Animal Mechanics

R. McNeil Alexander
Univ. of Wash. Press, Seattle 1968.
$9.50

With the increasing interest in biophysics on the part of physicists comes the need for appropriate review books for those who wish to move into biophysics. I have taught an introductory biophysics course twice, and have thereby become painfully aware of the dearth of good general biophysics books that both physicists and biologists can respect. R. McNeil Alexander's book essentially stands alone as such a book in the field of biomechanics.

The arrangement of the material into subject areas (force and energy; joints and mechanisms; elasticity and viscosity; strength; pressure, density and surface tension; motion in fluids; vibrations and changing forces) is especially well suited for physicists. For each area the author briefly reviews the relevant background physics at appropriate points and then proceeds to apply the physics to relevant and diverse biological situations. The mathematics used is mostly algebra and trigonometry, although some calculus is used. I have found that the few parts using calculus can be skipped by a biology student who is weak in calculus without impairing his ability to proceed through the rest of the book.

Some interesting representative applications covered in detail are why a pinnate muscle can exert more force than a parallel-fiber muscle of equal mass, how the human arm muscles are utilized in various arm motions, how kinematic chains are involved in wing rotations as a fly flaps its wings, how a catfish utilizes friction to keep its dorsal spine in an erect position, why bones are hollow, how bracing is used to reduce stress in bones, how swim bladders are used for both swimming and enhancing hearing in fish, how surface tension enables some insects to live under water, how various birds and insects fly, and how bats variously use sound for navigation. The author has done original research in many of these areas and there are copious references to the research literature and many diagrams illustrating the applications, although greater attention to labeling and explanation of the diagrams would be helpful.

The major deficiency of the book is its almost complete neglect of blood flow. Many of my students have expressed a desire for more applications to the human body. Some minor points of improvement would be to separate out more of the equations from the textual material, to box in the equations that are used most extensively in the applications, and to have appendices that derive or discuss some of the more difficult theory; for example, the second moments of area, birefringence, the aerodynamic equations and forced vibrations.

Animal Mechanics is the most interesting mechanics book I have seen. I have used this book in a Keller Plan biophysics course and have found the students to be highly satisfied with it as a text. The biological applications of mechanics in this book could be used to great advantage in spicing the usual introductory or intermediate mechanics courses.

L. David Roper
Virginia Polytechnic Institute and State University
Blacksburg, Virginia.

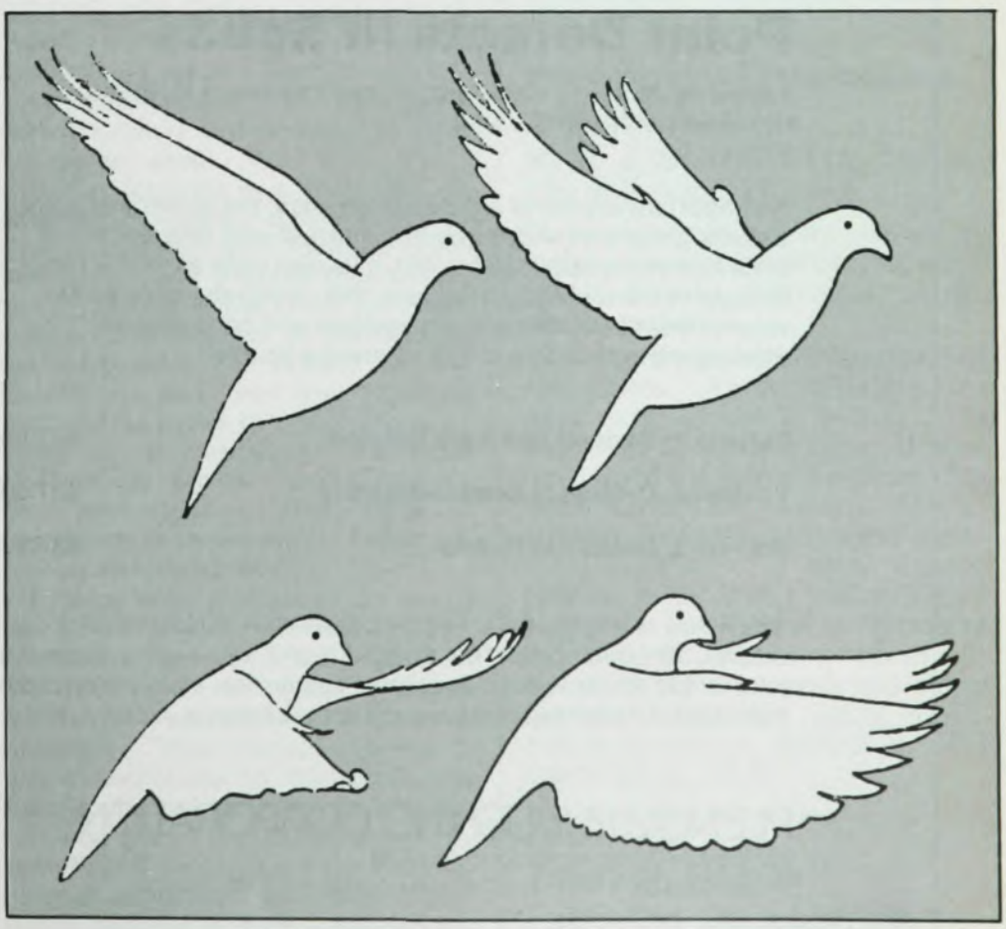
Introduction to High Energy Physics

Donald H. Perkins
353 pp. Addison-Wesley, Reading, Mass., 1972. $12.95

As high-energy physics is the concern of a large fraction of working physicists (and the sink of an even larger fraction of money invested in physics research) it is doubtless appropriate that advanced undergraduate or beginning graduate physics students receive some introduction to the subject. There is, unfortunately, a dearth of textbooks suitable for this task. By its very existence, then, Donald H. Perkins's *Introduction to High Energy Physics* is one of the most useful texts in the field.

The book is adapted from lectures delivered by the author at Oxford University and, indeed, reads much as a sequence of lectures. As a lecturer Perkins must be commended for his selection of topics and organization of material. The book delves into aspects of the weak, electromagnetic and strong interactions after prefatory chapters on conservation laws and symmetries and experimental technique. A happy product of the author's bias as a working experimental physicist is a strong emphasis on the phenomenological approach. It is possible in this fashion to cover a vast amount of material with a minimum of mathematical formalism. The discussion is generally clear and accurate, and—for a book on a rapidly evolving field—there are a minimum of obsolescent remarks. As an aid to the student, problems are given at the end of each chapter with a discussion of their solutions provided in an appendix.

The range of topics covered is really remarkable for a text of 300-odd pages. There is hardly a topic of current interest that does not receive some dis-



Outlines of the stages of motion of a pigeon flying slowly. The illustration, used in a discussion of the physics of bird flight, is from *Animal Mechanics* by R. McNeil Alexander.

cussion. It is, of course, impossible that each topic be treated in any great detail, and there are some ludicrously skimpy discussions. The notion of a partially conserved axial-vector current (PCAC) is covered in only eight lines—in which a trained eye might or might not be able to find some hint of the consequent low-energy theorems for pion production.

It may be that topics such as PCAC simply defy explanation at an elementary level. In any case it is still fair to point out that Perkin's presentation does not go far beyond standard approaches in bringing advanced topics such as this within the reach of the beginning student. A mere mention of these topics is simply inadequate.

In summary, the book is one that merits the attention of anyone teaching an introductory course in high-energy physics. As a set of lectures, the book is noteworthy for its range and clarity, but as a book it lacks that spark of brilliance that distinguishes insight from orderliness.

ROBERT CARLITZ
Enrico Fermi Institute
University of Chicago
Chicago, Ill.

The Thermodynamics of Simple Materials with Fading Memory

William Alan Day
134 pp. Springer-Verlag, New York, 1972. $13.70

When we consider thermodynamics as a field theory of density, deformation and temperature, we must find out what the field equations are. Of course, they are based on the equations of balance of mass, momentum and energy, but these lead to field equations only when supplemented by constitutive equations that relate the constitutive quantities stress, heat flux and internal energy to the thermodynamic fields in a materially dependent manner. Therefore, the problem of finding the field equations for a given material becomes the problem of determining its constitutive relations. Traditionally, with few exceptions, only those materials have been considered whose constitutive quantities depend on the present values of the field and perhaps on their first gradients and time derivatives; exceptions include the classical theories of linear viscoelasticity with their monotonically decreasing relaxation functions. These theories were, in fact, describing materials with fading memory and their constitutive relations were functional relations of a simple kind.

Now, in the last decade or two, thermodynamicists have studied functional constitutive relations of greater generality or, more specifically, they have studied materials whose stress, heat flux and internal energy are dependent on the histories of deformation, temperature and temperature gradient. The form of the constitutive relations is subject to certain restrictions that can be derived from physical principles that are supposed to hold for a large class of materials. Such restricting principles are the entropy principle and the principle of fading memory, and to the formulation and evaluation of both Alan Day has made important contributions. It is therefore very appropriate that he should present a first comprehensive account of this recent field.

Day's book on *The Thermodynamics of Simple Materials with Fading Memory* essentially contains two parts; in the first one the author presents mostly his own ideas about thermodynamics and in the second part he describes a theory that goes back to Bernard Coleman's work. The basic inequality and the fading-memory principle are different in the two parts, but the resulting restrictions on constitutive relations are similar for many materials.

At the outset Day proposes an inequality that he assumes to hold in cyclic processes. For materials whose stress and internal energy are independent of the temperature gradient, this inequality states that the time integral over the reduced heat supplied to the body is non-positive in a cyclic process or, in Day's words: The Clausius integral is non-positive. The principle of fading memory is then stated as an assumption about the additivity of Clausius integrals in a composite process, which, roughly speaking, is a series of processes with intervals during which the body is given time to "forget." For the bodies under his consideration Day succeeds in proving that an entropy can be defined both in equilibrium and away from equilibrium, and he shows that this entropy is given by a constitutive functional. Using these general results Day derives restrictions for the constitutive functionals of thermoelastic bodies and of some viscoelastic bodies.

Entropy is no problem in the second part of the book; its existence and specific forms for its flux and supply are assumed, and the Clausius–Duhem inequality is postulated to hold for all processes. This inequality serves to derive restrictions on the constitutive functionals, and the principle of fading memory enters the theory as an assumption of continuity of the functionals with respect to a norm that characterizes histories in such a manner that their differences in the distant past become unimportant.