

and log window. Burg's method estimates the power spectral density.

The last chapter delves into all ramifications of the entropy theory applied to stochastic problems. In heuristic interpretation of entropy, the measures of uncertainty and information always play important roles in the event. An important application of entropy determines the probability of an event, subject to various constraints. Entropy is a number assigned to a partition consisting of a number of events. Important features of entropy consider continuous RV, joint entropy of two discrete RV's and conditional entropy. For ME, the determination of various parameters of a probability space subject to given restraints must usually be accomplished numerically. Certain special cases concentrate on constraints in the form of expected values. This is accomplished by means of familiar variational techniques, i.e., Lagrange's multiplier or Euler's equation. The chapter concludes with the various codes employed in binary order, Shannon, Fanno, and Hoffman, plus channel capacity. The prime purpose of the latter is to determine the rate of information that can be transmitted through the channel.

In summary, this is an excellent book. It covers a good deal of information seldom found in other books on the subject. The book must be read carefully. The reviewer would have preferred seeing a table of abbreviations, a section on cepstrum analysis, and a more elaborate discussion of digital data processing accompanied by simple computer programs. The important topics of cross-spectrum and partial coherence are barely mentioned. Nevertheless, the reviewer recommends this book to those interested in obtaining information on random processes.

Proceedings of Sixth International Modal Analysis Conference (IMAC),

D. J. DeMichele, Editor and Director,
 Union College and Society of Experimental Mechanics,
 1988, 1729 pages, \$200.

This is a "humdinger" of a conference. Each succeeding conference attains greater esteem. From its inception to the present conference, the topics become "meatier." This is truly an international conference with authors from various countries. The entire collection of papers present interesting information pertaining to modal analysis and its various "cousins", i.e., vibration, acoustics, instrumentation accompanied by finite elements and associated computer programs. The newest addition this year are the topics on "Lanczos Method" and "System Identification and Control." As stated by the editor, "An international body of distinguished authors share their knowledge and experience in solving complex problems using modal analysis technology and offer them as a guide to readers in the pursuit of their own particular activities. These proceedings will act as a guide to individuals and institutions in pursuing analytical and experimental endeavors." The 2 volumes comprise a keynote address, 22 different topics containing 275 papers, plus an addendum.

Professor L. D. Mitchell opened the conference with a keynote address. He states that experimental modal analysis (EMA) reached its present status due to the difficulty of properly analyzing commercial type structures. Finite Element Analysis (FEA) jumped into the breach. Present day analysis employs EMA to pinpoint and improve the modelling differences of FEA. The trend towards increased activities in EMA has reached a plateau. This is exemplified by reduction of new entries to the modal analysis field, slowness in development of linking FEA to EMA plus difficulty in reducing labor

and capital costs in EMA. New innovations in EMA will spur growth. This is indicated by the modal analysis helping designers produce a product for redesign before the prototype is installed. Essentially EMA and FEA approached each other in the early 60's and 70's. Both communities, i.e., FEA and EMA are trying to make a lasting marriage but we have a long way to go. Although given great hurdles and "hurrahs," only the aeronautical and certain elements of the automotive industry employ EMA extensively. The present "foundation" firms are not prepared for the CAD/CAE/CAM revolution since the basic and fundamental CAE and CAD are still in their infancy. Both FEA and EMA have areas that must be resolved in order to move the modal analysis upward from the plateau. For future growth, there must be an integration of CAD/CAE/CAT/CAM communities and, above all, reduce computing time and increase computer power. More extensive use of multiple parallel processors should be factored in this effort in order to reduce computer time and analysis procedures.

The topics presented at this conference comprise the following:

Topic	Papers
Experimental Case Histories	13
Analytical Methods	34
Modal Test Methods	23
Lanczos Method	4
Processing Modal Data	10
Damping	5
Noise/Acoustic	12
Nonlinear Structures	12
Modal Techniques for Rotating Machinery Diagnostics	13
Finite Element Analysis	11
Transducers & Instrumentation	5
Linking Analyses and Test	15
Structural Dynamics Modification	33
Experimental Techniques	17
System Identification and Control	5
Machinery Diagnostics	10
Seismic Topics	4
Substructuring	12
Space Structures	8
Design Methods	5
Modelling Structures	14
Vehicular	6
Addendum	2

In "Experimental Case Histories," the initial paper claims that control scientists do not give credit to structural dynamacists idea and breakthrough in modal analysis. Other prominent papers state that results based on inadequate emphasis on details for a lightly damped structure can be significantly altered, proper utilization of tools in successful troubleshooting of structural problems, investigation of air baffle failures in motor generators (analyses and testing), troubleshooting using modal analysis for a crooked centrifuge. This continues with a new complex condensation method on use of time domain analysis and operational deflection shapes computed from time histories, vibration and noise reduction of thermowindows and a case study of propeller induced vibrations in the afterbody of fast patrol boats.

Analytical methods consist of a number of different topics. The opening papers report on a perturbation approach in determining eigenvalues and eigenvectors for nonproportionally damped systems, presentation of old and new modal identities in structural dynamics, further study of modal damping matrix for multidegrees of freedom systems plus investigation of a component modal synthesis technique in determining dynamic characteristics of a system. Additional papers consider ARMA use in determining Frequency

Response Function (FRF) in modal analysis with direct applications in area of high density, transient vibration analysis of nonproportionally damped linear systems using parametric vibration plus vibration analysis of simply supported rectangular plate with arbitrarily placed stiffeners. The next set of papers considers various methods of estimating external forces from acceleration time history data, calculation of rolling mill torsional vibration by differential operator methods estimating on-line and control of noise in hydraulic systems, employment of admittance models in predicting dynamic response of multi-component systems and a space variable transform method for modelling thick cylindrical shells with arbitrary boundary conditions. Continuing, we encounter the use of weighted frequency response functions and instrumented variable method identifying stiffness, mass and damping matrices of a nonlinear system, method of direct identification of modal parameters via physical parameters of local modes plus dynamic analysis of circular plates with stiffeners using Lagrange multipliers. The next set of papers talk about nonclassical flow induced response of a lifting surface due to localized distortion, a parameter refinement code for structural dynamic models (PAREDYM), determination of directional cosine matrix of various links of spatial mechanisms in 3D structures, and application of Newton-type schemes concerning convergence properties of iterative parameter estimation algorithms. The concluding papers talk about eigenvalue and eigenvector derivatives in modifying system natural frequencies, forced dynamic response of a rotating thin annular plate to a moving concentrated transverse load, probabilistic measure of multiple crack distribution in structures due to random noise plus vibration behavior of a rotor bearing system with nonlinearized hydrodynamic bearing forces.

Linking analysis and test focuses upon potential problems developed in application of experimental modal analysis, prediction of response of electrical equipment in a vibration environment using FEA and validation of FE model employing results from a modal test with high degree of confidence. Continuing, we encounter a methodology for comparing modal test and analysis using I-DEAS software package, physical significance of the modal mass for lightly damped structures, correlation of experimental and analytical study (FEA) of a waste-water pumping facility, validation of FE modal analysis using holographic intensity and recent developments in comparing experimental modal analysis vs power flow measurements. This concludes with analysis of spars and subreflector of a satellite, spatial correlation of mode shapes using COMAC program plus the comparison between flight flutter and analytical results of a PIAGGIO P180 "Avanti" aircraft.

Structural dynamics modifications consider localizing model changes based on least squares modal test data, NASTRAN DMAP ALTER program to compute modal contributions for vibration response at various airframe locations, damage assessment for nonlinear structures using idea of structural power, comparing complex and proportional mode structural dynamics modification concepts plus estimating the rotational degrees of freedom using shape functions. Continuing, we meet a study of flanged joint stiffeners when connected between thin walled beams, correction of FE models using eigenstructure assignment method (EAM), employment of EAM in active control of a flexible structure, enhancement of modal vector scaling by modal participation factors plus use of perturbation theory and measured modal data in predicting mass modification for certain dynamic requirements. This follows with S² DM program use in predicting dynamic effects of certain kinds of local design modifications, modal correlation and orthogonality criteria determining modal vector correlation. The next set of papers considers approximate calculation method of modal participa-

tion sensitivity coefficients for structural eigenfrequencies based on a FE proportionality assumption, component mode synthesis using experimentally measured component modes enhanced by mass loading, employment of many different shaped stiffeners in structural dynamics modification, the optimal structural modification principle in the maximum shift of natural vibration frequencies and furthermore the application of wide band damper using granular material. We continue with structural design modification of a high speed flexible shaft employing modal testing, transfer matrix analysis of cracked beams using modified elements (application and theory), feasibility study in modification of system characteristics by reanalysis techniques, an effective approach to determine natural frequencies using Lagrange multipliers. We conclude with the free vibration analysis of a continuous beam having stepped cross sections and employing Timoshenko beam theory.

Modal test methods report on testing of free-free flight payload of the Space Shuttle ASTRO-1, correction of errors in FRF using rigid body modes, correlating the operating deflection shapes of a transversely mounted inline four cylinder engine at idle using modal test data plus operational vibration measurements and modal testing of a ship deckhouse structure. This follows with the employment in determining the modes of vibration of disk drive heads and suspensions during actual operation, experimental approach to dynamic characteristics of universal milling machine plus the employment of a new generation modal data system utilizing distributed processing. We proceed in considering the vibration effects of vehicular seating system, comparison of single point excitation and base excitation for spacecraft modal survey and the proper design of a stringer between exciter and test specimen. We forge ahead with the employment of acoustic intensity, experimental modal analysis in updating a number of numerically controlled machine tools. The final set of papers report on the evaluation of accelerometer mount transmissibility for naval applications, dynamic consideration in development of centrifugal separators employed in reprocessing nuclear fuel plus a comparison of burst random, impact and random in obtaining good FRF, accompanied by a procedure in improving same.

Experimental test techniques reveal a number of interesting papers. They consider the use of modulated fiber optic sensors for structural vibration measurements, fatigue life determination of FRF at high energy excitation levels, and a force identification method for locating the strategic emplacement of accelerometers using sum of weighted acceleration plus analysis of beam and plate vibration by holographic interferometry. The next set of papers tells about the shorter records of time invariant spectral analysis employing maximum entropy methods applied to solid rocket motors and flow detection of a Bernoulli-Euler beam utilizing forced vibration testing.

The new addition of Lanczos method to IMAC contains some interesting papers. The initial paper traces the origin and advantages of Lanczos method in reducing large dynamic systems to much smaller ones, application of new version of Lanczos method to dynamic analysis of damped structural system with a number of applications factored into it. The last paper develops a component synthesis method using a combination of constraint modes and fixed interface Lanczos vectors.

In summary, this is an excellent symposium. The collection of papers hits "home" due to the vast number of timely topics. The reviewer would like to see a general table of nomenclature for the symposium. This would make it easier in reading the papers. In addition, an updated bibliography on modal analysis papers and reports would be an asset. Due to page limitations, the reviewer could not review each topic. The conference proceedings are recommended to those interested in modal analysis.