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Experimental Characterization and Modelling of Bicycles for Safety, Efficiency, and Performance

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Bicycle engineering increasingly requires a rigorous integration of experimental methods, modelling techniques, and design-oriented interpretation in order to improve safety, efficiency, and dynamic performance. Experimental characterization of bicycle tyres, which are treated as key subsystems governing stability, handling, rolling efficiency, and rider safety is outmost important. Bicycle dynamics cannot be reliably assessed without accurate measurements of tyre properties under representative operating conditions, including variations in vertical load, inflation pressure, camber angle, and slip. New indoor facilities were designed to measure rolling resistance and lateral tyre characteristics with a level of control and repeatability not achievable in conventional road testing.

These experimental platforms provided a sound basis for the calibration of physically meaningful models. The resulting method supports not only the analysis of racing and urban bicycles, but also the study of electric bicycles, whose wider load variability makes tyre characterization especially important. Recent studies extend this framework to thermal effects, showing that tyre temperature substantially influences mechanical response and therefore bicycle handling.

In this sense, the bicycle is addressed not merely as a lightweight vehicle, but as a coupled mechanical system in which tyre behaviour, operating conditions, and vehicle dynamics must be investigated concurrently for the design of safer, more efficient, and better-performing bicycles.

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