Review of the book by E. A. Barbashin "Introduction to the Theory of Stability"

Authors: Yu. S. Bogdanov, V. A. Pliss

Date: 1967-01-01T00:00:00+00:00

Abstract

Full Text

Preamble

DIFFERENTIAL EQUATIONS, DECEMBER 1967, VOLUME III, NO. 12 CRITIQUE AND BIBLIOGRAPHY

E. A. Barbashin, "Introduction to the Theory of Stability." Nauka Publishing House, Main Editorial Office for Physics and Mathematics Literature. Moscow, 1967. 224 pages with illustrations. Circulation: 20,000 copies.

Review

The monograph by E. A. Barbashin is devoted to several central issues in the theory of stability of motion, specifically those relating to the primary new directions in the modern development of this vital field of applied mathematics. Written by one of the leading researchers in the field and reflecting the most recent results, the monograph is undoubtedly highly useful for all specialists—mathematicians, mechanicians, physicists, and engineers—dealing with stability problems. This is the first time the core material of the reviewed book has been published in the form of a monograph.

The work is characterized by a broad perspective on the subject. The author provides a sufficiently general and compact mathematical treatment of the problems and research methods under consideration. At the same time, practical needs are carefully taken into account throughout the entire book. Both in content and form, the material is naturally divided into three chapters.

The first chapter provides a general formulation of the problem of stability of motion and a brief outline of the Lyapunov function method. Moving away from the traditional presentation of stability theory based on first approximations and small parameter methods, the author transitions to the problem of

the stability of nonlinear systems under arbitrary initial perturbations. This problem constitutes the main subject of the first chapter. The author identifies modifications of Lyapunov' s methods—most of which were developed by the author himself—that have played a significant role in the theory of stability of motion as a whole. The importance of these theorems is well known: nearly every successful attempt to construct functional Lyapunov functions for nonlinear systems necessitates reliance on these modified criteria. These general criteria are consistently accompanied by effective methods for constructing specific Lyapunov functions; in particular, the author' s elegant "method of separation of variables" deserves special mention. The theoretical material is illustrated and supported by substantial examples, each of which holds considerable independent interest and originated from various engineering problems. The originality of the presentation in the first chapter is noteworthy, as it remains accessible to a very wide range of readers.

The second chapter is of particular interest from an applied standpoint. It examines the selection of control forces that ensure the stable and high-quality operation of a regulated system described by ordinary differential equations in normal form with discontinuous right-hand sides. Thus, this section presents a branch of the general mathematical theory of optimal stabilization, which has developed rapidly in recent years at the intersection of the calculus of variations and the qualitative theory of differential equations. The author considers a limited range of tasks, primarily related to the synthesis of optimal systems with variable structures characterized by sliding modes. The author succeeds in providing a very deep analysis of the problem, which is attractive both for its skillful overcoming of difficulties associated with the extreme irregularity of discontinuous differential equations and for its definitive conclusions that allow for effective numerical solutions. The latter is especially significant because the systems under consideration, combining the advantages of optimality with feasibility, find important applications in problems related to modern technology.

The third chapter is devoted to the stability problems of systems described by an apparatus of a higher rank than ordinary differential systems. Here, the focus is primarily on linear and quasi-linear systems whose motions are considered in Banach spaces. By interpreting a linear stable object as a system performing a bounded linear operation on an input signal, and naturally incorporating relevant concepts from functional analysis, the author offers an exceptionally successful interpretation of the entire problem. On this basis, a fruitful and compact theory is constructed, unifying from a single perspective various concepts that play a fundamental role in the theory of stability of motion. This section includes the theory of stability with respect to instantaneous perturbations, the theory of stability under constantly acting perturbations, and, finally, the theory of implementing stable programmed motions. In the latter case, which is highly important for applications, the author has developed effective solution methods based on the requirements of the proximity of the corresponding differential operators. The third chapter will undoubtedly be of great interest to any specialist working in the qualitative theory of differential equations and related

fields of mathematics and mechanics.

E. A. Barbashin' s monograph, *Introduction to the Theory of Stability*, contains exceptionally well-selected and organized material presented with great skill. The book provides important new results and offers a unified presentation of refined results previously published disparately in journals. This work represents a new milestone in the modern theory of stability of motion.

Yu. S. BOGDANOV, V. A. PLISS

Figures

DIFFERENTIAL EQUATIONS

DECEMBER 1967, VOLUME III, No. 12

CRITICISM AND BIBLIOGRAPHY

E. A. Barbashin, "Introduction to the Theory of Stability". Publishing House "Nauka". Main Editorial Office of Physics and Mathematics Literature. Moscow 1967. 224 pages with illustrations. Circulation 20,000 copies.

Review

Monographic E. A. Barbashina посвящена ряду центральных вопросов теории устойчивости движения, относящихся к основным новым направлением современного развития этой актуальной области прикладной математика. Написанная одним из ведущих исследователей и отражающая самые последние результаты, монография бесспорно весьма полезна для всех специалистов: математиков, механиков, физиков, инженеров, имеющих дело с задачами об устойчивости. Весь основной материал излагается в форме монографии зверома.

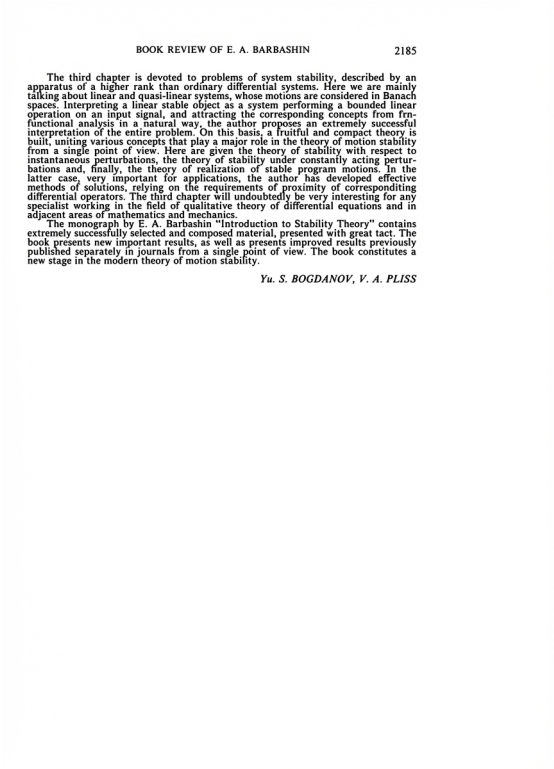
Монографии присуста широта взгляда на предмет. Автор придает рассматриваемым проблемам и методам их исследования достаточно общую и компактную математическую трактовку. Вместе с тем на протяжении всей книги внимательно учитываются практические нужды.

Материал книги и по содержанию и по форме естественно разделяется на три части—главы.

В первой главе дана общая постановка задачи об устойчивости движения к круткий очерк метода функций Ляпунова. Далее, уклонясь от традиционного изложения теории устойчивости по вервому пробликтению и методов малого параметра, автор переходит к кроблеме устойчивости нелинейных систем при любых малальных возмущениях. Эта проблема и составляет главный предмет первой славы. Автор указывает модификация методов Ляпунова, а большей части принадлежащие самому автору и сыгравшие значительную роль в теории устойчивости движения в целом. Важния роль этих теорок объяснкется, как извество, тем, что почти любая удавшаяся попытах построения работоспособных функций Ляпунова для нелинейных систем приводит к необходимости опереться на указанные модифицированные критерии. Общие критерии построенно сопровождаются в плого эффектными методами построения аппретных функций Ляпунова, причем следует специально упомянуть изящный метод автора, названный им способом разделения переменных. Весь теоретический материал такжт проллюстрирован и подкреплен содержательными примерами, каждый из которых имеет немалый самостаятельный интерес и возник на той или иной инженерной проблемы. Следует отметить ороглальность изложения первой славы, советающуюся с доступностью ее для самого широкого круга читателей.

Вторая глава представляет особый интерес с точки зрения приложений. Здесь разбирается вопрос о выборе управляющих сил, которые обеспечивают устойчивую и высококачественную работу регулируемой системы, описываемой обыкновенными дифференциальными уравнениями в нормальной форме с разрывными правыми частями. Таким образом, здесь падается один из разделов общей математической теории оптимальной стабилизации, бурно развивающейся в последние годы на стыке внутреннего печения и качественной теории дифференциальных уравнений. Автор рассматривает ограниченный круг задач, связанных сханым образом с проблемой синтеза оптимальных систем с переменной структурой, характеризуемых соответствии режимами. При этом автору удалось дать весема глубокий анализ изучаемой проблемы, привлекательный как искусным преодолением трудностей, связанных с крайней перегулярностью разрывных дифференциальных уравнений, так и окончательным выводами, позволяющими довести эффективные решения до числа. Последнее особенно существенно автому, что рассматриваемые системы, соединив достоинства оптимальность с реализуемостью, находит важные применения в задачах, связанных с новой техникой.

Figure 1: Figure 1



The third chapter is devoted to problems of system stability, described by an apparatus of a higher rank than ordinary differential systems. Here we are mainly talking about linear and quasi-linear systems, whose motions are considered in Banach spaces. Interpreting a linear stable object as a system performing a bounded linear operation on an input signal, and attracting the corresponding concepts from frn-functional analysis in a natural way, the author proposes an extremely successful interpretation of the entire problem. On this basis, a fruitful and compact theory is built, uniting various concepts that play a major role in the theory of motion stability from a single point of view. Here are given the theory of stability with respect to instantaneous perturbations, the theory of stability under constantly acting pertur-bations and, finally, the theory of realization of stable program motions. In the latter case, very important for applications, the author has developed effective methods of solutions, relying on the requirements of proximity of corresponditing differential operators. The third chapter will undoubtedly be very interesting for any specialist working in the field of qualitative theory of differential equations and in adjacent areas of mathematics and mechanics.

The monograph by E. A. Barbashin "Introduction to Stability Theory" contains extremely successfully selected and composed material, presented with great tact. The book presents new important results, as well as presents improved results previously published separately in journals from a single point of view. The book constitutes a new stage in the modern theory of motion stability.

Yu. S. BOGDANOV, V. A. PLISS

Figure 2: Figure 2