FEM U MEHANICI ČVRSTOG TIJELA

Vježba 1: Linearno-elastična analiza

$$\rho\,\ddot{\boldsymbol{u}} = \mathrm{div}\boldsymbol{\sigma} + \rho\,\boldsymbol{b} = (\sigma_{ij,j} + \rho\,b_i)\;\boldsymbol{e}_i$$

Osnovna jednačina mehanike kontinuuma

$$\boldsymbol{\sigma} = \boldsymbol{\mathcal{C}} : \boldsymbol{\varepsilon} = C_{ijkl}\;\varepsilon_{kl}\;\boldsymbol{e}_i \otimes \boldsymbol{e}_j$$

Konstitutivna relacija za linearno-elastični materijal

$$\boldsymbol{\varepsilon} = \begin{bmatrix} u_{1,1} & \frac{1}{2}(u_{1,2}+u_{2,1}) & \frac{1}{2}(u_{1,3}+u_{3,1}) \\ \frac{1}{2}(u_{1,2}+u_{2,1}) & u_{2,2} & \frac{1}{2}(u_{2,3}+u_{3,2}) \\ \frac{1}{2}(u_{1,3}+u_{3,1}) & \frac{1}{2}(u_{2,3}+u_{3,2}) & u_{3,3} \end{bmatrix} = \frac{1}{2}(u_{i,j}+u_{j,i})\;\boldsymbol{e}_i \otimes \boldsymbol{e}_j$$

Tenzor elastične deformacije (mala deformacija), matrična forma

$$\int_{\Omega} \delta u_i \, \ddot{u}_i \, \rho \, dV + \int_{\Omega} \delta \varepsilon_{ij} \sigma_{ij} \, dV = \int_{\Omega} \delta u_i \cdot b_i \, \rho \, dV + \int_{\Gamma_\sigma} \delta u_i \, t_i^{\star} \, dA$$

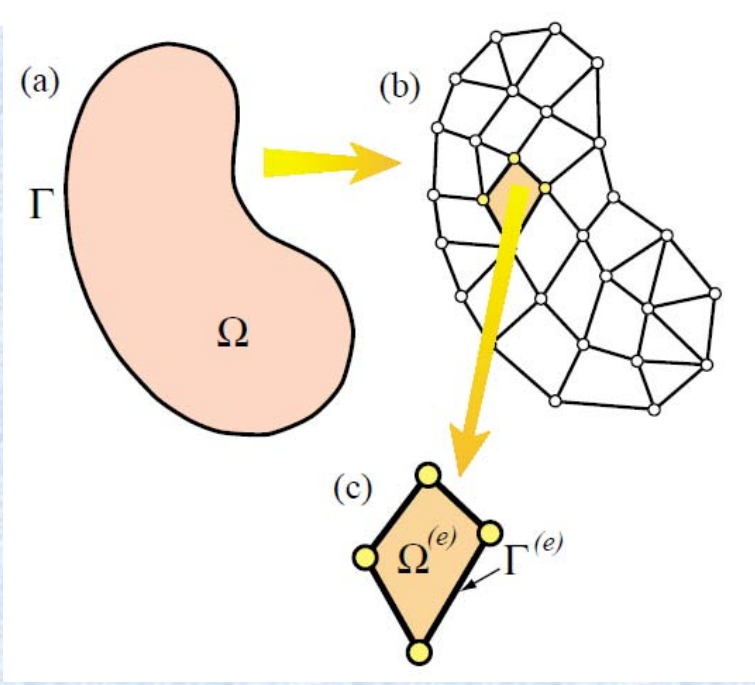
Integralni oblik, princip virtualnih pomaka

$$u(\underline{X}) = \sum_{i=1}^{i=n} N_i \cdot U_i$$

Diskretizacija funkcije pomaka
(N_i – interpolacijske funkcije)

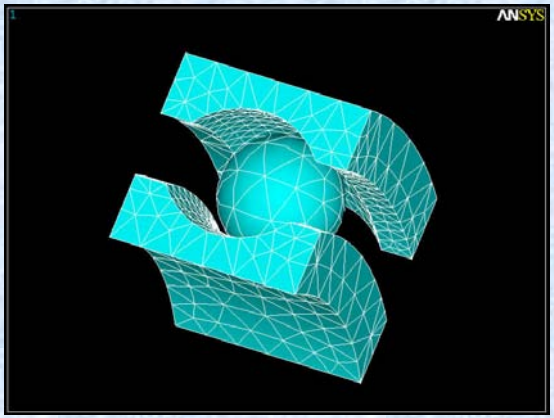
$$\mathbf{M}\,\ddot{\boldsymbol{u}} + \mathbf{K}\,\boldsymbol{u} = \boldsymbol{r}$$

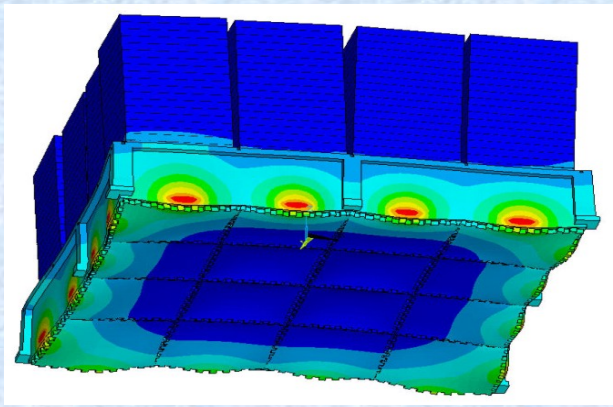
Sistem linearnih jednačina (n DOF)

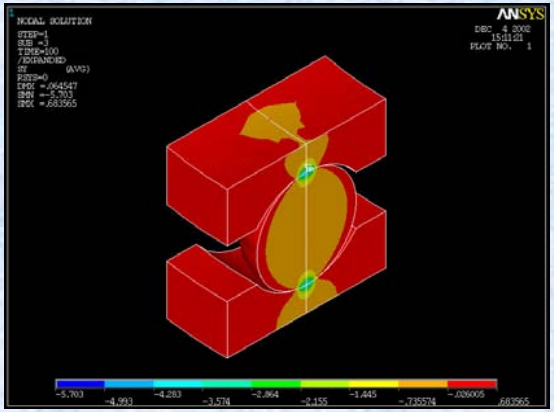


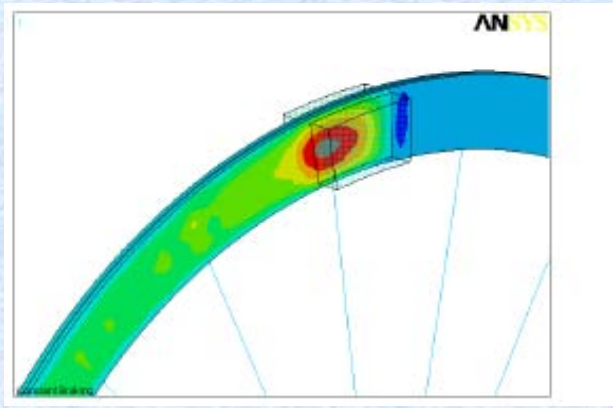
Diskretizacija domene

Kontaktna, toplotna i "multyphysics" analiza

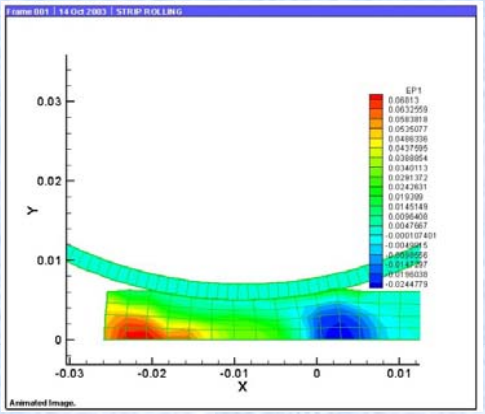


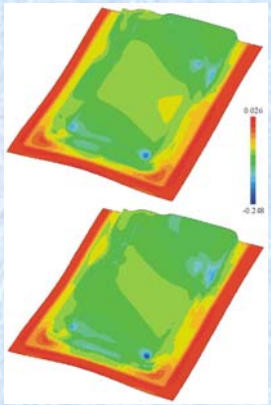


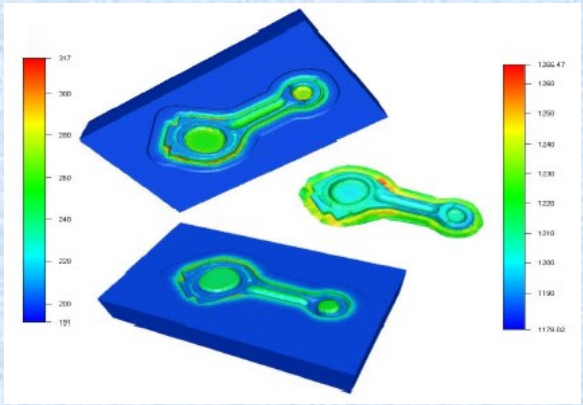


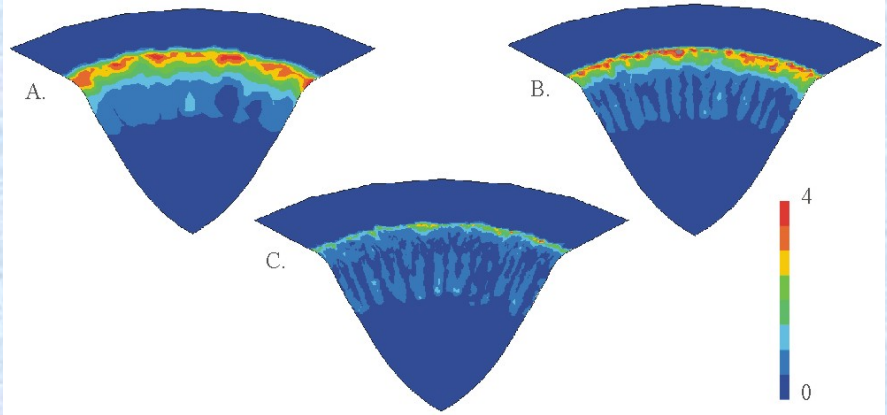


Simulacija obradnih procesa

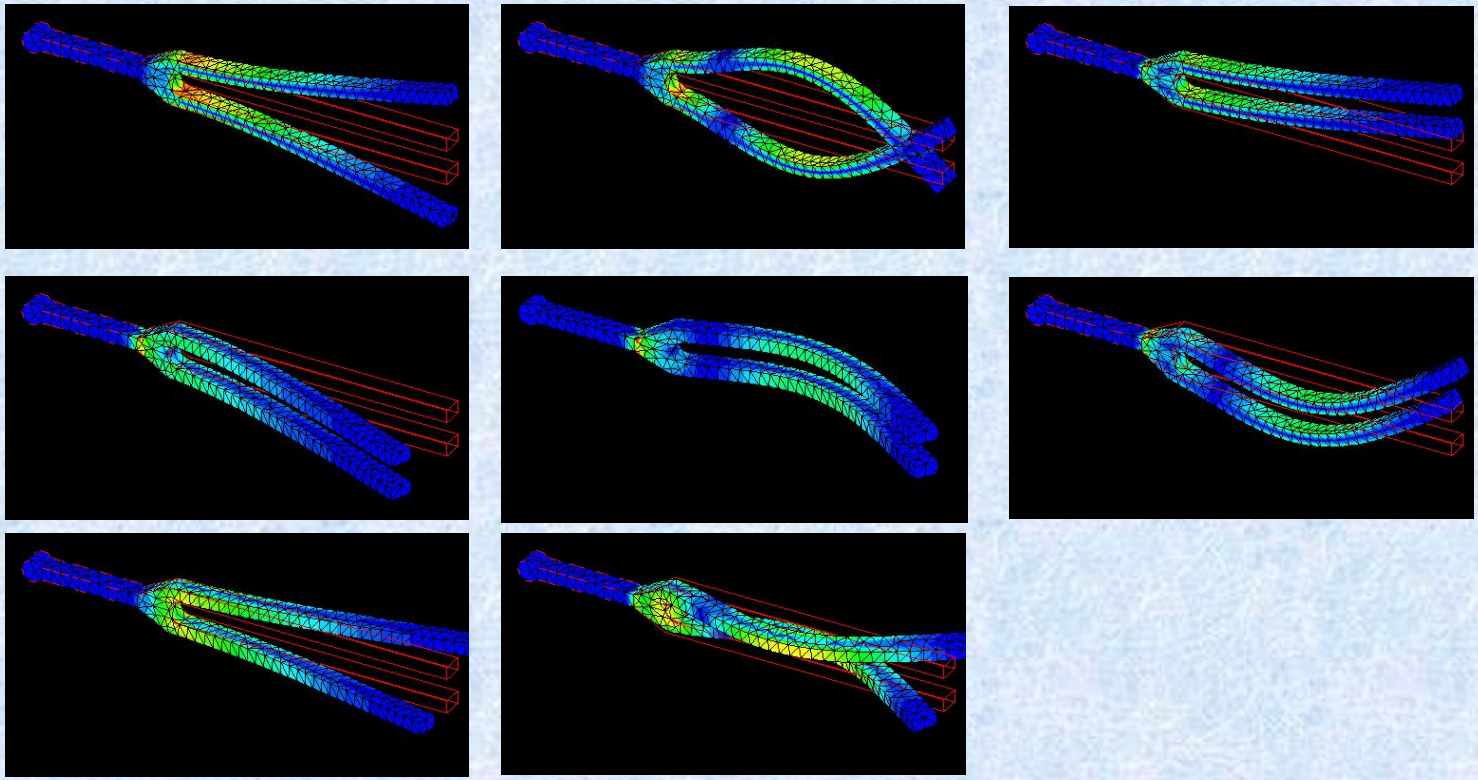






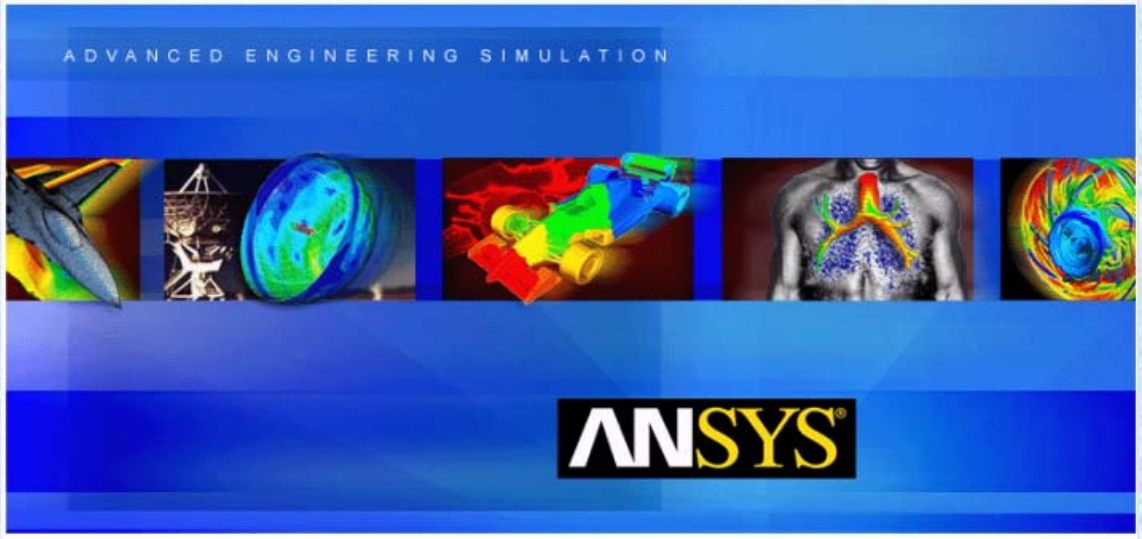


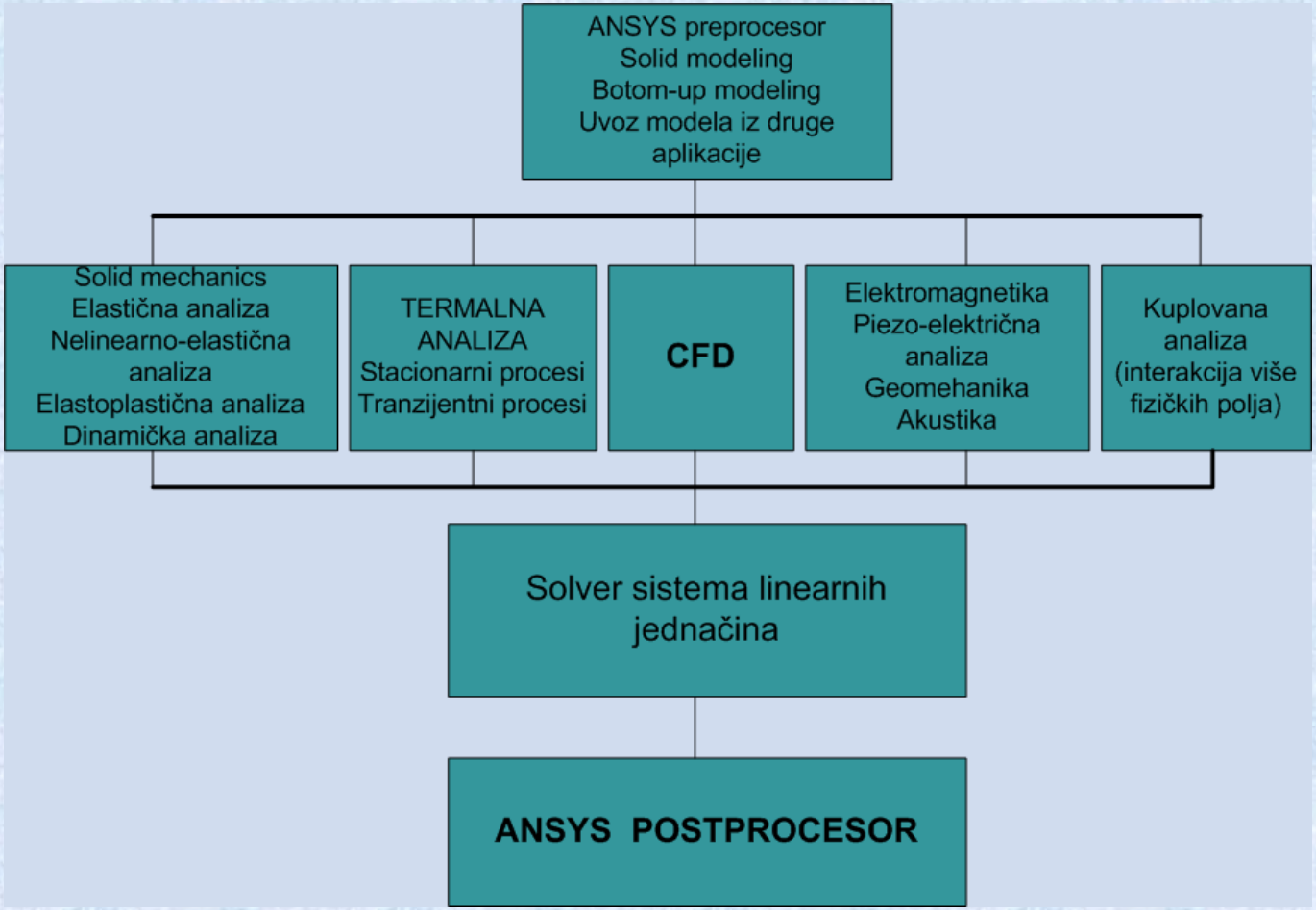
Dinamička analiza, sopstveni oblici vibracija



Vodeći komercijalni FEM programi:

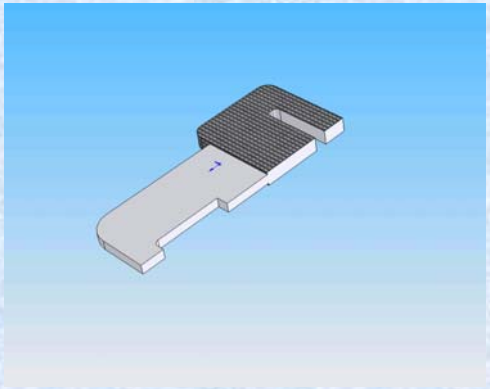
Abaqus
Adina (K.J. Bathe, MIT)
Algor
ALTAIR HyperMESH
Ansys
Cosmos (SolidWorks)
FEMAP
FEAP
IDEAS
LS-Dyna
Lusas
Marc
Nastran (NASA)
PATRAN (pre i post processor)
SAP (Građevinski fakulteti)

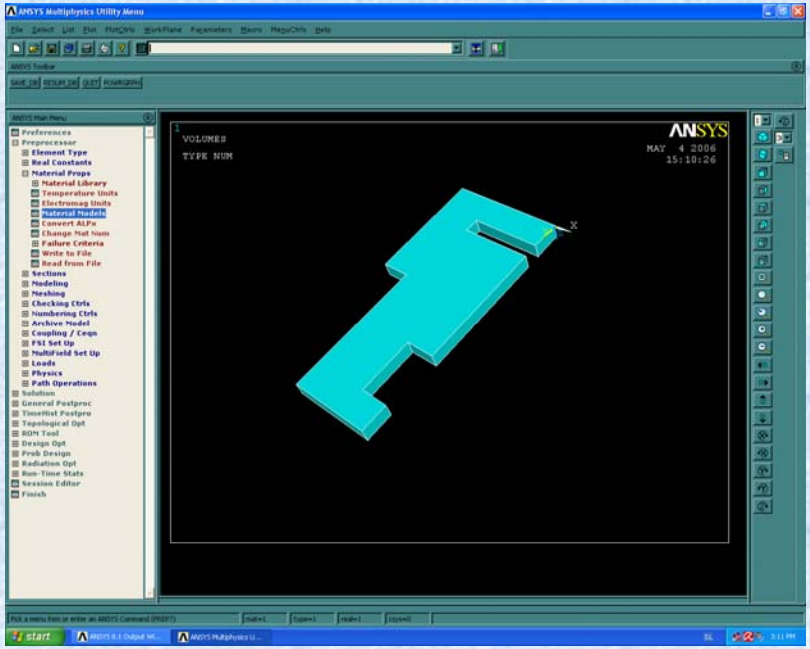



ANSYS preprocesor
Solid modeling
Botom-up modeling
Uvoz modela iz druge aplikacije
Solid mechanics
Elastična analiza
Nelinearno-elastična analiza
Elastoplastična analiza
Dinamička analiza
TERMALNA ANALIZA
Stacionarni procesi
Tranzijentni procesi
CFD
Elektromagnetika
Piezo-električna analiza
Geomehanika
Akustika
Kuplovana analiza (interakcija više fizičkih polja)
Solver sistema linearnih jednačina
ANSYS POSTPROCESOR

Ansys – Izgradnja 3D modela kopče sigurnosnog pojasa

Solid modeliranje, primitivi
Boolove operacije
Simetrija

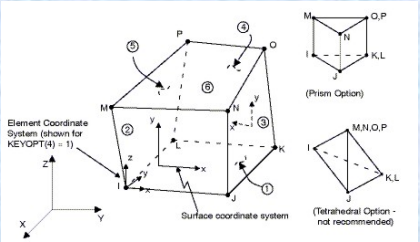




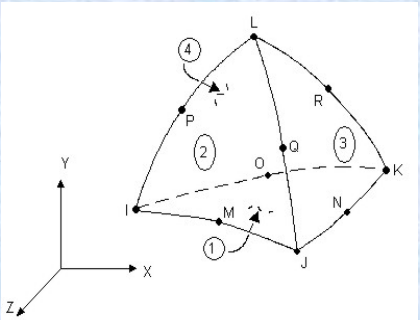
Diskretizacija, generator mreže tip i veličina elementa

brick elementi

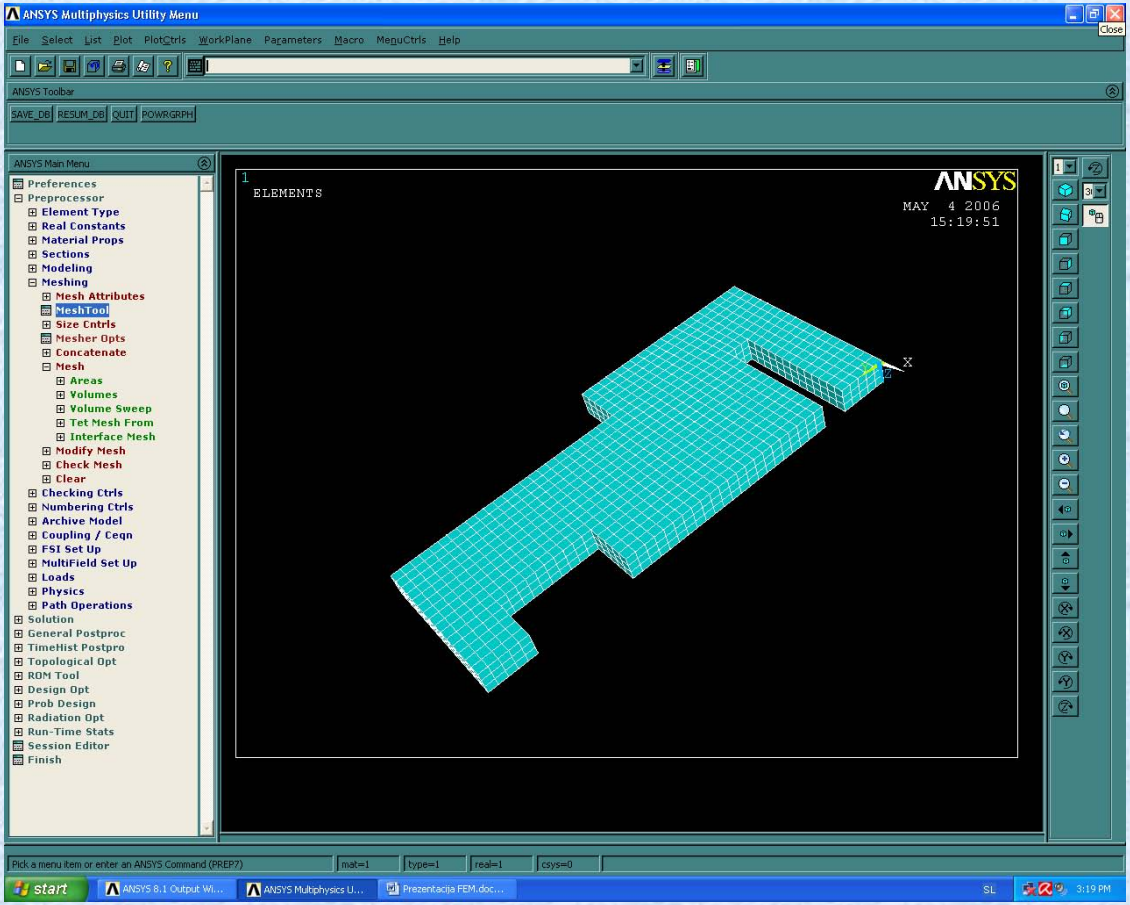
tetraedarski elementi



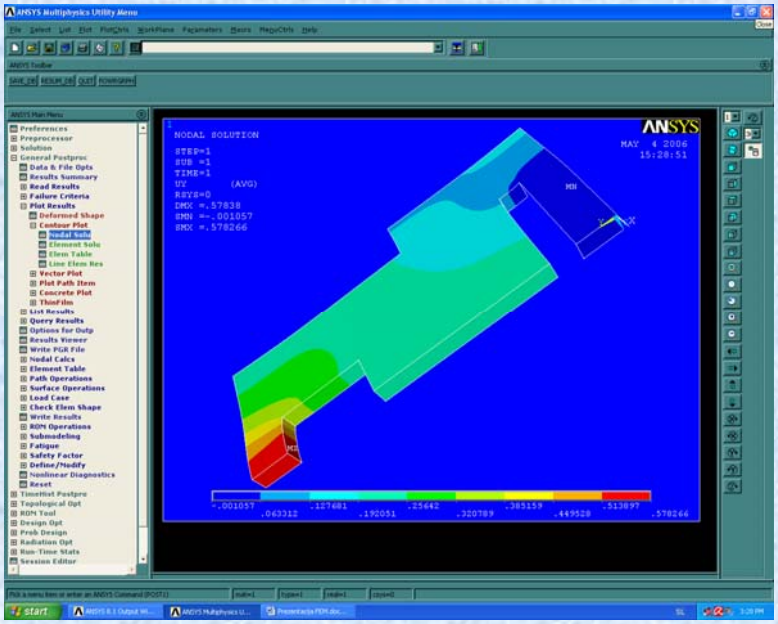
SOLID45 Input Data

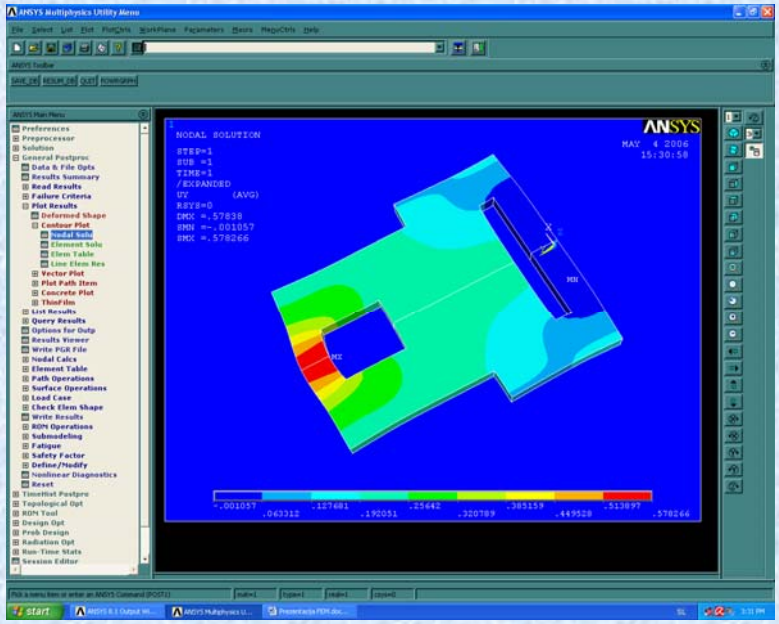


SOLID168 Input Data



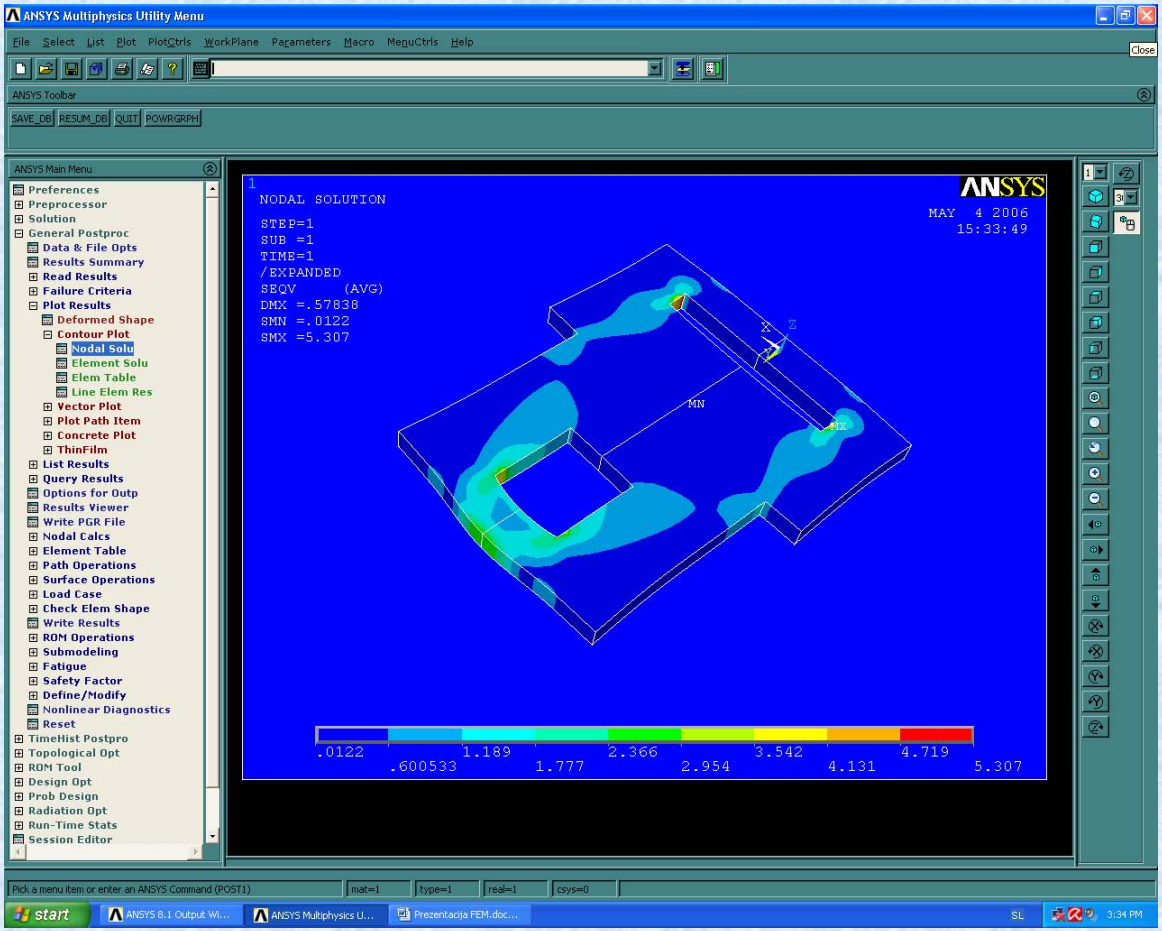
Granični uslovi, opterećenje, oslonci, fiksne tačke, simetrični BC





Sklapanje cijelog modela nakon analize simetričnog dijela

Analiza rezultata: deformacije, naprezanja, von-Mises stres optimizacija oblika



Slijedi prezentacija postupka direktno na PC-u…
(1 čas)