



P&S COMSOL® Design Tool

Lecture Week 3: Introduction to COMSOL

Manuel Kohli, Raphael Schwanninger

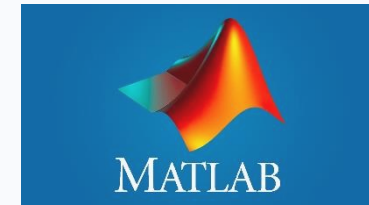
Content

- Software & Physics
- Meshing
- Boundary Conditions
- Source
- Tutorial 3: Young's Slit Experiments

Software & Physics

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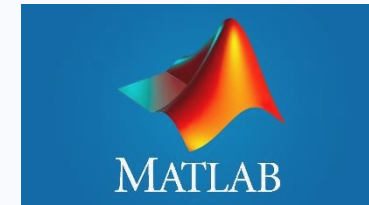
Simulation Software



Software & Physics

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Simulation Software



Simulation Method

Finite Element Method (FEM)



Finite Difference Time Domain (FDTD)



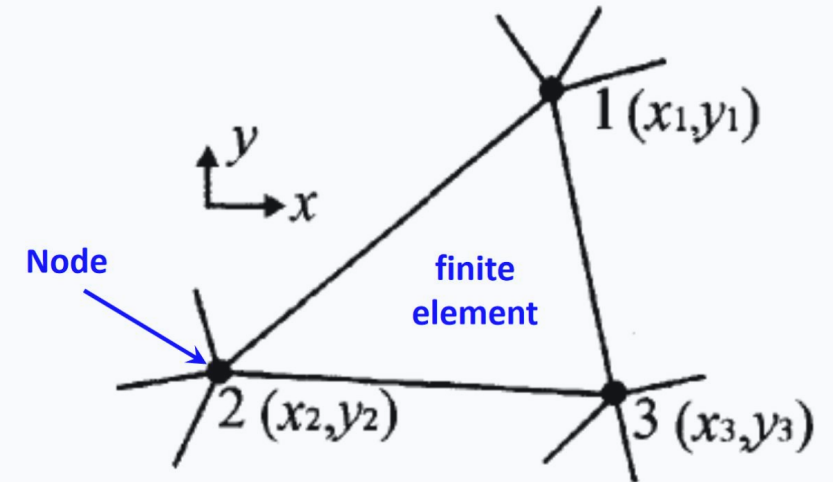
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FEM

1. *Division of space into finite elements*
 - *Local refinement*
 - *Almost perfectly conformal*
2. *Formulation of a boundary value problem*
 - *Field calculated at the node and interpolated at edges*
3. *Elimination of time derivatives (steady state)*



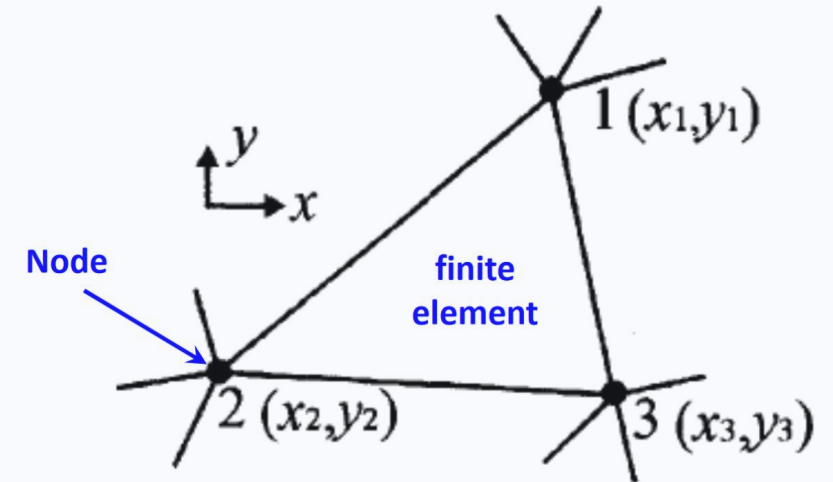
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Advantages of FEM

- + Modeling
- + Accuracy specification
- + Boundary conditions
- + Visualization
- + Material properties

Disadvantages of FEM

- Data required as input for mesh
- Sometimes large computational power
- Output can vary
- Frequency domain

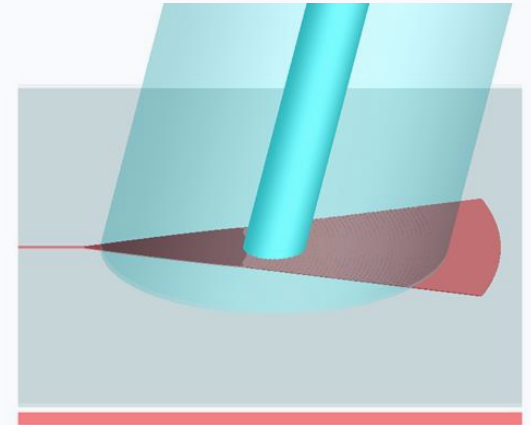
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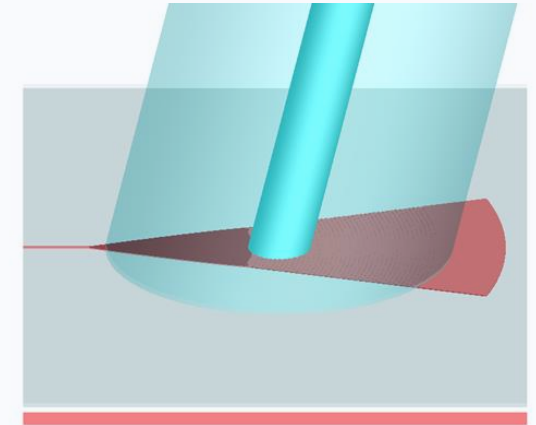
FDTD

1. *Replace derivative with finite difference, discretize in space and time*
2. *Solve resulting difference equations*
3. *Evaluate magnetic field one time-step in future*
4. *Evaluate electric field one time-step in future*
5. *Repeat the previous two steps*



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FDTD

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Advantages of FDTD

- + Intuitive
- + Time-domain
- + Animated display of evolving fields
- + Direct usage of E - and H -Fields

Disadvantages of FDTD

- Rectangular mesh
 - Conformality and refinement
- Material boundaries

Meshing

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FEM, FDTD, FDFD,
FEM, BEM

Frequency Domain,
Acoustics, Fluids,
Plasma, etc

Domain & Mesh

Meshing

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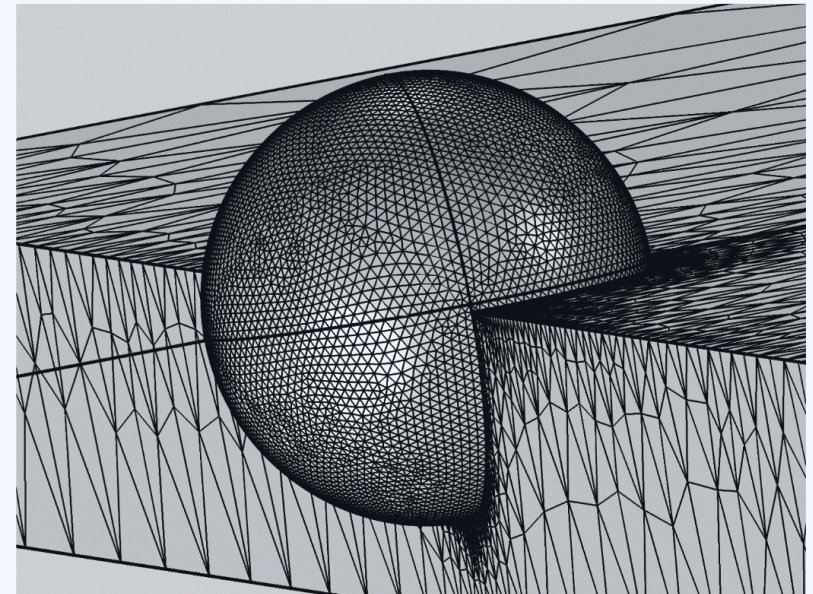
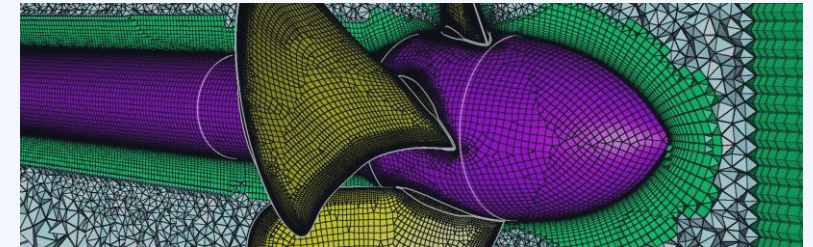
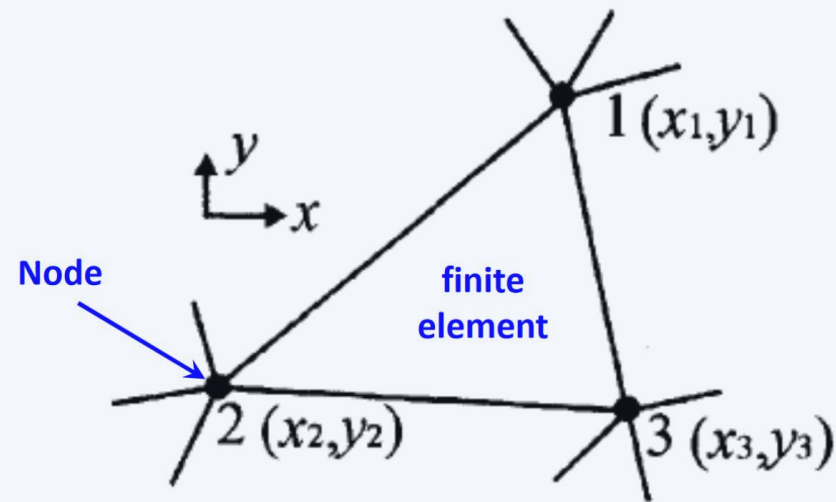
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FEM, FDTD, FDFD,
FEM, BEM

Frequency Domain,
Acoustics, Fluids,
Plasma, etc

Domain & Mesh



Meshing

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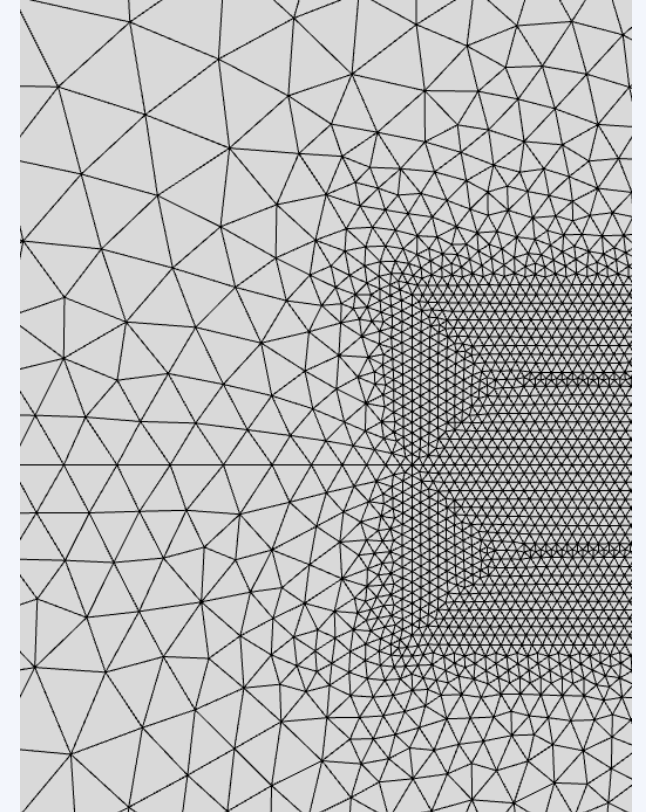


FEM, FDTD, FDFD,
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Frequency Domain,
Acoustics, Fluids,
Plasma, etc

Domain & Mesh

- Discretization of simulation domain
- Mesh size determines accuracy of solution
 - Too large mesh → wrong results
- Accuracy vs. simulation time
 - Too small mesh → very large simulation time
 - If RAM is too low, data is written onto hard drive → ultra large simulation time



Boundary Conditions

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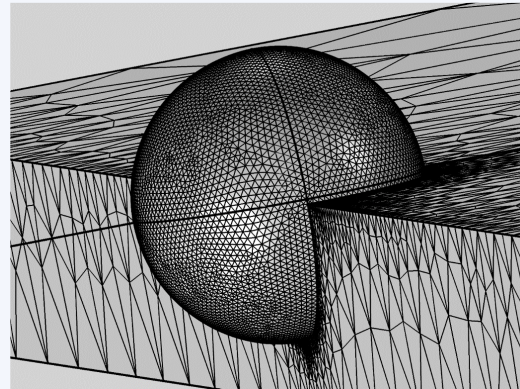
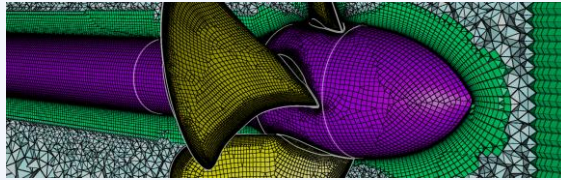
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Boundary Conditions

Boundary Conditions

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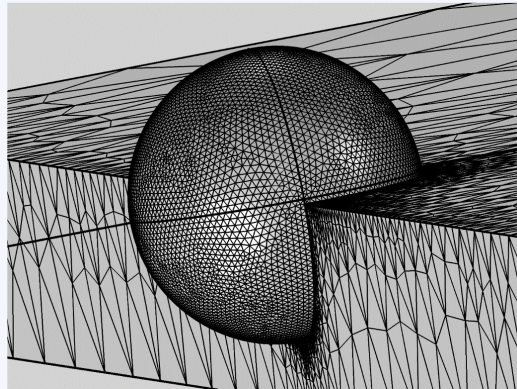
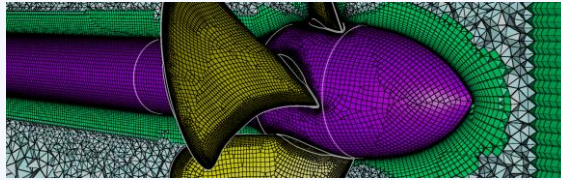
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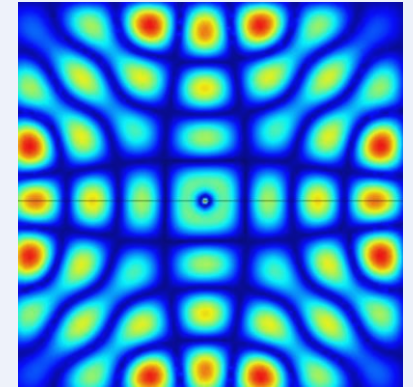
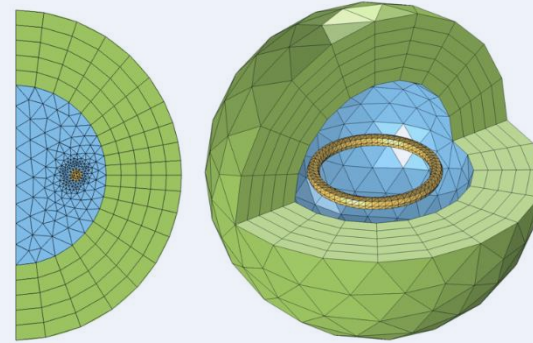
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Boundary Conditions

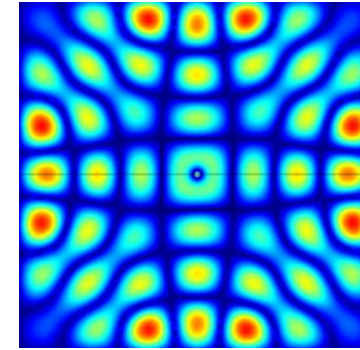


Types of boundary conditions in COMSOL

- Perfect Electric Conductor (PEC)
- Perfect Magnetic Conductor (PMC)
- Scattering Boundary Condition
- Periodic Boundaries Condition (PBC)
- Perfectly Matched Layer (PML)

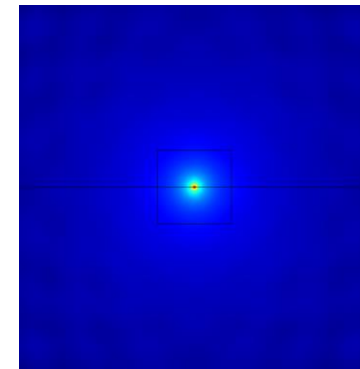
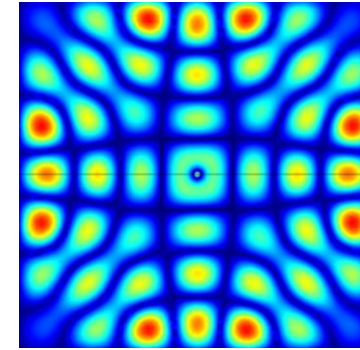
Boundary Conditions

- **Perfect Electric Conductor (PEC)**
 - Properties
 - Electric field cannot penetrate → reflection of electric field
 - Equivalent to infinite electric conductivity



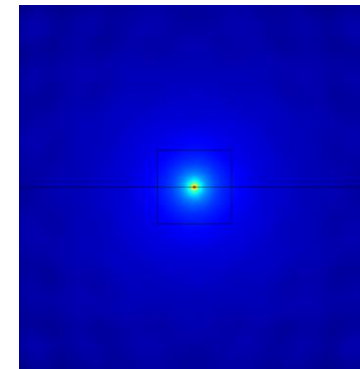
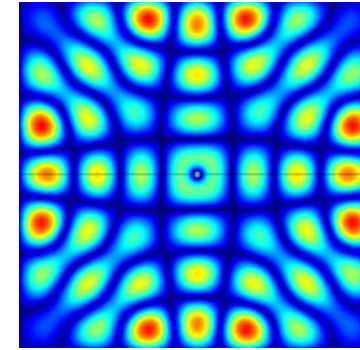
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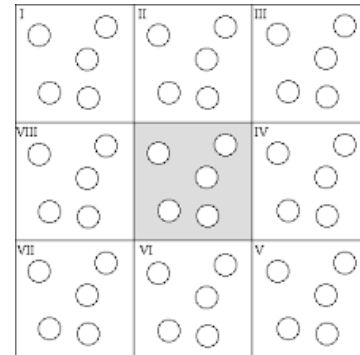
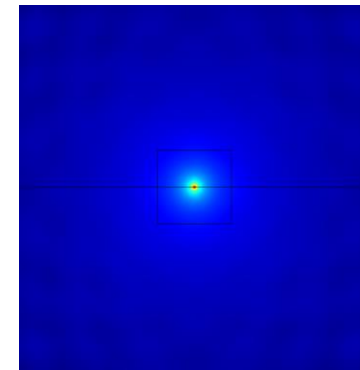
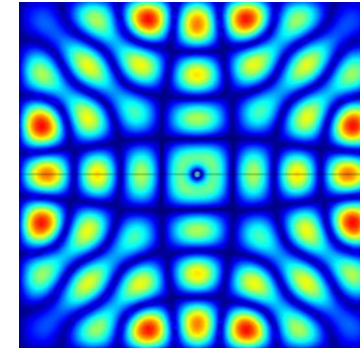
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- **Scattering Boundary Condition**
 - Properties
 - Electric field is absorbed → no reflection



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 - Magnetic field cannot penetrate → reflection of magnetic field
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- **Scattering Boundary Condition**
 - Properties
 - Electric field is absorbed → no reflection
- **Periodic Boundary Condition**
 - For repeating structures
 - Use a unit cell for the analysis
 - Simulates systems expanding infinitely in 1D/2D



Source

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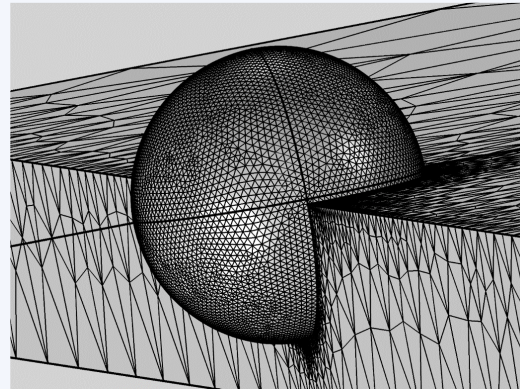
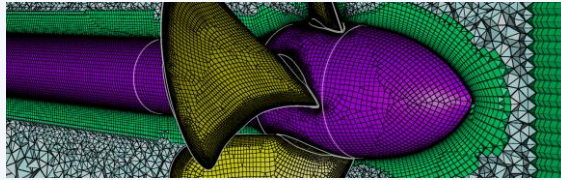
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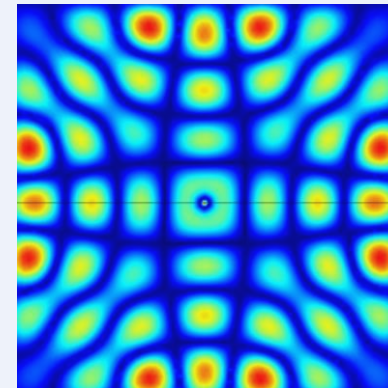
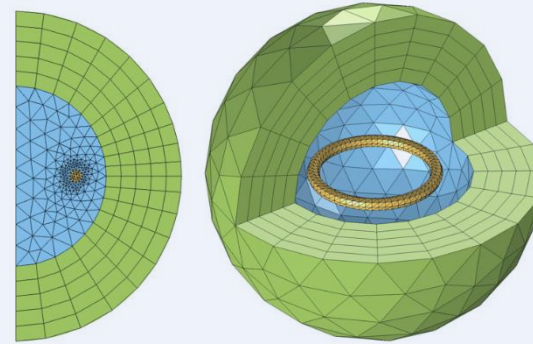
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Domain & Mesh



Bondary Condition



Source

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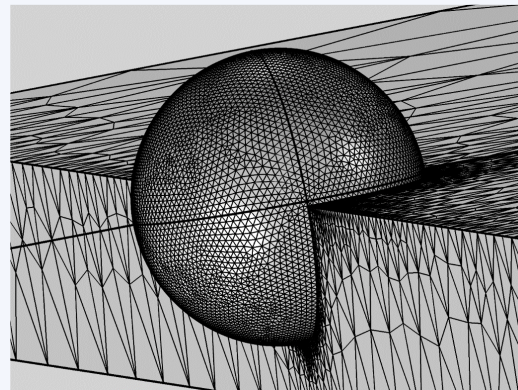
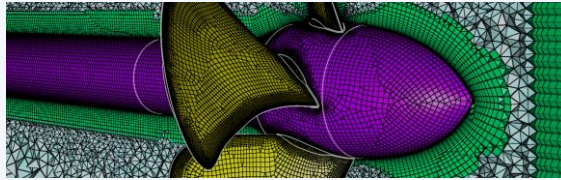
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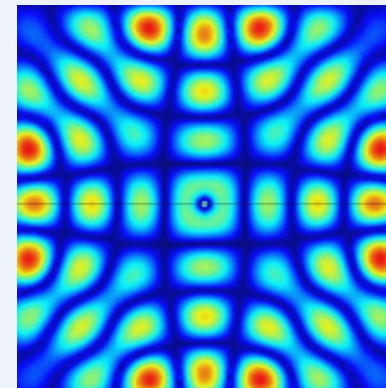
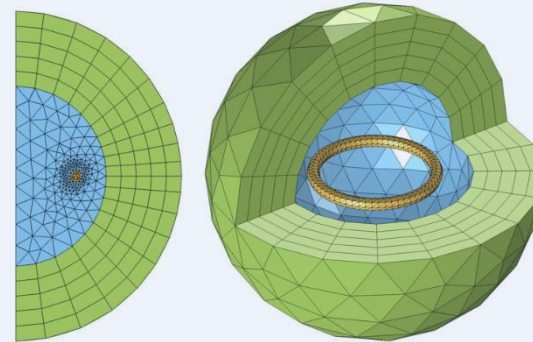
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