector of the elementary body mass dm with respect to the pole N. The illustration is given in the Figure 1.

It can also be considered the body mass square moment vector at the pole N for the axis through the pole oriented by the vector $\vec{n}$. The vector $\vec{\mathcal{J}}_n^{(N)}$ of the body mass inertia moment at the point N for the axis oriented by the unit vector $\vec{n}$ can be decomposed into three components: the colinear with the axis $J_n^{(N)}$ and the two other ones $D_{nv}^{(N)}$ and $D_{nu}^{(N)}$ in the directions normal to the orientation of axis $\vec{n}$. The colinear component represents the axial moment of the body mass inertia for the axis oriented by the unit vector $\vec{n}$ through the pole N. The other two components represent the deviational moments of the body mass for a couple of normal axes $\vec{n}$ and $\vec{u}$, that is, $\vec{n}$ and $\vec{v}$:

$$\vec{\mathcal{J}}_n^{(N)} = J_n^{(N)}\vec{n} + D_{nv}^{(N)}\vec{v} + D_{nu}^{(N)}\vec{u} \tag{2}$$

The definition – expression for the body mass inertia moment vector at the point N for the axis oriented by the unit vector $\vec{n}$ can be obtained starting from the expression for the axial body mass inertia moment for the axis oriented by the vector $\vec{n}$ drawn through the point N and for the deviational body mass moments

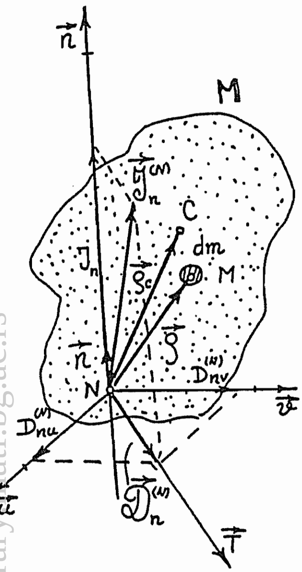

FIGURE 1.

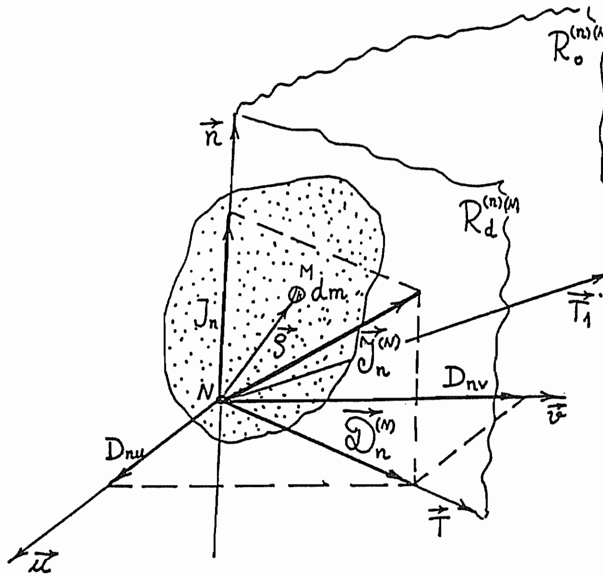

FIGURE 2.

for the couples of the orthogonal axes $(\vec{n}, \vec{v})$ and $(\vec{n}, \vec{u})$ according to the Ref./2/:

$$J_n^{(N)} = J_n = \iiint_V [\vec{n}, \vec{\rho}]^2 \, dm \tag{3}$$

$$D_{nv}^{(N)} = D_{nv} = \iiint_V ([\vec{n}, \vec{\rho}], [\vec{v}, \vec{\rho}]) \, dm \tag{4}$$

$$D_{nu}^{(N)} = D_{nu} = \iiint_V ([\vec{n}, \vec{\rho}], [\vec{u}, \vec{\rho}]) \, dm \tag{5}$$

by means of them we form the vector $\vec{\mathcal{J}}_{(n)}^{(N)}$ of the body mass inertia moment for the point (pole) N and the axis through this point oriented by the unit vector $\vec{n}$ in the form:

$$\vec{\mathcal{J}}_{(n)}^{(N)} = \vec{n} \iiint_V [\vec{n}, \vec{\rho}]^2 \, dm + \vec{v} \iiint_V ([\vec{n}, \vec{\rho}], [\vec{v}, \vec{\rho}]) \, dm + \vec{u} \iiint_V ([\vec{n}, \vec{\rho}], [\vec{u}, \vec{\rho}]) \, dm \tag{6}$$

Considering that the scalar product of the two vector products can be written in the form:

$$\left(\left[\vec{a}, \vec{b}\right], \left[\vec{c}, \vec{d}\right]\right) = \left(\vec{c}, \left[\vec{d}, \left[\vec{a}, \vec{b}\right]\right]\right) = \left(\vec{a}, \vec{c}\right)\left(\vec{b}, \vec{d}\right) - \left(\vec{a}, \vec{d}\right)\left(\vec{b}, \vec{c}\right) \tag{7}$$

we can write for the scalar product from the expression:

$$([\vec{n}, \vec{\rho}], [\vec{v}, \vec{\rho}]) = (\vec{n}, \vec{v})\left(\vec{\rho}, \vec{\rho}\right) - \left(\vec{n}, \vec{\rho}\right)(\vec{v}, \vec{\rho}) = (\vec{n}, \vec{v})\,\rho^2 - \left(\vec{n}, \vec{\rho}\right)(\vec{v}, \vec{\rho}) \tag{7*}$$

The rigid body mass deviation moment vector at the point N for the axis $\vec{n}$.

$$\vec{\mathcal{D}}_n^{(N)} = \vec{v}\iiint_V ([\vec{n},\vec{\rho}],[\vec{v},\vec{\rho}])\,dm + \vec{u}\iiint_V ([\vec{n},\vec{\rho}],[\vec{u},\vec{\rho}])\,dm \tag{8}$$

$$\vec{\mathcal{D}}_n^{(N)} = -\iiint_V \vec{T}\left(\vec{T},\vec{\rho}\right)(\vec{n},\vec{\rho})\,dm = \vec{T}\iiint_V \left(\left[\vec{T},\vec{\rho}\right],[\vec{n},\vec{\rho}]\right)dm \tag{8*}$$

By means of the previous expressions the expression (6) for the vector $\vec{\mathcal{J}}_n^{(N)}$ of the body mass inertia moment at the point N for the axis oriented by the unit vector $\vec{n}$ we can write the following:

$$\vec{\mathcal{J}}_n^{(N)} = \iiint_V [\vec{\rho},[\vec{n},\vec{\rho}]]\,dm \tag{1*}$$

and that's how we have come to the expression identical to the expression (1). The illustration is given in the Figure 2.

2. THE CHANGE OF THE BODY MASS INERTIA MOMENT FOR THE POINT AND THE AXIS AT THE AXIS ORIENTATION CHANGE THROUGH THE REFERENTIAL POINT

Let's now define the vectors $\vec{\mathcal{J}}_x^{(N)}, \vec{\mathcal{J}}_y^{(N)}$ and $\vec{\mathcal{J}}_z^{(N)}$ of the body mass inertia moments at the point N and for the coordinate axes N_x, N_y and N_z. These vectors can be expressed in the form:

$$\vec{\mathcal{J}}_x^{(N)} = \iiint_V \left[\vec{\rho},\left[\vec{i},\vec{\rho}\right]\right]dm = J_x\vec{i} + D_{xy}\vec{j} + D_{xz}\vec{k} \quad / \cdot \cos\alpha \tag{9}$$

$$\vec{\mathcal{J}}_y^{(N)} = \iiint_V \left[\vec{\rho},\left[\vec{j},\vec{\rho}\right]\right]dm = D_{yx}\vec{i} + J_y\vec{j} + D_{yz}\vec{k} \quad / \cdot \cos\beta \quad + \tag{10}$$

$$\vec{\mathcal{J}}_z^{(N)} = \iiint_V \left[\vec{\rho},\left[\vec{k},\vec{\rho}\right]\right]dm = D_{zx}\vec{i} + D_{zy}\vec{j} + J_z\vec{k} \quad / \cdot \cos\gamma \tag{11}$$

If we denote the sences cosine of the unit vector $\vec{n}$ with $\cos\alpha$, $\cos\beta$ and $\cos\gamma$ when the unit vector defines the orientation of the axis passing through the point N, then we can successively multiply the expressions from (9) to (11) and we obtain them by adding:

$$\vec{\mathcal{J}}_x^{(N)}\cos\alpha + \vec{\mathcal{J}}_y^{(N)}\cos\beta + \vec{\mathcal{J}}_z^{(N)}\cos\gamma =$$
$$= \iiint_V \left[\vec{\rho},\left[\vec{i}\cos\alpha + \vec{j}\cos\beta + \vec{k}\cos\gamma,\vec{\rho}\right]\right]dm = \iiint_V [\vec{\rho},[\vec{n},\vec{\rho}]]\,dm \tag{12}$$

From the previous expression we conclude that the body mass inertia moment vector $\vec{\mathcal{J}}_n^{(N)}$ for the point N and the axis passing through it oriented by the unit

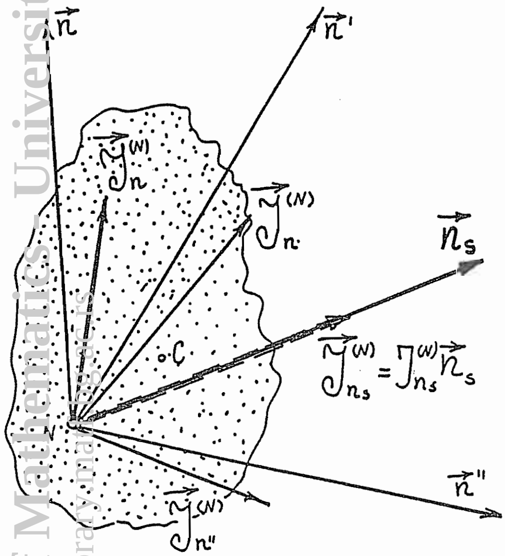

FIGURE 3.

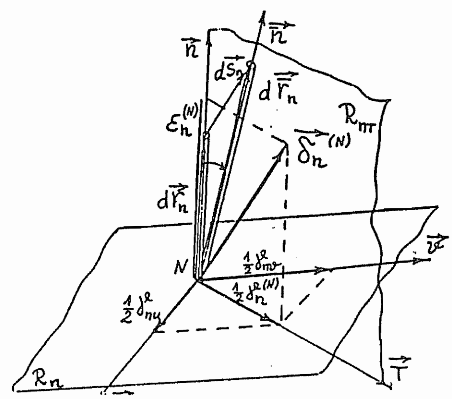

FIGURE 4.

vector $\vec{n}$ is equal to:

$$\vec{\mathcal{J}}_n^{(N)} = \vec{\mathcal{J}}_x^{(N)} \cos\alpha + \vec{\mathcal{J}}_y^{(N)} \cos\beta + \vec{\mathcal{J}}_z^{(N)} \cos\gamma \tag{13}$$

The last expression is analogous to the equation for determining the total stress vector $\vec{p}_n^{(N)}$ at the point N of the stressed body for the plane normal $\vec{n}$ which is known as the Cauchy equation in the Elasticity Theory. Therefore we are going to call it the Cauchy equation giving the relation of the body mass inertia moment vector $\vec{\mathcal{J}}_n^{(N)}$ for an arbitrary axis oriented by the unit vector $\vec{n}$ drawn through the point N and the vectors $\vec{\mathcal{J}}_x^{(N)}, \vec{\mathcal{J}}_y^{(N)}$ and $\vec{\mathcal{J}}_z^{(N)}$ of the body mass inertia moments at the same point for the coordinate axes.

3. MAIN INERTIA DIRECTIONS, MAIN INERTIA MOMENTS

By means of the vector $\vec{\mathcal{J}}_n^{(N)}$ of the rigid body inertia moment we can introduce a new definition of the main inertia axes. Through one pole N we can draw an infinite number of axes of orientation. Among them we are looking for the axis for which the vector $\vec{\mathcal{J}}_n^{(N)}$ of the body mass inertia moment had only one component colinear with the axis, that is, the one for which the vector $\vec{\mathcal{D}}_n^{(N)}$ of the deviation load of the axis by the body mass inertia moment is equal to zero. Using the analogy between the stress tensor matrices and the tensor matrices of mass inertia moments as well as the matrix interpretation as more appropriate for this case and by denoting the unit vector of the main inertia axis orientation with $\vec{n}$ which is in accordance with the Fig. 3, we can write:

$$\{\mathcal{J}_{n_s}^{(N)}\} = \mathbb{J}^{(N)}\{n_s\} = J_s^{(N)}\{n_s\} \tag{14}$$

$$\left(\mathbb{J}^{(N)} - J_s^{(N)}\mathbb{I}\right)\{n_s\} = \{0\} \tag{15}$$

so that the Hamilton equation for determining the main inertia moments:

$$f(J_s^{(N)}) = |\mathbb{J}^{(N)} - J_s^{(N)}\mathbb{I}| = 0 \tag{16}$$

$$f(J_s) = \begin{vmatrix} J_x - J_s & D_{yx} & D_{xz} \\ D_{xy} & J_y - J_s & D_{yz} \\ D_{xz} & D_{yz} & J_z - J_s \end{vmatrix} = 0 \tag{17}$$

$$f(J_s) = -\left(J_s^3 - \boldsymbol{J}_1 J_s^2 + \boldsymbol{J}_2 J_s - \boldsymbol{J}_3\right) = 0 \tag{17*}$$

while for the senses cosines of the main inertia axes the following relations are obtained:

$$\frac{\cos\alpha_s}{\boldsymbol{K}_{31}^{(s)}} = \frac{\cos\beta_s}{\boldsymbol{K}_{32}^{(s)}} = \frac{\cos\gamma_s}{\boldsymbol{K}_{33}^{(s)}} = C_s \tag{18}$$

$$\cos^2\alpha_s + \cos^2\beta_s + \cos^2\gamma_s = 1 \tag{19}$$

$\boldsymbol{K}_{31}^{(s)}, \boldsymbol{K}_{32}^{(s)}$ and $\boldsymbol{K}_{33}^{(s)}$ are co-factors of the third kind elements and the corresponding matrix column:

$$\begin{aligned} \boldsymbol{K}_{31}^{(s)} &= \begin{vmatrix} D_{yx} & D_{xz} \\ J_y - J_s & D_{yz} \end{vmatrix} \\ \boldsymbol{K}_{32}^{(s)} &= -\begin{vmatrix} J_x - J_s & D_{xz} \\ D_{xy} & D_{yz} \end{vmatrix} \\ \boldsymbol{K}_{33}^{(s)} &= \begin{vmatrix} J_x - J_s & D_{yx} \\ D_{xy} & J_y - J_s \end{vmatrix} \end{aligned} \tag{20}$$

successively for the roots of the Hamilton equations J_1, J_2 and J_3 which are the main inertia moments and which represent the axial inertia moments for the main inertia moments. There are three roots and three orthogonal main axes at every point with respect to which the rigid body inertia moment vectors are determined. The Hamilton equation coefficients are the first, second and third invariants of the inertia $\boldsymbol{J}_1^{(N)}, \boldsymbol{J}_2^{(N)}$ and $\boldsymbol{J}_3^{(N)}$, and they are the first, second and third scalar of the body mass inertia tensor matrix. These are the invariants of the rigid body mass inertia state at the point N. The roots of the Hamilton equation are always real and positive.

By using the Viette formulae we can write the relation between the inertia state invariants at the given point and the main moments of the body mass inertia at the given point:

$$\begin{aligned} \boldsymbol{J}_1^{(N)} &= J_1^{(N)} + J_2^{(N)} + J_3^{(N)} \\ \boldsymbol{J}_2^{(N)} &= J_1^{(N)} J_2^{(N)} + J_1^{(N)} J_3^{(N)} + J_2^{(N)} J_3^{(N)} \\ \boldsymbol{J}_2^{(N)} &= J_1^{(N)} J_2^{(N)} J_3^{(N)} \end{aligned} \tag{21}$$

4. THE LINE ELEMENT TOTAL STRAIN VECTOR

The displacement vector corresponding to the pure deformation (as well as the change of the shape and volume) of the line element $d\vec{r}_n = dr\,\vec{n}$ is defined as the deformation vector $d\vec{s}_n$ (see Ref. /8/):

$$\{ds_{def}\} = \{ds_n\} = \mathcal{E}\mathcal{E}\{dr_n\} \tag{22}$$

Following the concept of analogous parameters in the models of the stress theory and the strain theory and by applying the formal approach we can introduce the vector $\vec{\delta}_n = d\vec{s}_{def}/dr$ which is to be called the line element total strain vector in the direction of the unit vector $\vec{n}$ drawn from the point N of the deformable body which is an analogous parameter to the vector $\vec{p}_n^{(N)}$ of the total stress at the point N for the plane with the normal $\vec{n}$. The vector $\vec{\delta}_n^{(N)}$ of the line element total strain (specific deformation) in the direction of the unit vector $\vec{n}$ from the point N can be determined by the specific deformation tensor matrix of the following form:

$$\vec{\delta}_n^{(N)} = \varepsilon_n\vec{n} + \frac{1}{2}\gamma_{nT}\vec{T} = \frac{1}{2}\varepsilon_n\vec{n} + \frac{1}{2}\gamma_{nu}\vec{u} + \gamma_{nv}\vec{v} = \delta_{nx}\vec{i} + \delta_{ny}\vec{j} + \delta_{nz}\vec{k}$$

$$\{\delta_n^{(N)}\} = \mathcal{E}\mathcal{E}^{(N)}\{n\} \qquad \vec{\delta}_n^{(N)} = \vec{\delta}_x^{(N)}\cos\alpha + \vec{\delta}_y^{(N)}\cos\beta + \vec{\delta}_z^{(N)}\cos\gamma \tag{23}$$

so that the equations (23) correspond to the Cauchy's equations for the vector $\vec{p}_n^{(N)}$ of the total stress at the point N of the deformable body for the plane with the unit vector $\vec{n}$.

For the line elements dx, dy and dz from the point N in the directions of the coordinate axes x, y and z we can define three vectors $\vec{\delta}_x^{(N)}, \vec{\delta}_y^{(N)}$ and $\vec{\delta}_z^{(N)}$ of the total specific deformation (total strain) as:

$$\begin{aligned}\vec{\delta}_x^{(N)} &= \varepsilon_x\vec{i} + \frac{1}{2}\gamma_{xy}\vec{j} + \frac{1}{2}\gamma_{xz}\vec{k}\\ \vec{\delta}_y^{(N)} &= \frac{1}{2}\gamma_{yx}\vec{i} + \varepsilon_y\vec{j} + \frac{1}{2}\gamma_{yz}\vec{k}\\ \vec{\delta}_z^{(N)} &= \frac{1}{2}\gamma_{zx}\vec{i} + \frac{1}{2}\gamma_{zy}\vec{j} + \varepsilon_z\vec{k}\end{aligned} \tag{24}$$

or

$$\{\delta_x^{(N)}\} = \begin{Bmatrix}\varepsilon_x\\ \frac{1}{2}\gamma_{xy}\\ \frac{1}{2}\gamma_{xz}\end{Bmatrix} \qquad \{\delta_y^{(N)}\} = \begin{Bmatrix}\frac{1}{2}\gamma_{yz}\\ \varepsilon_y\\ \frac{1}{2}\gamma_{yz}\end{Bmatrix} \qquad \{\delta_z^{(N)}\} = \begin{Bmatrix}\frac{1}{2}\gamma_{zx}\\ \frac{1}{2}\gamma_{zy}\\ \varepsilon_z\end{Bmatrix} \tag{24*}$$

thus corresponding to the following stress theory vectors $\vec{p}_x^{(N)}, \vec{p}_y^{(N)}$ and $\vec{p}_z^{(N)}$ of the total stress for the coordinate planes through the same point N.

For an arbitrary line element $d\vec{r}_n$ drawn from the point N in the direction can be divided into two components, one in the direction of the vector $\vec{n}$ and the other in the direction perpendicular to the unit vector $\vec{n}$.

Figure 4. shows the line element $d\vec{r}_n$ drawn from the point N in the direction of the unit vector $\vec{n}$ in the body natural configuration as well as the same element $d\vec{r}_n$

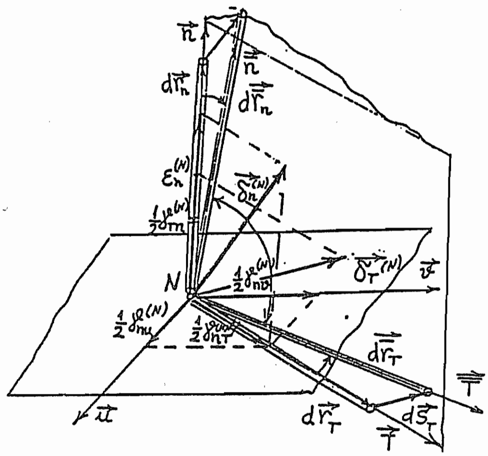

FIGURE 5.

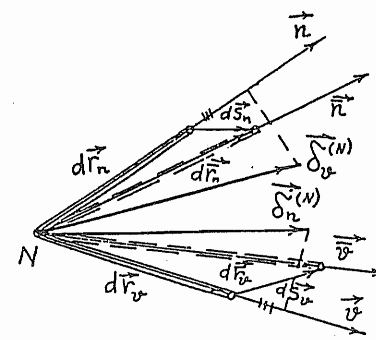

FIGURE 8.

in the forced configuration of the deformed deformable body drawn from the same point for the sake of comparison. The displacement vector $d\vec{s}_n^{(N)}$ corresponding to the pure deformation is also shown. In the same figure the vector $\vec{\delta}_n^{(N)}$ of the total strain (total specific deformation) is shown its projections being $\varepsilon_n^{(N)}$ on the direction of the unit vector $\vec{n}$ as well as $\gamma_n^{(N)}/2$ on the orthogonal direction $\vec{T}$ with respect to the unit vector $\vec{n}$ whereas on the orthogonal plane with respect to the unit vector $\vec{n}$. The plane R_n is the one in which the following vectors lie: $d\vec{r}_n, \vec{n}, d\vec{s}_n^{(N)}, \vec{\delta}_n^{(N)}, \vec{T}$ and $d\vec{r}_n$.

The component $\varepsilon_n^{(N)}$ in the direction of the unit vector $\vec{n}$ represents the dilatation of the observed line element from the direction determined by the unit vector $\vec{n}$ whereas the component $\gamma_n^{(N)}/2$ in the direction determined by the unit vector $\vec{T}$ orthogonal to the unit vector $\vec{n}$ represents the turning of the line element with respect to the natural configuration within the plane R_{nT} determined by the unit vector $\vec{n}$ and the specific deformation vector of the given line element. This is approximately half of the change of the right angle between the line elements in the direction of the unit vector $\vec{n}$ and its coupled direction determined by the unit vector $\vec{T}$ of the projection direction of the total strain (specific deformation) vector $\vec{\delta}_n^{(N)}$ on the plane orthogonal to the line element unit vector in the direction of the unit vector $\vec{n}$. The Figure 5. gives the sketch of the coupled line elements in the forced and natural configuration as well as their specific deformations vectors with respective parameters denoted. The same figure will also be used for further analysis.

If we now project the component $\gamma_n^{(N)}/2$ on the two orthogonal directions $\vec{u}$ and $\vec{v}$ in the plane R_n, we shall obtain two sliding (shear) components $\gamma_{nu}^{(N)}/2$ and

$\gamma_{nv}^{(N)}/2$, that is, half of the change of the right angle between the line elements in the directions determined by the unit vector $\vec{n}$ and the unit vector $\vec{u}$, that is, $\vec{v}$. In other words, we shall obtain the right angle changes of the basic line element with respect to the directions $\vec{u}$ or $\vec{v}$. In further comparison of the analogous parameters of the stress theory and the deformation theory it should be pointed out that the total stress vector $\vec{p}_n^{(N)}$ is related to the point and the plane with normal $\vec{n}$ as well as to the orthogonal direction indirectly, whereas the total strain (specific deformation) vector $\vec{\delta}_n^{(N)}$ is related to the point and line determined by the unit vector $\vec{n}$ and indirectly to the orthogonal plane R_n and the coupled direction $\vec{T}$ within it. The coupled direction $\vec{T}$ belonging to the deformation theory finds its correspondent in the coupled plane perpendicular to the plane $\vec{R}_n$ and in the shear stress $\tau_T^{(N)}$ within that plane within which, according to the rule of shear stress conjugativity, the stress of the same intensivity as $\tau_n^{(N)}$ occurs, which falls into the direction $\vec{T}$, since $\tau_n^{(N)} = \tau_T^{(N)}$, that is, $\tau_{nT}^{(N)} = \tau_{Tn}^{(N)}$.

Further analysis helps us perceive that the two orthogonal planes R_n and R_v with the normal unit vectors $\vec{n}$ and $\vec{v}$ in which the conjugated shear stresses $\tau_{nv}^{(N)}$ and $\tau_{vn}^{(N)}$ occur correspond to the two orthogonal directions determined by the unit vectors $\vec{n}$ and $\vec{v}$ of the line elements between which the right angle change is determined, i.e., the specific deformation (sliding/shear) $\gamma_{nv}^{(N)}/2$ and $\gamma_{vn}^{(N)}/2$ which represent the same angle.

5. THE PRINCIPAL STRAIN DIRECTIONS

Let's analyze the approach in the stress theory to the determination of the principal strain direction. From the point N of the deformable body in natural configuration we can draw an infinite number of line elements $d\vec{r}_n = \vec{n}dr$ and in forced configuration of the deformed stressed body we can define for each of them the displacement vector $d\vec{s}_{ndef}$ corresponding to the pure deformation and the corresponding vector $\vec{\delta}_n^{(N)}$ of the line element specific deformation in the direction of the respective unit vector $\vec{n}$ which in the general case has two components. Besides the very well known definition that the principal dilatation directions are characterized by the presence of dilatation, by the absence of sliding and by absence of the right angle change between the tree principal orthogonal directions they can also be defined now as those in which the total strain (specific deformation) vector $\vec{\delta}_n^{(N)}$ is colinear with the corresponding line element direction in natural configuration so that the line element retains its direction. Figure 6. gives a geometrical representation of the principal direction determined by the unit vector $\vec{n}_s$ as well as the corresponding representation in the stress theory.

The plane perpendicular to one principal dilatation direction in natural configuration of the deformable body includes at least two mutually orthogonal elements between which the right angle does not change during the body transition to forced configuration, in other words, no sliding occurs between them. These are the two remaining principal dilatation directions. Those line elements remain in this plane even in forced configuration although in the general case the remaining line elements in this plane in natural configuration drawn from the same point in forced configuration do not have to stay there (See Fig. 6).

6. THE SLIDING EXTREME VALUES OF THE ORTHOGONAL LINE ELEMENTS

Let's consider now an analogy between the shear stresses extreme values in orthogonal planes through one point and the sliding extreme values of the orthogonal line elements drawn from the same point of the body.

By using the analogy between the shear stresses $\tau_{nv}^{(N)}$ and sliding $\gamma_{nv}^{(N)}$ we can conclude that shear stresses extreme values correspond to the line elements sliding extreme values. Since we have determined the shear stresses extreme values planes by the angles of $\pm 45^0$ with respect to the principal stress directions, therefore, the line elements directions which the greatest slidings as specific deformations occur for, that is, between the pairs undergoing the greatest right angles changes,can be determined with respect to the principal dilatations. Therefore, these are the line elements determined by the directions forming an angle of $\pm 45^0$ with respect to the principal dilatations directions and these changes of the right angles are equal to the difference between the principal dilatations. There are three pairs of such line elements and six directions of the line elements. We can write that:

$$\gamma_{I_{ab}} = \pm(\varepsilon_2 - \varepsilon_3) \qquad \gamma_{II_{ab}} = \pm(\varepsilon_1 - \varepsilon_3) \qquad \gamma_{III_{ab}} = \pm(\varepsilon_1 - \varepsilon_2) \tag{25}$$

(2) The dilations corresponding to these slidings for these line elements in given point N are:

$$\varepsilon_{I_{ab}} = \frac{1}{2}(\varepsilon_2 + \varepsilon_3) \qquad \varepsilon_{II_{ab}} = \frac{1}{2}(\varepsilon_1 + \varepsilon_3) \qquad \varepsilon_{III_{ab}} = \frac{1}{2}(\varepsilon_1 + \varepsilon_2) \tag{26}$$

Figure 7. shows the line elements directions which the greatest extreme sliding (shear) values occur for.

If ε_1 and ε_2 are the greatest and the smallest dilatations then $\gamma_{II_a II_b}$ is the greatest sliding, that is, the greatest change of the right angle between these line elements of the pair II_a, II_b. Therefore, the pair of the two orthogonal directions determining the line elements between which the greatest shear occurs, that is, the right angle change lies in the plane defined by the principal dilatations directions which are the greatest and the smallest dilations halving the angle between them.

It should be noted that sliding is related to the line element direction and to the given plane in which this line element lies or otherwise for two orthogonal directions and the change of the right angle between them.

In the Figure 7. we can see the pairs of the directions I_a and I_b , II_a and II_b,III_a and III_b of the drawn line elements from the observed point of the deformable body which are mutually orthogonal in the configuration of the natural state of the body, and with respect to the forced configuration between which the extreme changes of

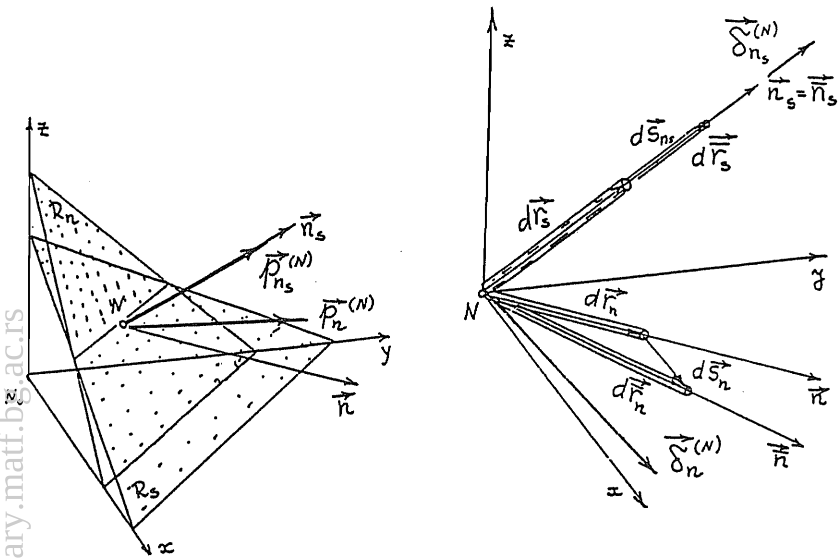

FIGURE 6.

the right angles occur comparing to the other pairs of the orthogonal line elements being drawn from the same point. Therefore, during the transition of the body from the natural into the forced configuration the extreme sliding value is between such pairs of the line elements.

If the two principal dilatations are mutually equal, then there is only at least one more pair of the orthogonal line elements between which there is no right angle change, that is, there is no sliding, but which lie in the plane of the principal dilatations directions being the pair of the directions forming an angle of $\pm 45^0$ with respect to these two directions. This leads us to conclude that the remaining principal direction is the axis of the deformation symmetry at the observed point of the body in natural configuration.

If the two principal dilatations at the observed point of the body are the same regarding their absolute values whereas different in sign (shortering - lengthening), then from this point the two orthogonal line elements can be drawn between which the extreme value of the specific deformation lies, that is, of sliding (shear), that is, of the right angle change. Therefore, these line elements are without dilatations, that is, without any change in length. These are directions of the line elements with the pure shear (pure sliding).

If between these line elements with pure shear we perceive a surface element whose edges follow the directions of these line elements, then such line element does not undegro any surface change during the deformable body transition from the natural into the forced configuration whereas the volumetric element designed above it in the third dimension in the direction of the remaining principal dilatation has a volumetric dilatation equal to this principal dilation.

7. EXTREME VALUES OF THE MASS DEVIATION MOMENTS

For determining the mass deviation moments extreme values we shall use this analogy which exists between the stress tensor matrices, the relative deformation tensor and the body mass inertia tensor as well as between the vector $\vec{p}_n^{(N)}$ of the total stress at a certain body point for the plane with the normal $\vec{n}$, the vector $\vec{\delta}_n^{(N)}$ of the total relative deformation of the line element drawn from the observed point in the direction of the unit vector $\vec{n}$ and the vector $\vec{\mathcal{J}}_n^{(N)}$ of the body mass inertia moment at the observed pole for the axis oriented by the unit vector $\vec{n}$.

On the basis of the given analogy the following conclusion are drawn though without proofs: on the basis of the analogy between the mass deviation moments extreme values for a couple of orthogonal axes (that is, of the mass centrifugal moments) and yield stress extreme values in the orthogonal planes that pass in pairs through one single stress direction and form an angle of $\pm 45^0$ with the other two we conclude that the mass deviation moments extreme values appear for the axes pairs I_a and I_b, II_a and II_b, III_a and III_b that pass in pairs through the main body mass inertia axis through the given point and form angles of $\pm 45^0$ with the other two main inertia axes. For these pairs of the defined axes the mass deviation moments (the mass centrifugal moments) are equal to the semi-difference between the two main (axial) moment of the body mass inertia and for each axis in the corresponding pair the axial inertia moments are equal to the semi-sum of the two corresponding main moments of the body mass inertia for the given point. For the geometrical interpretation the Figure can be used. The pairs of these coupled axes are the inertia asymmetry axes since for them the mass centrifugal moments are extreme values and the axial inertia moments for both the axes in pair are mutually equal. The concept of "asymmetry" can be accepted since for symmetry axes the mass centrifugal moment is equal to zero and for these axes the body mass centrifugal moment is of extreme value so that this leads to the conclusion about the asymmetry of the material body inertia properties. On the basis of the given analogy and for the axes according to the Fig. 7. we can write the values of the mass deviation moments and the body mass axial inertia moments for these axes:

$$\begin{aligned} D_{I_aI_b}^{(N)} &= \pm\frac{J_2^{(N)} - J_3^{(N)}}{2} & J_{I_a}^{(N)} &= J_{I_b}^{(N)} = \frac{J_2^{(N)} + J_3^{(N)}}{2} \\ D_{II_aII_b}^{(N)} &= \pm\frac{J_1^{(N)} - J_3^{(N)}}{2} & J_{II_a}^{(N)} &= J_{II_b}^{(N)} = \frac{J_1^{(N)} + J_3^{(N)}}{2} \\ D_{III_aIII_b}^{(N)} &= \pm\frac{J_2^{(N)} - J_1^{(N)}}{2} & J_{III_b}^{(N)} &= J_{III_b}^{(N)} = \frac{J_2^{(N)} + J_1^{(N)}}{2} \end{aligned} \tag{27}$$

These conclusions can be proved by means of the defined vector $\vec{\mathcal{J}}_n^{(N)}$ of the rigid body mass inertia moment and the vector $\vec{\mathcal{D}}_n^{(N)}$ of the axis deviation load oriented by the unit vectors of the defined axes with the extreme values of the rigid body mass deviation moments for the referential point.

8. THE BASIC RULE OF THE DEFORMATION ANALYSIS

By introducing the total strain (specific deformation) vector $\vec{\delta}_n^{(N)}$ of the line element in the direction of the unit vector $\vec{n}$ we can deduce the rule of the deformation analysis analogous to the stress analysis rule which comes to the rule of the shear stress conjugavity for the case of the orthogonal planes. Therefore, we should notice two line elements drawn from the point N of the deformable body in natural configuration in the direction of the unit vector $\vec{n}$ and $\vec{v}$ which in the general case form an arbitrary angle as it is shown in the Figure 8. The corresponding vectors $\vec{\delta}_n^{(N)}$ and $\vec{\delta}_v^{(N)}$ of the total strain (specific deformations) for these line elements are

$$\{\delta_n^{(N)}\} = \mathcal{E}\mathcal{E}^{(N)}\{n\} \qquad \{\delta_v^{(N)}\} = \mathcal{E}\mathcal{E}^{(N)}\{v\} \tag{28}$$

If the former is multiplied scalarly by the unit vector $\vec{v}$ and the latter by the unit vector $\vec{n}$ and if we compare the results, we will obtain the following:

$$pr_{\vec{v}}\vec{\delta}_n^{(N)} = pr_{\vec{n}}\vec{\delta}_v^{(N)} \qquad (v)\{\delta_n^{(N)}\} = (n)\{\delta_v^{(N)}\} \tag{29}$$

Hence we conclude that the projection of the vector $\vec{\delta}_n^{(N)}$ of the total strain (specific deformation) of the line element drawn from the point N in the direction of the unit vector $\vec{n}$ on the direction of the unit vector $\vec{v}$ is equal to the projection of the vector $\vec{\delta}_v^{(N)}$ of the total strain (specific deformation) of the line element drawn from the same point N of the deformable body in the direction of the unit vector $\vec{v}$ on the direction of the unit vector $\vec{n}$ for the same deformation state at the point N.

This is the basic rule of the deformation analysis. For the case of the orthogonal directions $\vec{n}$ and $\vec{v}$ and therefore for the orthogonal line elements, the product

$$\frac{1}{2}\gamma_{nv}^{(N)} = (v)\{\delta_n^{(N)}\}, \quad \text{that is,} \quad \frac{1}{2}\gamma_{vn}^{(N)} = (n)\{\delta_v^{(N)}\} \tag{30}$$

represents the line element sliding $\gamma_{nv}^{(N)}/2$, that is, $\gamma_{vn}^{(N)}/2$, that is, half of the change of the right angle between the line elements. Hence, it follows from the expression (29) that:

$$\frac{1}{2}\gamma_{nv}^{(N)} = \frac{1}{2}\gamma_{vn}^{(N)} \tag{31}$$

that is, that the line element sliding in the direction of the unit vector $\vec{n}$ in the plane $(\vec{n}, \vec{v})$ is equal to the line element sliding in the direction of the unit vector $\vec{v}$ in the plane $(\vec{v}, \vec{n})$.

9. THE BASIC RULE OF THE STATE ANALYSIS OF THE BODY MASS INERTIA MOMENT

On the basis of the analogy with the basic rule of the stress analysis, that is, the deformation analysis in the Elasticity Theory there is the basic rule of the state

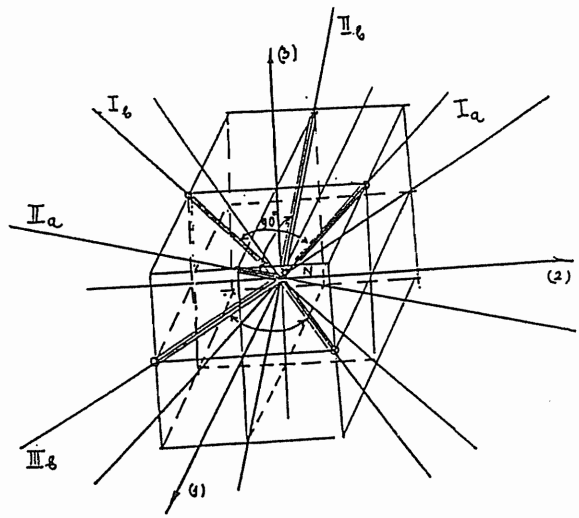

FIGURE 7A.

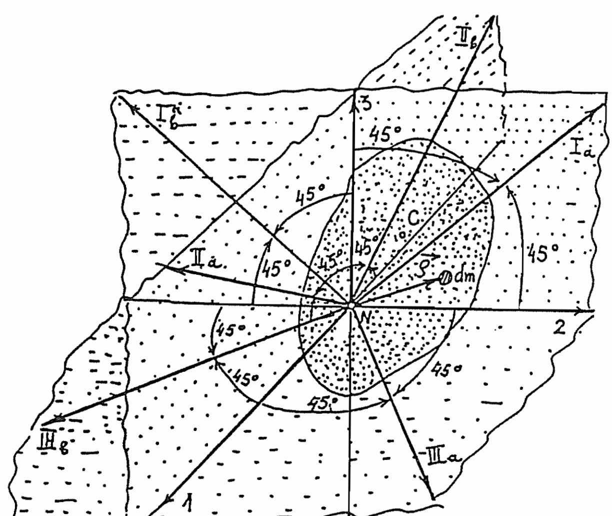

FIGURE 7B.

analysis of the body mass inertia moment with respect to a certain pole N in the form:

$$pr_{\vec{v}}\vec{\mathcal{J}}_n^{(N)} = pr_{\vec{n}}\vec{\mathcal{J}}_{\vec{v}}^{(N)} \tag{32}$$

which says that the projection of the vector $\vec{\mathcal{J}}_n^{(N)}$ of the rigid body mass inertia moment for the point N and the axis oriented by the unit vector $\vec{n}$ to the axis oriented by the unit vector $\vec{v}$ is equal to the projection of the vector $\vec{\mathcal{J}}_v^{(N)}$ of the same rigid body mass inertia moment for the same point N and the axis oriented by the unit vector $\vec{v}$ to the direction of the axis oriented by the unit vector $\vec{n}$. In the case when these two vectors $\vec{n}$ and $\vec{v}$ are the orthogonal axes orientation this rule comes to the equality of the body mass deviation moment for these axes.

10. CONCLUSION

The definitions: (1) of the vector $\vec{\mathcal{J}}_n^{(N)}$ of the mass inertia moment of the body for the axis oriented by the unit vector $\vec{n}$ through the point N; and (8) of the vector $\vec{\mathcal{D}}_n^{(N)}$ of the mass deviation moment at the point N for the axis oriented by the unit vector $\vec{n}$; are my original contributions in this paper.

The equations (13), (29) and (32) as well are my original results, although these equations we can take as mathematical analogy with corresponding equations from the stress theory of the deformable bodies.

The complete analysis of the mass inertia moment state by the vector $\vec{\mathcal{J}}_n^{(N)}$ of the mass inertia moment of the body for the axis oriented by the unit vector $\vec{n}$ through the point N represents the original way for definition and interpretation of kinetic parameters of the rigid bodies.

The analysis of the strain state of the elastic bodies by the vector $\vec{\delta}_n^{(N)}$ of the total specific deformation (strain) for the unit vector $\vec{n}$ drown from the point N also is original way, but less original than previous results.

Everything that has been said leads us to conclude that there exists a very fruitful analogy based on the possibility to use mathematical models for the explanations of various parameters and the systems of physical and geometric quantities. Such an approach enables various simplifications.

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J dedicate this paper to my dear and highly respected late
Professor ph. D. Dipl. Math. Danilo Rašković, who
introduced the vector interpretations into the University
program of Mechanics, which he loved very much.

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ANALOGIJE MODELA STANJA NAPONA, STANJA DEFORMACIJE I STANJA MOMENTA INERCIJE MASE NAPREGNUTOG DEFORMABILNOG TELA

Katica (Stevanović) Hedrih

U radu se uvode pojmovi: vektora $\vec{\delta}_n^{(N)}$ totalne specifične deformacije za linijski element povučen iz tacke N u pravcu odredjenog jediničnog vektora i vektora $\vec{\mathcal{J}}_n^{(N)}$ momenta inercije masa tela za osu povučenu iz iste tačke i pomoću njih i vektora totalnog napona za ravan odredjene normale analiziraju modeli stanja napona, stanja deformacije i stanja momenata inercije masa u posmatranoj tački tela i ukazuje na identičnost matematičkih modela. Koristeći pojmove tenzora napona, tenzora momenata inercije i tenzora specifične deformacije ističe se analogija pojmova, fizičkih i geometriskih veličina modela stanja napona, stanja deformacija i stanja inercije masa tela. Na osnovu te analogije izveden je niz zaključaka u teoriji deformacija i o momentima inercije masa tela.

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Application of Fractional Calculus for Dynamic Problems of Solid Mechanics: Novel Trends and Recent Results

Yuriy A. Rossikhin

Marina V. Shitikova[1]
e-mail: shitikova@vmail.ru

Department of Theoretical Mechanics,
Voronezh State University of Architecture and Civil Engineering,
Voronezh 394006, Russia

The present state-of-the-art article is devoted to the analysis of new trends and recent results carried out during the last 10 years in the field of fractional calculus application to dynamic problems of solid mechanics. This review involves the papers dealing with study of dynamic behavior of linear and nonlinear 1DOF systems, systems with two and more DOFs, as well as linear and nonlinear systems with an infinite number of degrees of freedom: vibrations of rods, beams, plates, shells, suspension combined systems, and multilayered systems. Impact response of viscoelastic rods and plates is considered as well. The results obtained in the field are critically estimated in the light of the present view of the place and role of the fractional calculus in engineering problems and practice. This articles reviews 337 papers and involves 27 figures. [DOI: 10.1115/1.4000563]

Keywords: fractional integrodifferentiation, free vibrations of viscoelastic systems with finite and infinite number degrees of freedom, impact response

1 Introduction

The authors' first state-of-the-art article [1] devoted to the application of fractional calculus in dynamic problems of solids was published in Applied Mechanics Reviews in January, 1997. 13 years have elapsed since its appearance. A rich variety of papers dealing with fractional calculus and its application to the problems of mechanics have appeared in scientific literature in this period, among them reviews [2–8] and monographs [9,10]. All technical articles in the field can be classified into two main groups:

- papers developing analytical approaches and methods
- papers utilizing numerical approaches and methods.

A list of papers from *the second group* is much longer than that of *the first group* since new analytical results are few and far between. Moreover, those papers fallen into the first group are mainly concerned with investigation of vibrations of 1DOF systems and fractional oscillators. *Fractional oscillator* is a notion that appears recently in the literature, principally in the field of physics, for an oscillator with the second derivative replaced by a fractional one of order less than 2, in so doing Riemann–Liouville, Grünvald–Letnikov, Caputo, or Riesz definitions for the general fractional differintegral have been utilized. But for mechanical and civil engineering applications, the introduction of a fractional derivative into inertial terms of equations of motion is neither attractive nor justified. In engineering practice, fractional derivatives are useful for describing viscoelastic features of advanced materials or dissipative forces in structural dynamics [1,3–7].

As for the second group, then in the majority of papers from this group, numerical methods are also applied to the simplest mechanical systems, such as oscillators and rods. Analysis of intricate mechanical systems is rather rare in occurrence.

Different numerical methods, such as finite-element and boundary element simulations, the method of finite differences with its modifications, and other numerical algorithms, are of frequent use for integration of equations of motion of fractionally damped structures in the time-domain as well as in the Laplace or Fourier domain. Some authors have utilized Grünvald–Letnikov definition for the fractional differintegral, while others preferred to develop various iterative algorithms for its evaluation. In regard to the methods of numerical treatment of integrodifferential equations of fractional order utilizing in various problems of mechanics, then the interesting reader can find their wide overview in Refs. [4,11–17] with references therein.

The present state-of-the-art article is devoted to the analysis of new trends and recent results carried out during the last years in the field of fractional calculus application to dynamic problems of solid mechanics and structural mechanics. When writing the second survey, the authors have been guided by the considerations that it should not repeat the first review [1], while it should be its logical continuation. Since all main definitions of a fractional derivative and fractional integral, as well as the detailed description of the simplest rheological models involving fractional derivatives, have been considered in Ref. [1], then we will not return to these questions here and refer the interesting reader to Ref. [1] or/and Refs. [2,8,9].

This review will focus on the papers dealing with study of dynamic behavior of linear and nonlinear 1DOF systems, systems with two and more DOF, as well as linear and nonlinear systems with infinite-number-degree-of-freedom: vibrations of rods, beams, plates, shells, suspension combined systems, and multilayered systems. Impact response of viscoelastic rods and plates will be considered as well. The results obtained in the field are critically estimated in the light of the present view of the place and role of the fractional calculus in engineering problems and practice.

Since this article is dedicated mainly to the audience of researchers and practicing engineers in the field of mechanical and civil engineering, then hereafter terms fractional oscillator and *fractionally damped structure* would mean application of fractional calculus representations for describing damping forces in governing equations of motion.

It might be well to point out that the analytical approaches and methods for studying the fractionally damped mechanical systems will be analyzed in more detail in the given paper. As for the

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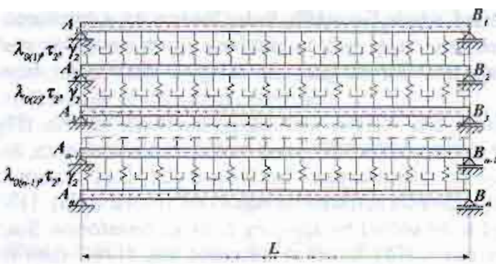

Fig. 23 Scheme of a multibeam system

equations describing the dynamic response of viscoelastic beams can be found in Ref. [69]. Zhu et al. [69] studied steady-state response of a simply supported fractionally damped beam under a simple harmonic excitation. The viscoelastic material of the beam is assumed to be homogeneous and isotropic, and its volume deformation is supposed to obey the elastic deformation law, while for pure shear deformation, it is assumed that the material obeys the three-dimensional fractional derivative standard linear solid model constitutive relations. The equations of motion were derived for a Timoshenko-type beam, and particular cases neglecting the rotary inertia and/or transverse shear deformations were discussed as well. Using the modal analysis approach, the solution was obtained for the beam's deflection and rotational angle

$$v(x,t)=\sum_{n=1}^{\infty}(A_n\sin\Omega t+B_n\cos\Omega t)\sin\left(\frac{n\pi x}{L}\right) \qquad (173a)$$

$$\varphi(x,t)=\sum_{n=1}^{\infty}(C_n\sin\Omega t+D_n\cos\Omega t)\sin\left(\frac{n\pi x}{L}\right) \qquad (173b)$$

where Ω is the frequency of the excitation, and A_n, B_n, C_n, and D_n are some coefficients defined in Ref. [69].

Further the same authors suggested a numerical method for solving weakly singular Volterra integrodifferential equations arising in the above mentioned problem [71]. The analytical and numerical results were compared, and a good correspondence between them was reported.

4.2.5 Solution in Terms of Series. The decomposition method, when the solution is sought in the form of the series (27), was utilized by Liang and Tang [308] to solve Eq. (158) with the fractional derivative damping term of an arbitrary order $0<\gamma<1$, in so doing, the forcing function is assumed as the product of a specified space-dependent deterministic function and a time-dependent process. For particular case of a simply supported beam subjected to a unit impulse load, the general solution was written in the form of an infinite series similar to Eq. (30). The numerical example was presented for the case of the first mode approximation, which is equivalent to one fractional oscillator idealization of the beam. Calculations were done by truncating the infinite series (30) to 16 terms.

The approach for solving the fractional differential equation obtained for the generalized displacement function of a fractionally damped rod [294] was utilized by Hedrih [307] when considering free transversal vibrations of a two-layered straight beam, which layers were made of inhomogeneous continuously creeping materials simulated by fractional derivative Kelvin–Voigt model. In the case of the simply supported beam, the problem was reduced to the same equation of the fractional derivative Kelvin–Voigt oscillator as in Ref. [294], and, thus, its time series form solution coincides with that of Refs. [297,294].

4.2.6 A Viscoelastic Beam With Nonhomogeneity Varying With Its Height. One of the approaches for simulating multilayered structures is to consider a sandwich structure as a multibeam or multiplate system, in which deformable elastic or viscoelastic bodies (beams or plates) are interconnected by distributed light viscoelastic constraint elements which have the ability to resist axial deformation under static and dynamic conditions [315].

Let us consider a discrete-continuum inhomogeneous vertical chain system (Fig. 23) involving a set of N viscoelastic beams with different material constants but with the same boundary contours and boundary conditions, which are interconnected by $N-1$ viscoelastic constraint layers with equal material constants. The number of degrees of freedom of such a multilayered structure is equal to N-infinity, where N is a number of deformable beams in the chain, in so doing, each Bernoulli–Euler beam admits the dynamic deflection $v_i(x,t)$. The origins of the corresponding N coordinate systems are N corresponding sets at the corresponding centers in the undeformed beams' middle surfaces, as shown in Fig. 23 and with parallel corresponding axes. The beams may be subjected to a transversal distributed external loads $q_i(x,t)$ $(i=1,2,\ldots,N)$ along corresponding beams' external surfaces.

The dynamic response of such a viscoelastic layer connected multiple beam system, or a sandwiched beam, can be described by the following system of the N governing coupled partial differential equations:

$$\widetilde{E_i}I_i\frac{\partial^4 v_i}{\partial x^4}+\rho_iA_i\ddot{v}_i=q_i+F_{i+1}-F_i \quad (i=1,2,\ldots,N) \qquad (174a)$$

$$F_1=\widetilde{\lambda_1}v_1, \quad F_i=\widetilde{\lambda_i}(v_i-v_{i-1}) \quad (i=2,3,\ldots,N-1), \quad F_N=\widetilde{\lambda_N}v_N \qquad (174b)$$

formulated in terms of N unknown transversal displacements $v_i(x,t)$, where F_i is the reaction of the ith viscoelastic layer. Young's modulus $\widetilde{E}_i$ of the ith beam and the coefficient of rigidity of the connecting viscoelastic layer $\widetilde{\lambda}$ are the following Kelvin–Voigt type operators of the fractional order:

$$\widetilde{E_i}=E_{0(i)}(1+\tau_1^{\gamma_1}D^{\gamma_1}), \quad \widetilde{\lambda_j}=\lambda_{0(j)}(1+\tau_2^{\gamma_2}D^{\gamma_2}) \qquad (174c)$$

and $E_{0(i)}$ and $\lambda_{0(j)}$ are prolonged magnitudes of coefficients of rigidity for the ith beam and jth layer, respectively, τ_1, γ_1 and τ_2, γ_2 are the retardation time and fractional parameter for the beams and layers, respectively.

Note that adding the Nth layer to this system allows one to consider the dynamic response of a multilayered beam on a viscoelastic foundation in the same manner as in Sec. 4.2.4.

Supposing the solution of Eq. (174*a*)–(174*c*) in the modal form

$$v_i(x,t)=\sum_{n=1}^{\infty}\varphi_n(x)T_{(i)n}(t), \quad i=1,2,\ldots,N \qquad (175)$$

substituting Eqs. (175), (174*b*), and (174*c*) into Eq. (174*a*), multiplying each equation by $\varphi_k(x)$, after integrating along the beams' length L, and taking into account orthogonality conditions and corresponding equal boundary conditions of the beams, we are led to the n-family of systems containing coupled only N-ordinary fractional-order differential equations for the determination of unknown generalized displacement functions $T_{(i)n}(t)$ $(i=1,2,\ldots,N,$ $n=1,2,\ldots,\infty)$,

$$\ddot{T}_{(i)n}+\omega_{(i)n}^2(1+\tau_1^{\gamma_1}D^{\gamma_1})T_{(i)n}+\frac{\lambda_{0(i)}+\lambda_{0(i+1)}}{\rho_iA_i}(1+\tau_2^{\gamma_2}D^{\gamma_2})T_{(i)n}$$
$$-\frac{\lambda_{0(i+1)}}{\rho_iA_i}(1+\tau_2^{\gamma_2}D^{\gamma_2})T_{(i+1)n}-\frac{\lambda_{0(i)}}{\rho_iA_i}(1+\tau_2^{\gamma_2}D^{\gamma_2})T_{(i-1)n}=P_{(i)n}(t) \qquad (176)$$

where

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Yuriy A. Rossikhin *is a Soros Professor of the Department of Theoretical Mechanics at the Voronezh State University of Architecture and Civil Engineering in Russia. He received his MSc degree in Applied Mechanics from the Voronezh State University in 1966, a PhD degree in Mechanics and Physics of Solids in 1970, a Habilitation Docent Degree in 1972, and an Associate Professorship in 1974, from the Voronezh Polytechnic Institute. He received a DSc degree in Solid Mechanics from the Chyvash University in 1991 and a full Professorship in 1992 from the Voronezh Civil Engineering Institute (which was renamed as Voronezh State University of Architecture and Civil Engineering in 1993). Since 1993, he has been a Full Member of the Acoustical Society of America, and in 1994 he was elected as an Active Member of the New York Academy of Sciences. Since 1995 he has been a Member of the EUROMECH, GAMM, and the ASME International. His area of research as well as teaching are theoretical mechanics and applied mathematics and mechanics. He has published over 300 papers in peer reviewed journals and proceedings dealing with wave dynamics, vibrations, acoustics, problems on dynamic contact interaction, mechanical and thermal shock, as well as on application of fractional calculus models in mechanics of solids and structures. He is an Associate Editor of the Applied Mechanics Reviews from 1996. His biography has been included in Who's Who in the World, Who's Who in Science and Technology, and 2000 Outstanding Scientists of the 20th Century. In 1998–2003, he was a grantee of the Russian Academy Fellowship for Outstanding Russian Scientists. Since 1999, he is a Director of the Center on Fundamental Research in Dynamics of Solids and Structures, Voronezh State University of Architecture and Civil Engineering. In 2003, Dr. Rossikhin was awarded the title of Honored Professor of High Education of the Russian Federation.*

Marina V. Shitikova *is a Soros Professor of the Department of Structural Mechanics at the Voronezh State University of Architecture and Civil Engineering in Russia. She received her MEng in Civil Engineering in 1982, a PhD degree in Structural Mechanics in 1987 from the Voronezh Civil Engineering Institute, a DSc degree in Solid Mechanics in 1995 from the Institute for Problems in Mechanics, Russian Academy of Sciences, and a Professorship in 1995 from the Voronezh State University of Architecture and Civil Engineering. Since 1994, she has been an Associate Member of the Acoustical Society of America, since 1995 she has been a Member of the EUROMECH, GAMM, the ASME International, and Russian Association "Women in Science and Education." She has published about 150 papers dealing with structural mechanics, vibrations, wave dynamics, acoustics, as well as on application of fractional calculus models in mechanics of solids and structures. Her biography has been included in Who's Who in the World, Who's Who in Science and Technology, and 2000 Outstanding Scientists of the 20th Century. She received a Commemorative Medal "1997 Woman of the Year" from the American Biographical Institute. In 1998 she was awarded the Russian President's Fellowship for Outstanding Young Doctors of Sciences. Dr. Shitikova is a grantee of the Russian Foundation for Basic Research, DAAD, Fulbright Foundation, and Russian Agency on High Education.*

THE DISSIPATION FUNCTION OF A NONCONSERVATIVE SYSTEM OF MASS PARTICLES.

By Katica (Stevanović) HEDRIH.

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THE DISSIPATION FUNCTION OF A NONCONSERVATIVE SYSTEM OF MASS PARTICLES.

On occasion of the Anniversary of "Akitsugu Kawaguchi's 100 years birth", who is the Founder of Tensor Society.

By Katica (Stevanović) HEDRIH.

Abstract. The paper presents the determination of a class of generalized Rayleigh's dissipation functions, which correspond to dissipative force proportional to p-step of the velocity of the material particles, as well as corresponding extend generalized relation between the generalized Rayleigh's dissipation function and the rate of system energy dissipation (degradation) for the systems with holonomic rheonomic and/or scleronomic constraints.

Introduction. The description of mechanics of a system of material particles would be unrealistic if the absence of dissipative or frictional forces would be assumed. In many physical systems these forces, when present, are proportional to particle velocities and can therefore be derived as a dissipation function (see Ref. [**2**][1), [**8**]).

Book *Theory of Sound by Lord Rayleigh* [**2**], [**8**], is one of the old classic monograph of physics literature. This treatise contains a wealth of theorem and physical illustrations on all of the aspects of vibration theory, and is very concurrent. Rayleigh himself was responsible for introduction of the *dissipation function* into vibration theory.

In the classical monographs F. Gantmaher [**1**] and H. Goldstein [**2**] are treatises, which contain fundamentals of the analytical mechanics. The series of papers by V. V. Rumyantsev contain current knowledge on analytical mechanics, and especially Ref. [**9**] present an introduction in the general theory of general and generalized Poincaré's and Chetaev's differential equations system based on a closed system of infinitesimal operators. These equations include both the motion equations in independent and dependent, holonomic and nonholonomic coordinates for holonomic and nonholonomic mechanical systems with finite number of degrees of freedom. In this sense Poincaré-Chetaev-Rumyantsev's equations [**14**] are general equations of analytical dynamics.

In monographs [**11**], [**12**] V. A. Vujičić gave a modification of the analytical mechanics of rheonomic systems, with the aim to include the influence of nonstationary constraints into the laws of motion. In his approach, rheonomic coordinate is chosen

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1) Numbers in brackets refer to the references at the end of the paper.

as a function derived from rheonomic constraints. On this basis, an extended system of Lagrangian equations was formulated with an additional equation corresponding to rheonomic coordinate. In the paper by Vujičić and Hedrih [**13**] the rheonomic constraints generalized force in the extension of the Lagrange's system of differential equations of motion of the first and the second kind is introduced. In the paper by K. Hedrih [**3**] the power of the rheonomic constraints change is introduced.

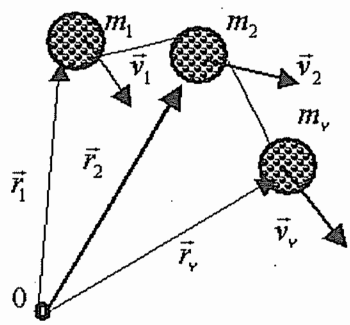
In the paper Dj. Mušicki [**5**], [**6**] formulated a new parametric formulation of mechanics and based on the separation of the double role of time (independent variable and a parameter) with the aid of a family of varied paths. These results are extended to arbitrary rheonomic systems with variable mass. Also, the same general principles of mechanics and the energy relations for such systems are studied.

In the university book by D. P. Rašković [**8**] the Lagrange's equations of the motion of mass particles nonconservative system expressed by using Rayleigh's dissipation function which corresponds to the dissipative force proportional to the velocity of the material particle, based on the Theory of Sound by Lord Rayleigh. In the Ref. [**8**], [**2**], for nonconservative system of mass particles nonconservative system with holonomic scleronomic constraints with dissipative force proportional to the velocity of the material particle, we can find relation between system energy and Rayleigh's dissipation function. This formulation is: Duplicate of the Rayleigh's dissipation function is the rate of system energy dissipation (degradation).

J. J. Stoker in the Ref. [**10**] presented example of the heavy material particle pendulum nonlinear dynamics in the turbulent field damping with corresponding phase portrait and constant energy curves.

References [**8**] and [**10**] and Rayleigh's dissipation function which corresponds to the dissipative force proportional to the velocity of the material particle are inspiration for me to define a new class of generalized Rayleigh's dissipation functions which correspond to the dissipative force proportional to p-step of the velocities of the material particles, as well as corresponding extend generalized relation between the generalized Rayleigh's dissipation function and the rate of system energy dissipation (degradation).

§ 1. **Kinetic and potential energy.** Now, we will consider a discrete system of N material particles with masses m_ν, $\nu = 1,2,3,\dots,N$, which positions are defined by corresponding position vectors in the forms of vector functions $\vec{r}_\nu(q^k,t)$, $\nu = 1,2,3,\dots,N$; $k = 1,2,3,\dots,n = 3N - s$ where s is number of holonomic rheonomic constraints $f_\alpha(\vec{r}^j,t) = 0$, $\alpha = 1,2,3,\dots,s$. By q^k, $k = 1,2,3,\dots,n = 3N - s$ are denoted generalized coordinates. By using form of the one of the rheonomic constraints we can introduce rheonomic coordinate [**11**] in the form of $q^0 = g(t)$. By introducing other rheonomic constraints, position radius vectors of material particles we can express with respect to the extended system of the generalized coordinates q^k, $k = 1,2,3,\dots,n = 3N - s$ with rheonomic coordinate q^0. Extended system of generalized coordinates have $n+1$ generalized coordinates: q^k, $k = 0,1,2,3,\dots,n$, $n = 3N - s$ and the position vectors of the material particles m_ν, $\nu = 1,2,3,\dots,N$ we can express in the form: $\vec{r}_\nu(q^0,q^1,q^2,\dots,q^n)$.



Velocities of the material particles m_ν, $\nu = 1, 2, 3, \ldots, N$ of the system is:

$$\vec{v}_\nu = \sum_{i=1}^{n} \frac{\partial \vec{r}_\nu}{\partial q^i}\dot{q}^i + \frac{\partial \vec{r}_\nu}{\partial q^0}\dot{q}^0.$$

Kinetic energy of motion of the material particles system is:

$$E_k = \frac{1}{2}\sum_{\nu=1}^{N} m_\nu (\vec{v}_\nu, \vec{v}_\nu) = \frac{1}{2}\sum_{i=0}^{n}\sum_{j=0}^{n} A_{ij}\dot{q}^i\dot{q}^j,$$

where, for consideration of a special class of rheonomic systems, $q^0 = \Omega t$ is rheonomic coordinate, which corresponds to the rotation angle, Ω is angular velocity, and introduced notations for coefficients of system inertia-functions A_{ij} are:

$$A_{ij} = \sum_{\nu=1}^{N} m_\nu \left(\frac{\partial \vec{r}_\nu}{\partial q^i}, \frac{\partial \vec{r}_\nu}{\partial q^j}\right), \quad i, j = 0, 1, 2, 3, \ldots, n.$$

Potential energy expression is:

$$E_p = E_p(\vec{r}_1, \vec{r}_2, \vec{r}_3, \ldots, \vec{r}_\nu, \ldots, \vec{r}_N, q^0) = E_p(q^1, q^2, q^3, \ldots, q^i, \ldots, q^n, q^0).$$

For the system equilibrium position the following conditions must be satisfied: $(\frac{\partial E_p}{\partial q^i})_{q^i = q^{i0}} = 0$. The generalized conservative system forces which have potential we can write:

$$Q_i = -\frac{\partial E_p}{\partial q^i}, \quad i = 0, 1, 2, 3, \ldots, n.$$

§ 2. Dissipative forces and Rayleigh's dissipative functions. If the friction forces $\vec{F}_{w,\nu}$, $\nu = 1, 2, 3, \ldots, N$, are present to the material particles m_ν, $\nu = 1, 2, 3, \ldots, N$ in rest conditions, and are different them zero, than these forces are dry friction forces. These friction forces can be sliding friction or rolling friction forces. If a material particle is constrained to move on a stationary surface and the force of constraint is not perpendicular to the surface, than the sliding friction force are present. The friction is essentially a macroscopic phenomenon [15]. Phenomena related to dry friction appear in poorly lubricated or non-lubricated contact surfaces of bodies in relative motion. The classical model of a system with dry friction forces develop between the base and the body contact surface, which can be modelled by a material particle moving on a slider. Friction forces naturally appear between two bodies in motion.

If the dissipative friction forces, $\vec{F}_{w,\nu}(\vec{v}_\nu) \neq 0$, $\nu = 1,2,3,\ldots,N$, are present to the material particles m_ν, $\nu = 1,2,3,\ldots,N$ at the motion in the dissipative space, and in rest are equal to zero, $\vec{F}_{w,\nu}(\vec{v}_\nu, t)|_{\vec{v}_\nu=0} = 0$, than these forces are viscosic friction forces or turbulent friction forces. The friction forces of the real constraints appear in the general case as a function of velocities and positions into dissipative space.

Let we define the dissipative forces $\vec{F}_{w,\nu}(\vec{v}_\nu) \neq 0$, $\nu = 1,2,3,\ldots,N$, which are present in material particles m_ν, $\nu = 1,2,3,\ldots,N$ during motion with velocities $\vec{v}_\nu$:

$$\vec{F}_{w,v} = \begin{cases} -b_\nu(\vec{v}_\nu, \vec{v}_\nu)^{p-1}\vec{v}_\nu \\ -b_\nu(\vec{v}_\nu, \vec{v}_\nu)^{p-1}|\vec{v}_\nu|\vec{v}_\nu \end{cases}, \quad p = 1,2,3,\ldots,$$

where b_ν and p are dissipative force coefficients.

Corresponding dissipative function:

$$\Phi(\vec{v}_1, \vec{v}_2, \ldots, \vec{v}_N) = \begin{cases} \displaystyle\sum_{\nu=1}^{N} \frac{b_\nu}{2p}(\vec{v}_\nu, \vec{v}_\nu)^p \\ \displaystyle\sum_{\nu=1}^{N} \frac{b_\nu}{2p+1}(\vec{v}_\nu, \vec{v}_\nu)^p|\vec{v}_\nu| \end{cases}, \quad p = 1,2,3,\ldots$$

Dissipative forces $\vec{F}_{w,\nu}(\vec{v}_\nu) \neq 0$ can be expressed by derivative of the scalar dissipative function $\Phi(\vec{v}_1, \vec{v}_2, \vec{v}_3, \ldots, \vec{v}_\nu, \ldots, \vec{v}_N)$ with respect to the ν-th material particles velocities $\vec{v}_\nu$ with opposite direction:

$$\vec{F}_{w,\nu}(\vec{v}_\nu) = -\frac{\partial\Phi(\vec{v}_1, \vec{v}_2, \vec{v}_3, \ldots, \vec{v}_\nu, \ldots, \vec{v}_N)}{\partial \vec{v}_\nu}, \quad \nu = 1,2,3,4,\ldots,N.$$

Generalized forces, which correspond to the dissipative forces, are denoted by $Q_{w,k}$, $k = 0,1,2,3,\ldots,n$, and expressed by following relation:

$$\begin{aligned} \delta A^{\Sigma\vec{F}_{w,\nu}} &= \sum_{\nu=1}^{N}(\vec{F}_{w,\nu}, \delta\vec{r}_\nu) = \sum_{k=0}^{n}\left(\sum_{\nu=1}^{N}\vec{F}_{w,\nu}, \frac{\partial\vec{r}_\nu}{\partial q^k}\right)\delta q^k \\ &= \sum_{k=0}^{n}\left(\sum_{\nu=1}^{N}\vec{F}_{w,\nu}, \frac{\partial\vec{v}_\nu}{\partial \dot{q}^k}\right)\delta q^k = \sum_{k=0}^{n} Q_{w,k}\delta q^k, \end{aligned} \tag{2.1}$$

$$Q_{w,k} = \sum_{\nu=1}^{N}\left(\vec{F}_{w,\nu}, \frac{\partial\vec{r}_\nu}{\partial q^k}\right) = \sum_{\nu=1}^{N}\left(\vec{F}_{w,\nu}, \frac{\partial\vec{v}_\nu}{\partial \dot{q}^k}\right),$$

where $\delta A^{\Sigma\vec{F}_{w,\nu}}$ are work of the dissipative forces in the arbitrary infinitesimal displacements $\delta\vec{r}_\nu$.

We multiplied relation (2.1) with $\delta\dot{q}^k$ and summarize left and right side with respect to index k from zero to n, and we obtained possible variation of the work of dissipative forces with respect to a unit of time, or rate of possible variation of dissipative energy, or possible variation of power of dissipative forces in following form:

$$\sum_{k=0}^{n} Q_{w,k}\delta\dot{q}^k = \sum_{k=0}^{n}\sum_{\nu=1}^{N}\left(\vec{F}_{w,\nu}, \frac{\partial\vec{v}_\nu}{\partial\dot{q}^k}\right)\delta\dot{q}^k = \sum_{\nu=1}^{N}\left(\vec{F}_{w,\nu}, \sum_{k=0}^{n}\frac{\partial\vec{v}_\nu}{\partial\dot{q}^k}\delta\dot{q}^k\right),$$
$$\sum_{k=0}^{n} Q_{w,k}\delta\dot{q}^k = \sum_{\nu=1}^{N}(\vec{F}_{w,\nu}, \delta\vec{v}_\nu).$$

Let consider the special cases:

a* The dissipative forces are linearly proportional to the velocity $\vec{v}_\nu$ of the corresponding material particle: $\vec{F}_{w,\nu} = -b_\nu\vec{v}_\nu$ and with opposite direction to the velocity. Generalized dissipative forces (2.1) of this type may be derived in terms of the dissipative function:

$$Q_{w,k} = \sum_{\nu=1}^{N}\left(\vec{F}_{w,\nu}, \frac{\partial\vec{v}_\nu}{\partial\dot{q}^k}\right) = -\sum_{\nu=1}^{N} b_\nu\left(\vec{v}_\nu, \frac{\partial\vec{v}_\nu}{\partial\dot{q}^k}\right)$$
$$= -\sum_{\nu=1}^{N}\frac{\partial}{\partial\dot{q}^k}\left[\frac{1}{2}b_\nu(\vec{v}_\nu,\vec{v}_\nu)\right] = -\frac{\partial\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n)}{\partial\dot{q}^k}.$$

For that case dissipative function is defined as:

$$\partial\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n) = \sum_{\nu=1}^{N}\frac{1}{2}b_\nu(\vec{v}_\nu,\vec{v}_\nu).$$

This function is known as Rayleigh's dissipation function.

b* The dissipative forces are proportional to the square of the velocity $\vec{v}_\nu$ of the corresponding material particle: $\vec{F}_{w,\nu} = -b_\nu|\vec{v}_\nu|\vec{v}_\nu$ and with opposite direction to the velocity. Generalized dissipative forces of this type may be derived in terms of the dissipative function:

$$Q_{w,k} = -\sum_{\nu=1}^{N} b_\nu\left(|\vec{v}_\nu|\vec{v}_\nu, \frac{\partial\vec{v}_\nu}{\partial\dot{q}^k}\right) = -\sum_{\nu=1}^{N}\frac{\partial}{\partial\dot{q}^k}\left[\frac{1}{3}b_\nu|\vec{v}_\nu|(\vec{v}_\nu,\vec{v}_\nu)\right]$$
$$= -\frac{\partial\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n)}{\partial\dot{q}^k}.$$

For that case dissipative function is defined as:

$$\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n) = \sum_{\nu=1}^{N}\frac{1}{3}b_\nu|\vec{v}_\nu|(\vec{v}_\nu,\vec{v}_\nu).$$

c* The dissipative forces are proportional to the $\bar{p} = 2p$, $p = 1, 2, 3, \ldots, K$-th degree of the velocity $\vec{v}_\nu$ of the corresponding material particle: $\vec{F}_{w,\nu} = -b_\nu(\vec{v}_\nu, \vec{v}_\nu)^{p-1} |\vec{v}_\nu|\vec{v}_\nu$ and with opposite direction to the velocity. Generalized dissipative forces of this type may be derived in terms of the dissipative function:

$$Q_{w,k} = -\sum_{\nu=1}^{N} b_\nu \left((\vec{v}_\nu, \vec{v}_\nu)^{p-1}|\vec{v}_\nu|\vec{v}_\nu, \frac{\partial \vec{v}_\nu}{\partial \dot{q}^k}\right) = -\sum_{\nu=1}^{N} \frac{\partial}{\partial \dot{q}^k}\left[\frac{1}{2p+1} b_\nu |\vec{v}_\nu|(\vec{v}_\nu, \vec{v}_\nu)^p\right].$$

For that case dissipative function is defined as:

$$\Phi(\dot{q}^0, \dot{q}^1, \dot{q}^2, \ldots, \dot{q}^k, \ldots, \dot{q}^n) = \sum_{\nu=1}^{N} \frac{1}{2p+1} b_\nu |\vec{v}_\nu|(\vec{v}_\nu, \vec{v}_\nu)^p.$$

d* The dissipative forces are proportional to the $\bar{p} = 2p-1$, $p = 1, 2, 3, \ldots, K$-th degree of the velocity $\vec{v}_\nu$ of the corresponding material particle: $\vec{F}_{w,v} = -b_\nu(\vec{v}_\nu, \vec{v}_\nu)^{p-1} \vec{v}_\nu$ and with opposite direction to the velocity. Generalized dissipative forces of this type may be derived in terms of the dissipative function:

$$Q_{w,k} = -\sum_{\nu=1}^{N} b_\nu \left((\vec{v}_\nu, \vec{v}_\nu)^{p-1}\vec{v}_\nu, \frac{\partial \vec{v}_\nu}{\partial \dot{q}^k}\right) = -\sum_{\nu=1}^{N} \frac{\partial}{\partial \dot{q}^k}\left[\frac{1}{2p} b_\nu (\vec{v}_\nu, \vec{v}_\nu)^p\right].$$

For that case dissipative function is defined as:

$$\Phi(\dot{q}^0, \dot{q}^1, \dot{q}^2, \ldots, \dot{q}^k, \ldots, \dot{q}^n) = \sum_{\nu=1}^{N} \frac{1}{2p} b_\nu (\vec{v}_\nu, \vec{v}_\nu)^p.$$

From previous considerations we may generalize the relation between generalized dissipative force and dissipative function:

$$Q_{w,k} = -\frac{\partial \Phi(\dot{q}^0, \dot{q}^1, \dot{q}^2, \ldots, \dot{q}^k, \ldots, \dot{q}^n)}{\partial \dot{q}^k}.$$

§ 3. Work of the dissipative forces in unit of time. Let us determine the sum $\sum_{k=0}^{n} Q_{w,k}\dot{q}^k$ for previously considered law of dissipative forces with respect to material particles velocities of the system with n degrees of freedom:

$$\sum_{k=0}^{n} Q_{w,k}\dot{q}^k = \sum_{k=0}^{n}\sum_{\nu=1}^{N}\left(\vec{F}_{w,\nu}, \frac{\partial \vec{v}_\nu}{\partial \dot{q}^k}\right)\dot{q}^k = \sum_{\nu=1}^{N}\left(\vec{F}_{w,\nu}, \sum_{k=0}^{n}\frac{\partial \vec{r}_\nu}{\partial q^k}\dot{q}^k\right)$$
$$= \sum_{\nu=0}^{N}(\vec{F}_{w,\nu}, \vec{v}_\nu) = \frac{dA^{\Sigma \vec{F}_{w,\nu}}}{dt}, \tag{3.1}$$

where $\frac{dA^{\Sigma \vec{F}_{w,\nu}}}{dt}$ is the work of dissipative forces with respect to the unit of time, or rate of dissipative energy, or power of dissipative forces.

Now, let us determine the work of dissipative forces with respect to a unite of time $\frac{dA^{\Sigma \vec{F}_{w,\nu}}}{dt}$, or power of dissipative forces for previous considered generalized cases of defined dissipative forces.

a* For the case: $\vec{F}_{w,\nu} = -b_\nu(\vec{v}_\nu,\vec{v}_\nu)^{p-1}|\vec{v}_\nu|\vec{v}_\nu$ for $\bar{p}=2p$, $p=1,2,3,\dots,K$.

$$\text{(3.2)}\quad \begin{aligned}\frac{dA^{\Sigma \vec{F}_{w,\nu}}}{dt} &= \sum_{\nu=1}^{N}(\vec{F}_{w,\nu},\vec{v}_\nu) = -\sum_{\nu=1}^{N} b_\nu((\vec{v}_\nu,\vec{v}_\nu)^{p-1}|\vec{v}_\nu|\vec{v}_\nu,\vec{v}_\nu)\\ &= -\sum_{\nu=1}^{N}[b_\nu|\vec{v}_\nu|(\vec{v}_\nu,\vec{v}_\nu)^p] = -(2p+1)\Phi(\vec{v}_1,\vec{v}_2,\vec{v}_3,\dots,\vec{v}_\nu,\dots,\vec{v}_N)\\ &= -(2p+1)\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n).\end{aligned}$$

b* For the case: $\vec{F}_{w,\nu} = -b_\nu(\vec{v}_\nu,\vec{v}_\nu)^{p-1}\vec{v}_\nu$, for $\bar{p}=2p-1$, $p=1,2,3,\dots,K$.

$$\text{(3.3)}\quad \begin{aligned}\frac{dA^{\Sigma \vec{F}_{w,\nu}}}{dt} &= \sum_{k=0}^{n} Q_{w,k}\dot{q}^k \sum_{k=0}^{n}(\vec{F}_{w,\nu},\vec{v}_\nu) = -\sum_{\nu=1}^{N} b_\nu((\vec{v}_\nu,\vec{v}_\nu)^{p-1}\vec{v}_\nu,\vec{v}_\nu)\\ &= -\sum_{\nu=1}^{N}[b_\nu(\vec{v}_\nu,\vec{v}_\nu)^p] = -2p\Phi(\vec{v}_1,\vec{v}_2,\vec{v}_3,\dots,\vec{v}_\nu,\dots,\vec{v}_N)\\ &= -2p\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n).\end{aligned}$$

By using previous and by introducing the following scalar λ we can write the following:

$$\begin{aligned}\frac{dA^{\Sigma \vec{F}_{w,\nu}}}{dt} - \sum_{i=1}^{n}\dot{q}^i\frac{\partial\Phi}{\partial\dot{q}^i} &= -\lambda\Phi(\vec{v}_1,\vec{v}_2,\vec{v}_3,\dots,\vec{v}_\nu,\dots,\vec{v}_N)\\ &= -\lambda\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n).\end{aligned}$$

This relation is relation between the power of the dissipation forces and corresponding dissipation function.

§ 4. The rate of the energy dissipation of nonconservative system having dissipative function.

4.1. Nonconservative system, with holonomic scleronomic constraints, having dissipative function. Let us consider the Lagrange's differential equations of the second kind (see Ref. [2], [7] or [8]) for nonconservative system, with holonomic scleronomic constraints, having dissipative function corresponding to the dissipative forces, and with n degree of freedom. These equations for generalized coordinates q^k, $k=1,2,3,\dots,n=3N-s$ are in the following form:

$$\text{(4.1)}\quad \frac{d}{dt}\frac{\partial E_k}{\partial\dot{q}^i} - \frac{\partial E_k}{\partial q^i} + \frac{\partial E_p}{\partial q^i} + \frac{\partial\Phi}{\partial\dot{q}^i} = 0, \quad i=1,2,3,\dots,n.$$

We multiplied equations (4.1) with $\dot{q}^i$ and summarize left side with respect to index i from 1 to n, and we obtain the following:

$$\frac{d}{dt}\left[\sum_{i=1}^{n}\left(\dot{q}^i\frac{\partial E_k}{\partial \dot{q}^i}\right)\right]-\sum_{i=1}^{n}\left(\ddot{q}^i\frac{\partial E_k}{\partial \dot{q}^i}+\dot{q}^i\frac{\partial E_k}{\partial q^i}\right)+\sum_{i=1}^{n}\dot{q}^i\frac{\partial E_p}{\partial q^i}+\sum_{i=1}^{n}\dot{q}^i\frac{\partial \Phi}{\partial q^i}=0$$

Having in mind relations (3.3), (3.1) and (3.2) previous relation we can rewrite in following form:

$$\text{(4.2)}\qquad \frac{d(E_k+E_p)}{dt}=\frac{dA^{\Sigma\vec{F}_{w,\nu}}}{dt}=-\lambda\Phi(\vec{v}_1,\vec{v}_2,\vec{v}_3,\dots,\vec{v}_\nu,\dots,\vec{v}_N)$$
$$=-\lambda\Phi(\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n),$$

where is $\lambda = 2p$, or $\lambda = 2p+1$, scalar parameter depending of previous considered special cases of defined dissipative forces and corresponding dissipative functions.

The relation of the (4.2) is generalized theorem of the rate of energy dissipation. For the previous known Rayleigh's dissipation function corresponding to the dissipation forces linearly proportional to the velocity $\vec{v}_\nu$ of the corresponding material particle this scalar parameter is equal to 2 (see Ref. [**2**] and [**7**], [**8**]).

Generalized theorem of the rate of energy dissipation I: *If in the nonlinear nonconservative mass particles system with holonomic scleronomic constraints are present dissipative forces proportional to the $\tilde{p}$-th degree of the velocity $\vec{v}_\nu$ of the corresponding material particle, than the corresponding dissipative function multiplied by $\tilde{p}+1$ is the rate of energy dissipation with respect to time.*

4.2. Nonconservative system, with holonomic rheonomic constraints, having dissipative function. Let consider extended system of the Lagrange's differential equations of the second kind (see Ref. [**7**]) for nonconservative system, with holonomic rheonomic constraints, having dissipative function corresponding to the dissipative forces, and with n degree of freedom. These equations for generalized coordinates q^k, $k = 1,2,3,\dots,n = 3N-s$, extended by rheonomic coordinate q^0 are in the following form:

$$\text{(4.3)}\qquad \frac{d}{dt}\frac{\partial E_k}{\partial \dot{q}^i}-\frac{\partial E_k}{\partial q^i}+\frac{\partial E_p}{\partial q^i}+\frac{\partial \Phi}{\partial \dot{q}^i}=0,\quad i=1,2,3,\dots,n,$$
$$\frac{d}{dt}\frac{\partial E_k}{\partial \dot{q}^0}-\frac{\partial E_k}{\partial q^0}+\frac{\partial E_p}{\partial q^0}+\frac{\partial \Phi}{\partial \dot{q}^0}=R_0,$$

where R_0 is rheonomic constraint force.

We multiplied equations (4.3) with $\dot{q}^i$ including rheonomic coordinate q^0 and summarize left side with respect to index i from 0 to n, and we obtain the following:

$$\frac{d(E_k+E_p)}{dt}=\frac{dA^{\Sigma\vec{F}_{w,\nu}}}{dt}=-\lambda\Phi(\dot{q}^0,\dot{q}^1,\dot{q}^2,\dots,\dot{q}^k,\dots,\dot{q}^n)+R_0\dot{q}^0,$$

where is $\lambda = 2p$, or $\lambda = 2p + 1$, scalar parameter depending of previous considered special cases of defined dissipative forces and corresponding dissipative functions.

Generalized theorem of the rate of energy dissipation II: *If in the nonlinear nonconservative mass particles system with holonomic rheonomic constraints are present dissipative forces proportional to the $\tilde{p}$-th degree of the velocity $\vec{v}_\nu$ of the corresponding material particle, than the difference of the corresponding dissipative function multiplied by $\tilde{p} + 1$ and product of rhenomic constraint force and derivative of the rheonomic coordinate with respect to time is the rate of energy dissipation with respect to time.*

In the other formulation: *The difference of the corresponding dissipative function multiplied by $\tilde{p}+1$ and power of the rheonomic constraints change is the rate of energy dissipation with respect to time.*

§ 5. Concluding remarks. The dissipative functions corresponding to dissipative forces proportional to the $\tilde{p}$-th degree of the velocity $\vec{v}_\nu$ of the corresponding material particle, in the nonconservative material particles system, are determined. Two generalized theorem of the rate of energy dissipation with respect to time for the material particles systems with holonomic scleronomic and rhenomic systems are defined.

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Faculty of Mechanical Engineering
University of Niš
Vojvode Tankosića, Yugoslavia
E-mail: katica@masfak.masfak.ni.ac.yu

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Appendix.

c* The dissipative forces are proportional to the $\tilde{p} = 2p$, $p = 1, 2, 3, \ldots, K$-th degree of the velocity $\vec{v}_\nu$ of the corresponding material particle: $\vec{F}_{w,\nu} = -b_\nu(\vec{v}_\nu, \vec{v}_\nu)^{p-1} |\vec{v}_\nu|\vec{v}_\nu$. Generalized dissipative forces of this type may be derived in terms of the generalized coordinates:

$$Q_{w,k} = \sum_{\nu=1}^{N} \left(\vec{F}_{w,\nu}, \frac{\partial \vec{v}_\nu}{\partial \dot{q}^k} \right)$$

$$= -\sum_{\nu=1}^{N} \frac{\partial}{\partial \dot{q}^k} \left[\frac{1}{2p+1} b_\nu \left| \sum_{i=1}^{n} \frac{\partial \vec{r}_\nu}{\partial q^i} \dot{q}^i \right| \left(\sum_{i=n}^{n} \sum_{j=n}^{n} \left(\frac{\partial \vec{r}_\nu}{\partial q^i}, \frac{\partial \vec{r}_\nu}{\partial q^i} \right) \dot{q}^i \dot{q}^j \right)^p \right],$$

$$k = 1, 2, 3, \ldots, n.$$

Dissipative function of this type may be derived in terms of the generalized coordinates:

$$\Phi(\dot q^1, \dot q^2, \dots, \dot q^k, \dots, \dot q^n) = \sum_{\nu=1}^{N} \frac{1}{2p+1} b_\nu |\vec v_\nu| (\vec v_\nu, \vec v_\nu)^p$$

$$= \frac{1}{2p+1} \sum_{\nu=1}^{N} \left[b_\nu \left| \sum_{i=1}^{n} \frac{\partial \vec r_\nu}{\partial q^i} \dot q^i \right| \left(\sum_{i=1}^{n} \sum_{j=1}^{n} \left(\frac{\partial \vec r_\nu}{\partial q^i}, \frac{\partial \vec r_\nu}{\partial q^j} \right) \dot q^i \dot q^j \right)^p \right].$$

d* The dissipative forces are proportional to the $\tilde p = 2p-1$, $p = 1, 2, 3, \dots, K$-th degree of the velocity $\vec v_\nu$ of the corresponding material particle: $\vec F_{w,\nu} = -b_\nu (\vec v_\nu, \vec v_\nu)^{p-1} \vec v_\nu$. Generalized dissipative forces of this type may be derived in terms of the generalized coordinates:

$$Q_{w,k} = \sum_{\nu=1}^{N} \left(\vec F_{w,\nu}, \frac{\partial \vec v_\nu}{\partial \dot q^k} \right) = -\sum_{\nu=1}^{N} \frac{\partial}{\partial \dot q^k} \left[\frac{1}{2p} b_\nu (\vec v_\nu, \vec v_\nu)^p \right]$$

$$= -\sum_{\nu=1}^{N} \frac{\partial}{\partial \dot q^k} \left[\frac{1}{2p} b_\nu \left(\sum_{i=1}^{n} \sum_{j=1}^{n} \left(\frac{\partial \vec r_\nu}{\partial q^i}, \frac{\partial \vec r}{\partial q^j} \right) \dot q^i \dot q^j \right)^p \right],$$

$$k = 1, 2, 3, \dots, n.$$

Dissipative function of this type may be derived in terms of the generalized coordinates:

$$\Phi(\dot q^1, \dot q^2, \dots, \dot q^k, \dots, \dot q^n) = \sum_{\nu=1}^{N} \frac{1}{2p} b_\nu (\vec v_\nu, \vec v_\nu)^p$$

$$= \sum_{\nu=1}^{N} \frac{1}{2p} b_\nu \left(\sum_{i=1}^{n} \sum_{j=1}^{n} \left(\frac{\partial \vec r_\nu}{\partial q^i}, \frac{\partial \vec r_\nu}{\partial q^j} \right) \dot q^i \dot q^j \right)^p.$$