

**TREATISE ON THE MECHANICS OF
ENGINEERING AND MACHINERY.
IN THREE VOLUMES. VOL. I:
THEORETICAL MECHANICS**

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Treatise on the Mechanics of Engineering and Machinery. In Three Volumes. Vol. I: Theoretical Mechanics by Julius Weisbach

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JULIUS WEISBACH

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TREATISE
OF
THE MECHANICS
OF
ENGINEERING AND MACHINERY,

WITH
REQUISITE ANALYTICAL INSTRUCTIONS
FOR THE USE OF
POLYTECHNIC INSTITUTES AND FOR THE REFERENCE OF
ENGINEERS, ARCHITECTS, MACHINISTS, &c.

BY JULIUS WEISBACH, PH.D.,

COUNSELLOR OF MINES AND PROFESSOR IN THE ROYAL SCHOOL OF MINES, FREIBERG, SAXONY;
KNIGHT OF THE SAXON ORDER OF MERIT, AND OF THE RUSSIAN IMPERIAL ORDER
OF ST. ANNE; CORRESPONDING MEMBER OF THE IMPERIAL ACADEMY OF
SCIENCES AT ST. PETERSBURG; HONORARY MEMBER OF THE
SOCIETY OF GERMAN ENGINEERS, &c.

Translated from the Fourth Revised and Enlarged German Edition.

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(GRAND DUKE OF BADEN).

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PREFACE TO THE SECOND AMERICAN EDITION.

DR. WRISBACH's treatise on the "Principles of Mechanics" is too well known to demand any explanation of its merits at the present time. The fact that it has been translated into at least four modern languages, is sufficient proof that it supplies a want long felt by scientific men, and a decided acknowledgment of its superiority over all other works of its kind. The practical engineer here finds not only the results of continued and profound study, but is also enabled, by the clearness and precision of the author's reasonings, to review each and every step leading to those results.

The first American edition of the above work was issued in 1848, and the fact of its having been a long time out of print, while the necessity for such a work is constantly increasing, is the only consideration which has prevailed upon the translator to undertake a work requiring so much careful labor, and involving so great a responsibility. In the meantime, the original has reached its *fourth* edition, and has, by virtue of constant developments in the field of science, assumed much larger proportions. The prefaces of the author to the different editions are sufficiently explicit in regard to the nature and object of the original work, and as the translator has only sought an accurate reproduction of the same, no additional explanations are necessary.

The only essential difference between the original and the translation is the occasional substitution of the English, for the German and French, weights and measures. Yet, in all cases, the original co-efficients have been given, so that recourse may be had to them by the student, and a familiar

acquaintance with the modes of foreign calculations thus maintained. It is evident that readiness in transposing from foreign systems of computation to our own should be possessed by the practical engineer and machinist; for foreign calculations are constantly copied into our scientific publications.

Especial pains have been taken to retain the clear and accurate style of the erudite author, and if the present edition shall occupy in our country the position which the work has taken in Europe, the most sincere wish of the translator will have been attained.

AUTHOR'S PREFACE TO THE FIRST EDITION.

It is not without some hesitation that I present the First Volume of my elementary treatise on the "Mechanics of Engineering and Machinery" to the public. Although I am conscious of having composed this work with the greatest care and deliberation, I am, nevertheless, apprehensive of not having been able to satisfy the demands of all; in fact, the views and requirements of different individuals are so various as to render my task peculiarly difficult. Some will find one or another chapter too minute, whilst others will find the very same too short; some will require a more scientific treatment of certain subjects, which others would have desired to have had presented in a more popular manner. But many years of study, much experience in teaching, and manifold observation, have indicated to me the method according to which I have prepared the present work, and which I have considered the most suitable for the intended purpose.

My principle aim while preparing this work has been to attain the greatest simplicity in enunciation and proof, and to solve all important problems by means of the elementary mathematics only. When we consider the manifold knowledge to be acquired by engineers and machinists before they become capable in their departments, it is our duty as instructors, to simplify in our explanations the fundamental studies of science, by eschewing all superfluities, and by the application of the best known and most accessible auxiliaries. I have, therefore, in the present work, entirely avoided the application of the differential and integral calculus; for although the facilities for learning these methods are no longer rare, it is, nevertheless, an unquestionable fact that without constant practice the nec-

essary readiness in using them is very soon lost, and there are, therefore, many practical men, otherwise very efficient, who have forgotten how to apply them. As I am not of the same opinion as those authors who, in popular works, give the results of the more difficult problems without proofs, I have preferred to prove those which are practically important in an elementary, although sometimes prolix manner. Hence, in this work, a formula is seldom given without its derivation. Some general knowledge of certain laws of natural philosophy, and especially, a fundamental knowledge of pure elementary mathematics, is of course to be assumed in the study of this work. I have particularly endeavored to observe the just medium between *generalization* and *specialization*; for although I am not ignorant of the advantages of the former, I am, nevertheless, of the opinion that, in this, as in every elementary work, too much of it should be avoided. In practice, examples of a simple character occur more frequently than complicated ones. It is also not to be denied that, in comprehensive examples, the simple and fundamental principles are frequently out of sight, and that it is often easier to derive the compound from the simple than the simple from the compound.

This work should not be mistaken for a treatise on the construction of machines, as it is merely an introduction to the latter. Mechanics should hold the same relation to the science of the construction of machines, as descriptive geometry to the drawing of machines. After the knowledge of mechanics and descriptive geometry has been acquired, it seems most advantageous to combine the instruction on the construction and drawing of machines in one course.

There may perhaps be a doubt of the advantage of dividing this work into theoretical and practical parts; but if we consider that it is to impart instruction on all the mechanical relations in the science of architecture and machinery, the utility, or rather the necessity, of this division becomes obvious. In order to be able to judge properly of any construction, partic-

ularly of a machine, the most diverse knowledge of the laws of mechanics, as the laws of friction, strength, inertia, impact, efflux, &c., is requisite; therefore, the material for the comprehension of architecture or machinery must be gathered from nearly all the departments of mechanics. Now as it is in practice much more advantageous to study the mechanical principles of each machine in connection than to be obliged to collect them from the various departments of mechanics, the utility of the adopted division seems beyond doubt.

Having the practical application of principles constantly in view, I have sought, as far as possible, to illustrate the doctrines advanced with appropriate examples, and I can also assert that, in the great number and appropriate selection of worked examples, this work excels many others of a similar nature. I also hope that the large number of carefully executed figures will be of great service in the study of this work.

Especial attention has been devoted to the accuracy of the calculations, each example having been worked by three different persons; and it seems, therefore, hardly possible to discover any considerable errors in the same. A careful inspection of the drawings will convince the student that they have been executed with much care; in a subject of equal magnitudes, the dimensions of breadth or depth are, as a rule, made to appear only half as great as those of length and height.

Finally, it is necessary to inform the reader that he will, in this work, find much that is new, and much that is peculiar to the author. Omitting many lesser articles which occur in almost every chapter, I will call the attention of the student to the more comprehensive subjects. A universal and easy method of finding the centre of gravity of plane surfaces and plane-surfaced polyhedra may be found at §§ 107, 112, and 113; an approximate formula for the catenary at § 148; and supplements to the theory of the friction of axes at §§ 167, 168, 169, 172, and 173. The doctrine of impact has received essential