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ON THE LIFE AND WORKS OF
EMANUELS GRINBERGS

Janis Dambitis

Computer Center
University of Latvia

translated from Latvian and reconstructed from the presentation notes by Juris Reinfelds

Abstract: Emanuels Grinbergs was one of the greatest all round mathematicians of the Baltics. In the isolation imposed by the former Soviet Union most of his remarkable results and achievements are unknown in the Western world. It is therefore fitting that the first international graph theory conference in the Baltics should review the life and achievements of this remarkable scientist whose only fault was that he did things at the wrong time and was in the wrong place with respect to two of the most brutal totalitarian regimes that overran his country in 1940 (Stalin), 1941 (Hitler) and 1945 (Stalin again). Among his unpublished major achievements are a number of remarkable results in graph theory. He independently discovered spline theory to provide a method to form the hulls of ocean going ships by cutting of flat plates into shapes that after three dimensional forming fitted together precisely enough for welding without further machining.

Emanuels Grinbergs was born in St. Petersburg on January 25, 1911, into a famous family of diplomats and artists. He entered the University of Latvia, Faculty of Mathematics and Science, in the fall semester of 1930 and graduated in 1934. In 1935 and 1936 Grinbergs studied mathematics in the Ecole Normale Supérieure in Paris, France. His research work started with studies in geometry. He wrote his first publication in German, entitled "Über die Bestimmung von zwei spezieller Klassen von Eilinien" in the *Mathematische Zeitschrift*, Volume 42, 1936.

He was elected as a faculty member (Dozent) by the University of Latvia in 1940. He lectured in Analytical Geometry, Differential Geometry, Probability Theory, Group Theory and other branches of mathematics. In 1943 he defended his doctoral thesis at the University of Latvia. The topic of his dissertation was "On Osculations, Superosculations and Characteristic Points". He was 32 years old in 1943 and the Germans drafted him into the German Army. It is not known whether Grinbergs ever fought at the front but when the Soviet Union reoccupied Latvia in 1944 his presence in the German Army (over which he had no choice) was regarded as an unforgivable sin over which he had no choice either.

After World War II Grinbergs was in Stalin's camp in Kutaisy, Georgia for about two years. When he returned to Latvia, he had to work as a janitor in the house which the Soviets had taken away from his mother. In January 1947 Grinbergs was allowed to become a factory worker in the factory "Radiotehnika"... While he worked in the factory he was interrogated for five or more hours every week by the KGB who asked endless questions about his relatives who had gone to Sweden and the USA at the end of the war.

In 1954 he was permitted to return to the University of Latvia, now renamed the State University of Latvia. He supervised graduation projects in the Faculty of Physics and Mathematics. In 1956 Grinbergs transferred to the Physics Institute of the Latvian Academy of Sciences and in the spring of 1960 he defended a doctoral thesis for the second time. This time the topic was "Problems of Analysis and Synthesis in Simple Linear Circuits".

Having achieved a doctorate acceptable to the then current political powers, Grinbergs was appointed as a senior engineer at the Computer Center of the State University of Latvia where he subsequently became a Section Leader and Chief Scientist. At last Grinbergs had an opportunity to expand his scientific work in several directions. In each direction he found new, original, non-standard approaches. His interests and capabilities were remarkably diverse. He was a master of classical as well as modern mathematics and he contributed new, original and valuable ideas to every area in which he took an interest.

His contributions to the development and reputation of the Computer Center of the State University of Latvia are many, varied and very significant. For many years most of the mathematical problems that were solved at the Computer Center contained major contributions from his work. His research interests often determined the directions in which the Computer Center chose to work. The main contributions by Grinbergs and his collaborators were:

(i) studies in the theory of electrical circuits and the practical application of these theories. Grinbergs is the founder of this line of work in Latvia. He led the research to develop original and optimal methods for the design of electronic filters. Some results are in his publications [9, 10, 12, 13, 22, 23, 27, 40, 41, 42, 46, 50, 52].

(ii) Research on nonlinear electronic circuit theory. He and his collaborators received the State Prize of the Latvian SSR for this work in 1980. Results were published in [30, 33, 34, 36, 37, 38, 39, 43, 44, 48, 49, 51].

(iii) One of the greatest achievements of the research group led by Grinbergs was the development of analytical methods to calculate planar contours of three-dimensional components of the hulls of ocean-going ships so that the steel plates could be cut as flat sheets, shaped into three-dimensional objects after cutting and welded together to form the hulls of ships with practically no machining of the joints between the components. The Computer Center of the Soviet Academy of Sciences and the Institute of Cybernetics of the Ukraine Academy of Sciences could not solve this problem but Grinbergs and his group at the Computer Center of the University of Latvia developed a computer program for the design of a tanker in 1962/1963. This method was highly acclaimed throughout the Soviet Union and used by many shipbuilding companies. The development of this method led to an independent discovery of spline theory. Due to the classified nature of this work the spline theory results were never published but only appear in technical reports [16].

Grinbergs studied actuarial problems [6, 7] and numerical methods in

the analysis of Markov processes [28, 29]. His work in geometry is published in [1, 2, 3, 4, 5, 11]; he also has papers in magnetic hydrodynamics [14], in telephony [15, 29, 21], in operations research [26] and in modelling problems in oil exploration and oil-field exploration [25]. His unpublished archives contain studies in the applications of mathematics in medical research [35]. His manuscripts on studies of blood circulation and composition problems have not yet been edited and made available to the public. Grinbergs also took an active interest in the problems associated with the teaching of mathematics [18]. Archives contain interesting materials written in the 1930's and 1960's.

His work in graph theory and in combinatorics has been widely recognized. In addition to his publications in this field his archives contain many unpublished results. We will mention several of his published and unpublished results in this area. The editing work on his unpublished archives of over 20,000 pages of documents has not been completed. Here are brief descriptions of some of his graph theory results.

Coloring of the nodes of unoriented graphs [17] with co-author I. Ilzina. Papers written in response to some practical problems that are equivalent to the coloring of the nodes of a graph. His method is similar to the ideas expressed by H. Yambe and D. Pope "A Computational Approach to the Four Colour Problem".

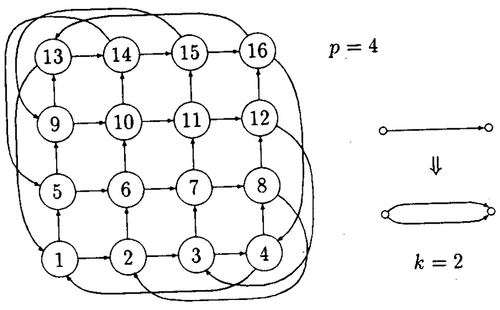
His paper on cubic non-Hamiltonian graphs [24] determines a necessary condition for the existence of a Hamiltonian cycle in a planar graph. He used this condition to construct graphs without Hamiltonian cycles. The condition is formulated as a theorem:

If a planar graph G contains a Hamiltonian cycle H then every planar realization of G has a plane representation in which the edges are partitioned into two subsets with the Hamiltonian cycle H as the boundary.

The theorem permits the construction of non-Hamiltonian planar graphs as well as Hamiltonian planar graphs which do not have H as the boundary of the partitioning. For a recent practical reference to this theorem, see Ian Stewart, "Murder at Ghastleigh Castle", *Scientific American*, October 1992, pp. 118–120.

The paper on "Some Properties of Digraphs with Cycles" [20] examines graphs that contain cycles and defines two operations that remove the cycles. Hungarian mathematician A. Adams has independently proved this result.

The construction of complete Steiner Triple Systems [45] with B. A. Ikauniece develops a method to construct Σ_{13}, Σ_{15}, and Σ_{19}. These results confirm the hypothesis of J. Doyen published in *Proc. American Math. Soc.*, **32** (1972) 409–416.



G_4

Figure 1. A Counterexample to the Conjecture of Adams

The paper "A class of counterexamples to the Adams problem" was published posthumously in the *Latvian Mathematical Yearbook*, pp. 128–138 in 1987. It is therefore not listed in his publication list. A. Adams published a conjecture that every tournament with cycles has an arc whose reversal results in a tournament with fewer cycles. Grinbergs defines a special class of oriented graphs whose nodes lie

on a mesh as shown in Figure 1. Let p be the number of vertical lines in the mesh and call the corresponding graph G_p. Figure 1 shows G_4. Then for $p = 4$ Grinbergs replaces every arc (a, b) with $k = 2$ parallel arcs producing a graph that is a counterexample to the conjecture of Adams.

"The use of some invariant characteristics for the determination of graph isomorphism". [47] with A. Kaca, develops further an idea of M. K. McCarthy and G. I. David to place the nodes of a graph into equivalence classes using as an invariant the number of geodesics (paths of minimum length). The method has complexity $O(n^4)$.

"The number of partitioning coverings of complete graphs" is an unpublished manuscript found in 1990. Grinbergs first mentioned this theorem in his lectures in September 1971. The work was completed without the help of a computer in about 1975.

"On geodetic graphs" is an unpublished manuscript found in 1990 containing results obtained in the mid-seventies. Two problems are studied in this paper:

(i) If edge (a, b) of a geodetic graph belongs to a cycle then every shortest cycle containing (a, b) contains an odd number of edges.

(ii) In a geodetic graph, each basis of linearly independent cycles of minimal total length contains only cycles of odd length.

The paper describes a method for converting a cycle of length $2b$ with $b = 3, 4, \ldots$ into a geodetic graph with nodes of order greater than two. If $b = 3$ then such a cycle can produce the Petersen graph.

"On three-connected graphs with one Hamiltonian cycle" is an unpublished manuscript describing work done in the late seventies on the construction of triply connected graphs. A graph G contains a a-triple $\langle x, y, z\rangle$ if G contains three nodes x, y and z such that

(i) there is a unique Hamiltonian path between nodes x and y;

(ii) there is no Hamiltonian path between nodes x and z;

(iii) either G is triply connected or it becomes triply connected through the addition of a new node t and new edges (t, x), (t, y) and (t, z).

Grinbergs showed that from two graphs with s-triples $\langle x, y, z \rangle$ and $\langle x', y', z' \rangle$ we can obtain a graph with only one Hamiltonian cycle if we add edges (x, y'), (y, x'), (z, z'). Also, a graph that contains one Hamiltonian cycle becomes a graph containing an s-triple by the removal of two edges. Therefore it is possible to construct arbitrarily large graphs with only one Hamiltonian cycle.

Bibliography

The study and analysis of the extensive archives left by E. Grinbergs continues and some interesting results and manuscripts may still be added to his bibliography in the future. Here we give an list of his publications (with the titles translated into English) as they appear in the *Latvian Mathematical Yearbook* Vol. 27, pp. 14–16 (1983).

1. The determination of two special classes of ovals. *Math. Zeitschrift* **42** (1936) 51–57 (in German).
2. On some transformations in elementary geometry. *Latv. Matem. Kongr.* Riga (1936) 21–36 (in Latvian).
3. *On curves in n-dimensional euclidean space.* Latv. Univ., Raksti (1937) (in Latvian).
4. *On the volumes of polyhedra.* Latv. Univ., Raksti (1940) Part 1, 7–9 (in Latvian).
5. On osculations, superosculations and characteristic points. Doctoral Dissertation. Latv. Univ. (1943) (in Latvian).
6. On the characterization of birth rates, death rates and natural population growth. *Ž. Latv. Ekonomists* (1943) N 13/14 (in Latvian).
7. On the numerical development of population with constant birth and death rates. *Ž. Latv. Ekonomists* (1943) N 23/24 (in Latvian).
8. *Calculation methods for passive electronic circuits*, N 23/24. Riga (1956) 3–19 (in Russian).
9. The analysis and synthesis of simple multicontour filters. *Izv. AN Latv. SSR* (1957) N 1, 149–159 (in Russian).

10. The analysis and synthesis of multicontour filters. *Sb. tr. NTORiE im. A. S. Popova.* Moscow (1958) 50–57 (in Russian).
11. On a problem of geometric variations. *Uch. Zap. LGU* **20** (1958) 153–164 (in Russian).
12. The analysis and synthesis of simple linear circuits. Summary of doctoral dissertation. Leningrad (1959) (in Russian).
13. A method to synthesize circuits from given impedances. *Izv. AN Latv. SSR* (1960) N 10, 79–86 (with L. Z. Kacnelson, in Russian).
14. The determination of some properties of potential fields. *Prikl. Magnito-Gidrodinamika* (1961) N 12, 147–154 (in Russian).
15. On lost flow properties in telephone communications. *Uch. Zap. LGU* **47** (1963) 253–260 (with M. A. Schneps, in Russian).
16. On the analytical definition and alignment of ship hull component boundaries. *Trudy CNIITS* **52** (1964) 3–40 (4 co-authors, in Russian).
17. On the coloring of the nodes of unoriented graphs. *Avtomatika i vychislit. tehnika* **7** (1964) 143–153 (with I. P. Ilzina, in Russian).
18. On an experiment in programmed learning. *Uch. Zap. LGU* **69** (1964) 143–155 (with M. A. Schneps, in Russian).
19. On applications of the integral form of Erlang's formula. *Sistemy upravlenija i kommutacii.* Nauka, Moscow (1965) 47–49 (with M. A. Schneps, in Russian).
20. On properties of graphs with cycles. *Latv. mat. ezhegodnik* **2** (1966) 65–70 (with J. J. Dambitis, in Russian).
21. An estimate of maximal loss difference on the exchange of two components. *Latv. mat. ezhegodnik* **2** (1966) 71–78 (with G. L. Yonin, in Russian).
22. The algebraic construction of Chebyshev's isoextremal components in the synthesis of optimal electronic fluctuations in filters. *All-Union Symposium on Applied Mathematics and Cybernetics.* Gorkij (1967) 37 (3 co-authors, in Russian).
23. The algebraic construction of Chebyshe's isoextremal components. *Latv. mat. ezhegodnik* **3** (1968) 89–100 (with L. Z. Kacnelson, in Russian).

24. On plane cubic graphs without Hamiltonian circuits. *Latv. mat. ezhegodnik* **4** (1968) 51–58 (in Russian).

25. On the determination of temperature fields when hot water is pumped into a three-layered environment. *Teorija i praktika dobychi nefti.* Nedra, Moscow (1968) 271–280 (11 co-authors, in Russian).

26. On an optimal management problem in manufacturing. *Latv. mat. ezhegodnik* **7** (1970) 47–57 (3 co-authors, in Russian).

27. An algebraic structure of Chebyshev isoextremals for the design of electrical circuits. *Latv. mat. ezhegodnik* **8** (1970) 43–66 (with L. Z. Kacnelson, in Russian).

28. Analysis of Markov processes. I. Classification of states. *Trudy vsesojuznogo NII med. priborostroenija* **1** (1971) 37–44 (in Russian).

29. Analysis of Markov processes. II. Computational algorithms. *Trudy vsesojuznogo NII med. priborostroenija* **1** (1971) 45–52 (in Russian).

30. Automated analysis system of models of integrated circuits in FORTRAN (ASAMS-F) *4th All-Union Conference on Theory and Methods of Computing Non-Linear Electrical Circuits and Systems.* Tashkent (1971) Part 1, 128–129 (10 co-authors, in Russian).

31. Numerical analysis of models of semiconductor circuits. *4th All-Union Conference on Theory and Methods of Computing Non-Linear Electrical Circuits and Systems.* Tashkent (1971) Part 1, 129–131 (7 co-authors, in Russian).

32. A review of the works of E. Arins in mathematics and cybernetics. *Latv. mat. ezhegodnik* **11** (1972) 220–224 (3 co-authors, in Russian).

33. A system for the analysis of electronic circuits. *All-Union Conference "Automating the Design of Computers".* Moscow (1972) 105–106 (10 co-authors, in Russian).

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39. An analysis system for integrated circuits and intercircuit connections. *Latv. mat. ezhegodnik* **14** (1974) 22–35 (10 co-authors, in Russian).

40. Application of Chebyshev's isoextremal components to the optimal design of electronic circuits. *Izbiratel'nye sistemy s obratnoj svjaz'ju.* Taganrog (1974) 215–216 (with L. Z. Kancelson and M. M. Neizvestnyj, in Russian).

41. Application of Chebyshev's isoextremal components to the optimal design of electronic circuits. *Conference "Automating Industrial Design using Computers".* Zaporozhye (1974) 23–27 (with L. Z. Kancelson and M. M. Neizvestnyj, in Russian).

42. Optimal filter design using Chebyshev's isoextremal components. *Tez. Dokl. LatINTI.* Riga (1974) 15–19 (with L. Z. Kancelson and M. M. Neizvestnyj, in Russian).

43. Computer analysis of electronic circuits. *All-Union Conference on Problems of Improving the Design of Radio Systems and Their Elements.* Minsk (1975) 176–177 (10 co-authors, in Russian).

44. Automated electronic circuit optimization system. *All-Union Conference on Problems of Improving the Design of Radio Systems and Their Elements.* Minsk (1975) 178–179 (7 co-authors, in Russian).

45. On the construction of complete systems of Steiner triples. *Voprosy Kibernetiki* **16** (1975) 21–29 (with B. A. Ikauniece, in Russian).

46. On the construction of Chebyshev's isoextremal components of all types for the optimal design of electronic filters. *Radiotehnika i elektronika*. Riga (1977) 103–109 (with L. Z. Kancelson and M. M. Neizvestnyj, in Russian).
47. On the determination of graph isomorphism using some characteristic invariants. *Latv. mat. ezhegodnik* **21** (1977) 124–135 (with A. Kaca, in Russian).
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(ii) A class of counterexamples to the conjecture of Adams.
(iii) On the number of partitioning coverings of complete graphs.
(iv) On geodetic graphs.