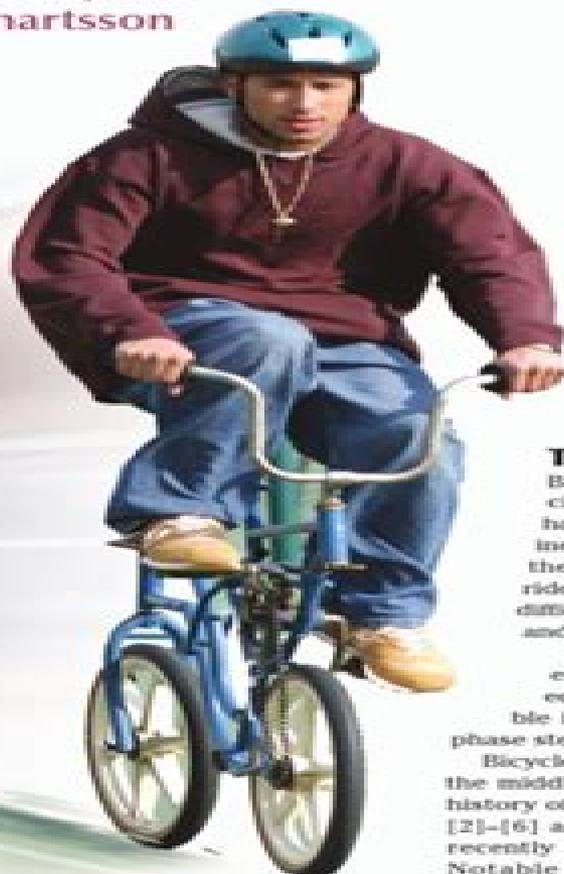


Bicycle Dynamics and Control

By Karl J. Åström,
Richard E. Klein, and
Anders Lennartsson

Adapted bicycles for
education and research



This article analyzes the dynamics of bicycles from the perspective of control. Models of different complexity are presented, starting with simple ones and ending with more realistic models generated from multibody software. We consider models that capture essential behavior such as self-stabilization as well as models that demonstrate difficulties with rear wheel steering. We relate our experiences using bicycles in control education along with suggestions for fun and thought-provoking experiments with proven student attraction. Finally, we describe bicycles and clinical programs designed for children with disabilities.

The Bicycle

Bicycles are used everywhere—for transportation, exercise, and recreation. The bicycle's evolution over time has been a product of necessity, ingenuity, materials, and industrialization. While efficient and highly maneuverable, the bicycle represents a tantalizing enigma. Learning to ride a bicycle is an acquired skill, often obtained with some difficulty; once mastered, the skill becomes subconscious and second nature, literally just “as easy as riding a bike.”

Bicycles display interesting dynamic behavior. For example, bicycles are statically unstable like the inverted pendulum, but can, under certain conditions, be stable in forward motion. Bicycles also exhibit nonminimum phase steering behavior.

Bicycles have intrigued scientists ever since they appeared in the middle of the 19th century. A thorough presentation of the history of the bicycle is given in the recent book [1]. The papers [2]–[6] and the classic book by Sharp from 1896, which has recently been reprinted [7], are good sources for early work. Notable contributions include Whipple [4] and Carvallo [5], [6], who derived equations of motion, linearized around the

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1 Introduction Bicycle Dynamics

J. I. Woodfill



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Advances in Dynamics of Vehicles on Roads and Tracks II Anna Orlova, David Cole, 2022-08-08 This book offers a snapshot of the latest research and developments in road and railway vehicle dynamics Gathering peer reviewed contributions to the 27th Symposium of the International Association of Vehicle System Dynamics IAVSD held online on August 17 19 2021 from Saint Petersburg Russia it offers extensive information for both researchers and professionals in the field of ground vehicle dynamics control and design It covers cutting edge methods and solutions for solving ground vehicle system dynamics related problems concerning control and monitoring performance safety and braking of road and rail vehicles including electric and autonomous ones Further it reports on significant advances in vehicle design and important applications to improve ride comfort Overall the book provides academics and professional with a timely reference guide on theories and methods to understand analyze and improve vehicle stability and dynamics in a broad range of different operating conditions Chapter Experimental Validation of a Semi physical Modelling Approach of the Influence of Tyre Rotation on the Vertical Tyre Force Transmission and Tyre Kinematics is available open access under a Creative Commons Attribution 4 0 International License via link [springer.com](https://www.springer.com) *16th International Symposium on Advanced Vehicle Control* Giampiero Mastinu, Francesco Braghin, Federico Cheli, Matteo Corno, Sergio M. Savaresi, 2024-10-03 This open access book highlights the latest advances innovations and applications in the field of vehicle systems dynamics and control as presented by leading international researchers at the 16th JSAE International Symposium on Advanced Vehicle Control AVEC held at Politecnico di Milano Milan Italy on September 2 6 2024 It covers a diverse range of topics such as vehicle dynamics theory steering brake tire suspension chassis control powertrain electrified vehicles stability enhancement systems driver vehicle systems advanced driver assistance systems and automated driving systems driving simulator dynamics and control The contributions which were selected by means of a rigorous international peer review process present a wealth of exciting ideas that will open novel research directions and foster multidisciplinary collaboration among different specialists

Advances in Nonlinear Dynamics Walter Lacarbonara, Balakumar Balachandran, Michael J. Leamy, Jun Ma, J. A. Tenreiro Machado, Gabor Stepan, 2022-03-01 This second of three volumes includes papers from the second series of NODYCON which was held virtually in February of 2021 The conference papers reflect a broad coverage of topics in nonlinear dynamics ranging from traditional topics from established streams of research to those from relatively unexplored and emerging venues of research These include Nonlinear vibration control Control of nonlinear systems and synchronization Experimental dynamics System identification and SHM Multibody dynamics *Evolutionary Computation in Combinatorial Optimization* Christian Blum, Gabriela Ochoa, 2014-08-21 This book constitutes the refereed proceedings of the 14th European Conference on Evolutionary Computation in Combinatorial Optimization Evo COP 2014 held in Granada Spain in April 2014 co located with the Evo 2014 events Euro GP Evo BIO Evo MUSART and Evo Applications The 20 revised full

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Robots XV Howie M. Choset, Douglas Whitney Gage, Matthew R. Stein, 2001 **5th International Conference on
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