tory manual and, indeed, it could be used as the principal reading in an undergraduate mathematical statistics course. However, the book and laboratories are intended as support for a course or course sequence organized around a conventional text. For example, the flow of laboratory topics neatly meshes with the coverage provided by Larsen and Marx (2001), the text used for a third-year two-quarter sequence offered regularly by my department.

AU: See query

The laboratories are organized around the 15 chapters of the book. For each chapter there is a main laboratory and a number of supplementary problems. The laboratory surveys the chapter, introduces an additional set of *Mathematica* tools, and poses a series of problems to be solved by the student using those tools. The supplementary problems go into specific applications in greater depth and require the student to choose and use the appropriate tools. Baglivo's laboratories provide a total of 288 problems, so the typical instructor would likely choose among the supplementary problems, if not among the laboratories themselves.

The laboratories and supplementary problems are provided on the CD as *Mathematica* Version 5 notebooks. They may be printed out from the CD as workbooks as well. The latter are convenient for students to have at hand while interacting with *Mathematica*. Early chapter laboratories, those linked with probability concepts, center on the use of simulation to support mathematical intuition. Later laboratories develop a full range of statistical concepts and applications. And, to my joy, the final two chapters focus on bootstrapping and permutation tests. In the latter, Baglivo takes the commendable step of distinguishing between population (sampling) and randomization models of inference.

To ease the interface with *Mathematica*, Baglivo's CD provides a collection of "StatTools." Even with this help, students still face a bit of *Mathematica* learning. Providing computer support for a course always involves a tradeoff: an improved understanding of concepts and their application at the cost of time and energy spent in "learning the computer." That downside is ameliorated, of course, if the cost of computer learning can be amortized over a curriculum, rather than over a single course.

For departments committed to, or committing to, the instructional use of *Mathematica*, the adoption of these laboratories ought to be a no-brainer. Not only are the laboratories and problems wide-ranging, but these are not infrequently posed in ways that may tweak, if not challenge, how we teach certain topics. There is much to be learned here.

Where adoption would mean a one-off use of *Mathematica*, the choice is more complicated. Even so, for a two-term sequence, I should think it worth the time spent introducing students to the program.

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The Interaction of Ocean Waves and Wind. *By Peter Janssen.* Cambridge University Press, Cambridge, UK, 2004. $120.00. viii+300 pp., hardcover. ISBN 1-8523-3868-7.

This book deals with a challenging and fascinating subject. Sea-waves are generated by the action of the wind; in turn, the wave field exerts a marked influence on the airflow above it. Thus, we have strong two-way interaction: The momentum transfer depends on the sea-state. Janssen's book provides the first comprehensive treatment of this two-way interaction. The center-point is the energy balance equation, which describes changes in the wave spectrum due to advection, wind forcing, nonlinear interactions, and dissipation. The author has focused on the theory of the energy balance equation, on practical methods for integrating it, and on the relationship between wave forecasting and weather prediction. Inevitably, there are omissions: Analysis of the sea state, interpretation of satellite data, shallow water effects, freak waves, and tsunamis are hardly mentioned. But the result is a comprehensive treatment of the central topic, the two-way interaction between wind and waves. The book will be of great interest and benefit to ocean wave modelers and researchers, who are recommended to acquire a copy. The relatively high price may put it beyond the reach of many students.

The book is well designed and well written, at a fairly advanced mathematical level. The material is presented in a logical sequence, with just the right amount of historical detail to provide context and motivation. Comparison of theoretical results with the best available observational data is made consistently throughout. Gaps in the observational evidence are also identified. There is a good list of references (about 300) and the index appears to be adequate and accurate. The reviewer encountered only a few errors in the text. Figure 4.20 is incorrect; the amended version is on the CUP website. Axis labels are missing from Figure 5.17. Presumably, a list of other errors will appear on the website.

Chapter 1 opens with a description of how an analogy with the interaction between plasma waves and electrons led to the development of the quasi-linear theory of wind-wave generation. Then the work of the WAM (wave modeling) Group, culminating in the operational implementation of the WAM model, is sketched. Momentum transfer depends on the sea-state. The determination of the transfer requires an accurate specification of the high-frequency part of the spectrum, which is generated by a wave model. This dependence of transfer on sea-state is important for weather prediction, climate modeling, the ocean circulation, and storm-surge modeling, so a coupled model is required. The chapter ends with a summary of the contents of the remaining four substantive chapters.

In Chapter 2 (49 pages), the basic equation for ocean wave modeling, the energy balance equation, is derived, starting from the Navier–Stokes equations. The smallness of the wave steepness and air-to-water density ratio facilitate a perturbation approach. Free gravity waves have short space and time scales. The envelope of the energy spectrum has a longer time-scale and a multiple-scale analysis is apposite. The problem of free surface waves is cast in both Hamiltonian and Lagrangian formalisms. However, functional derivatives will be unknown to many readers; the intermezzo on theoretical dynamics will be of little help to them. The weakly nonlinear theory which is developed requires the wavelength to be small compared to the depth and so is invalid for shallow water. Linear waves are discussed, followed by the key concept of wave groups. Then the evolution equations for a wave group are derived using the powerful average Lagrangian technique (some more detail in the derivation would be helpful). The action balance equation for a continuous wave spectrum, generally called the energy balance equation, is derived next. This equation is of central relevance. There follows a kinematic analysis of some particular phenomena: shoaling, refraction, and reflection of waves. Finally, a number of empirical laws for the growth of windsea are reviewed. The JONSWAP parameterization was an important advance in this field. The Toba spectrum, with friction velocity scaling, is discussed; this provides a better fit to the JONSWAP observational data. Janssen concludes that the Toba formulation is the preferred description of fetch-limited windsea spectra.

The third chapter (73 pages) considers the generation of ocean waves by wind, a difficult problem involving the modeling of turbulent flow over a surface varying in space and time. The linear, quasi-laminar theory of wind-wave generation is discussed first. This involves a resonant interaction of gravity waves with a plane parallel shear flow (Miles' critical layer mechanism). The problem is reduced to the Rayleigh equation, a Sturm–Liouville equation with an internal singularity, and the solution of this is discussed in some detail, resulting in an expression for the growth of surface gravity waves due to shear flow. The full solution is obtained by combining numerical integration with analytical continuation across the critical layer. It is in reasonable agreement with observational data.

In considering the effects of turbulence, the author distinguishes small-scale, high-frequency turbulence from gustiness. A number of contrasting, even conflicting, treatments of turbulence are reviewed critically. Inclusion of small-scale turbulence does not result in significant changes in energy transfer rates. In contrast, gustiness has a significant effect on wave growth, particularly for the later stages of low-frequency waves. A neat estimate of growth, the average of growth rates for mean friction velocity plus and minus its standard deviation, is derived. A lucid description of the dynamics in the critical layer is given, followed by a detailed mathematical treatment of quasi-linear theory for a continuous spectrum. The quasi-linear system (Janssen's (3.115)) admits solutions for which the instability of the growing waves is limited as energy transfer from air to water is quenched through feedback on the wind profile. Numerical solutions are presented illustrating the drag of the airflow by the sea-waves. It is concluded that there is a strong two-way interaction between wind and waves for young windsea. For older windsea, the coupling is much weaker. The quasi-linear theory gives a realistic description of the transfer of momentum, in good agreement with available observations. The chapter ends with a discussion of the parameterization of the wind input source term for use in numerical models.

Chapter 4 (80 pages) is devoted to nonlinear wave–wave interactions and to a derivation of an expression for the nonlinear source function in the energy balance equation. Introduction of an action variable simplifies considerably the nonlinear development. Using a Hamiltonian formalism first discovered by Zakharov, the basic evolution equation for weakly nonlinear gravity waves is derived. This is reduced, through a nonsingular canonical transformation which removes nonresonant terms, to the Zakharov equation (Janssen's equation (4.19)). The stability of uniform finite amplitude wave trains is examined next and they are found to be unstable to sideband perturbations; this is the Benjamin–Feir instability, a four-wave interaction phenomenon. The long-time behavior is studied by approximate solution of the nonlinear Schrödinger equation, and recurrence rather than degeneration of the primary wave is found. This follows from Janssen's equation (4.48). This equation implies that the squared modulus of the sideband perturbation may be expressed in closed form in terms of elliptic functions. Curiously, Janssen makes no mention of this fact, which could simplify the ensuing discussion. In the text, the distinction between recurrence for a system with just a few components and the Fermi–Pasta–Ulam phenomenon for higher order systems is not made.

Five-wave interactions are briefly discussed. Then the focus moves to the statistical treatment of nonlinear interactions. The evolution equation for the second moment is derived from Zakharov's equation. The usual requirement that secular behavior vanishes implies that the evolution of action density depends only on resonant four-wave interactions. Janssen derives a more general result, called the Boltzmann equation, which allows also for nonresonant interactions. The question is, Do we need to take account of nonresonant interactions? Janssen concludes that it depends on the application: For the open ocean, their effect is small except when the wind increases abruptly. The assumptions underlying the statistical approach are analyzed in detail. The intermezzo on multiple scale analysis is a distraction at this point: Readers in need of it must already be all at sea. Some consequences of four-wave interactions for the evolution of a random, homogeneous sea are examined next. The conservation of wave action, momentum, and energy constrain the flux of energy in a manner analogous to quasi-geostrophic turbulence. As a result, an inertial subrange, in which nonlinear interactions dominate, is found. The source function for nonlinear interactions (4.75) requires enormous computation, so some form of parameterization is required. The discrete interaction approximation, which performs well, is described. To conclude the chapter, dissipation of energy due to wave breaking, an essentially nonlinear phenomenon, is discussed. This is perhaps the least-understood aspect of ocean wave dynamics, and there remains great uncertainty about the spectral distribution of dissipation.

The final chapter (66 pages) is about numerical prediction of ocean waves and the European Centre for Medium-Range Weather Forecasts' (ECMWF) wave model ECWAM. The numerical integration schemes are described; schemes which are ideal for atmospheric models are not necessarily suited for wave models. For ECWAM, advection is treated with a first-order upwind scheme. Some details of the code parallelization are included, with reference to www.ecmwf.int for full documentation. A single gridpoint version of the model is used to examine fetch and duration-limited growth, and the results compare well with observations.

There is now ample evidence that two-way interaction is important for the prediction of both wind and waves. Steep waves extract more momentum from the air than smooth, gentle waves, so the momentum transfer depends on the sea-state. To enable this two-way interaction, ECWAM is called as a subroutine every time-step by the ECMWF atmospheric model. The two-way coupling has been found to be important for forecast quality. Janssen describes an experiment with the FASTEX storm where coupling resulted in a surface pressure difference (from control without coupling) of 15 hPa, with the coupled run verifying better. More generally, coupling has been found to be consistently beneficial for medium-range weather forecasting and also for seasonal forecasting.

The impact of ocean waves on the circulation of the ocean is at an early stage of study, and the discussion by Janssen is correspondingly brief. One result of particular interest is the beneficial effect of model coupling on storm-surge prediction. There is no direct use of ocean buoy data in ECWAM, so buoy observations provide a valuable independent data set for verification. Clear progress over the past decade is shown by the verification scores. However, the averaging of the buoy data over a period as long as four hours is unsettling: this may mask defects in the model. Verification of forecasts against wave analysis obtained by optimal interpolation using ERS-1/ERS-2 altimeter data confirms the progress. Much of the improvement in skill comes from better wind forecasts. There is a symbiotic relationship here: Wave model results have provided a powerful diagnostic tool for detecting problems with the atmospheric model. Janssen concludes on an optimistic note: "Considerable progress in wave modelling is ... expected in the near future." He has played a vital role in recent progress. His book will be of great value to researchers wishing to enter this field and to contribute to the exciting developments that lie ahead.

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The Linear Algebra a Beginning Graduate Student Ought to Know. *By Jonathan S. Golan.* Kluwer Academic, Dordrecht, The Netherlands, 2004. $132.00. x+406 pp., hardcover. ISBN 1-4020-1824-X.

This is an unusual book with an intriguing title. Golan "assumes no previous knowledge of linear algebra." He starts by defining the elementary notions of fields and vectors spaces and then develops the topics covered in an undergraduate linear algebra course: linear independence, dimensions, row echelon form, linear systems, orthogonality, eigenvalues, etc. Unlike the standard undergraduate text, fields are not assumed to be $\mathbf{R}$ or $\mathbf{C}$, and vector spaces are not assumed to be finite-dimensional, unless this is required for the result. In addition, there is a wide range of other topics, including the matrix exponential, Hamel bases and their applications, Krylov subspaces, the numerical range, dual spaces, pseudo-inverses, and the polar decomposition.

A particular strength of this text is its treatment of linear algebra over finite fields, an important component in cryptography. Another strength is its generality.

The exercises, which are interesting, numerous, and of widely differing difficulty, contain examples, counterexamples, and useful insights. They are an important part of the book; for example, the spectral norm is defined only in an exercise. Since "seriousness of purpose" is assumed, the exercises are not accompanied by solutions nor by indications of the degree of difficulty.

There is something new for everyone here. The eigenvalue chapter contains a result of Edelman, Kostlan, and Shub:

> Let E_n denote the expected value of the number of real eigenvalues of an $n \times n$ random matrix with i.i.d. $N(0,1)$ entries. Then
>
> $$\lim_{n} \frac{E_n}{\sqrt{n}} = \sqrt{\frac{2}{\pi}}.$$

The inner product chapter presents generalizations of the Cauchy–Schwarz–Bunyakovsky inequality. Among the exercises one finds:

> Let $F = GF(7)$. Find a nonzero polynomial $p(X) \in F[X]$ such that the