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Book Reviews

The Biokinetics of Flying and Swimming

Akira Azuma, Springer-Verlag, New York, 1993, 265 pp., 273 figs., $198.00.

Professor Azuma's distinguished career in teaching and research in the life sciences and in fluid and flight dynamics is reflected in this truly remarkable contribution to a field that touches the frontiers of many specialties. Clear descriptions of, and observational data on life styles, flight, and maneuvers are supplemented by mathematical analyses covering the entire range of flying and swimming creatures.

Chapter 1 describes the fundamental concepts involved in biokinetics, the evolution of plants and animals, their form, their body shape, way of life, and locomotion in various stages of adaptation to changing environmental factors. The time required to reach maturity, called the generation time, is determined by the complexity of the organism; generation times for micro-organisms are of the order of minutes while that for humans is several decades.

Similarity parameters, the most important of which are the Reynolds and Froude numbers, the cavitation number, the density ratio between the animal and the medium, and the reduced frequency are introduced, as well as the range of values for various creatures from bacterium to man.

Chapter 2, entitled "Dragging, Floating and Jumping," is devoted to the motion of small animals and plants that utilize fluid drag force to determine their trajectories in the atmosphere and in water. In general the flows treated are in the low Reynolds number range. Approximate fall speeds are indicated for a wide range of particle sizes; e.g., 0.003 cm/s for some bacteria or viruses of diameter down to microns. The population dynamics of spiders involves a novel means for dissemination of the species: on a warm sunny fall day, particularly after a cold night, spiders climb to the tips of the grass blades, stretch their legs, and eject threads of silk from their spinnerets. The convection currents stretch the threads and carry the spiders aloft so that on clear, calm days in autumn one can often see the "gossamer" generated by a multitude of these glistening threads.

In Chapter 3, "Flight by Gliding" presents experimental data and, to the extent possible, aerodynamic theory required to treat the flight of large land and sea birds, flying squirrels, flying fish, squid, and flying seeds.

The aerodynamics of flight of a feather and of wings are treated on the bases of theory, experiment and flight observations. Flight modes, such as gliding and soaring, hovering, take-off and landing, the use of high-lift devices such as vortex generators, the allulae, and the Krueger flap are discussed. Performance in relation to body weight and configuration, environmental conditions, and way of life are described.

Other topics treated theoretically and compared with experiment include the membranous wing of gliding and rotary seeds (e.g., maples), the Rogallo wing and mollusks, and flying mammals such as the flying squirrel.

Chapter 4, entitled "Flight by Beating," is devoted to powered flight and to the mechanical means by which birds and insects generate the power required for level flight and for maneuvering. Data from many sources are presented for a wide range of flying creatures, from the chalcid wasp (mass 2.5×10^{-8} kg, beating frequency 370 Hz) to the stork (3.5 kg, 2 Hz).

Topics include: Mechanics of hovering flight, wake vortex systems, optimum lift distributions, planforms of various species of carnivorous birds, power-saving flight, i.e. favorable interference of wing wakes during migration, ground image interference, and bounding flight of small birds,

Flight in insects is treated in detail. Topics include: dimensions and performance of the various families of insects, their flight muscles, flight modes, and mechanical properties of various resilient compounds found in many animals.

A major section of the chapter is devoted to flight mechanics in insects. The many investigations of airfoils at low Reynolds numbers by Wortmann, Liebeck, McMasters, and others provide a wealth of aerodynamic data, and wind tunnel tests of insect models by Azuma and his coworkers are analyzed along with those of Weis-Fogh and others to give an insight into the mechanics of flight. The Local Momentum Theory, originated by Prof. Azuma and his colleagues, in connection with rotary wing studies, forms the basis for many of the theoretical studies in this and other chapters.

The propulsion of micro and medium size elongate organisms by utilizing a snaking motion is the subject of Chapter 5. The studies of undulating motion of micro-organisms at low Reynolds numbers are covered in detail as are the spiral motion of flagella. The treatment covers the range from very slow motion to motion at Reynolds numbers at which inertia effects are important. The significant theoretical researches by G. I. Taylor, Hancock, Lighthill, and others are reviewed, supplemented by a semi-empirical method and compared with experiment.

Swimming by Fanning is covered in some detail in Chapter 6. Two types of motion are discussed; the first is treated as rhythmic transverse unsteady motion of the entire body as treated in Chapter 5, the second is treated in terms of the fanning motion of the caudal fin. Photographs and experimental data reveal the possibilities of some fluid mechanical features familiar to aerodynamicists such as riblets, compliant surfaces, vortex generators, and roughness effects,

Chapter 7, entitled "Swimming by other Methods," treats paddling, whipping, jetting, sweeping, beating, sailing, skating, and wave riding.

Professor Azuma's writing reflects his deep knowledge and enthusiasm for the devices that creatures have invented to cope with their ever-changing environment.

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Engineering Applications of Correlation and Spectral Analysis

Julius S. Bendat and Allan G. Piersol, 2nd Ed., Wiley, New York, 1993, xiv + 458 pp., $69.95.

One of the major engineering applications of correlation and spectral analysis is in the area of random vibration in which theoretical developments and numerical simulation techniques prevail. These developments have been associated with a number of controversies. Different methods can lead to different answers for the same problem [see Ibrahim, "Nonlinear Random Vibration: Experimental Results," *ASME Applied Mechanics Reviews* **44**(10), pp. 423-446, 1991]. Very few researchers appreciate and have been involved in random vibration testing. Experimental investigations provide more physical insight and reveal new phenomena not predicted theoretically, but experimental techniques are not without difficulties and errors. *Engineering Applications of Correlation and Spectral Analysis,* written by two well known authorities in the field, provides valuable information and answers to many questions asked by practical engineers and researchers involved in experimental random testing. This second edition is enlarged and includes the answers to questions such as (1) what data should be collected? (2) what practical problems exist, and how should they be handled? (3) what particular functions should be computed? (4) how should the data be processed to reduce statistical bias and random errors? and (5) how should computed estimates be interpreted to give physically meaningful answers? The book consists of 15 chapters which treat the application of correlation and spectral analysis of stationary and nonstationary random data as applied to linear and nonlinear systems.

The first chapter introduces definitions of different classes of random data, Fourier series and transforms, and response statistics of linear systems. The probabilistic description and amplitude measures are treated in Chapter 2. Related topics such as special probability density functions and statistical errors are well explained. Chapter 3 introduces correlation and spectral density functions and their general interpretations.

The basic relationships for single-input/single-output (SI/SO) problems are developed in Chapter 4. The treatment includes stationary and transient inputs, effects of non-zero mean values, and coherence functions. Similar treatment is given to feedback control systems. Chapter 5 is a direct application of Chapter 4, and it demonstrates the estimation of system frequency response functions based on measured input/output data and the prediction of system response characteristics. The system identification problem is the main objective of this chapter and includes system parameter estimation and errors associated with estimating frequency response functions. Illustrations of errors are demonstrated via practical examples such as a cantilever beam and a free-free panel under wideband random excitation.

Chapter 6 treats different classes of problems related to acoustic-noise and vibration control engineering. It outlines the differences between frequency dispersive and nondispersive propagations, i.e. whether the propagation speed is or is not a function of frequency. Correlation functions, spectra, and other response measurements are developed for nondispersive propagation, input/output data, and output data alone. Another development is given for the case of dispersive propagation, where the propagation velocity is a function of frequency.

Chapters 7 and 8 deal with single-input/multiple-output (SI/MO) and multiple-input/multiple-output (MI/MO) problems, respectively. These include input/output relations in terms of cross-correlations, coherence and multiple coherence functions, and relative time delay. These chapters also include common applications of the analysis procedures such as the problem of source locations in fluids and solids. Chapter 9 deals with the problem of energy-source identification as a major application of MI/MO relationships. The source identification problem is formulated for uncorrelated noise signals. The authors discuss 10 problems usually encountered in the identification of energy source and thus limit the application of the input/output relationship.

Chapter 10 deals with computational algorithms for estimating the relationships of SI/SO and MI/MO which are developed in Chapters 4 and 8. Formulation of models include two-input systems, multiple-input systems, Fourier transforms, and optimum system relationships. The computational algorithms are based on iterative operations which are more convenient than the traditional matrix solutions. The statistical errors in the computational algorithms are discussed in Chapter 11 for estimates of frequency domain quantities. The errors include bias error and random errors and are discussed for SI/SO, MI/SO problems.

The analyses presented in the first 11 chapters are only valid for stationary random processes for which statistical properties are determined by time-averaging operations over a single time history record. Special treatment for nonstationary random data is presented in Chapter 12. This chapter introduces the practical considerations of using only a single record of a nonstationary signal for statistical analysis. The basis concepts of segmented sta-