# Engineering Optimization

- **Most engineering design involves using optimization software**
- **Minimizes or maximizes a merit function**
- **Applies functional constraints**
- **Applies regional constraints**

# You Must…

- **Select or define**
  - **the Merit Function (MF)**
  - **the Analysis Variables (AV)**
  - **and their sub-set of Design Variables (DV)**
  - **the Analysis Functions (AF)**
- **Define the constraints**
  - **Functional**
  - **Regional**

# Software Tools

- **At least 4 software tools to solve optimization problems of different scope:**
  - **COSMOS finite element stress & thermal**
  - **ANSYS finite element multi-physics**
  - **OPTDESX user defined**
  - **TK Solver user defined**

# Problem Scopes

- **Large FE system with a limited number of pre-defined MF, AV, DV, AF.**
- **MF is a user defined equation. Very general ability defined by application dependent subroutines in f90 or C.**

# OptdesX

- **The X-Windows interface to the Optdes (Optimum design) system.**
- **Requires 3 user-written, compiled, and linked subroutines (for AV, AF, MF).**
- **Optionally, user can supply operating system commands to use a big "black box" code to form the MF.**
- **You supply consistent units.**

# OptdesX Interface

- **Allows interactive selection (mapping) of the DV from the AV.**
- **Allows interactive definition of the problem constraints.**
- **Allows interactive definition of multiple Merit Functions (MFs).**
- **Graphical displays of design history, etc.**

# OptdesX Algorithms

- **Includes multiple algorithms for**
  - **Continuous optimization (smoothly changing variables)**
  - **Discontinuous optimization (tabular non-smooth items like pipe sizes or standard structural shapes)**

# 3 OptdesX Subroutines

- **ANAPRE (ANAlysis PRE-processor) is called only once. Open files, etc.**
- **ANAFUN (ANAlysis FUNctions) is called every iteration to define MF, etc.**
- **ANAPOS (ANAlysis POSt-processor) is called only if the user hits the post-process button.**

# Subroutine ANAPRE (model_name)

- **Provides one time calculations, if any, before optimization.**
- **Can also be used to open files needed in ANAPOS or to initialize ANAPRE.**
- **Often it simply sets the model_Name (of 17 characters, max).**

# Subroutine ANAFUN, 1

- **Provides double precision analysis function calculations of the trial vector**
- **Three major segments:**
  - **a) gets the scalar Analysis Variable (AV) values from the X-Window subprogram AVDSCA**
  - **b) you must use those AV names to compute needed constants and the Analysis Functions (AF) values**
  - **c) returns the scalar Analysis Function (AF) values to the X-Window subprogram AFDSCA**

# Subroutine ANAFUN, 2

- **Step b) above could call any other analysis program, such as an FE code.**
- **Optdes provides a operating system level interface to aid with the calls**
- **Optdes can run in background**
- **These options are difficult to implement**

# X-Window Interfaces

- **Two arguments to AVDSCA**
  - **local variable name used in ANAFUN**
  - **name (and units) used in the X-Window display, limited to 15 characters.**
- **Two arguments to AVFSCA**
  - **local variable name you created for the analysis function in step b.),**
  - **name (and units) used in the X-Window display, limited to 15 characters.**

# Subroutine ANAPOS

- **Provides optional calculations, if any, after optimization**
- **Can be invoked by pushing the "Post process" button in the Design Variable Window**
- **Usually, if this function actually does any calculations they are written to a I/O unit you opened in ANAPRE**

# ANAPRE, ANAFUN, ANAPOS

- **Fortran 90 source examples are on class web page, with compile, link, and run info.**
- **C and f77 source examples are in online manual.**

# ANAPRE, ANAFUN, ANAPOS

- **Most common errors:**
  - **Integer division instead of double precision, 1 / 2 = 0, not 0.5d0 as do 1.d0 / 2 or 1 / 2.d0**
  - **Inconsistent engineering units in input and analysis functions**
  - **Omitting units in X-Window displays**

# OptdesX Documentation

- PDF Manual is on class web site
- Continuous optimization tutorial on p. 30
- Discrete optimization tutorial on p. 80
- Algorithm theories on p. 175
- Contents on p. 4, Index on p. 230
- Example source files are on class web site