

電腦輔助工程設計與實作

-工程圖學

國立陽明大學 生物醫學工程系

林峻立 特聘教授

參考資料：工程圖學：與電腦製圖之關聯(第六版)

(康鳳梅 朱鳳傳 楊永然 王輔春 詹世良, 全華圖書)

本講義資料部分來自於上述文獻，僅作教學使用，請同學勿作其他商業用途並尊重版權

工程圖學綱要

Chapter 1 工程圖學概論

Chapter 2 投影及正視圖

Chapter 3 剖視圖

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Chapter 1 工程圖學概論

- 工程係一種應用科學，為一切工業建設所需知識與實際經驗之融合。其作業過程乃藉圖以表達，此圖謂之工程圖。
- 工程圖為工程師、設計者以及各級工程人員所用之圖解文字，亦即為共同之圖畫語言。
- 以線條與符號等來表達及紀錄機械設計及製造或結構建築等所必須之觀念與資料。所以工程圖對物體實質之描述必須完整及確實。
- 視圖用以表示其形狀，尺度標註用以表示其大小，而文字符號則完成各種說明，其表達之方法均有一定之規範，為大家共同遵守之準則。

1-1 概論

牙齒切片觀測試驗 Interface observation



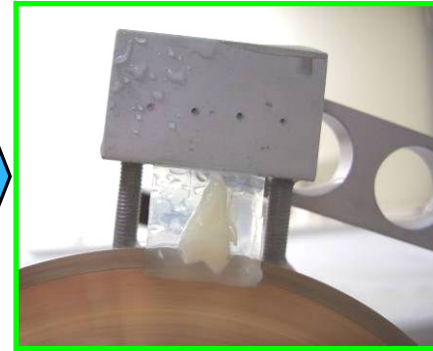
Intact premolar



Embedding



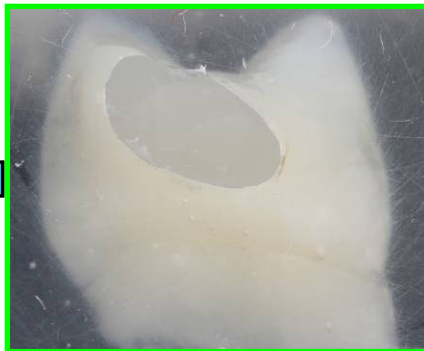
Embedding



Section



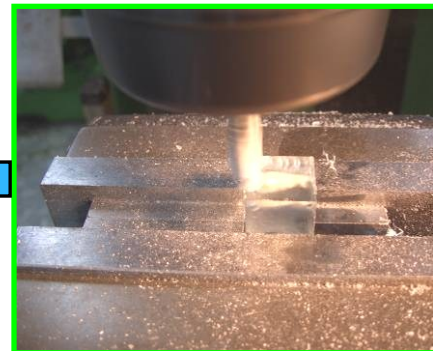
SEM observation



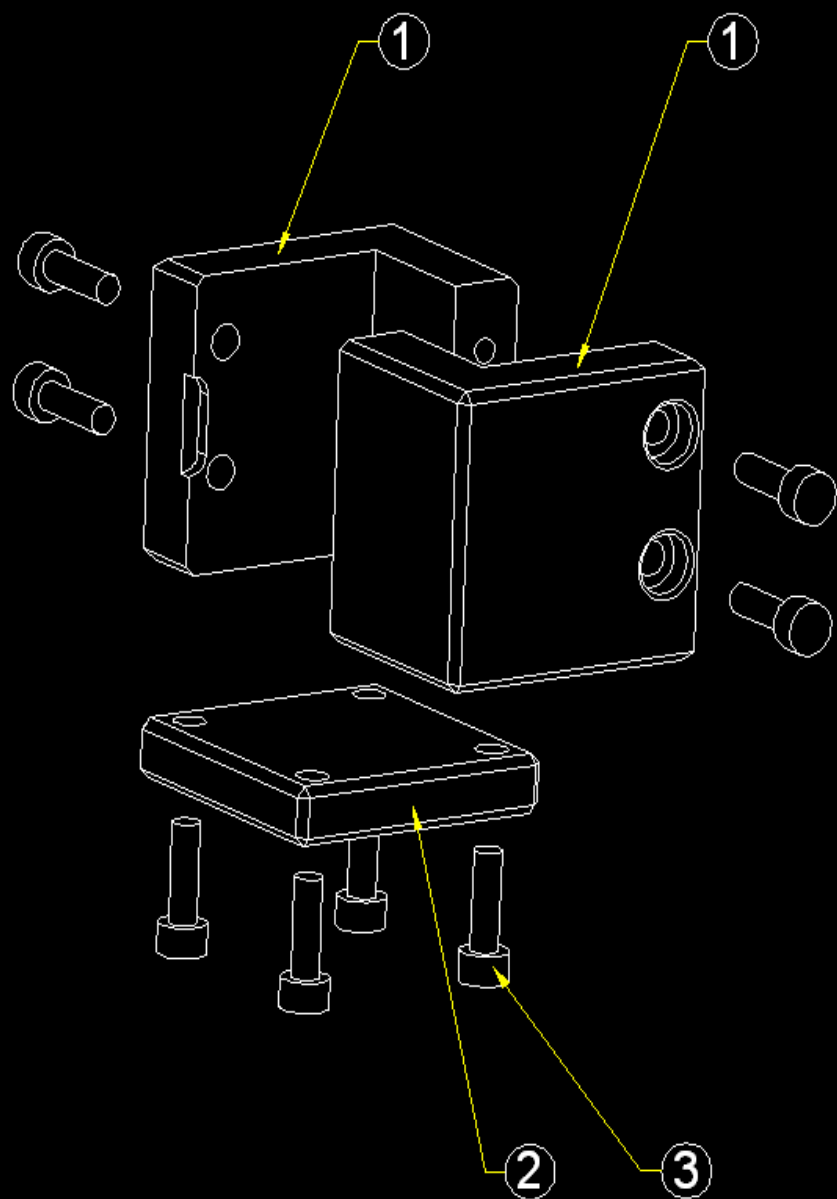
Enamel exposition



Grinding



Milling



3	M3螺絲長8	8	
2	底 座	1	
1	本 體	2	
件號	名 稱	數量	
系統名	90度包埋模具		
設計者	劉恒良	單位	mm
件號	---	比例	---
圖名	爆炸圖		

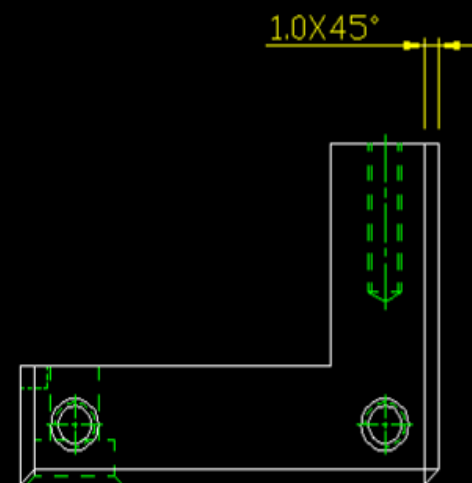
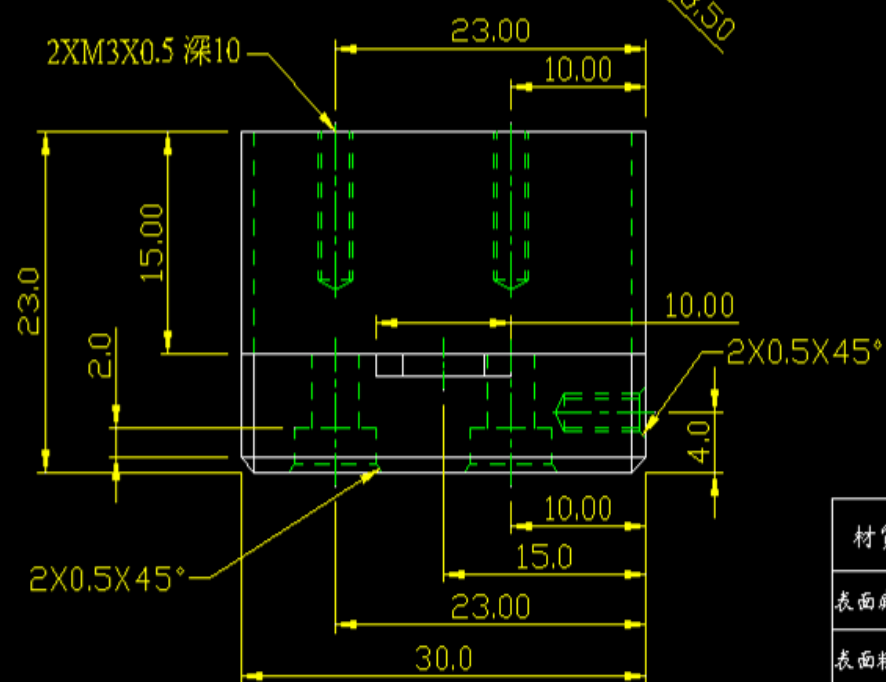
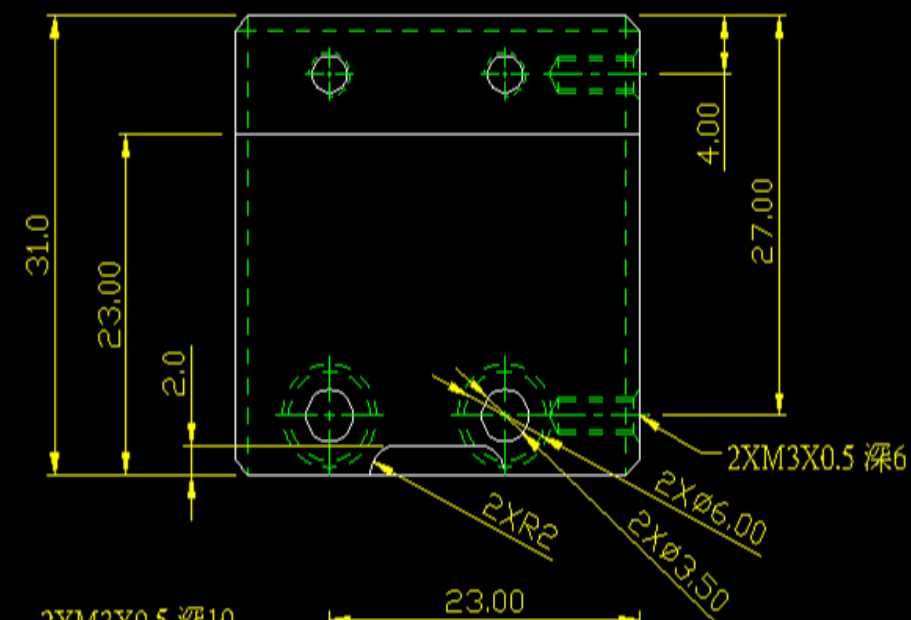
A

B

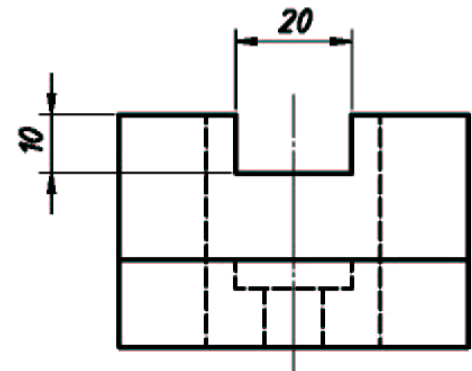
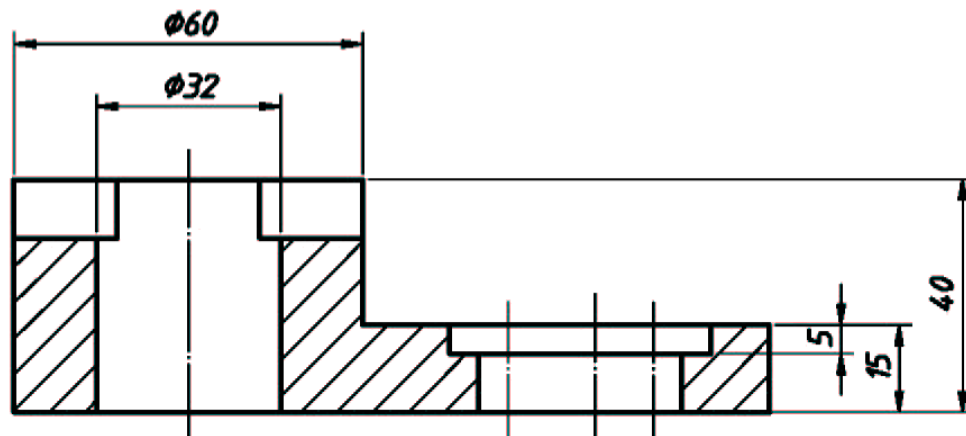
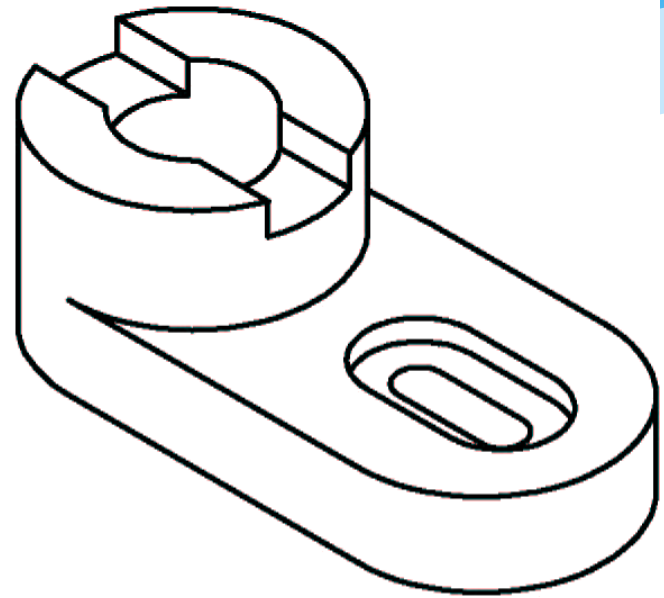
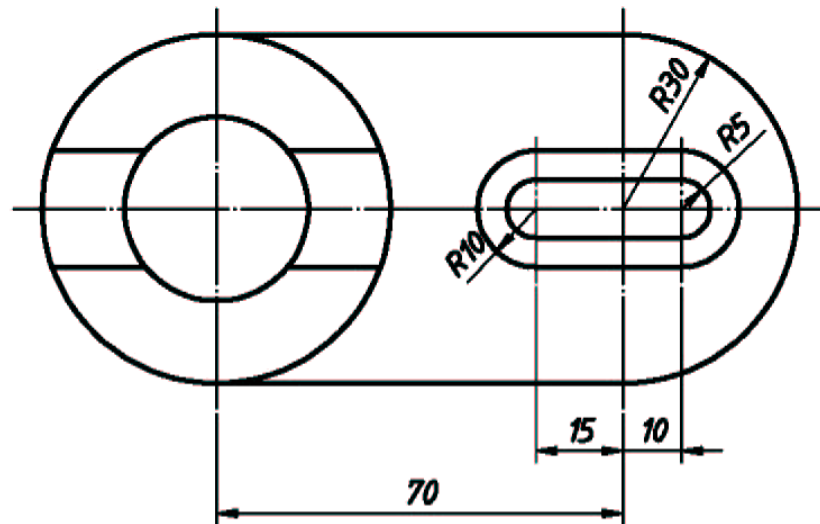
C

D

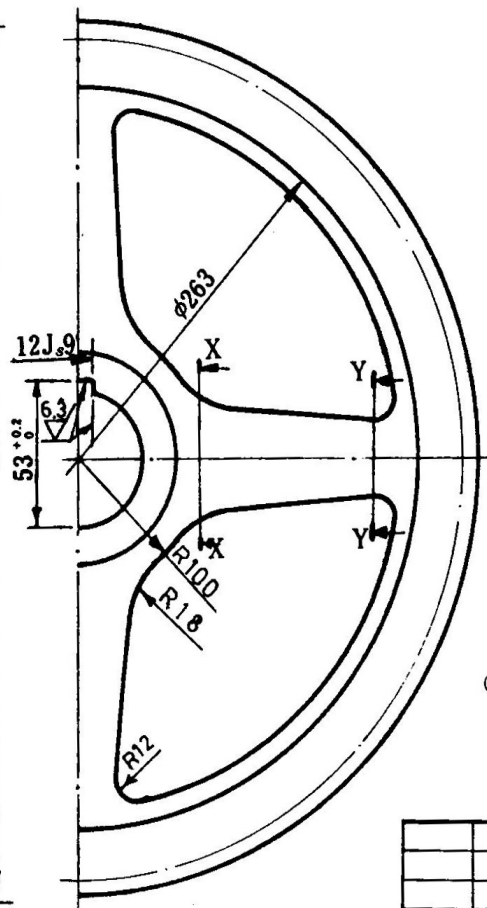
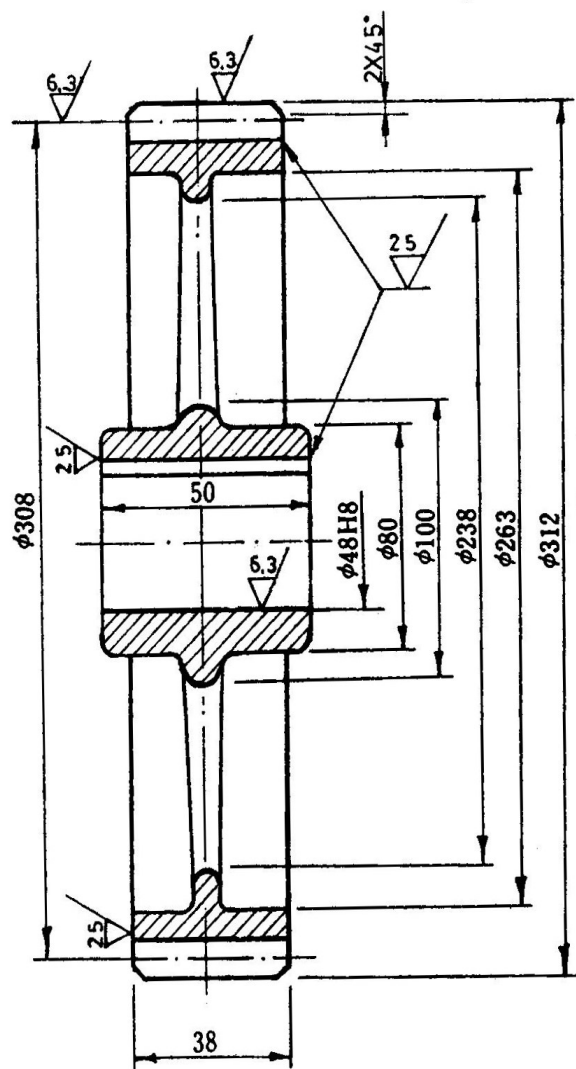
E



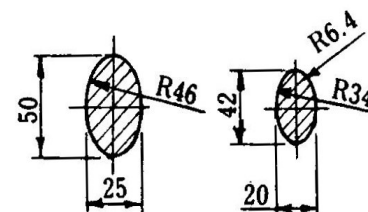
材質	鋁合金	尺寸	公差	系統名	90度包埋模具		
表面處理	--	整數	± 0.15	設計者	劉恒良	單位	mm
表面粗度	--	.X	± 0.10	件號	1	比例	2:1
熱處理	--	.XX	± 0.05	圖名	本體		
硬度	--	角度	± 2°	長庚大學機械所生醫工程分析實驗室			



302 $\nabla^{12.5/}$ ($\nabla^{25/}$ $\nabla^{6.3/}$)



正 齒 輪		
齒輪齒形	標 準	
工 齒 形	普通齒	
具 模 數	4	
壓 力 角	20°	
齒 數	77	
基準節圓直徑	308	

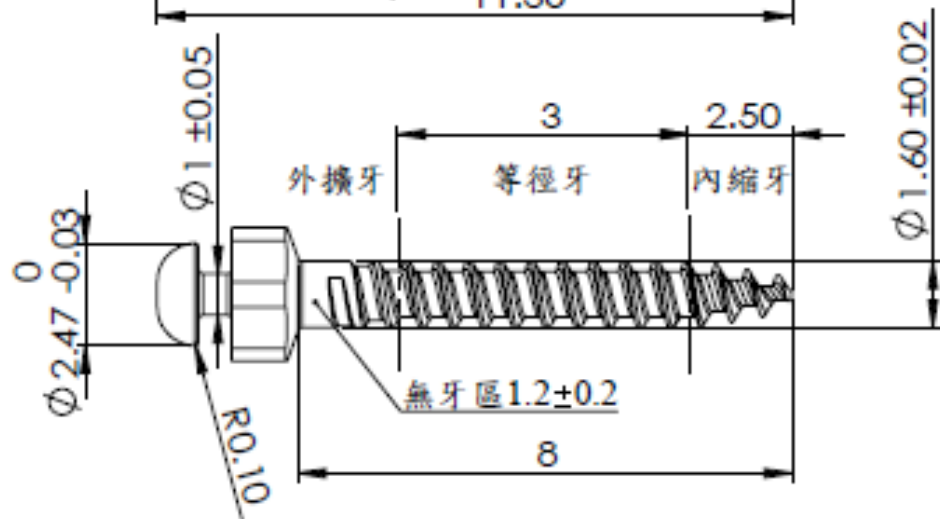
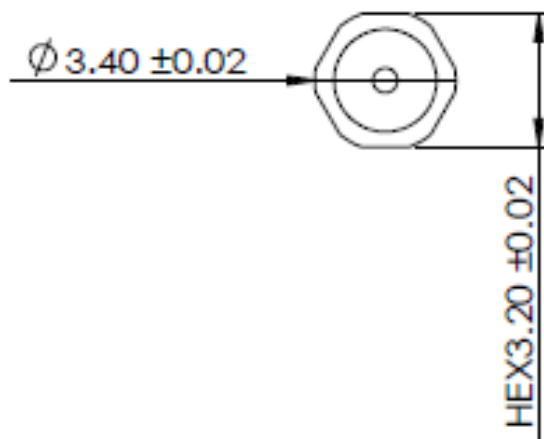
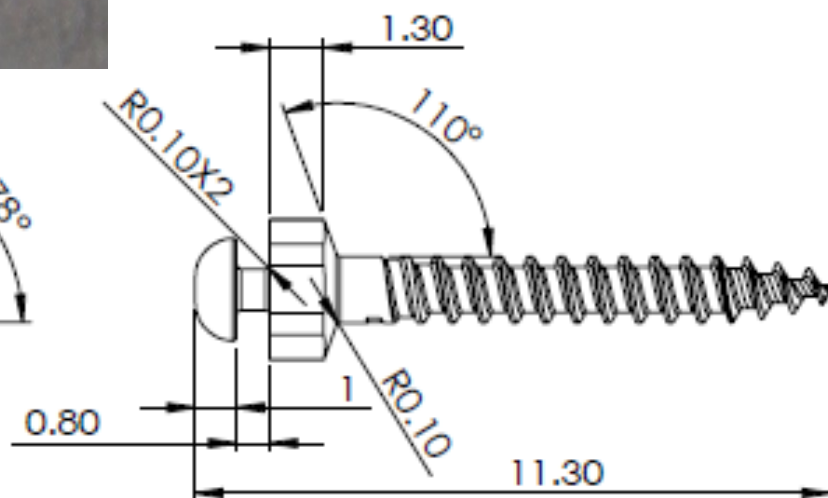
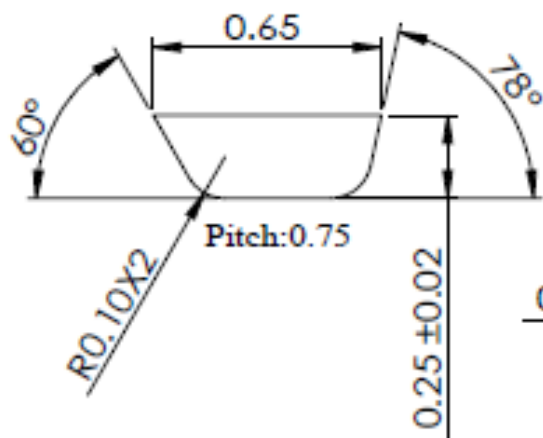


X-X剖面

Y-Y剖面

(註)無特別指定鑄造部之R以R3為之。

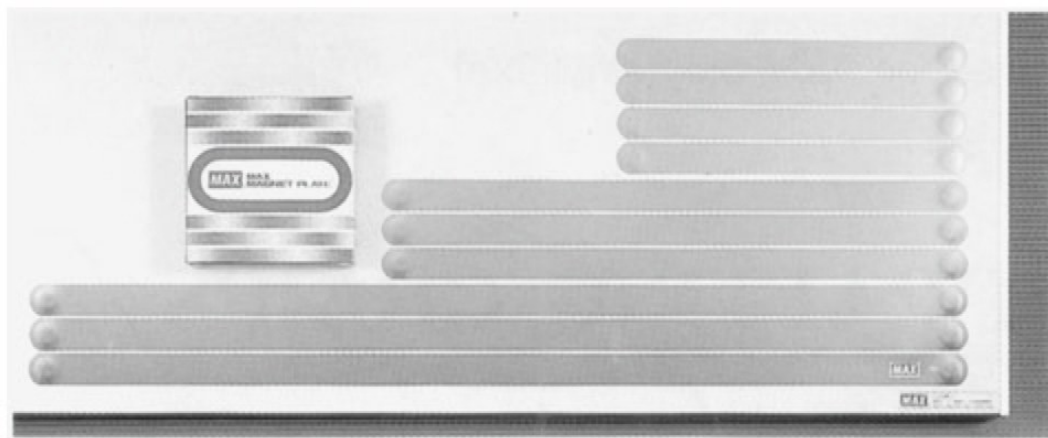
1	中間大齒輪	302	FC20	木機鑄				
件數	名 稱	件號	標準件號	材料	工程	備 註		
設計	日期	姓 名	機 構 名 稱					
繪圖								
描圖								
校核								
審定								
比例: 1/2.5		圖 名	電動絞車零件圖			圖 號	PW-2004	
第三角							8	



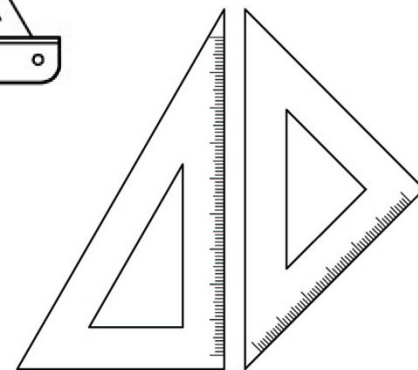
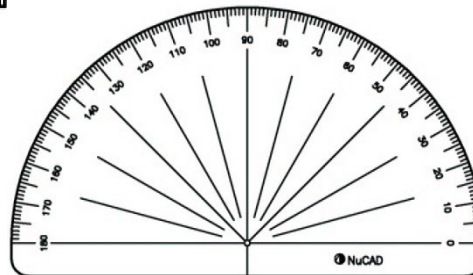
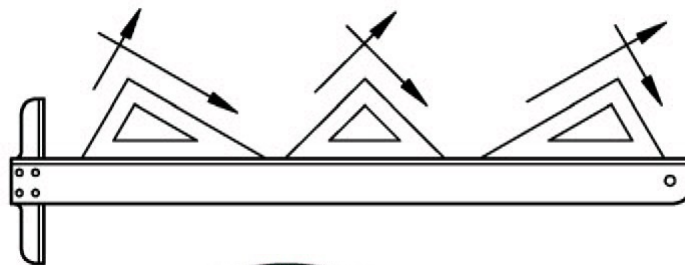
1-2 傳統製圖用具介紹



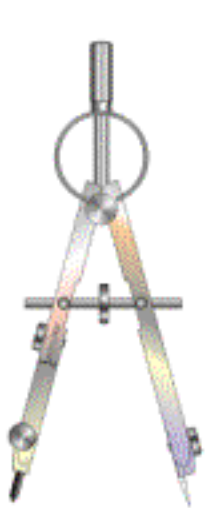
整套之製圖設備



附壓條之製圖板



1-2 傳統製圖用具介紹



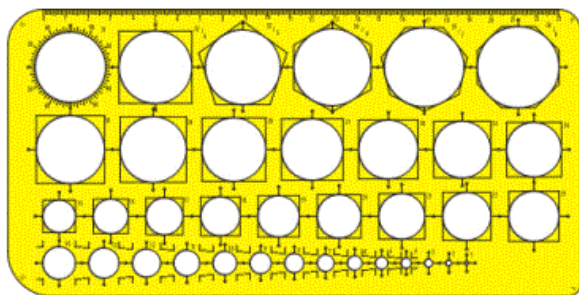
彈簧圓規



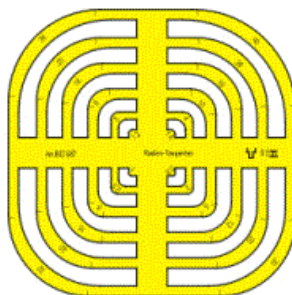
普通圓規



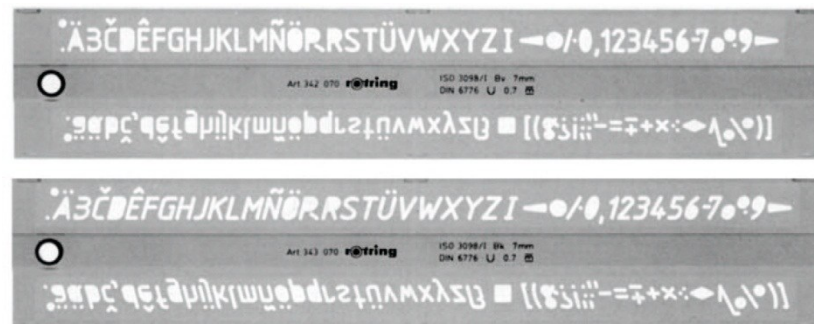
速調圓規



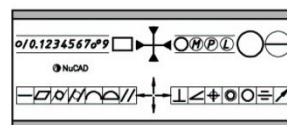
圓模板



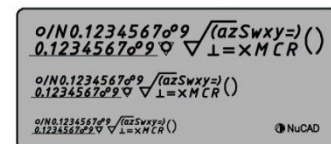
圓弧切線模板



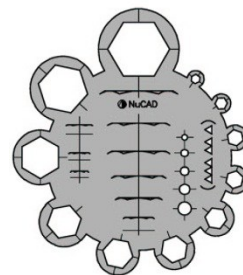
字規



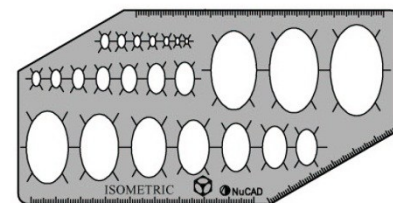
(a)幾何公差符號板



(b)表面符號板



(c)六角螺帽板



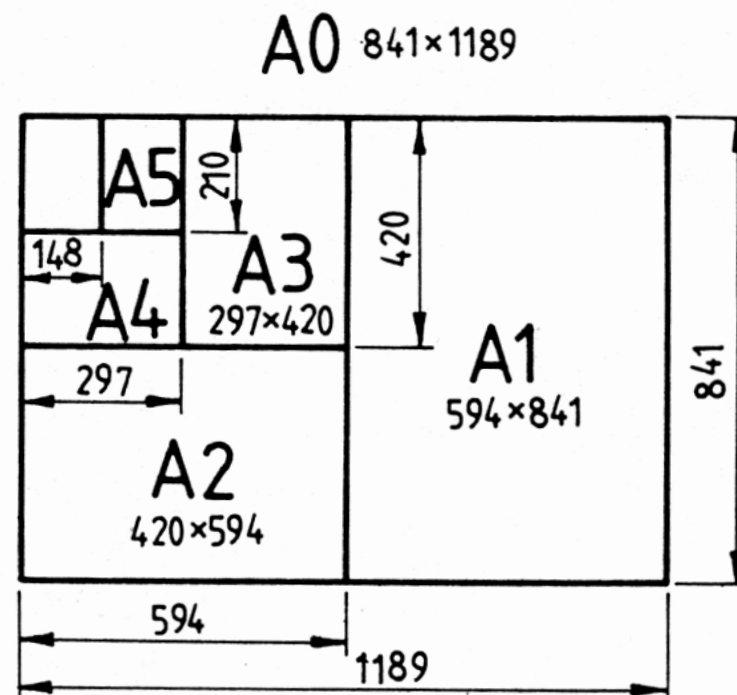
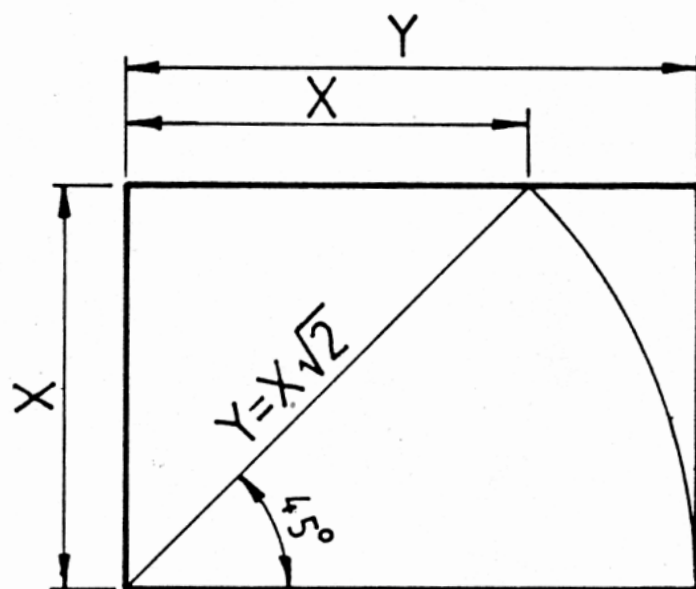
(d)等角圖用橢圓板

常用的模板

1-2 傳統製圖用具介紹

單位：mm

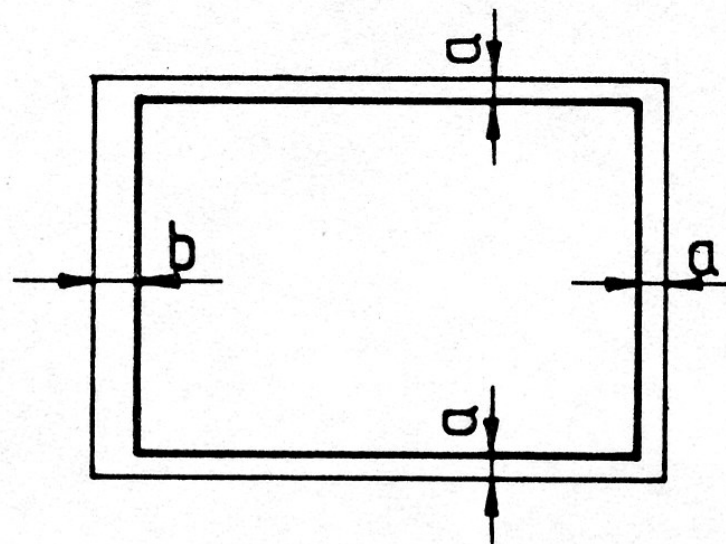
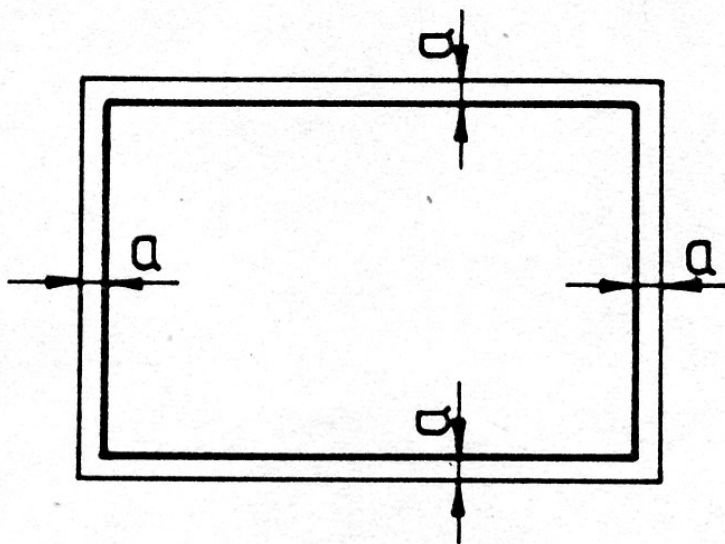
格式	A0	A1	A2	A3	A4	A5
尺度	841 × 1189	594 × 841	420 × 594	297 × 420	210 × 297	148 × 210



1-2 傳統製圖用具介紹

單位：mm

格 式	A0	A1	A2	A3	A4	A5
a	15	15	15	10	10	5
b	25	25	25	25	25	25



(a)不裝訂者

(b)需裝訂成冊者

1-2 傳統製圖用具介紹

標題

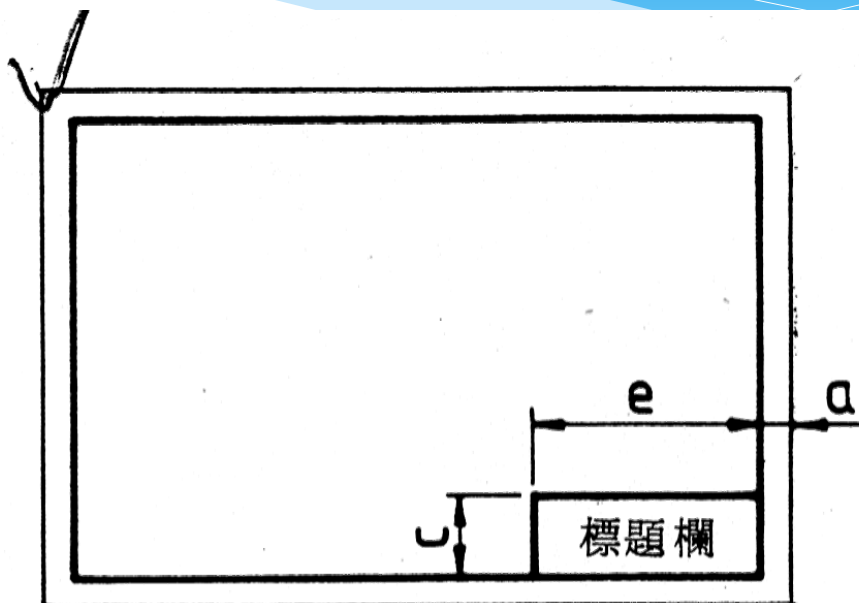
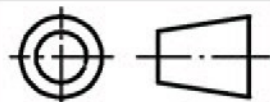


圖 紙 大 小	A0, A1, A2, A3, A4	A5
標題欄大小 (c×e)	55×175	18×175

	日期	姓 名	(機 構 名 稱)
設 計			
繪 圖			
描 圖			
校 核			
審 定			
比 例			((圖 名)
		(圖 號) 14	

1-2 傳統製圖用具介紹

件 號	圖 名			圖 號	數 量	材 料	備 註
單 位	mm	數 量	1	比 例	1 : 1		
材 料	FC15	日 期	Sep. 28, 1997				
班 級	M1	座 號	0	大同工學院			課 程
姓 名	Adam Smith			圖 名	底 座	圖 號	M100-1
教 師							
得 分							

學校單位標題欄範例

1-2 傳統製圖用具介紹

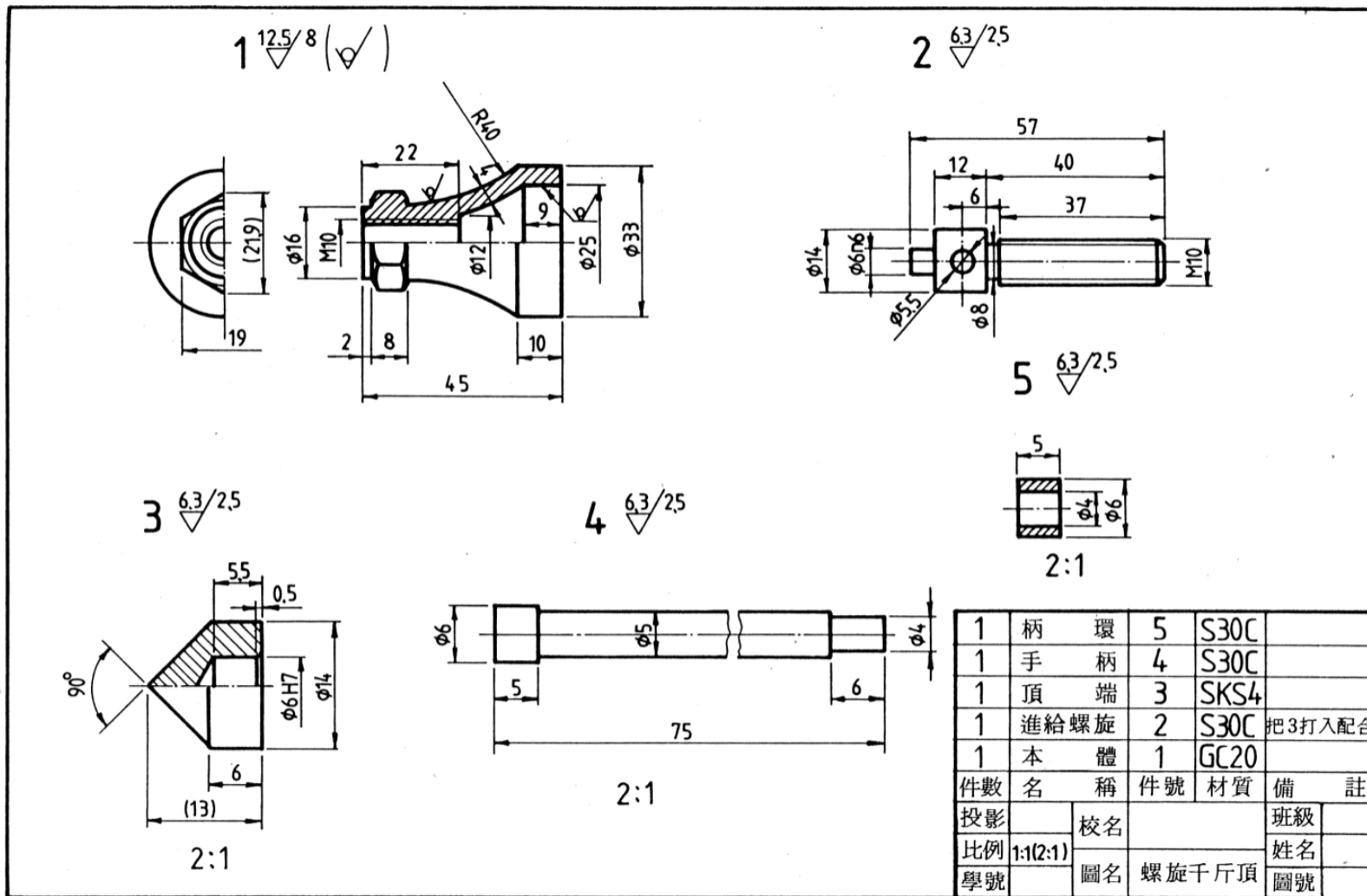
尺度單位：mm

比例：盡可能使用 1:1

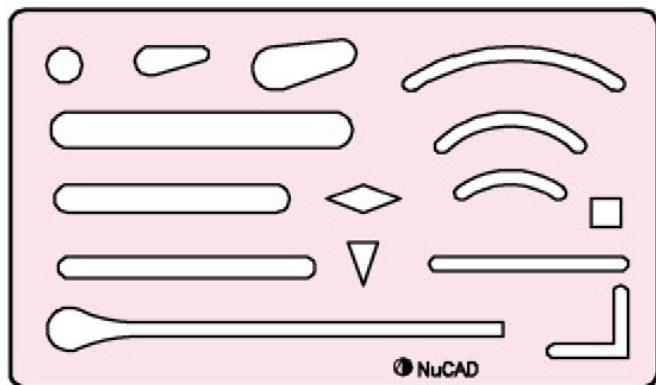
規格 比例尺	CNS 工程製圖
常用比例	以 2 , 5 , 10 倍數的比例為常用者
實大比例	1 : 1
縮小比例	1 : 2 , 1 : 2.5 , 1 : 4 , 1 : 5 , 1 : 10 , 1 : 20 , 1 : 50 , 1 : 100 , 1 : 200 , 1 : 500 , 1 : 1000
放大比例	2 : 1 , 5 : 1 , 10 : 1 , 20 : 1 , 50 : 1 , 100 : 1

1-2 傳統製圖用具介紹

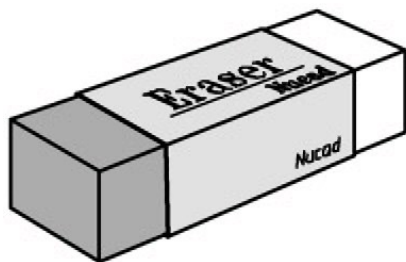
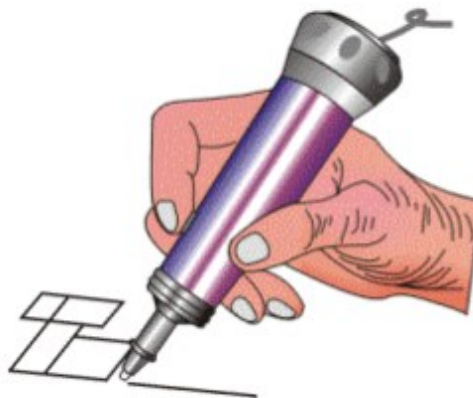
比例標註：全張圖以一種比例為原則，並於標題欄內註明，若



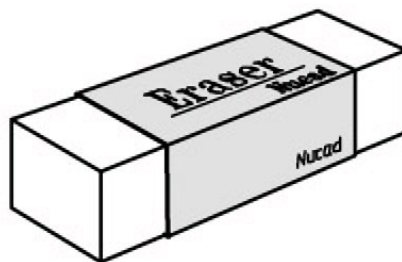
1-2 傳統製圖用具介紹



消字板

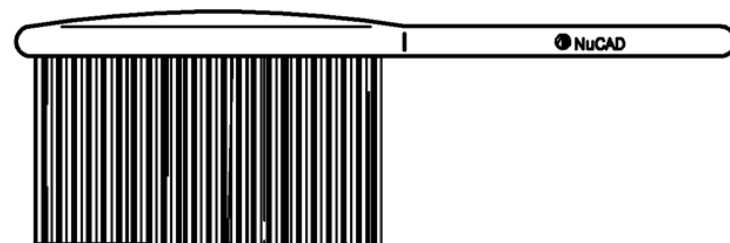


(a) 墨線及鉛筆線用



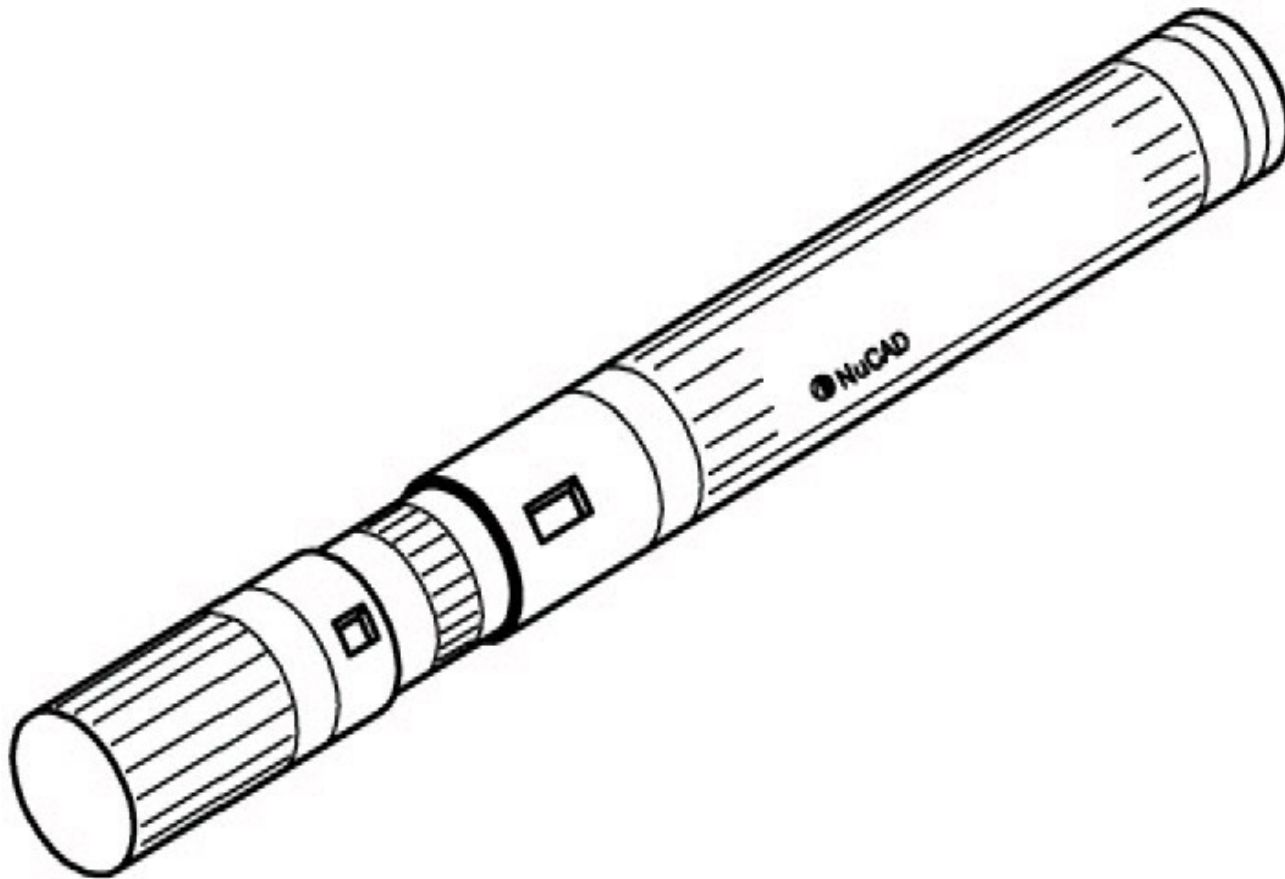
(b) 鉛筆線用

橡皮擦

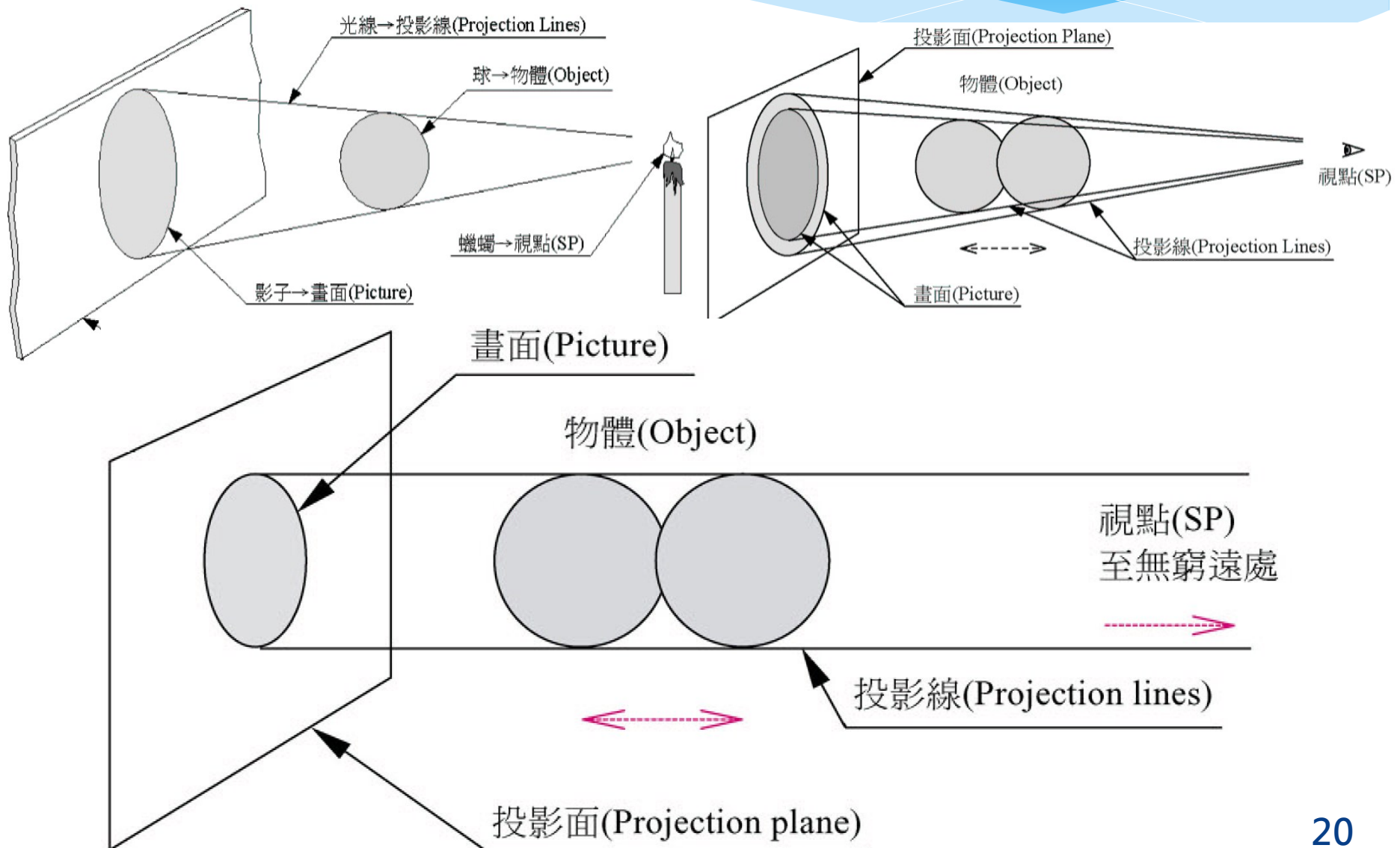


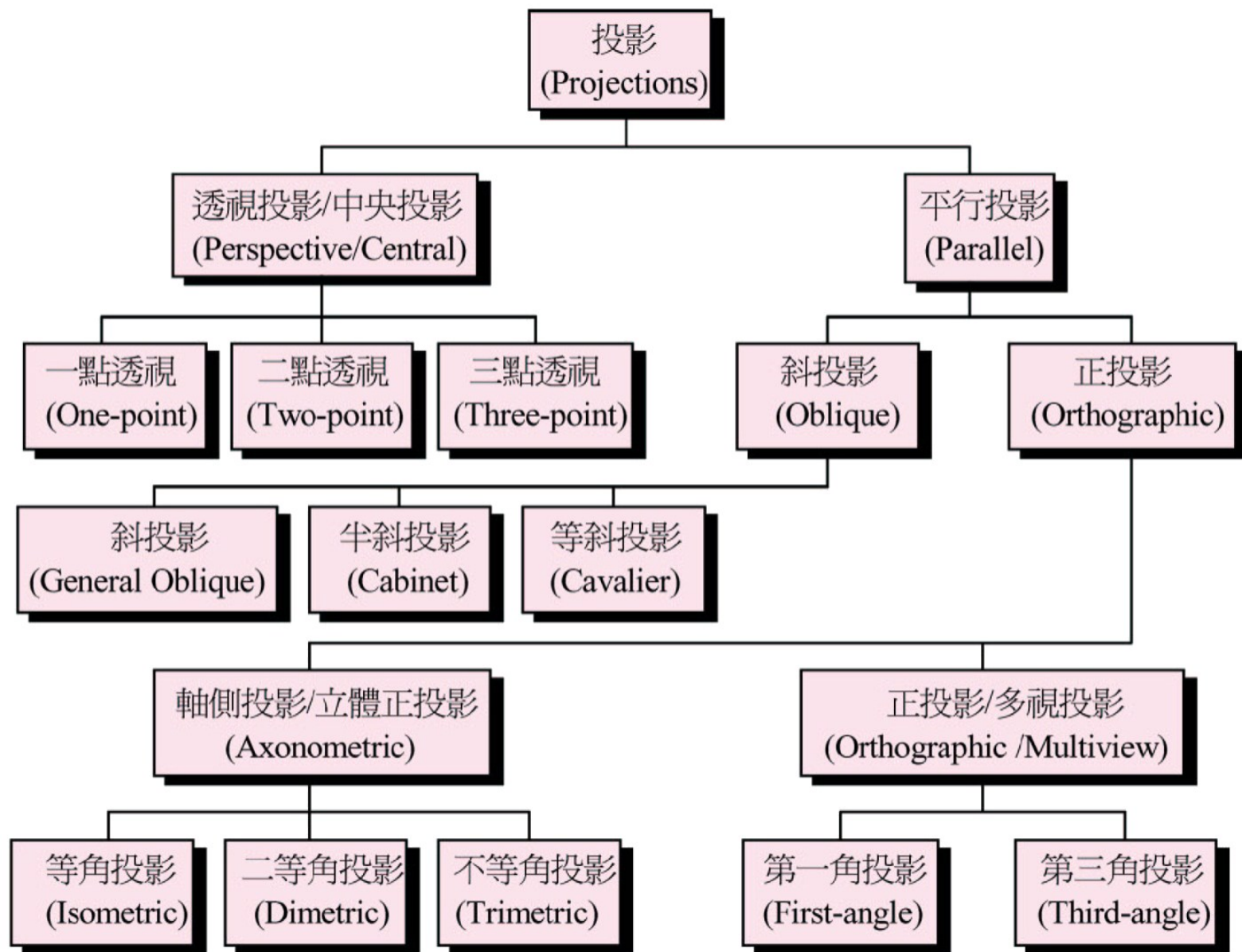
清潔毛刷

1-2 傳統製圖用具介紹



Chapter 2 投影及正視圖-投影





2-1 投影

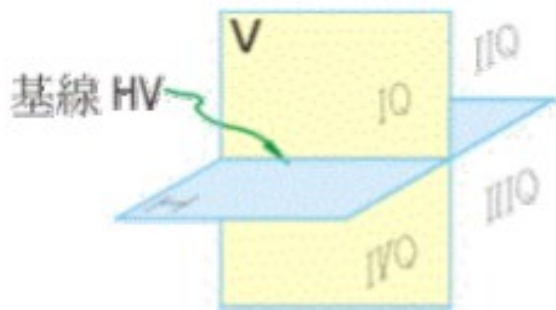
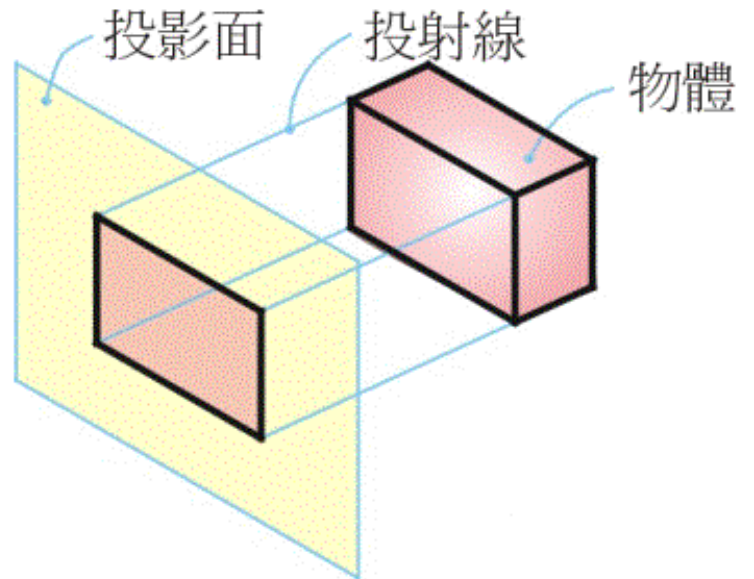
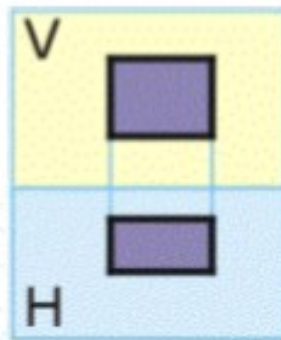
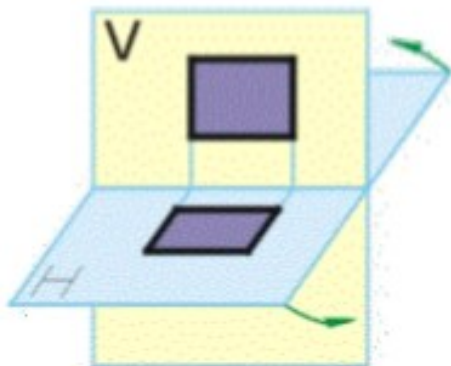
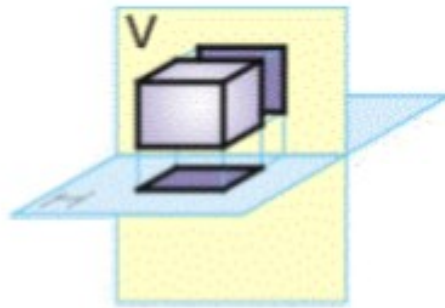


圖5-4 四個象限



2-1 投影

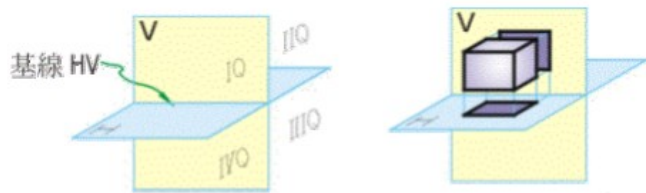
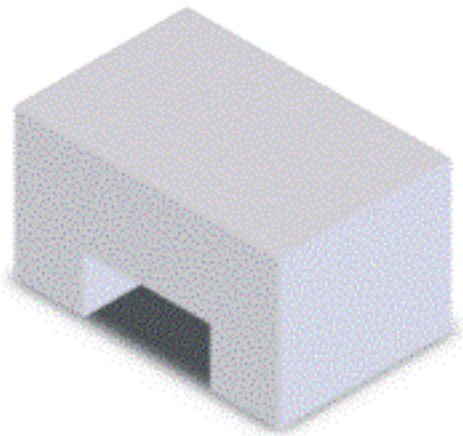
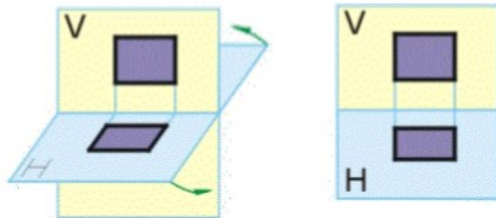
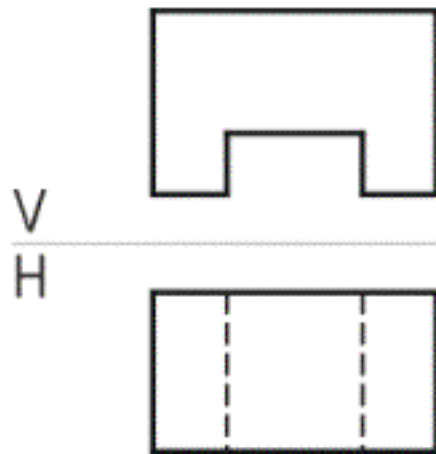


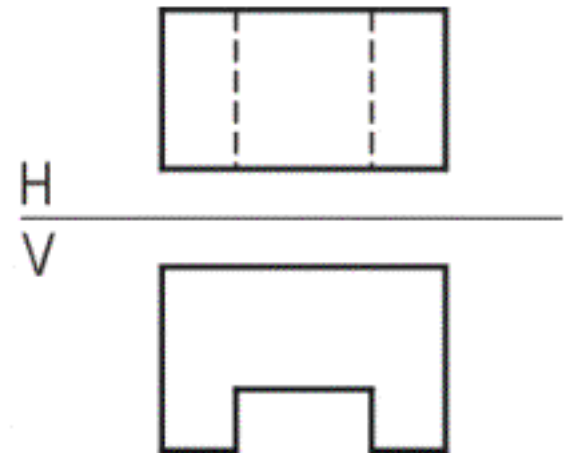
圖5-4 四個象限



角柱



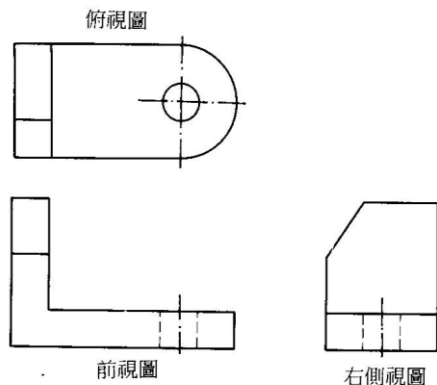
角柱在第一象限之視圖



角柱在第三象限之視圖

2-2 正視圖

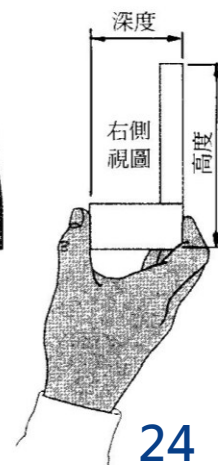
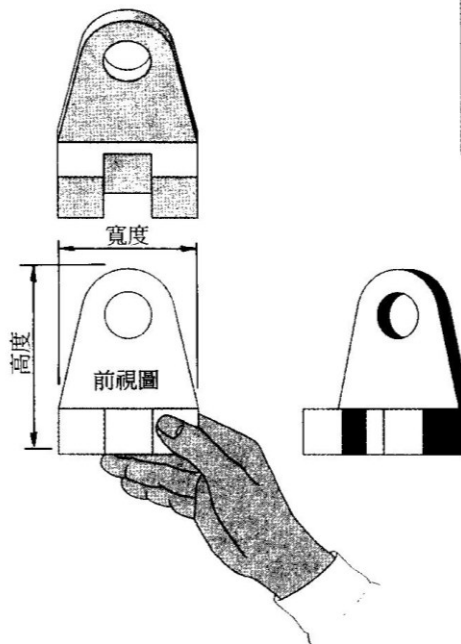
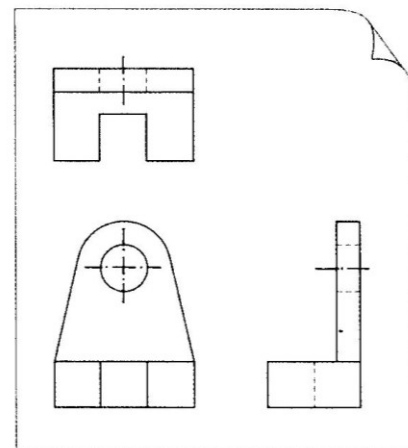
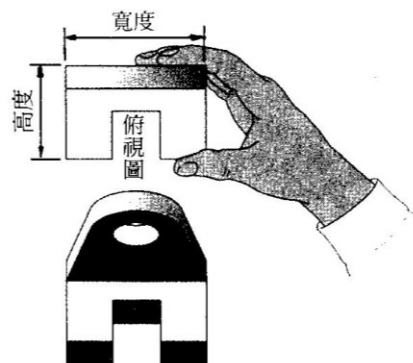
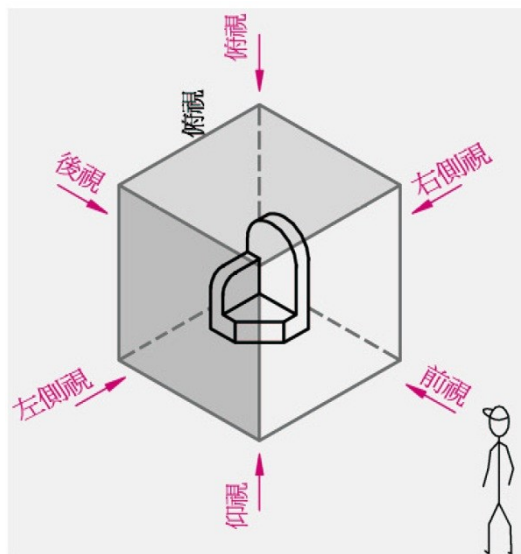
通常以前視圖、俯視圖及右側視圖為正投影的三個主要視圖



寬度 (width)：物體左右方向之距離

高度 (height)：物體上下方向之距離

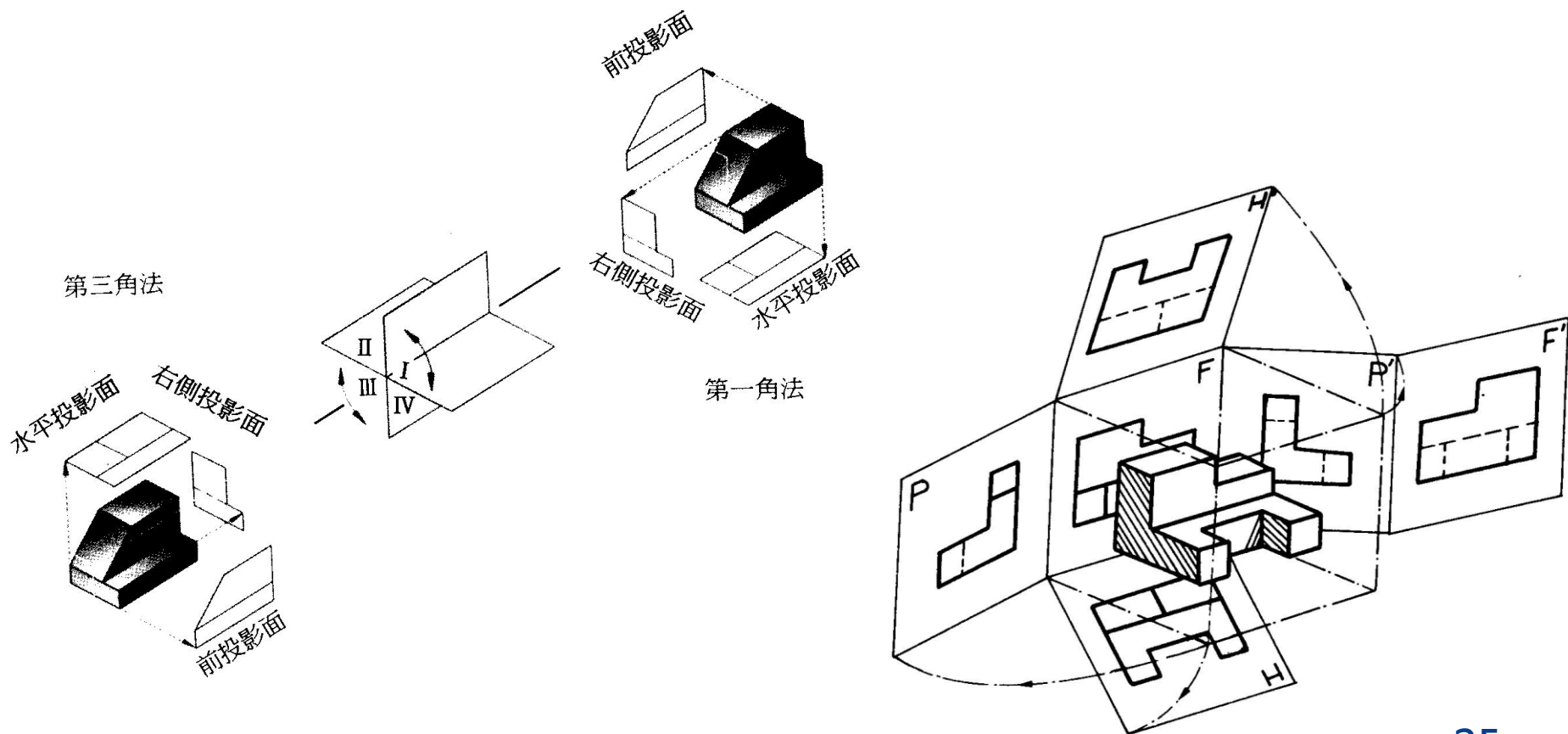
深度 (depth)：物體前後方向之距離



2-2 正視圖

第一角法與第三角法

將物體置於投影箱中可獲得六個投影（視圖），依規定將投影箱展開可獲得六個正投影視圖

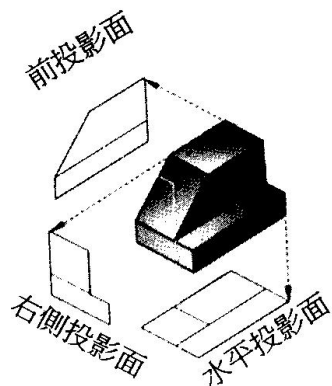
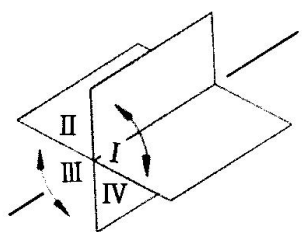
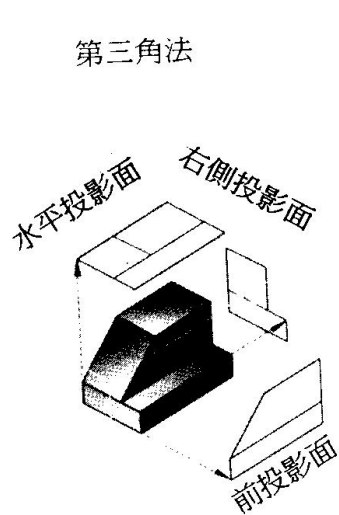


第一角法

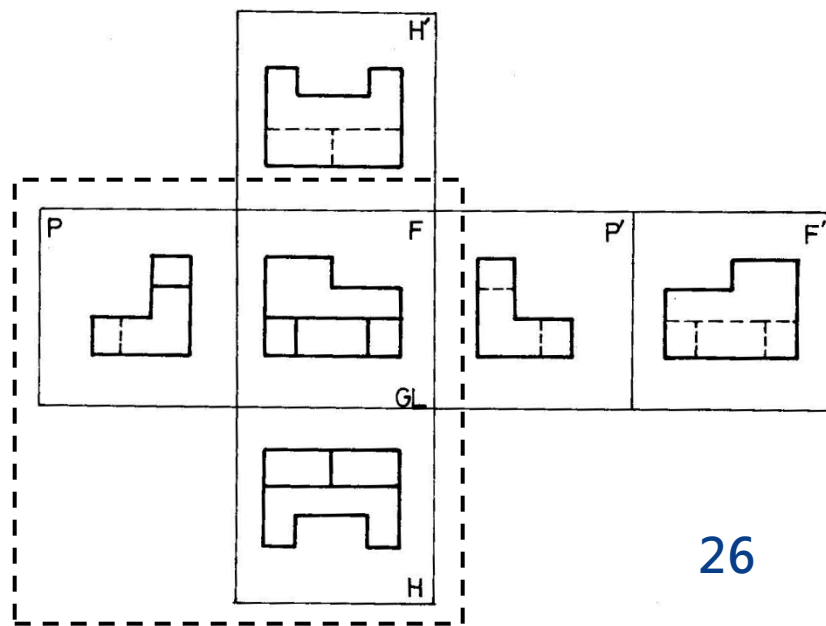
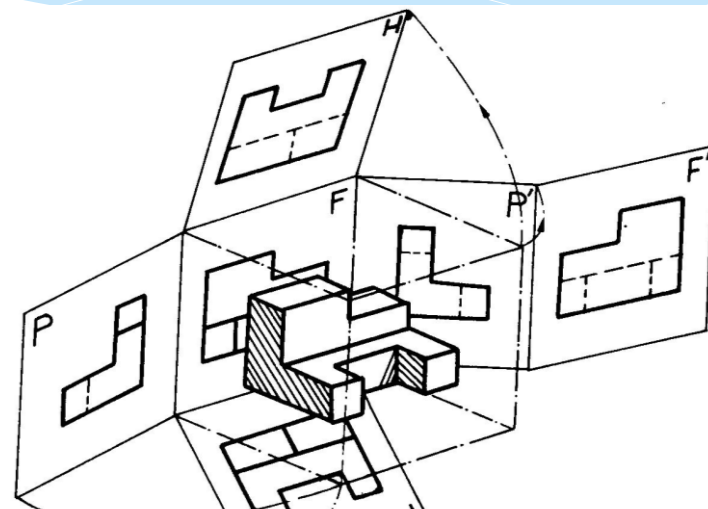
正投影之投影箱位於第一象限

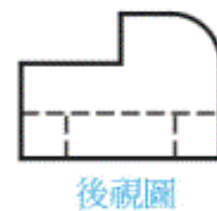
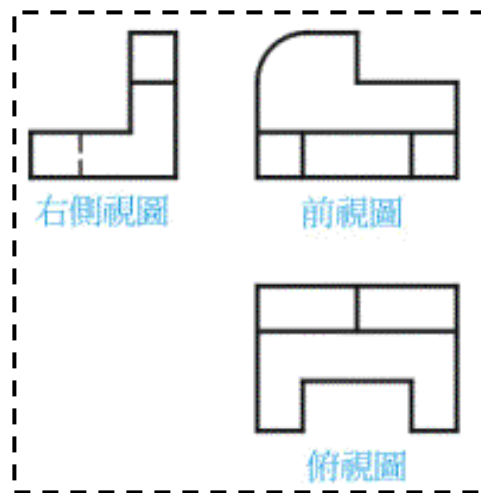
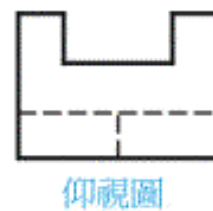
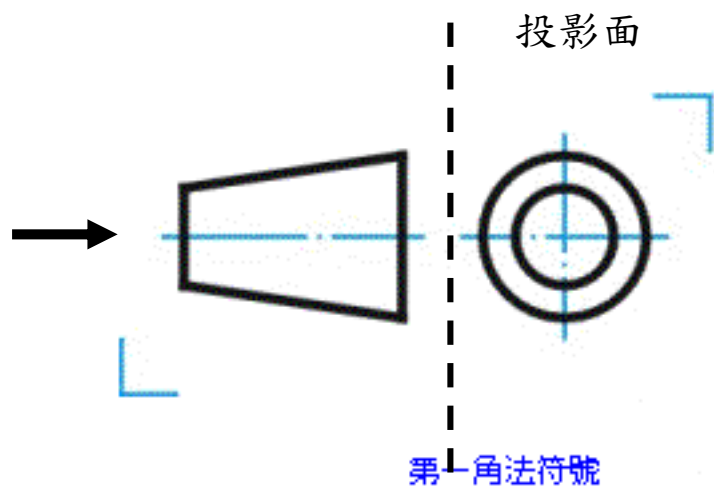
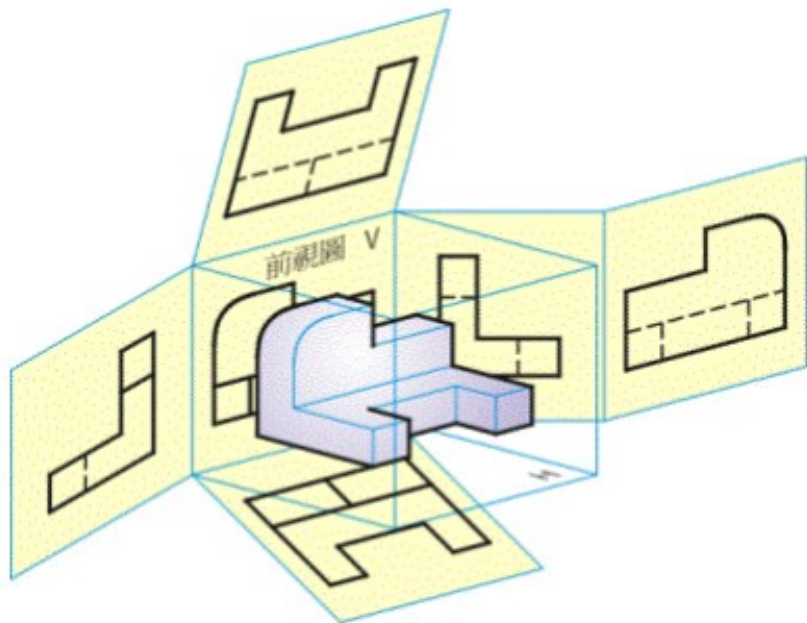
展開後得第一角正投影

第三角法



第一角法

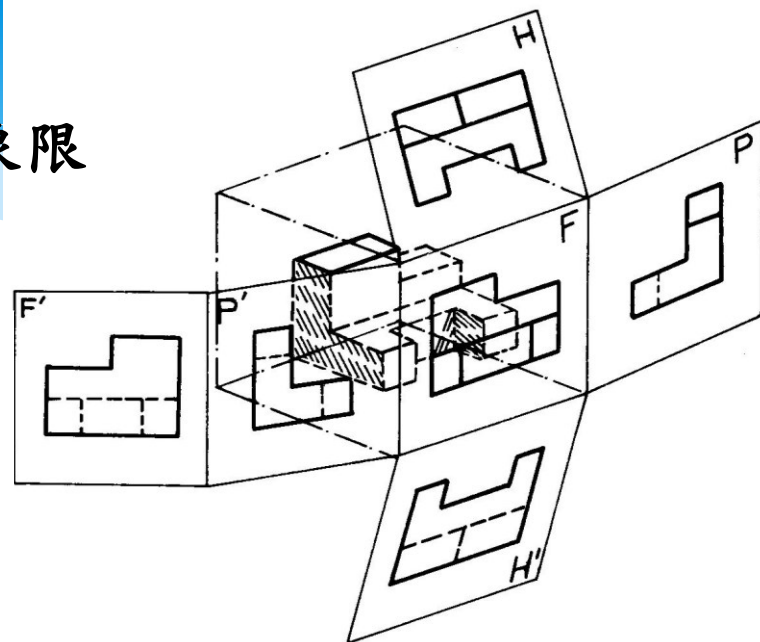




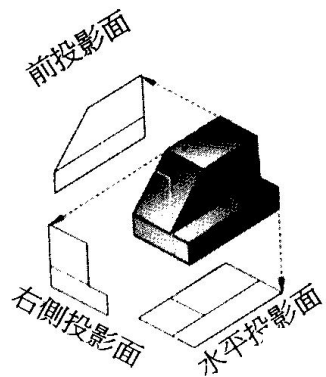
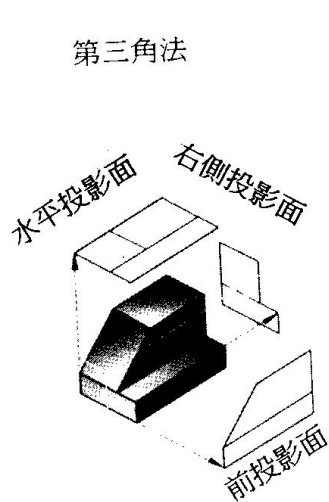
第一角法各視圖之排列位置及名稱

第三角法

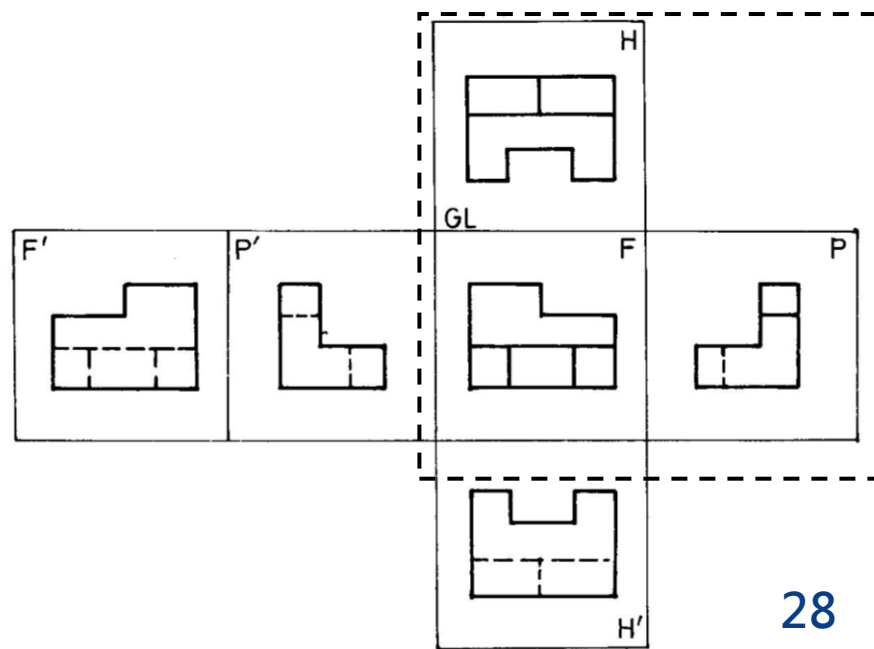
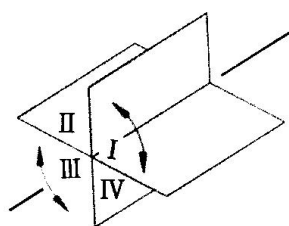
第三角法正投影之投影箱位於第三象限

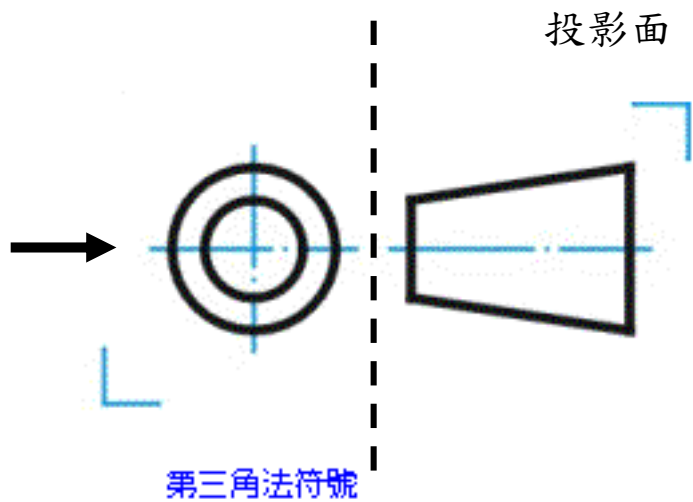
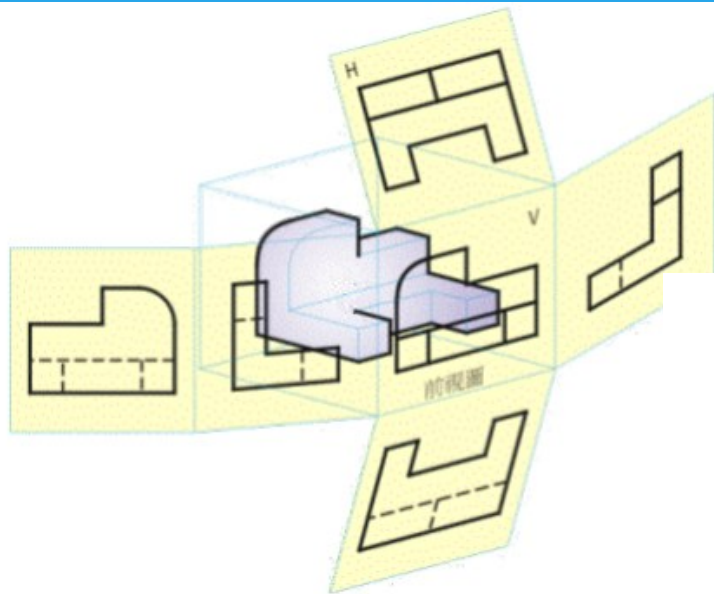


第三角法

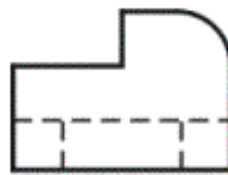


第一角法

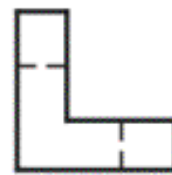




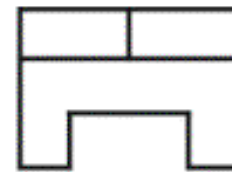
投影面



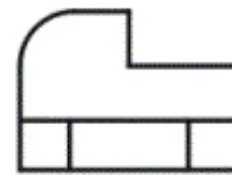
後視圖



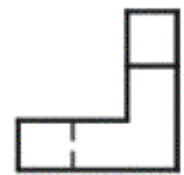
左側視圖



俯視圖



前視圖



右側視圖



仰視圖

第三角法各視圖之排列位置及名稱

2-2 正視圖

第一角法與第三角法之比較

- 1.我國目前大都採用第三角法
- 2.工程製圖國家標準規定，第一角法與第三角法同等適用，但於同一張圖中不得同時使用兩種投影
- 3.第一角法：物→投影面（後）；第三角法：投影面（前）→物
- 4.各視圖之形狀輪廓相同
- 5.展開後視圖排列不同

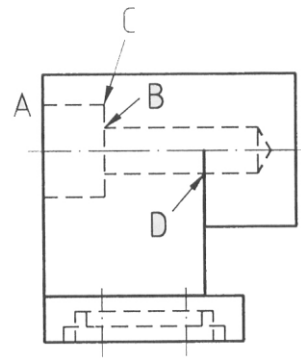
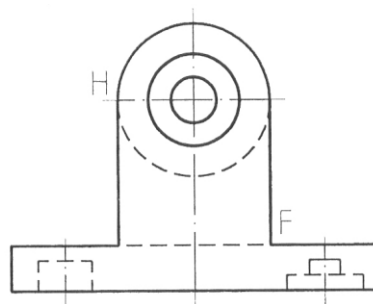
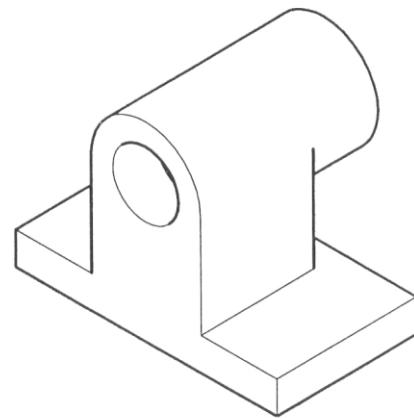
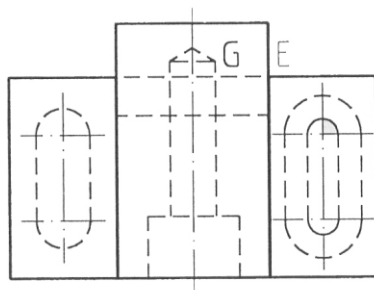
2-3 線條優先順序

輪廓線

表達物體輪廓形狀之線，若輪廓形狀直接與視線接觸，稱為“可見輪廓線”，用“粗實線”畫出。若輪廓位於物體之內部，被某些可見輪廓線遮住而無法與視線直接接觸則為“隱藏輪廓線”，用“虛線”畫出

虛線

物體的某些部分被遮住，無觀察到時，而此時的線條就做隱藏線，以虛線畫出

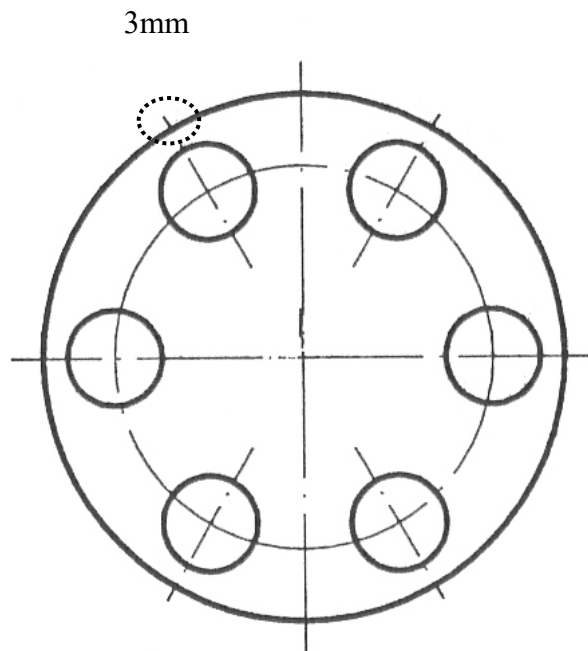
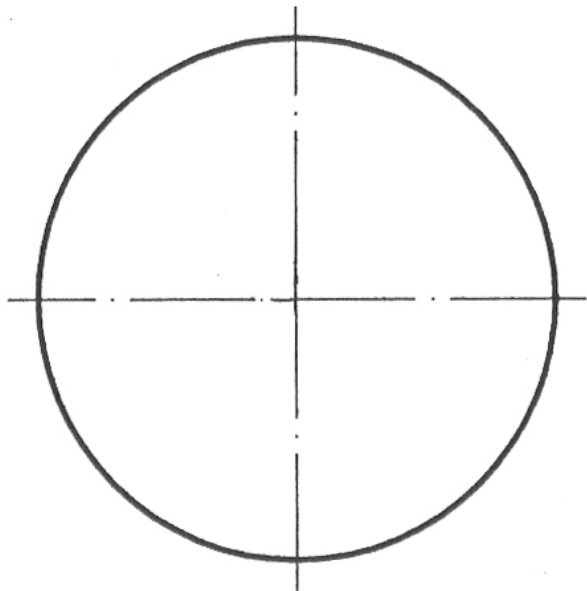


2-3 線條優先順序

中心線

物體之輪廓形狀對稱於某一軸線者，如圓、圓柱、圓錐等，必須表示對稱軸線之位置，通常用細鏈線畫出稱為“中心線”，中心線之兩端應超出對稱部分以外約3mm

正投影視圖中，圓的中心軸線都以中心線來表示，以細鏈線畫出



2-3 線條優先順序

各種線之優先順序如下：

粗實線（輪廓線）

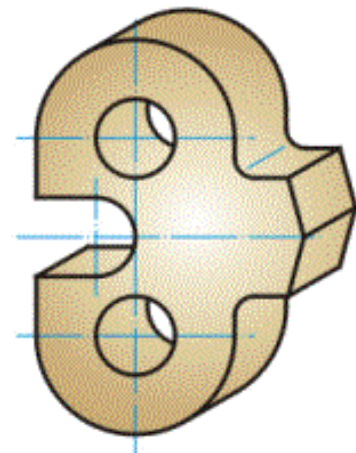
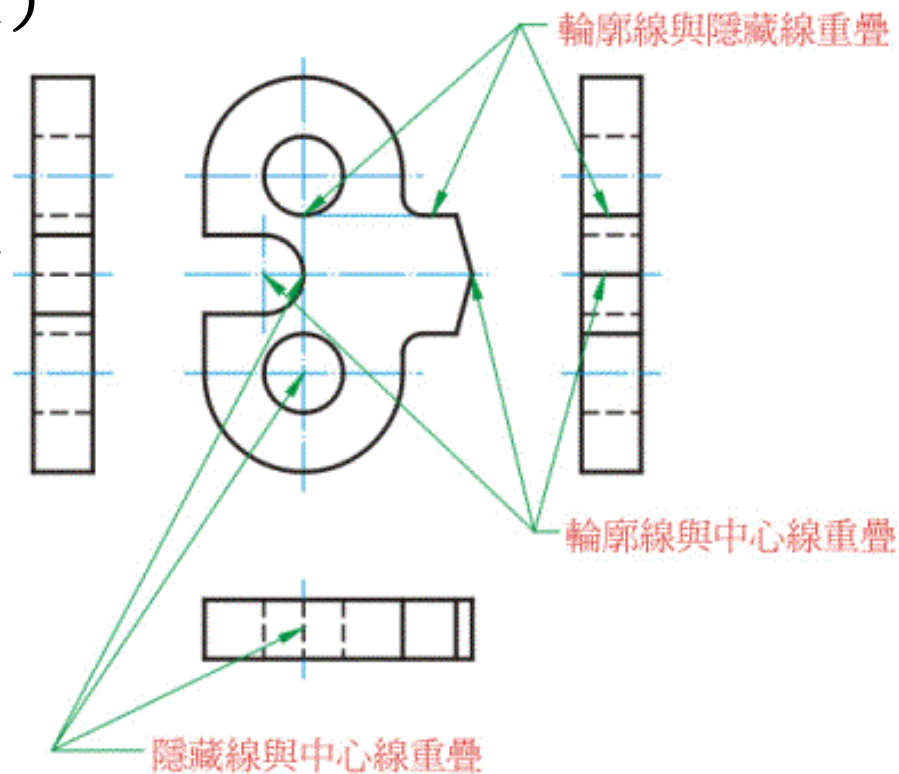
虛線（隱藏輪廓線）

中心線或剖面線

折斷線或假想線

尺度線與尺度界線

剖面線



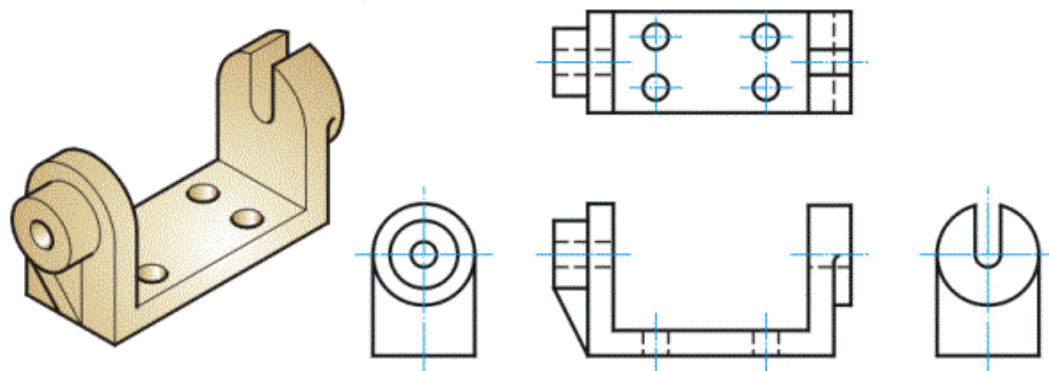
2-3 線條優先順序

線的起迄與交接

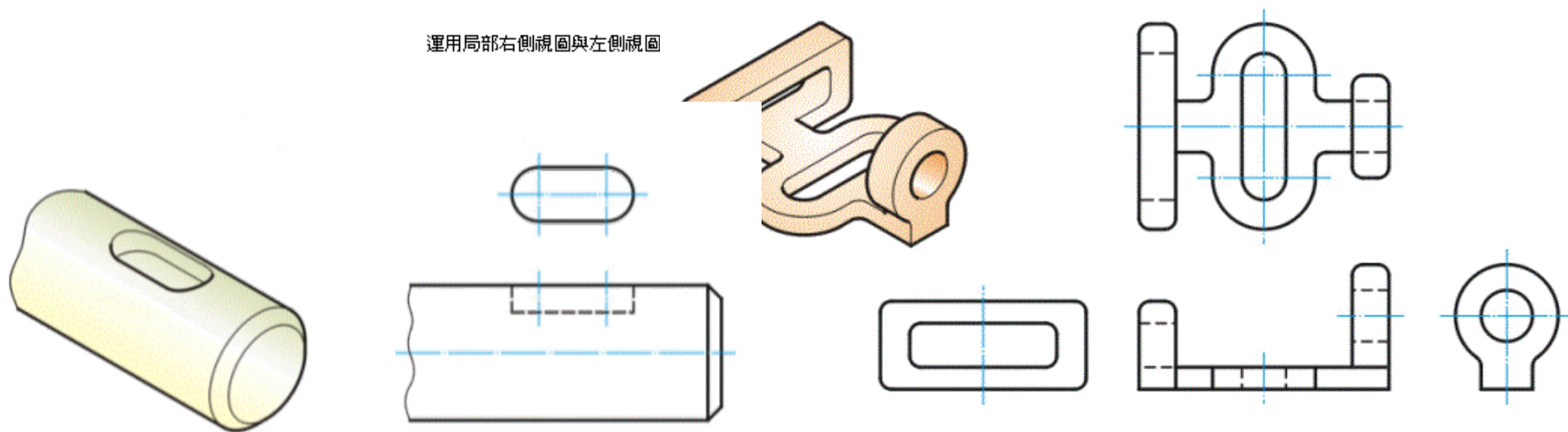
符號	正 確	錯 誤	符號	正 確	錯 誤
A			F		
			G		
B			H		
C			K		
D			L		
E			M		

2-4 視圖習用畫法

1. 局部視圖



運用局部右側視圖與左側視圖

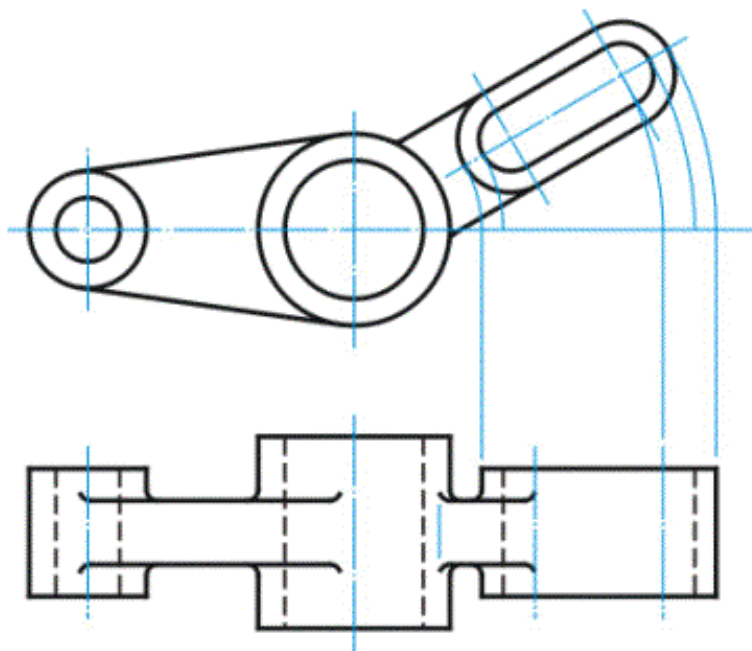


局部俯視圖

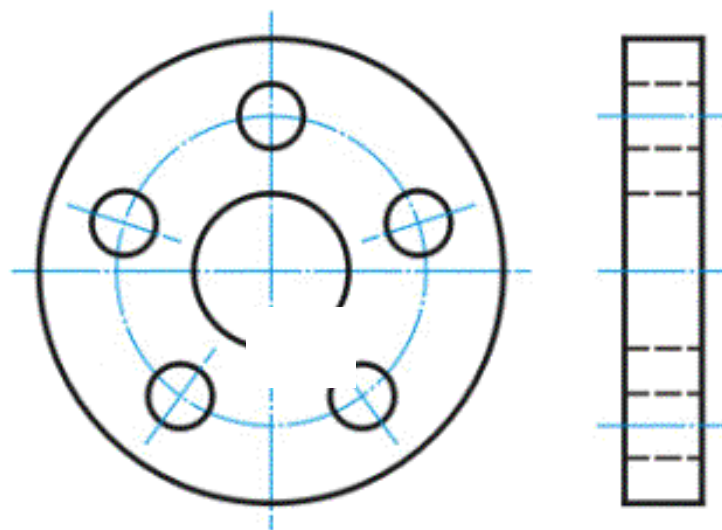
運用局部右側視圖與左側視圖

2-4 視圖習用畫法

2.轉正視圖



轉正視圖



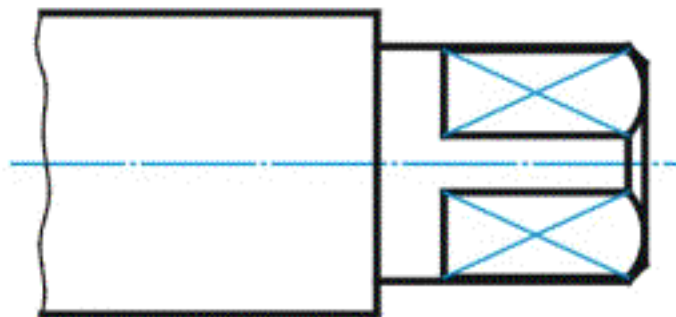
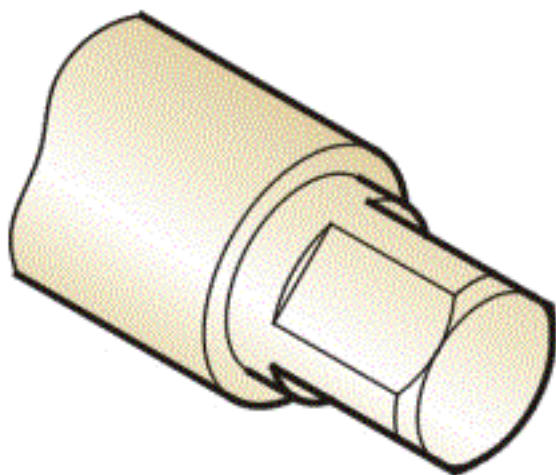
等距圓孔之表示法

2-4 視圖習用畫法

3. 中斷視圖



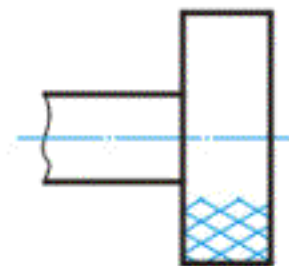
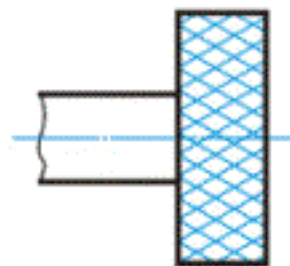
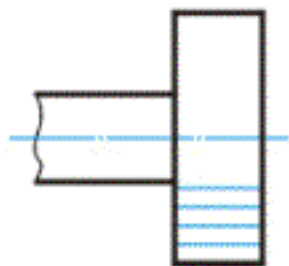
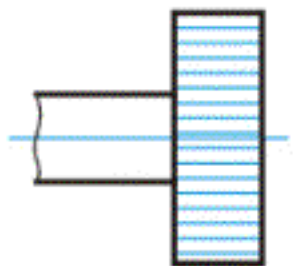
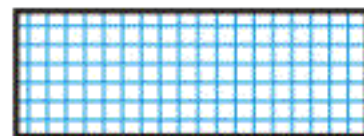
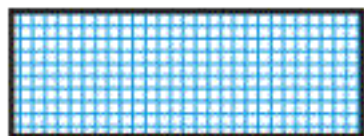
4. 軸上平面之表示法



2-4 視圖習用畫法

5. 滾花金屬網及紋面板之表示法

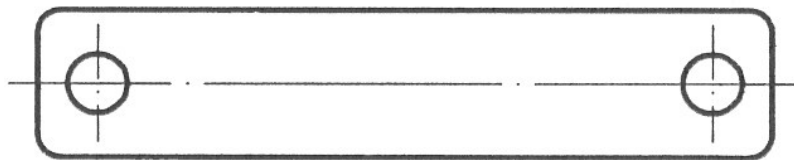
以細實線表示或亦可僅畫出一角表示之



滾花、金屬網及紋面板之表示法

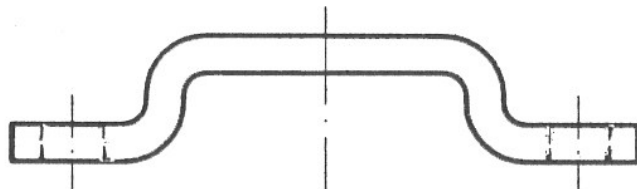
2-4 視圖習用畫法

6. 展開表示法

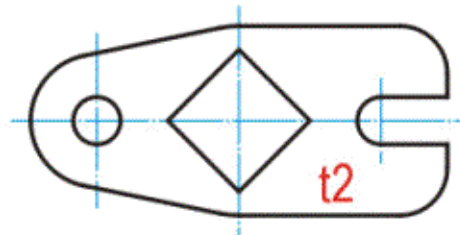
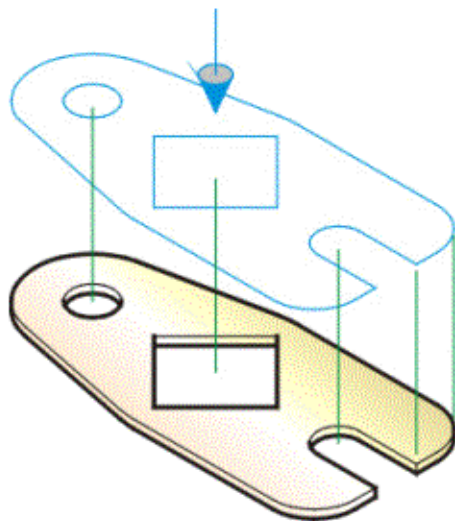


實際長度

真實形狀

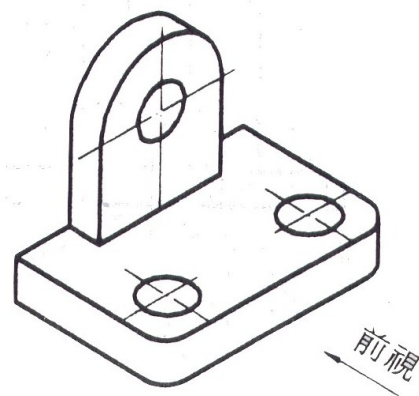
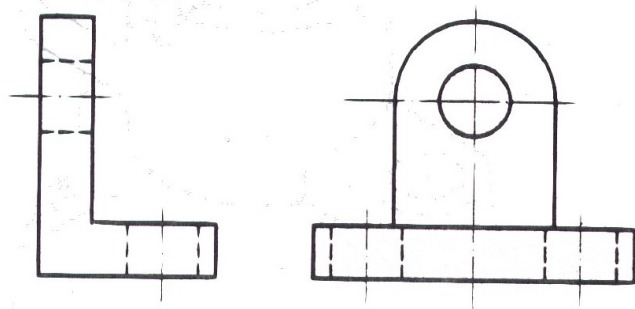


7. 薄件畫法

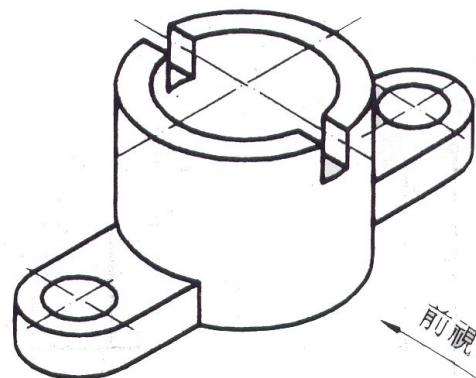
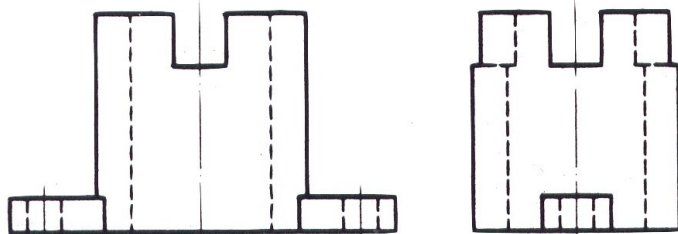


(一)已知兩視圖想像立體形狀，參考立體圖添畫第三視圖。
習用第三角法或用第一角法，按指定繪製。

(1)



(2)

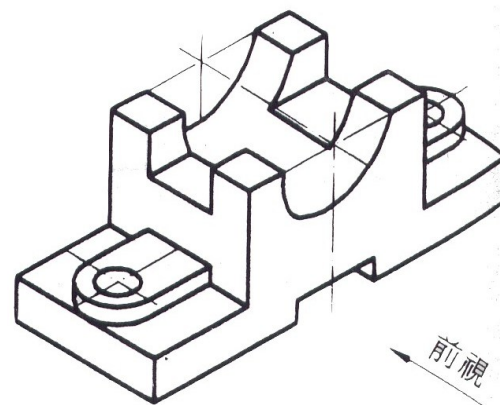
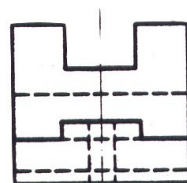
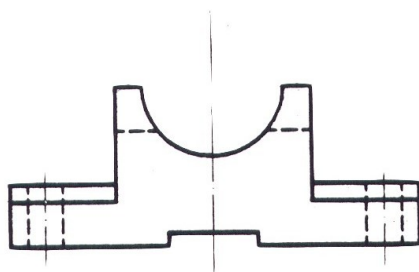




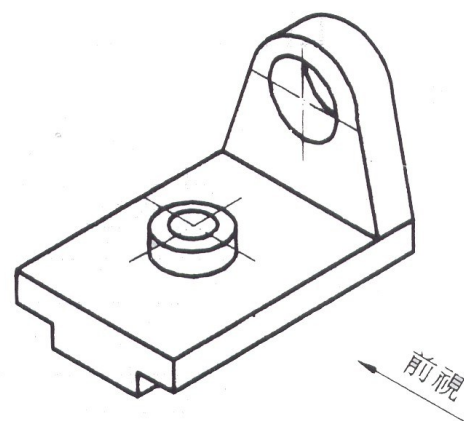
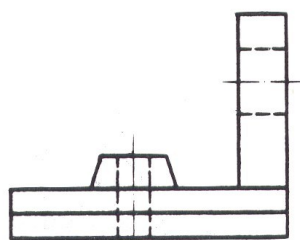
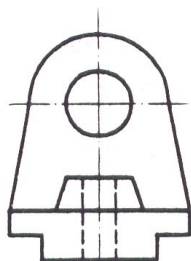
解(1)

解(2)

(3)



(4)





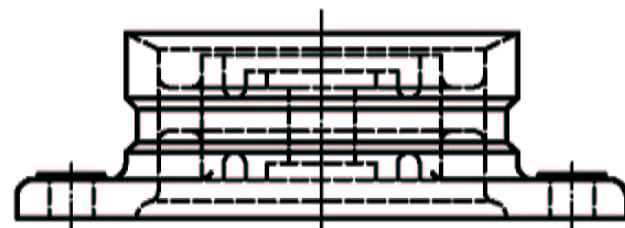
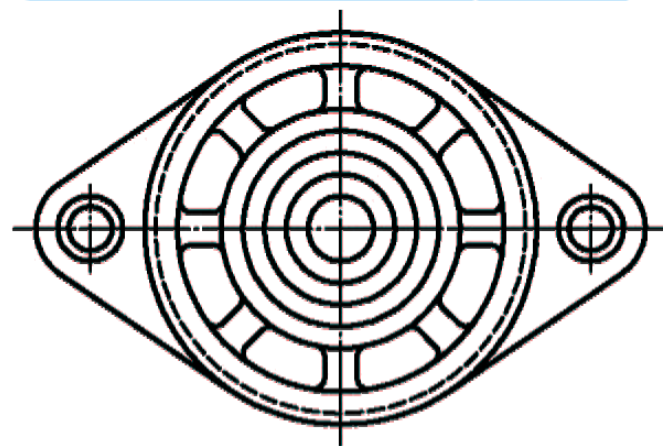
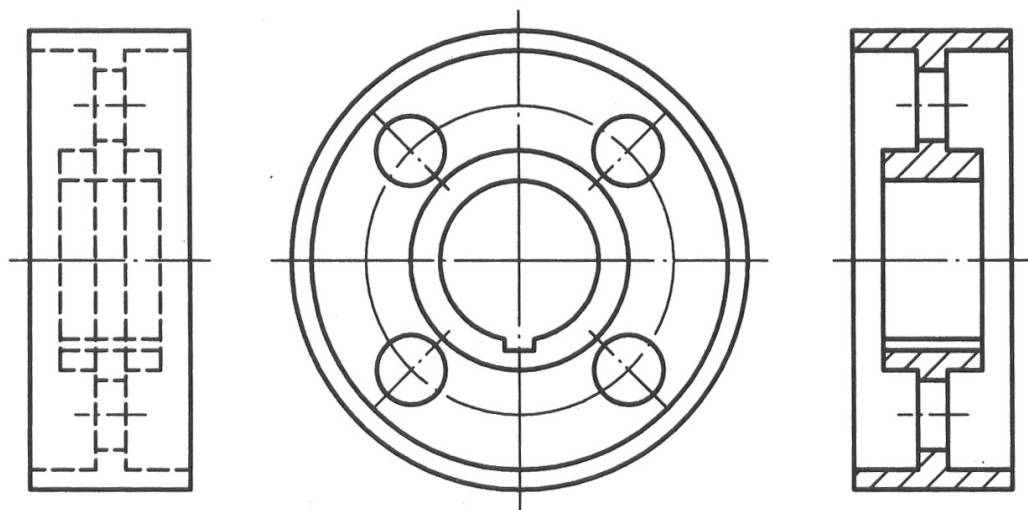
解(3)

解(4)

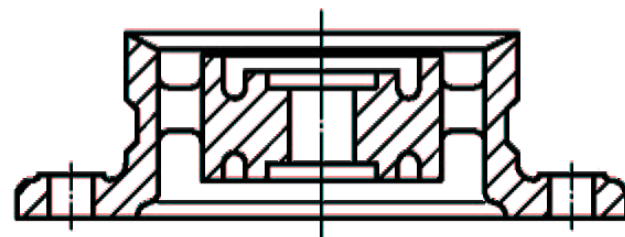
Chapter 3 剖視圖

3-1 剖視

內部形狀複雜可用剖視圖觀察內部



(a) 外形投影視圖

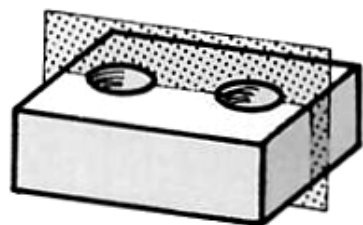


(b) 剖視圖

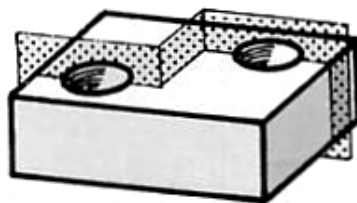
3-2 剖面及剖面線

剖面

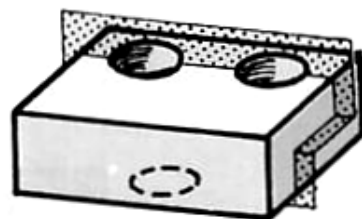
機件切開之切割平面，可轉折



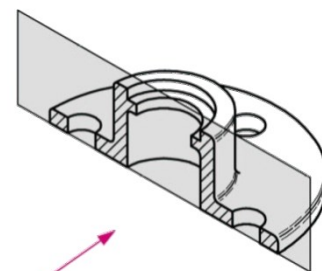
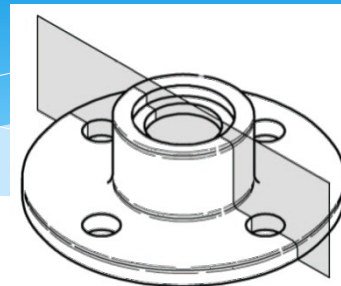
(a) 平直剖面



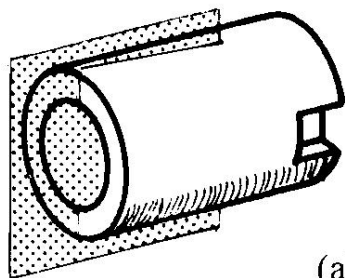
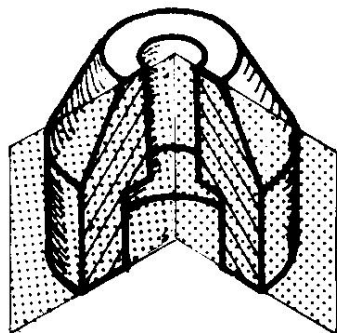
(b) 轉折剖面



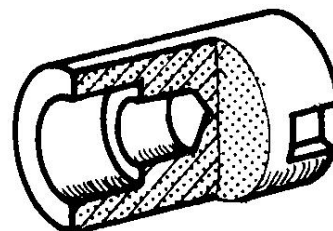
(c) 偏置剖面



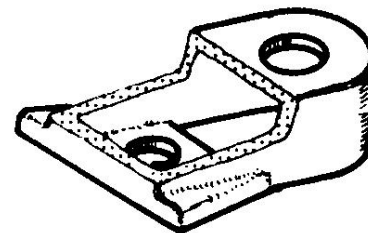
剖面可僅延伸至必須表達之部分，不必將整機件全部切割，稱為局部剖面



(a)

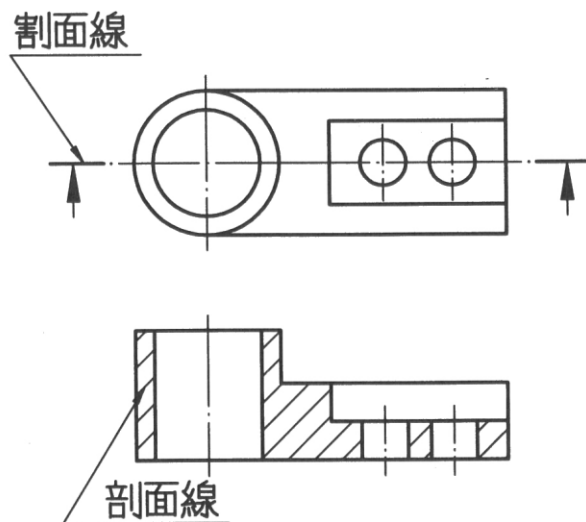
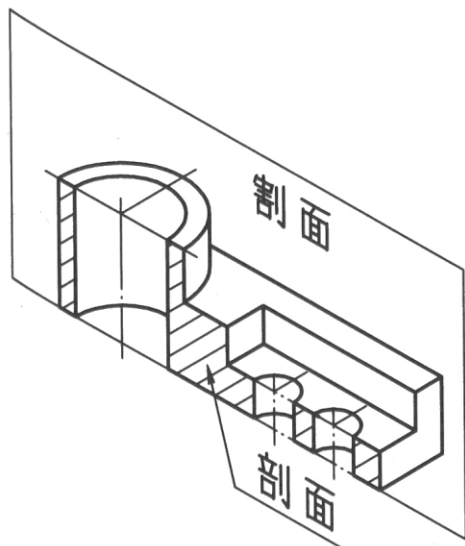


(b)

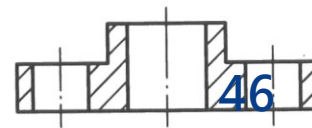
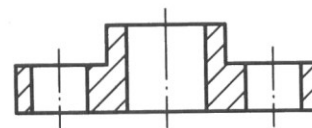
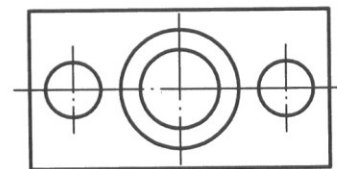
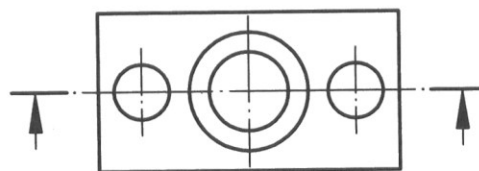
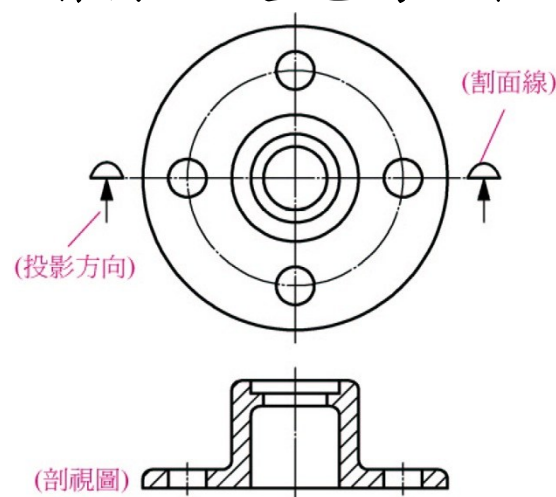


剖面線

用以表示機件之切割位置，隨剖面之變化可轉折或偏置，兩端及轉折處需以粗實線畫出，中間以細鏈線連接，兩端以箭頭標示正對剖面之方向，多個剖面時需用英文字母分別標之，註寫於粗實線之外端



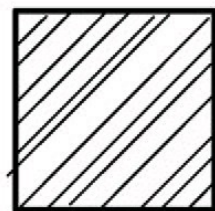
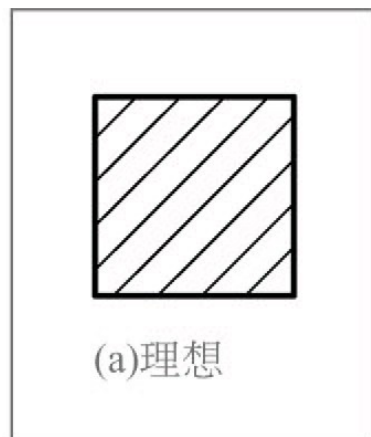
當剖面位置甚為明確時



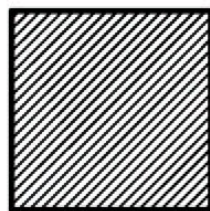
3-3剖面及剖面線

剖面及剖面線

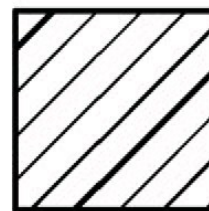
實體被切割後所呈現之實體面稱為剖面，必須在剖面上用細實線加畫一組與機件之主軸線或輪廓線成 45° 之平行線，視為剖面線（2-5mm間距）。



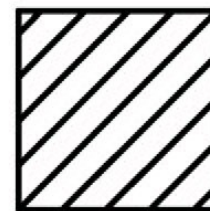
(b)間隔不均勻



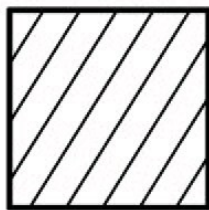
(c)間隔太密



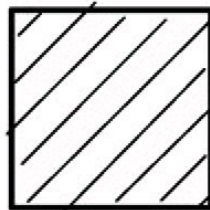
(d)粗細不均勻



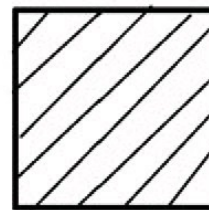
(e)太粗



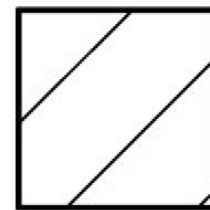
(f)角度不理想



(g)接線不良



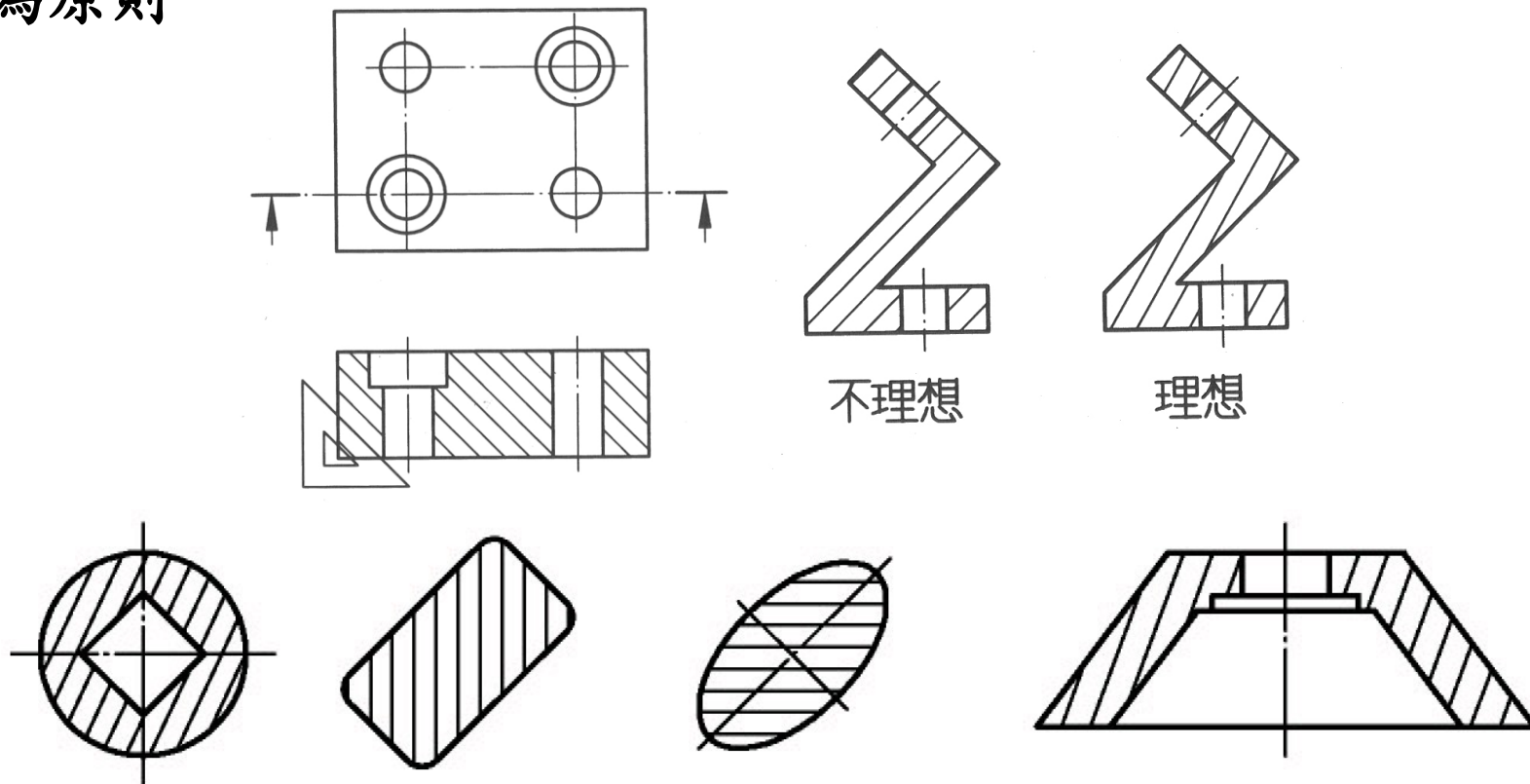
(h)不平行



(i)間隔太寬

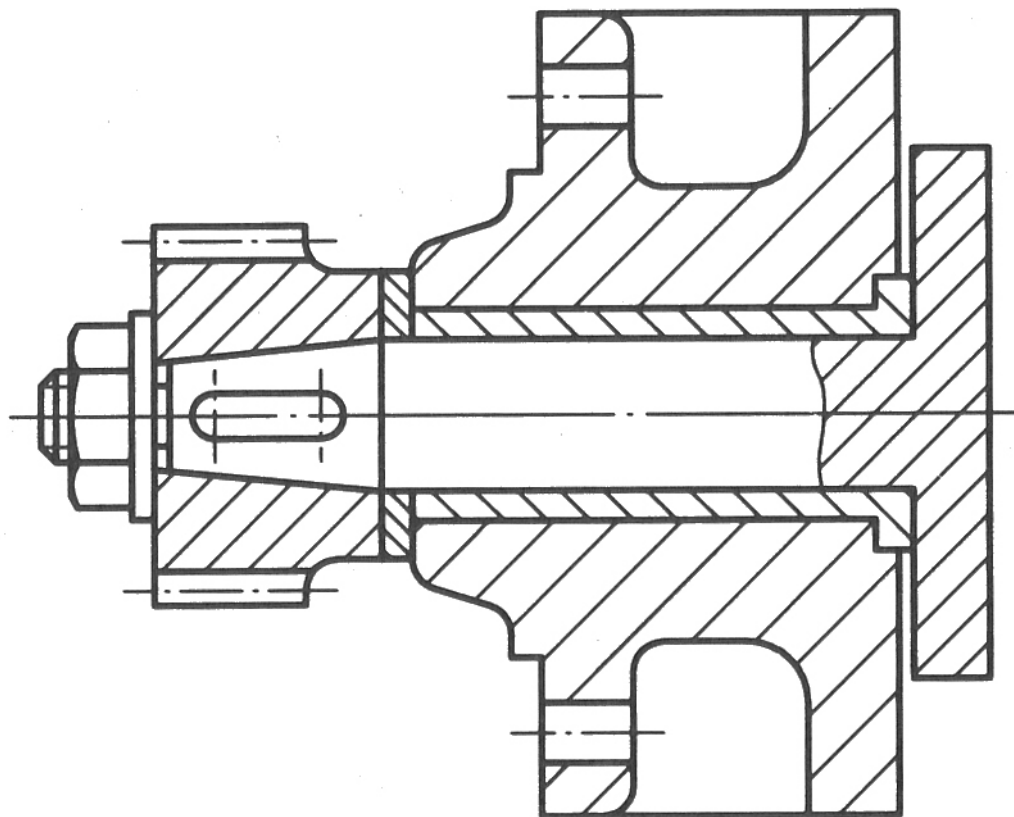
常見之不良剖面線畫法

同一機件的剖面，不論其割面轉折與否，或分畫成幾個視圖，剖面線之方向需一致，如果剖面的外形線有傾斜時，則剖面線應改為與水平線成 30° 或 60° ，以不與物體的外形線平行或垂直為原則

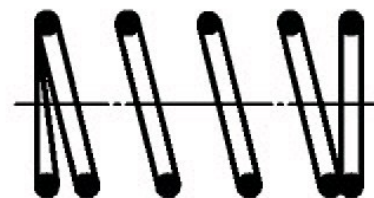
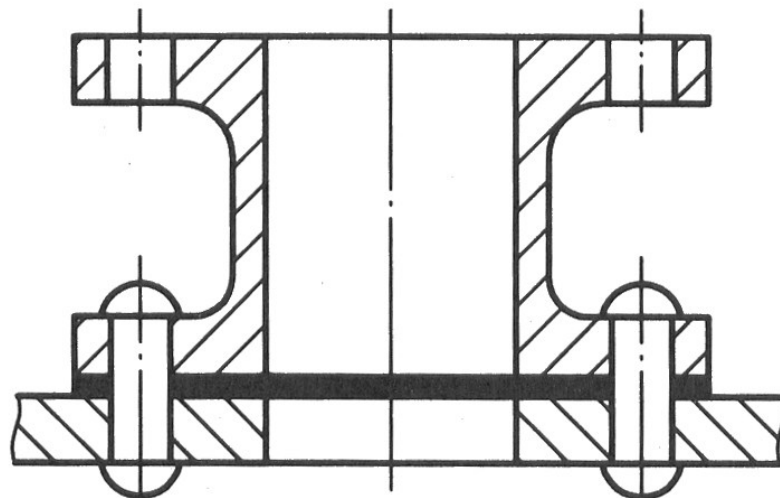
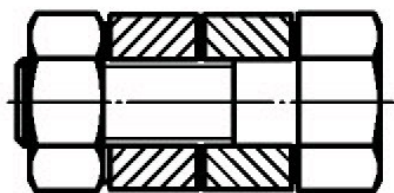
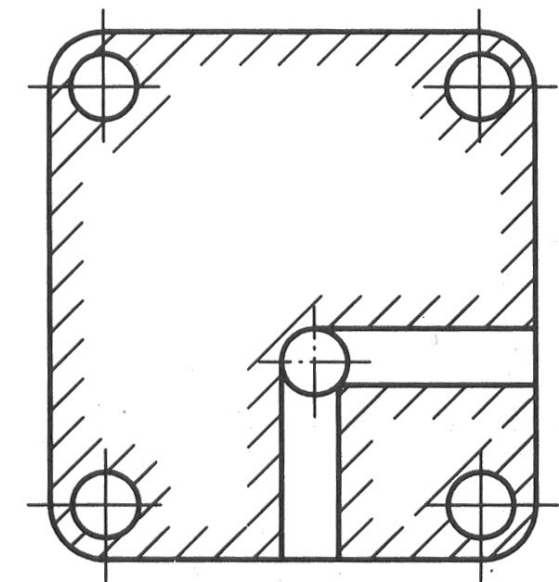


使剖面線與面積之外形盡量成 45°

同一剖面切割不同機件時，相鄰兩機件之剖面線應取不同的方向或不同的間隔已區別之



剖面範圍太大或太小

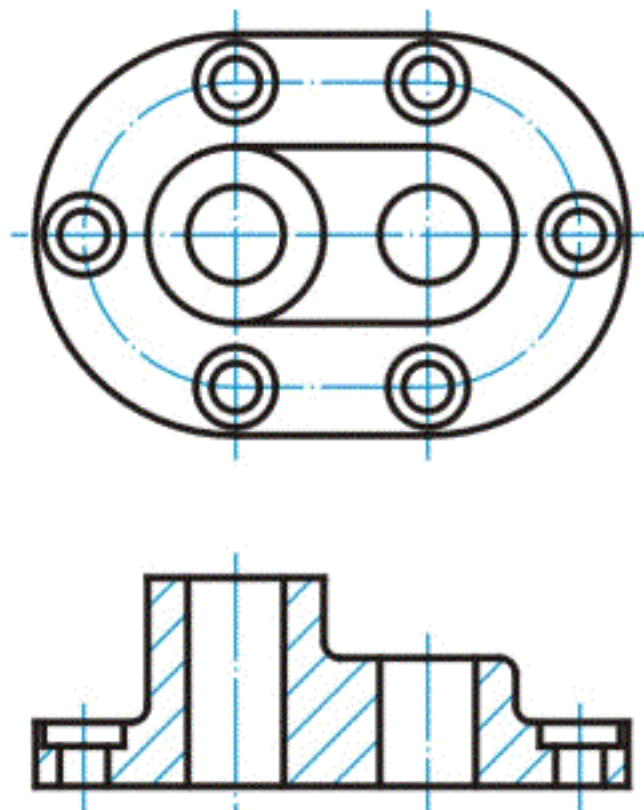
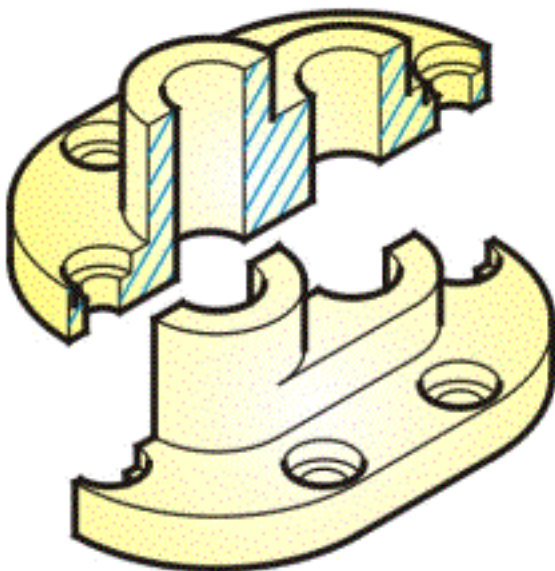


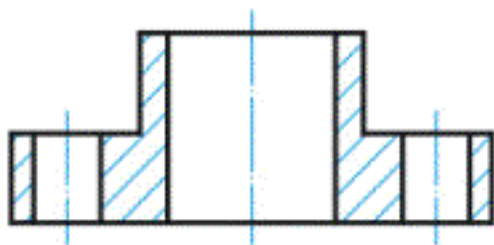
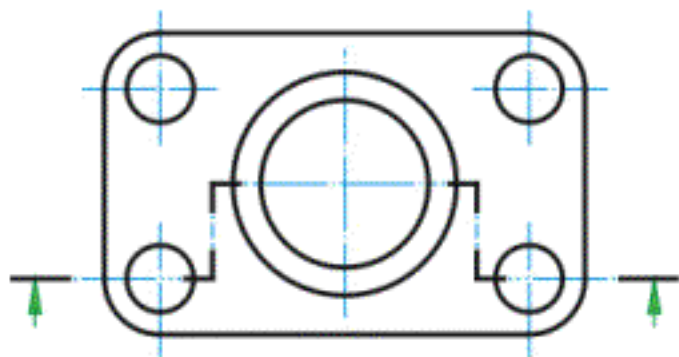
當剖面面積狹小時以塗黑表之

3-4 剖面種類

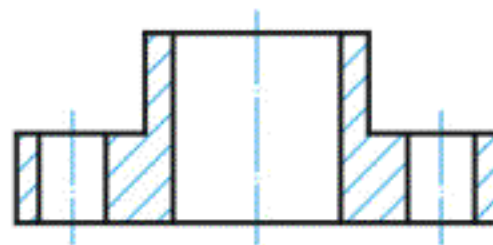
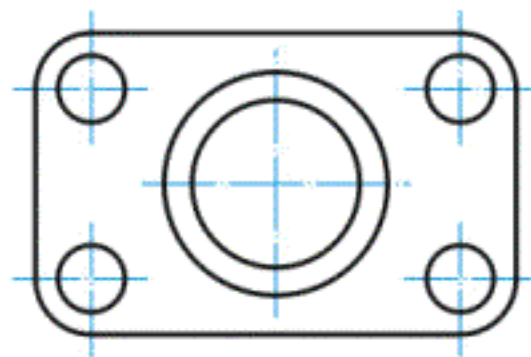
一、全剖面

全剖面之剖面線通常均為於機件之主要軸線或其中心線，採用轉折剖面，剖面轉折處在剖視圖中是不加以表出的





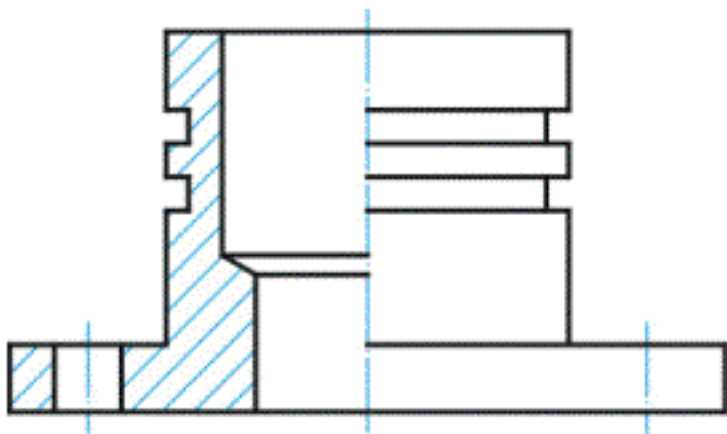
(a) 不理想



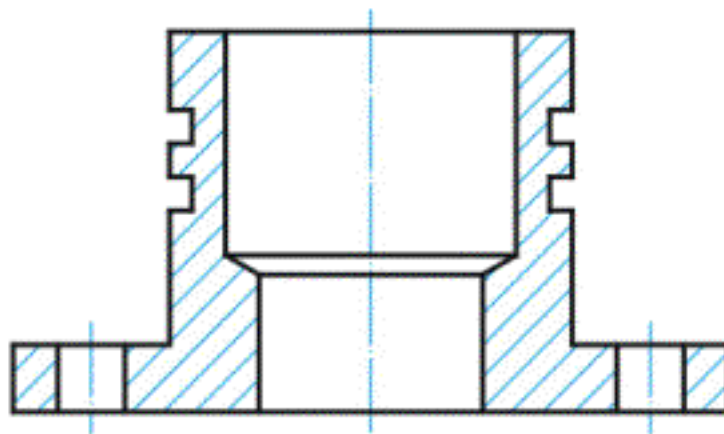
(b) 理想

二、半剖面

物體對稱時用之，可同時表示內外部形狀



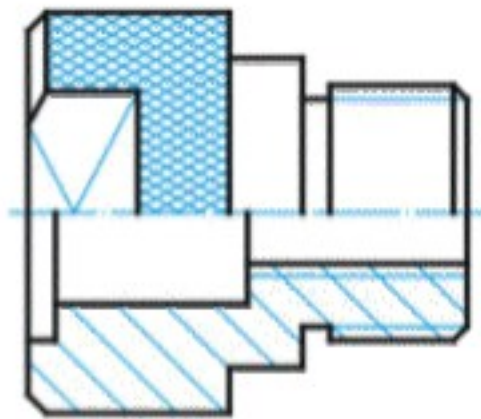
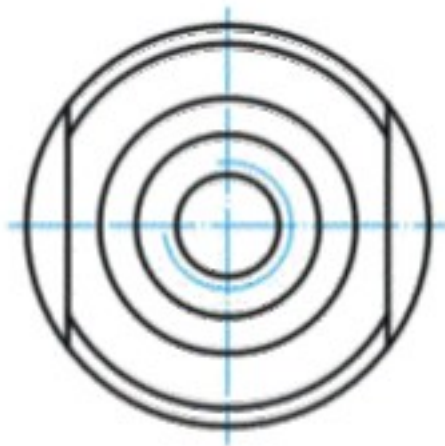
(a) 半 剖 視 圖



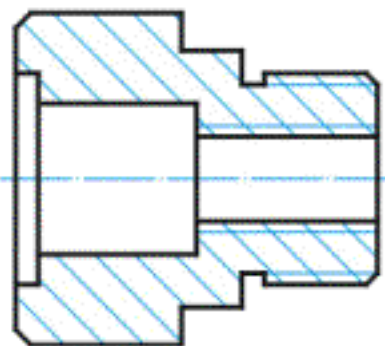
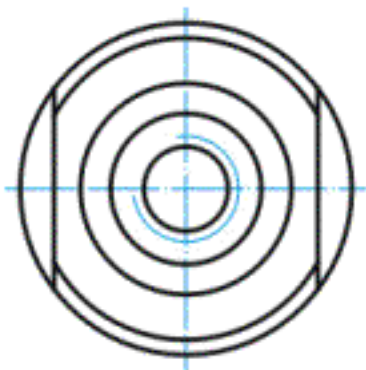
(b) 全 剖 視 圖



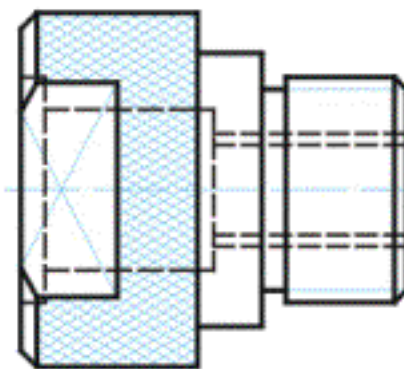
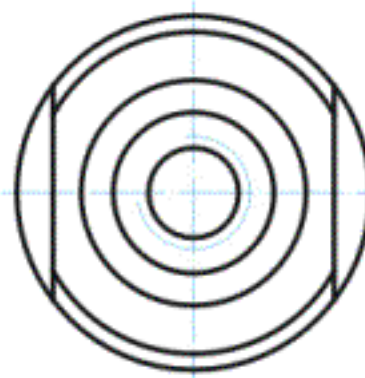
物體實體圖



採用半剖視圖



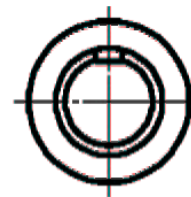
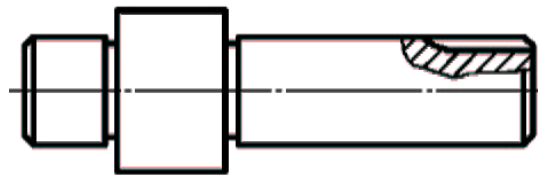
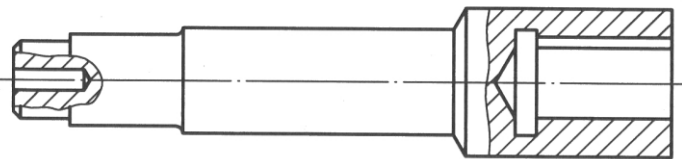
採用全剖視圖外形不易表達清楚



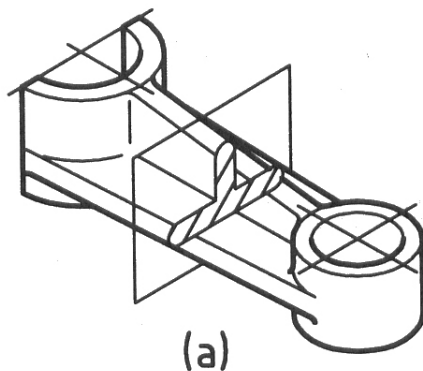
不加剖視內部形狀亦不能清晰表達

三、局部剖面

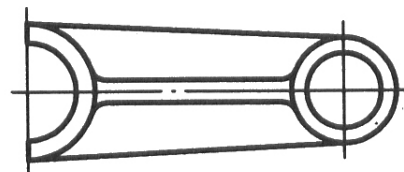
分界線以折斷線化之



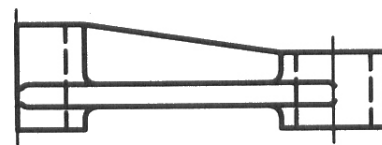
四、旋轉剖面



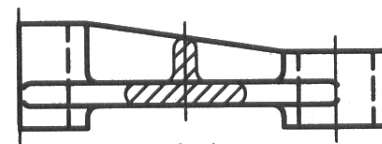
(a)



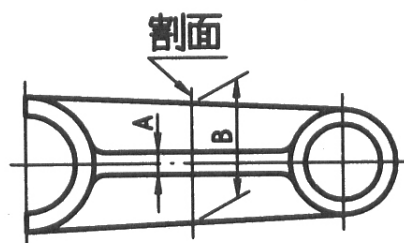
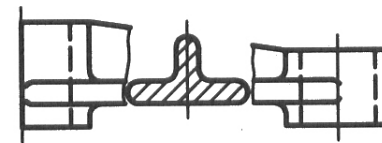
(b)



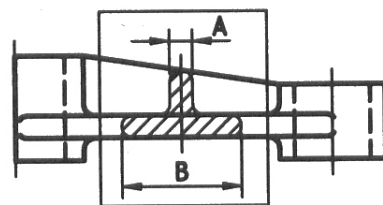
(d)



(e)

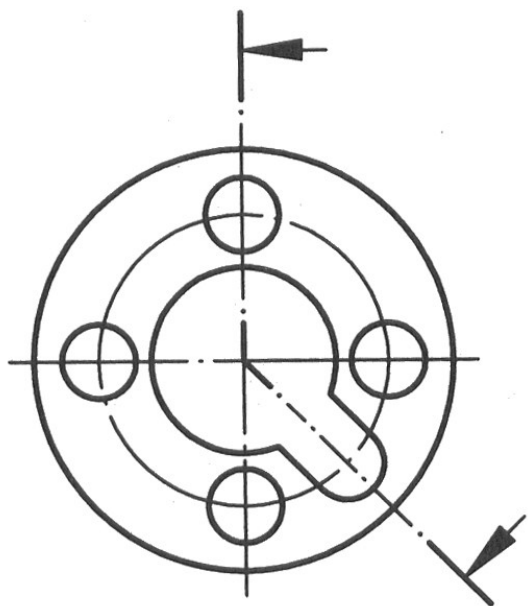


(c)

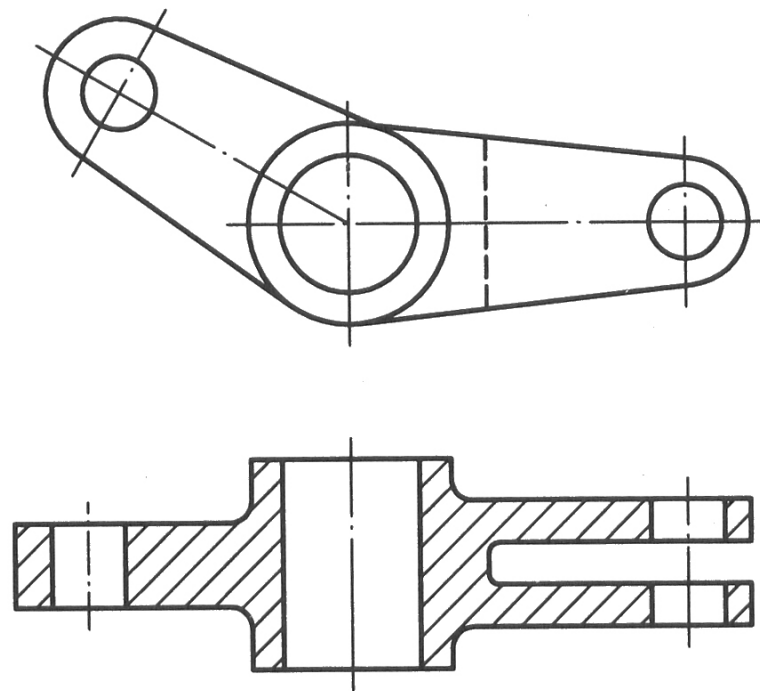
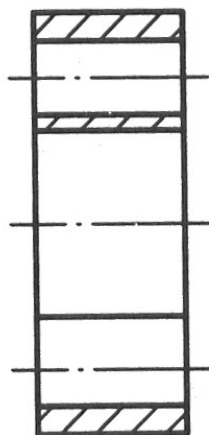


3-6 剖視習用畫法

一、剖面轉正表示法



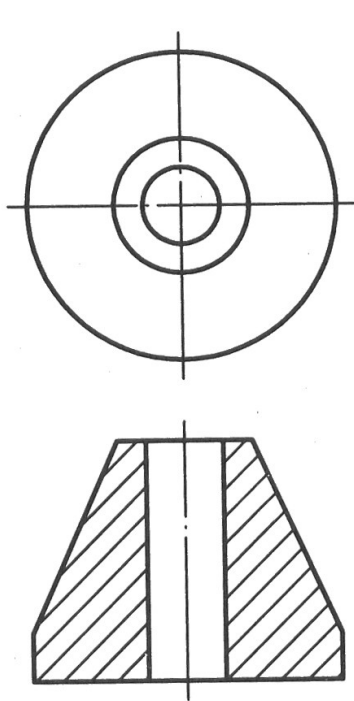
剖面轉正後所得剖視圖



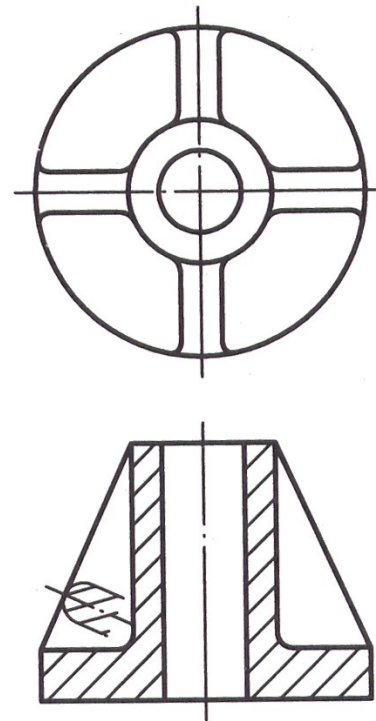
物體轉正後再加剖切

二、不加以剖視部分

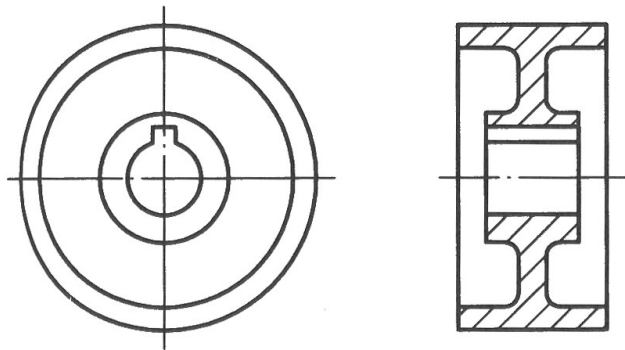
凡是支撐物體之肋輻耳是不縱剖的，但肋與輻狀可旋轉剖面表示



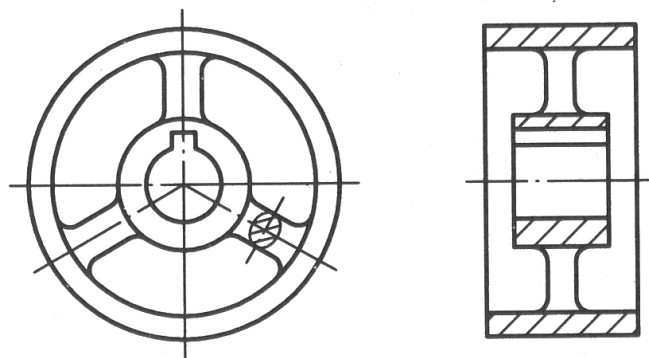
錐體剖視圖



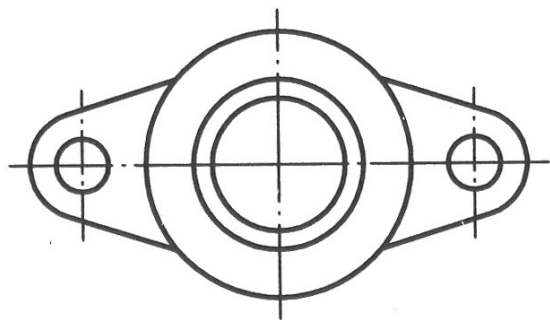
肋之剖視圖



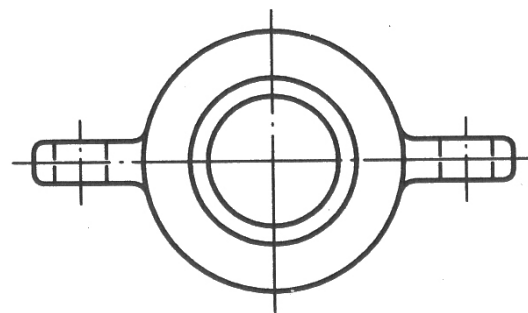
腹板之剖視圖



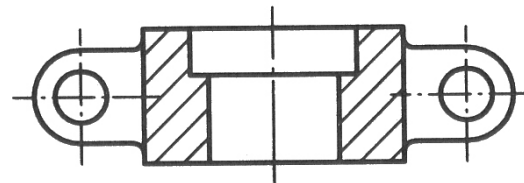
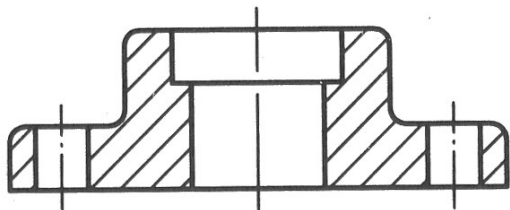
輻之剖視圖



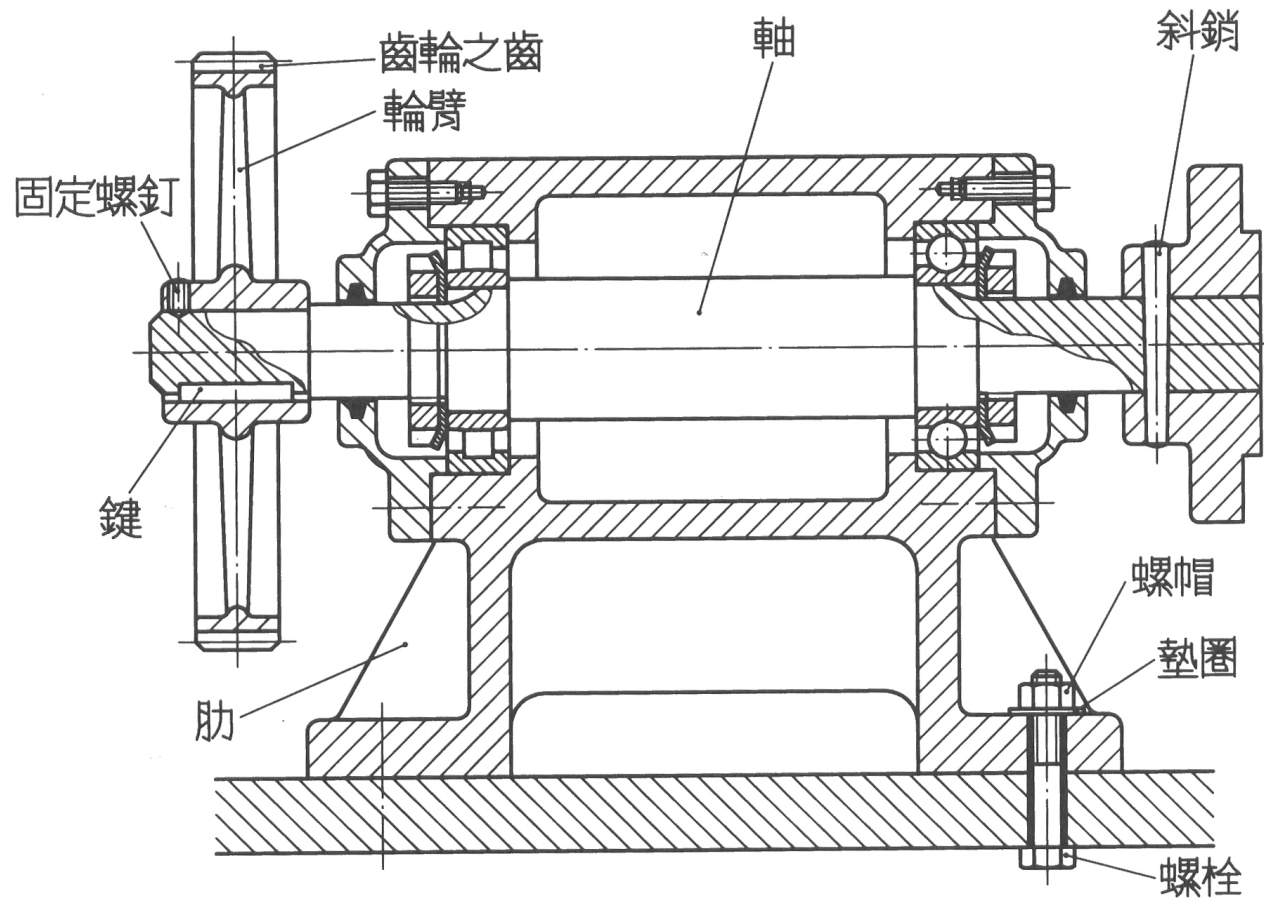
凸緣之剖視圖



耳不加以剖視



三、不加剖視之零件

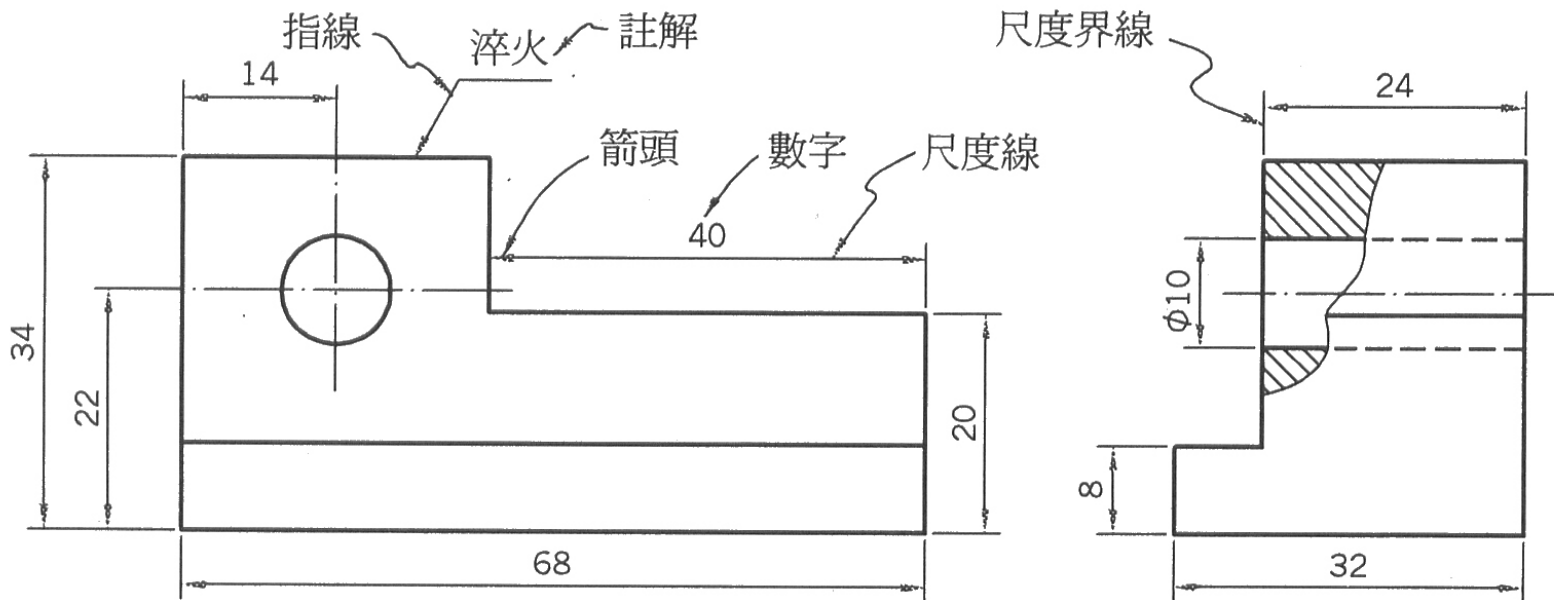


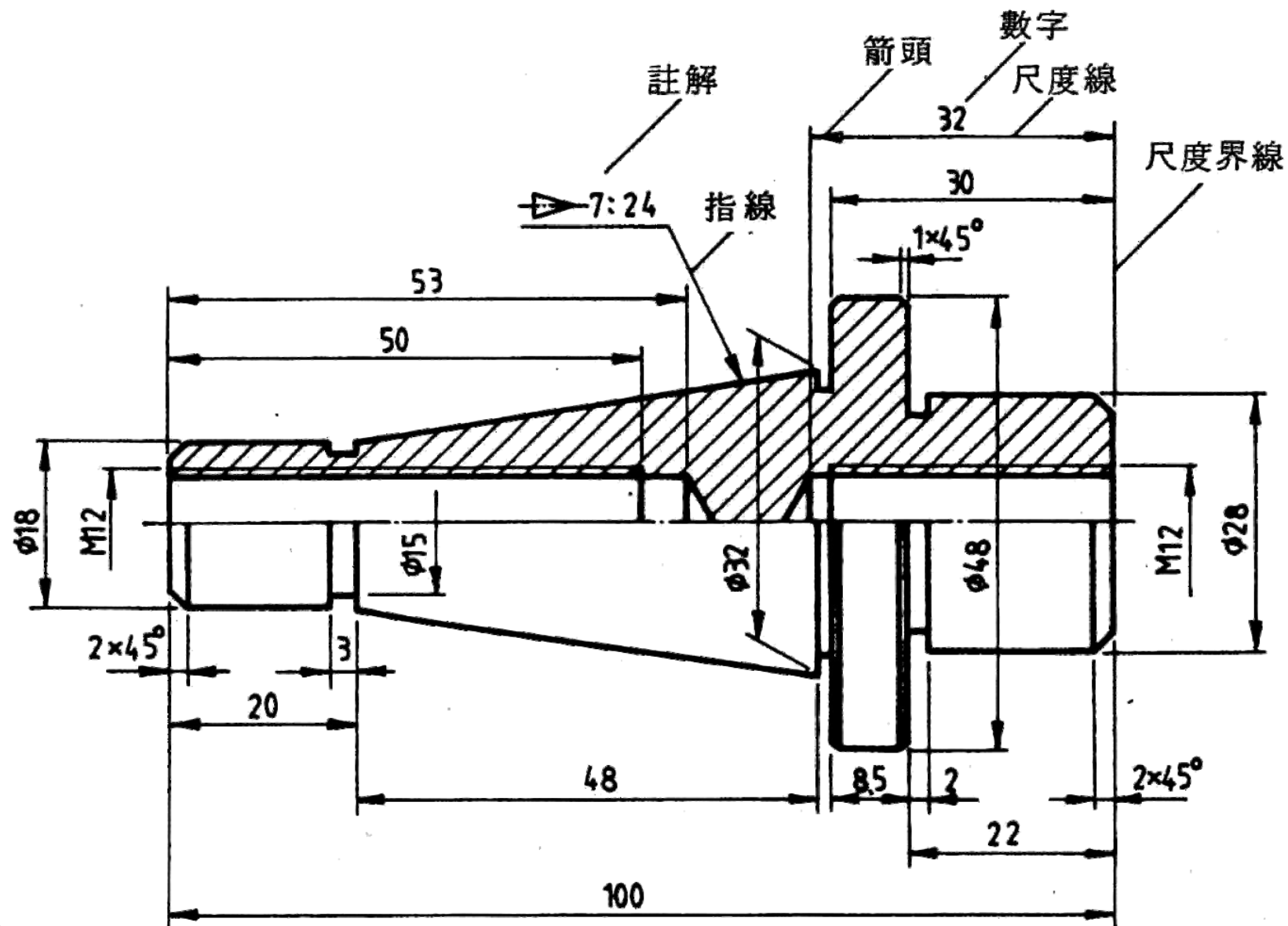
不加剖視之零件

Chapter 4 尺度標註

4-1 概述

尺度包括：長度、角度、錐度、斜度、弧長、直徑、半徑、面積、體積等，其大小均以標註符號、數字及量測單位等組合表示之，所有量測單位除mm外均需註明單位符號



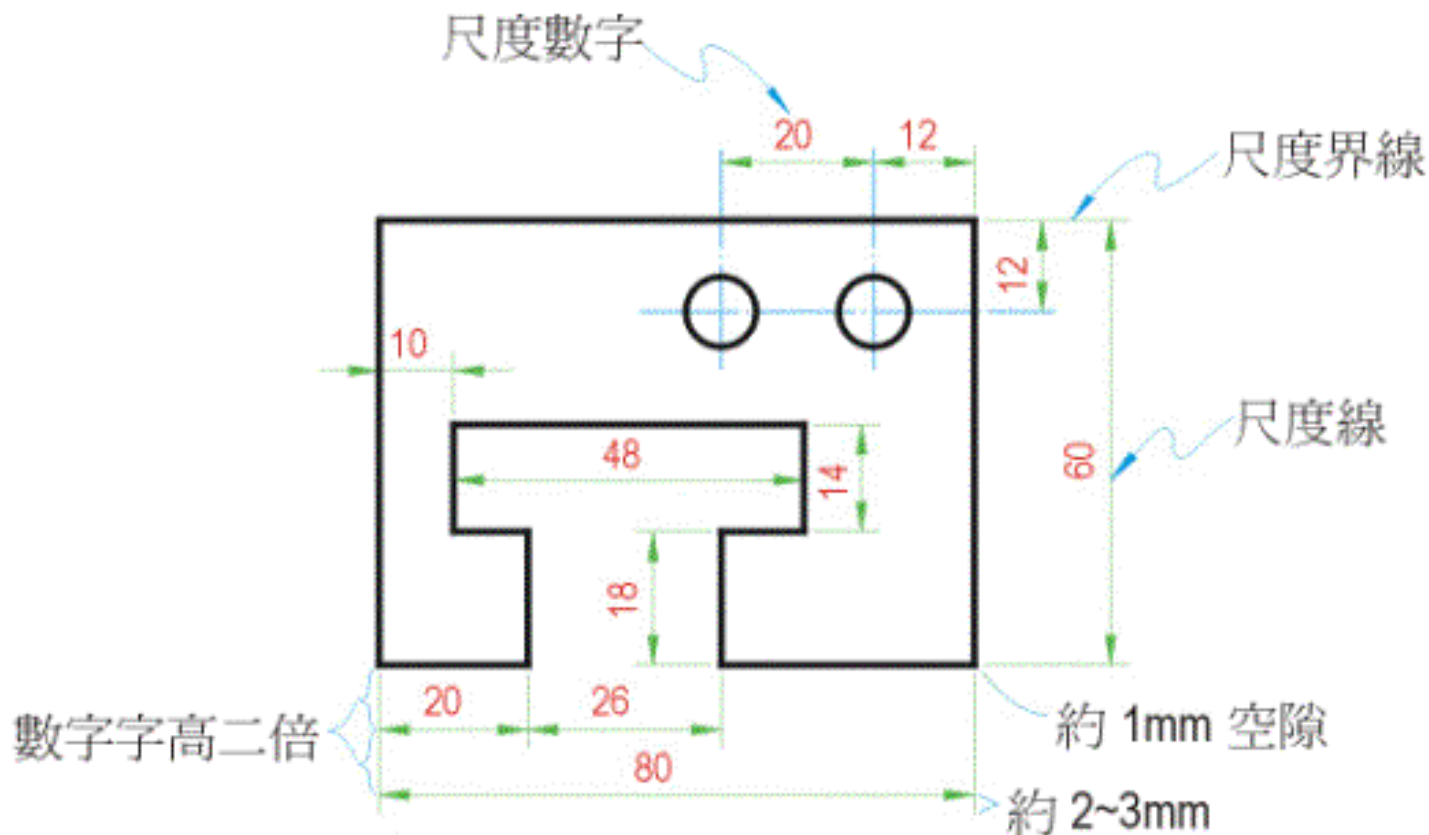


尺度表示法

4-2 尺度標註說明

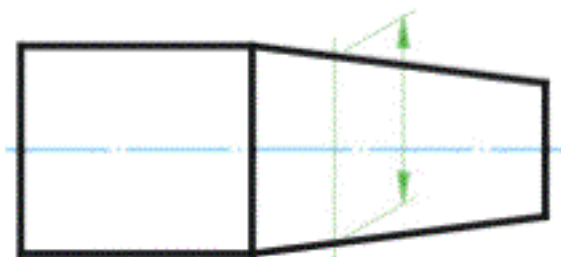
尺度界線：

用以指出輪廓界線之位置，在欲標註輪廓之兩端沿輪廓垂直方向用細實線延伸畫出，但其前端需與輪廓線保留約1mm之空隙，尾端需超出尺度線2-3mm，尺度界線可利用中心線或輪廓線，當尺度界線與輪廓線近似平行時，可引出與尺度線約成 60° 之傾斜線作為尺度界線

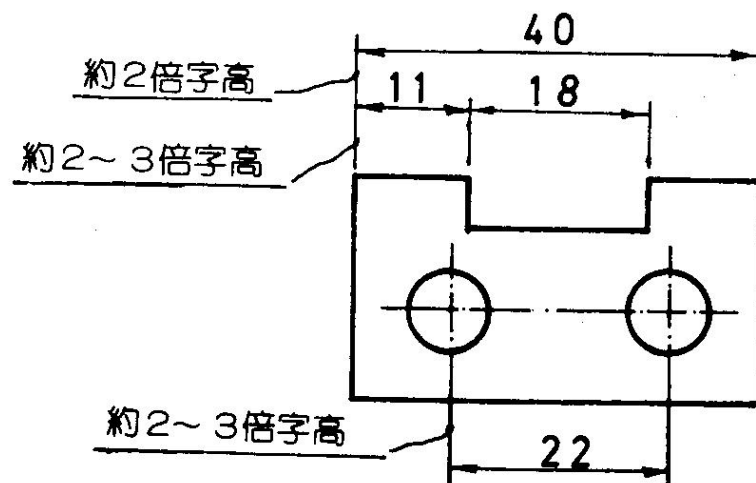


尺度線：

1. 細實線，兩端帶有箭頭在尺度界線上
2. 通常與尺度界線垂直，若以輪廓線為尺度界線，則尺度線應垂直該輪廓
3. 尺度線與物體輪廓線之間隔約為字高之2-3倍，尺度線與尺度線之距離約為字高之2倍
4. 輪廓線、中心線、剖面線不得用作尺度線

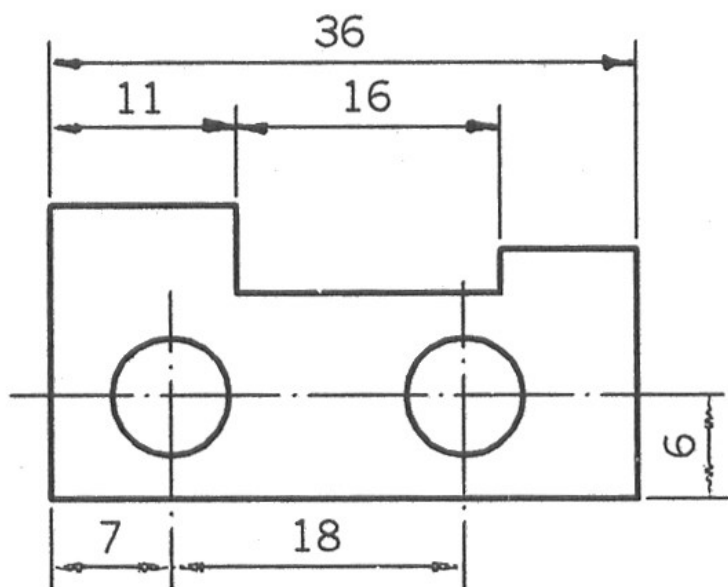


尺度界線與尺度線不垂直

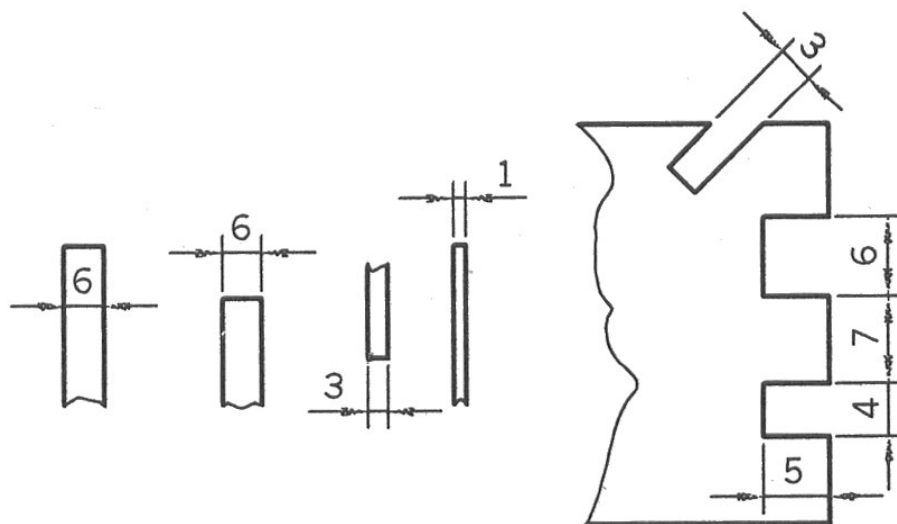


尺度數字及其書寫方向

尺度線不可中斷，長度尺寸數值應寫在尺度線之上方中央部分且尺度應盡量標於圖外



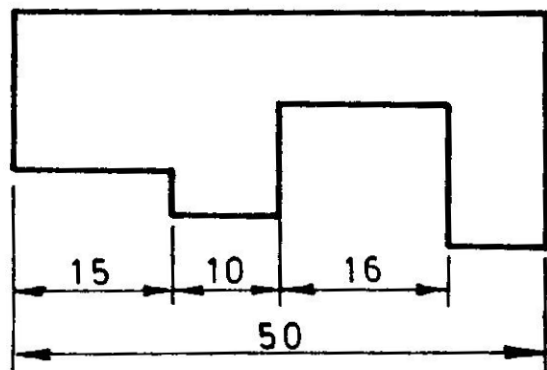
數字寫於尺度線上方



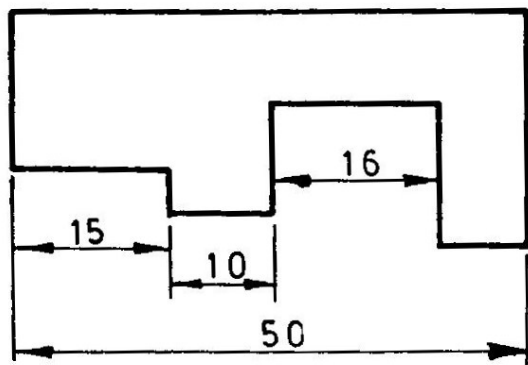
狹窄處尺度數字之註法

可在同一層上連續
完整標註之尺寸，
不宜分成多層

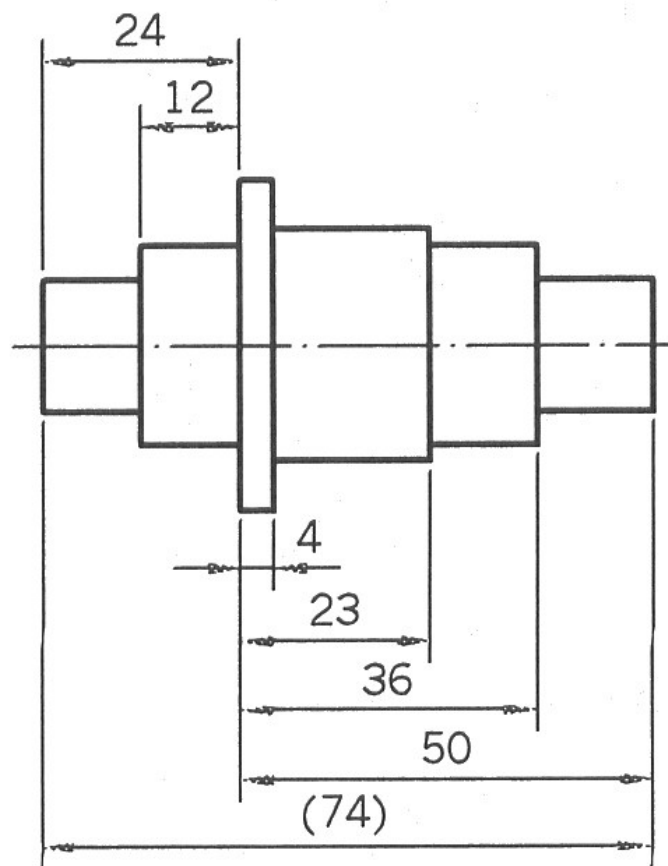
尺度線應於小至大順
序向視圖外方排列

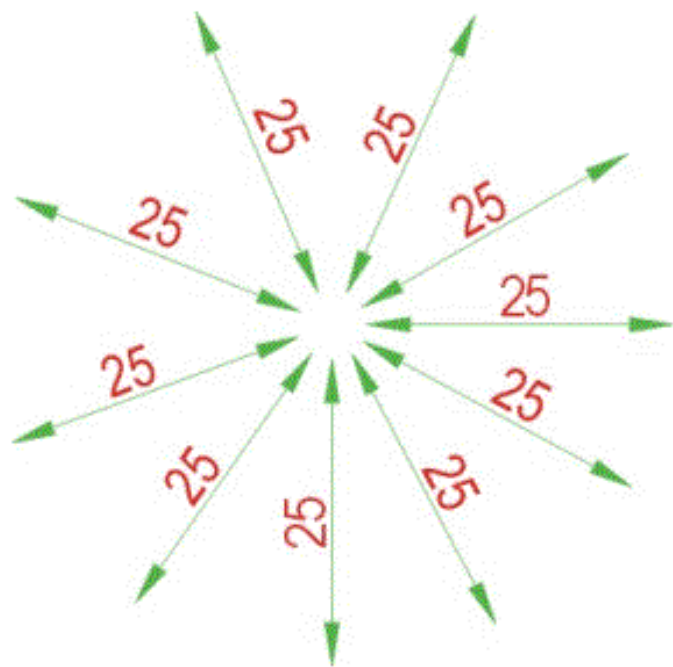


(a) 良

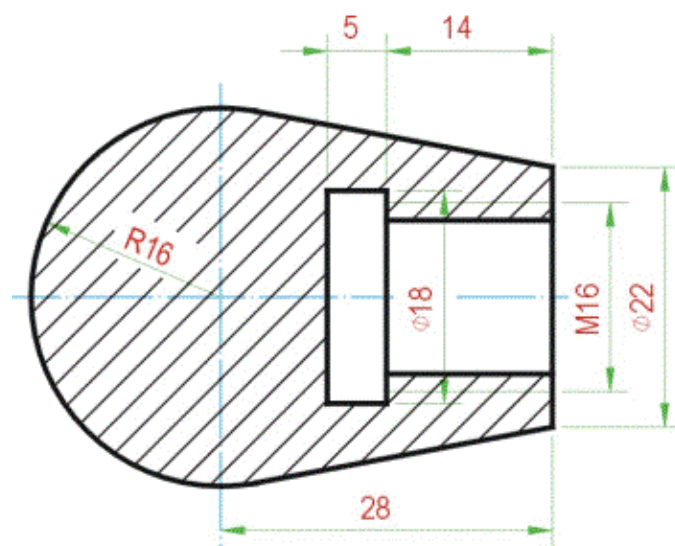
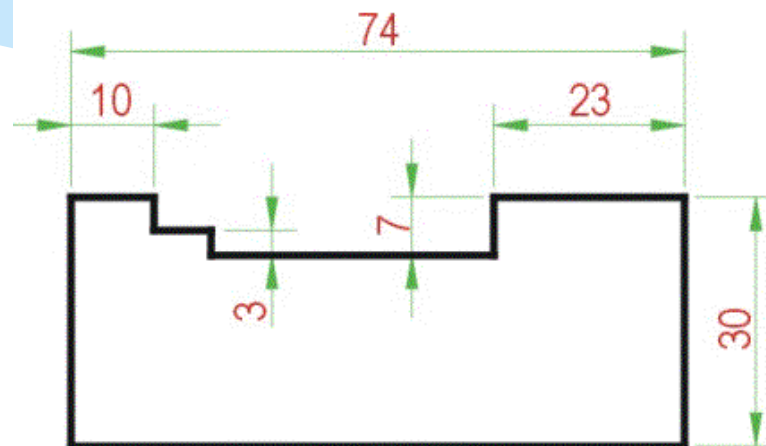


(b) 不良





尺度數字順尺度線橫書於尺度線上方中央

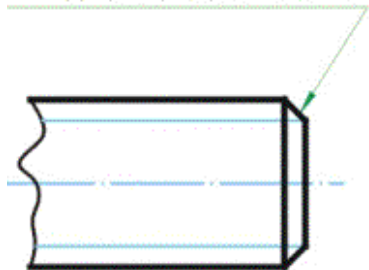


剖面線或中心線中斷讓開

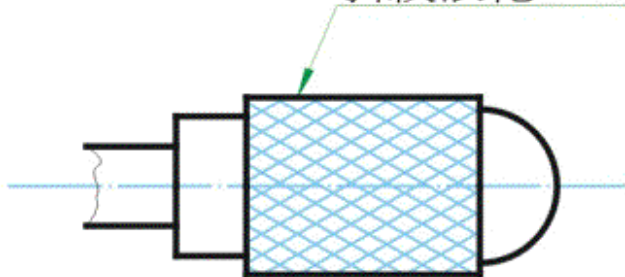
4-3指線與註解

- 1.導引註解說明至圖上之細實線
- 2.與水平線成 45° 或 60° ，帶有箭頭與標示位置接觸
- 3.避免與尺度線、尺度界線或剖面線平行
- 4.指線尾部為一水平線，註解文字在水平線上方，文字應與水平線等長

端部去角或呈扁圓
由廠商自行決定

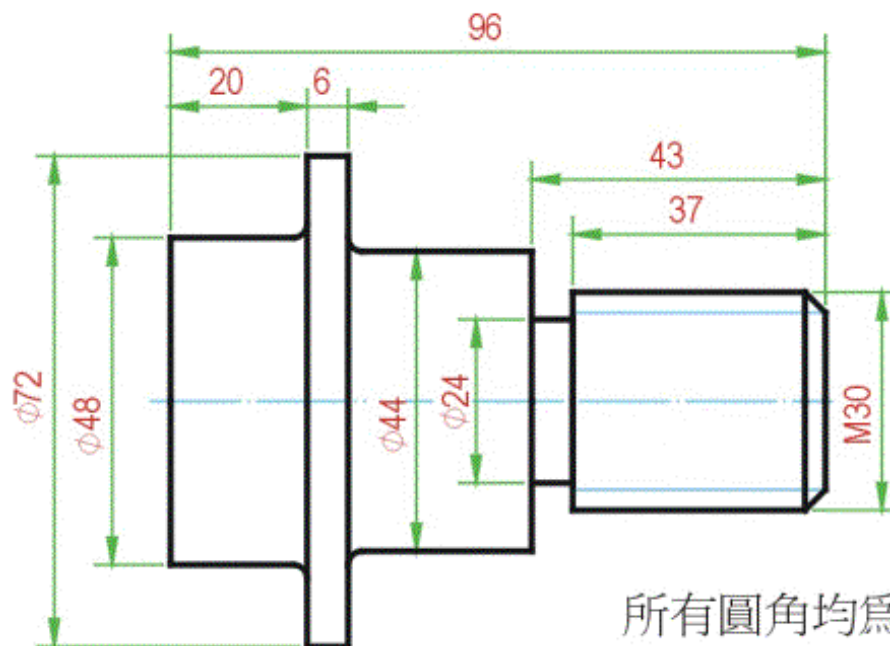


斜紋滾花1.2CNS75



註解：

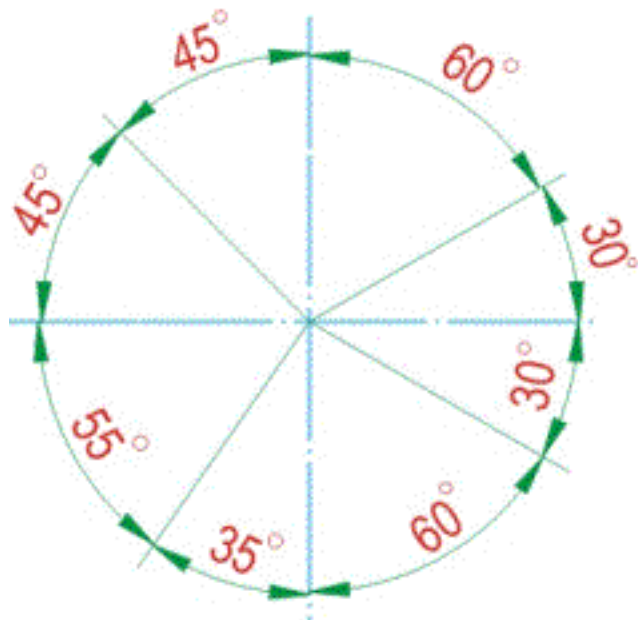
一般註解；專用註解



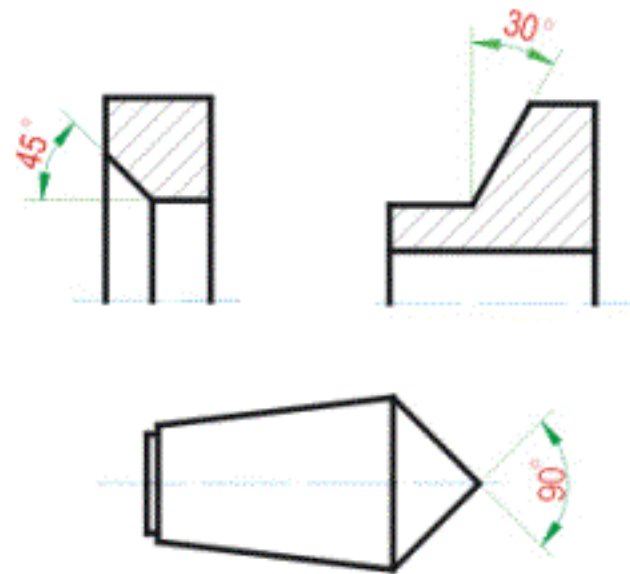
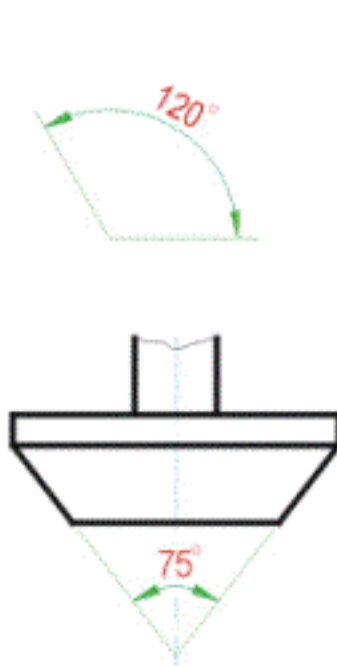
所有圓角均為 R2

一般註解

5-4 角度標註



角度度數的書寫方向

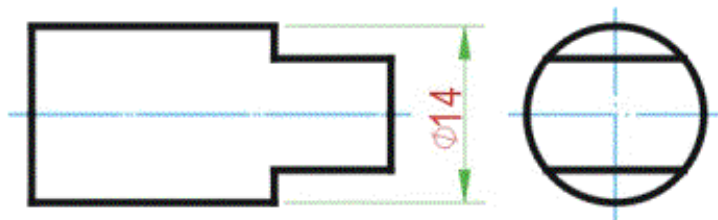


標註角度

4-5 直徑標註

$\varnothing 12$

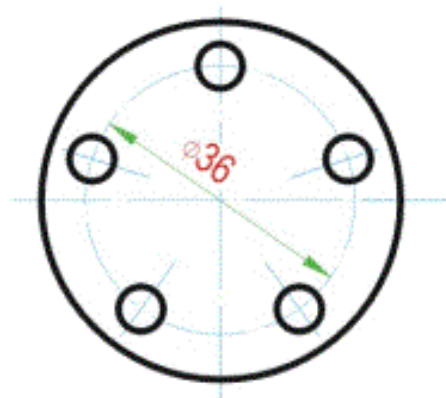
直徑符號之畫法



標註整個圓的直徑



僅有圓形視圖時標註圓的直徑



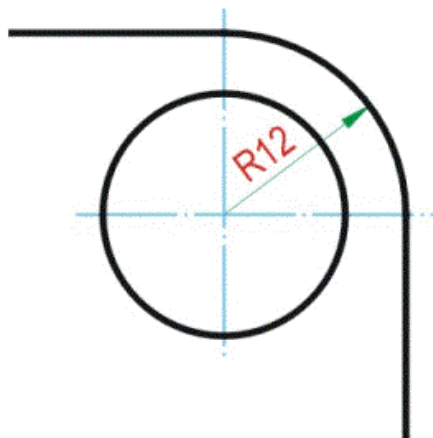
孔位圓的直徑標註

名 稱	符 號
直 徑	ϕ
半 徑	R
方 形	□
球 面 直 徑	S ϕ
球 面 半 徑	SR
錐 度	∇
斜 度	∇
板 厚	t
弧 長	—

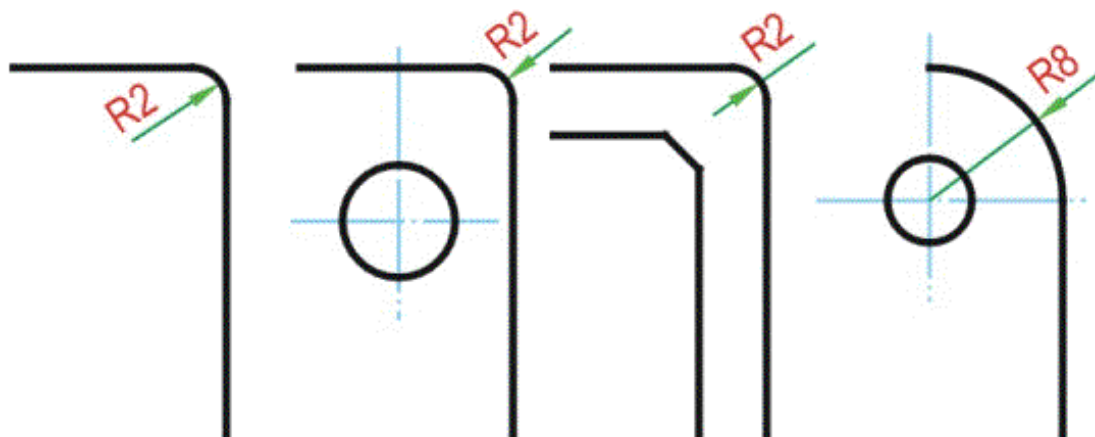
4-6 半徑標註

R5

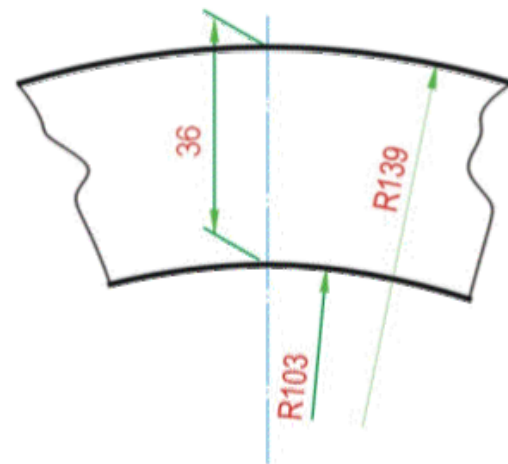
半徑符號之畫法



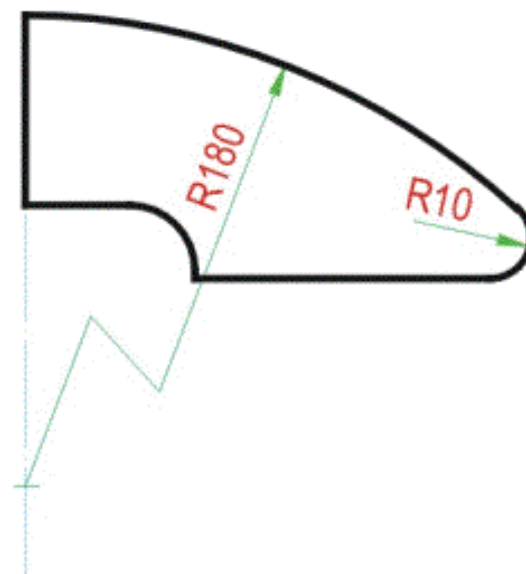
標註圓弧半徑



半徑過小時各種標註法

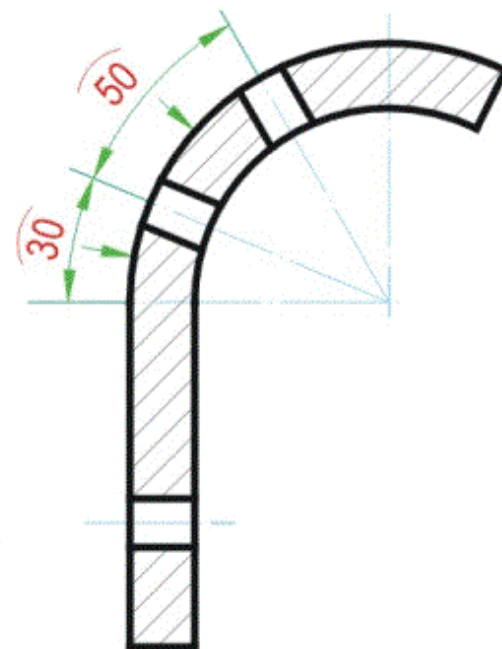
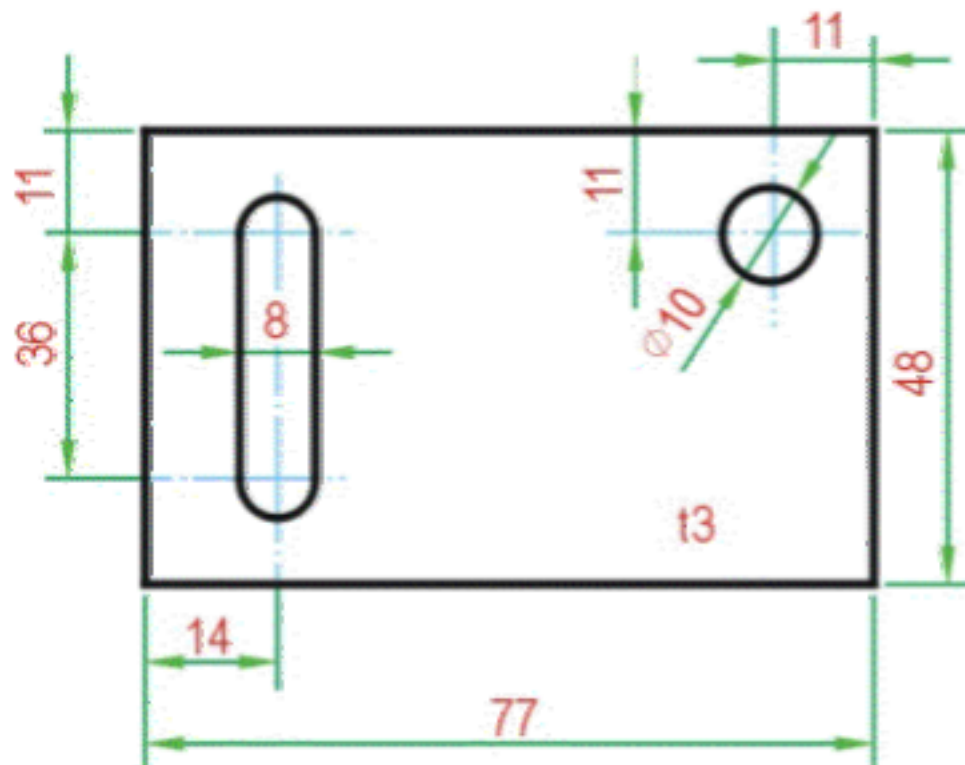


半徑過大時之標註法

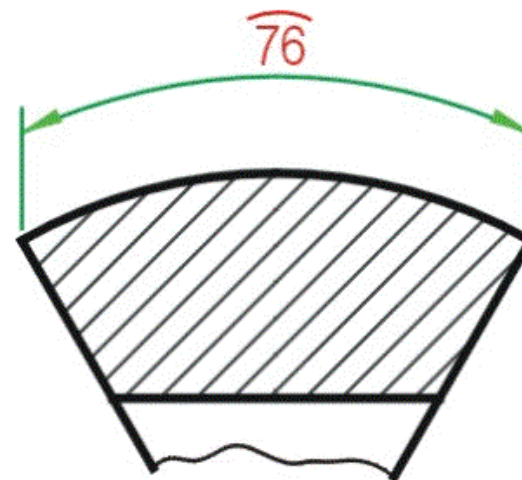


半徑大且須表出圓心位置時之標註法

4-7 厚度標註及弧長標註

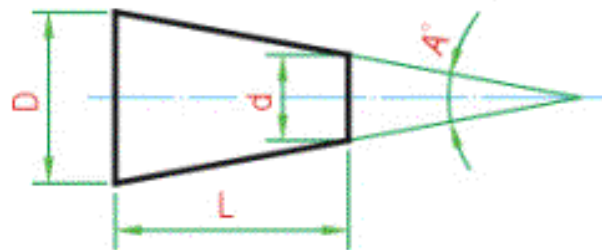


用半徑線之延長為尺度界線

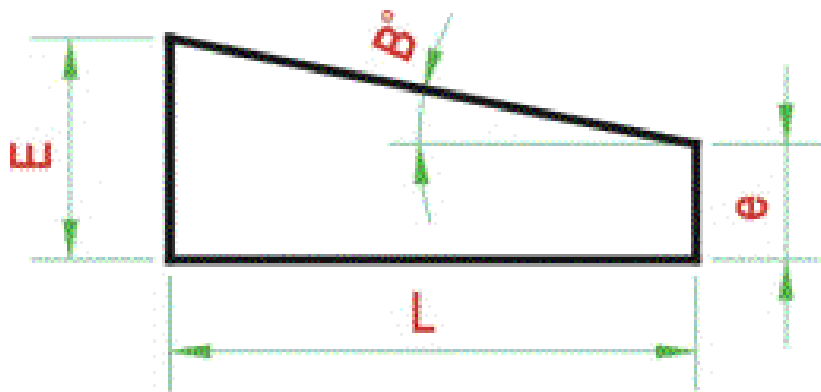
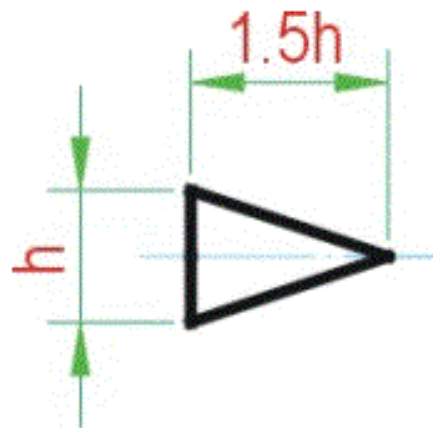


圓心角小於90°之一個弧長

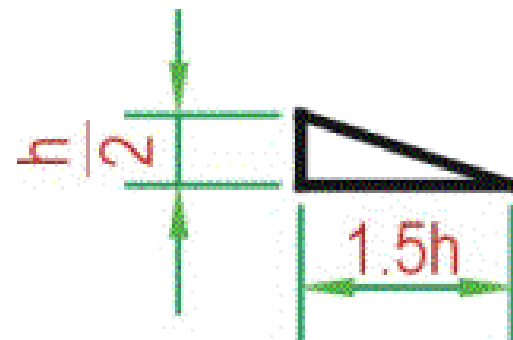
4-8 錐度標註及斜度標註



$$\text{錐度} = (D - d)/L = 2\tan(A/2)$$

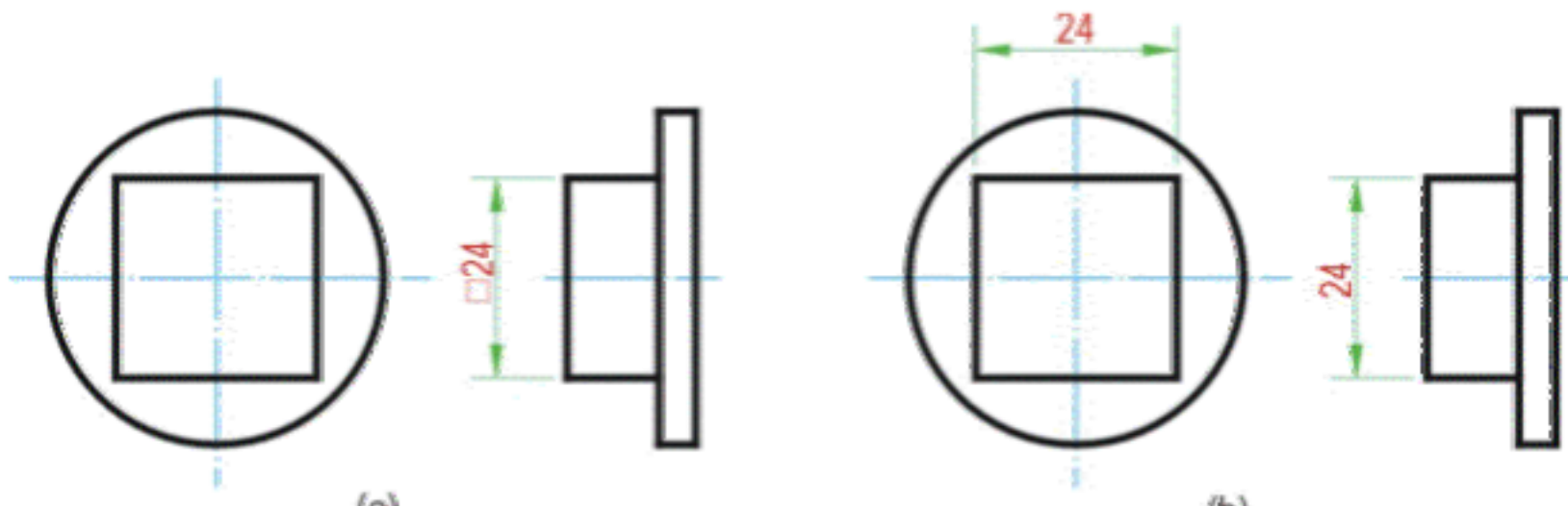


$$\text{斜度} = (E - e)/L = \tan B$$

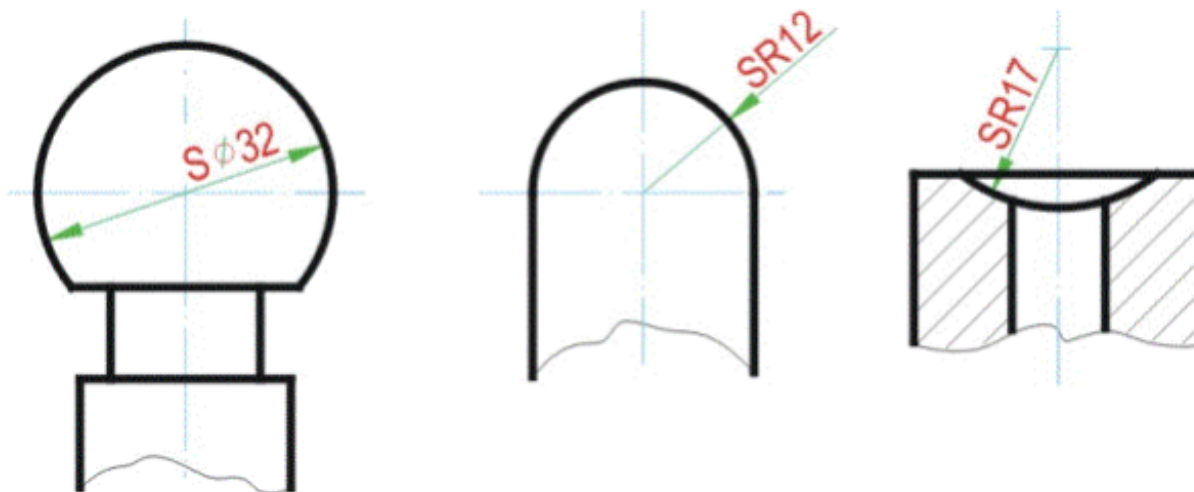


4-9 其他尺度標註方法

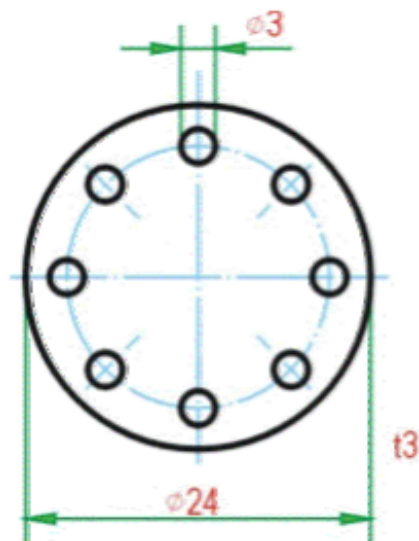
正六形



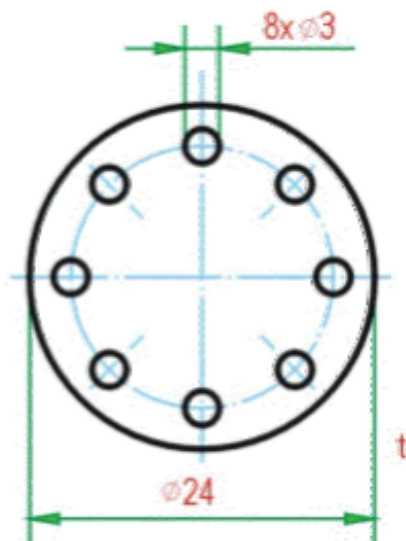
球面



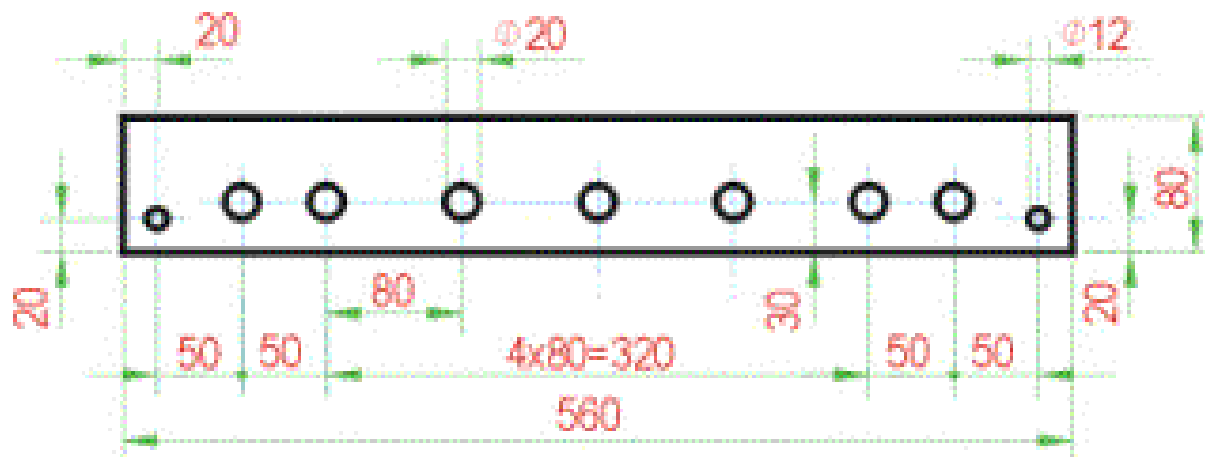
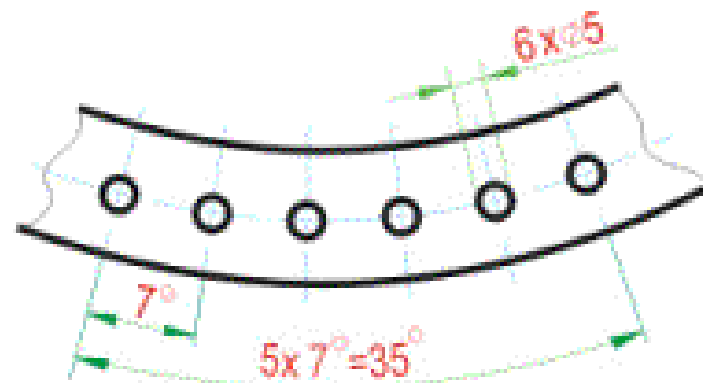
相同形態尺度標註



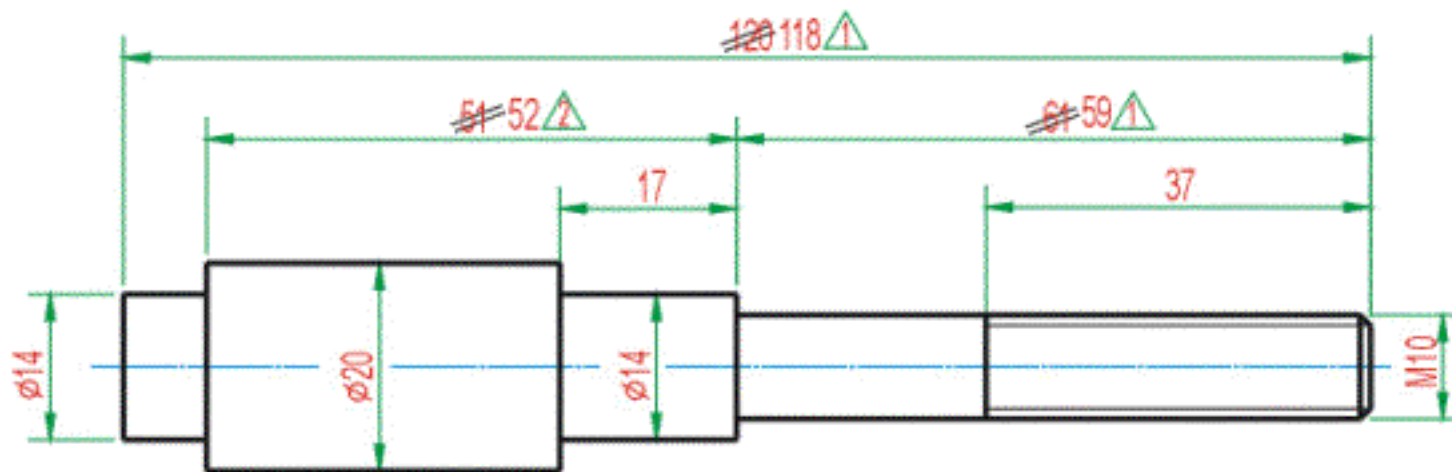
(a)



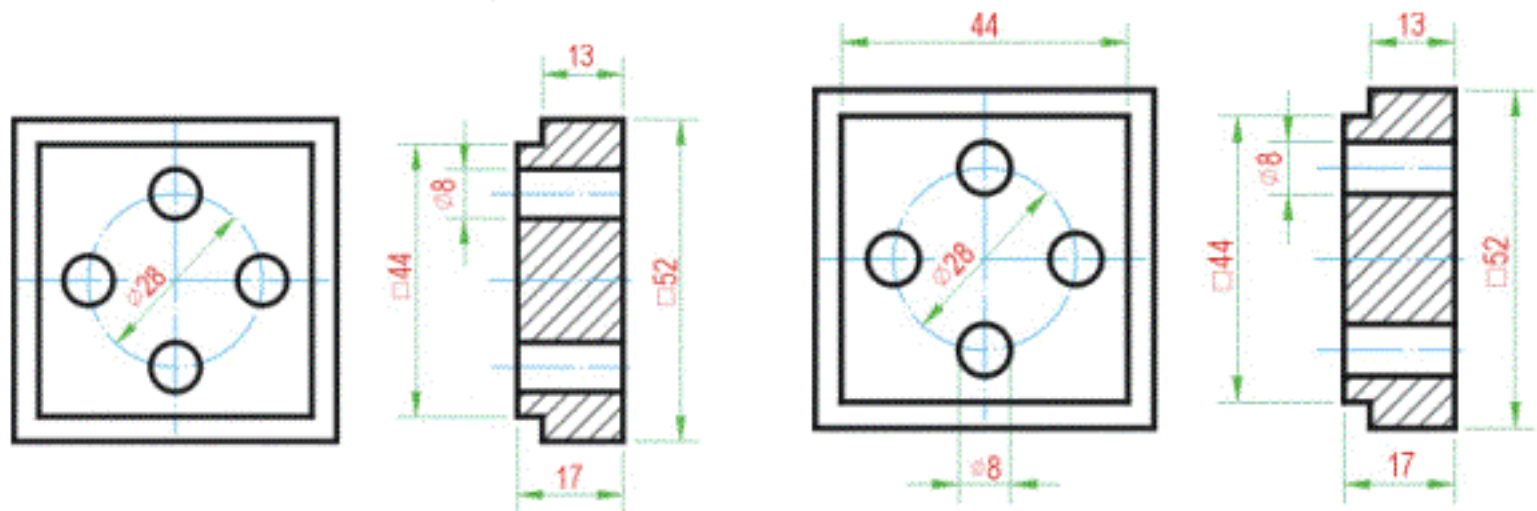
(b)



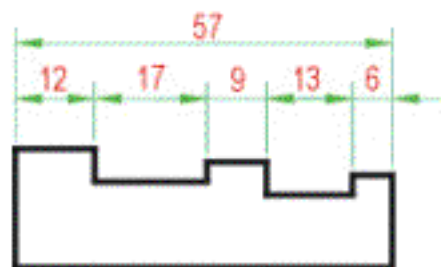
尺度更改標註



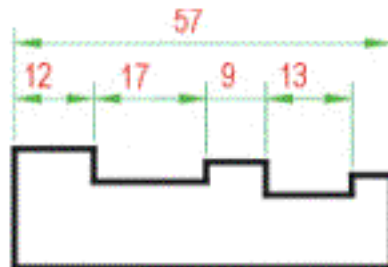
4-10 尺度重複與多餘



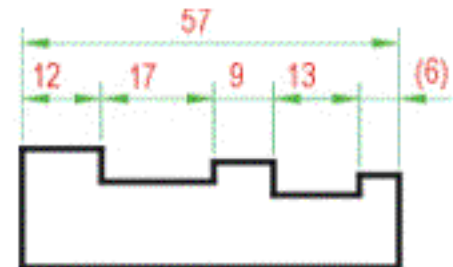
尺度之重複



(a) 有多餘尺度



(b) 選擇標註總寬度



(c) 參考尺度

多餘尺度或參考尺度

局部尺寸及尺度過小

