



電腦輔助工程分析 ANSYS WORKBENCH

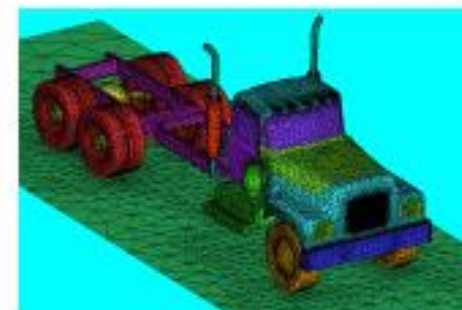
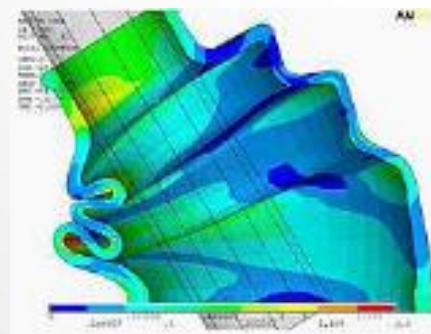
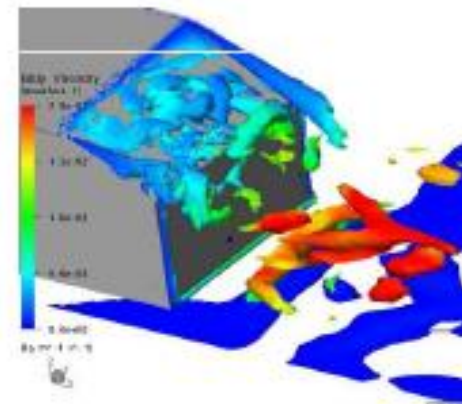
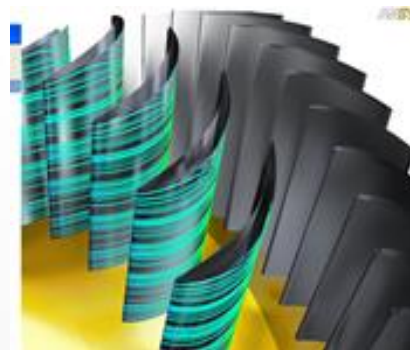
國立陽明交通大學 生物醫學工程系
林峻立 特聘教授

ANSYS WORKBENCH

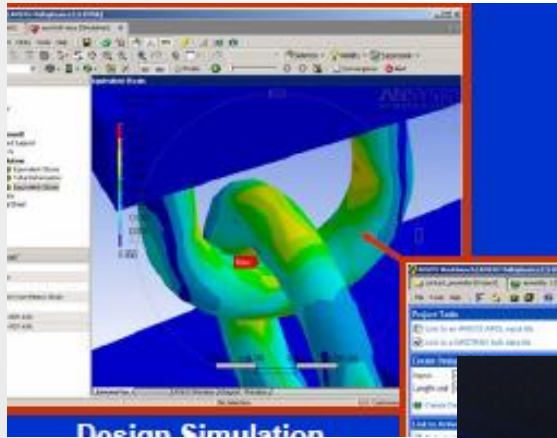
- Workbench 為開發用來提供一個強大與獨特的之模擬分析軟體。並提供一參數化及人性化界面供大部分使用者容易使用。



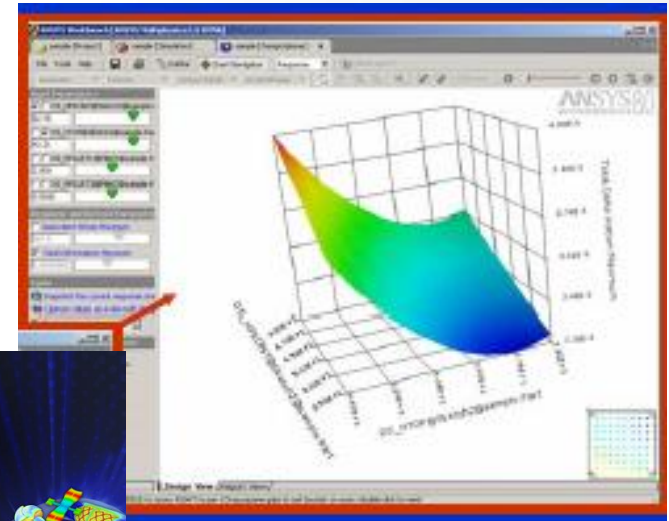
- 優點
 - 模型建構能力佳
 - 與CAD軟體結合及通用性高
 - 建模形之運算及網格切割能力佳
 - 結果圖案美觀效果佳
- 缺點
 - 過多數值被預設設定
 - 容易造成分析結果不正確
 - 結果觀察較難深入



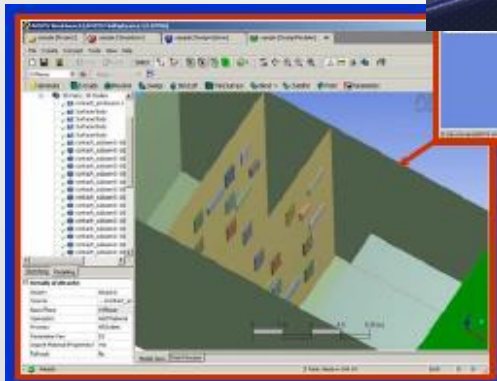
Workbench概述



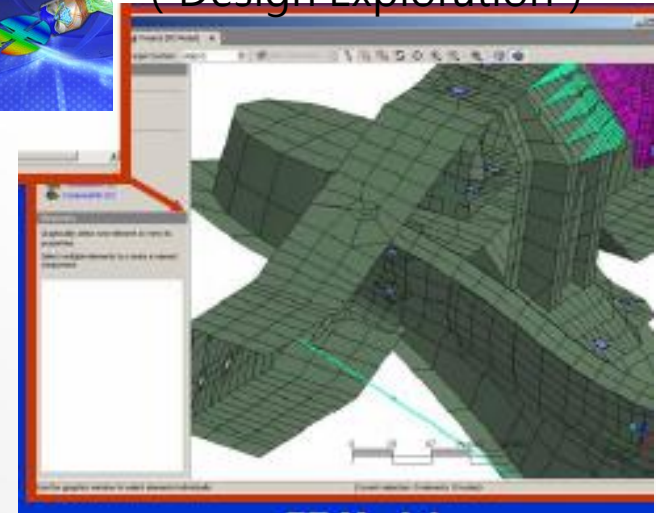
模擬分析
(DesignSpace)



參數管理與最佳化工具
(Design Exploration)



參數化建模
(DesignModeler)



分析連結 (FE Modeler)³

狀態顯示



最新的狀態(數據輸入完整)











需要刷新：上游部數據已改變。需更新單元



需要注意：可能需要改正本項資訊或是上游資訊



需要更新：數據已改變，輸出需重新產生

	G	
1	 Steady-State Thermal	
2	 Engineering Data	✓
3	 Geometry	✓
4	 Model	
5	 Setup	?
6	 Solution	⚡
7	 Results	⚡

工程資料(Engineering Data)

Unsaved Project - Workbench

File View Tools Units Help

New Open... Save Save As... Import... Reconnect Refresh Project Update Project Return to Project Compact Mode

Toolbox

- Physical Properties
 - Linear Elastic
 - Isotropic Elasticity
 - Orthotropic Elasticity
 - Anisotropic Elasticity
 - Experimental Stress Strain Data
 - Uniaxial Test Data
 - Biaxial Test Data
 - Shear Test Data
 - Volumetric Test Data
 - Simple Shear Test Data
 - Uniaxial Tension Test Data
 - Uniaxial Compression Test Data
 - Hyperelastic
 - Neo-Hookean
 - Arruda-Boyce
 - Gent
 - Blatz-Ko
 - Mooney-Rivlin 2 Parameter
 - Mooney-Rivlin 3 Parameter
 - Mooney-Rivlin 5 Parameter
 - Mooney-Rivlin 9 Parameter
 - Polynomial 1st Order
 - Polynomial 2nd Order
 - Polynomial 3rd Order
 - Yeoh 1st Order
 - Yeoh 2nd Order
 - Yeoh 3rd Order
 - Ogden 1st Order
 - Ogden 2nd Order
 - Ogden 3rd Order
 - Biomechanical

Outline of Schematic A2: Engineering Data

	A	B	C	D
1	Contents of Engineering Data			Description
2	Material			
3	Structural Steel			Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
4	cortical bone			
*	Click here to add a new material			

材料號碼及名稱

Properties of Outline Row 4: cortical bone

	A	B	C	D	E
1	Property	Value	Unit		
2	Isotropic Elasticity				
3	Derive from	Young's M...			
4	Young's Modulus	17000	MPa		
5	Poisson's Ratio	0.3			
6	Bulk Modulus	1.4167E+10	Pa		
7	Shear Modulus	6.5385E+09	Pa		

數值輸入

Table of Properties Row 5: Isotropic Elasticity

	A	B
1	Temperature (C)	Poisson's Ratio
2		0.3
*		

Chart of Properties Row 5: Isotropic Elasticity

Messages

	A	B	C	D
1	Type	Text	Association	Date/Time
2	Events	Automotive Powertrain Fluid-Structure Interaction (FSI)		
3	Events	Ask the Expert - External Data Mapping in ANSYS Workbench & Mechanical 14.0		
4	Events	Understanding Hardware Selection for Structural Mechanics		
5	Events	SPE Annual Technical Conference & Exhibition		

特性種類

Design Modeler

選擇功能

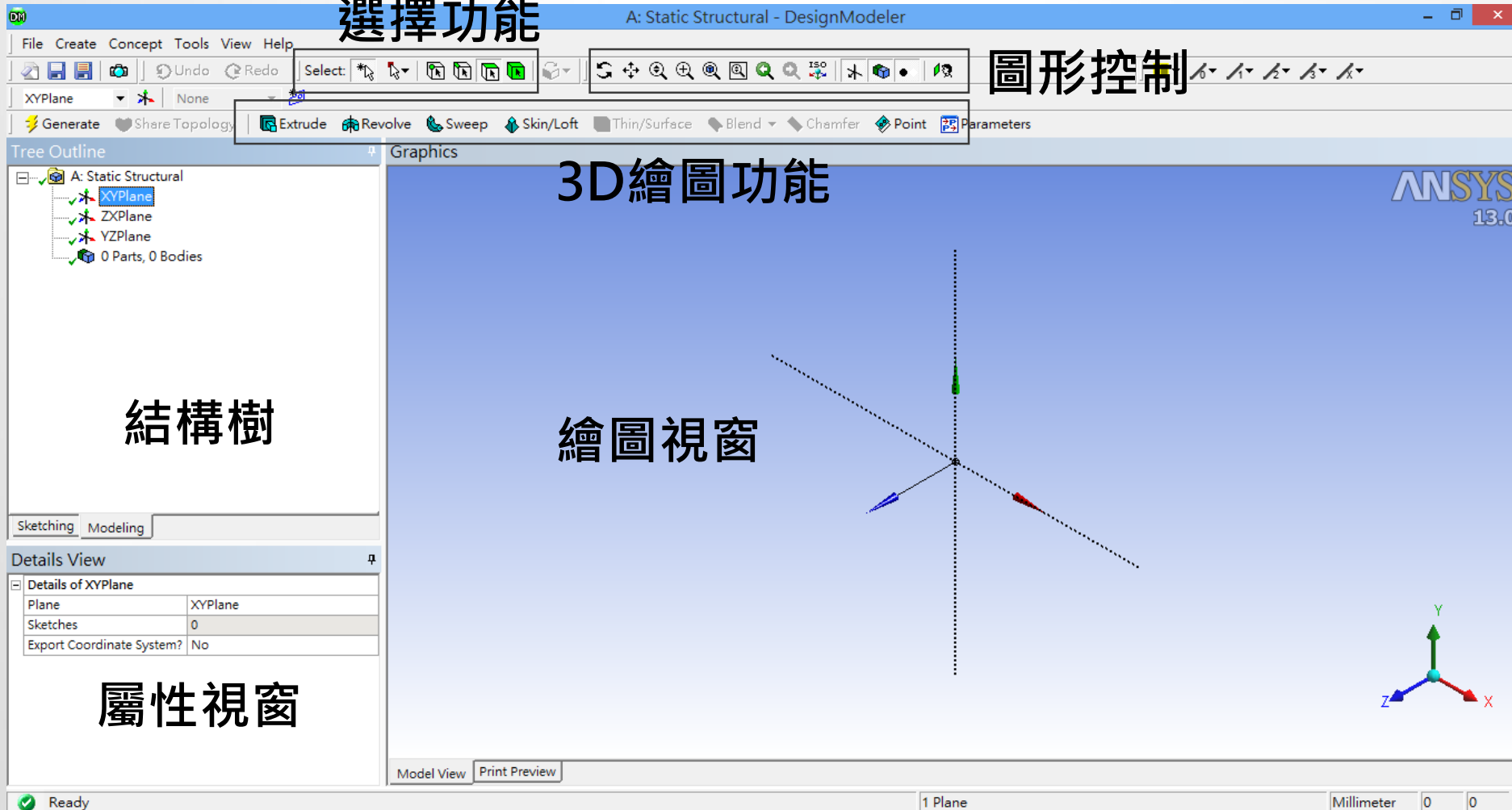
圖形控制

3D繪圖功能

繪圖視窗

結構樹

屬性視窗



結構樹狀態顯示



- 說明分支全部被定義



- 說明輸入的數據不完整



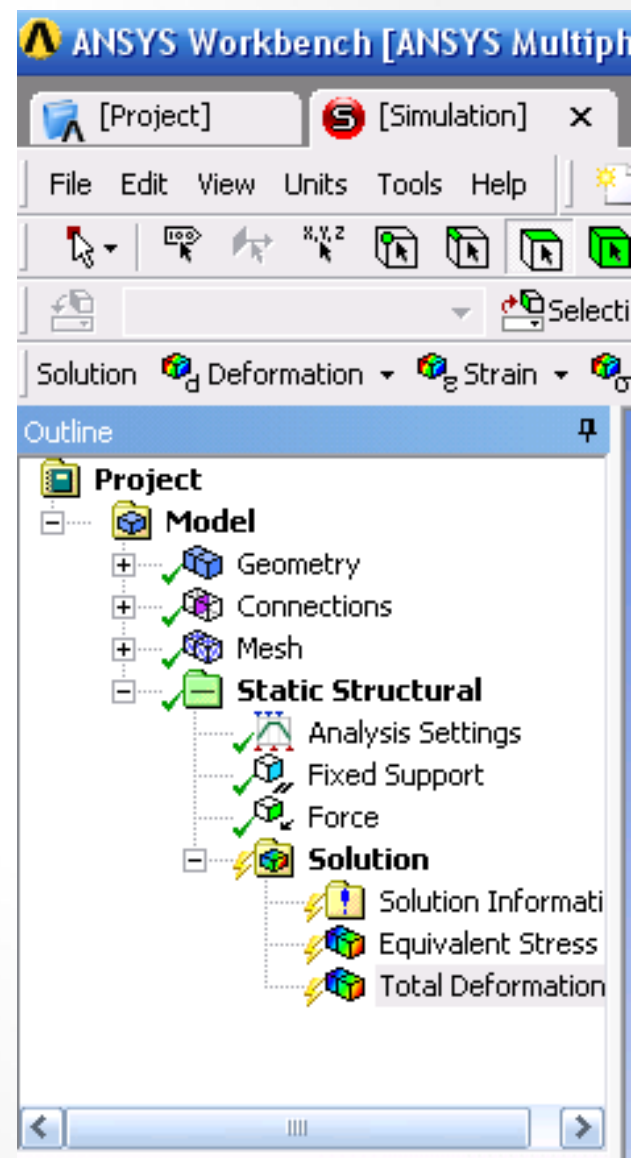
- 說明需要求解



- 說明被抑制，不能被求解



- 說明體積或零件被隱藏



屬性視窗顯示

- 白色區域：顯示當前輸入的數據。(可編輯)
- 灰色區域：顯示信息數據。(不可編輯)
- 黃色區域：未完成的信息輸入












Details of "Force"	
Scope	
Scoping Method	Geometry Selection
Geometry	6 Faces
Definition	
Define By	Components
Type	Force
Coordinate System	Coordinate System
<input type="checkbox"/> X Component	0. N (ramped)
<input type="checkbox"/> Y Component	0. N (ramped)
<input type="checkbox"/> Z Component	0. N (ramped)
Suppressed	No

Design Modeler












- 草圖模式
 - 包括建構二維幾何模型。此二維幾何模型可作為3D模型建構之依據。
- 3D建模
 - 將草圖進行拉伸旋轉等操作建構3D幾何模型。
- CAD模型輸入
 - 直接導入商業化CAD模型進入，並對其進行修正。
- 概念建模
 - 用於創建和修改直線和表面實體，使之能用於代表樑和殼之有限元素模型。

2D Sketching












Draw

-  Line
-  Tangent Line
-  Line by 2 Tangents
-  Polyline
-  Polygon
-  Rectangle
-  Rectangle by 3 Points
-  Oval
-  Circle
-  Circle by 3 Tangents
-  Arc by Tangent












Modify

-  Fillet
-  Chamfer
-  Corner
-  Trim
-  Extend
-  Split
-  Drag
-  Cut
-  Copy
-  Paste
-  Move


Dimensions

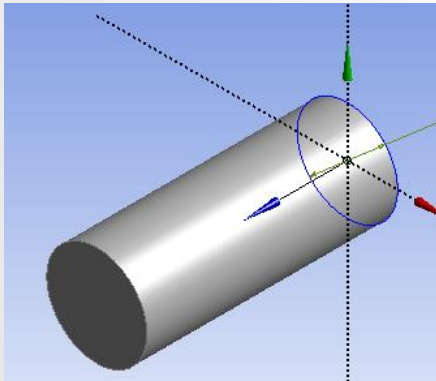
-  General
-  Horizontal
-  Vertical
-  Length/Distance
-  Radius
-  Diameter
-  Angle
-  Semi-Automatic
-  Edit
-  Move
-  Animate

Constraints

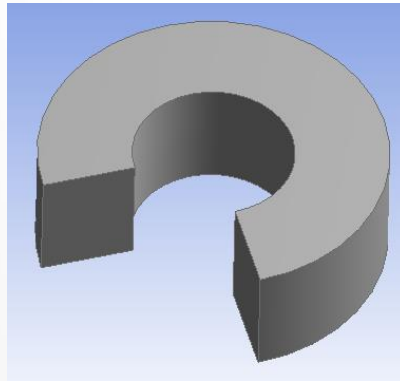
-  Fixed
-  Horizontal
-  Vertical
-  Perpendicular
-  Tangent
-  Coincident
-  Midpoint
-  Symmetry
-  Parallel
-  Concentric
-  Equal Radius

3D Modeling

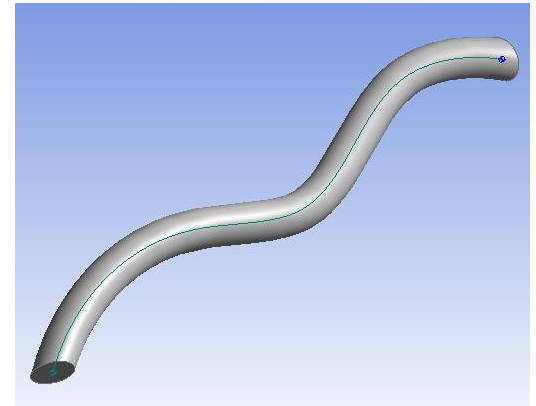
 Extrude



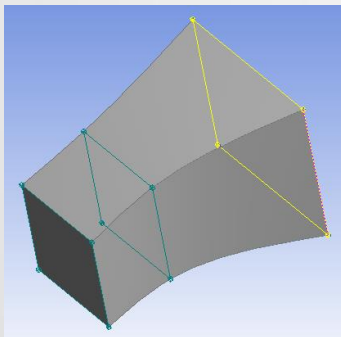
 Revolve



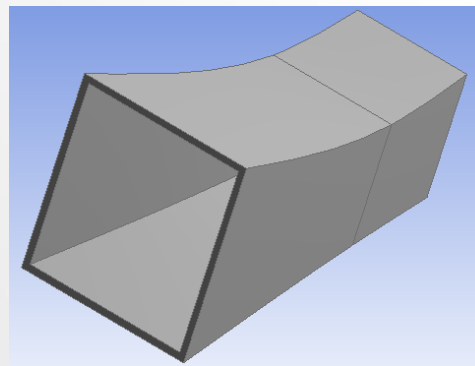
 Sweep




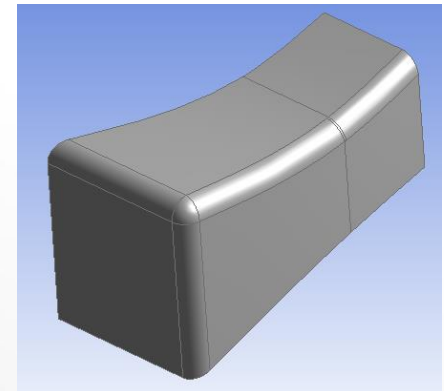
 Skin/Loft



 Thin/Surface

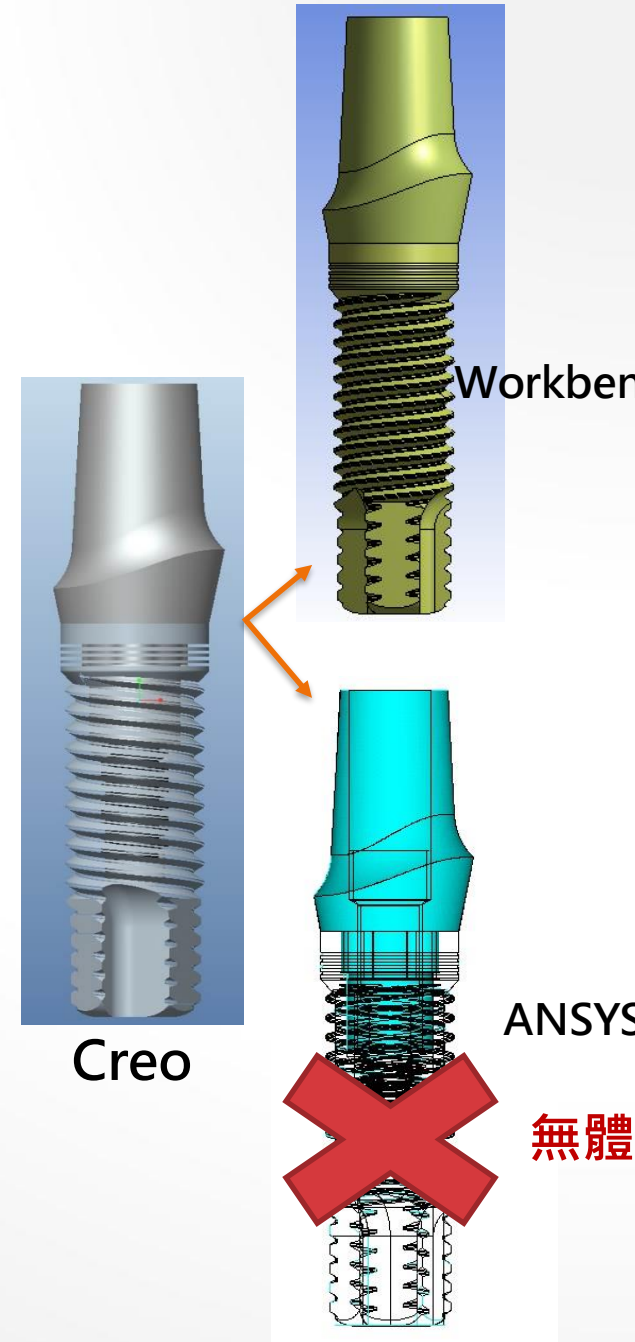


 Blend



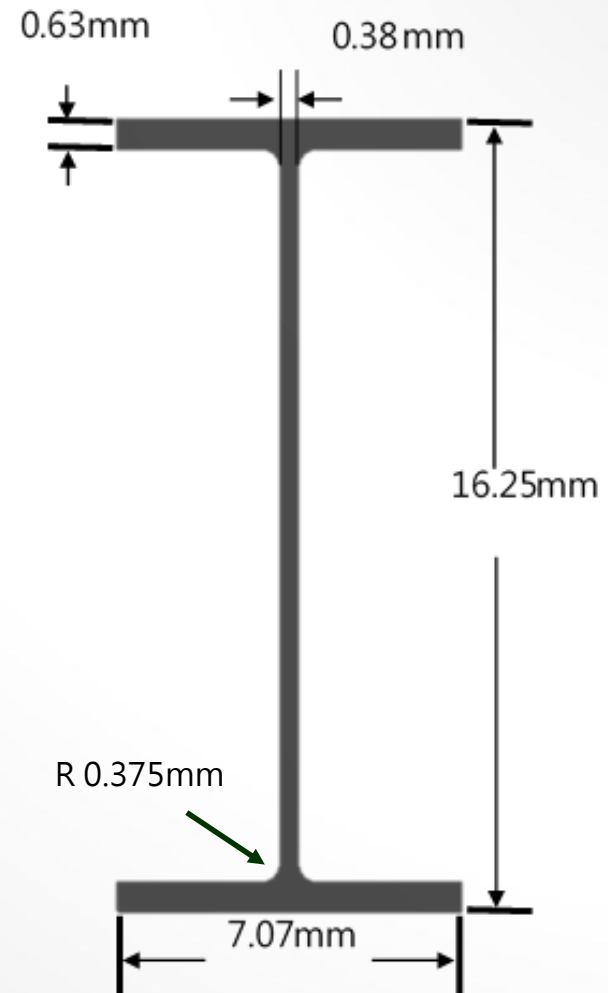
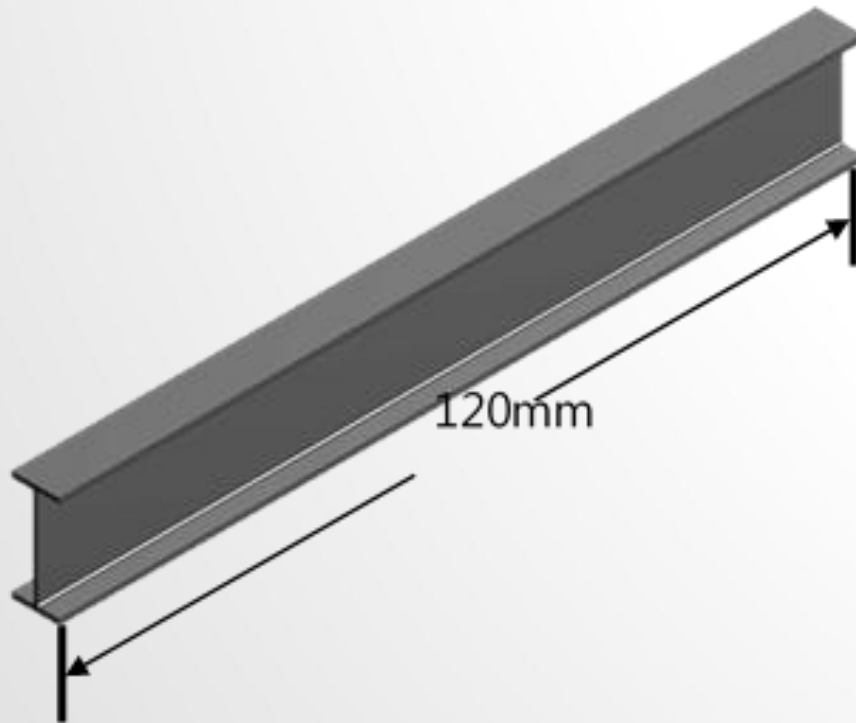
CAD模型輸入

- 3D Modeling
 - Import External Geometry File
 - UG NX(*.prt) , CATIA(*.model, *.CATpart)
 - Creo(*.prt, *.asm) , Solid Edge(*.par, *.asm)
 - SolidWorks(*.sldprt, *.sldasm) , STEP(*.stp)
 -
 - Attach to Active CAD Geometry
 - CATIA
 - Creo (Pro/ENGINEER)
 - SolidWorks
 - Solid Edge
 - ...



Exercise 1 CAD (來源：成功大學李輝煌教授)

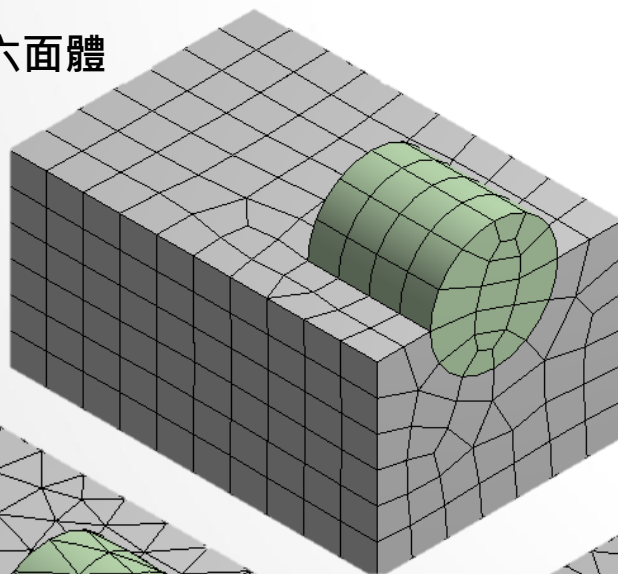
- I Beam model



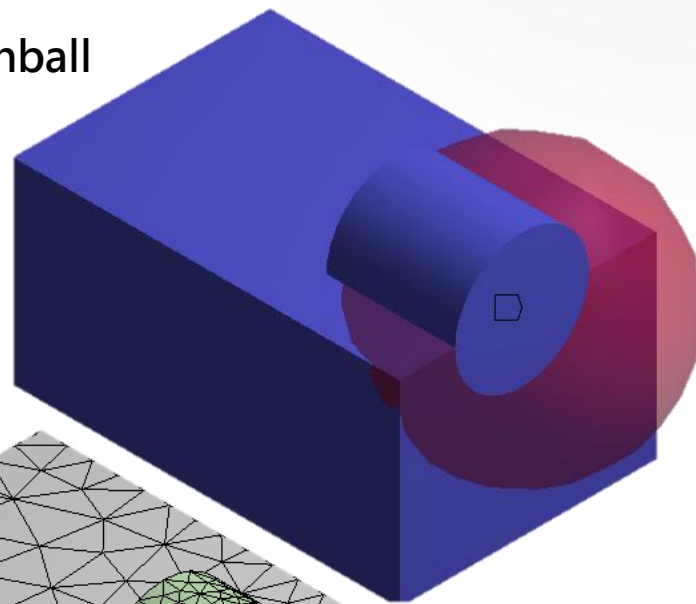
Cross section

網格分割(mesh)

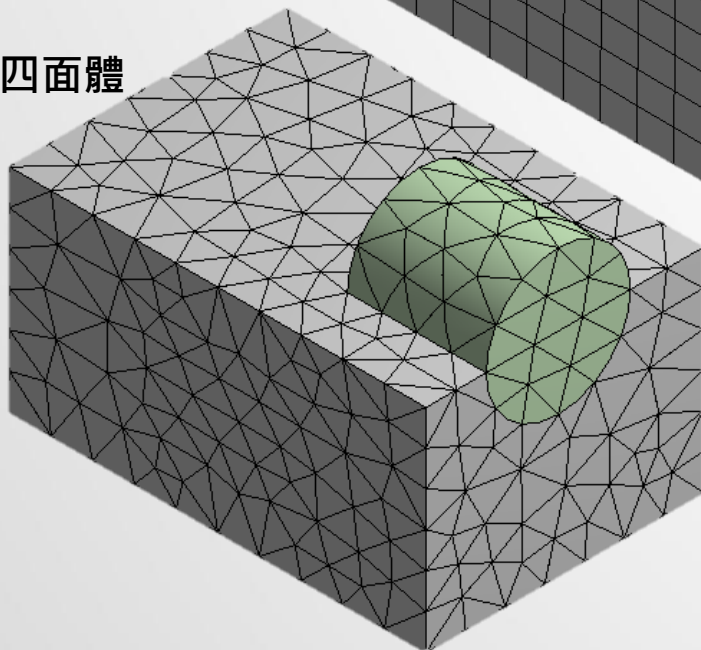
六面體



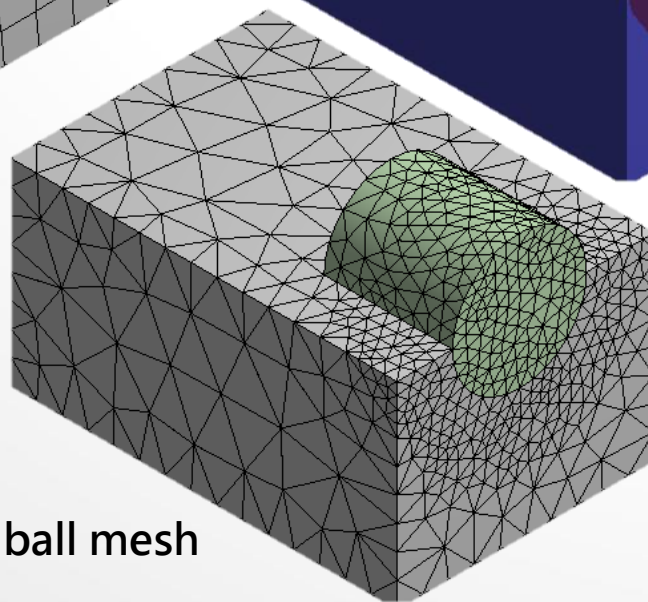
Pinball



四面體

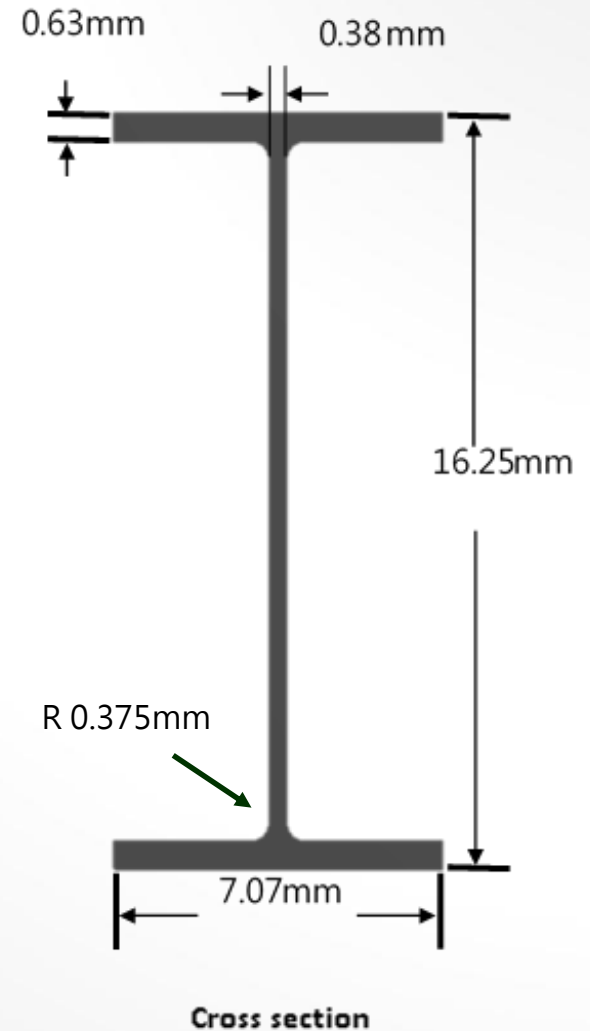
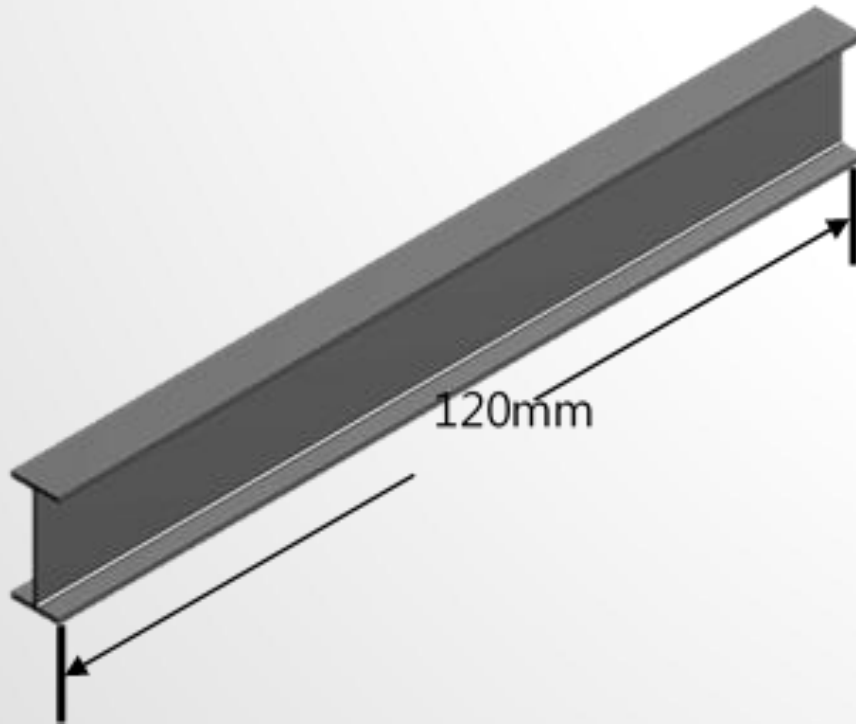


Pinball mesh



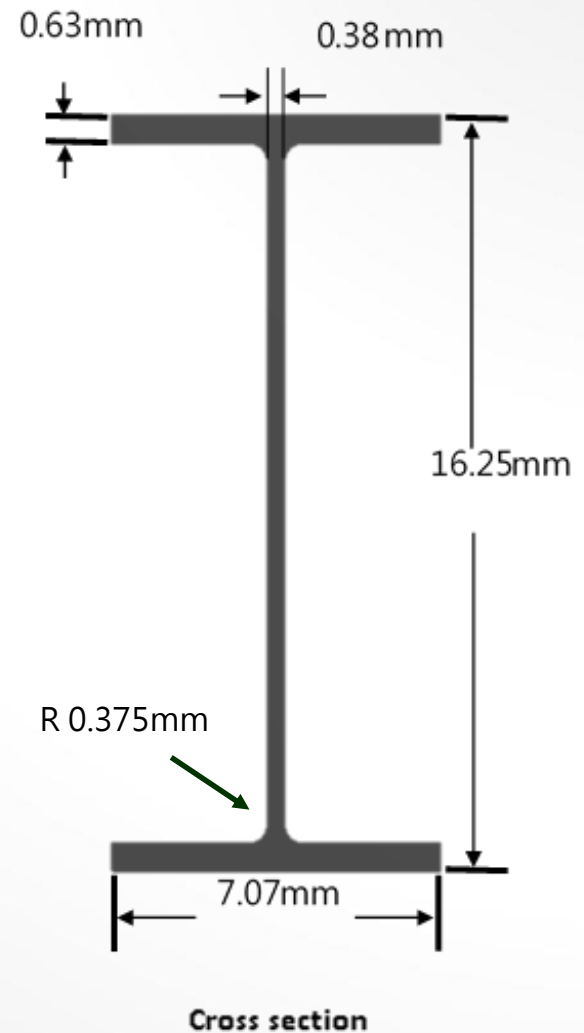
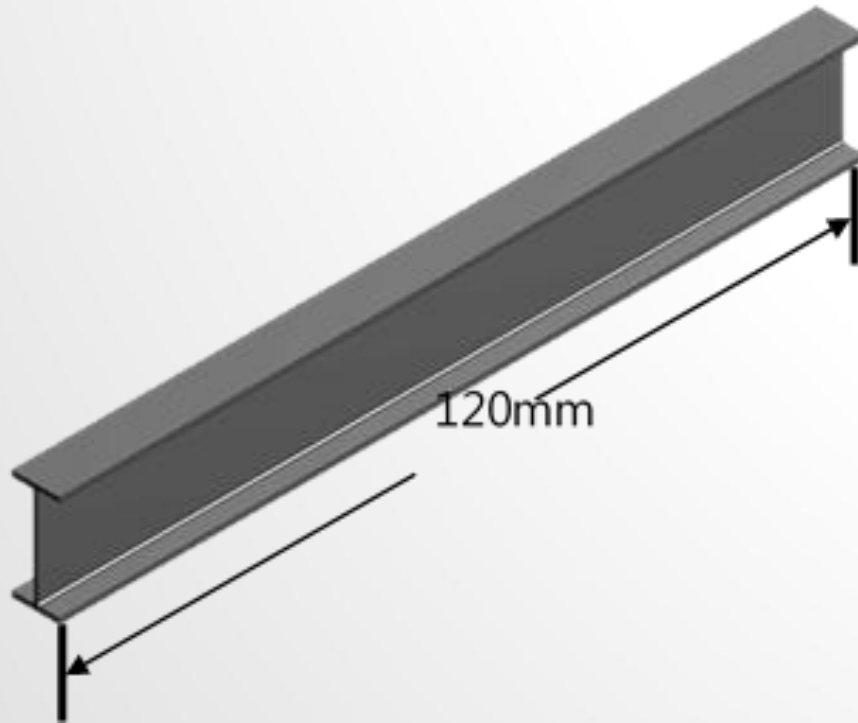
Exercise 1 MESH (來源：成功大學李輝煌教授)

- 進行不同網格切割 (1) 四面體 (Tetrahedrons), (2) 六面體 (Hex Domain), (3) 四面體mesh, 尺寸 2mm, (2) 六面體, 尺寸 2mm

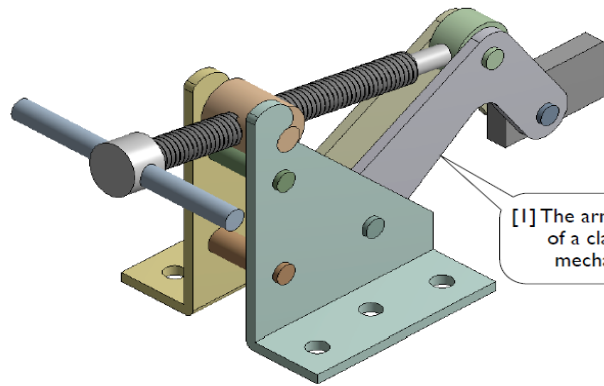


Exercise 1 CAE (來源：成功大學李輝煌教授)

- 於樑一端進行固定，另一端施予一壓力 100MPa。觀察其等效應力及位移量變化。
材料特性：楊氏係數：110000 MPa，浦松比：0.3



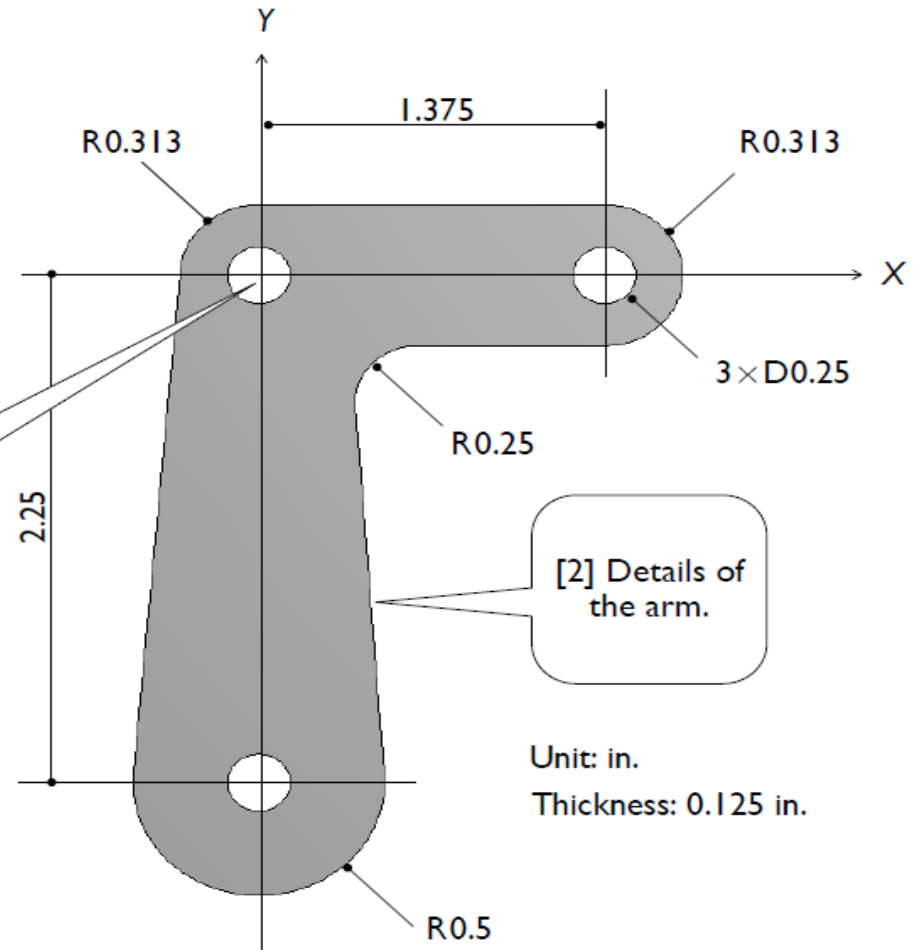
Exercise 2 CAD (來源：成功大學李輝煌教授)



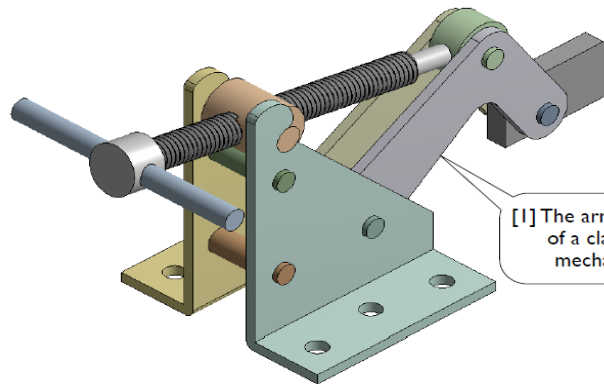
[1] The arm is a part of a clamping mechanism.



[3] The global coordinate system.



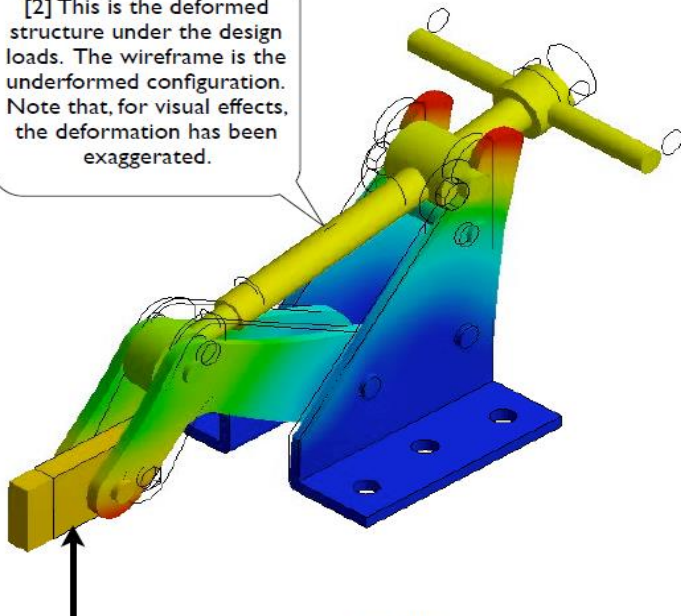
Exercise 2 CAE (來源：成功大學李輝煌教授)



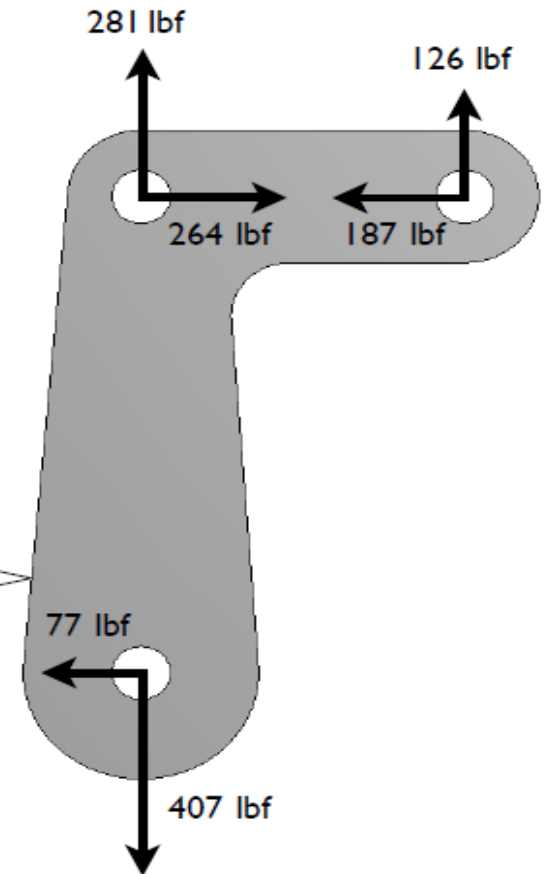
[1] The arm is a part of a clamping mechanism.

[1] The clamping mechanism is designed to withstand a clamping force of 450 lbf.

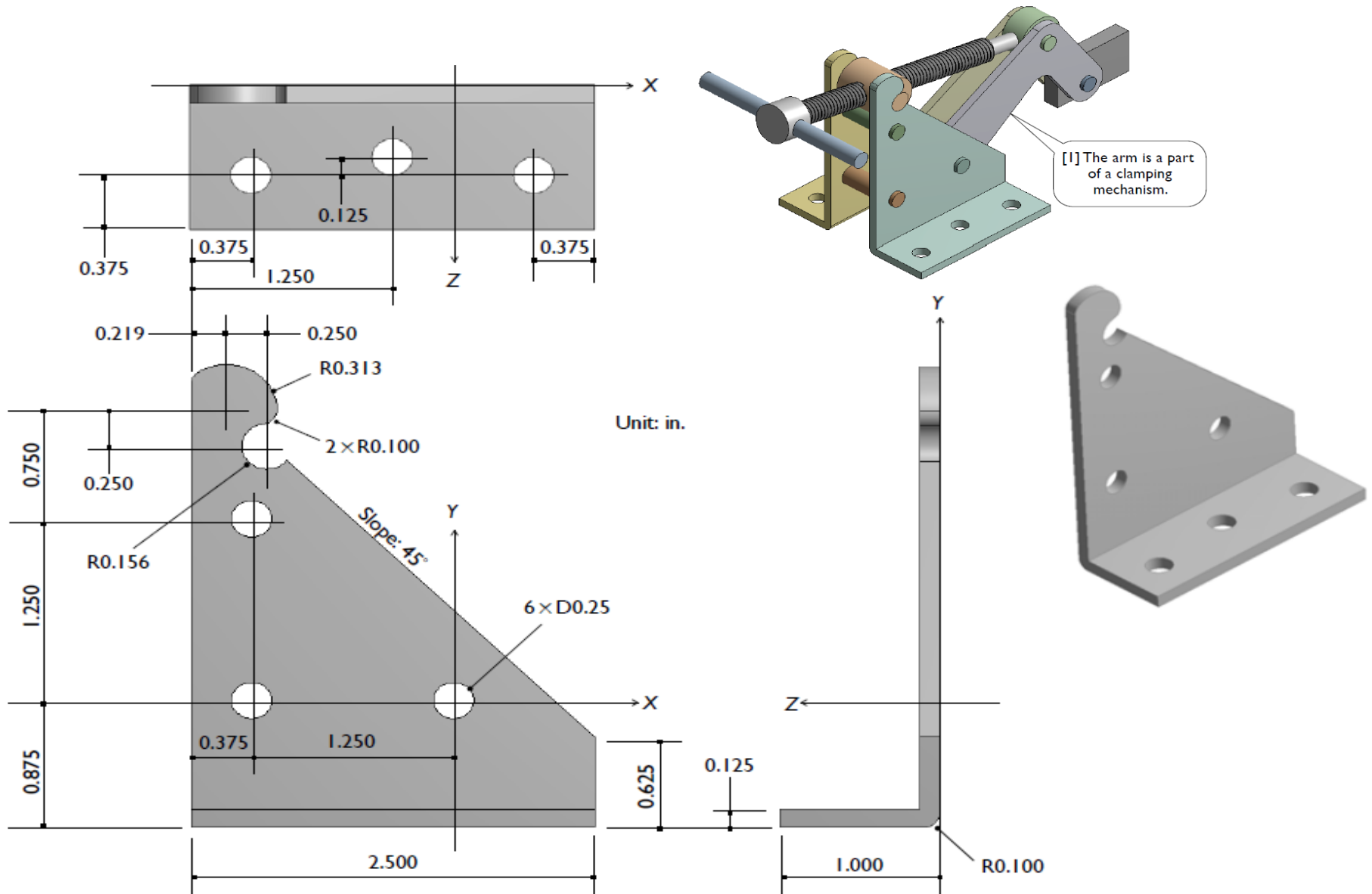
[2] This is the deformed structure under the design loads. The wireframe is the undeformed configuration. Note that, for visual effects, the deformation has been exaggerated.



[3] The external forces on the arm. These forces are calculated according to 17a-13.

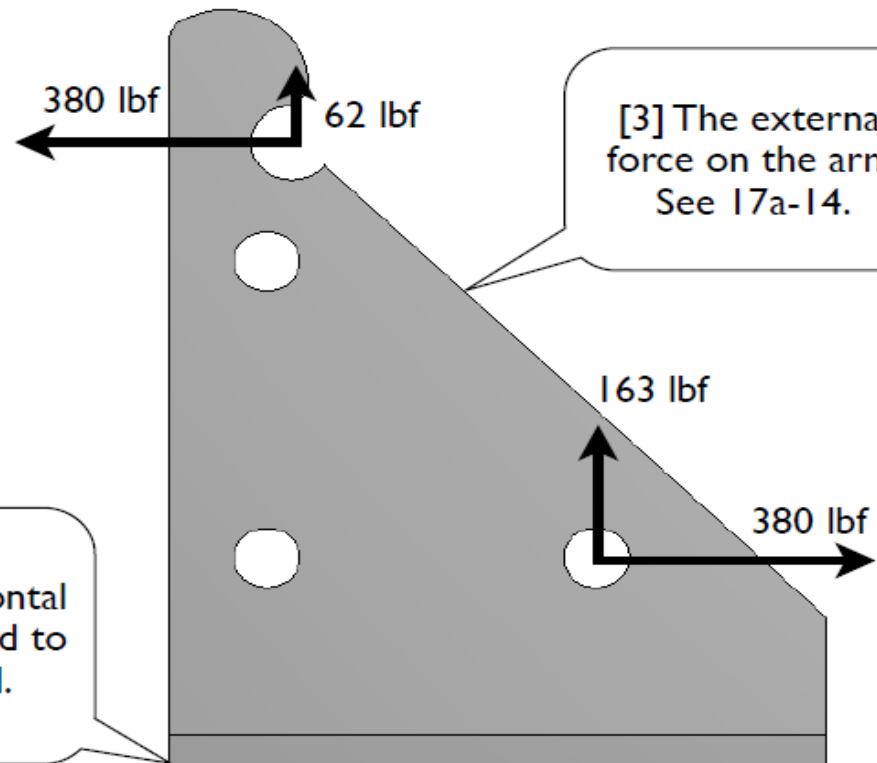
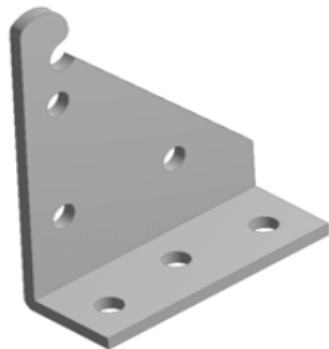
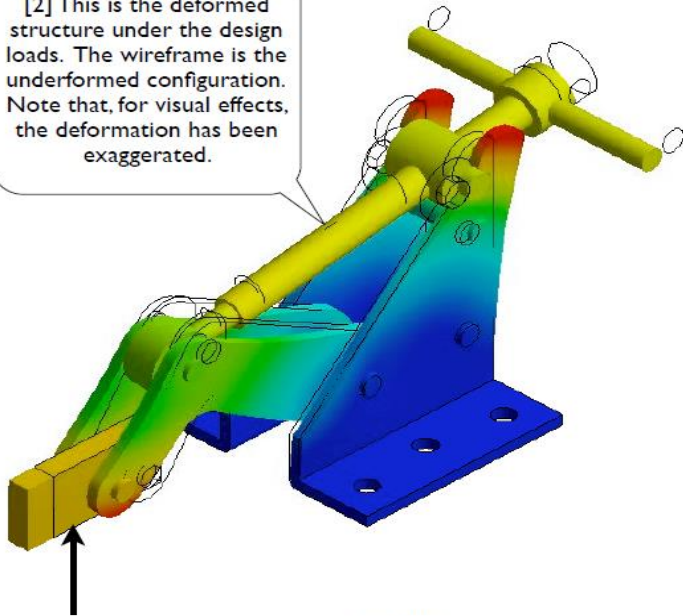


Exercise 3 CAD (來源：成功大學李輝煌教授)



Exercise 3 CAE (來源：成功大學李輝煌教授)

[2] This is the deformed structure under the design loads. The wireframe is the undeformed configuration. Note that, for visual effects, the deformation has been exaggerated.

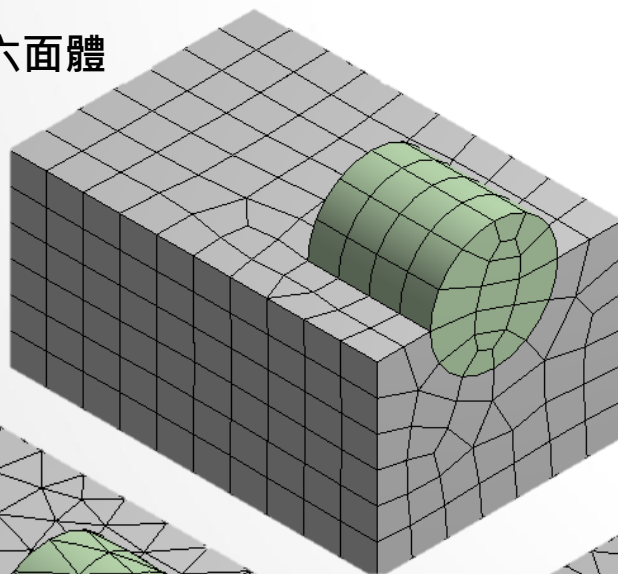


[3] The external force on the arm. See 17a-14.

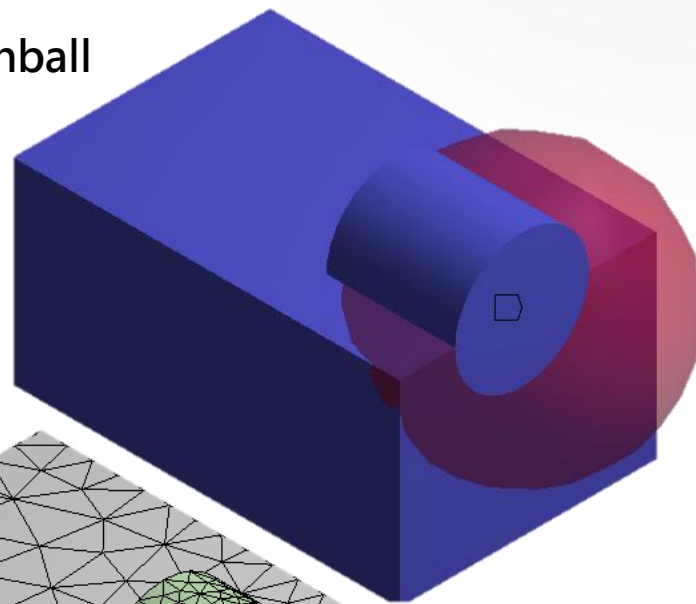
[4] The horizontal plates are fixed to the ground.

網格分割(mesh)

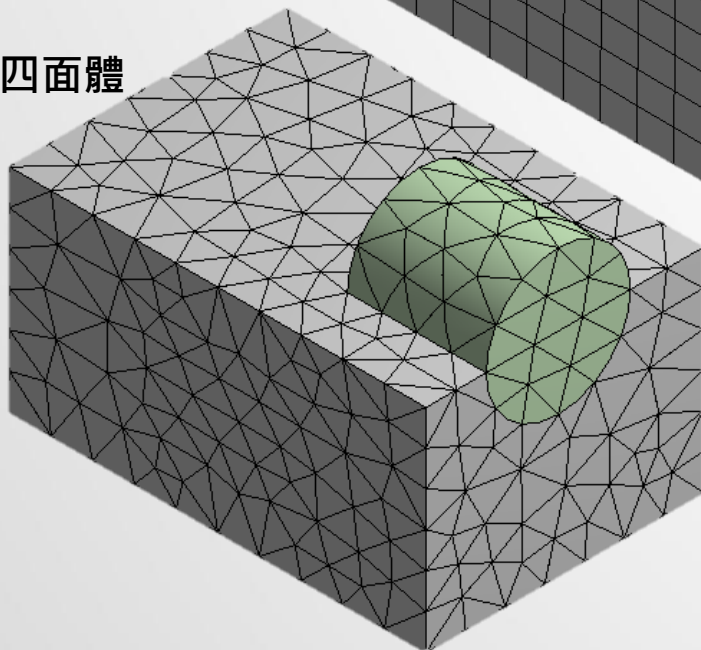
六面體



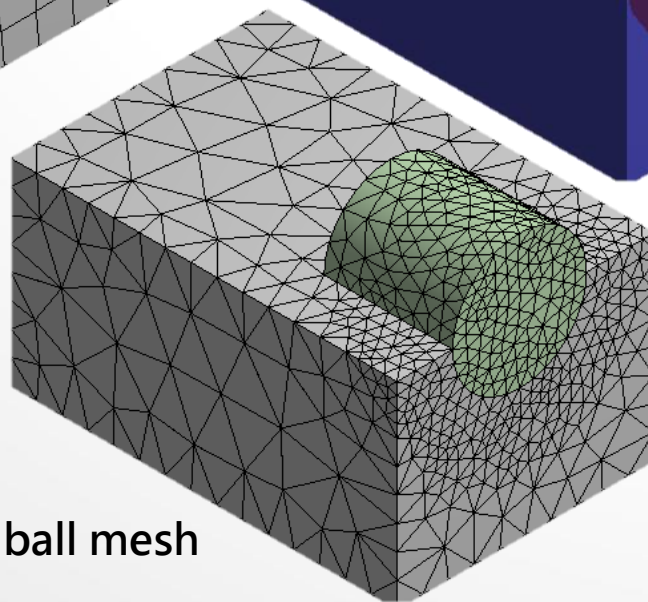
Pinball



四面體

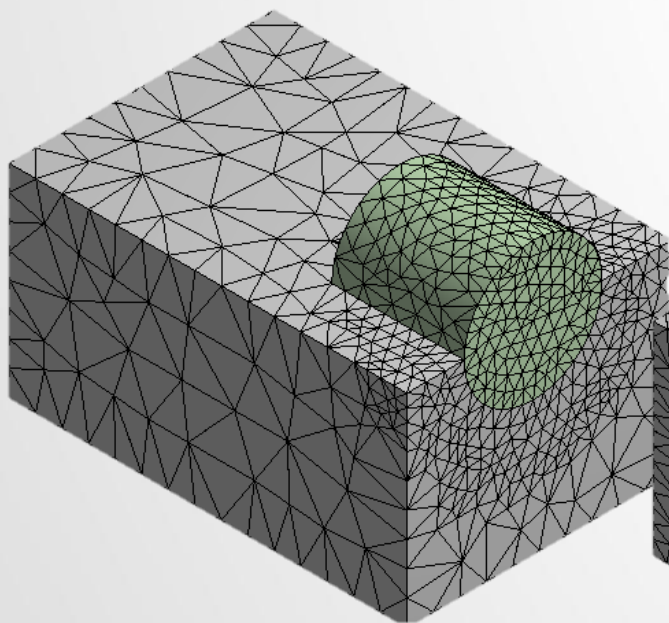


Pinball mesh

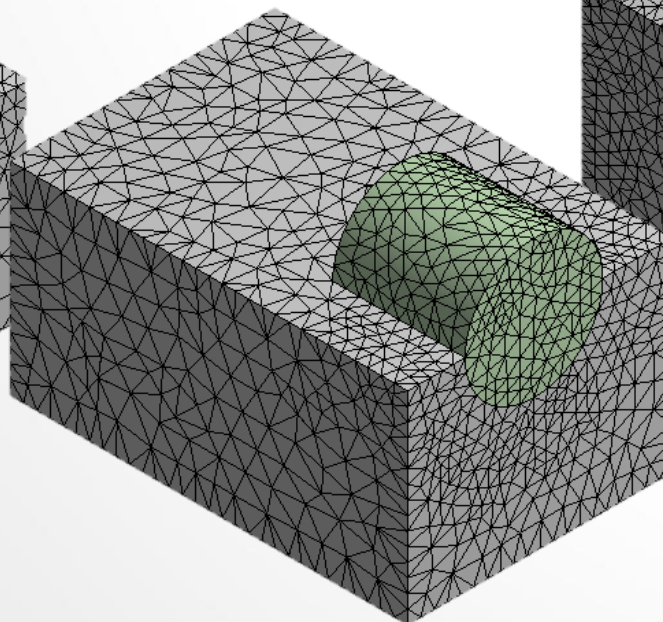


網格分割(mesh)

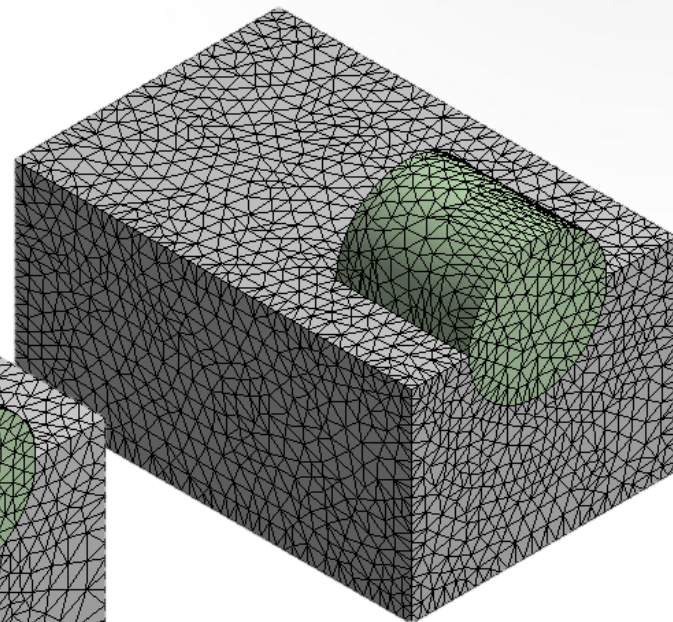
- Relevance Center



Coarse



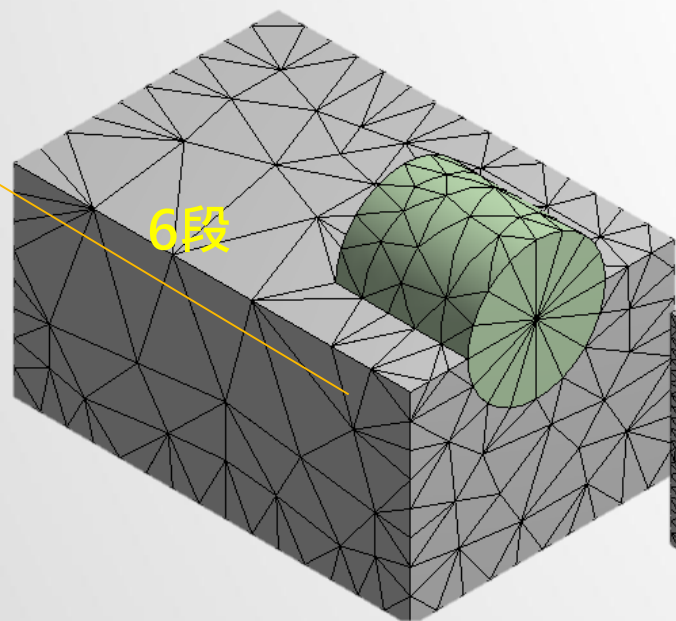
Medium



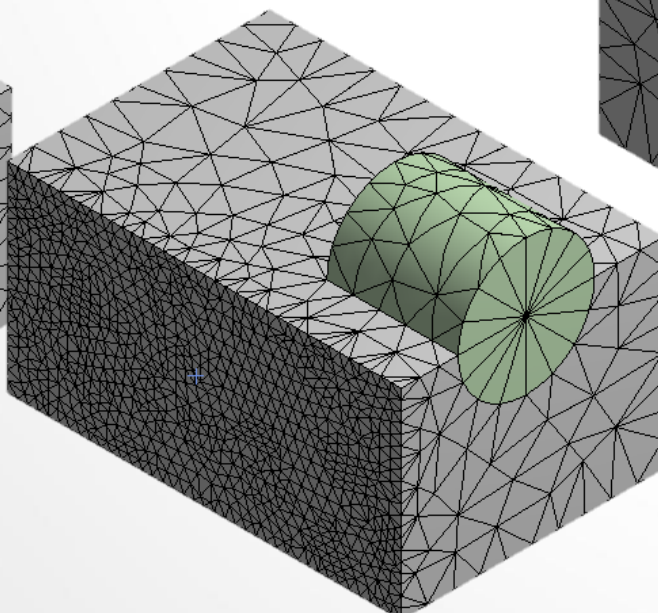
Fine

網格分割(mesh)

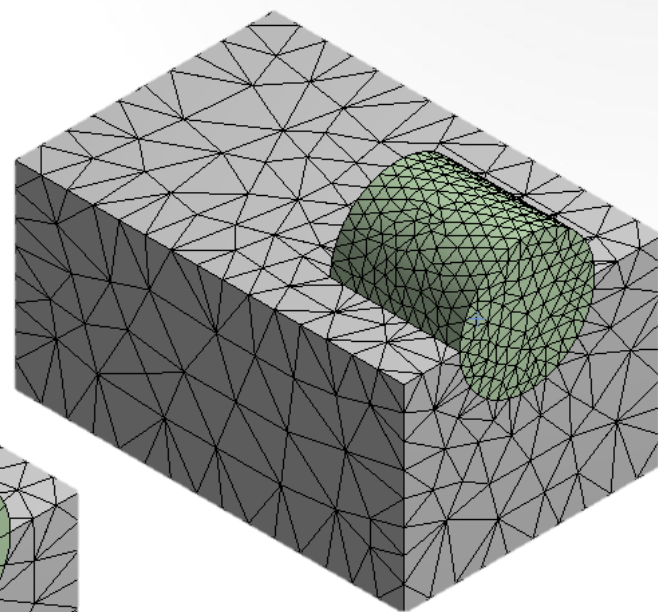
- Sizing



Line



Area

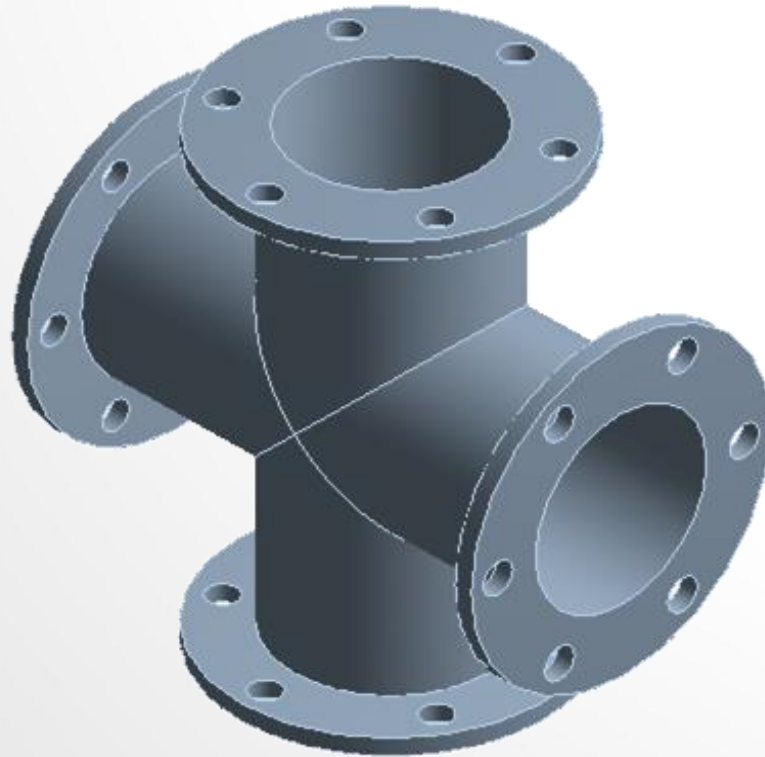


Volume

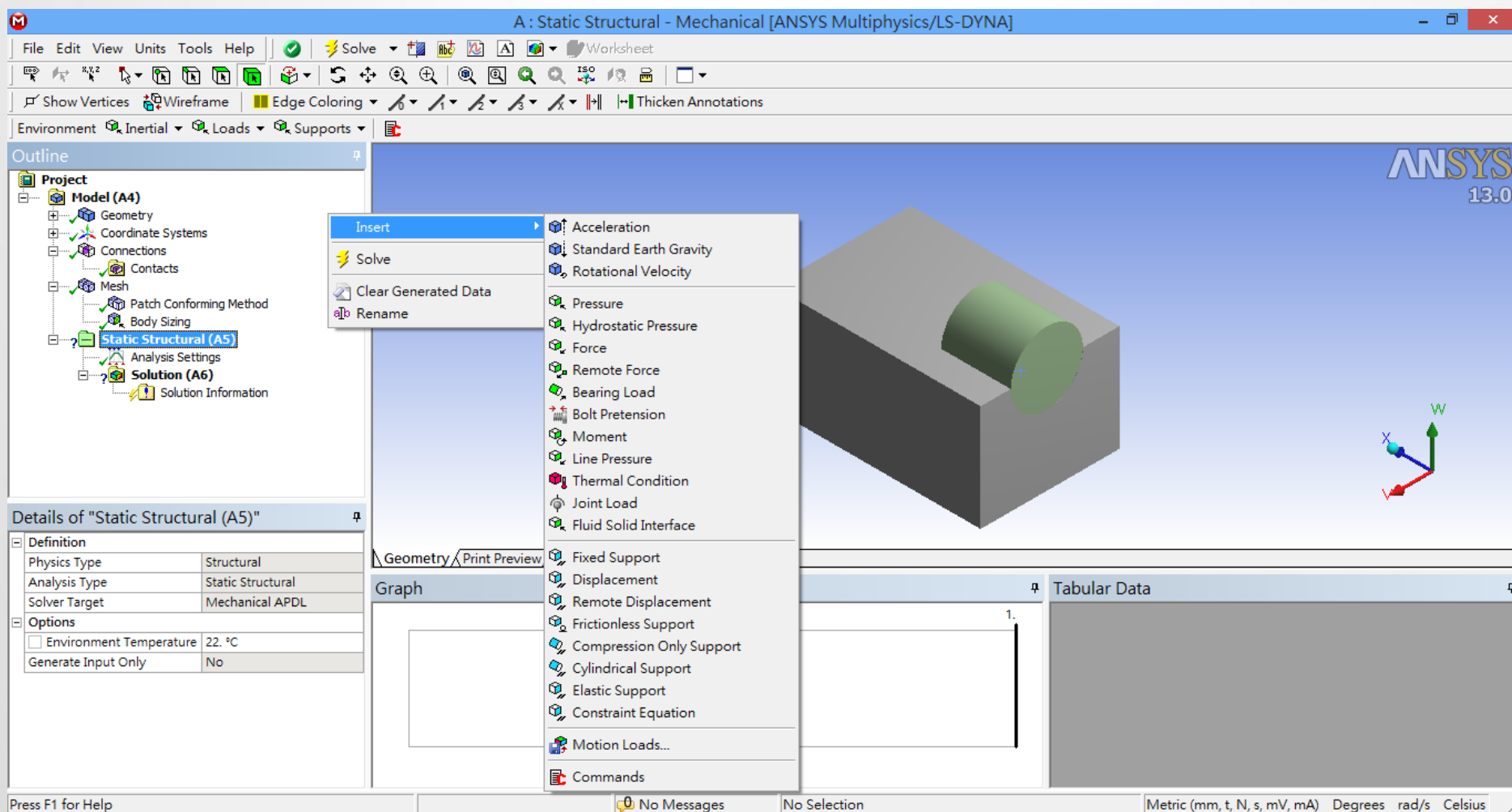
Exercise 4 MESH

(來源：ANSYS Workbench 有限元分析從入門到精通)

- 請依下列實體模型 (pipe.agdb) 進行不同功能之網格化練習

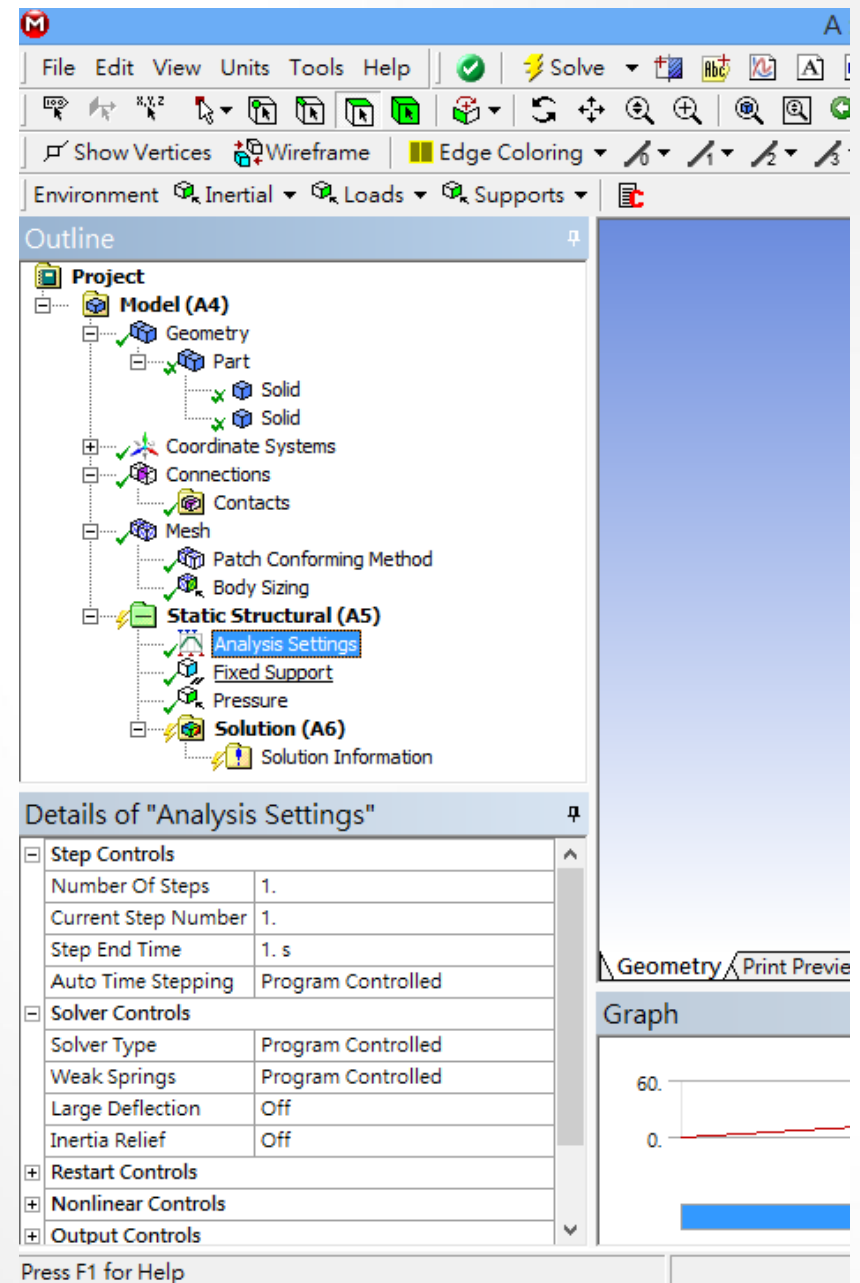


邊界條件給定



解題條件設定

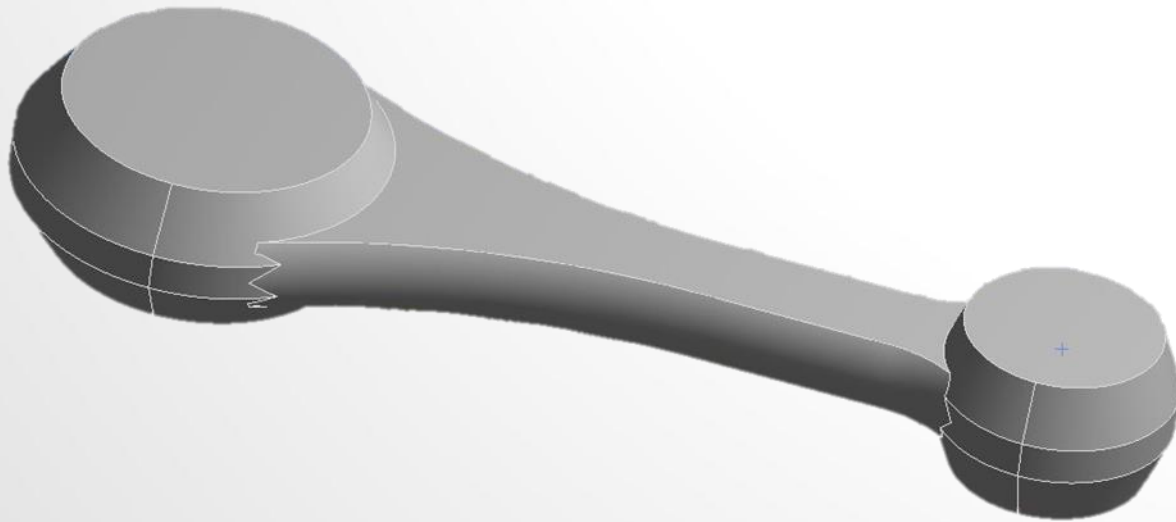
- Step Control
 - Number of steps,
 - Current Step Number,
 - Step Ends
- Time Control
 - 解題形式
 - 大變形等



Exercise 5 CAE

(來源：ANSYS Workbench 有限元分析從入門到精通)

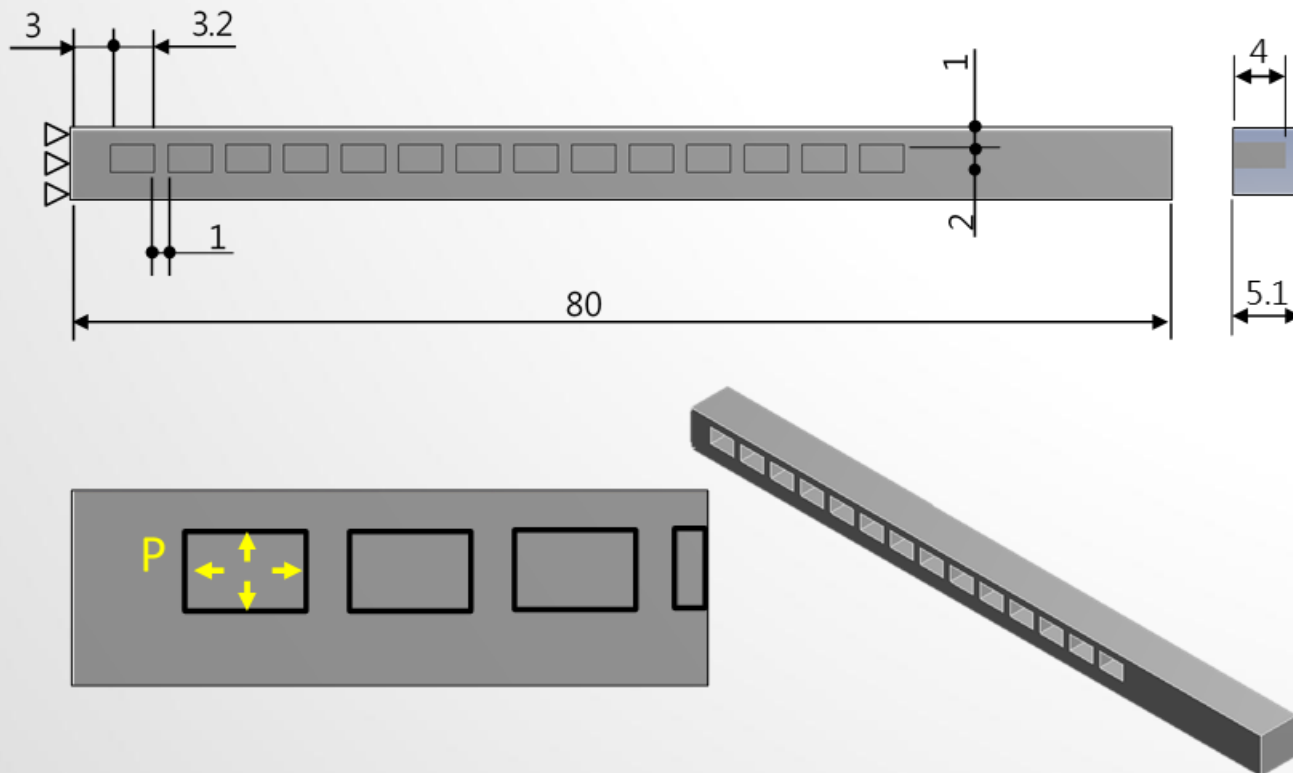
連桿基體模型由外部導入，ELEMENT SIZE為10，於兩大圓面積進行固定，另一端施予一外力1000N。觀察其等效應力及位移量變化。材料特性：灰鑄鐵(GRAY CAST IRON)



Exercise 6

(來源：成功大學李輝煌教授)

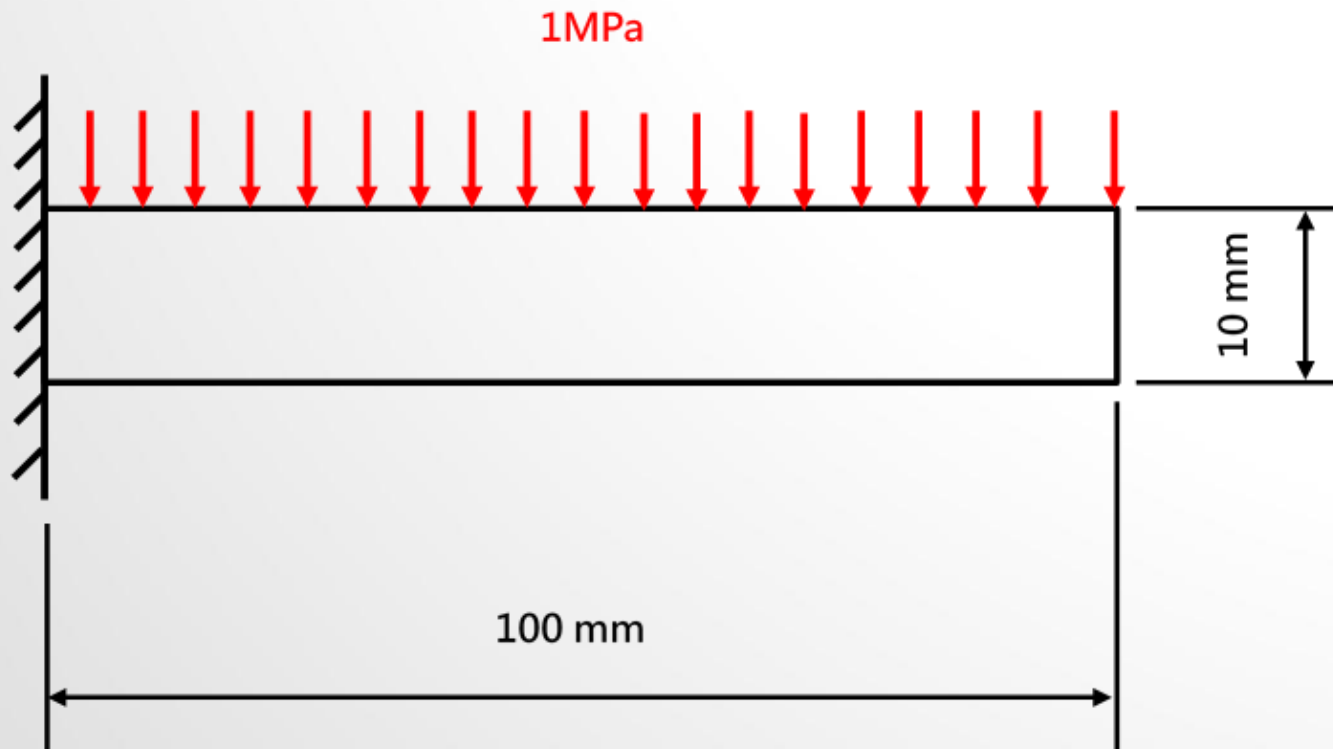
- Pneumatic Fingers 模型 (Symmetry) 如圖所示，請依不同網格形式進行切割 (1)自動網格(Automatic)、(2) 掃描網格(Sweep)、進行線性分析。將pneumatic fingers 左側固定，chamber空間施以0.2MPa壓力，觀察其Y軸位移量變化。楊氏係數 $E=2\text{MPa}$ ，樸松比 Poisson's ratio=0.48



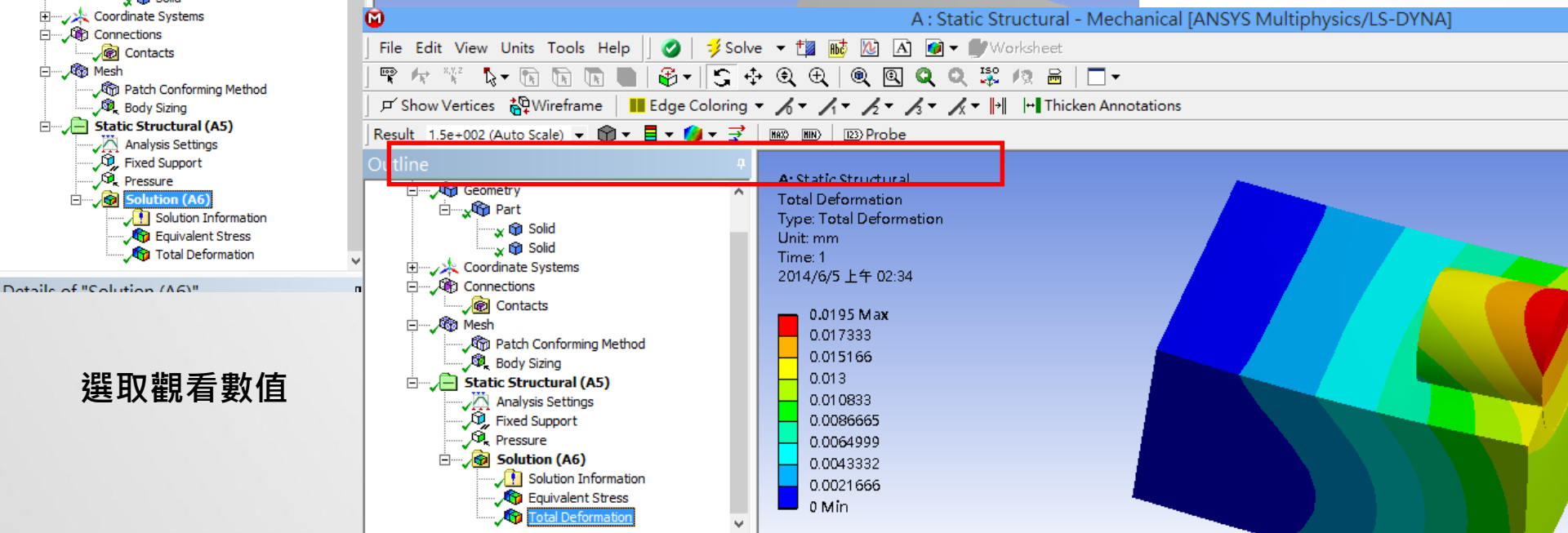
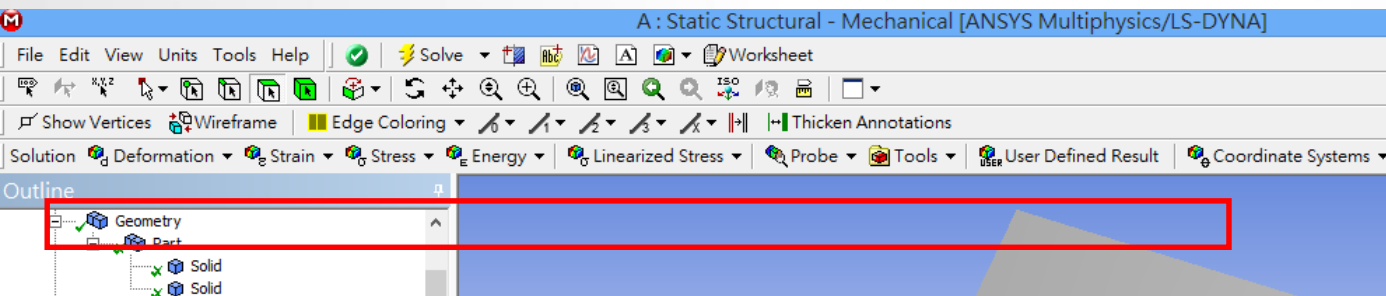
Exercise 7 CONVERGENCE

(來源：成功大學李輝煌教授)

一材料為鋼(steel)製成之懸臂樑，尺寸為100X10X10 mm，上端平面施以1MPa均佈負載，請應用不同高/低階元素及不同元素大小(element size)探討懸臂樑模型之收斂性 (1)low order Hex、(2) low order Tet、(3)high order Hex、(4)high order Tet



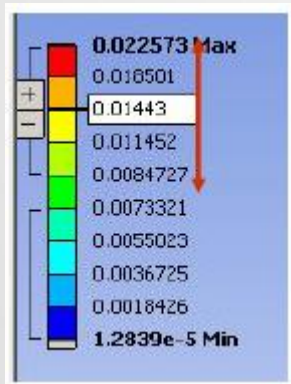
後處理(Post-processing)



設定顯示方式

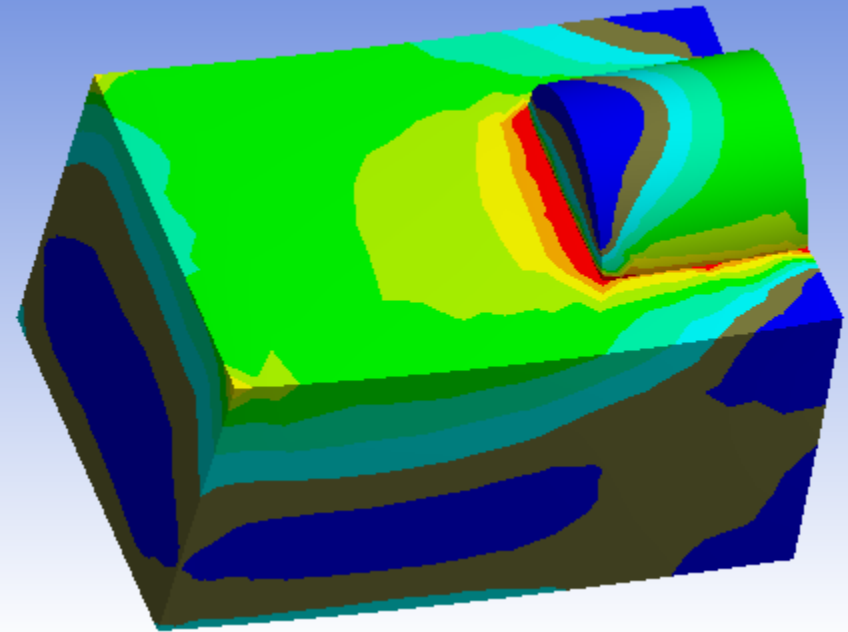
Contour 控制

- 在圖形上之contour按右鍵可進行設定
 - 自訂數值
 - 增加色塊
 - 自訂色彩

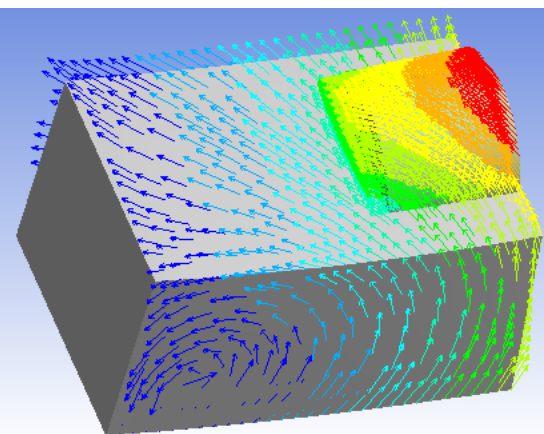
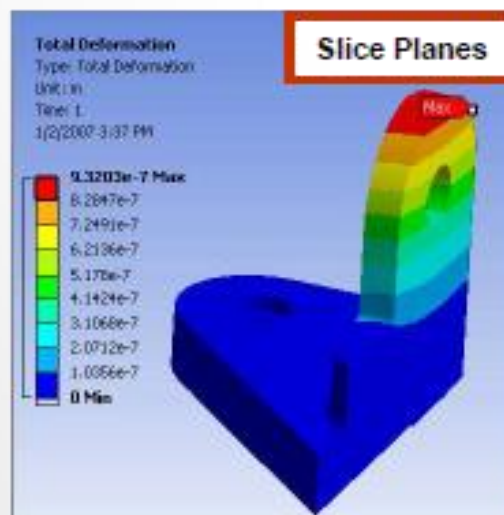
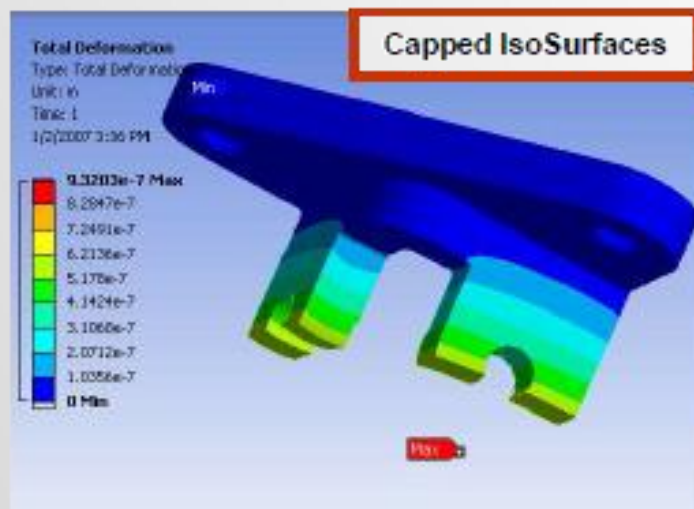
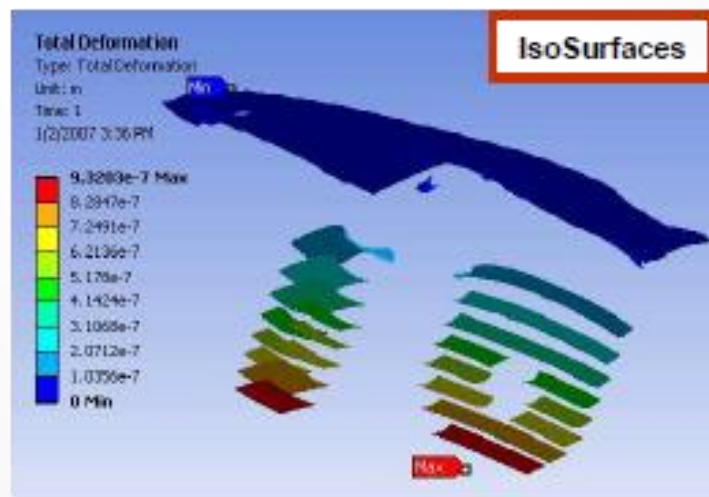
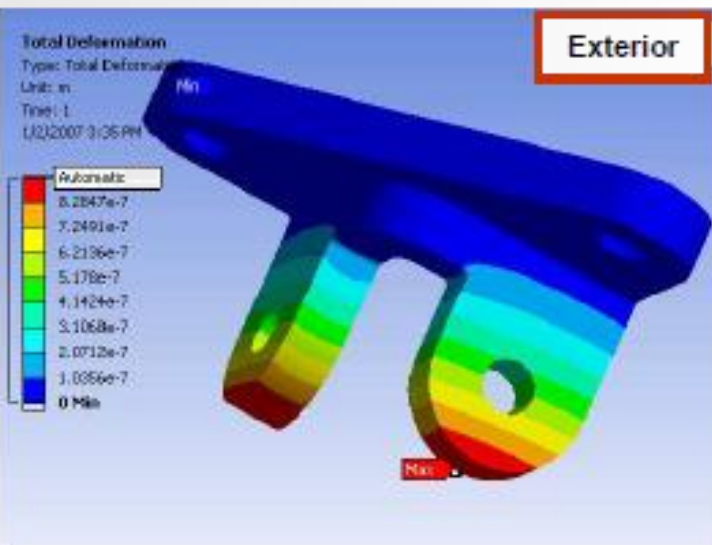


A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
2014/6/5 上午 02:45

150.24 Max
90
78.778
67.557
56.335
45.114
33.892
22.671
11.449
0.22792 Min

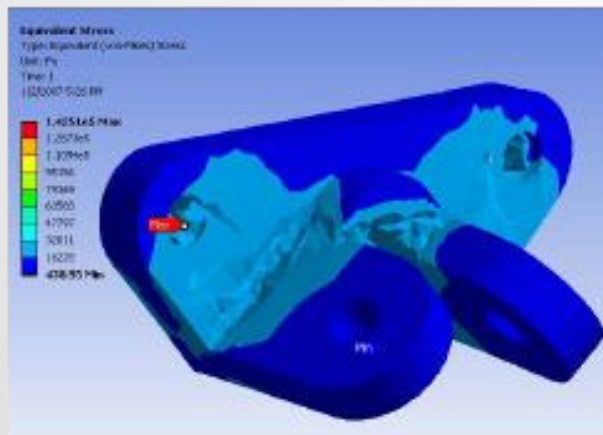


結果顯示方式

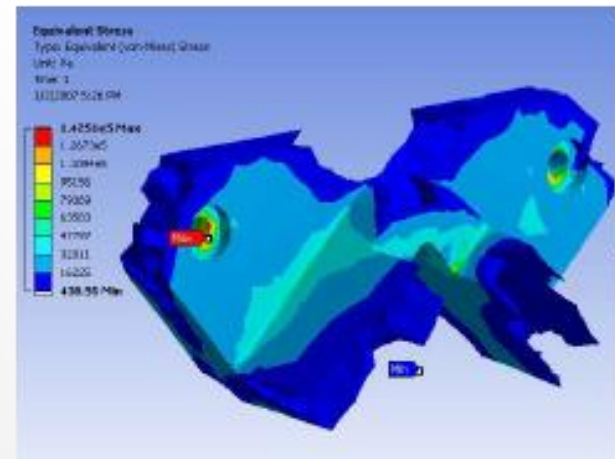


Capped ISO surface

- 可設定閾值以外區域之圖案不顯示
 - Top capped 超過閾值區域不顯示
 - Bottom capped 低於閾值區域不顯示

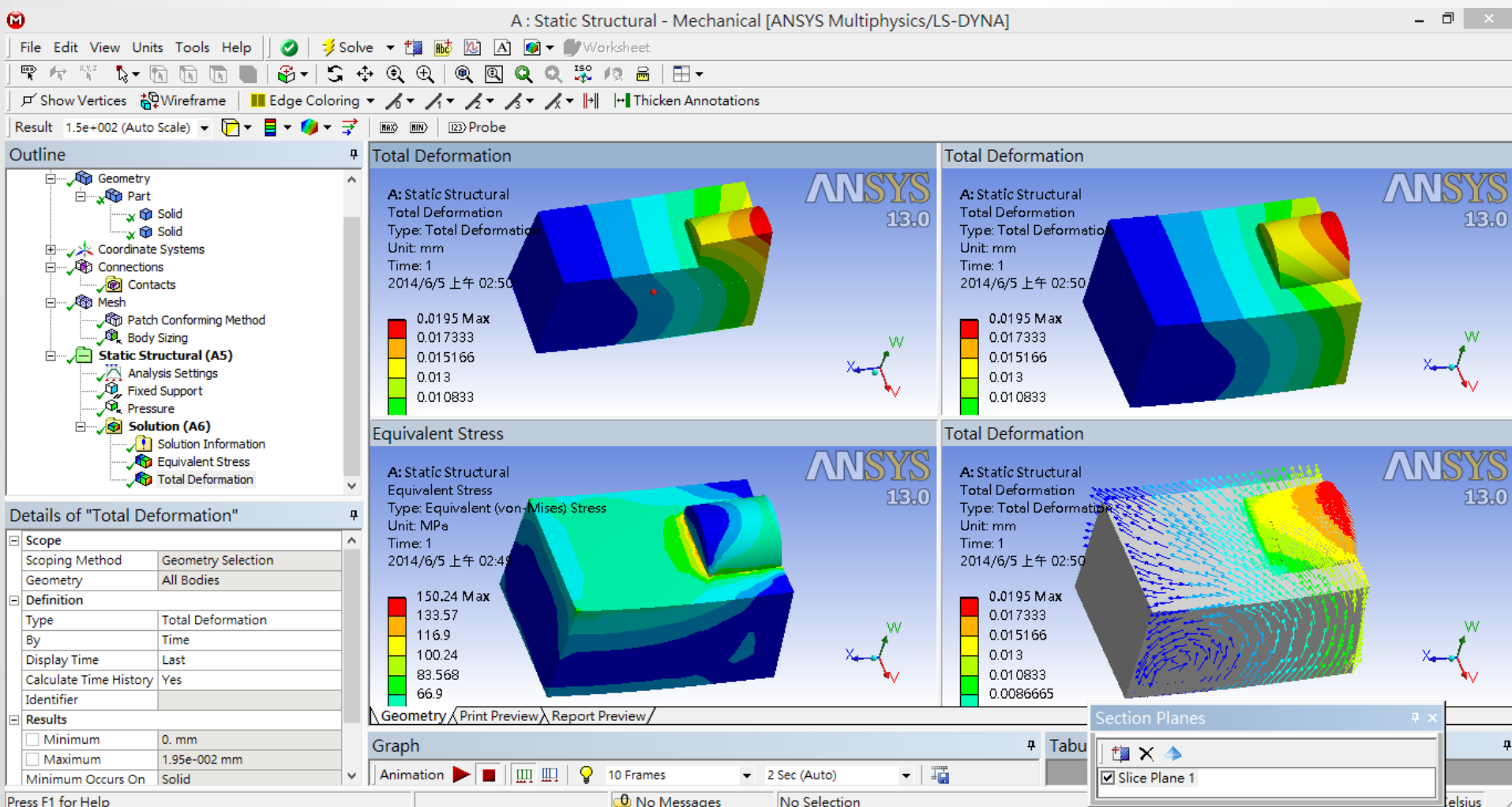


顶部封顶等值面

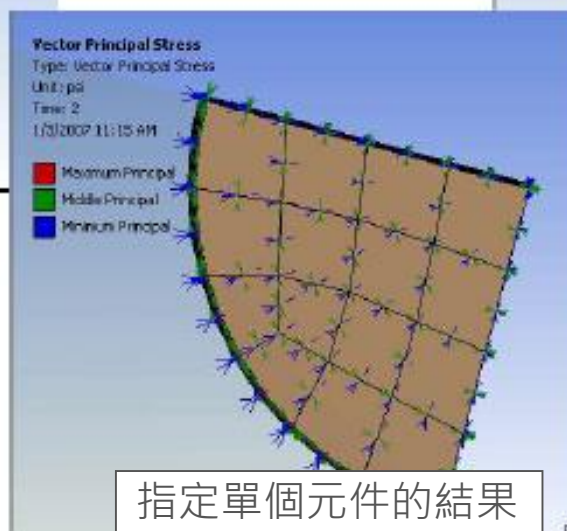
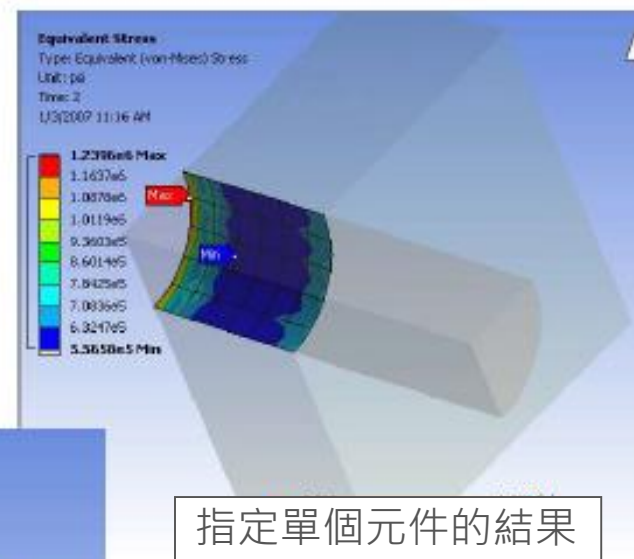
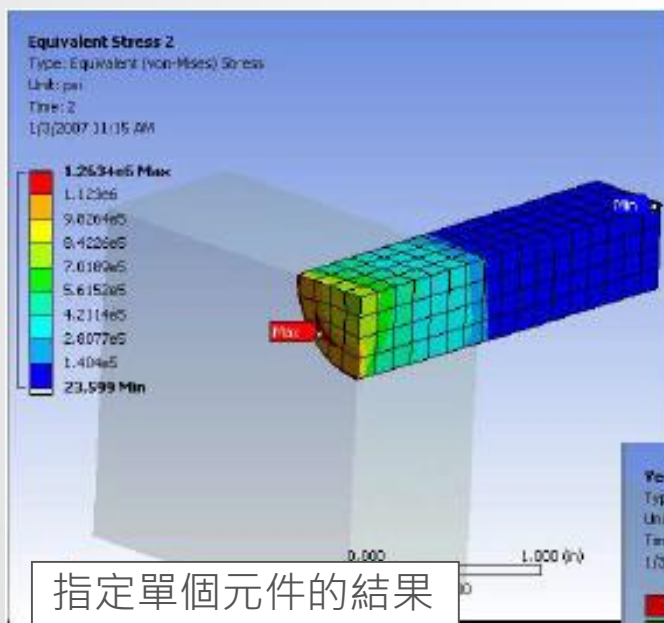


底部封顶等值面

多觀察視窗

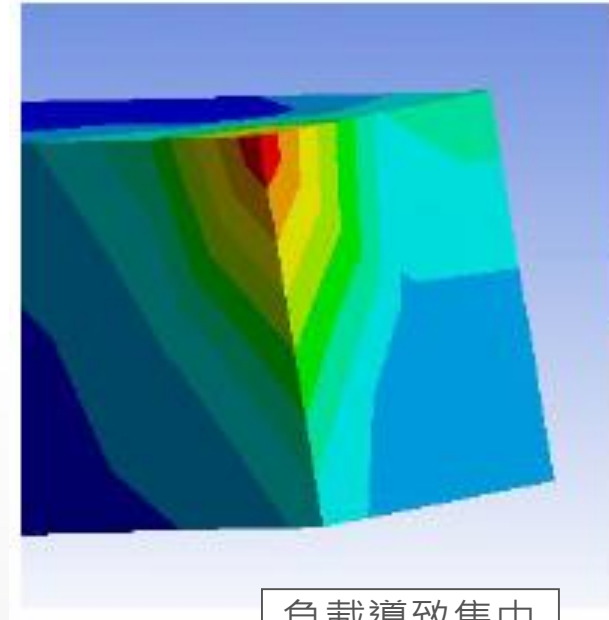


指定元件觀察結果



應力奇異點

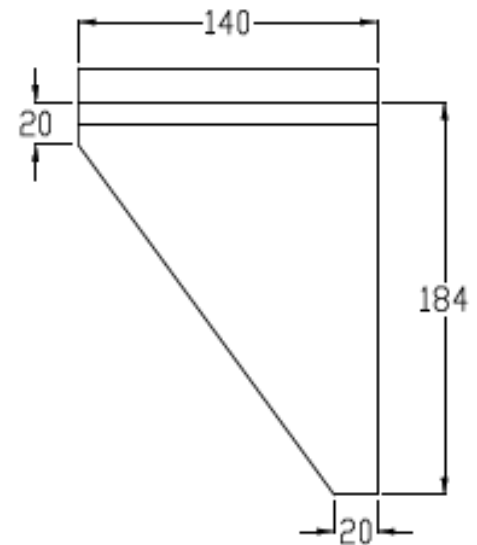
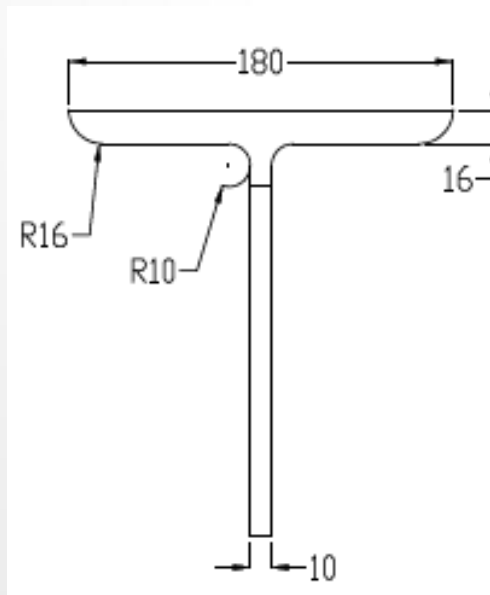
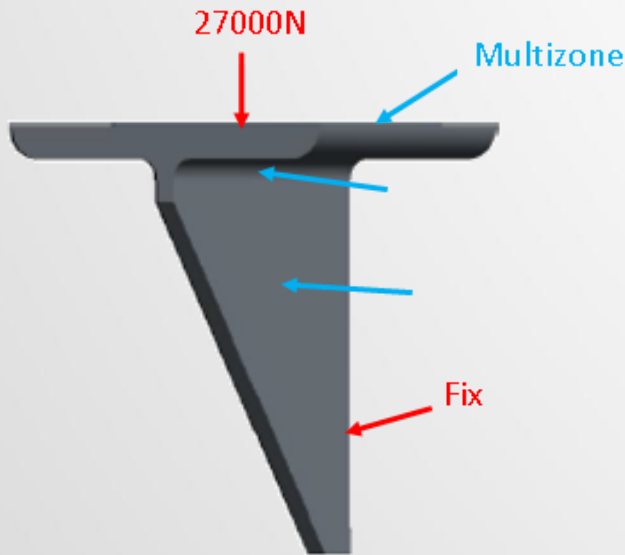
- 當結果顯示發生奇異點時，例如力量及壓力施加在模型點或線上
- 補救措施
 1. 使用New Section Plane將應力奇異點刪除
 2. 若為相反方向需點擊切開軸
 3. 於contour點右鍵，並點選進行Adjust to Visible



Exercise 8 機尾

(來源：成功大學李輝煌教授)

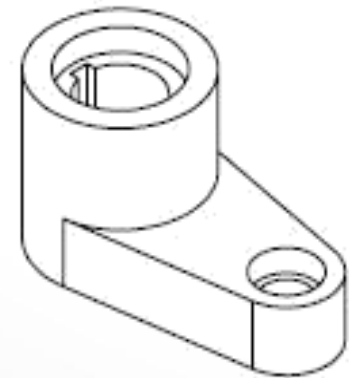
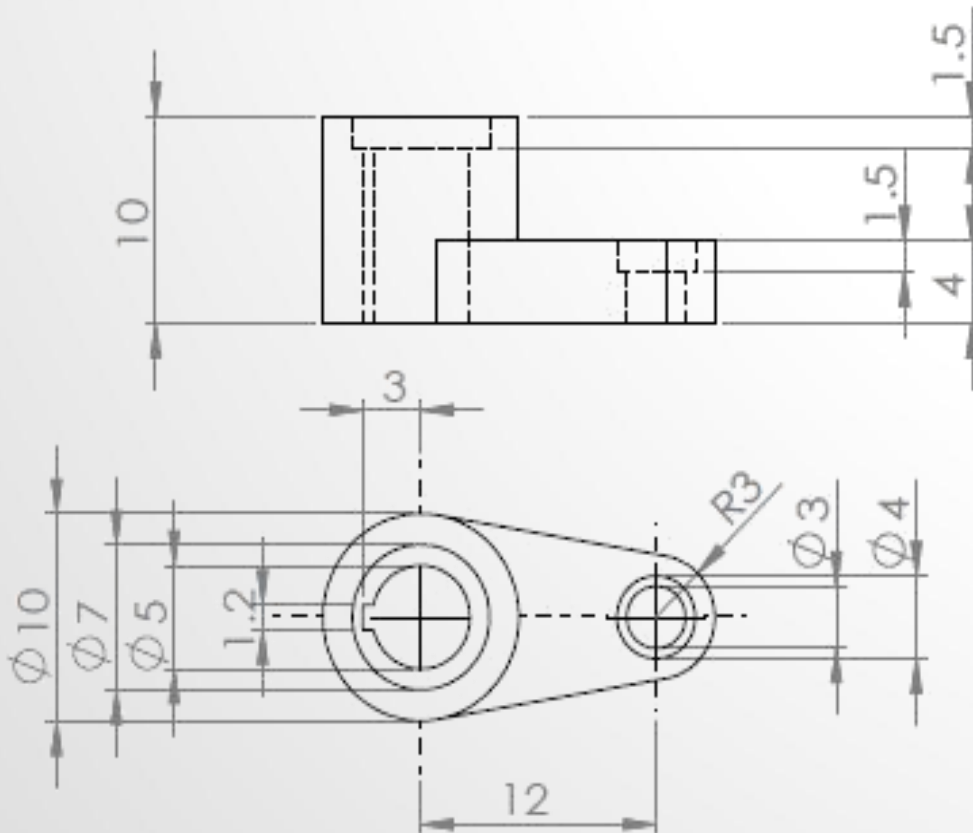
機翼模型，尺寸如下所示，使用MULTIZONE之網格方法將翼板頂面、腹板側面、接合處圓角面進行MESH設定，並將翼板與腹板接合處之圓角兩面設定ELEMENT SIZE為7的MESH。邊界條件如圖所示，板子後方之面固定，上方施予頂面一力。觀察其等效應力、位移量變化、結構誤差及SAFETY FACTOR。材料選用鋼。(單位：MM, N)



Exercise 9

(來源：ANSYS Workbench 有限元分析從入門到精通)

聯軸器模型，尺寸如圖所示，聯軸器在底面的四周邊界不能發生上下運動；在底面的兩個圓周尚不能發生任何方向的運動；在大軸孔的鍵槽的一側受到 $1E5\text{PA}$ 的壓力。觀察其等效應力及位移量變化。



Exercise 10

(來源：ANSYS Workbench 有限元分析從入門到精通)

試建構機蓋模型，尺寸如圖所示並於中央孔內給一均勻往外推之250MPa壓力，觀察其等效應力、位移量變化，材料選用鋼。

