Research Contributions
with Former Students and Collaborators

It is believed that the research of Professor Ma and his collaborators over the years has advanced the methodology of systems modelling and design. Only time can tell what impact, if any, that their research has or will make. In a description of past accomplishments, there are three problem areas to which their contributions are particularly noteworthy.

I. Generalization of Modal Analysis

Together with his students, the method of modal analysis was extended to decouple any linear system in real space (solution of the diagonalization problem). To be specific, let $\mathbf{M}$, $\mathbf{C}$ and $\mathbf{K}$ be arbitrary real square matrices of the same order with $\mathbf{M}$ assumed nonsingular. A real and invertible transformation is developed to convert $\mathbf{M}\ddot{\mathbf{q}} + \mathbf{C}\dot{\mathbf{q}} + \mathbf{K}\mathbf{q} = \mathbf{f}(t)$ into $\ddot{\mathbf{p}} + \mathbf{D}\dot{\mathbf{p}} + \mathbf{\Omega}\mathbf{p} = \mathbf{g}(t)$ for which $\mathbf{D}$, $\mathbf{\Omega}$ are real and diagonal.* The extension has been applied to streamline design and optimization.

II. Rotating Flow of Thin Films

Together with former students, a new theory of viscous flow of thin layers over a rough rotating surface was developed. Surface roughness was represented as a stochastic process and, using Monte Carlo simulation, it was shown theoretically for the first time that surface roughness played a dominant role in retaining a film on a rotating surface against centrifugation. The theory has been applied to spin coating and lubricant retention.

III. Nonlinear Random Vibration

There are few exact solutions to nonlinear systems. In collaboration with other scholars, exact steady-state solutions were constructed for a class of nonlinear stochastic systems.** In addition, global sensitivity of each control parameter of the differential model of hysteresis (nonlinear damping) was assessed for the first time.

Representative Publications

1. T. K. Caughey and F. Ma, The exact steady-state solution of a class of nonlinear stochastic systems, *International Journal of Nonlinear Mechanics* **17**(3), 137-142 (1982). [Times cited: 79]***

2. F. Ma, Extension of second moment analysis to vector-valued and matrix-valued functions, *International Journal of Nonlinear Mechanics* **22**(3), 251-260 (1987). [Times cited: 31]

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* This extension of modal analysis has recently been included in the following popular textbook:
H. Benaroya, M. Nagurka and S. Han, *Mechanical Vibration: Analysis, Uncertainties, and Control*, 4*th* ed., CRC Press, Boca Raton, Florida, 251-256 (2018).

** A discussion of these new exact solutions is given in the following books:

a. T. T. Soong and M. Grigoriu, *Random Vibration of Mechanical and Structural Systems*, Prentice Hall, Englewood Cliffs, New Jersey, 220-222 (1993).
b. Y. K. Lin and G. Q. Cai, *Probabilistic Structural Dynamics*, McGraw-Hill, New York, 192-193 (1995).
c. J. B. Roberts and P. D. Spanos, *Random Vibration and Statistical Linearization*, Dover, New York, 310-311 (2003).

*** Web of Science All Databases citation index

3. J. H. Hwang and F. Ma, On the flow of a thin liquid film over a rough rotating disk, *Journal of Applied Physics* **66**(1), 388-394 (1989). [Times cited: 55]

4. T. K. Caughey and F. Ma, Complex modes and solvability of nonclassical linear systems, *ASME Journal of Applied Mechanics* **60**(1), 26-28 (1993). [Times cited: 33]

5. J. H. Hwang and F. Ma, On the approximate solution of nonclassically damped linear systems, *ASME Journal of Applied Mechanics* **60**(3), 695-701 (1993). [Times cited: 28]

6. H. Zhang, G. C. Foliente, Y. Yang and F. Ma, Parameter identification of inelastic structures under dynamic loads, *Earthquake Engineering and Structural Dynamics* **31**(5), 1113-1130 (2002). [Times cited: 57]

7. F. Ma, H. Zhang, A. Bockstedte, G. C. Foliente and P. Paevere, Parameter analysis of the differential model of hysteresis, *ASME Journal of Applied Mechanics* **71**(3), 342-349 (2004). [Times cited: 149]

8. M. Morzfeld, N. Ajavakom and F. Ma, Diagonal dominance of damping and the decoupling approximation in linear vibratory systems, *Journal of Sound and Vibration* **320**(1-2), 406-420 (2009). [Times cited: 22]

9. F. Ma, A. Imam and M. Morzfeld, The decoupling of damped linear systems in oscillatory free vibration, *Journal of Sound and Vibration* **324**(1-2), 408-428 (2009). [Times cited: 21]

10. F. Ma, M. Morzfeld and A. Imam, The decoupling of damped linear systems in free or forced vibration, *Journal of Sound and Vibration* **329**(15), 3182-3202 (2010). [Times cited: 21]