Drop Test Simulation Made Easy
With ANSYS Simulation

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• Introduction
• Methods of Drop Test Analysis
  – Implicit Transient Dynamics
  – Explicit Dynamics
  – Response Spectrum (Linear Dynamics)
• Examples
• Live demonstration of Explicit STR
Introduction

- Many commercial and electronic components have drop test specifications
- Build and test methodology takes large amounts of calendar time and labor and material costs
- It would be very useful to be able to determine before the drop test if the component will survive.
- That can be done with simulation (or virtual drop test)
Response Spectrum (frequency integration)

- The impact is assumed to be a half sine loading with a hand calculated time duration expressed as a harmonic frequency.
- This is a mode superposition method that requires the model to be completely linear.
- This analysis solves much faster than the transient approaches and uses significantly fewer resources.

Implicit (time integration)

- The solution is obtained using a series of linear approximations.
- Small iterative time steps are required to achieve convergence.
- Good for drop simulation with long time durations and no or moderate nonlinearities.

Explicit (time integration)

- The equations become uncoupled and can be solved for directly (explicitly).
- Tiny time steps solved once
- No inversion of the stiffness matrix is required.
- Good for problems with short time transients and extreme nonlinearities. This includes extremely large distortions and deformation, material failure, extremely nonlinear materials.
Response Spectrum Drop Test Simulation

- Method described in *Vibration Analysis of Electronic Equipment*, by Dave Steinberg
- Set up the model as you would for any response spectrum analysis
- Load Spectrum are hand calculated based on drop height and
Implicit Transient Dynamics

- Solution depends on previous time step and current time step
- Resolves nonlinearities with standard Newton–Raphson iteration approach
- Can handle moderate nonlinearities
  - Most contact
  - Moderate nonlinear materials
  - Moderate distortion and strain
- Can handle events of second-minute duration
- Uses standard 2\textsuperscript{nd} order solid elements
  - No hourglass energy issues
- Use for problems of duration of seconds to minutes with moderate or no nonlinearities
Example Implicit Drop Simulation
Electronic Enclosure

- Linear elastic materials
- Small strain
- Straight forward contact
- Prefailure only
Explicit Dynamics

• Solution depends only on previous time step
• Requires a very small (sub-μs) time step
  – Limited to problem with duration in milliseconds or less
  – Most drop problems are of this duration
  – Time step is partially based on mesh size
• Does not require non-linear convergence, therefore can resolve the most severe nonlinearities
  – Excessive distortion and displacement
  – Extremely non-linear material
  – Buckling
  – Material failure
  – Contact failure
• Uses 1st order elements
  – Need finer mesh to get same accuracy as implicit
Explicit Dynamics Solutions

• ANSYS/LS-DYNA
  – Jointly developed product (since 1995)
  – Mechanical Interface for preprocessing – MAPDL or LS-Post for post processing
  – LSTC – LS-DYNA solver
  – Brick meshes
  – Solid problems only

• ANSYS Explicit STR
  – Purchased Century Dynamics in 2005
  – Continual development over 30 years
  – Same interface as ANSYS Mechanical
  – Tetrahedral and brick meshing
  – Easy restart
  – Easy parametric studies
    • Angle of strike
  – Design Exploration
ANSYS/LS-DYNA Applications

Electronics

- Large Distortion
- Material Failure
DROP TEST OF A SCREWDRIVER (SD.INP)
Explicit/STR Applications
Electronics Product

- Material Failure
- Contact Failure
Explicit/STR Applications
Nuclear Waste Containment Vessel
Live Demonstrations
• Example:: Sports equipment design (Extreme and otherwise)
Conclusions

- **Explicit Dynamics simulation is very useful when**
  - Time durations are very short (approximately msec.)
  - Extremely non-linear behavior
  - Implicit schemes will not converge

- **ANSYS has 3 of the top Explicit Dynamics solutions.**
  - ANSYS Explicit/STR
  - ANSYS/LS-DYNA
  - ANSYS Autodyn