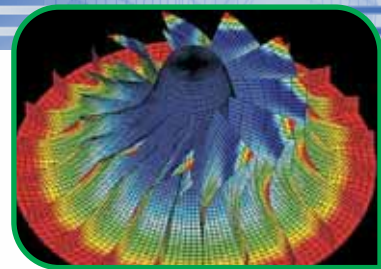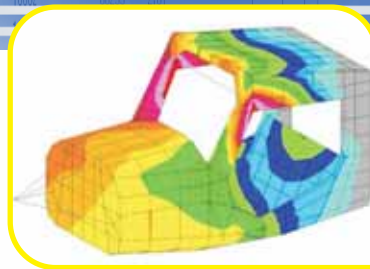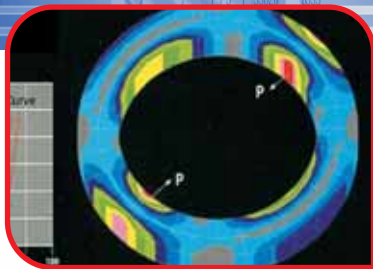# NISA II - STATIC & DYNAMIC ANALYSIS

**NISA**™

Linear Static Analysis

Linear Dynamic Analysis

Non-Linear Static & Dynamic Analysis

NISA II is the parent program of the NISA family. It offers an impressive list of linear/non-linear static/dynamic analysis features complemented with an extensive finite element library. NISA II has efficient solvers like direct (frontal and sparse) and iterative solvers.



NISA II FINITE ELEMENT LIBRARY

# Liner Static Analysis

## STATIC ANALYSIS FEATURES

- Multiple load cases
- Linear buckling analysis
- Automatic wavefront optimization
- Interlaminar shear and edge effects for composite elements
- Restarts
- Automatic submodeling in user-defined regions for more accurate stress calculations

## MATERIAL PROPERTIES

- Isotropic or orthotropic, temperature dependent
- Directional tensile, compressive, and shear failure stresses for composite elements
- Tsai-Wu coupling coefficients for composite structures

## LOADING

- Point force, moment on nodes or range of nodes in local or global coordinate system
- Distributed force, pressure load
- Linear, angular acceleration
- Thermal loading
- Temperature distribution may be obtained from NISA II/HEAT TRANSFER analysis
- Specified displacement

## BOUNDARY CONDITIONS

- Specified nodal displacement (zero/ non-zero; translation or rotation)
- Coupled displacement; multipoint constraints

## PRINTED AND GRAPHICAL OUTPUT

- Displacements, stresses, and strains at elements and nodes
- Principle stresses and their directions
- von Mises, maximum shear, and octahedral shear stresses
- Averaged and unaveraged nodal stresses, element stresses at Gauss points and centroid
- Buckling load forms and mode shapes
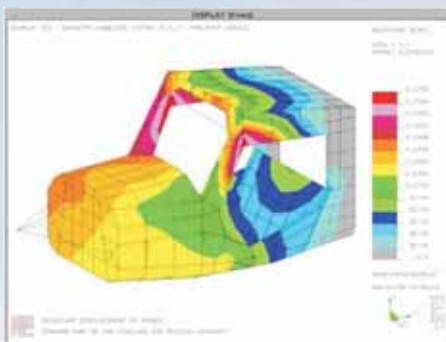
# Linear Dynamic Analysis

## EIGENVALUE ANALYSIS

- Natural frequencies and mode shapes
- Modal stresses and strain energy computation
- Eigenvalue extraction algorithms
  - Conventional subspace iteration
  - Accelerated subspace iteration
  - Lanczos Method
  - Inverse iteration
  - Guyan reduction
- Extraction of zero frequencies (rigid body modes) and coincident frequencies
- Component mode synthesis to evaluate natural frequencies and mode shapes for:
  - Normal structures, given the mode shapes of the substructures or components
  - Cyclic symmetric structures, given the mode shapes of one sector
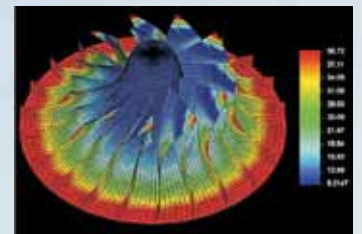


*Bending Mode of an Impeller*

## MODAL DYNAMIC ANALYSIS

- Viscous, structural, proportional and material damping
- Capabilities to handle rigid body modes
- Transient Dynamic Analysis
  - Time dependent ground excitations, nodal forces, and pressure loading
  - Nonzero initial displacements
  - Time dependent loads using time functions and arrival times
  - Time history and snapshot output for displacements, velocities, accelerations, stresses, reactions, and beam end forces
  - Generation of floor response spectra
- Frequency response analysis
  - Frequency dependent harmonic ground excitations, nodal force, and pressure loading
  - Amplitude and phase spectrum input
  - Point-to-point transfer function calculation
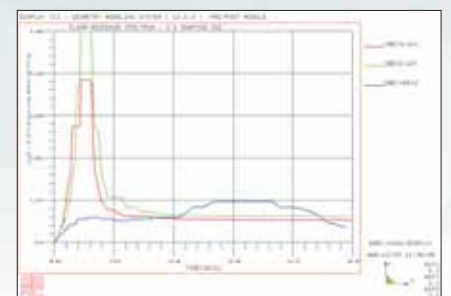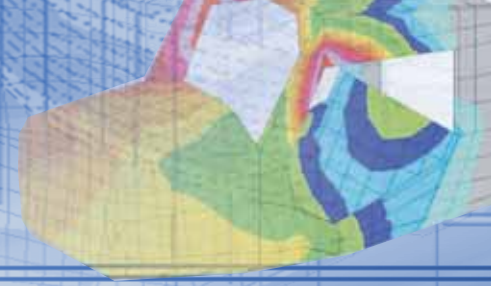
- Amplitude and phase spectra output for displacements, velocities, accelerations, reactions, and beam end forces
- Random Vibration Analysis
  - Stationary nodal forces, ground excitations, and pressure loading
  - Non-Stationary inputs
  - Auto PSD and complex cross PSD input
  - Numerical or exact integration of the PSDs to compute the covariance matrices
  - Auto PSD output for displacements, velocities, accelerations, stresses, reactions, and beam end forces
  - RMS responses for displacements, velocities, accelerations, stresses, reactions, and beam end forces
- Shock (response) spectrum analysis
  - Multi directional displacement, velocity or acceleration spectra input
  - Modal combination rules
    - Absolute sum
    - Square root of sum of squares or RMS sum
    - Peak RMS or NRL sum
    - Complete quadratic combination (CQC) sum
  - Direction combination by RMS or absolute sum
  - Automated mode selection and spectra computation by U.S. Navy DDAM method
  - Missing mass correction

## NISA DYSPAN (Dynamic Spectrum Analyzer)
- Response spectrum generation
- PSD generation
- Spectrum compatible time history generation
- FFT generation

## DIRECT TRANSIENT DYNAMIC ANALYSIS
- Newmark-Beta method for implicit time integration
- Lumped and consistent mass formulation
- Discrete damper elements and proportional (Raleigh) damping
- Nonzero initial conditions
- Time dependent boundary conditions
- Forces due to moving frames of references
  - Centrifugal forces
  - Coriolis forces
  - Linear and angular forces
  - Time dependent concentrated and distributed loading Absolute motion of unconstrained structures

# Non-linear Static & Dynamic Analysis

## MATERIAL NONLINEARITY
- Material models include von Mises, Tresca, Mohr-Coulomg, and Drucker-Prager yield criterion
- Elastic perfectly plastic, elastoplastic with isotropic, kinematic or mixed work hardening
- Uniaxial stress-strain curve description includes elastic perfectly plastic, elastic linear hardening, elastic piece-wise linear hardening, and Ramberg-Osgood curve
- Hyperelasticity and rubber-like material behavior, material models include generalized Mooney-Rivlin, Blatz-Ko, Alexander, etc.
- Creep laws such as Norton, McVetty, Soderberg, Dorn, ORNL, etc. are supported. These laws can be expressed as general functions of time, stress, and temperature
- Anisotropic elastoplastic material model with linear of piece-wise linear hardening for composite shell elements
- Temperature dependent inelastic properties
- User-defined material model

## GEOMETRIC NONLINEARITY
- Large displacements, large rotations, finite strains
- Total and updated Lagrangian formulation
- Large strain deformation
- Stress stiffening
- Post buckling analysis

## CONTACT CAPABILITIES
- Simple 2D and 3D node-to-node contact elements with friction
- General surface-to-surface frictional contact between flexible-flexible and flexible-rigid bodies
- A priori knowledge of contact region not required
- Contact surfaces may be of arbitrary curved geometry
- Formulation accounts for nonlinear kinematics of large deformation analysis and employs consistent tangent stiffness for contact



- Master-slave implementation with single-pass or symmetric-pass treatment
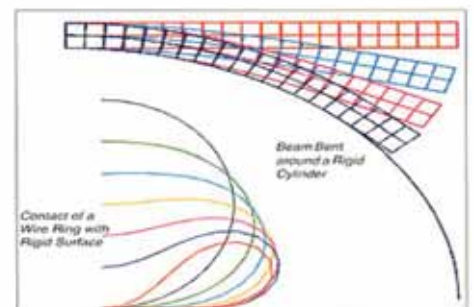
- Automatic substructuring analysis, within a wavefront environment, when the nonlinearity is due to contact conditions only
- General wavefront solution scheme, with dynamic update of wavefront parameters, for general contact problems involving geometric and/or material nonlinearity





Contact between Flexible Plate and Elastic Ring

Ring Pressed between Two Rigid Surfaces
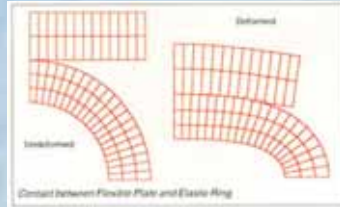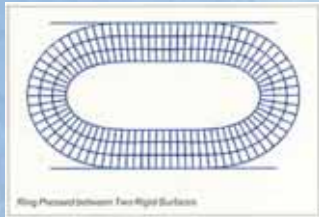
- Conservative loading (fixed direction force, moment, and pressure)
- Non-conservative loading (deformation dependent follower concentrated force and follower pressure)
- Body forces (weight and inertia)
- Thermal loading (specified temperature vs. time curve)

## SOLUTION PROCEDURE

- Incremental-iterative solution procedure
- Full or modified Newton-Raphson techniques
- Special formulation for pure incremental analysis with no iterations
- Equal, user-defined or automatic load steps
- Line search for faster convergence
- Convergence checks with displacments, rotation, force, moment, and energy criterion
- ARC-length method to improve convergence characteristics specially for post-buckling and snap through problems
- Time integration schemes for dynamics, creep and viscous effects



Inflation of a Circular Rubber Plate under Follower Pressure
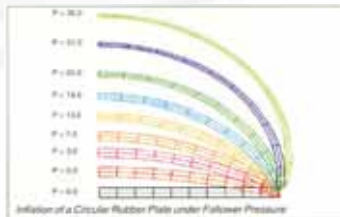
including Newmark, Wilson-Theta Central difference, and Houbolt methods
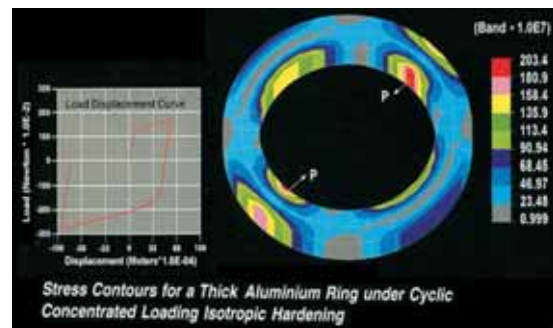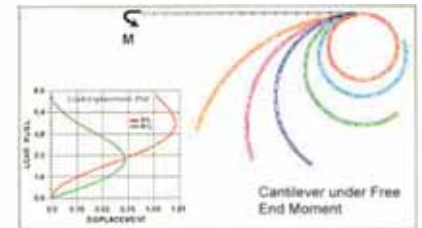- Restarts from the last converged load step

## NONLINEAR DYNAMICS

- Direct integration method
- Various implicit/explicit time schemes
- Consistent or lumped mass matrix
- Geometric and material nonlinear effects
- Stress stiffening
- Discrete damper elements and proportional (Raleigh) damping
- Non-zero initial displacements and velocities, and moving boundary conditions
- Self adaptive time steps

## OUTPUT

- Output at each load step or at every 'N' load step
- Stress output in second Picola-Kirchoff or Cauchy stress for geometry nonlinearity
- Nodal, Gauss point, and centroidal stresses and strains
- Multiple displacement history and stress contours



Cantilever under Free End Moment



Stress Contours for a Thick Aluminium Ring under Cyclic Concentrated Loading Isotropic Hardening

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