



### Product Features

#### Analysis Classes

##### Structural

- ▶ Static, dynamic and time transient
- ▶ Natural frequency, harmonic and spectrum response
- ▶ Random vibration
- ▶ Topological optimization

##### Thermal

- ▶ Steady-state or transient
- ▶ Conduction
- ▶ Convection
- ▶ Radiation
- ▶ Phase change via enthalpy

##### Electrostatics

- ▶ H and adaptive p-elements
- ▶ Hybrid FEA/BEA domain

##### Magnetostatics

- ▶ 2-D and 3-D magnetic vector potential (MVP) and scalar formulations
- ▶ 3-D edge element formulation

##### Ion Optics

- ▶ Trace charged particles in electric or magnetic static fields, or both
- ▶ Plot trajectories in 2-D, 3-D or listed current conduction
- ▶ Joule heating and coupled heat transfer
- ▶ Currents can be used for magnetostatic excitation

##### CFD

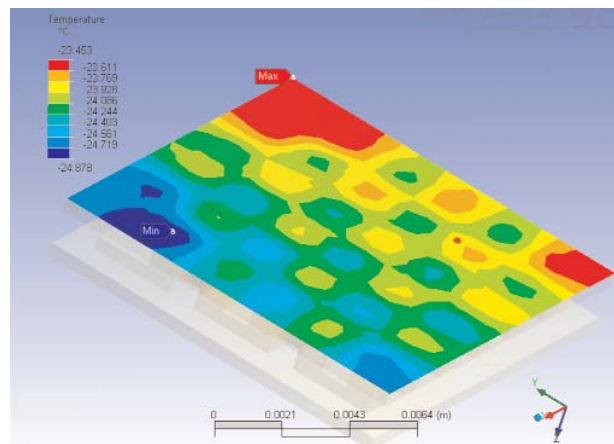
- ▶ Steady-state, time transient
- ▶ Incompressible, compressible
- ▶ Laminar, turbulent

##### Acoustics

- ▶ Fully coupled fluid-structural
- ▶ Harmonic, transient and modal

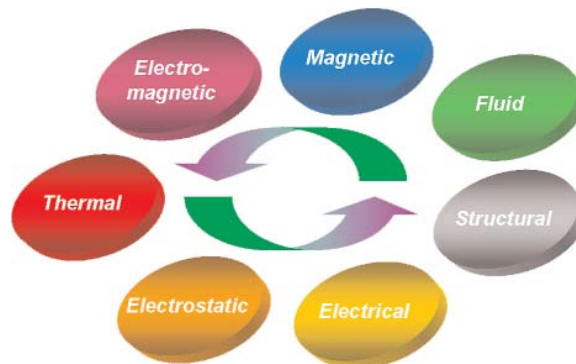
### The Most Comprehensive Coupled Physics Solution

The ANSYS® Multiphysics™ solution provides the analysis industry's most comprehensive coupled physics tool combining structural, thermal, CFD, acoustic and electromagnetic simulation capabilities in a single software product. With the ANSYS Multiphysics solution, users can realize the benefits of the core physics of the entire ANSYS simulation suite in one convenient package. Applications include rotating machines (motors and alternators), sensors and actuators, power generators and transformer systems, and micro-electro mechanical systems (MEMS).



An ANSYS Multiphysics analysis of a thermoelectric (Peltier) effect cooler

ANSYS Multiphysics software is a general-purpose analysis tool that allows users to combine the effects of two or more different yet inter-related physics within one unified simulation environment. Many classes of physics are provided.



## Product Features

### Low-Frequency Magnetic

- ▶ Quasistatic magnetic
- ▶ Time-harmonic analysis for linear materials
- ▶ Time-transient analysis for linear and nonlinear materials
- ▶ 2-D and 3-D magnetic vector potential (MVP) formulation
- ▶ 3-D edge flux formulation

### Low-Frequency Electric

- ▶ Quasistatic electric
- ▶ Time-harmonic analysis for linear materials
- ▶ Time-transient analysis for linear materials
- ▶ Joule heating and coupled heat transfer
- ▶ Currents can be used for magnetostatic excitation

### High-Frequency Electromagnetic

- ▶ First- and second-order tangential vector elements
- ▶ 3-D brick, pyramid, prism and tetrahedral element shapes
- ▶ Cavity modal analysis
- ▶ Harmonic analysis: wave propagation, radiation and scattering
- ▶ SPICE equivalent circuit output

### Circuit Analysis and Coupling

- ▶ Static, harmonic and transient
- ▶ SPICE-like circuit elements
- ▶ Resistors, capacitors, inductors, diodes, transformers, voltage and current sources
- ▶ Easy-to-use circuit builder GUI
- ▶ Coupling to electrostatic analysis
- ▶ Coupling to stranded and massive conductors

## Coupled Physics

The ANSYS Multiphysics solution provides two powerful methods to couple multiple physics together — Direct and Iterative.

### ▶ Direct

- Solves coupled physics equations directly
- Solves each physics simultaneously

### ▶ Iterative

- Physics coupled by passing loads across physics field interfaces
- Solves each physics simultaneously or sequentially
- At least two iterations, one for each physics, in sequence are needed to achieve a coupled response

Providing both coupling methods allows the ANSYS Multiphysics solution to address an extremely broad range of analysis applications.

Direct Coupled Physics	Applications
Pressure–structural (Inviscid FSI)	Acoustics, sonar, SAW
Piezoelectric	Microphones, sensors
Piezoresistive	Pressure sensors, strain gauges, accelerometers
Circuit coupled electromagnetics	Motors, MEMS
Electrostatic–structural	MEMS
Electro–thermal–structural–magnetic	IC, PCB, electro-thermal stress, MEMS actuators
Fluid–thermal	Piping networks, manifolds
Iterative Coupled Physics	Applications
Thermal–structural	Gas turbines, anything with a structure
Electromagnetic–thermal	Induction heating, RF heating
Electrostatic–structural–fluid	MEMS
Electrostatic–charged particle	Ion optics, field emission display technology, analytical instruments
Magnetic–structural	Solenoids, electromagnetic machines
Fluid structure interaction	Aerospace, automotive fuel, hydraulic systems, fluid-bearing, MEMS fluid damping, drug delivery pumps, heart valves
Thermal–CFD	Electronics cooling
Multi-field solver	Many, all of the above
Third-party product coupling: Sigfit: unidirectional, structural–optical	Automotive lighting, astronomy, any optical instruments

Table showing direct and sequential coupled physics available with the ANSYS Multiphysics solution and some typical applications

## ANSYS Multi-field Solver

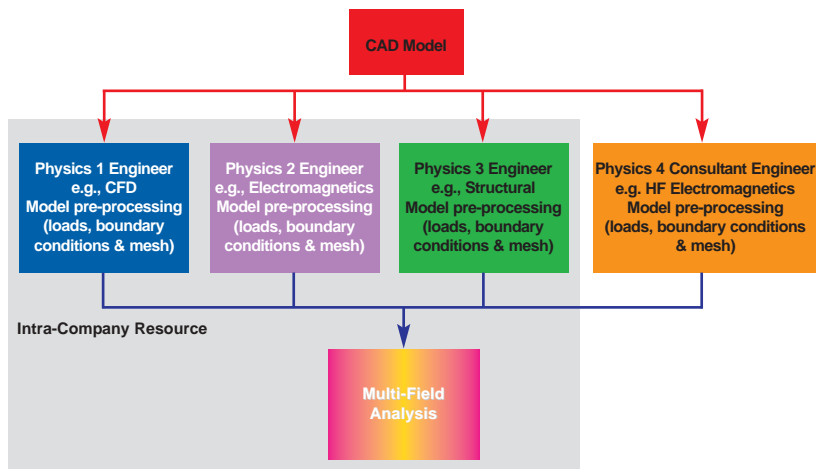
In recent years, there has been an increase in the number of industries/applications needing to solve coupled physics problems. The ANSYS® Multi-field™ solver provides an easy-to-use framework to solve coupled field problems in many new markets and applications in which solutions have not existed in the past. The Multi-field solver is a general purpose, automated iterative coupled physics solver ANSYS applicable across all physics and available in the ANSYS Multiphysics solution. The Multi-field solver is an evolution of the successful fluid solid interaction (FSI) solver from ANSYS, Inc.

### Key Features of the Multi-field Solver

- ▶ Each physics treated as a field with an independent model and mesh
- ▶ Dissimilar mesh allowed for each field
- ▶ Any number of physics fields allowed
- ▶ Surface and volumetric loads transfer across physics fields
- ▶ Iterative (load vector) coupling is between fields and each field may have different:
  - Analysis types (transient, static or harmonic)
  - Solvers and analysis options
  - Mesh discretization
- ▶ Automated morphing of non-structural elements
- ▶ Material and geometric nonlinearity
- ▶ Independent results files for each physics “field”
- ▶ Coupling with ANSYS® CFX® for fluid structure interaction (FSI) applications:

Multi-field solution is distributed between more than one product (for example, between ANSYS Multiphysics and ANSYS CFX)

An important feature of the Multi-field solver is the dissimilar mesh interface allowed between each physics field. Independent users can build and set up their physics analysis field instead of having to rely on a “super-physicist” to handle all aspects of the multiphysics analysis. The dissimilar mesh interface allows more efficient meshing of physics fields, resulting in more-compact finite element models with faster solution times.



The Multi-field solver allows an analysis problem to be distributed so separate physics can be processed by individual analysis experts sharing a common CAD model in your company.

## Product Features

### Materials, Boundary Conditions and Effects

- ▶ 3-D and 2-D planar and axisymmetric geometry
- ▶ Geometric nonlinearity: large strain and deflection, stress stiffening and spin softening
- ▶ Coriolis effect
- ▶ Material nonlinearity: plasticity, hyper-elasticity, viscoplasticity, viscoelasticity, creep, swelling
- ▶ Contact, cracking, crushing
- ▶ Thermo-elastic damping
- ▶ Permeable and non-permeable domains
- ▶ Current and voltage excitation
- ▶ Stranded coils and massive conductors
- ▶ Biot-Savart coils
- ▶ Capacitive and inductive effects
- ▶ Velocity effects, eddy and displacement currents
- ▶ Lossy dielectrics
- ▶ Inductance and capacitance matrix calculations
- ▶ Cyclic symmetry
- ▶ Electromagnetic and thermal contact
- ▶ Electromagnetic force
- ▶ Force coupling to structural
- ▶ Piezoelectric and piezoresistive materials
- ▶ Thermoelectrics: Joule heating, Seebeck, Peltier and Thomson effects
- ▶ Newtonian and non-Newtonian fluids
- ▶ Free, forced or mixed convection heat transfer
- ▶ Surface-to-surface radiation heat transfer
- ▶ Fluid-free surface boundaries

## Product Features

### Materials, Boundary Conditions and Effects for HF Electromagnetics

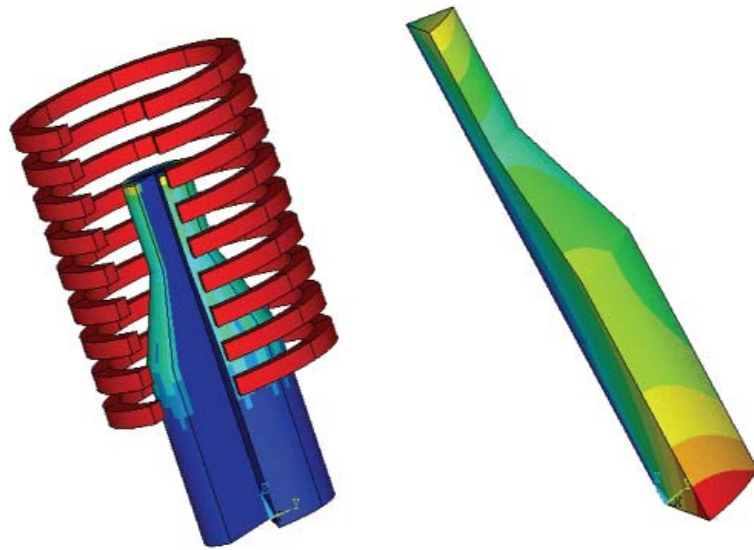
- ▶ Complex permittivity and permeability
- ▶ Frequency dependent material properties
- ▶ Lossy/lossless, isotropic and diagonal anisotropic material properties
- ▶ Perfect electric and magnetic conductors (PEC and PMC)
- ▶ Impedance boundary condition (IBC)
- ▶ Perfectly matched absorber (PMA)
- ▶ Coupled heat generation from lossy dielectrics
- ▶ Rectangular, circular, coaxial, parallel plate waveguide modal source
- ▶ Plane wave source
- ▶ Surface magnetic and electric field sources
- ▶ Point, line, surface and volume current source, line voltage source
- ▶ Cavity resonant frequency
- ▶ Quality factor (Q)
- ▶ S-parameters of a network and Touchstone® S-parameter output
- ▶ Joule losses, port power
- ▶ Voltage, current and impedance
- ▶ Near and far electromagnetic field extension
- ▶ Radar cross section (RCS) and antenna pattern
- ▶ Phased array antennas
- ▶ Periodic structures
- ▶ Frequency selective surfaces (FSS)
- ▶ ANSYS Variational Technology (VT) analysis fast-frequency sweep S-parameter extraction option

## ANSYS Multiphysics Benefits

The ANSYS Multiphysics solution is a unique, powerful analysis tool with thousands of features as well as high performance and reliability to meet analysis requirements.

Analyses closely match reality — the ANSYS Multiphysics solution is a virtual prototyping lab on the desktop.

- ▶ Reduced assumptions that question certainty and compromise accuracy
- ▶ Lower cost: fewer analysis software tools to purchase, learn and manage
- ▶ Lower cost: R&D process compression



Multi-field solver example: Electromagnetic-thermal-mechanical analysis of induction heating process. Left image shows induced eddy currents in sample; right image shows structural displacement resulting from thermal expansion after 25 seconds.

[www.ansys.com](http://www.ansys.com)