laws, Rossi had brief stops in Copenhagen, Manchester, and Chicago before taking up a position at Cornell. Soon after his arrival in the United States, he made the first determination of the lifetime of the muon (mesotron, in those days).

As with many European émigré scientists, there was an interlude for Rossi in Los Alamos, where his coincidence circuitry again proved useful, but it is clear that he was glad to return to academic life, to a position at M.I.T., where he was able to resume his cosmic ray work. His cloud chamber group was one of the leaders during the 1945–55 period, when much of the attention of cosmic ray workers was directed to studying the interactions of the cosmic ray particles and elucidating the properties of the newly discovered V-particles. A natural extension was the investigation of the highest-energy particles and their interactions, through the extensive air showers they produce. Then, a few years later, Rossi went into space physics, with a plasma probe on Explorer 10. Still one more area was opened up when Rossi, with colleagues in American Science & Engineering, a small company he had helped found, discovered the first nonsolar x-ray sources during a rocket flight.

Rossi's influence has been widely felt. The names of his associates that flow through these pages are in themselves an impressive testimonial. Rossi makes modest mention of his books—on high-energy particles, optics, and cosmic rays—but his clarity of exposition is well known. His 1941 review paper with Greissen stood as a bible of high-energy particles until the appearance of his book on the subject, which still, after nearly 40 years, has one of the best introductions to the electromagnetic interactions. From his similarly brief mention of the International Cosmic Ray Conference at Bagneres-de-Bigorre in 1953, one would not guess that his review presented at the closing session was one of the conference highlights, bringing clarity to a truly confused situation in particle physics.

We are fortunate to have these reminiscences, for they describe a time that now seems far gone, an age of innocence (as Rossi aptly terms it) before particle physics was taken over by the accelerators and before space physics had grown to its present proportions. If I have a regret after reading this book, it is that it is too short. It would have been good to have more of Rossi's recollections of the departments where he worked, of the people there, of the selection process for university chairs. There are glimpses—vignettes of Bologna, Padua, and Florence—that remind me of Born's memoirs, evoking a very different time, a different pace of research. There is a charming postscript from Nora Rossi. In all, this is a fascinating document, not only for those of us who have also worked with cosmic rays but for everyone with an interest in the history of 20th-century physics.

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Kinetostatics

Freedom in Machinery. Vol. 2, Screw Theory Exemplified. JACK PHILLIPS. Cambridge University Press, New York, 1990. xiv, 251 pp., illus. $85.

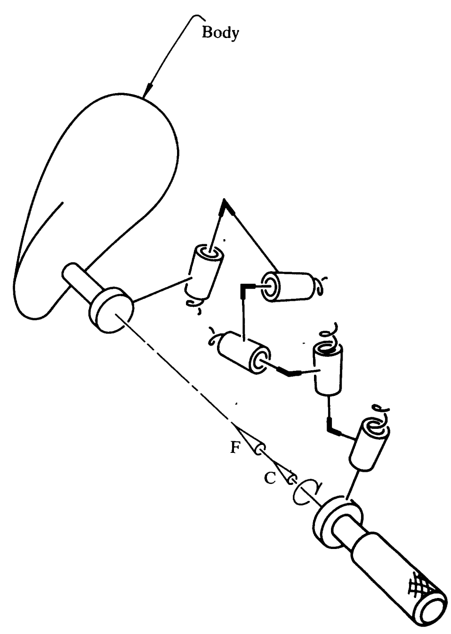
The treatise "Screw Theory Exemplified" completes a two-volume work that stands uniquely as an authoritative account of the subject of screw theory. In these volumes, Phillips manages to do what no other seems to have done before him—that is, excite and inspire the reader's imagination about mechanisms. He convinces the reader that it is possible to visualize the freedoms and constraints of a general mechanism, and he does this in a way that is unrestricted and unhindered by algebra. The theories that he painstakingly proves are synthetic in nature, apparently presented with the intention of establishing in the reader a new thought process—one that is based upon the pure geometry of the mechanism itself and not upon an algebraic manipulation of the vector quantities that numerically describe it. After all, readers can write down their own equations, which become more meaningful and more useful as their understanding of geometry evolves.

The first volume of the work, "Introducing Screw Theory," which was published in 1984, proceeds in the simplest possible way, investigating the contact of two bodies in a single point. Phillips brings to life such examples, delineating them spectacularly to instill in the reader a sense of how an interactive force can be transmitted in the general case along a normal line of contact. Tangential to a given normal line of contact exist the possible routes of relative travel of points in the two bodies. Phillips illustrates these motion capabilities and concurrently begins the groundwork for the theory of freedom and constraint in machinery.

Volume 2 picks up where volume 1 left off, illustrating the properties of line systems and concentrating on the importance of the line in kinematics and statics. Phillips further investigates, in a sophisticated way, the path routes of points in neighboring bodies and the forces that interact between them. This development is a prelude to the final unveiling of the notion of reciprocity, which is the crux of all freedom and constraint found in machinery.

Much of the theory contained in these volumes has already been established, and Phillips recognizes this by accurately citing the earlier literature. Throughout the work, it is his intention to couch established theory in a more manageable form so that the beauty of the pure geometry can be appreciated and, once understood, be applied. This is the case especially with the cylindroid. Phillips mentions the cylindroid on numerous occasions in volume 1, but not until volume 2 does he bring it to life in mechanisms. He strives effectively to convince the reader that the cylindroid is "ubiquitous in mechanism" and that the reader "may effectively cope with it and its ramifications."

In a chapter entitled "Fundamental relations and some algebraic methods," Phillips investigates various ways in which screws, vectors, and pairs of vectors can be located with coordinates. On this subject he uncovers deep-rooted seeds in our minds, causing us to ponder What are vectors anyway? He summons the established work of Brand to explain the helicoidal property of pairs of vectors, which is the requirement that two vectors (a motor) describe a twist or a wrench. Continuing on this subject, he quotes the historic works of Clifford, Keler,



"A wrench applicator across five screw joints which is almost certainly unstable. The joints are merely arranged as members of a 5-system of motion screws whose reciprocal 1-system is the required wrench. If the screw joints were all simply hinges, namely screw joints of zero pitch, the hinge axes would belong to the same linear complex whose pitch would be the pitch of the wrench." [From *Freedom in Machinery,* vol. 2]

Grassmann, Kotelnikov, and Ball. (He does not, however, incorporate the similar and often-cited works of Study [1903] and Von Mises [1924].)

All in all, volume 2 complements volume 1 nicely but does not at all "close the book" on the subject of screw theory. The work is written in a way that leaves readers with research areas to investigate, questions to ponder, and issues to resolve for themselves. (In fact, in some passages, such as 11.50 and 12.70, Phillips acknowledges some vagueness in his accounts of the subject matter.) These volumes present themselves as powerful learning tools that should bring the novice mechanism student to the forefront or send the experienced researcher back to assess his or her own foundation.

We would like to suggest that the cylindric joint noted to exist at A in figure 13.07 be done away with. This joint is not necessary because it is colinear with the revolute existing at B, and, furthermore, the two joints acting together confuse the explanation given in the figure caption. This is because the reader may be led to believe erroneously that the force acting on the line AP is the force acting in the cylindric joint. But this is a minor criticism of what is otherwise an excellent treatise.

Unfortunately, the vast majority of researchers today studying the kinematics and statics of mechanisms and robot manipulators have failed completely to recognize the power of the tools afforded to them with screw theory. The study of kinematics and statics without screw theory is analogous to the study of heat engines without the laws of thermodynamics or of electricity without Kirchoff's laws.

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The Universe Updated

The Astronomer's Universe. Stars, Galaxies, and Cosmos. HERBERT FRIEDMAN. Norton, New York, 1990. xxii, 359 pp., illus. $24.95. Commonwealth Fund Book Program.

In 1975 Herbert Friedman published a book for the National Geographic Society entitled *The Amazing Universe,* in which he described for a lay audience the wonders revealed by modern astronomy and astrophysics. His latest book, *The Astronomer's Universe: Stars, Galaxies and Cosmos,* seems in part to be another look, 15 years later. Indeed, the six chapters that make up the last two-thirds of the volume deal with the same topics as the six chapters of the 1975 book: the sun, stars, neutron stars and black holes, galaxies, cosmology, and life in the universe. But they reflect the remarkable changes that have occurred in our understanding. Friedman describes Supernova 1987A and the detection of its neutrinos; exotic close binary pairs of stars including SS433; gravitational lenses; the problem of dark matter in the universe; and inflationary universes and GUTs. For all these he points out their significance for the frontiers of our knowledge of the universe.

Friedman precedes these chapters with a section on The Tools of Astronomy, introducing devices ranging from radio telescopes and new-technology optical ones to x-ray and gamma-ray detectors and the Hubble Space Telescope. (In his section on the HST, written before its launch, he describes in considerable detail the care with which the mirror was figured and mounted; this now has an ironic ring.) This part of the book is a useful account of the many recent technological advances that have had major effects on the way astronomical research is conducted these days.

The intended audience for this book is not clear to me. Lewis Thomas's foreword, for the Commonwealth Fund, which sponsored it, indicates that the goal is to broaden public understanding of astronomy by presenting the subject in an accessible way. Part of the time Friedman does this well, using basic vocabulary, analogies, and visualization. But he is not consistent; often he uses technical terms with no definition or explanation—as in the case of a reference to piezoelectric transducers or a description of photinos as "the supersymmetric partners of photons of light." There is a glossary, but it does not help here either, since neither "transducer" nor "photino" is to be found in it. Some of these topics are discussed later on; but this gives the book a rather disorganized feel. If a lay audience is intended, I think Friedman has been less successful here than in his 1975 book; if he is writing for readers who are scientifically more sophisticated, he should say so.

Friedman is at his best describing the rocket and x-ray work with which he has himself been associated, as in his discussions of the Sun and the Crab Nebula. In other areas he is sometimes careless or misleading with his facts, as when he says that most stars evolve "along" the main sequence (they don't) or when he refers to the Sun "reaching its supergiant stage" (it will only become a red giant). His historical material is not always correct or consistent either; in some cases he states one thing in his introductory chapter and makes a contradictory statement in a later chapter, as in describing Bessel's measurements of stellar parallax. Historical dates are in error on several occasions.

Despite these shortcomings and some careless proofreading, there is a lot of fascinating material here, and the book is fairly easy to read if one has some prior acquaintance with the vocabulary of astronomy and modern physics. Readers of this journal should find it of interest; but it is not a book for the scientifically naive general reader.

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Earthquakes

The Mechanics of Earthquakes and Faulting. CHRISTOPHER H. SCHOLZ. Cambridge University Press, New York, 1990. xii, 439 pp., illus., $79.50.

Earthquakes are fascinating—clues to inner workings of the earth, sources of primordial fear, and the root of complex engineering, social, and political problems for rapidly growing societies. Research into the mechanics of faulting and earthquake generation is splintered among a number of earth science disciplines—seismology, geodesy, structural and surficial geology, geomorphology, rock mechanics, and geochemistry. Christopher Scholz's goal in *The Mechanics of Earthquakes and Faulting* is to review our present understanding of earthquake and faulting processes based on work contributed by specialists from all of these disciplines. In so doing he hopes to partly remove communication barriers between the various groups of scientists. He does an admirable job on both counts.

The text proceeds in a logical fashion, from the basic physics of rock friction and crack propagation, through the nature of the fault zone, the mechanics of earthquakes, seismotectonics, and finally earthquake hazards and prediction. Scholz has done research not only in his primary field of rock mechanics but also in seismology, and he has some experience in geodesy and structural geology. This breadth is evident in his writing. The physical basis for understanding earthquakes is developed from the perspective of rock mechanics, with focus on the physics of friction and experimental results. A preferred mechanical model of faulting is proposed in which earthquake generation is confined between the upper and lower stability transition between stick-slip and stable sliding. The model is rooted in velocity-dependent friction laws, which are consistent with many experimental and earthquake phenomena. This fault model forms the