Relating Forces to Real-World Systems

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Gautam Dasgupta has been working on a wide range of basic engineering problems that span from analytical formulation and mathematical modeling to practical applications. His work in classical civil engineering focuses on analyses of safe but economical design-analysis, such as the dynamic response of nuclear power plants in conjunction with the outwardly radiating waves generated at the soil interface under the action of earthquake excitation, and the effects of acoustic vibrations created by ocean waves on submerged or floating structures, initiating excessive material degradation and damage. He has also worked with spacecraft engineers, dentists, anthropologists, and historic preservationists. The common thread of his research is to relate the force and deformation of real-world systems. His personal interests are reflected in his research applications in computer music and computer-aided graphics.

Dasgupta focuses on research in engineering mechanics. The major objective is to relate the forces (causes) and changes of shapes and sizes (effects) in the real world of uncertainty. Thus his stochastic (models based on probability and statistics) were used by the NASA Glenn Research Center in Cleveland, Ohio, (then NASA Lewis Research Center) in the 1980s to analyze the damage in the main engine turbine blades of the space shuttles. His high-accuracy finite element formulations have been used since the 1990s to analyze the changes in facial bones, including the shape of teeth, as clinicians perform corrective surgery on patients.

Basic engineering mechanics also focus on material properties that change with time under sustained static loading or dynamic impact. The subsequent shape and size changes, which are studied under viscoelasticity and plasticity, have been adapted to computer simulations. Dasgupta derived important theorems for such changes that can vary with frequency and are different in different directions of deforming bodies. In conjunction with his defect-free (finite element) numerical models (of extremely low error), he proposed very large-scale simulations of crash tests for super computers. In order to minimize computing time, a large part of the calculation is carried out algebraically. This led to Dasgupta's development of symbolic computer programs to derive equations and generate conceptual (elegant) codes for numerical execution in a parallel computing environment.

Dasgupta is working on 3D analyses and computer code generation of incompressible fluids and solid mechanics modeling of complex surfaces and solid objects with zones of mechanical failure to be applied in a wide class of applications ranging from blood flow to the cooling mechanism of wind turbines.

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