

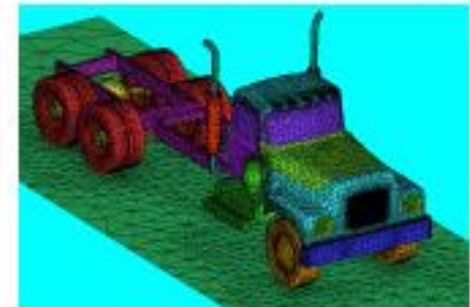
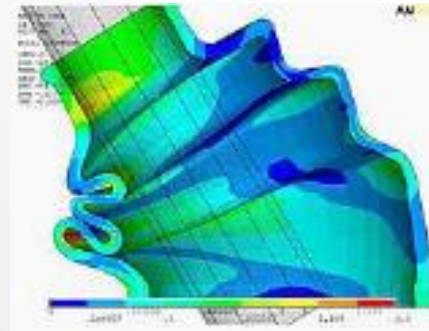
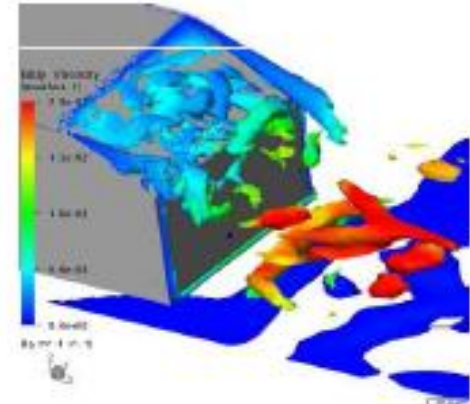
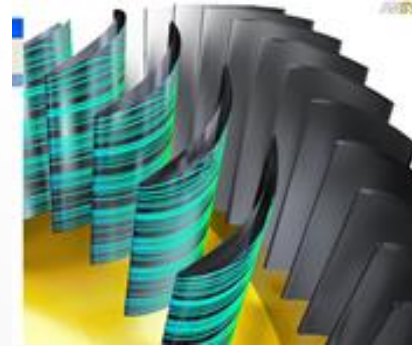
A faint, light gray world map is visible in the background, centered on the Atlantic Ocean. The map shows the continents of North America, South America, Europe, Africa, Asia, and Australia.

電腦輔助工程分析 ANSYS WORKBENCH

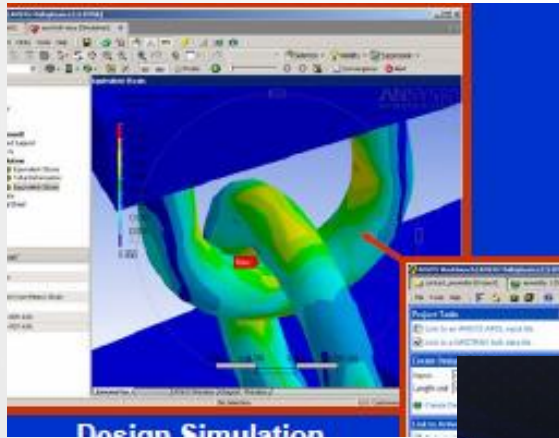
林峻立 教授 國立陽明大學 生物醫學工程系

ANSYS WORKBENCH

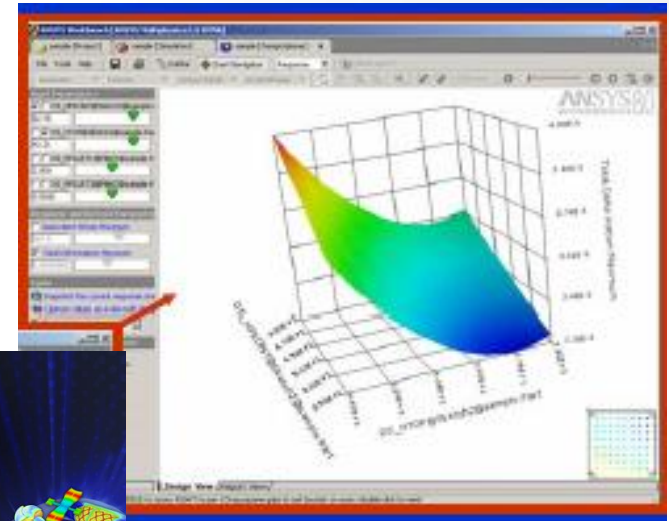
- Workbench 為開發用來提供一個強大與獨特的之模擬分析軟體。並提供一參數化及人性化界面供大部分使用者容易使用。
- 優點
 - 模型建構能力佳
 - 與CAD軟體結合及通用性高
 - 建模形之運算及網格切割能力佳
 - 結果圖案美觀效果佳
- 缺點
 - 過多數值被預設設定
 - 容易造成分析結果不正確
 - 結果觀察較難深入



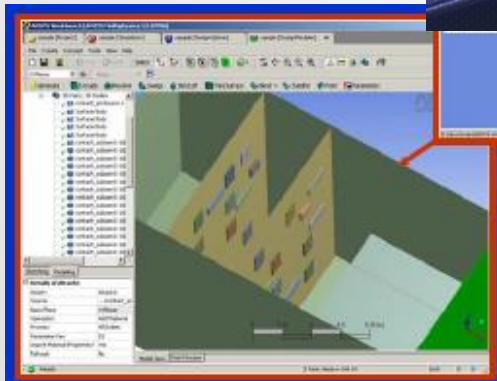
Workbench概述



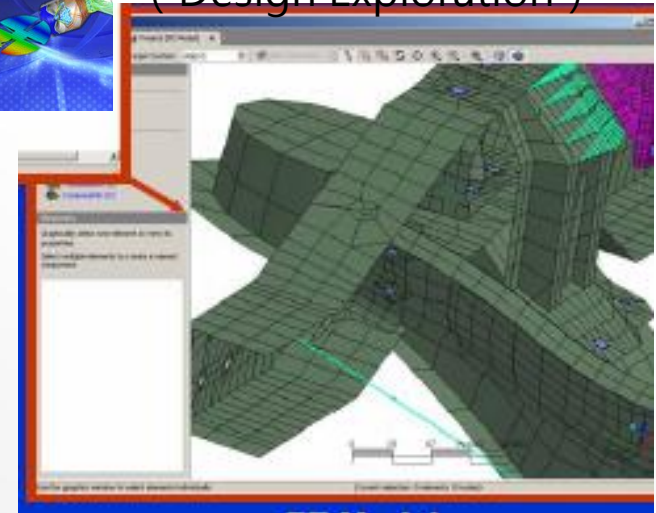
模擬分析
(DesignSpace)



參數管理與最佳化工具
(Design Exploration)



參數化建模
(DesignModeler)



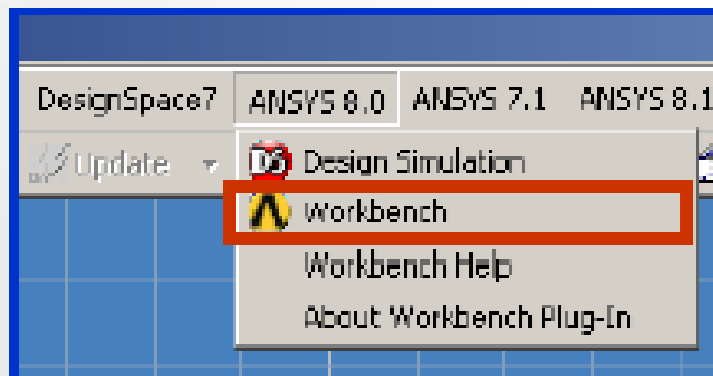
分析連結 (FE Modeler)³

啟動ANSYS WORKBENCH

- 與ANSYS同一個開啟目錄



- 或者可由其他市面上CAD軟體系統中插入



起始界面

Unsaved Project - Workbench

File View Tools Units Help

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

Toolbox

- Analysis Systems
 - Design Assessment
 - Electric
 - Explicit Dynamics
 - Fluid Flow (CFX)
 - Harmonic Response
 - Linear Buckling
 - Magnetostatic
 - Modal
 - Random Vibration
 - Response Spectrum
 - Rigid Dynamics
 - Shape Optimization
 - Static Structural
 - Steady-State Thermal
 - Thermal-Electric
 - Transient Structural
 - Transient Thermal
- Component Systems
 - BladeGen
 - CFX
 - Engineering Data
 - Explicit Dynamics (LS-DYNA Export)
 - External Connection
 - External Data
 - Finite Element Modeler
 - Geometry
 - Mechanical APDL
 - Mechanical Model
 - Mesh
 - Microsoft Office Excel
 - Results
 - TurboGrid
 - Vista CCD
 - Vista RTD
 - Vista TF
- Custom Systems
 - FSI: Fluid Flow (CFX) -> Static Structur
 - Pre-Stress Modal
 - Random Vibration
 - Response Spectrum
 - Thermal-Stress
- Design Exploration
 - Goal Driven Optimization
 - Parameters Correlation
 - Response Surface
 - Six Sigma Analysis

Project Schematic

Steady-State Thermal

Static Structural

Message

	B	C	D
	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	

Ready

Show Progress Hide 4 Messages

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

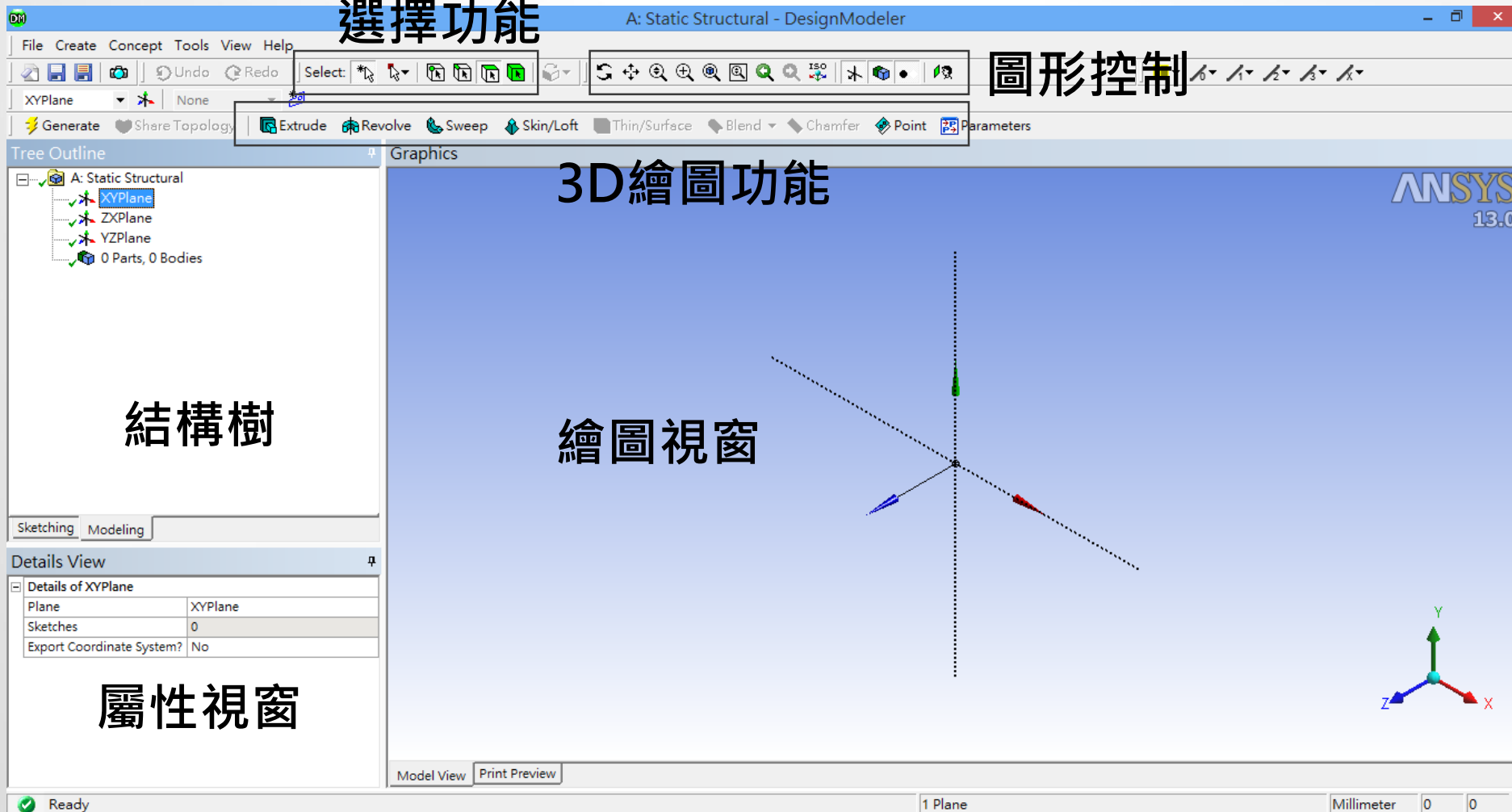
圖形控制

3D繪圖功能

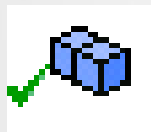
繪圖視窗

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



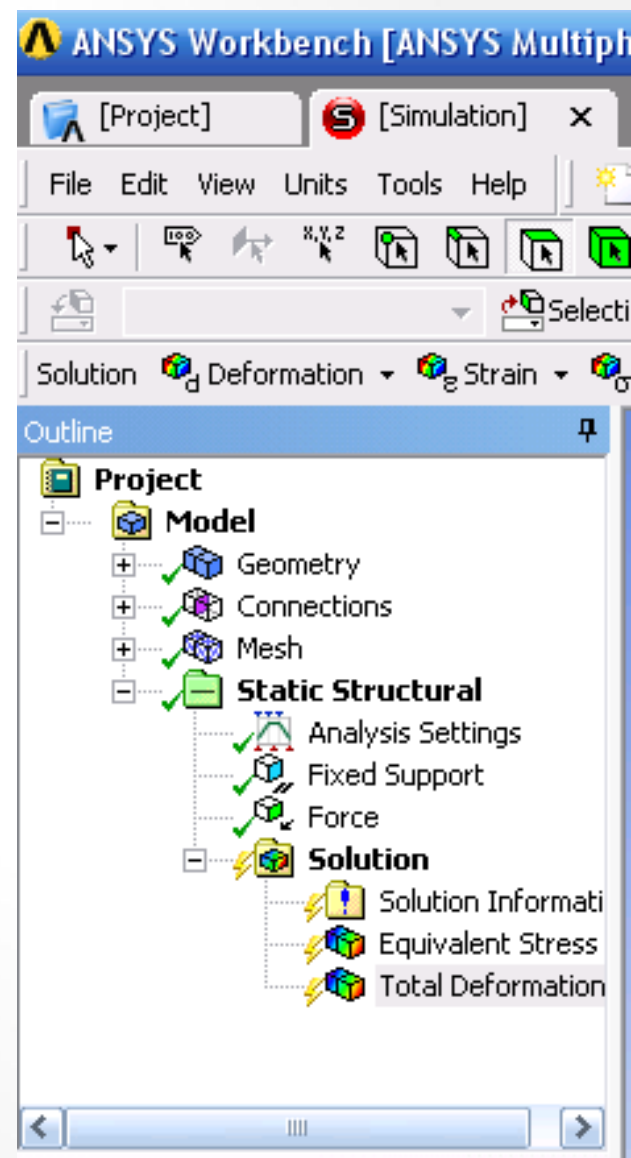
- 說明需要求解



- 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
☐ X Component	0. N (ramped)
☐ Y Component	0. N (ramped)
☐ 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

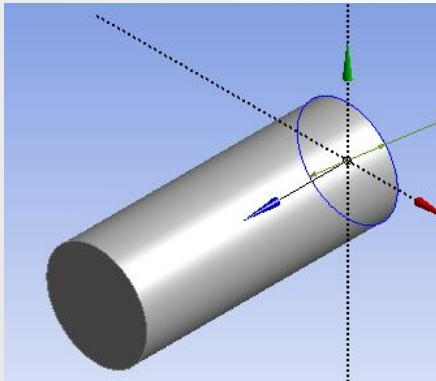
-  General
-  Horizontal
-  Vertical
-  Length/Distance
-  Radius
-  Diameter
-  Angle
-  Semi-Automatic
-  Edit
-  Move
-  Animate

Constraints

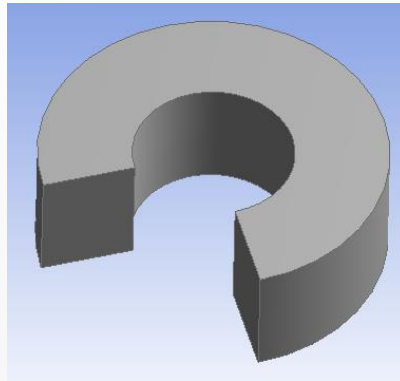
-  Fixed
-  Horizontal
-  Vertical
-  Perpendicular
-  Tangent
-  Coincident
-  Midpoint
-  Symmetry
-  Parallel
-  Concentric
-  Equal Radius

3D Modeling

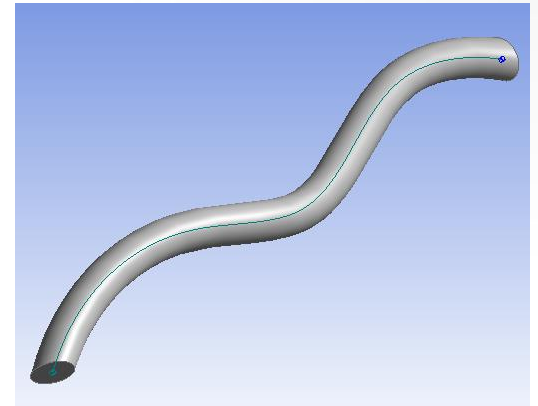
 Extrude



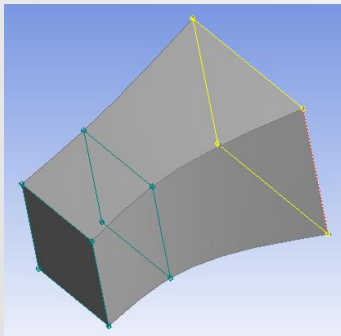
 Revolve



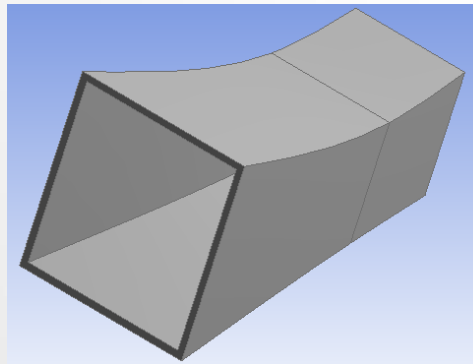
 Sweep



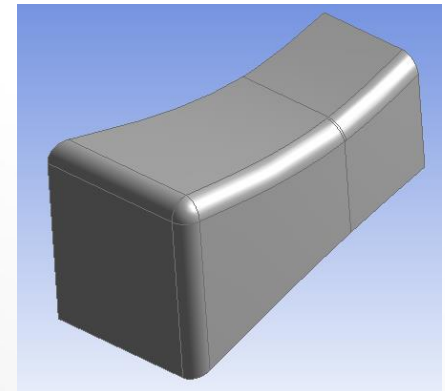
 Skin/Loft



 Thin/Surface

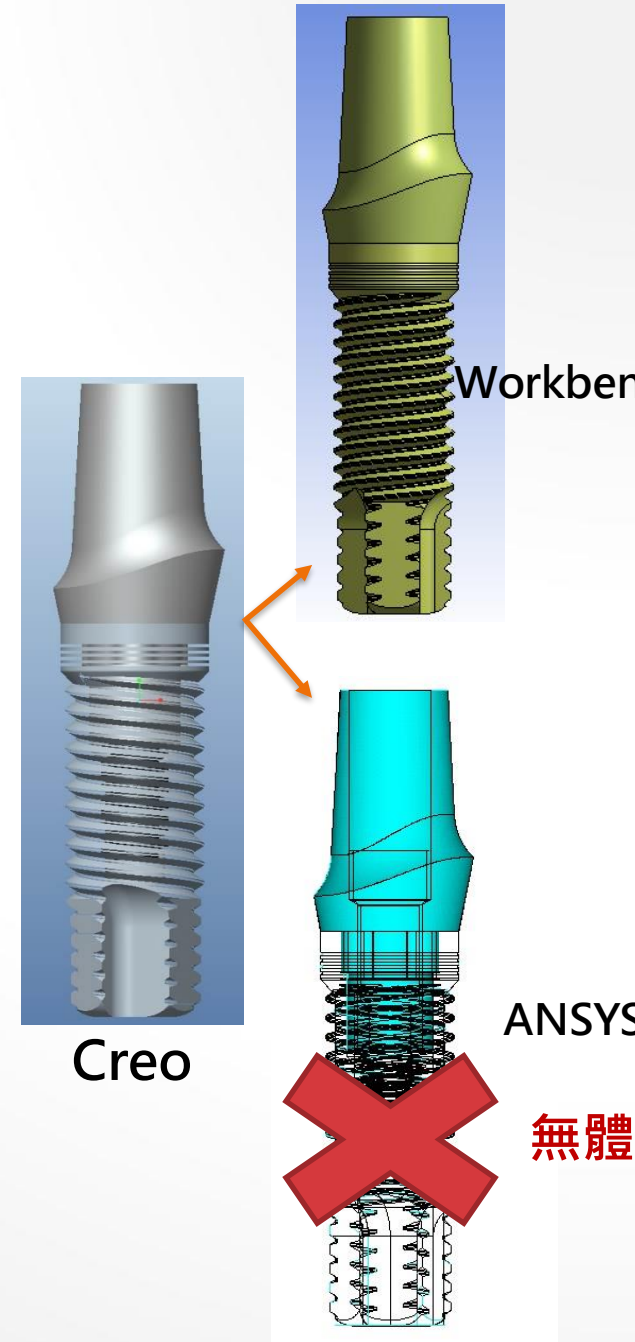


 Blend

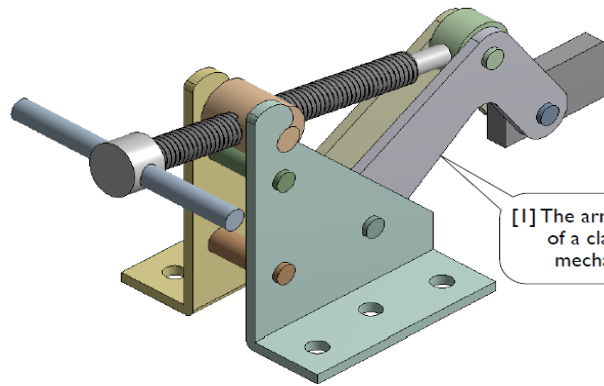


CAD模型輸入

- 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
 - ...



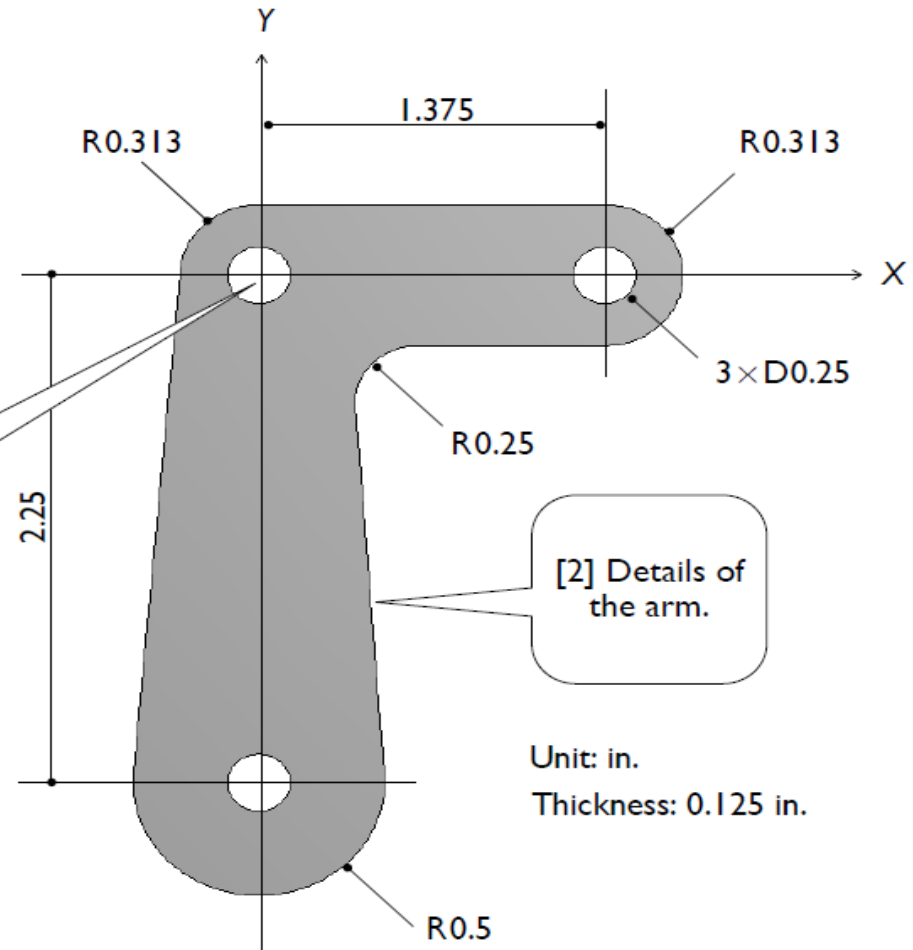
Exercise 1 CAD-1 (來源：成功大學李輝煌教授)



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

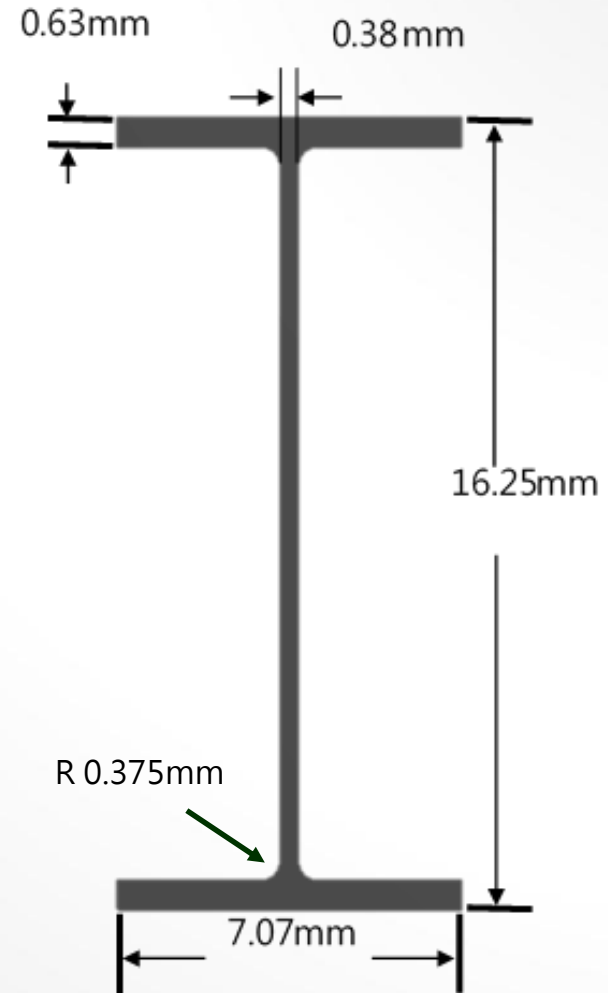
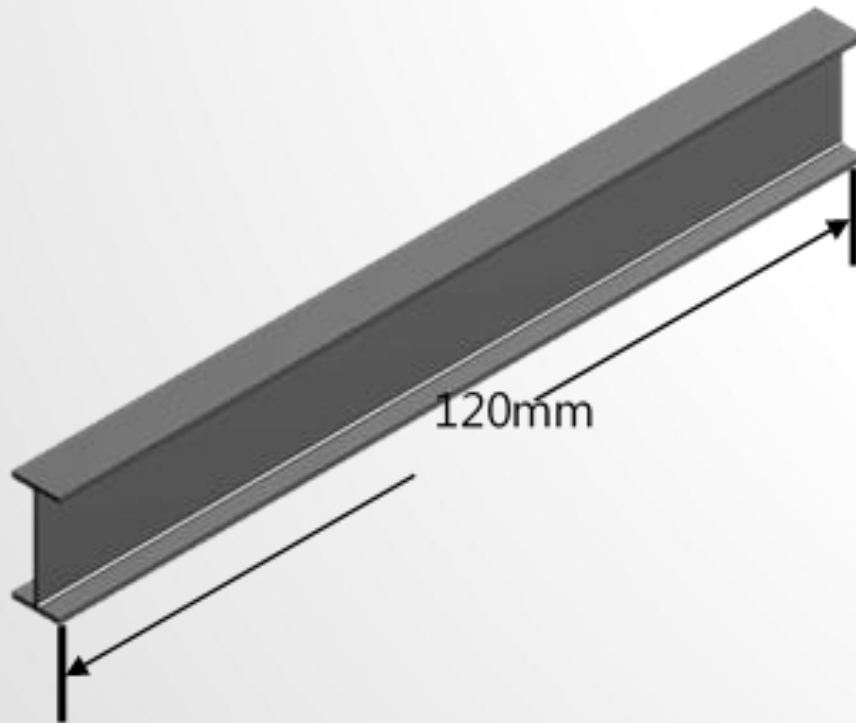


[3] The global coordinate system.



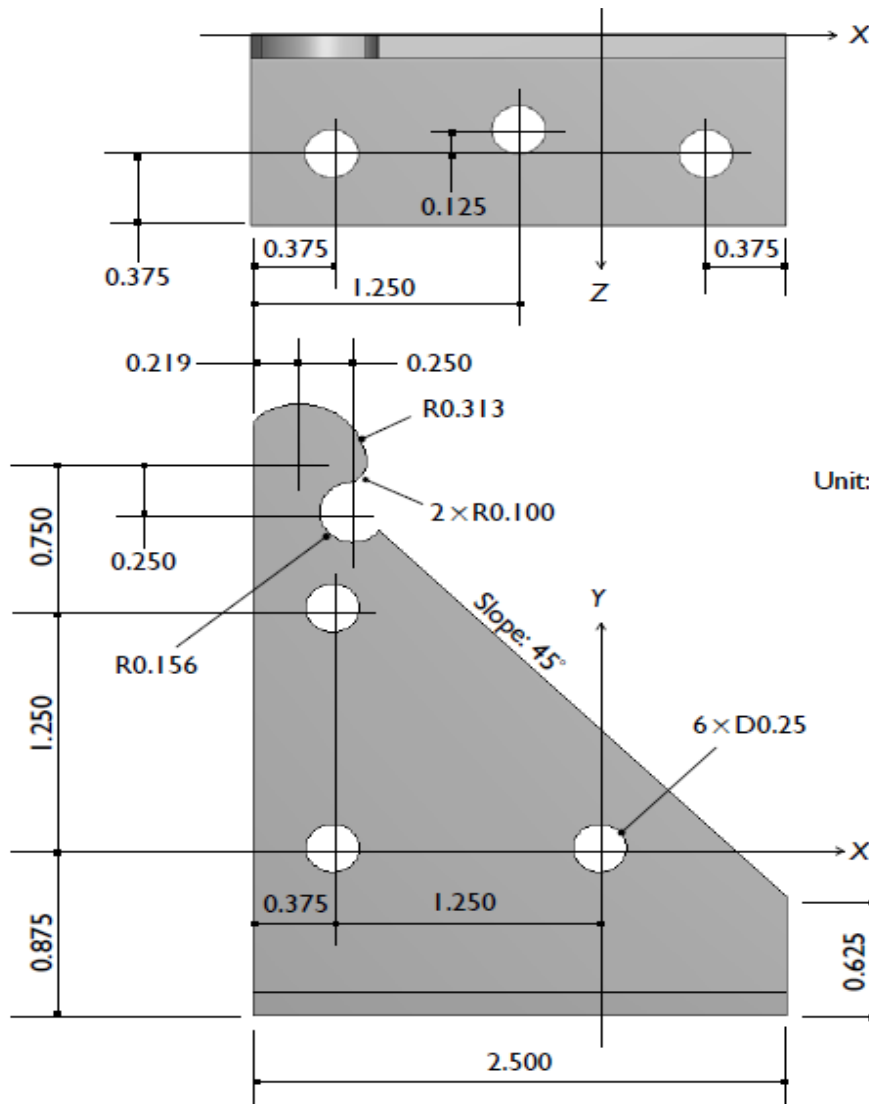
Exercise 2 CAD-2 (來源：成功大學李輝煌教授)

- I Beam model

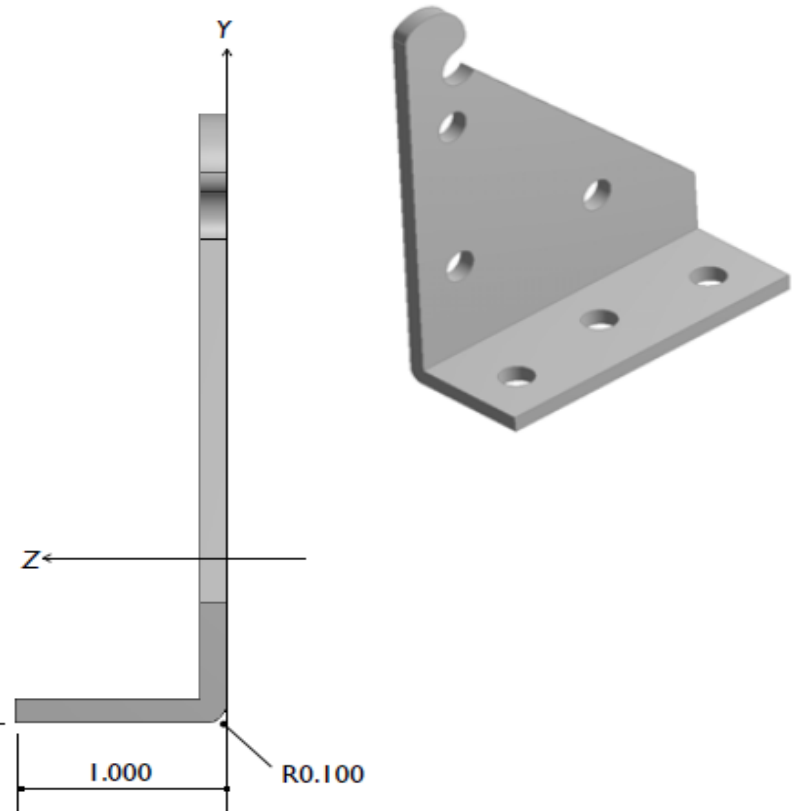
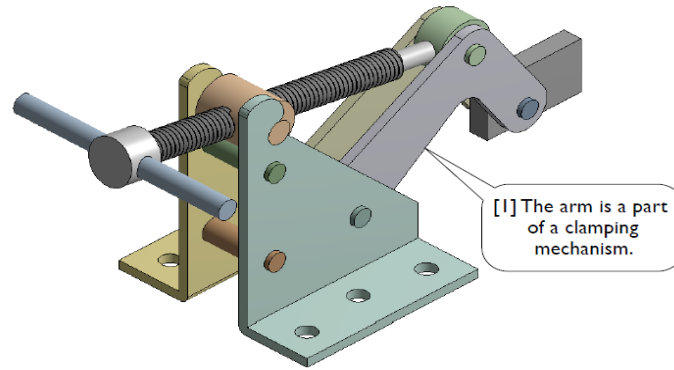


Cross section

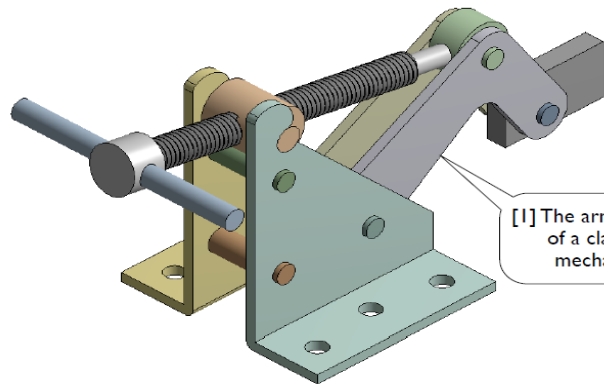
Exercise 3 CAD-3 (來源：成功大學李輝煌教授)



Unit: in.



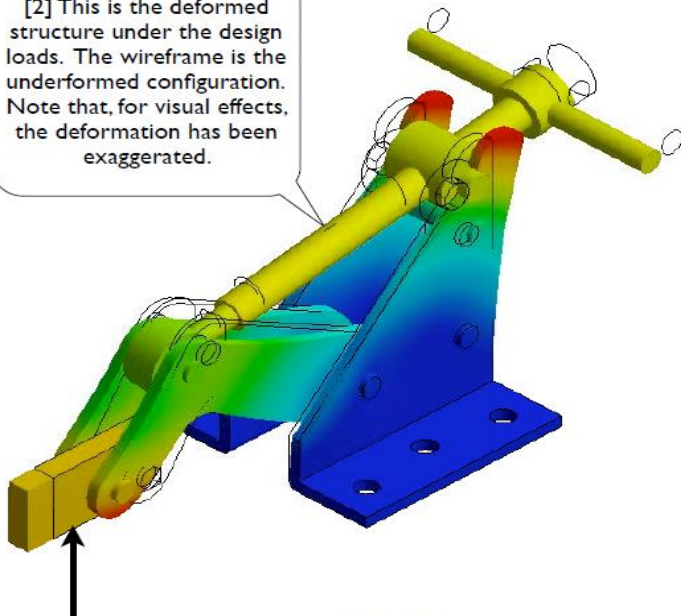
Exercise 4 CAE-1 (來源：成功大學李輝煌教授)



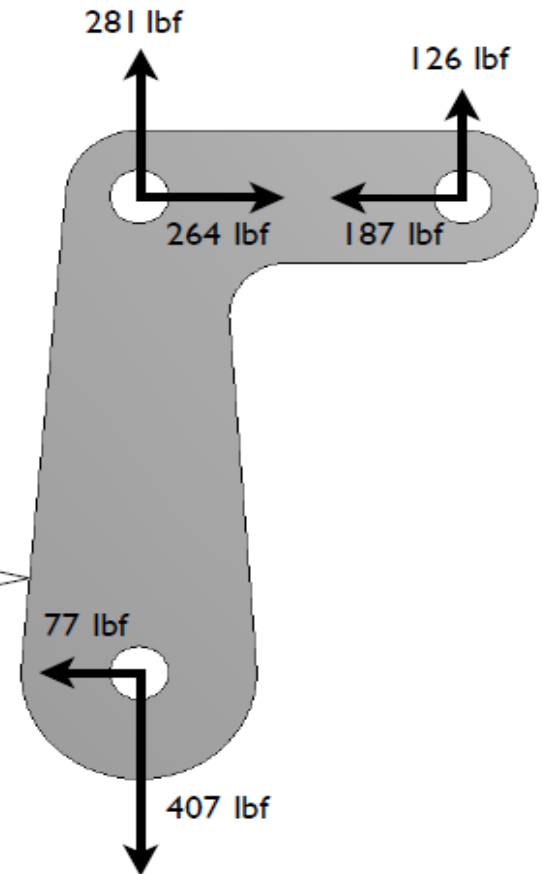
[1] The arm is a part of a clamping mechanism.

[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.

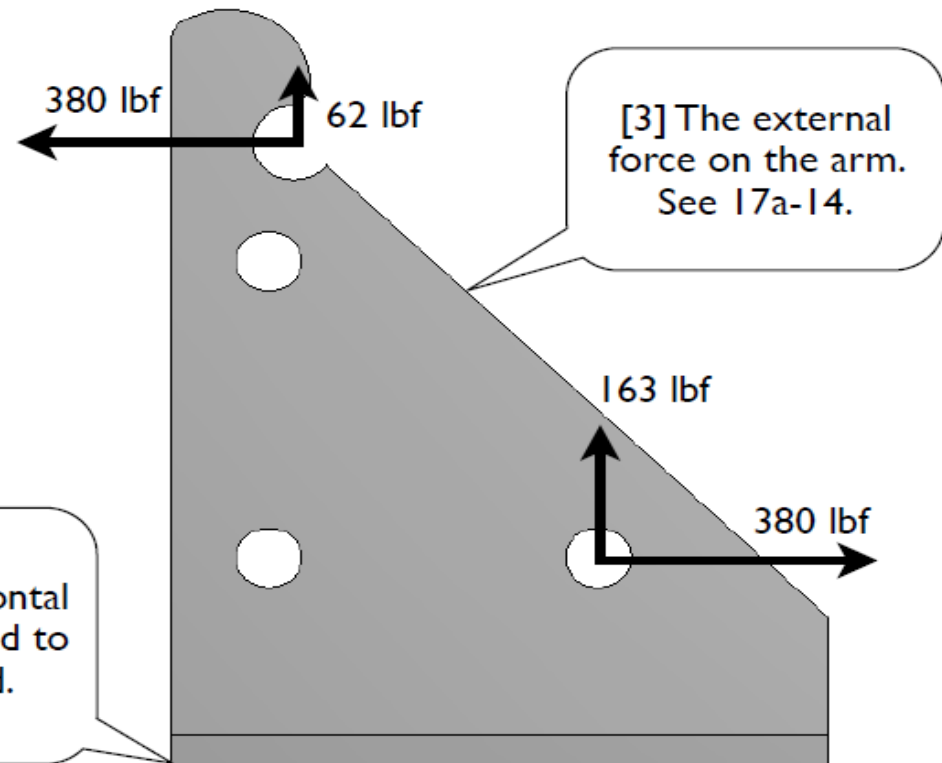
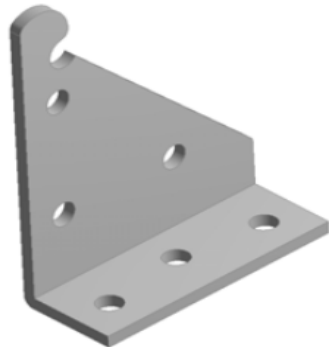
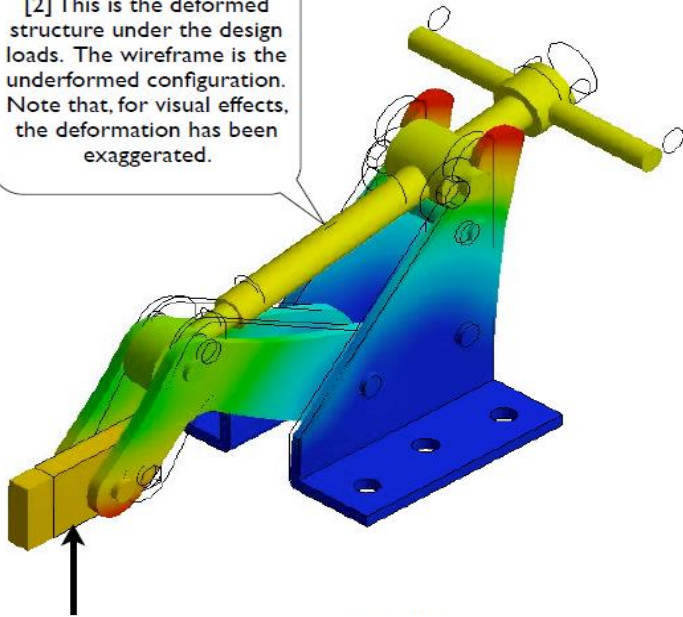


[3] The external forces on the arm. These forces are calculated according to 17a-13.



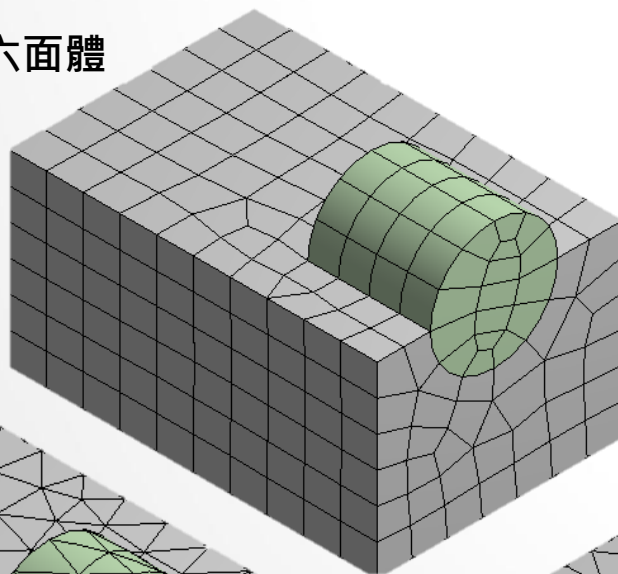
Exercise 5 CAE-2 (來源：成功大學李輝煌教授)

[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.

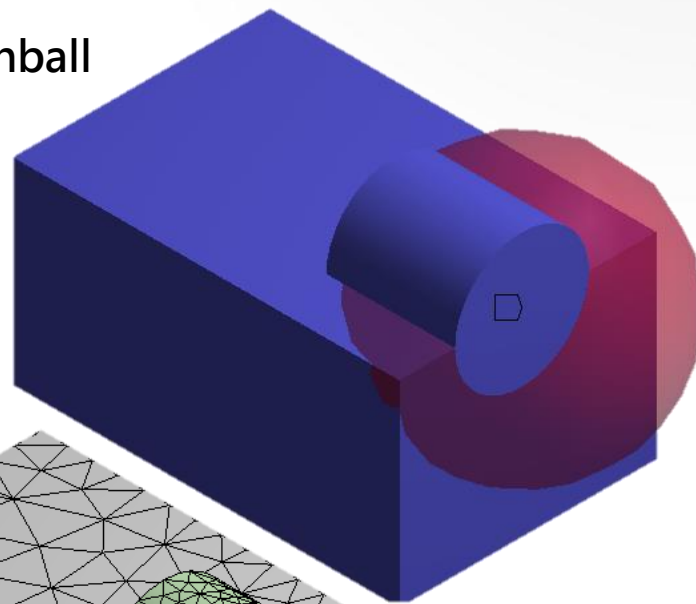


網格分割(mesh)

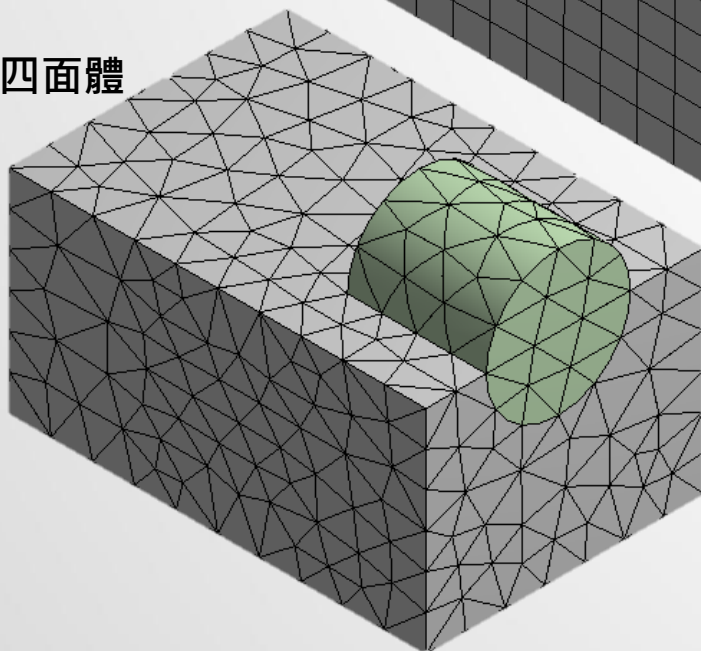
六面體



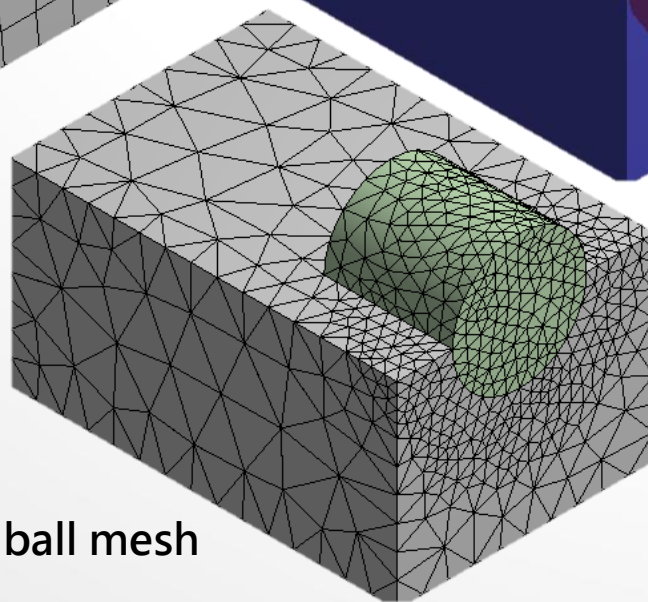
Pinball



四面體

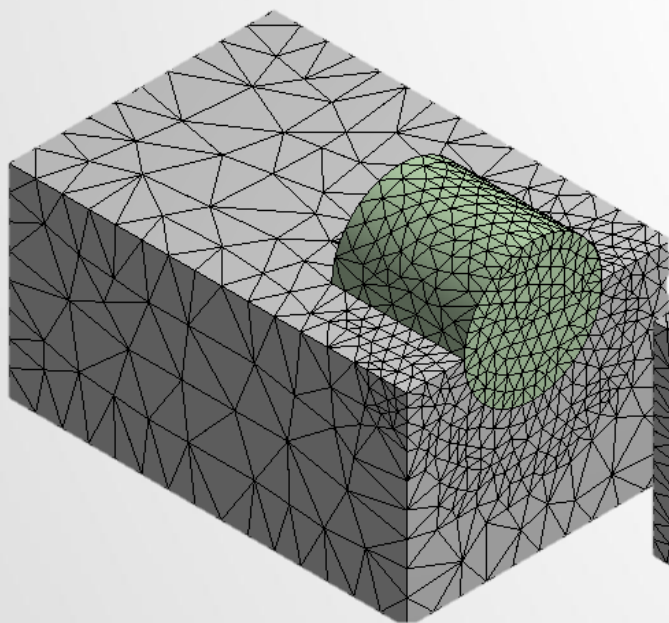


Pinball mesh

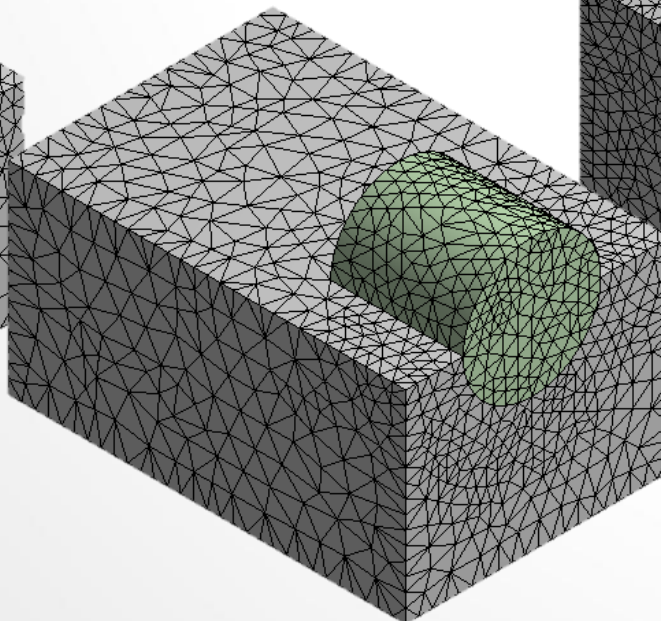


網格分割(mesh)

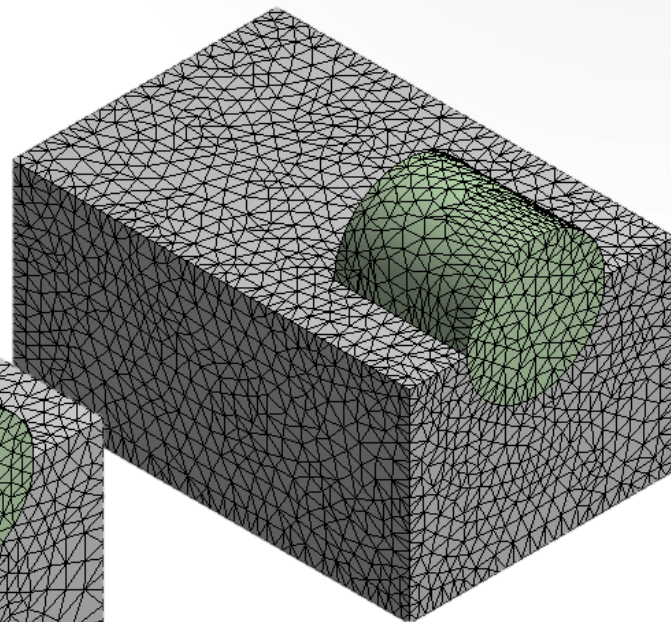
- Relevance Center



Coarse



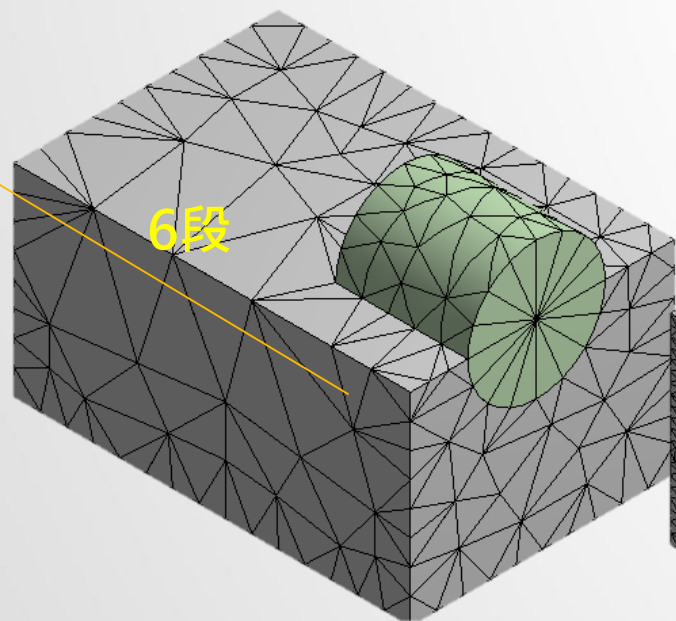
Medium



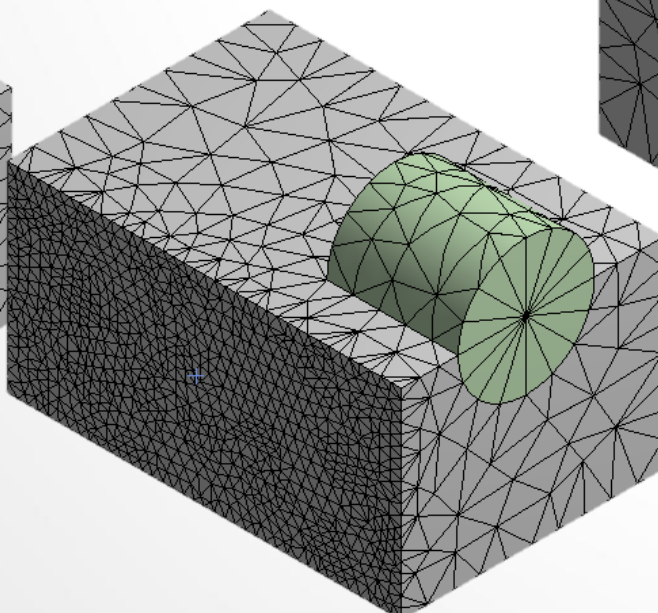
Fine

網格分割(mesh)

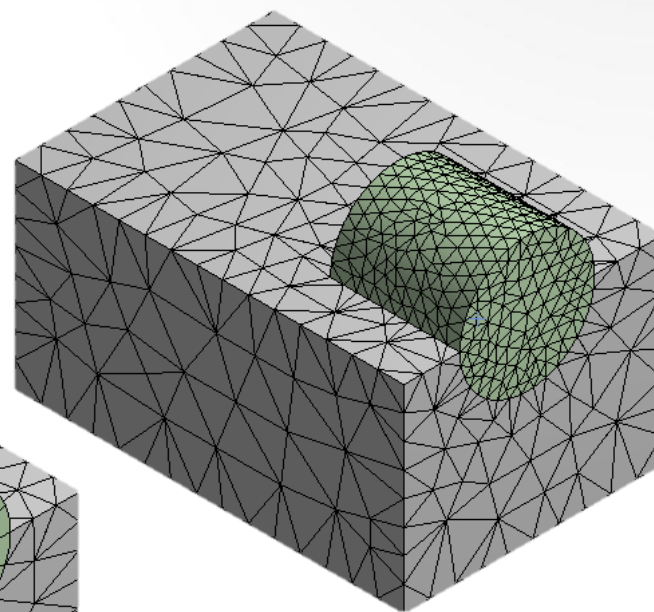
- Sizing



Line



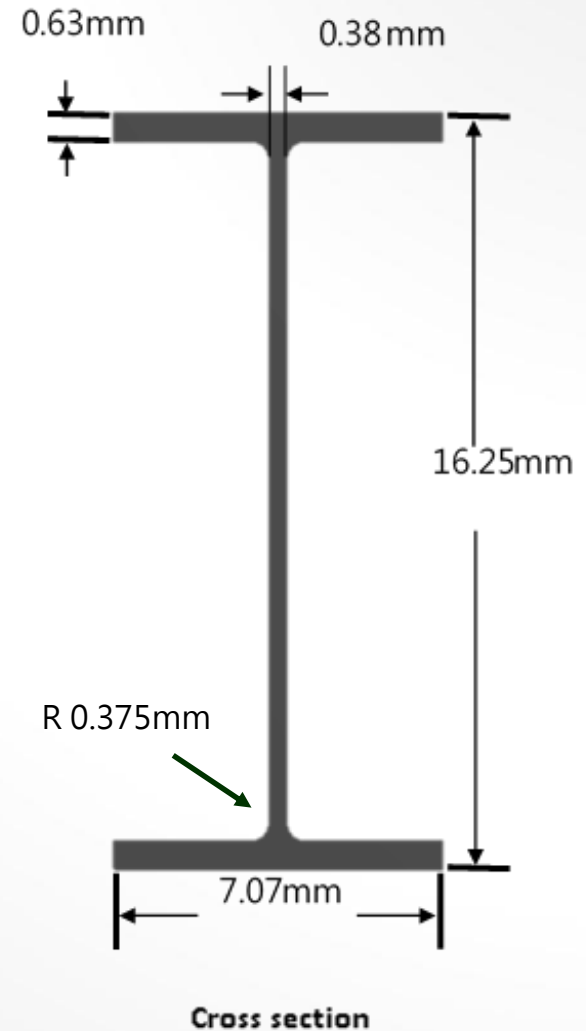
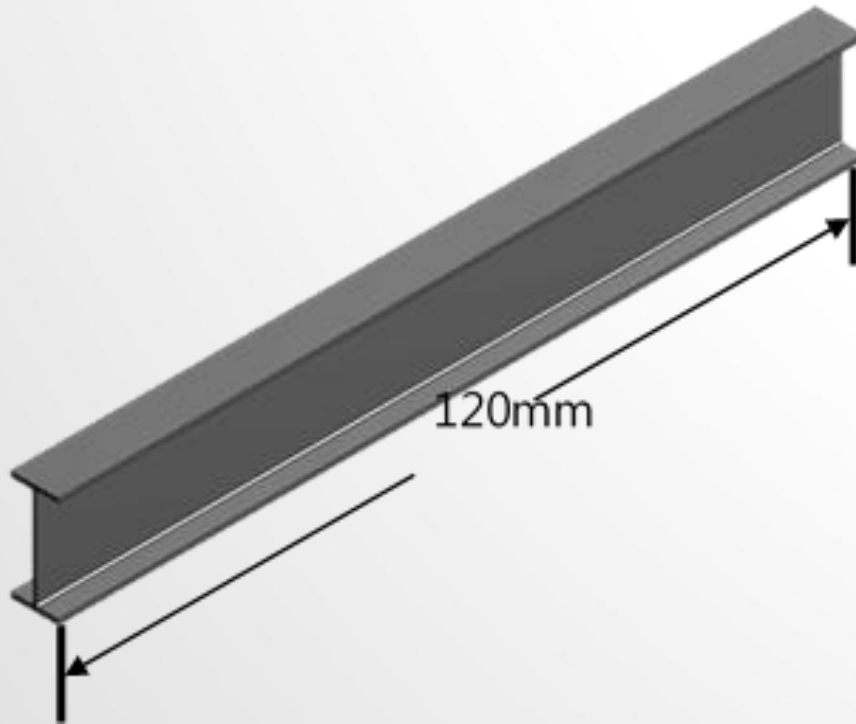
Area



Volume

Exercise 6 MESH-1 (來源：成功大學李輝煌教授)

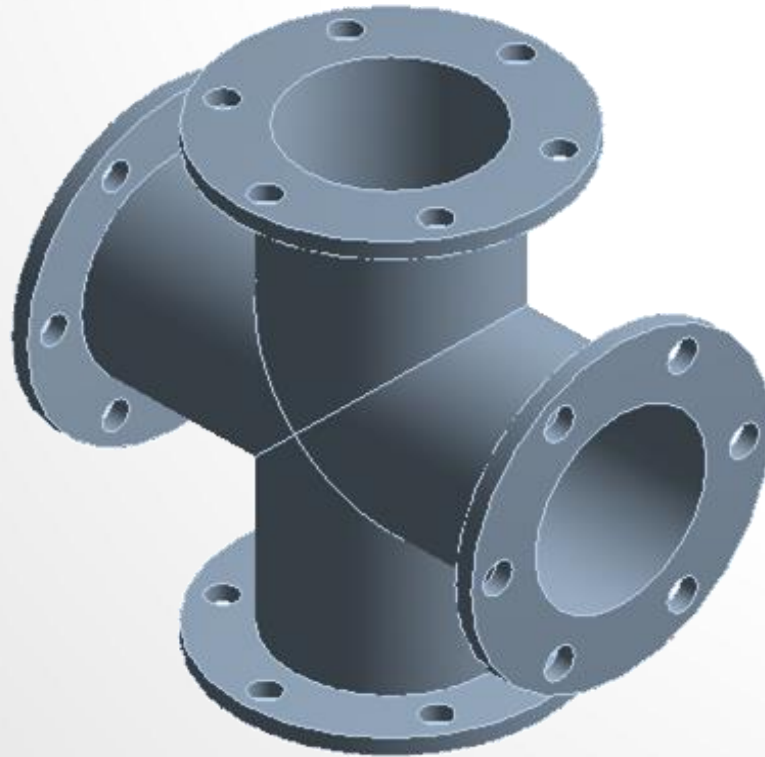
- 進行不同網格切割 (1) 四面體 (Tetrahedrons)，(2) 六面體 (Hex Domain)，(3) 四面體 mesh，尺寸 2mm，(2) 六面體，尺寸 2mm



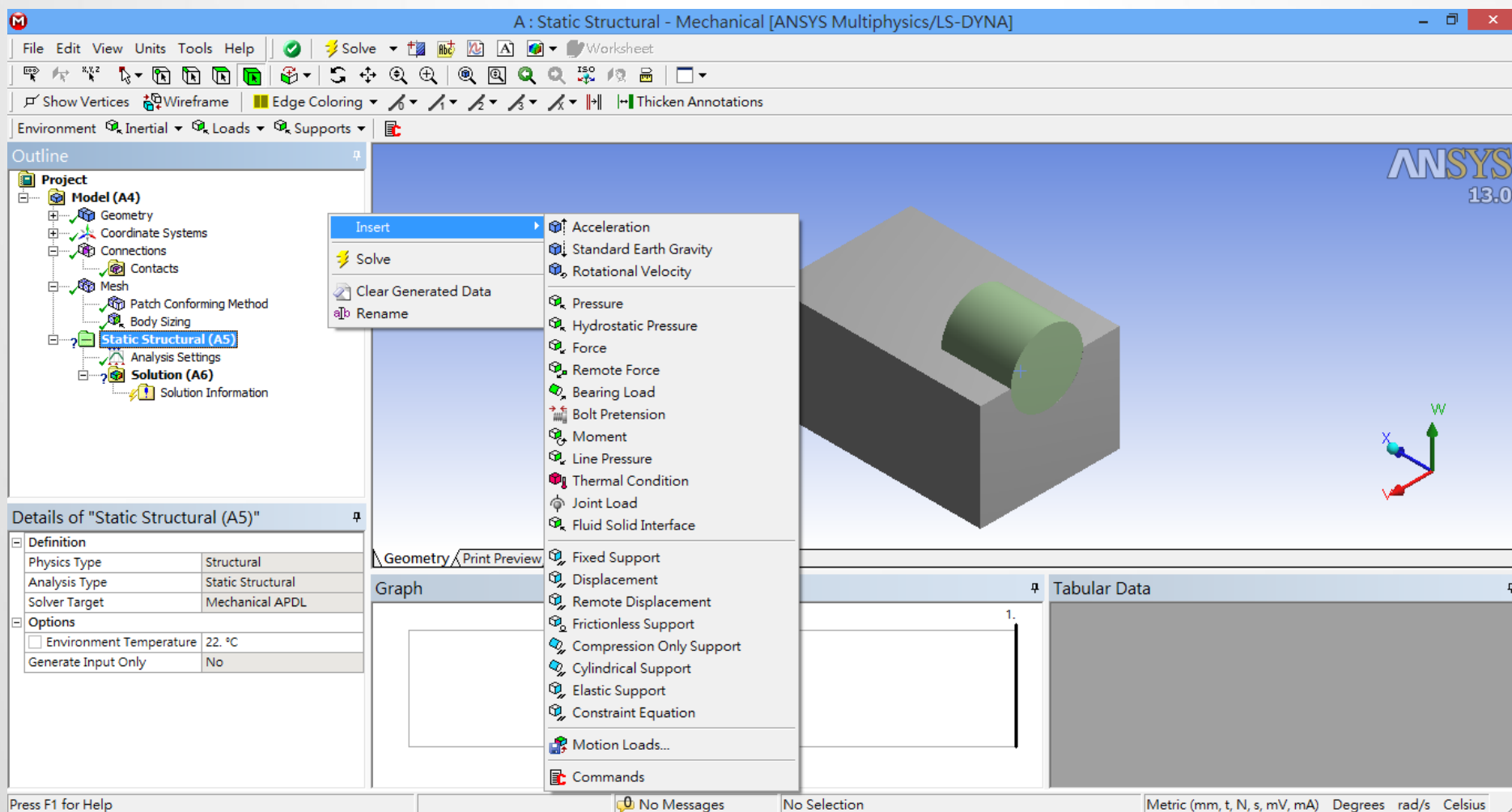
Exercise 7 MESH-2

(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

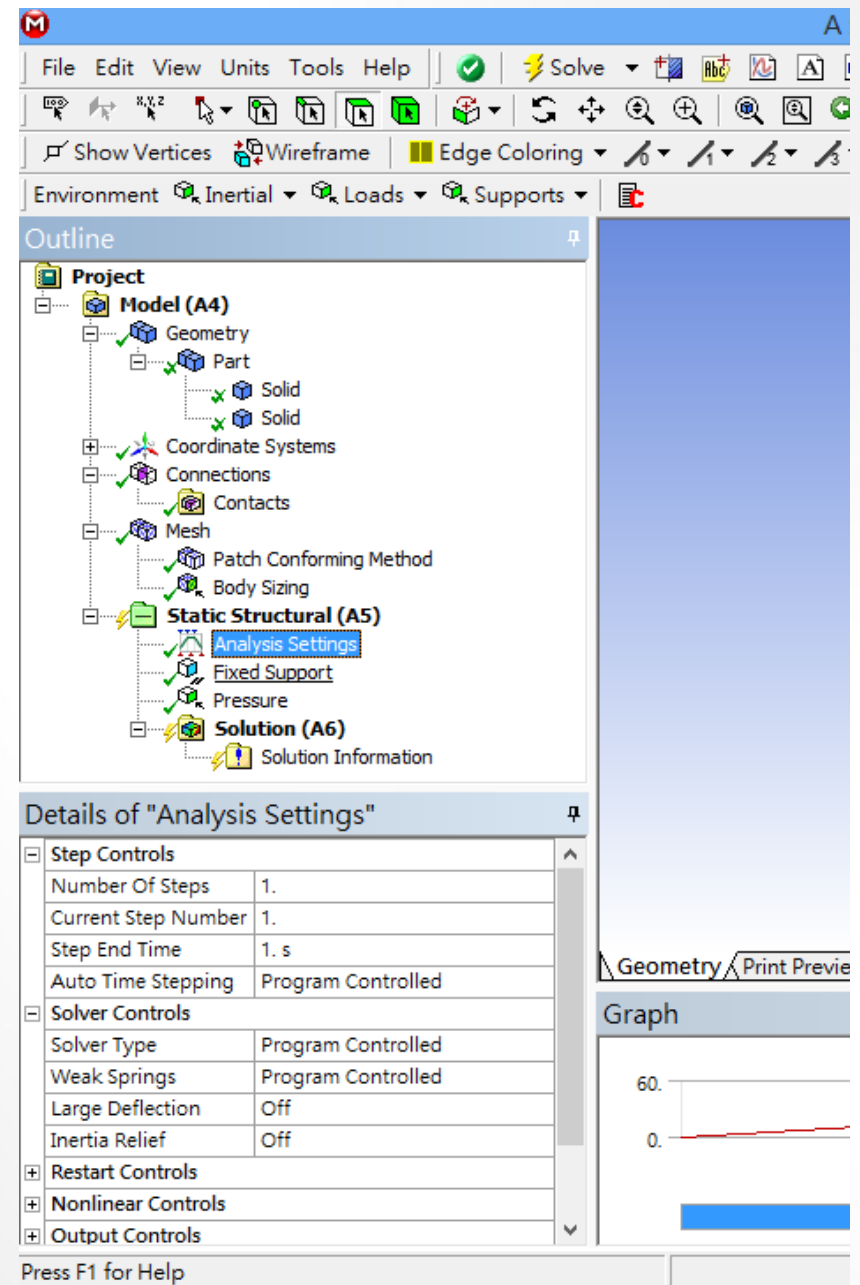


邊界條件給定



解題條件設定

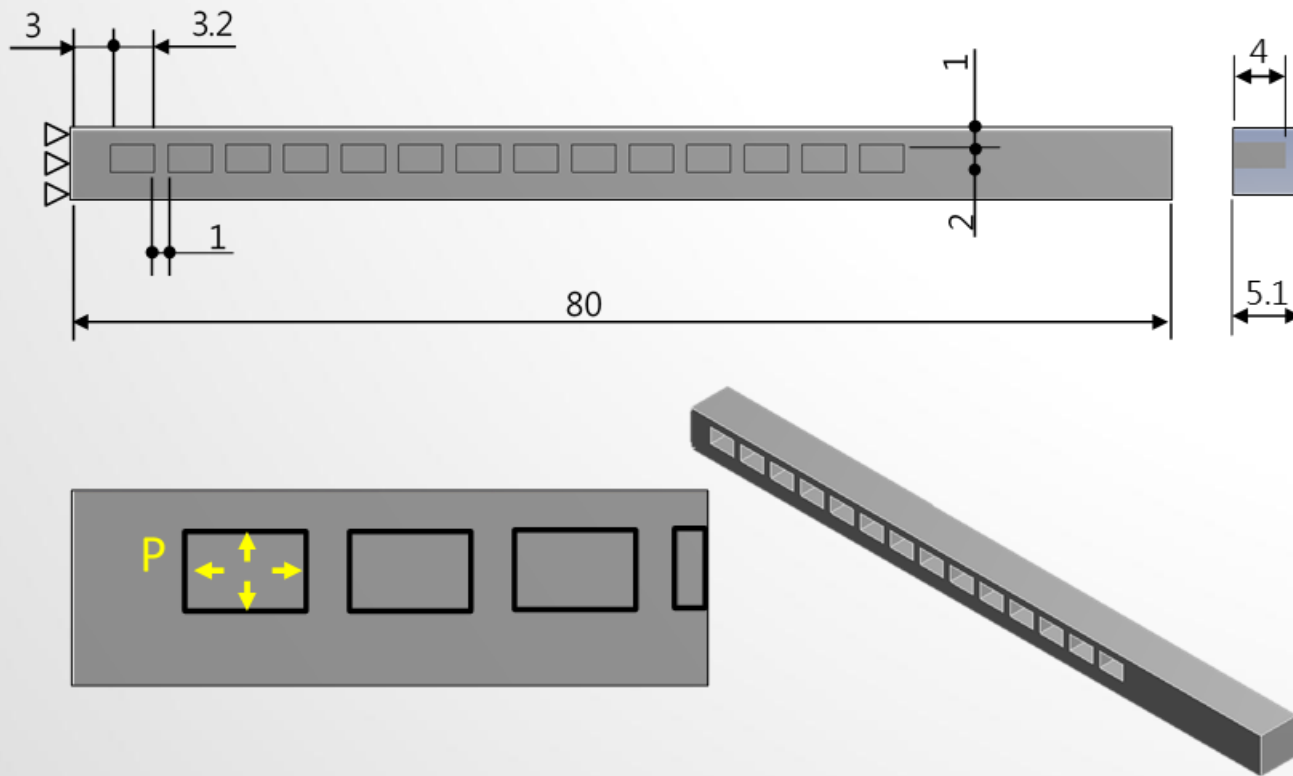
- Step Control
 - Number of steps,
 - Current Step Number,
 - Step Ends
- Time Control
 - 解題形式
 - 大變形等



Exercise 8 MESH-3

(來源：成功大學李輝煌教授)

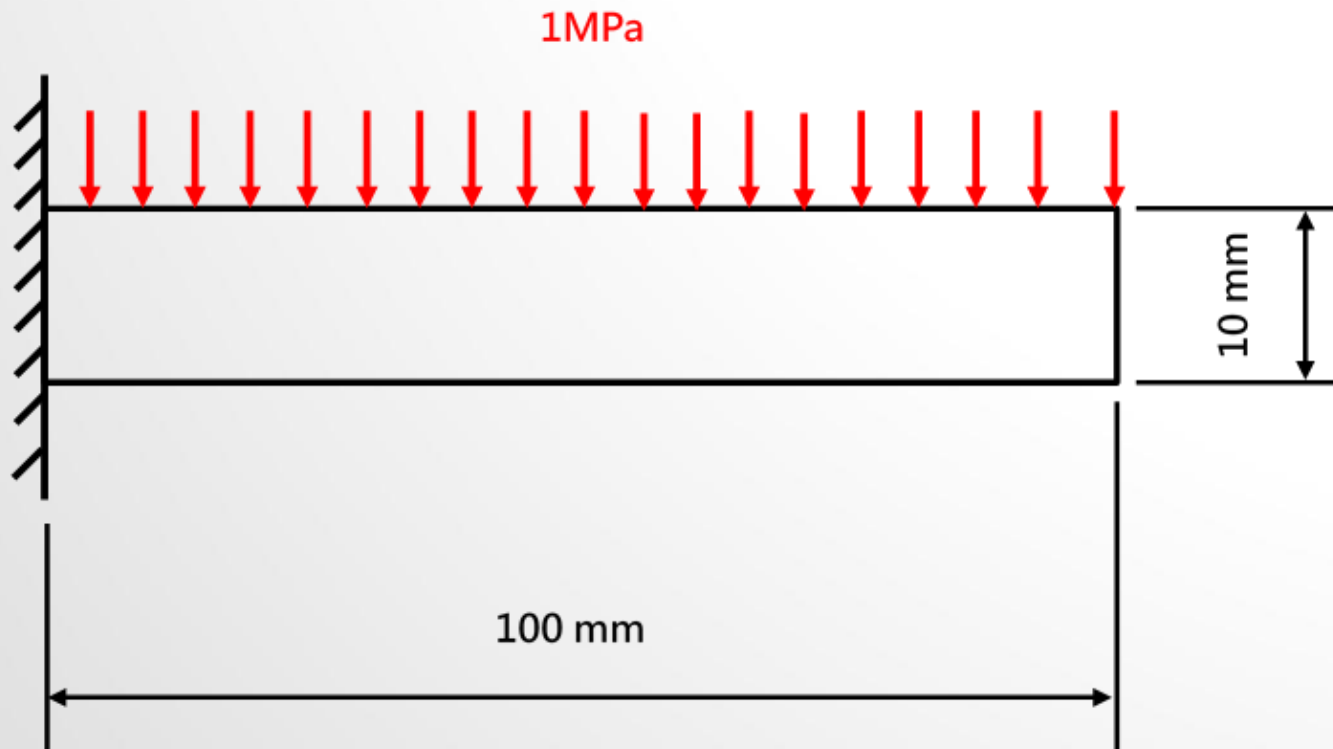
- Pneumatic Fingers 模型 (Symmetry) 如圖所示，請依不同網格形式進行切割 (1)自動網格(Automatic)、(2) 掃描網格(Sweep)、進行線性與非線性的分析。將pneumatic fingers 左側固定，chamber空間施以0.2MPa壓力，觀察其Y軸位移量變化。楊氏係數 $E=2\text{MPa}$ ，樸松比Poisson's ratio=0.48



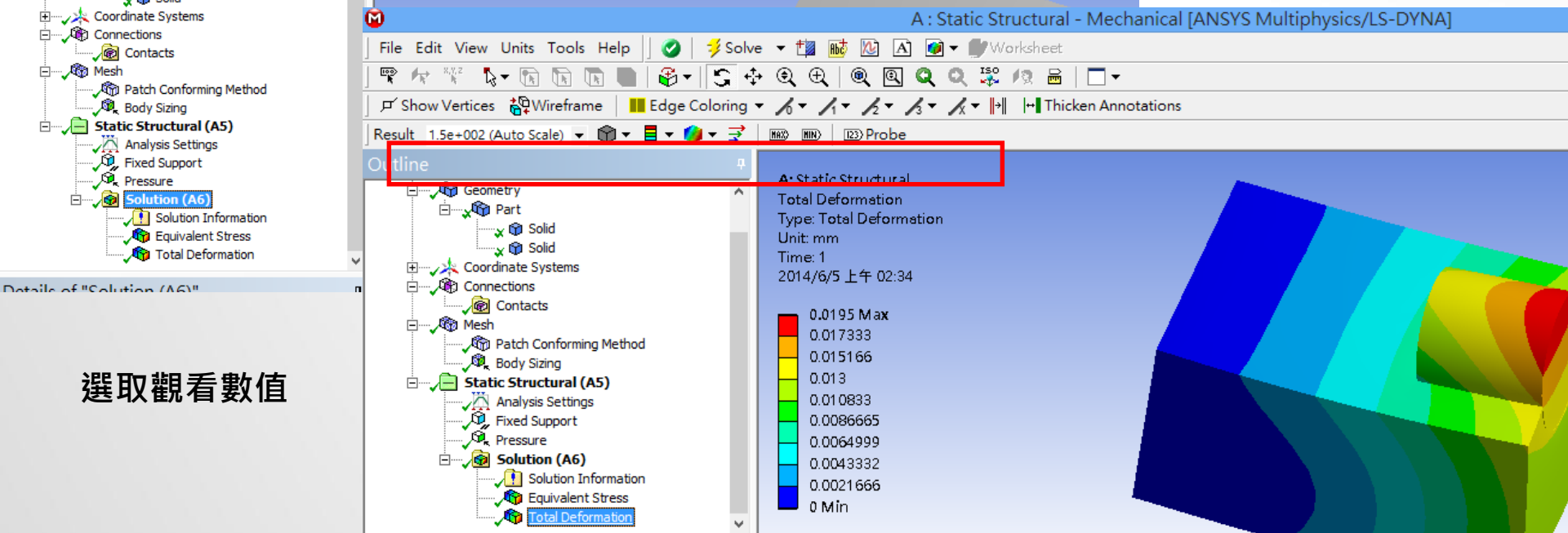
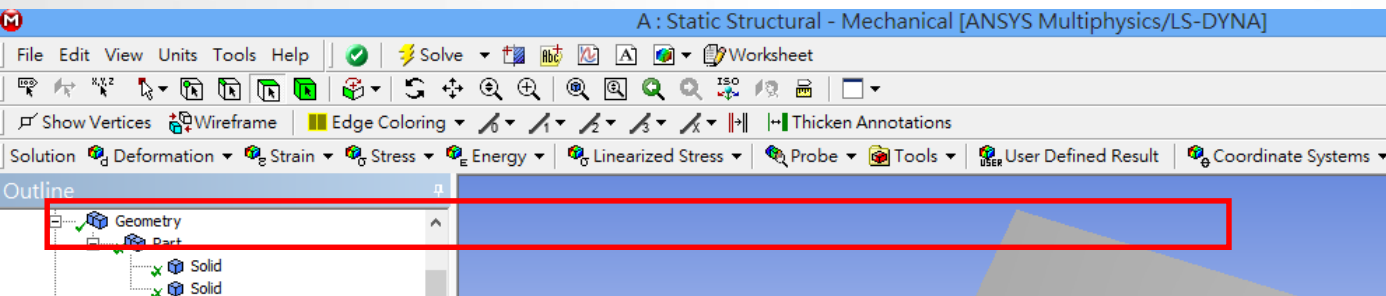
Exercise 9 MESH-4-CONVERGENCE

(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)

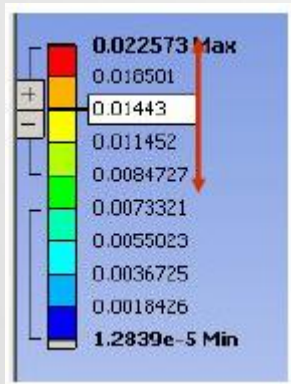


選取觀看數值

設定顯示方式

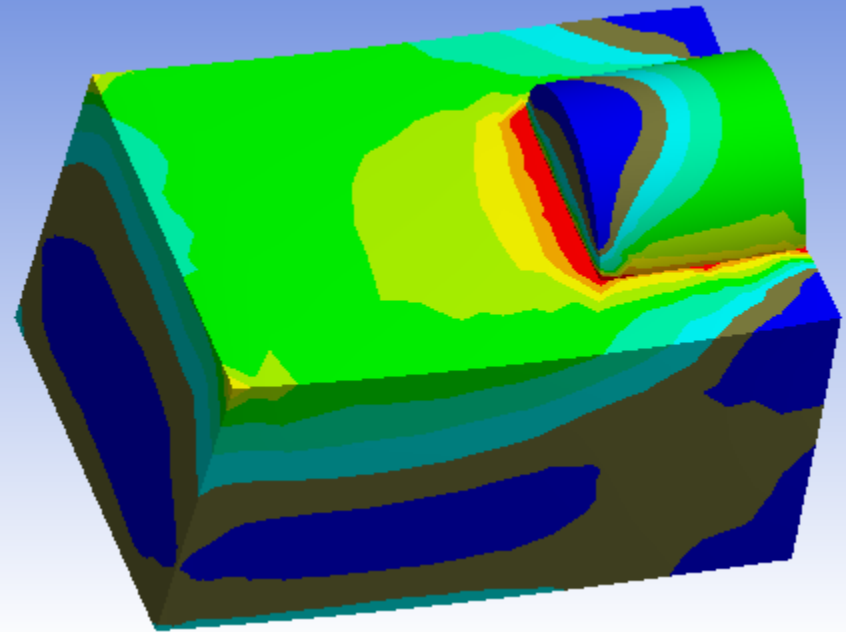
Contour 控制

- 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

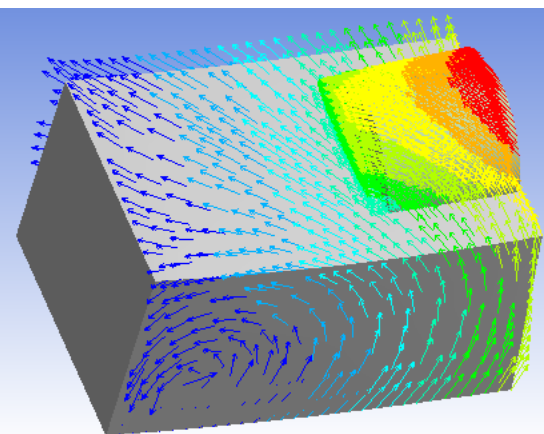
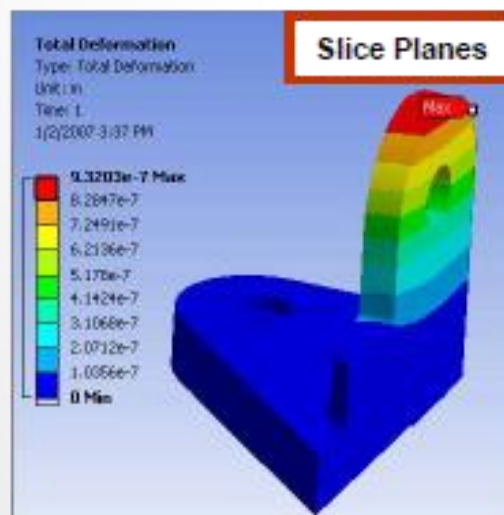
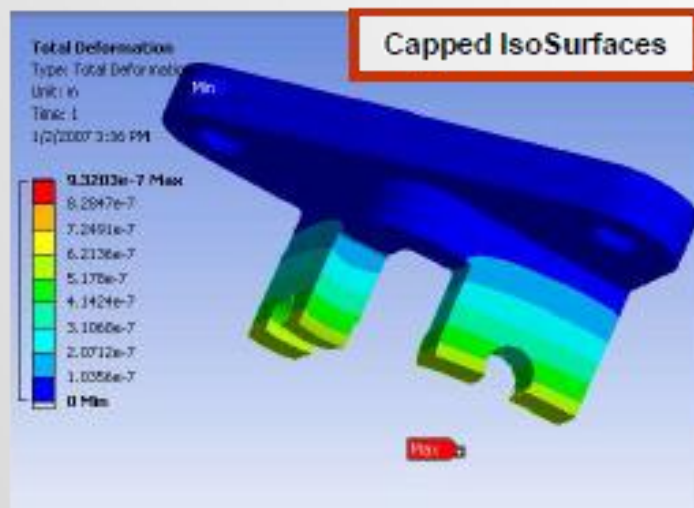
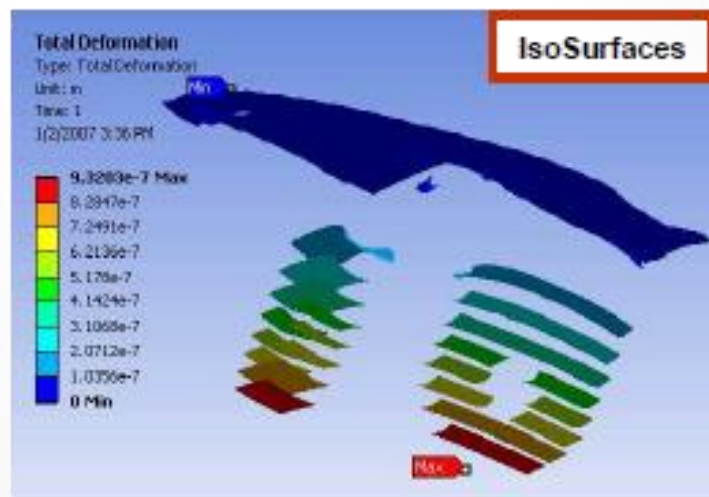
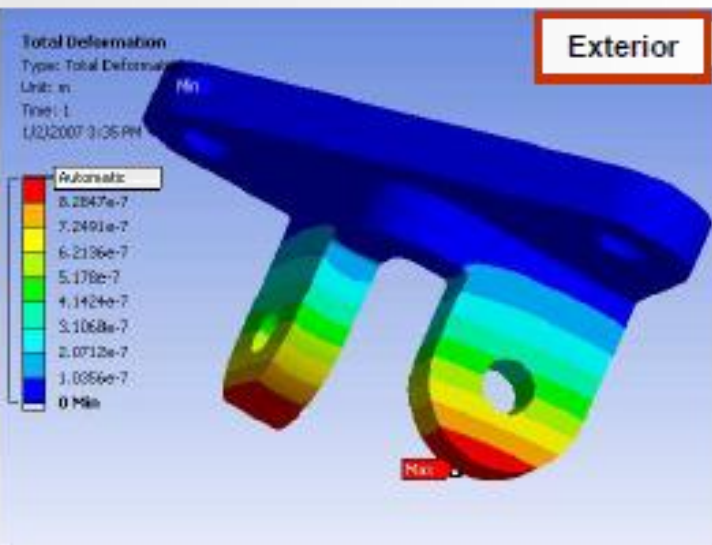


A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
2014/6/5 上午 02:45

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

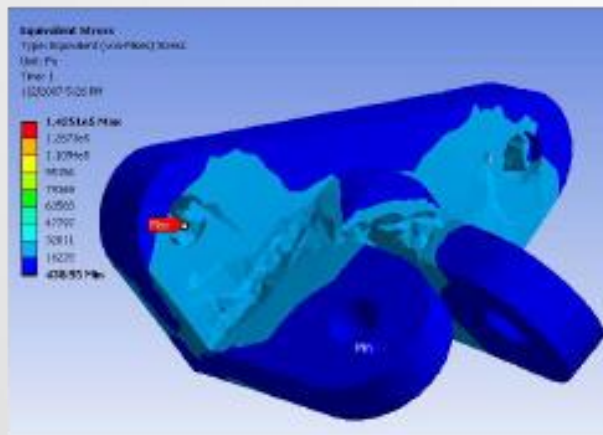


結果顯示方式

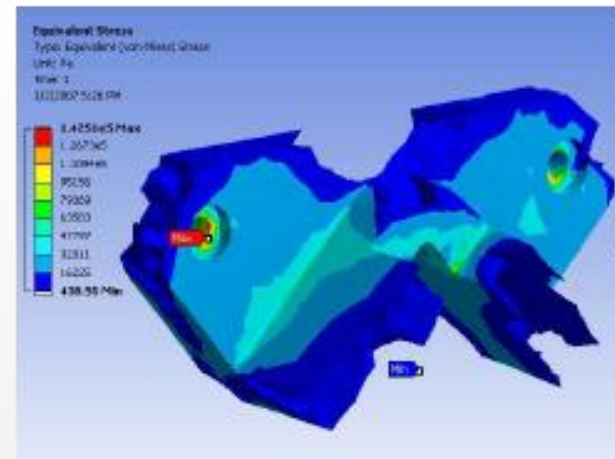


Capped ISO surface

- 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

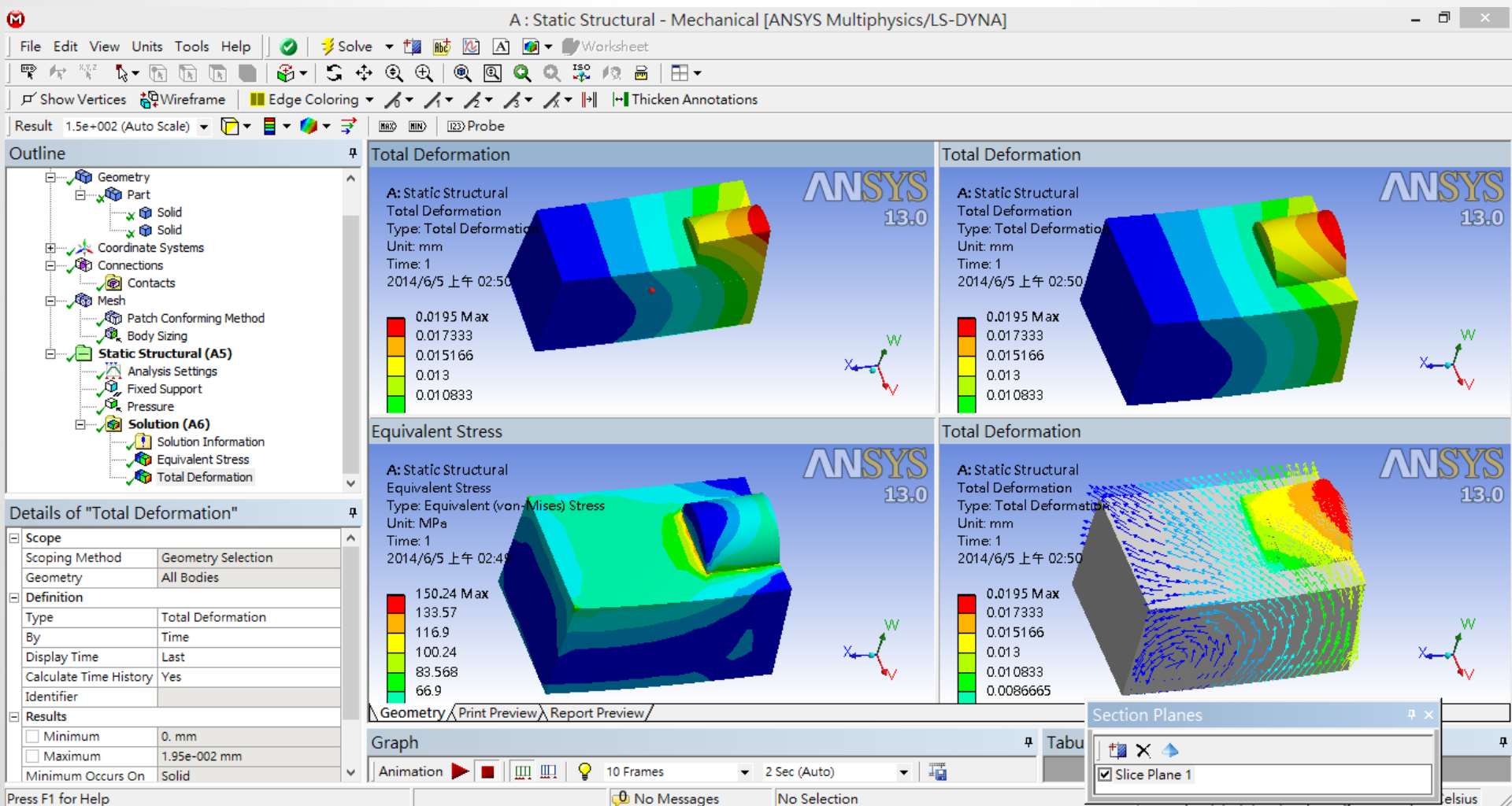


顶部封顶等值面

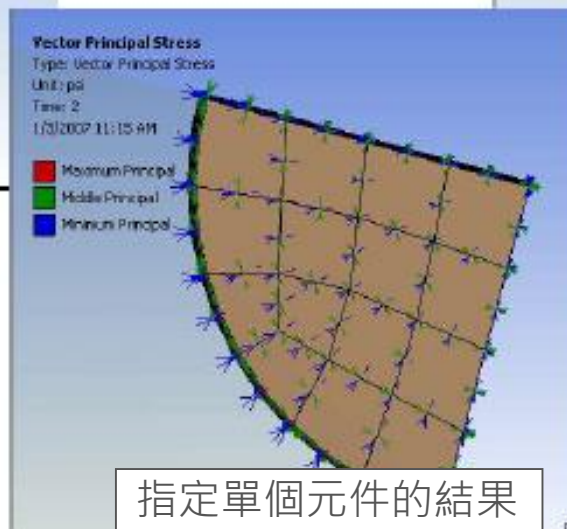
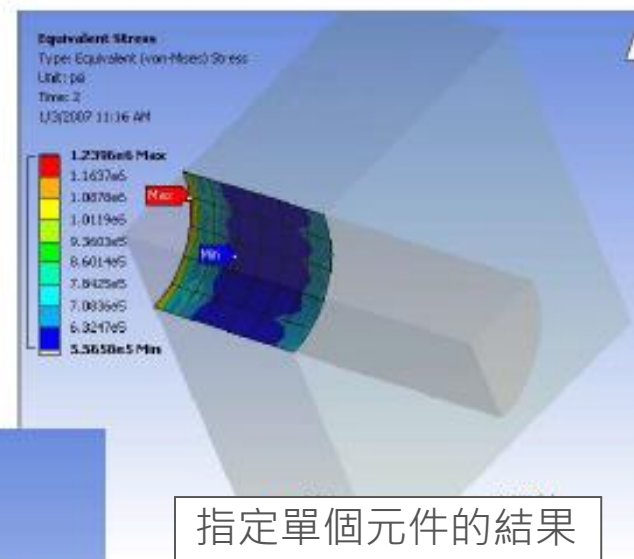
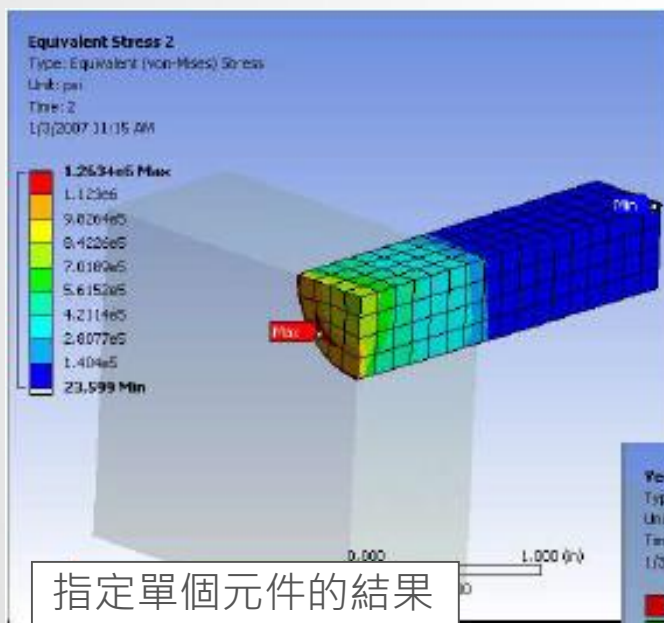


底部封顶等值面

多觀察視窗

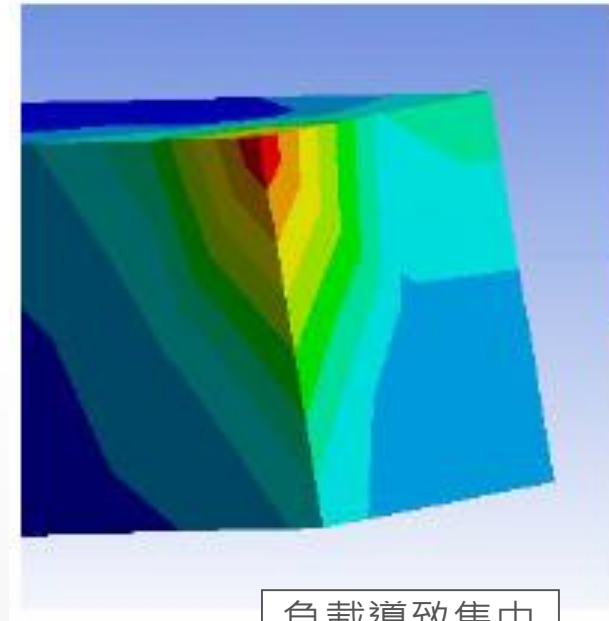


指定元件觀察結果



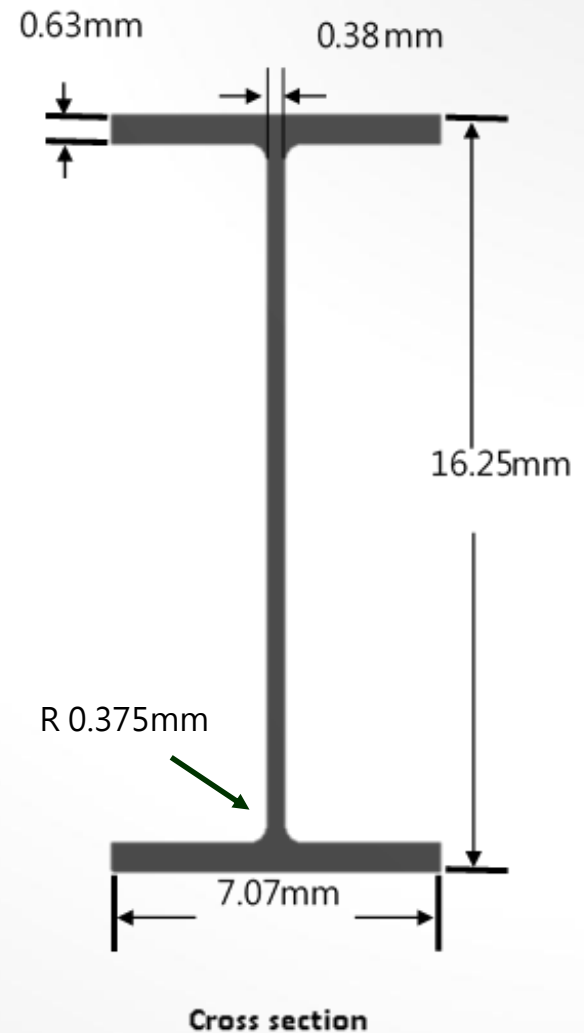
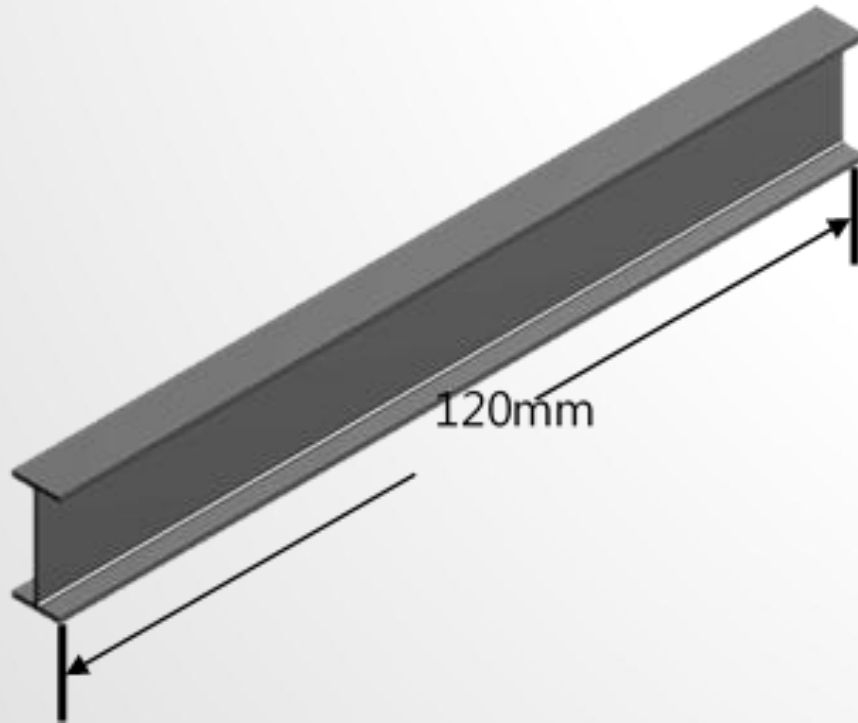
應力奇異點

- 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 10 CAE-3 (來源：成功大學李輝煌教授)

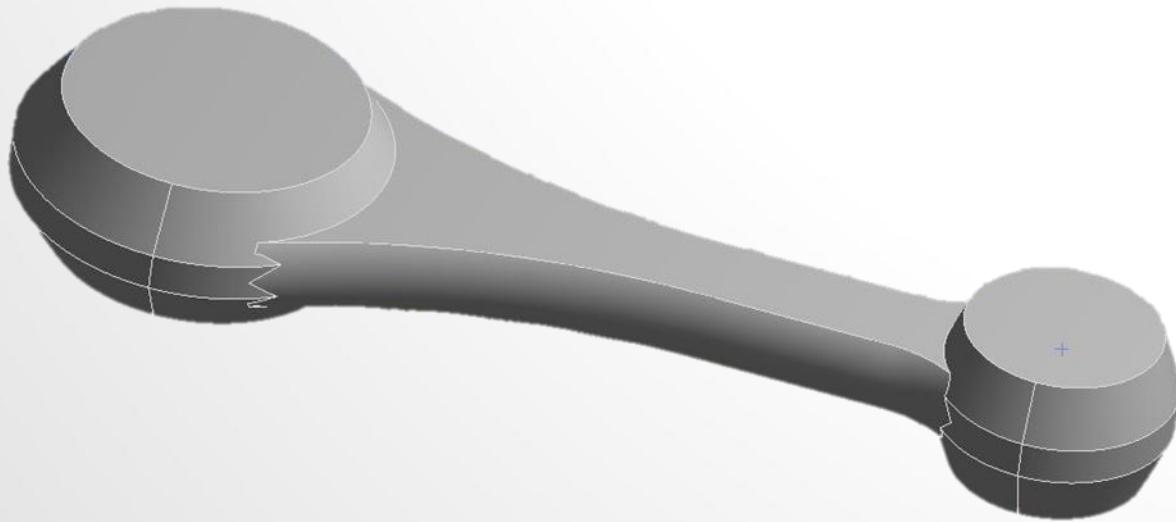
- 於樑一端進行固定，另一端施予一壓力 100MPa。觀察其等效應力及位移量變化。
材料特性：楊氏係數：110000 MPa，浦松比：0.3



Exercise 11 CAE- 4

(來源：ANSYS Workbench 有限元分析從入門到精通)

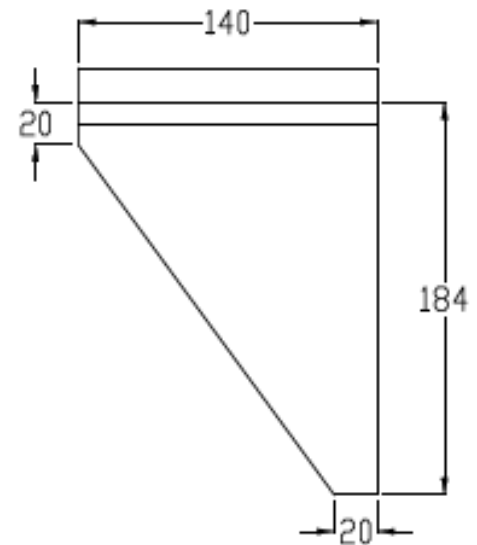
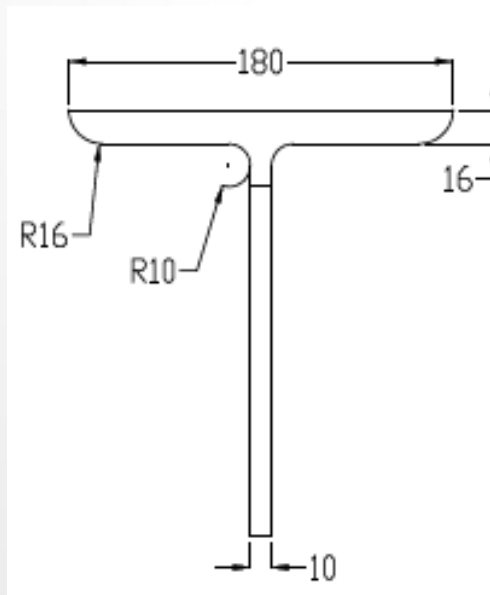
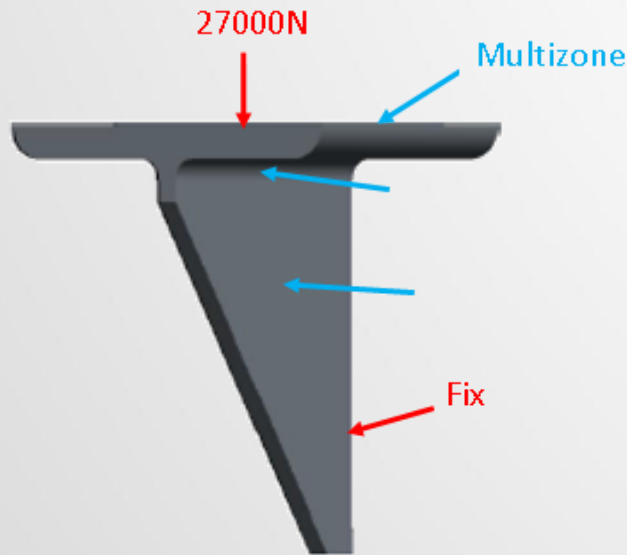
連桿基體模型由外部導入，ELEMENT SIZE為10，於兩大圓面積進行固定，另一端施予一外力1000N。觀察其等效應力及位移量變化。材料特性：灰鑄鐵(GRAY CAST IRON)



Exercise 12 CAE- 5-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)



(來源：ANSYS Workbench 有限元分析從入門到精通)

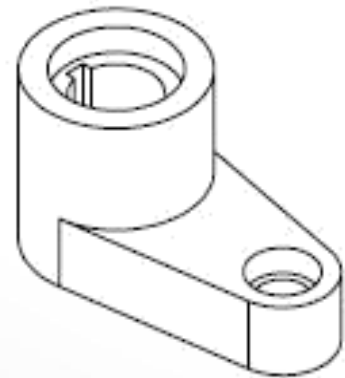
Technical drawing of a mechanical part, showing front and top views with dimensions.

Front View (Top):

- Overall width: 10
- Overall height: 1.5
- Top flange width: 1.5
- Top flange thickness: 4
- Bottom flange width: 1.5
- Bottom flange thickness: 4

Top View (Bottom):

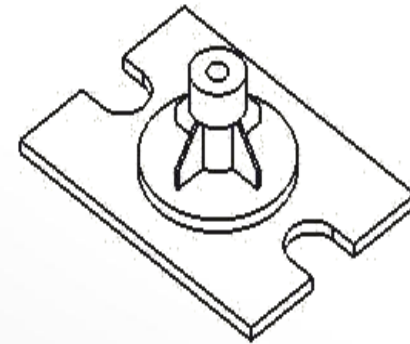
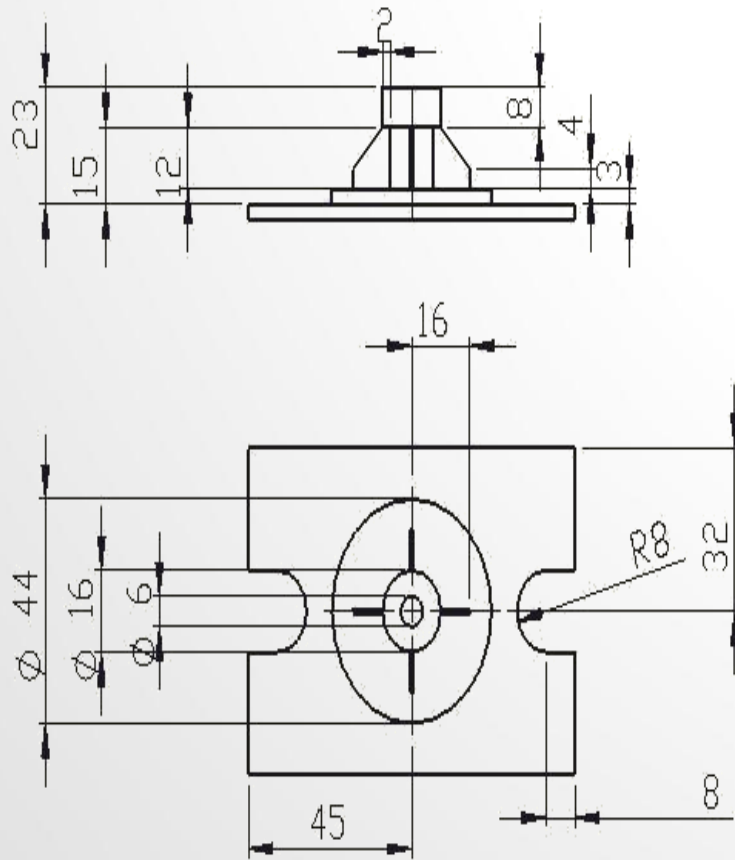
- Overall length: 12
- Overall width: 10
- Inner hole diameter: $\phi 7$
- Outer hole diameter: $\phi 5$
- Distance from center to outer edge: 1.2
- Distance from center to inner hole: 3
- Radius of fillet: $R3$
- Distance from center to outer edge (right): $\phi 3$
- Distance from center to outer edge (right): $\phi 4$



Exercise 14 CAE- 7

(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。



Exercise 8-1 MESH-3

(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)並進行線性與非線性分析比較。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

