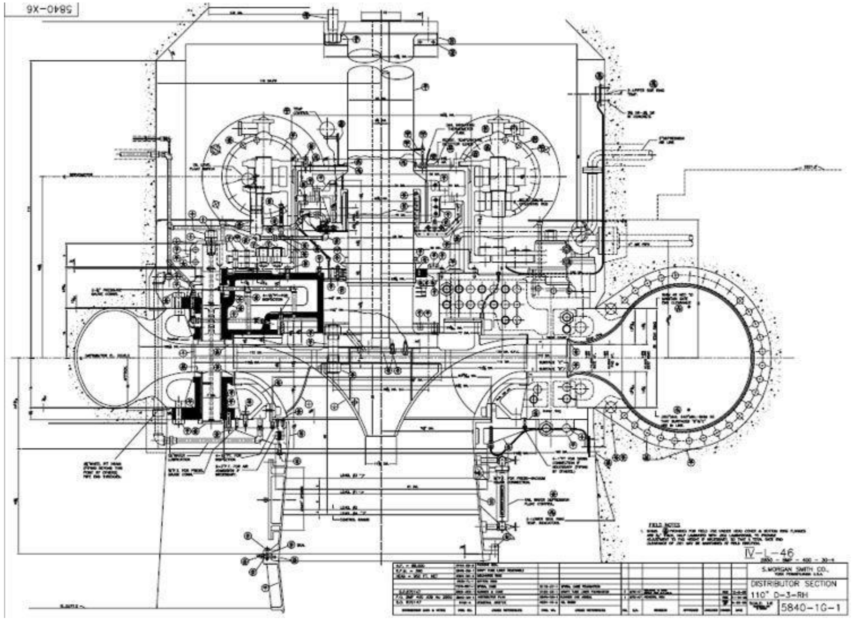
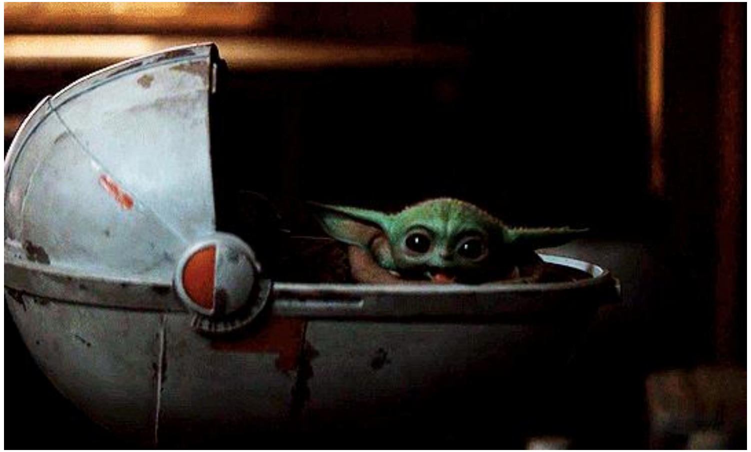
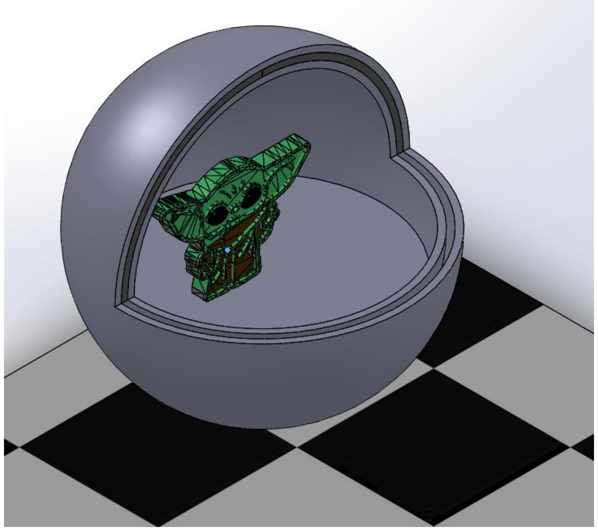
Engineering Drawings and Australian Standards



Before we get started…

- Each year I like to give a demonstration on how we utilise Solidworks to go from concept to assembly.
- Last year I made this little cutie!





What should I create during the CAD live demonstration?

“ need to creat a folder first ”

“ Safe ”

“ Iron Man Helmet! Bonus if it flicks up. ”

“ A pair of Jordans ”

Total Results: 150

Before we get started…

- Check out the following two announcements if you haven't already!
- Solidworks Templates and Engineering Drawings Documents
- Question Organiser

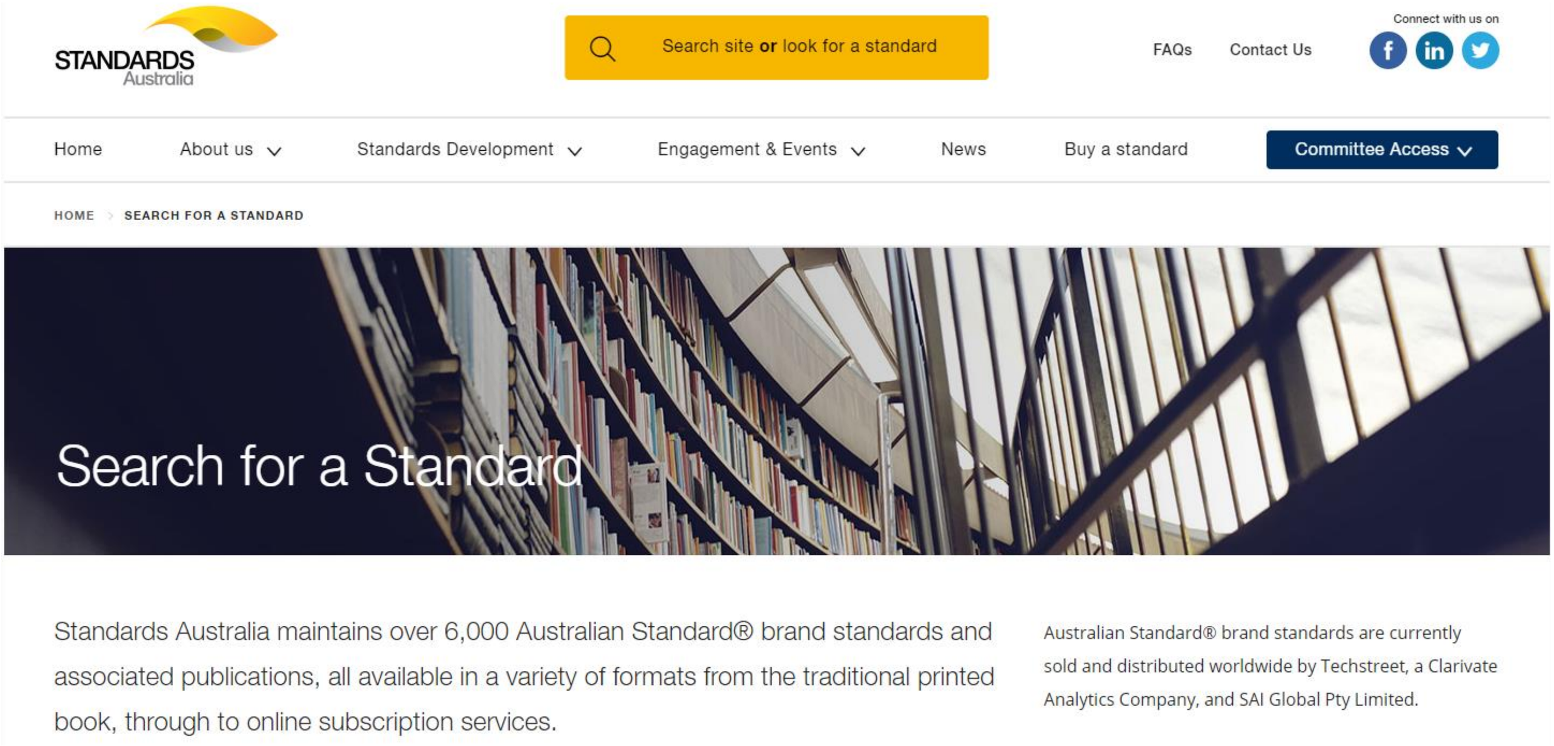
Topics

- Australian Standards
- Engineering Drawings
  - The Sheet and Title Block
  - Third-angle Views
  - The Scale
  - The use of Centre-lines
  - The Dimensioning Scheme
  - Tolerances
  - Callouts
  - Specification of Material
  - Specification of the Surface Finish

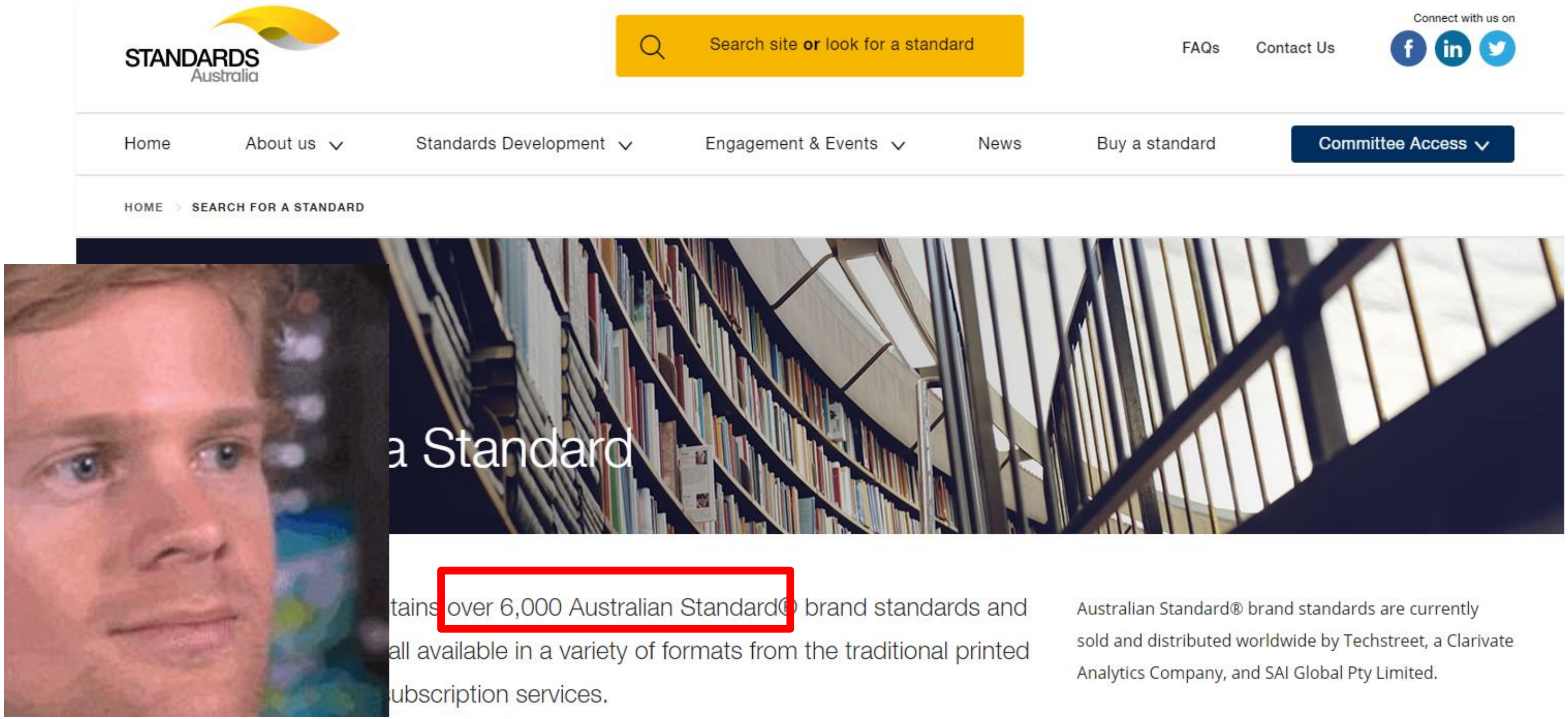
Australian Standards

- Australian Standards are the rules that govern what we can and cannot do in engineering.
- Before you are able to implement a solution, it must comply with the relevant Australian Standards.
- How many standards in Australia could there possibly be?

Australian Standards



Australian Standards



Australian Standards

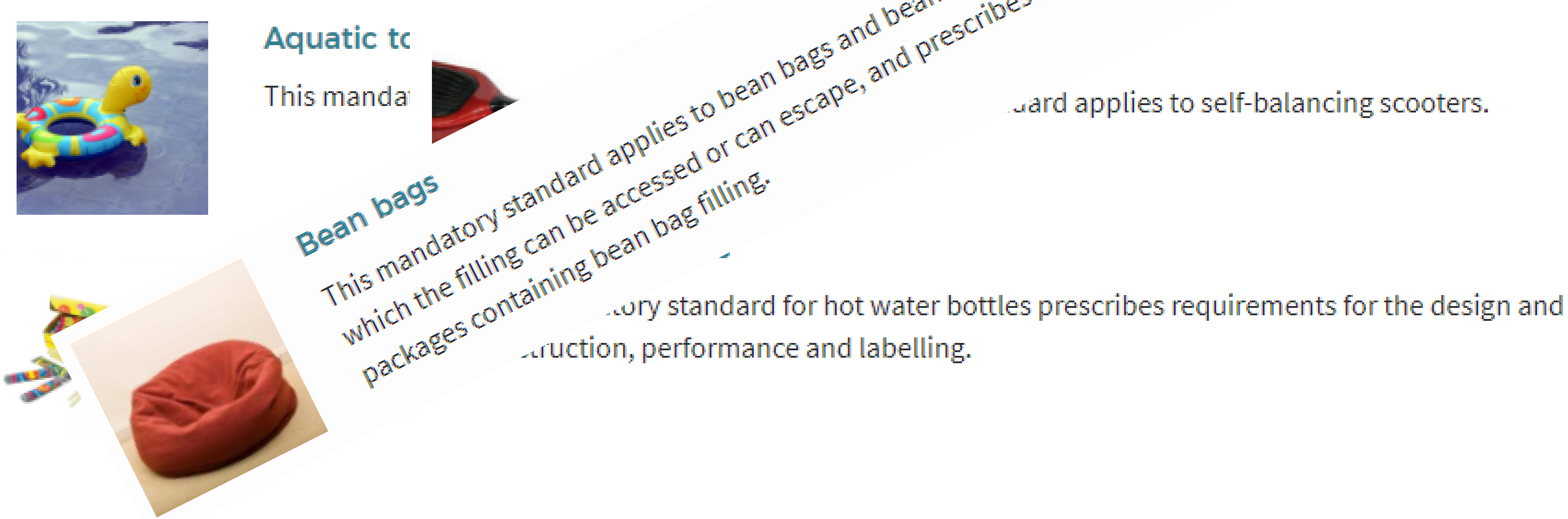
- That is a lot of standards!
- Essentially, for whatever you want to design, there will be multiple standards that need to be checked for compliance.
- For example, if you are building a toaster you would need to be compliant with at least (and this is not a full list)
  - AS/NZS 3100:2017 Approval and test specification - General requirements for electrical equipment
  - AS/NZS 60335.1:2011 Household and similar electrical appliances - Safety, Part 1: General requirements (IEC 60335-1 Ed 5, MOD)

Australian Standards

- But that's not all!
- There are other standards that may apply depending on what you want to engineer
  - For example, vehicle manufacture must comply with Australian Design Rules (ADR)
  - There are 96 ADRs for passenger vehicles

Australian Standards

- We still aren’t done!
- Product Safety Australia also has many mandator ... iety of various products like



Australian Standards

- The take home point here is that we must always be aware that our design will need to comply with various standards
- As engineers, it is our job to prove compliance!
- In third year, I usually ask my students to prove compliance for just ONE sub-section of a single standard.
- AS 1418.1-2002 – Cranes, hoists and winches – General requirements
  - 14 sections
  - Each section contains many, MANY requirements
  - 179 pages

Australian Standards

Minimum wire rope breaking load (AS1418.1, 7.16.2.2)

$$F_0 = S_R . Z_P$$

$$Z_P = \frac{F_0}{S_R}$$

$Z_p = minimum\ practical\ coefficent\ of\ utilisation$

$F_0 = 305\ kN\ (rope\ minimum\ breaking\ load)$

$S_R = 64\ kN\ (max. wire\ rope\ tension)$

$$Z_P\ actual = \frac{305\ kN}{64\ kN} = 4.766$$

Classification of mechanism, over a 10 year life cycle (Table 7.3.4.2):

Hoist speed – 0.22 m/s

Hoist lift distance – 3 m x 2 (up and down) = 6 m

Duration per lift = 6 m /0.22 m/s = 30 secs/lift

20 lifts of 3 tonnes/12 hr shift = 200 lifts per week = 1.7 hrs/week = 870 hrs/10 yrs

2 lifts of 29 tonnes/week = 1 min/week = 9hrs/10yrs

Total duration of use = 870+9 = 879 hours/10 years

Class of utilisation → T_3

State of Loading (Clause 7.3.4.3):

$$K_m = \Sigma\left[\frac{t_i}{t_T}\left(\frac{P_i}{P_{max}}\right)^{M_M}\right]$$

$$P_{max} = 29 tonnes = 290\ kN$$

$$M_M = 3$$

	Load 1	Load 2
t_i	870 kN	9 kN
t_T	879 kN	879 kN
P_i	3 tonnes = 3kN	29 tonnes = 290kN
$\frac{t_i}{t_T}\left(\frac{P_i}{P_{max}}\right)^{M_M}$	$\frac{870}{879}\left(\frac{30\ kN}{290\ kN}\right)^3 = 0.0012$	$\frac{9}{879}\left(\frac{290\ kN}{290\ kN}\right)^3 = 0.0102$

$$K_m = 0.011 \rightarrow L1 - Very\ Light\ (Table\ 7.3.4.3)$$

Group Classification of crane mechanisms (Table 7.3.4.4):

Minimum coefficient of utilization (Z_p) for reeved systems (Table 7.16.2.1)

M2 classification, $Z_P = 3.35$

$Satisfies: Z_p = 3.35 < Z_p actual = 4.766$

Why do standards in engineering matter?

" To ensure that the product is both effective and safe. "

" Safety "

" Allows for minimum safety requirements for each application or industry. "

Total Results: 205

Australian Standards

- Ensuring compliance is a massive pain… So why do it?
- We will spend a bit more time contextualising various standards in the tutorial this week
- The format will be a bit of pre-reading before the PSS
- I'll have a little mini presentation
- We will then engage in a bit of discussion around various themes and case studies

- Now, onto engineering drawings!

Engineering Drawings

- The advent of mass-production demanded more specific and precise specifications:
- It became more common for manufacturing to be undertaken remotely from the design office.
- The mass-production of parts meant that there were just too many parts to be hand-matched
- These days, in Australia and New Zealand, we use AS 1100 as our standard for engineering drawing.

AS 1100

- If you would like to torture yourself, feel free to download the standard through the library.
- First, head to https://subjectguides.library.unsw.edu.au/engineering
- Then, on the right-hand side of the screen click on Australian Standards (via SAI Global)
- Log in with your university credentials, and search for AS 1100.
- Download and enjoy all 85 pages

AS 1100

- Thankfully, we have created a condensed check list for you.
- As you progress through your career, this will all become second nature.
- But until it is… always go through each item and ensure that you comply with AS 1100.

MANUFACTURABILITY REVIEW
DRAWING CHECKLIST READING GUIDE
"Engineering Drawing", A. W. Boundy, McGraw Hill (8th Edition)

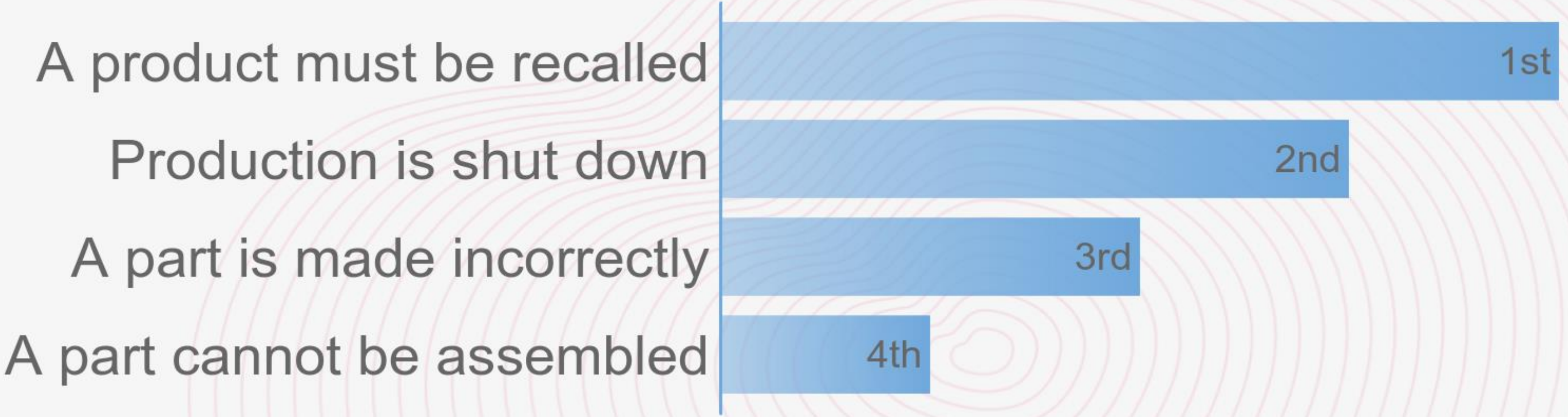
Orthogonal Drawing:	**Chapter**	**Page**
Is the drawing drawn in third angle projection?	6.2	p.146
Are the drawing views labelled appropriately (i.e. TOP VIEW, FRONT VIEW, etc?	6.2	p.147
Are the drawing view names (i.e. FRONT VIEW, TOP VIEW etc) centred under the respective drawing view?	6.2	p.147
Are capital letters used for the drawing view names?	1.3	p.8
Are centre lines and hidden lines shown in the drawing views?	1.4 6.3 10.1	p.9 p.150 p.280
Are there any redundant drawing views (i.e. do you have two drawing views that are the same)?	6.2	p.148
Is there an isometric view of the product/component appropriately placed on the drawing?	8.3	p.214

Title Block:	**Chapter**	**Page**
Are all the sections of the Title Block completed?	9.1	p.244
Is an appropriate Australian Standard drawing scale used (i.e. 1:1, 1:2, 5:1, etc)?	1.6 9.1	p.10 p.244
Is the type of material the component is made from specified?	9.1	p.244
Is your name **and** student number indicated in the Designed/Drawn by section of the title block?	9.1	p.244
Is checker name **and** student number indicated in the Checked/Check by section of the title block?	9.1	p.244
Is the date the drawing was completed indicated?	9.1	p.244
Is the name of the product/component specified (i.e. BASE, PISTON, etc)?	9.1	p.244
Is the drawing sheet size specified (i.e. A4, A3, A2, etc)?	1.7 9.1	p.11 p.244
Is a drawing number specified for the General Assembly and each component drawing?	1.8 9.1	p.13 p.244
Is a sheet number given for the General Assembly and each part drawing?	9.1-9.2	p.244
Are capital letters used to complete the various sections of the title block?	1.3	p.8
Dimensioning:	**Chapter**	**Page**
Is an appropriate dimensioning technique used (i.e. origin or Incremental dimensioning)?	2.1 4.1 6.3	p.20 p.78 p.151
Are there any double dimensions?	6.3	p.151
Are dimensions placed in ascending order (i.e. lowest to highest)?	2.1	p.23
Are threaded holes and shafts appropriately dimensioned?	2.3	p.34
Are counter bore and counter sunk holes appropriately dimensioned?	2.2	p.25-28
Are dimensions placed off the drawing views?	2.1	p.20
Are your dimensions easy to interpret (i.e. could someone else make your component if you gave them your drawing)?	6.3	p.151
Tolerances:	**Chapter**	**Page**
Are appropriate tolerances specified in the drawing?	4.1	p.66-78
Section View:	**Chapter**	**Page**
Is the Section view placed in accordance with third angle projection?	3.2	p.47
Have you specified where you sectioned the drawing with section arrows?	3.1	p.43
Are threads and shafts not sectioned?	3.1	p.43

Why Are Engineering Drawings Important?

- They are the ONLY way to get your ideas to become a reality.
- They are the sole reference used when manufacturing, fabricating and assembling designs.
- Any mistakes within the drawing can have significant consequences.
  - Such as?

Rank the following consequences of incorrect engineering drawings in order of severity



Total Results: 171

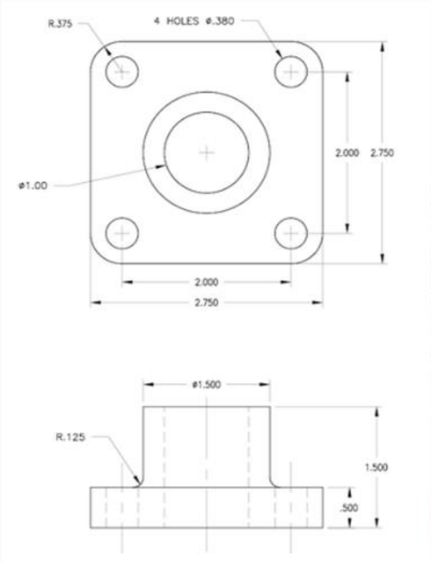
What makes up a good drawing?

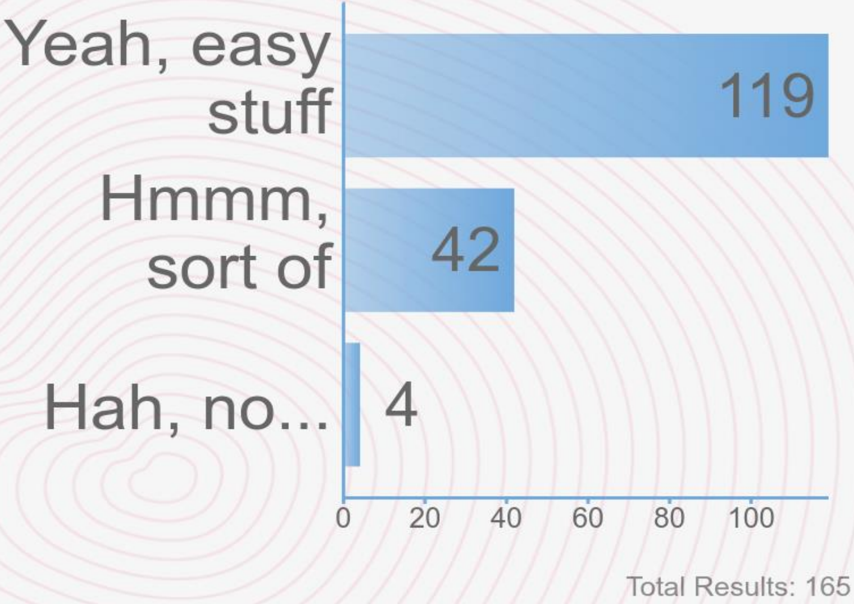
- Clear and easy to read
  - Has exactly what you need to understand the drawing, nothing more or less.

- Contains all the necessary information to manufacture/assemble the component/system
  - Not just dimensions but material type, processes and so on…

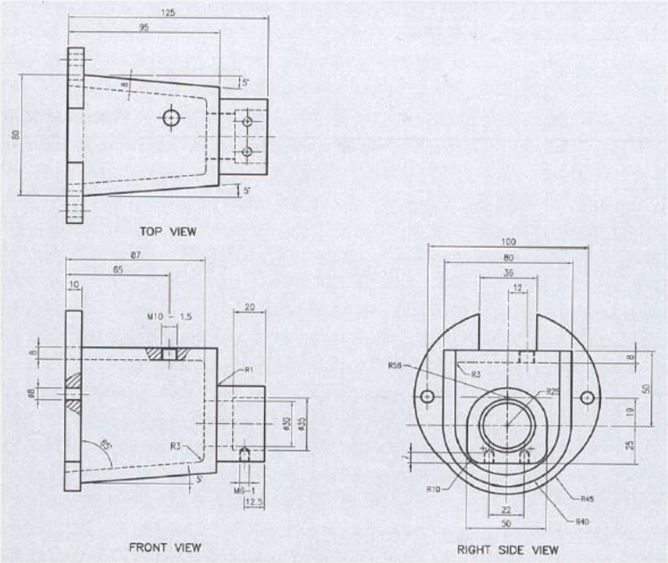
- Complies with the relevant standards
  - In Australia that is AS1100 – Technical drawing.

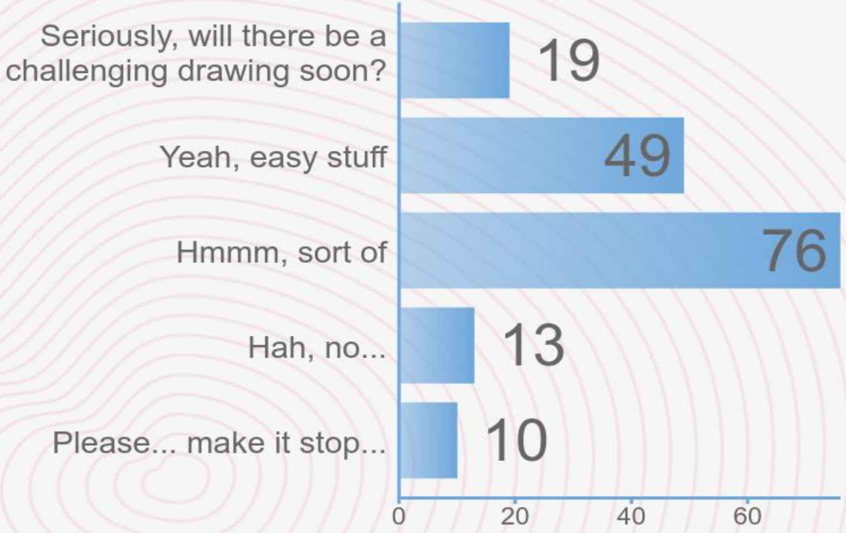
Can you visualise this part in three dimensions?





Can you visualise this part in three dimensions?





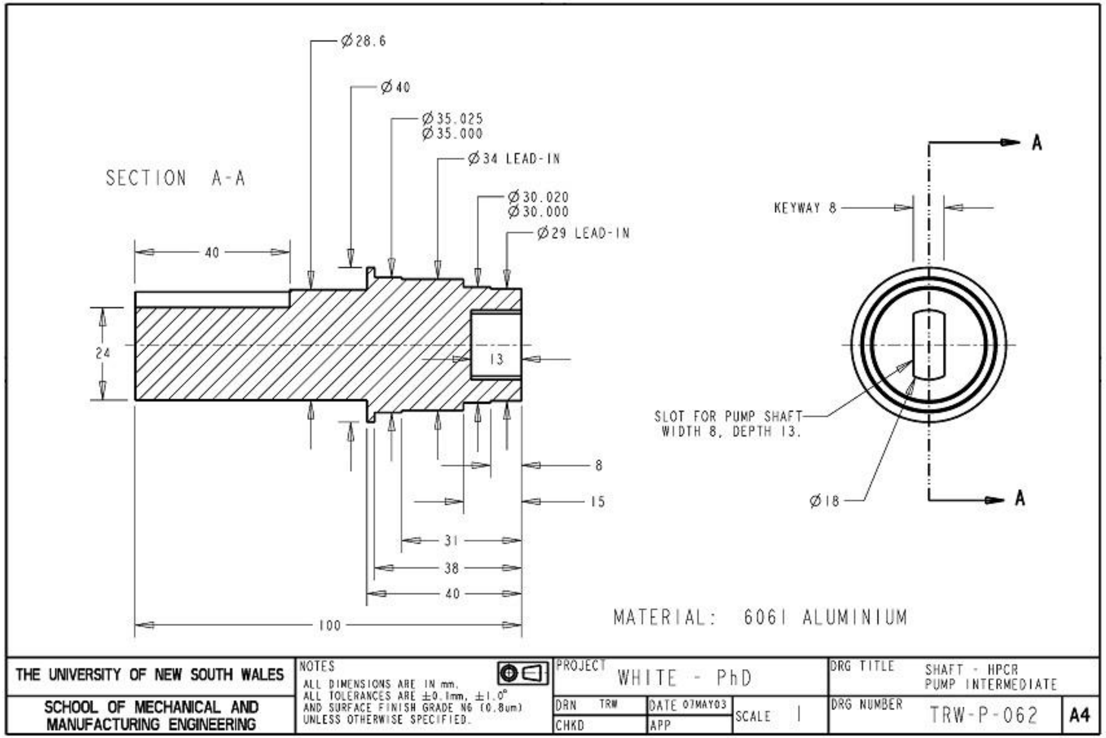
Total Results: 167

Powered by Poll Everywhere

Let’s have a look at an example

Let’s have a look at an example

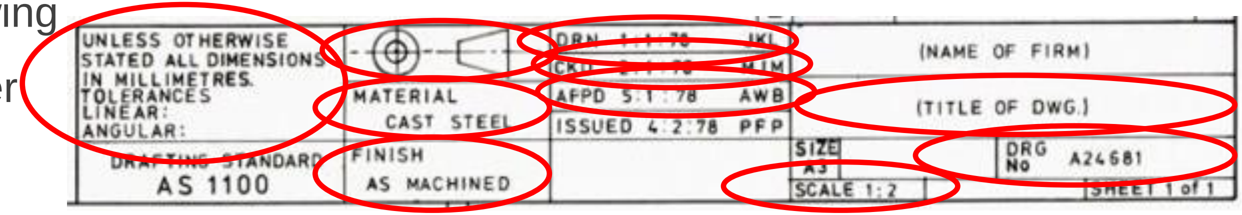
Let’s have a look at an example



- Title Block
- Third Angle Projection
- Dimensions
- Lines and symmetry
- Section views
- Scale
- Specification of Material
- Specification of Surface finish

Title Block

- The title block contains important information about the component such as
  - Projection type
  - The title of the drawing
  - The drawing number
  - Material
  - Surface finish
  - Scale
  - The draughtsman’s name
  - Who checked and approved the drawing
  - Tolerancing information



Third angle projection

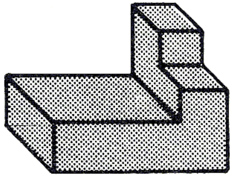
- Technical drawings use a technique called orthogonal projection to convey information about designs.

- In Australia, we use **third-angle projection** as a standardised drawing views.

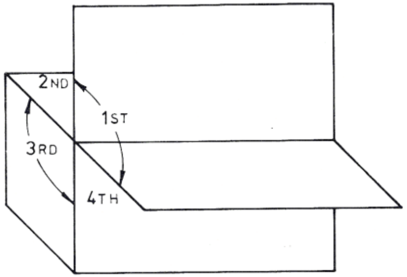
- ~~In Europe and Asia they tend to use **first-angle projection**~~

- But don’t worry about that, let’s just focus on what we do here!

How do we apply third-angle projection?



+



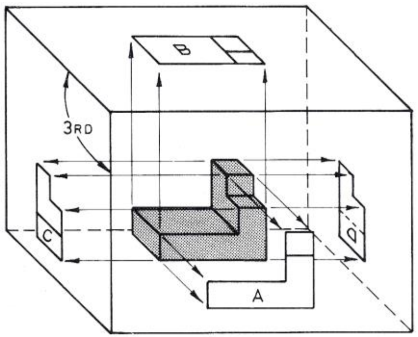
(a) the dihedral angles

The object

The three principal planes: horizontal, vertical and end (or profile)

How do we apply third-angle projection?

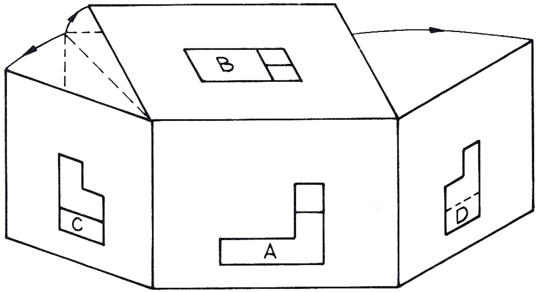
- Imagine the object is suspended in a glass box where the near and top sides represent the dihedral planes.
- The object is thus placed in the “third quadrant” and it is viewed **behind** and **below** the principal planes.
- Views of the object are projected **towards** and drawn on the principal planes.
- This is called **“third angle projection”**.



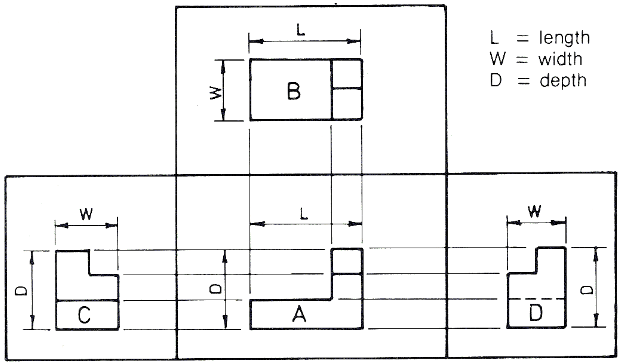
(b) third-angle projection box

How do we apply third-angle projection?

With Views A, B, C, D projected onto the principal planes….



(c) box unfolding

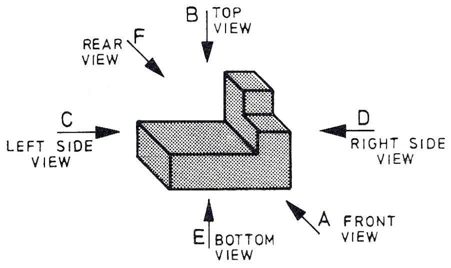


(d) box unfolded showing relative position of views

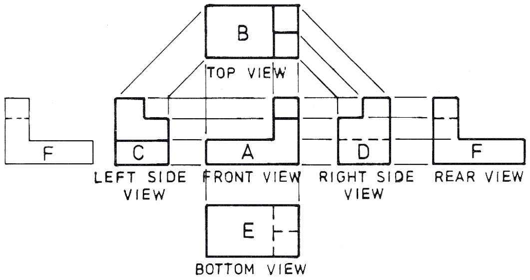
….the principal planes can be "folded out" so that all four views can be placed on one flat drawing sheet.

How do we apply third-angle projection?

- "Unfolding" the box sides 90° allows three views to be shown on one drawing sheet, i.e. **on one plane**.
- A good choice of **three views** will generally allow maximum detail to be seen….
- …Note though that the projection method allows all six faces of the object to be shown **if required**.



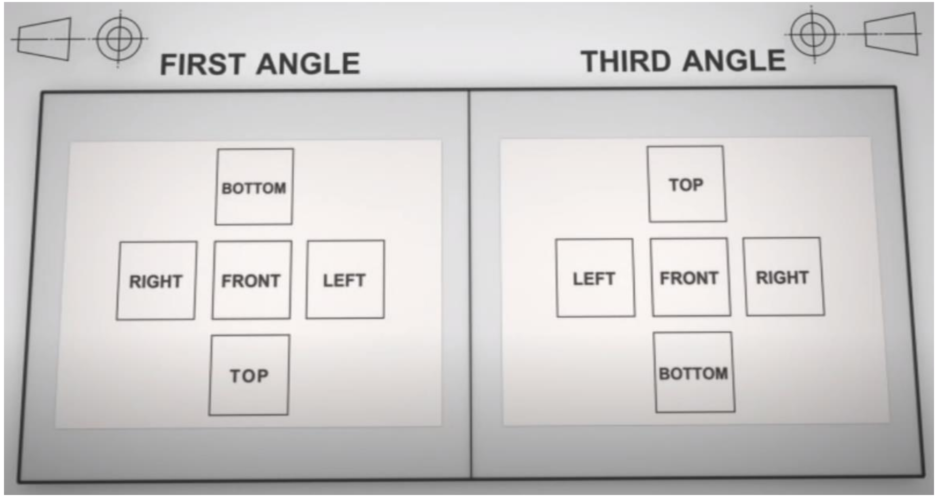
(e) designation of views



(f) placement of third-angle views

How do we apply third-angle projection?

- Whilst that is the technical explanation behind third-angle projection, there is a much easier way to visualise this.
- https://www.youtube.com/watch?v=bk2E8P33Ztc



Scale

- There are then **two main things** to note about the scale as it appears on an engineering drawing:

1. **The scale must be an accepted standard:**
   - Actual-size: 1:1
   - Reduction: 1:2, 1:5, 1:10, 1:20
   - Enlargement: 2:1, 5:1, 10:1, 20:1

Scale

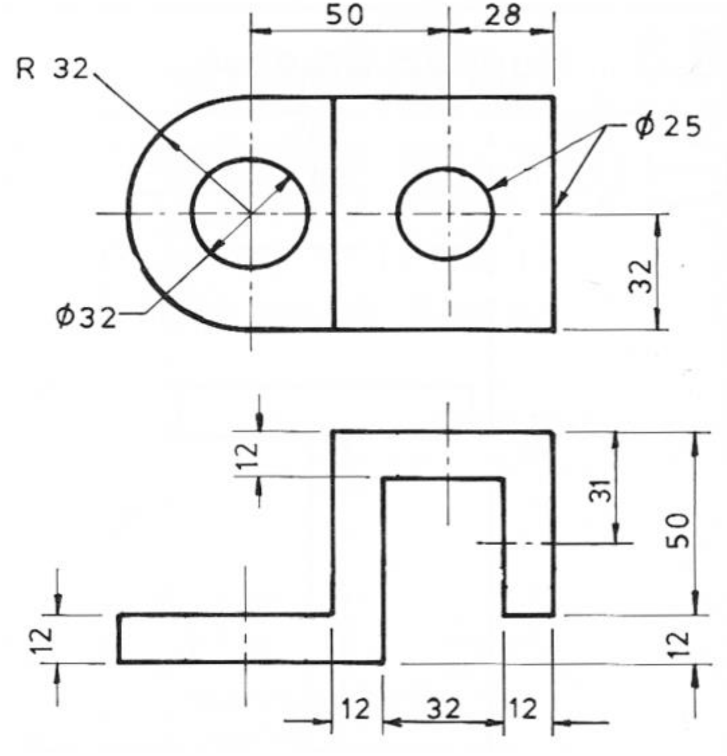
- There are then **two main things** to note about the scale as it appears on an engineering drawing:

2. The scale is not there to be measured from.

- A scale is almost always put on an engineering drawing
- Like on a printed map, it is there for quick reference only
- You will often see the words DO NOT SCALE on a drawing. This serves as a reminder that an engineering drawing conveys very precise information.

Centre-lines

- Centre-lines are used to denote an axis of symmetry as well as holes.
- Centre lines should extend for a short distance beyond the feature unless they are required for dimensioning or other purpose.
- Centre lines should **not extend** through the spaces **between views** and should never terminate at another line on the drawing.



Dimensions

- Dimensions must be placed so they are clearly distinguishable, readable and completely unambiguous.
  - Outlines are **thick black** Type A lines which stand out.
  - Dimension and projection lines **are thin black** Type B lines.
  - Centre lines are **thin short dash – long dash**.

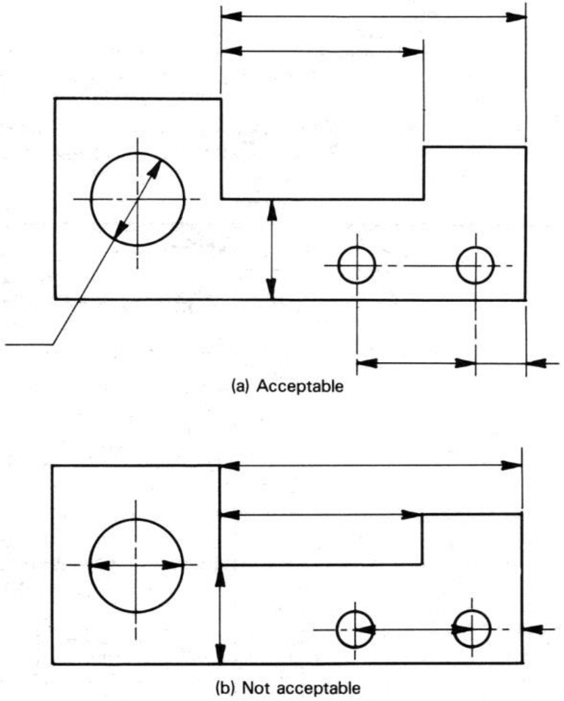


Fig. 9.7 — Centre-lines and extension lines not used as dimension lines.

Dimensions

- Dimension and leader lines must not touch outlines (a gap of 1-2 mm is recommended) or hide centerlines.
- Don’t stress too much though, CAD packages do almost all the work these days

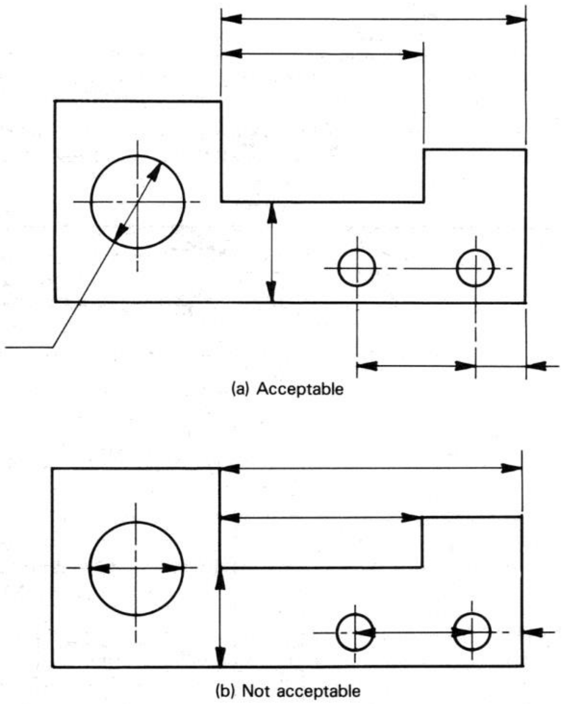


Fig. 9.7 — Centre-lines and extension lines not used as dimension lines.

Dimensioning Strategy

1. Every dimension that is **necessary** to completely define the size and shape of the object must be shown.

2. There must be **no duplication** of any dimension (even across views).

   – This is known as redundant dimensioning

   – It should not be necessary to deduce (calculate) a dimension.

   – It is permissible to add a (redundant) overall dimension, in brackets, as a “reference dimension”, without tolerances, for information only.

Dimensioning Strategy

3. Avoid “chain dimensioning”. Instead, try to **dimension from datums** (datum points or datum planes).

4. The datum points or planes chosen should be **important to the** function of the component.

Dimensioning Strategy

a) Chain dimensions. Avoid this method.

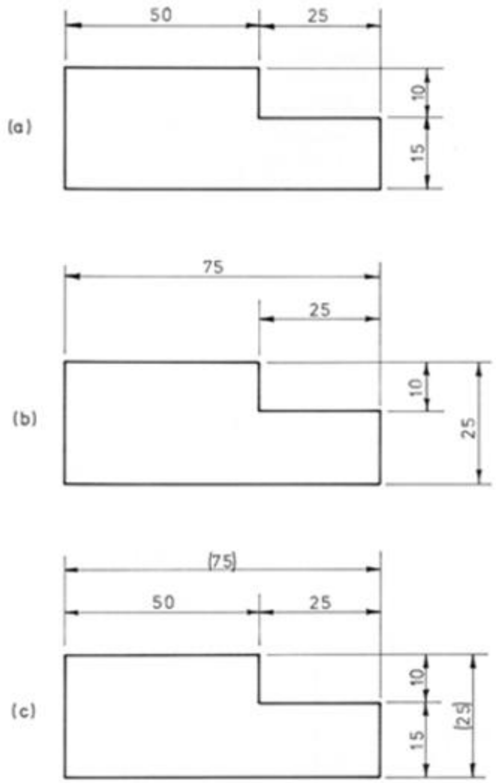
- We'll see why in a few minutes when we discuss tolerancing.

b) Dimensions from datum planes. This is the preferred method.

- It usually simplifies manufacturing.

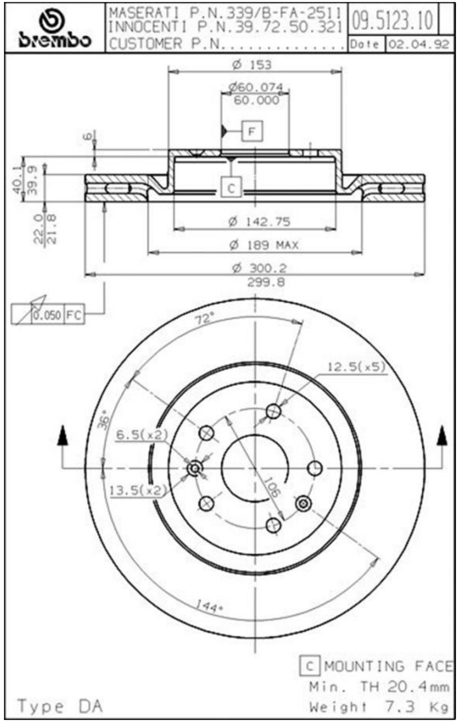
c) Chain dimensions with reference dimensions in brackets.

- Reference dimensions can be useful to over-view a part



Tolerances

- When a part is being manufactured, the raw material usually goes through several forming and/or machining processes before it becomes a finished component of the correct size.
- The dimensions on a drawing are there to specify the final size of the part in question....
- **….and how close a final dimension on a part needs to be to that specified on the drawing is called the tolerance.**

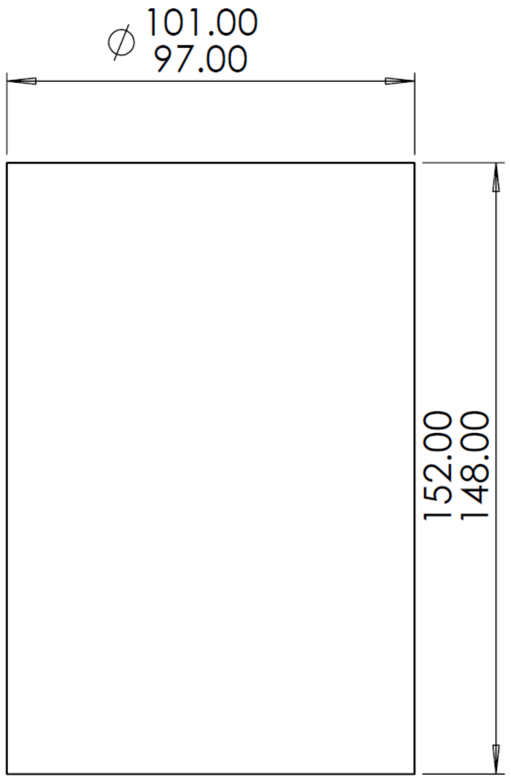


Tolerances

- A tolerance on a given dimension is the **allowable variation** in the size of that dimension. Tolerances on a drawing most often take the form of one of three types:

- **Limits:** The tolerance is shown by providing lower and upper dimension limits

- This component is acceptable if
  - Its actual length lies between 148.0 and 152.0 mm.
  - Its actual diameter lies between 97 and 101 mm.

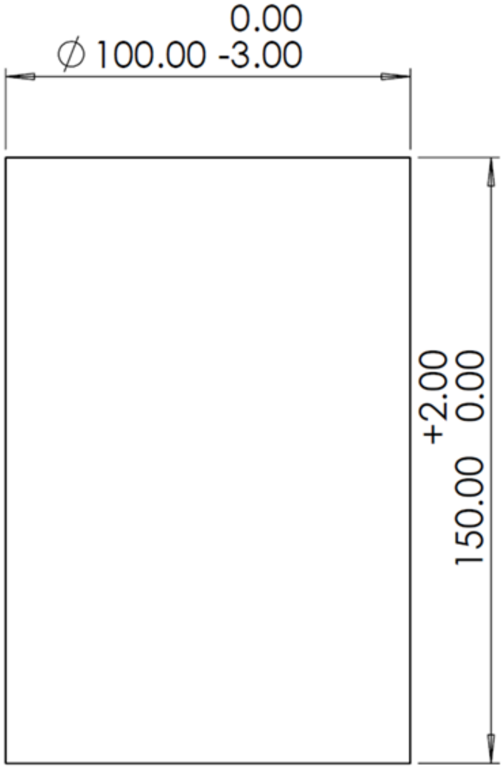


Tolerances

- A tolerance on a given dimension is the **allowable variation** in the size of that dimension. Tolerances on a drawing most often take the form of one of three types:

- **Unilateral:** This tolerance specifies a lower OR upper deviation from the basic dimension.

- This component is acceptable if
  - Its actual length lies between 150.0 and 152.0 mm.
  - Its actual diameter lies between 97.0 and 100.0 mm.

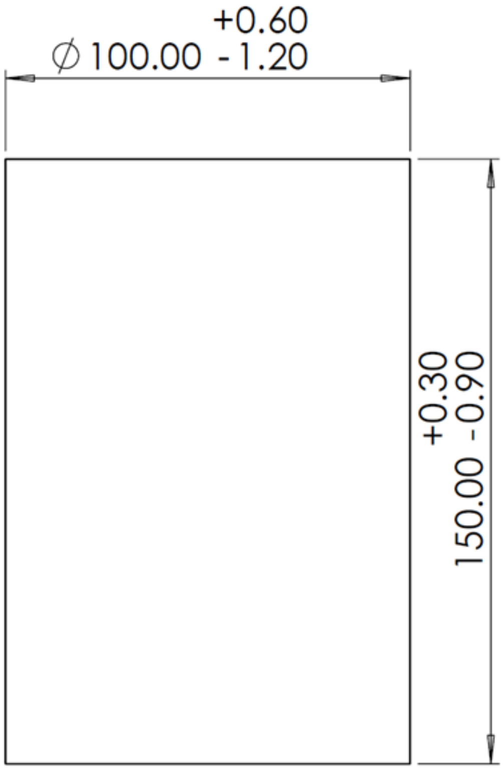


Tolerances

- A tolerance on a given dimension is the **allowable variation** in the size of that dimension. Tolerances on a drawing most often take the form of one of three types:

- **Bilateral:** This tolerance specifies a lower and upper deviation from the basic dimension.

- This component is acceptable if
  - Its actual length lies between 149.1 and 150.3 mm.
  - Its actual diameter lies between 98.8 and 100.6 mm.



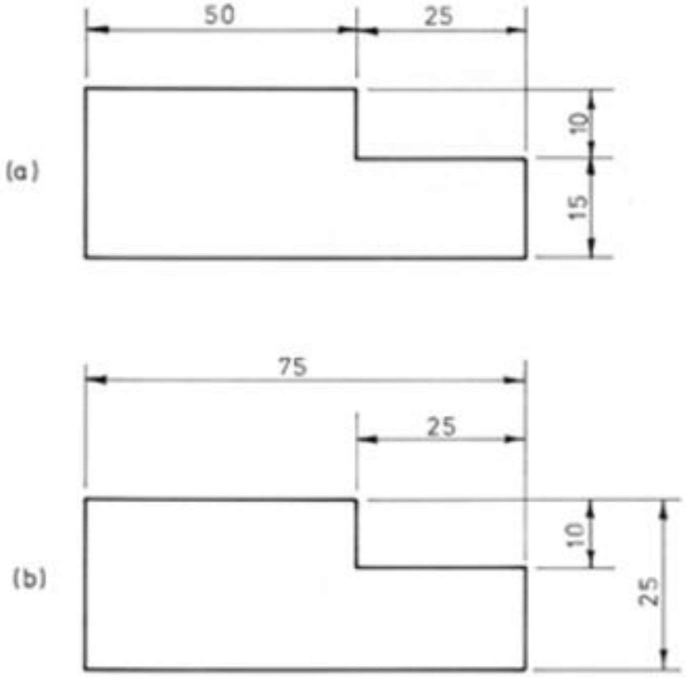
Which dimensioning scheme would cause more errors/issues? Assume all dimensions have a tolerance of ±1 mm

Total Results: 152

Tolerances

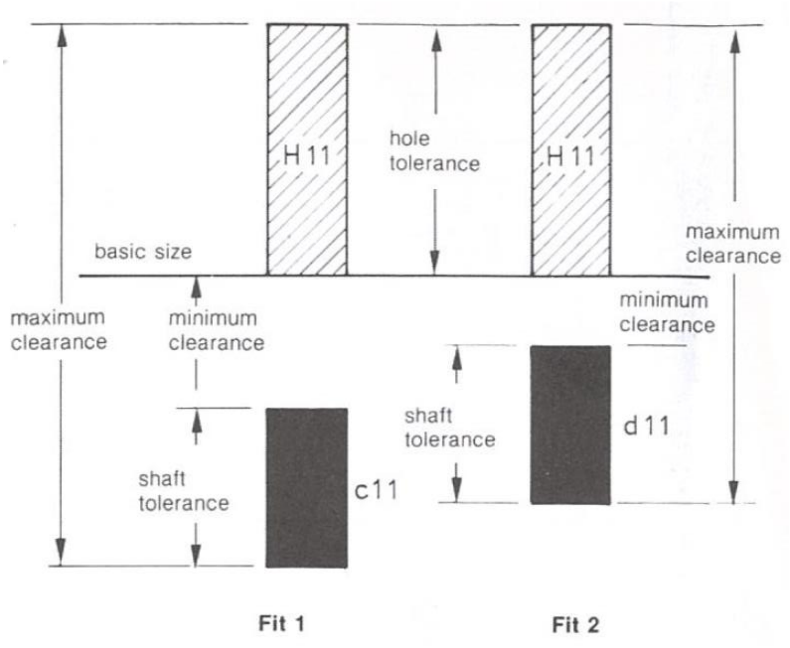
The Evils of Chain Dimensioning

- In the example from Boundy, let's say **the tolerance on all the dimensions is +/- 1.0 mm**.
- For (a), which is chain dimensioned, the allowable overall length is then 75 ± 2.0.
- For (b), dimensioned from datum planes,
- The allowable overall length is 75 ± 1.0.
- ***Note the importance of carrying-out a "tolerance stack-up" when designing a part.***



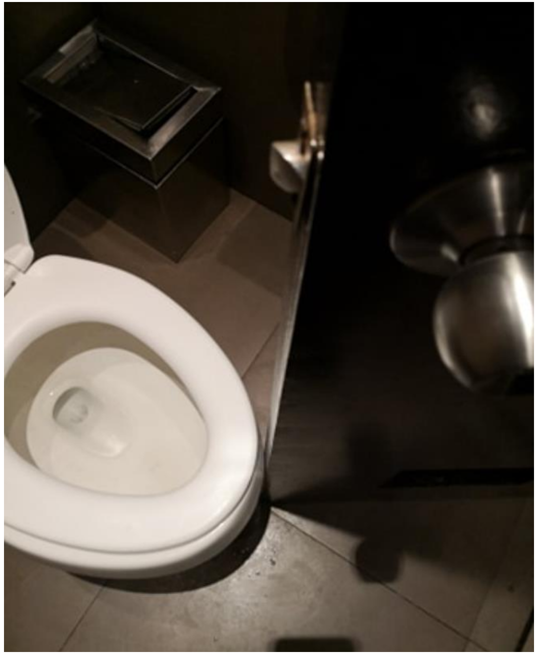
Tolerances

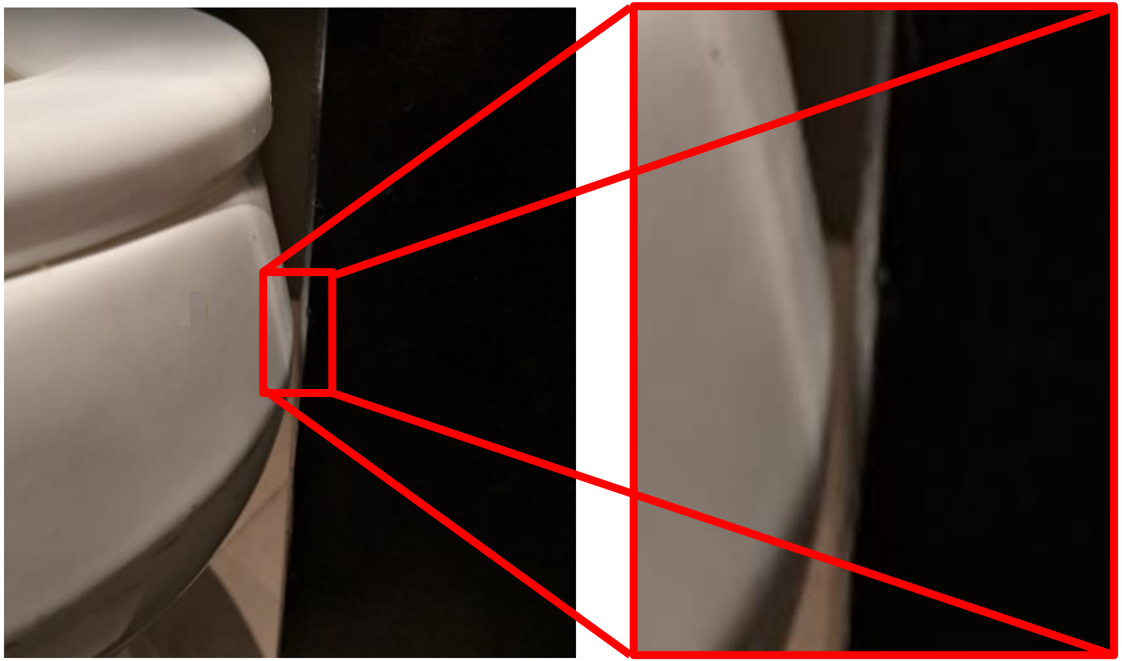
- There are also other tolerancing systems that we need to understand like the hole-shaft basis system
- Depending on the application will determine whether we use a Hole basis or a Shaft basis
- This will be covered in more detail in Hole Making and Turning Processes.



Tolerances

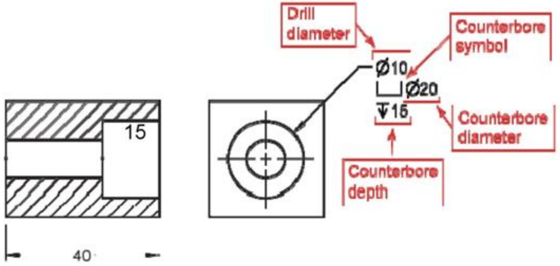
- Here is an example of precision engineering I encountered while over in the Philippines.

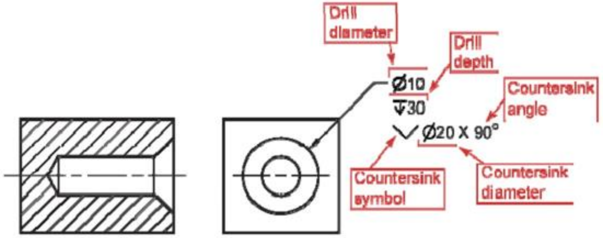


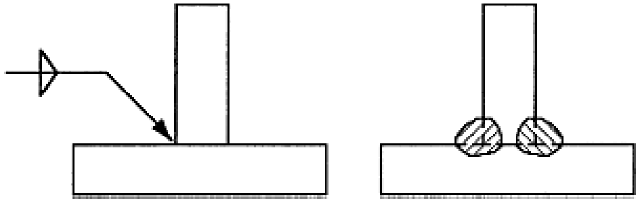


Callouts

- Whenever we have special features in a drawing, we need to use callouts.
- Features that need callouts include
  - radius
  - fillets
  - threading
  - holes
  - tapped holes
  - countersinking/counterboring
  - welding
- We will focus on call outs more in other lectures.







Material Specification

- It might seem pretty obvious that you need specify what to actually make the part out of…. but lots of people forget to!
- **Make sure you fully specify the material.**
- “Mild steel” is okay if you need a steel part and the strength and other material properties aren’t critical.
- Aluminium should always have its alloy specified
  - e.g. Al 5051, Al 2011.
- Carbon and stainless steels should also have their alloys specified.
  - e.g. AISI 1020, SS 316 etc.
- If the part is to be made from plastic, specify which kind.
  - e.g. Nylon, Delrin, PTFE etc.

Surface Finish

- We learnt about surface finish the other day; it is incredibly to convey this information to the machinist in a drawing

- In many cases the surface finish is not critical, e.g. the “natural” finish from the sand- or die-casting process is okay.

- However, for certain parts it is critical to have a very good surface finish.
  - Piston housing in an engine

- If it is possible to achieve a great surface finish, why don’t we do it for all parts?

Why don't we specify the highest quality surface finish for all parts we manufacture?

Total Results: 178

Powered by Poll Everywhere

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Surface Finish

$$$$$$$

$$

R_a value (μm)		Process and application
0.025 or 0.025 and 0.05 or 0.05	very fine quality surface finishes, costly to produce	This very smoothly finished surface is produced by fine honing, lapping, buffing or super-finishing machines. It is costly to produce and seldom required. It has a highly polished appearance, depending on the production process, and is normally used on precision instruments such as gauges, laboratory equipment and finely made tools.
0.1 or 0.1		This is similar to the finer grades of finish and has much the same application. Very refined surfaces have this high degree of finish. It is produced by honing, lapping and buffing methods and is costly to produce.
0.2 or 0.2		This fine surface is produced by honing, lapping and buffing methods. This texture could be specified on precision gauge and instrument work, and on high speed shafts and bearings where lubrication is not dependable.
0.4 or 0.4		This fine quality surface can be produced by precision cylindrical grinding, coarse honing, buffing and lapping methods. It is used on high speed shafts, heavily loaded bearings and other applications where smoothness is desirable for the proper functioning of a part.
0.8 or 0.8	medium quality finishes, used where reasonable surfaces are required	This first-class machine finish can be easily produced on cylindrical, surface and centreless grinders but requires great care on lathes and milling machines. It is satisfactory for bearings and shafts carrying light loads and running at medium to slow speeds. It may be used on parts where stress concentration is present. It is the finest finish that it is economical to produce; below this costs rise rapidly.
1.6 or 1.6		This good machine finish can be maintained on production lathes and milling machines using sharp tools, fine feeds and high cutting speeds. It is used when close fits are required but is unsuitable for fast rotating members. It may be used as a bearing surface when motion is slow and loads are light. This surface can be achieved on extrusions, rolled surfaces, die castings and permanent mould castings in controlled production.
3.2 or 3.2		This medium commercial finish is easily produced on lathes, milling machines and shapers. A finish commonly used in general engineering machining operations, it is economical to produce and of reasonable appearance. It is the roughest finish recommended for parts subjected to slow speeds, light loads, vibration and high stress, but it should not be used for fast rotating shafts. This finish may also be found on die castings, extrusions, permanent mould castings and rolled surfaces.
6.3 or 6.3	rough finishes, used where quality surfaces are unimportant	This coarse production finish is obtained by taking coarse feeds on lathes, millers, shapers, boring and drilling machines. It is acceptable when tool marks have no bearing on performance or quality. This texture can also be found on the surfaces of metal moulded castings, forgings, extruded and rolled surfaces, and can be produced by hand filing or disc grinding.
12.5 or 12.5		This surface is produced from heavy cuts and coarse feeds by milling, turning, shaping, boring, disc grinding and snagging. It can also be obtained by sand casting, saw cutting, chipping, rough forging and oxy cutting. This finish is rarely specified and is used only where it is not seen or its appearance is unimportant, e.g. on machinery, jigs and fixtures.
25		This very rough finish is produced by sand casting, torch and saw cutting, chipping and rough forgings. Machining operations are not required as this finish is suitable as found, e.g. on large machinery.

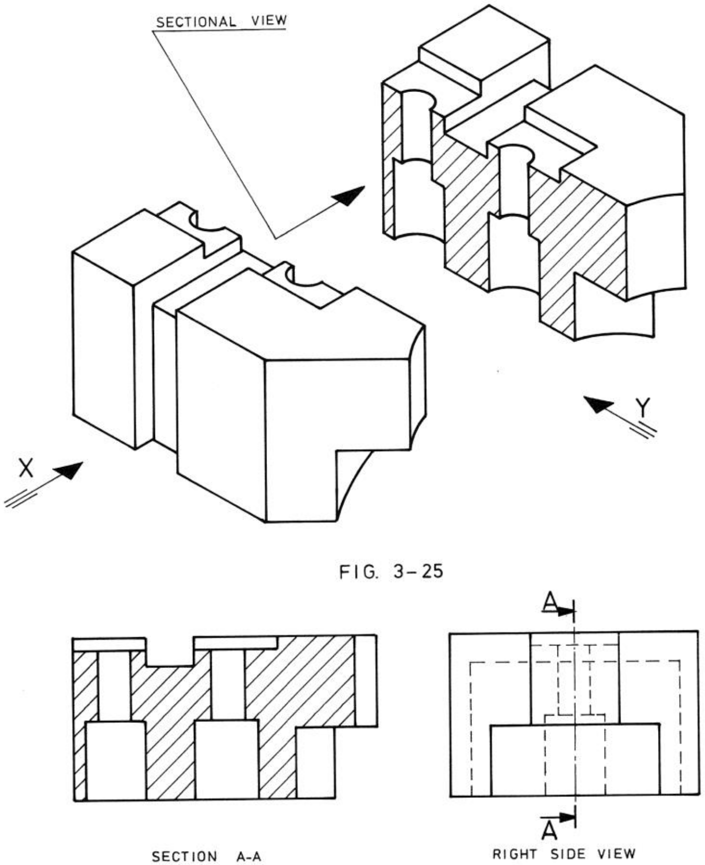
Symbol	Interpretation	Symbol	Interpretation
CONTROLLED SURFACE	the basic symbol—consists of two unequal legs inclined at 60° and resting on the surface to be controlled	0.4/ALL OVER	may be applied in the title block or as a note when a single value applies to all machined surfaces controlled
	used when machining is necessary to obtain the desired finish	6.3/ ALL OVER EXCEPT WHERE OTHERWISE INDICATED	may be applied in the title block or as a note when a single value applies to the majority of machined surfaces; exceptions should be indicated on the individual surfaces concerned
	used when the surface finish is to remain as found from the last process and no material, e.g. a cast or forged part, is to be removed	2 1.6 TURN	used to specify a turning allowance of 2 mm after which a surface finish of 1.6 μm is required
6.3 3.2	used to specify maximum and minimum limits of surface roughness obtained by any machining process	N4	used to specify the roughness value by a standard number equivalent to 0.2 μm or 8 μ in
25 6.3	used to specify maximum and minimum limits of surface roughness obtained by any process without machining	3.2 M	used to specify a roughness value together with a multidirectional lay finish
3.2 MILL	used to indicate a particular machining process and roughness value	0.8 0.008–4	used to specify a roughness value together with a waviness height of 0.008 mm and spacing of 4 mm
1.6 2.5	used to indicate a sampling length in millimetres and a machined surface finish	√ = 3.2 MILL	used when a surface texture specification is complicated and is required on a number of surfaces and space on the drawing is limited; the basic symbol is used on the surfaces in question and its meaning is clearly defined in note form on the drawing as shown
CADMIUM PLATE 1.6 0.8	used to indicate roughness before and after surface treatment; note the use of type J line representing the surface after treatment		

Section views

- Need more detail?
  - Try a “sectioned view”.

- Sectioning is used to show hidden or internal detail. Imagine a saw-cut through the critical cross section.

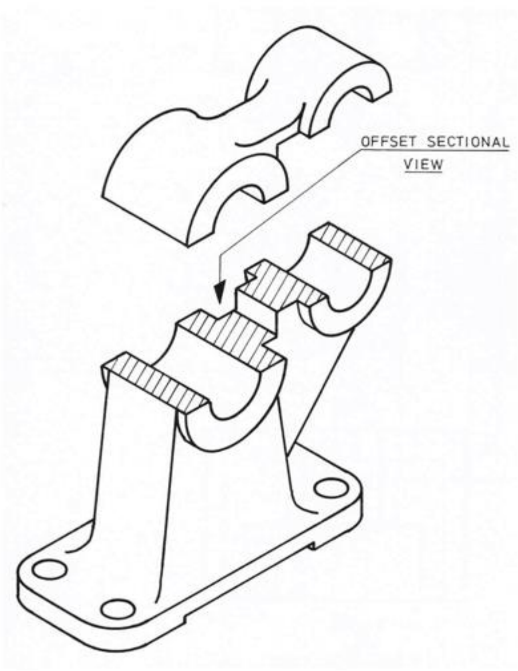
- Cross-hatching lines (thin black lines at 45 deg) indicate the **cut** (i.e. sectioned) areas.



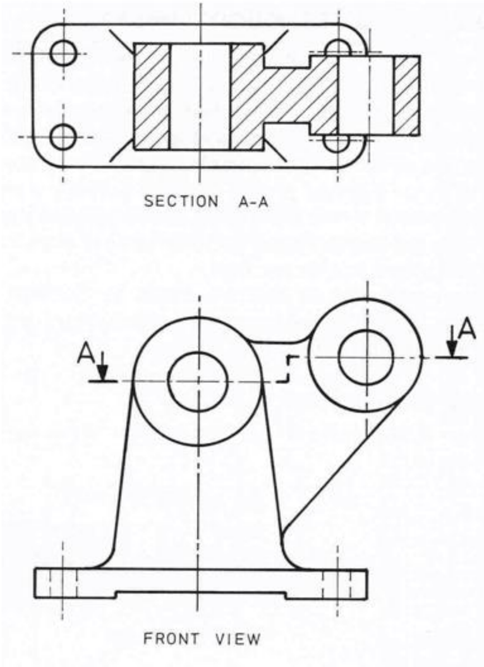
Section views

- Here is an example of an offset sectioning plane, showing details at two different heights.

- **Note that arrows AA indicating the course of the sectioning plane are essential to understanding.**



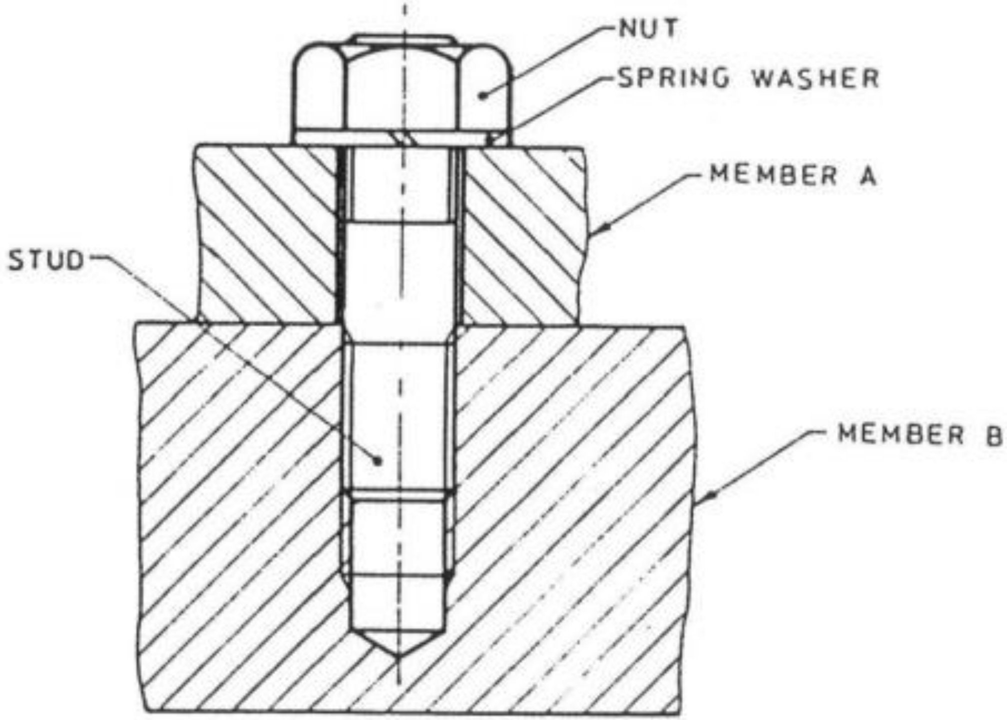
Isometric View



Orthogonal views for an engineering drawing

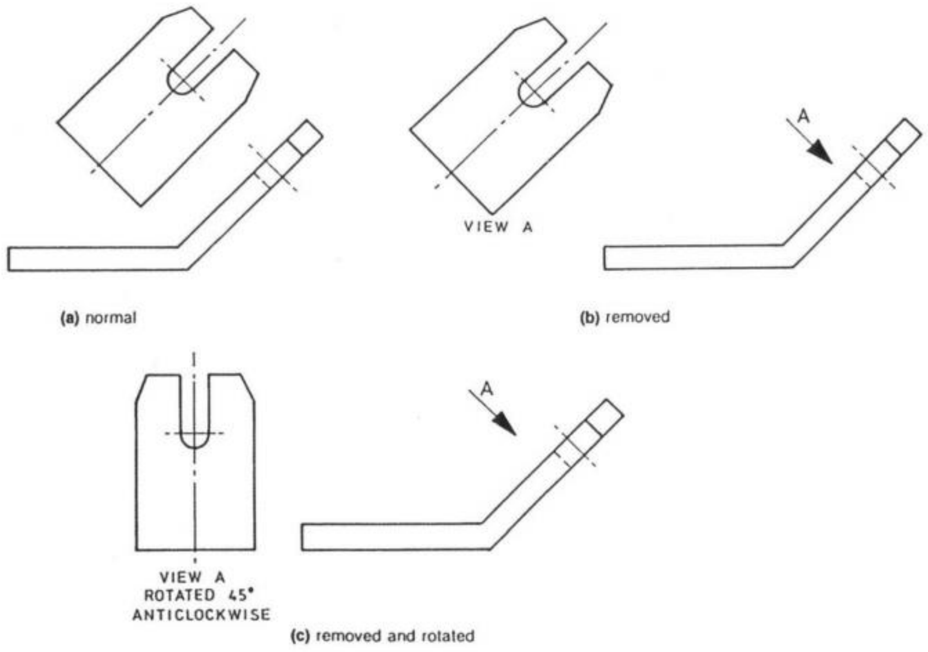
Section views

- An interesting rule when creating section views is that if the cutting plane passes through the centre of:
  - shafts
  - bolts
  - rivets
  - keys
  - pins
- that object IS NOT sectioned!



Auxiliary views

- An auxiliary view is used to detail an inclined face of an object that would be distorted on a standard view.
- This view is projected at right angles to the edge view of the inclined face.
- In third-angle projection, the auxiliary view is placed on the same side that an observer would see it.
  - However, it can also be removed and placed in a more convenient location.



Final Thoughts and Next Steps

- Wow, that was a lot of information!
- Engineering standards are very, very important!
- Engineering drawings are also very, very important!
- Don’t worry too much about remember it all. You will learn more about engineering drawing throughout your undergraduate career!
- Practice, practice, practice!
- PRACTICE! ☺
- We will have a tutorial on Australian Standards next week.
- The CAD labs will be teaching how to create 3D parts next week.