School of Mechanical and Manufacturing Engineering

MMAN2130 Design and Manufacturing

Term 3 – 2019

Week 6

| Process Planning |

Very important content for assessments 1 & 3:

Manufacturability Review

& Final Report

Revision from last week

Quick Quiz

1TB HDD

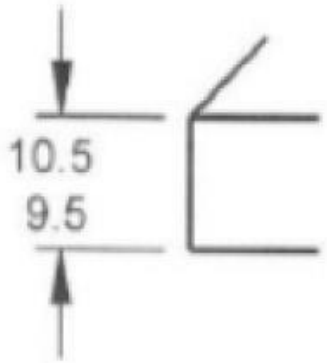
Nominal size?

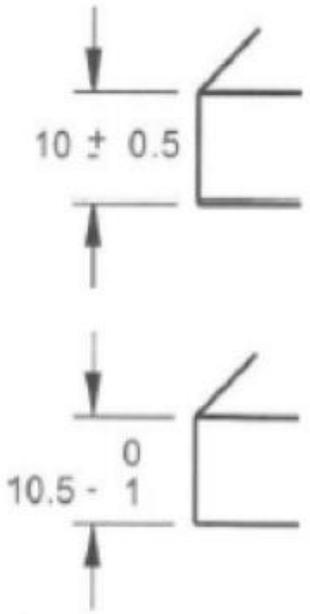
or

Basic size?

Q2) What type of tolerance is this?

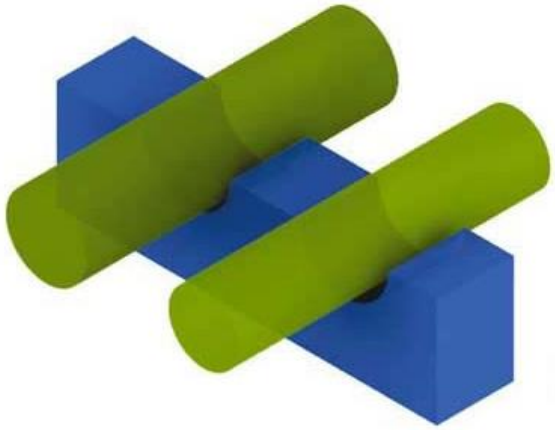
Limit of size
Bilateral
Unilateral

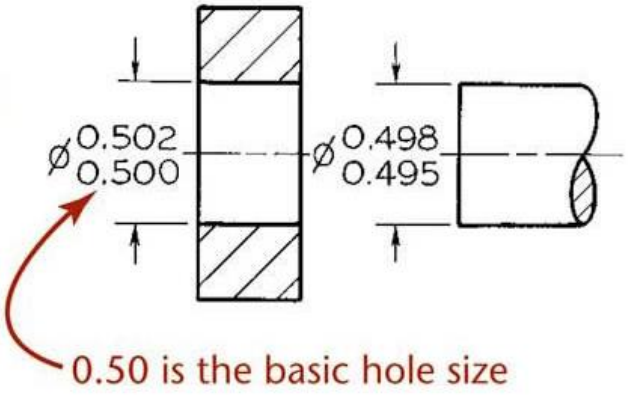


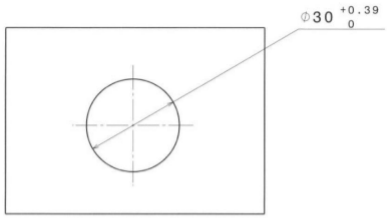


Limits of size.

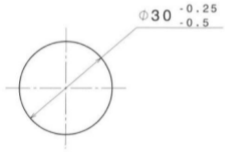
Q3) What is the hole basis system, and why does it exist?





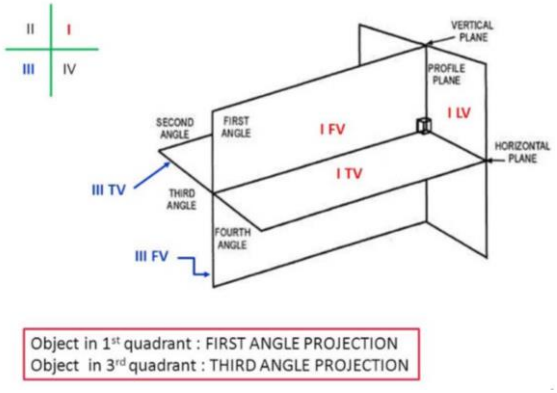


- Hole-basis (tables 4.1a & b)
  - Hole is standard with zero deviation
    - is commonly used
    - easier to produce standard holes
    - easier to turn the shaft to suit

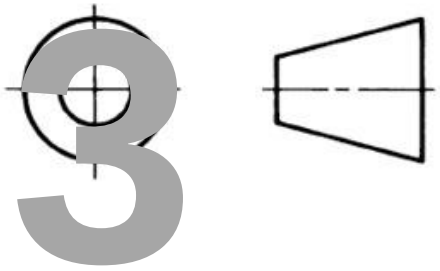


H8f7
Hole-basis

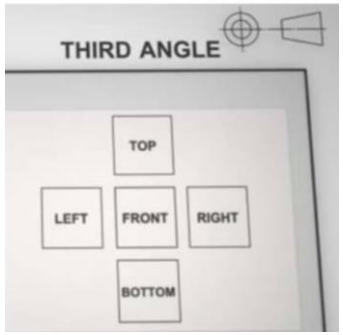
Q4) What is this symbol and what does it mean?



Object in 1st quadrant : FIRST ANGLE PROJECTION
Object in 3rd quadrant : THIRD ANGLE PROJECTION



3rd (third) angle projection

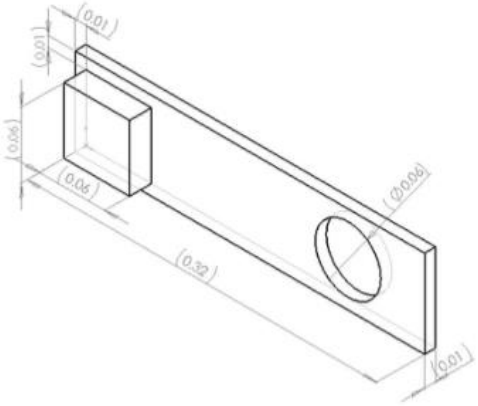


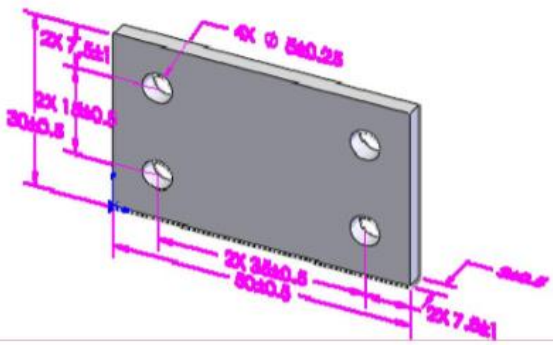
Q5) What is the difference between a Dimension, Tolerance & Limit

Dimension: Numerical value that defines the size, location, orientation, form or other geometric location.

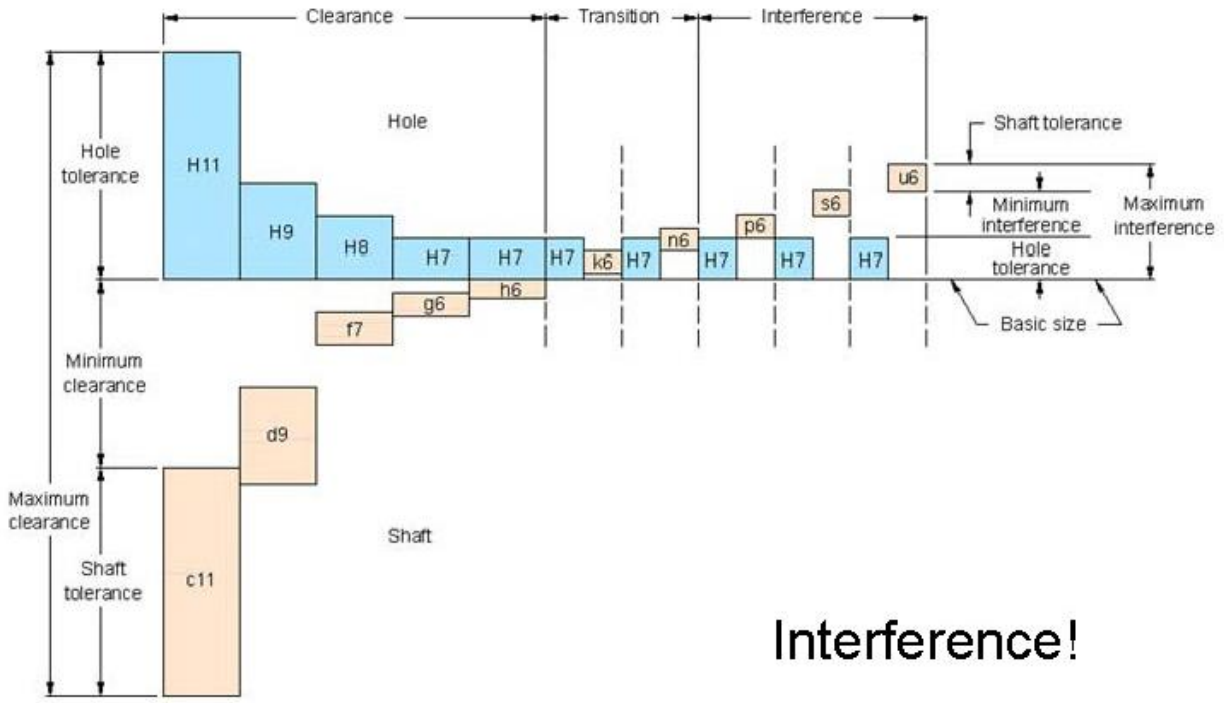
Tolerance: The total amount a specific dimension is permitted to vary. The tolerance is the difference between the max and min limits.

Limits: The maximum and minimum value the specific dimension can be.

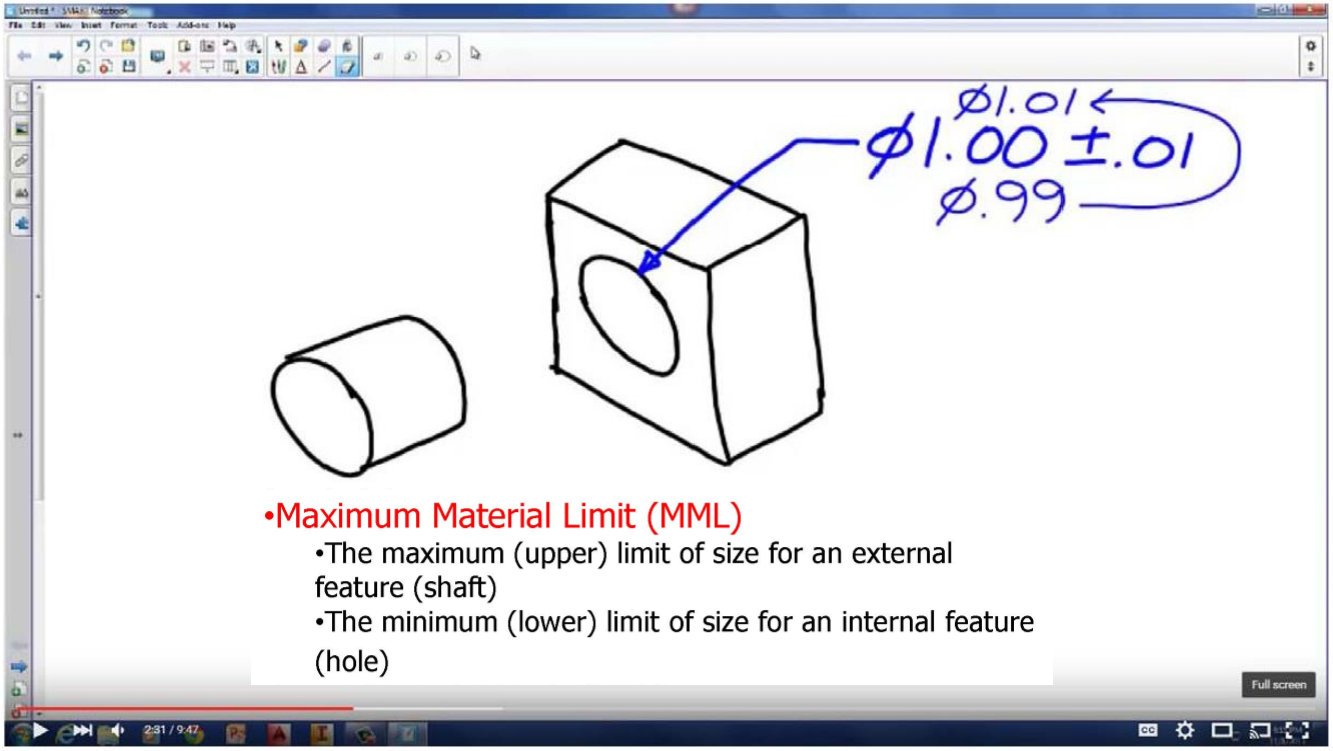




What type of fit is H7p6?



What dim is the MML for the hole?



0.99

Q9) Why are tolerances important 4 points ?

1. Saves money

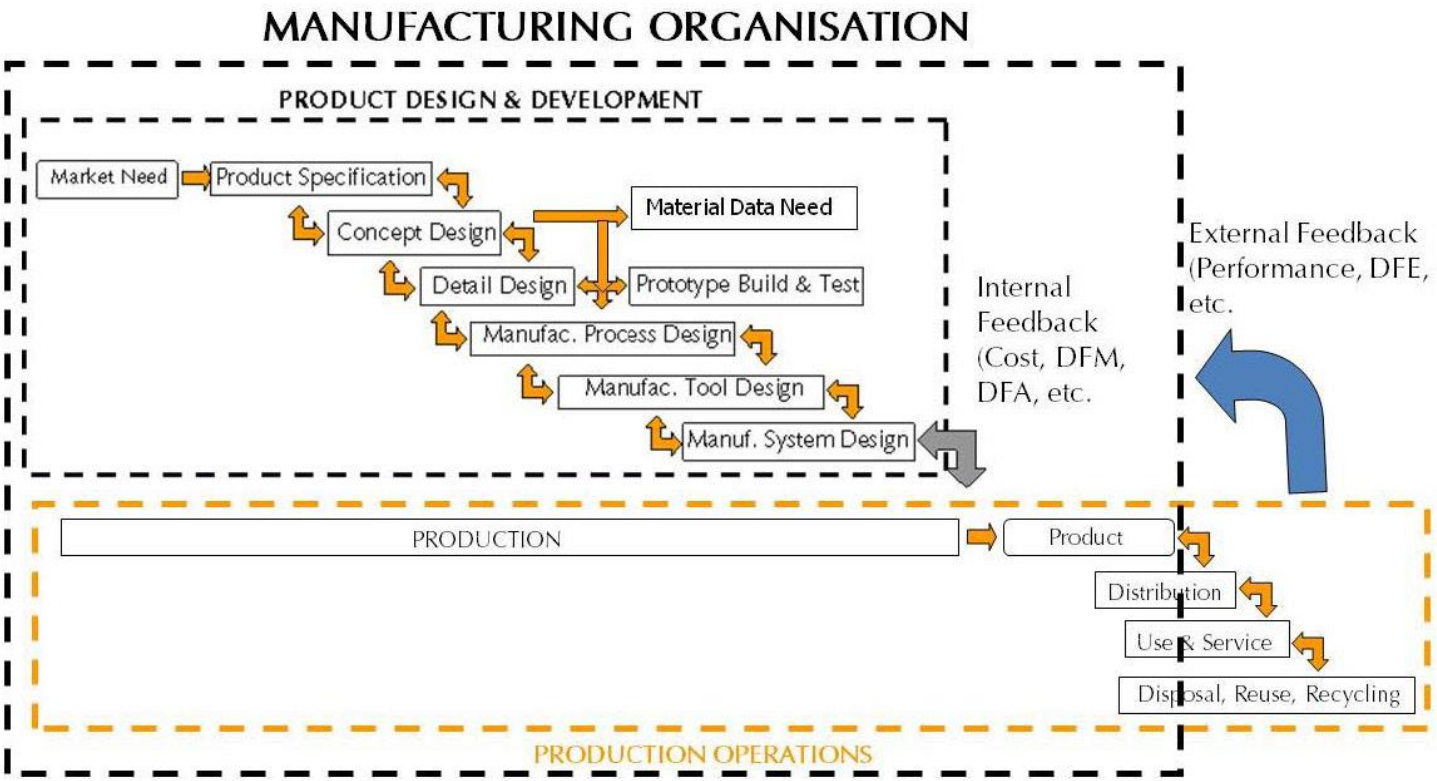
2. Ensures inter-changeability of mating parts

3. Maximises quality

4. Uniform interpretation of specification
   - No guess work for the manufacturer
   - Clear who is at fault if there is an issue

Process Planning

Where does this fit in?



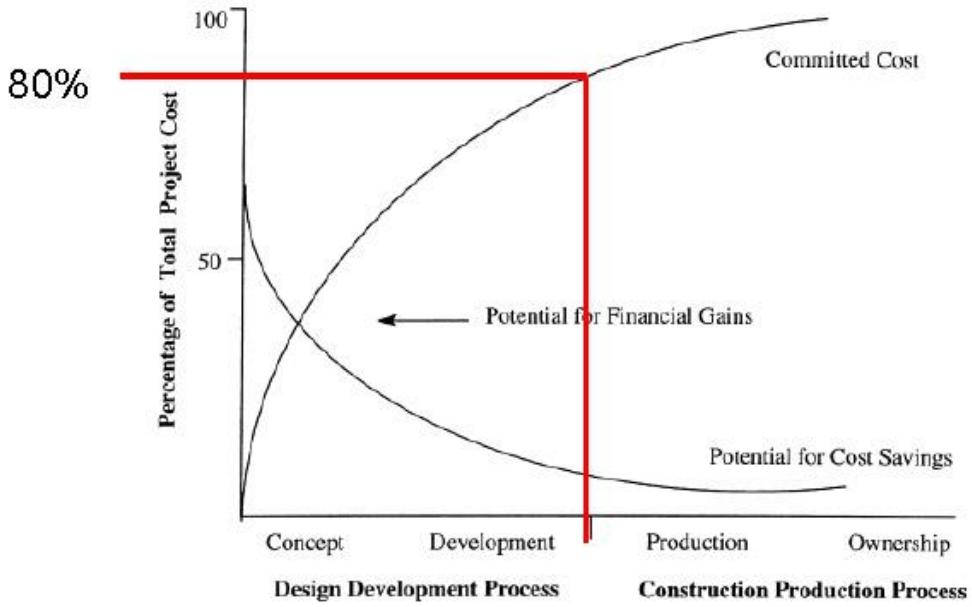
Slide adapted from Prof S Kara (UNSW, 2017)

Learning outcomes

At the end of this lecture, you should be able to:

1. Understand what a **Process Plan** is.
2. Understand the importance of the **Exploded View** and **Bill Of Materials** (BOM).
3. Be able to create an **Assembly Chart**, **Work Method Sheet** and **Routing Sheet**.

80% of cost is during design phase



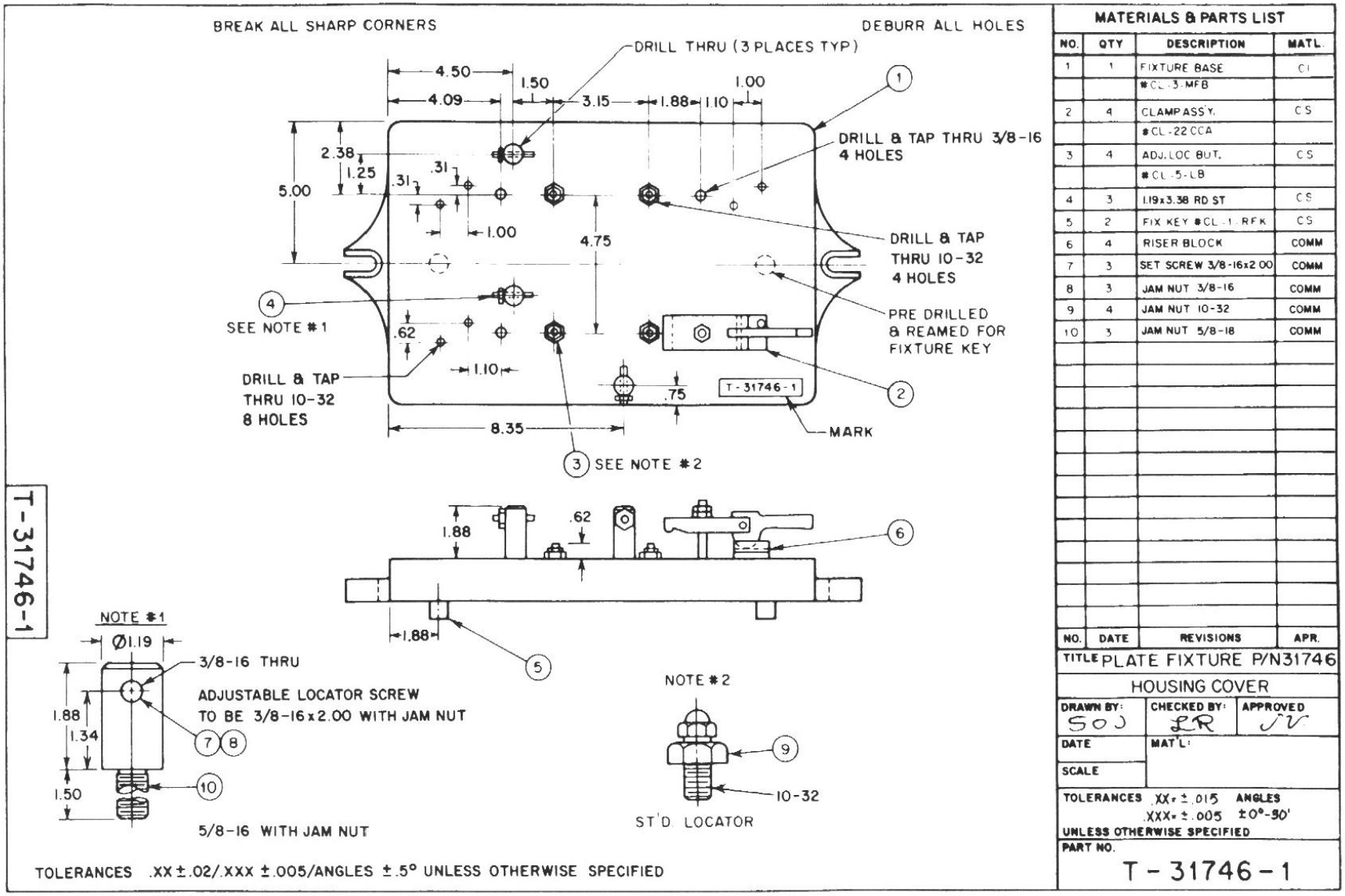
Barton, Love, Taylor 2001.

Process Plans

Set of documents that detail the **manufacturing** specifications.

- *Designed to address a number of the key issues identified on the previous slide!*

- Engineering Drawings/Blue print
- A Bill Of Materials
- An Assembly Diagram (Exploded Assembly)
- An Assembly Chart
- A Work Method Sheet
- A Routing Chart



MATERIALS & PARTS LIST

NO.	QTY	DESCRIPTION	MATL.
1	1	FIXTURE BASE	CI
		#CL-3-MFB	
2	4	CLAMP ASS'Y.	CS
		#CL-22 CCA	
3	4	ADJ. LOC BUT.	CS
		#CL-5-LB	
4	3	1.19x3.38 RD ST	CS
5	2	FIX KEY #CL-1-RFK	CS
6	4	RISER BLOCK	COMM
7	3	SET SCREW 3/8-16x2.00	COMM
8	3	JAM NUT 3/8-16	COMM
9	4	JAM NUT 10-32	COMM
10	3	JAM NUT 5/8-18	COMM

NO.	DATE	REVISIONS	APR.

TITLE PLATE FIXTURE P/N31746
HOUSING COVER

DRAWN BY:	CHECKED BY:	APPROVED
SOJ	ER	JV
DATE	MAT'L:	
SCALE		

TOLERANCES .XX ± .015 ANGLES ±0°-30'
.XXX ± .005
UNLESS OTHERWISE SPECIFIED

PART NO. T-31746-1

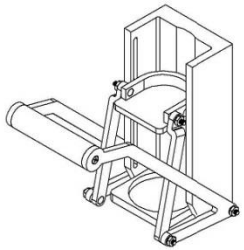
Bill of Materials (BoM)

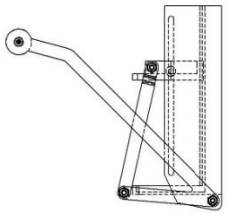
&

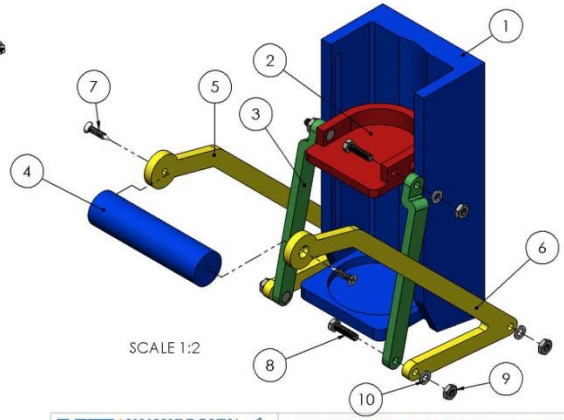
Exploded Assembly

Bill of Materials External

ITEM NO.	QTY.	PART/ASSEMBLY NUMBER	PART/ASSEMBLY NAME
1	1	CAD-MP-0001	BASE
2	1	CAD-MP-0002	SLIDER BLOCK
3	2	CAD-MP-0003	COUPLER
4	1	CAD-MP-0006	HANDLE
5	1	CAD-MP-0004	LEFT BAR
6	1	CAD-MP-0005	RIGHT BAR
7	2	MCMASTER 90031A194	WOOD SCREW #8 1/2 INCH LONG
8	6	MCMASTER 94081A144	HEX BOLT #10-24 3/4 INCH LENGTH
9	6	MCMASTER 90545A011	HEX NUT #10-24
10	6	MCMASTER 96100A137	WASHER #10







SCALE 1:2

UF UNIVERSITY of FLORIDA

COMPUTER AIDED GRAPHICS AND DESIGN

SPECIFICATIONS AND TOLERANCES	PROJECT: HW 6	
UNLESS OTHERWISE NOTED: DRAWINGS ARE CREATED ACCORDING TO ASME Y14.5:2009	PART/ASSEMBLY NAME:CAN CRUSHER	APPROVED BY: C. CRANE
DEFAULT DIMENSIONAL TOLERANCES: LINEAR DIMENSIONS (inches): ± ±.5, X.X ± 1, X.XX ± .03, X.XXX ± .005 ANGULAR DIMENSIONS (degrees): ± ±5, X.X ± .5, X.XX ± 1 MINIMUM SURFACE FINISH: 1000microinches	PART/ASSEMBLY NUMBER:CAD-MA-0001	ENGINEER: AL GATOR
	NEXT ASSEMBLY NUMBER: N/A	DATE CREATED: 2/14/2011
	MATERIAL: N/A	DATE APPROVED: 2/15/2011
THIRD ANGLE PROJECTION	FINISH: N/A	SHEET SCALE: 1:3 SHEET NUMBER: 1 OF 1

Bill of Materials Internal

Qty	Part Type	Designator	Footprint (Package type)	Description	Manufacturer	Supplier	Order Status (30/5/08)	R = Reflow W = Wave S H = Hand S N = Non	Cost per unit Ex GST	Total Cost Ex GST	N
1	22K	R43	0805(ACTUAL)	Res 1%	Open PHYCOMP 232273462203	Open FEC: 9237798	Ordered: Farnell (RECEIVED) Sent to C.M: Entech		0.09	0.09	
1	39K	R44	0805(ACTUAL)	Res 1%	Open PHYCOMP 232273463903	Open FEC: 9237828	Ordered: Farnell (RECEIVED) Sent to C.M: Entech		0.09	0.09	
1	74HC14 HEX SCHMITT	U7	SOIC14	HEX NON Inverting Schmitt Trigger	Open e.g: NXP Semiconductors: 74HC7014D	open e.g Digikey: 568-1488-5-ND	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	1.15	1.15	
4	Jumper	JP2 JP4 JP3 JP1	JUMPER_2PIN	CON, JUMPER, Through Hole 0.1",	Open	Open e.g. FEC: 521817 & 1098694	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	1.71	6.84	
1	91K	R45	0805(ACTUAL)	Res 1%	Open MULTICOMP MC 0.1W 0805 1% 91K	Open FEC: 9333649	Ordered: Farnell (RECEIVED) Sent to C.M: Entech		0.06	0.06	
11	100K	R6 R12 R13 R46 R47 R11 R9 R3 R8 R10 R4	0805(ACTUAL)	Res 1%	Open PHYCOMP 232273461004	Open FEC: 9237879	Ordered: Farnell (RECEIVED)		0.09	0.99	
22	100N	C16 C6 C15 C14 C24 C17 C7 C4 C9 C3 C5 C2 C12 C11 C9 C10 C21 C18 C1 C13 C20 C19	0805(ACTUAL)	Cap, 50V, 5%, NPO	Open AVX 08051C104KAZ2A	Open FEC: 1301805	Ordered: Farnell (RECEIVED)		0.83	18.26	
1	200R	R15	0805(ACTUAL)	Res 1%	Open MULTICOMP MC 0.1W 0805 1% 200R	Open FEC: 9332759	Ordered: Farnell (RECEIVED)		0.06	0.06	
2	220u	C26 C25	SMD_CAP_CASE_G	Electrolytic 220u 50V +-20%	Open e.g PANASONIC EEEFH1H221P	Open e.g FEC: FEC:8695966	Ordered: Farnell (RECEIVED)	RoHS	2.02	4.04	
14	510R	R22 R28 R27 R32 R29 R21 R20 R30 R31 R19 R25 R26 R24 R23	0805(ACTUAL)	Res 1%	Open MULTICOMP MC 0.1W 0805 1% 510R	Open FEC: 9333312	Ordered: Farnell (RECEIVED)		0.06	0.84	
2	.	U2 U10	2981-RELAY-DRIVER	High Side Driver, Imax (Soruce) 500mA, Vmax 50V	ALLEGRO MICROSYSTEMS:A2982SLW-T	open e.g Farnell:1329620	Ordered: Farnell 13/6/08 (RECEIVED) At BCS	RoHS	4.03	8.06	
1	ADM1232 BROWN OUT/TIMEOUT	U9	SOIC8	Adj voltage monitor 4.5V or 4.75V, Adj strobe monitor with 150ms, 600ms, 1.2s options	ANALOG DEVICES: ADM1232ARNZ	open e.g FEC: 1438812	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	3.9	3.9	
2	BSS138	Q2 Q1	SOT23_MOS	MOSFET	Open FAIRCHILD SEMICONDUCTOR BSS138...	Open FEC: 9845330	Ordered: Farnell (RECEIVED) Sent to C.M: Entech		0.76	1.52	
2	DNP	C22 C23	0805(ACTUAL)	Cap	DNP	DNP	N/A			0	
1	DPDT REED RELAY	U6	OMRON-G6K-2F-5VDC	DPDT reed relay, Coil Voltage 5V, Pmax 10W, Ricoil 150R, Imax 0.5A	OMRON: G6K-2F-DC5	Farnell: 4963714	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	5.92	5.92	
1	Driver Connector	P1	IDC26VERT_LATCHED	Conn, Through, 26 Pin, IDC Keyed Boxed Header with Latch	MULTICOMP: MC9B132-2634, 3M: N3429-6302RB, HARTING: 0918 526 7904	open e.g FEC:**3166508**, 1099029, 9838139, 1097009	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	1.7	1.7	
1	EPM7192SQC160-15N	U3	PQFP160	IC, PQFP, Programmable Logic Device (PLD)	Altera: EPM7192SQC160-15	open e.g Digikey: EPM7192SQC160-15N	Ordered: Austest (RECEIVED) At BCS		52.5	52.5	
1	IDC_10PIN	P3	IDC10VERT	Conn, Through, 10 Pin, IDC Keyed Boxed Header, 0.1",	Open"	Open e.g. FEC: **1099254** , Electus: PP1100 (Non RoHS)	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	0.93	0.93	
1	L298 Motor Driver	U1	L298 MOTOR DRIVER	Dual H bridge motor driver, Vs up to 46V, Total DC Current 2A, Over temp protection	ST Microelectronics L298	open e.g Digikey:**497-3624-1-ND**(Preffered), RS Components:370-6953, FEC:403295,	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	6.26	6.26	
1	LM6132	U11	SOIC8	IC SOIC8 DUAL OPAMP, Rail to Rail input, Rail to Rail output, 2.7V to 24V	NATIONAL SEMICONDUCTOR: LM6132AIM	open e.g FEC:9490043	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	7.07	7.07	
1	Laser Diode Driver	S1	CON-DB15-FEMALE-VERTICAL	Conn, Through, DB15 Straight, Female	TYCO ELECTRONICS / AMP: 3-1634223-2	open e.g FEC:5082067	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	4.14	4.14	
1	Over Temp Conn	J2	CON-MOLEX-3	Conn, Through, MOLEX KK 2.54mm, 3 Pin Straight	Molex: 22-27-2031	Open e.g. FEC: 9731156	Ordered: Farnell (RECEIVED) Sent to C.M: Entech	RoHS	1.56	1.56	
1	PBBA-2405C	U5	PBBA-2405C	Vin 24V, Vout 5V, Iout 1.2A, Pmax 6W,120-150mV ripple	Powerbox: PBBA-2405C	Powerbox: PBBA-2405C	Ordered: Farnell (RECEIVED) Sent to C.M: Entech		55	55	

Much more detail, has every single component, order status, unit cost, supplier, manufacturer etc.

Assembly Chart

Assembly Chart

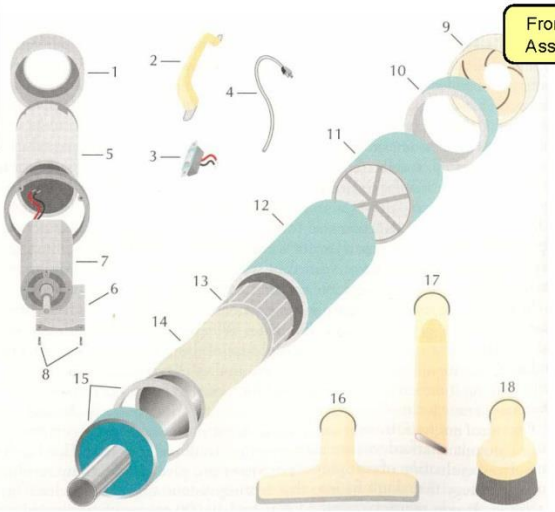
- Shows the order of assembly (Given to factory workers to assemble a product).
- Shows the grouping of parts that make up a sub-assembly.
- Don't confuse with exploded view.

Assembly Chart

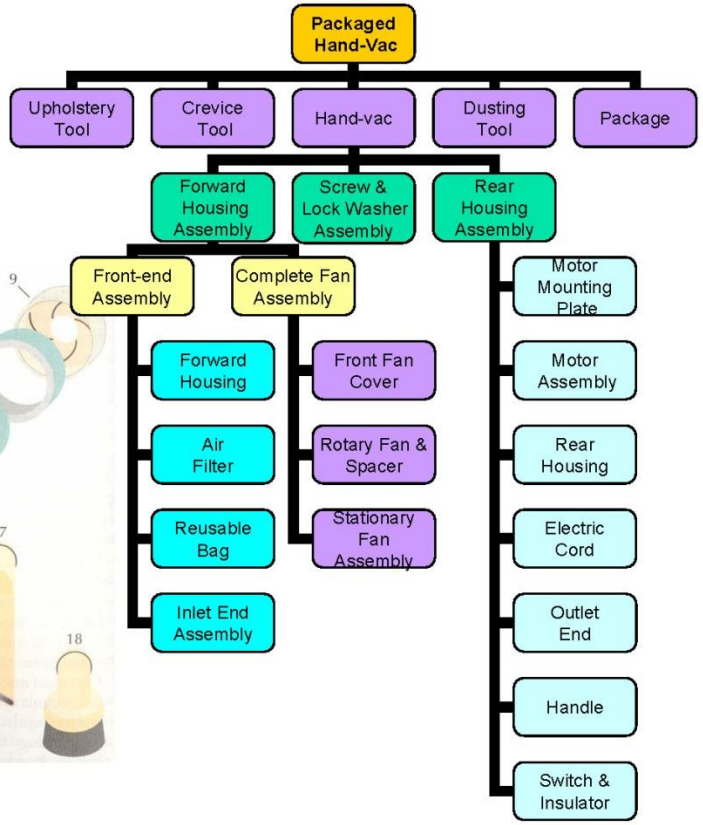
BOM

No.	Part No.	Part Name
1	51292	Outlet End
2	51284	Handle
3	52043	Switch & Insulator
4	51576	Electric Cord
5	51265	Rear Housing
6	51268	Motor Mounting Plate
7	51495	Motor Assy. & Fan Spacer
8	51270	Screw & Lock Washer Assy.
9	51273	Stationary Fan
10	51488	Rotary Fan & Spacer Assy.
11	51281	Front Fan Cover
12	51272	Forward Housing
13	51286	Air Filter
14	52388	Reusable Bag
15	51288	Inlet End Assy.
16	51642	Upholstery Tool
17	52074	Crevice Tool
18	50815	Dusting Tool
19	57432	Packaging Material (not shown)

Exploded View



Assembly Chart



Work Method Sheet

- Shows in detail **how** a component is to be **manufactured.**
- List individual operations to be performed on a component.
- **Includes:**
  1. Operation times
  2. Required tools, fixtures, gauges
  3. Machine setup
  4. Risk assessment and OHS issues (Take 5)

Work method sheet

Part Name:	Valve Body
Part No:	302
Customer Name:	Midwest Valve Co.
Quantity:	15

Op. #	Process Description	Machine/Tools	Speed /Feed	Tooling	Time	Risk Assesment
10	Inspect forging, check hardness	Rockwell tester				
20	Rough machine flanges	Lathe No. 5				
30	Check Settings & Start	Lathe No. 5				
40	Bore & counter bore holes	Boring mill No. 1				
50	Turn internal groves	Boring mill No. 1				
60	Drill & tap holes	Drill press No. 2				
70	Grind flange end faces	Grinder No. 2				
80	Grind bore	Int. grinder No. 1				
90	Clean	Vapour degreaser				
100	Inspect	Ultrasonic tester				

What would a work method sheet look like for your part?

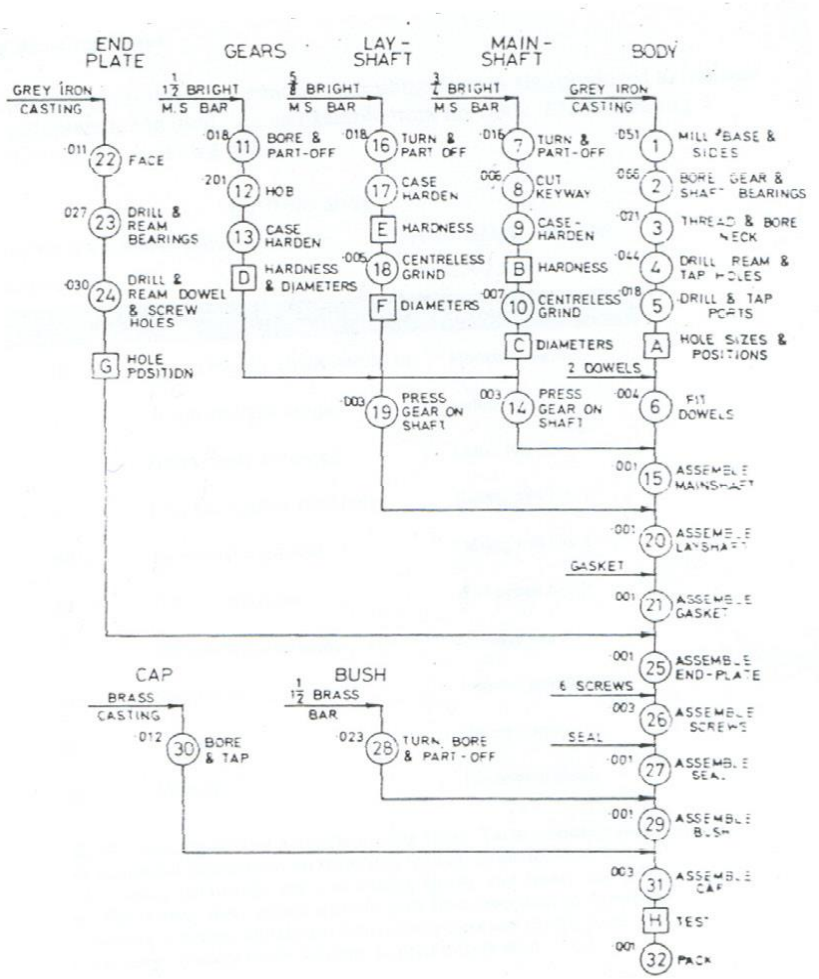
Part Name:	Piston
Part No:	xxxxxx
Customer Name:	xxxxxx
Quantity:	1

Op. #	Process Description	Machine/Tools	Speed /Feed	Tooling	Time	Risk Assesment
1	Cut aluminium rod to length	Bandsaw	200 fpm	10 TPI fine tooth blade	3 minutes	Look out for heat build up

Routing Chart

- Graphical representation of the entire manufacturing process

- Links to the work method sheet (for more detail via the operation #)



Summary

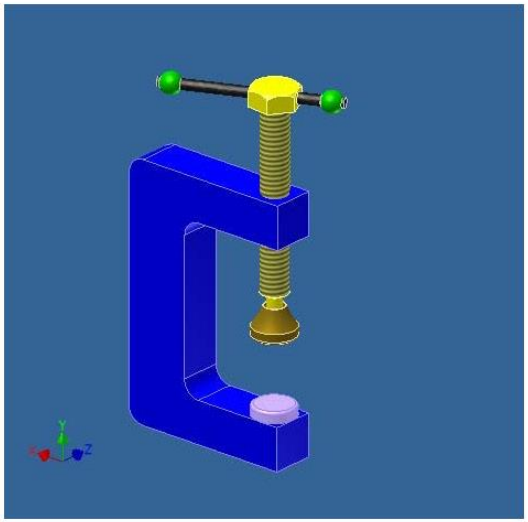
Exploded View & BOM:	Shows all the separate parts in an easy to read fashion, doesn't show how they are assigned. Internal & External.
Assembly Chart:	Shows how the product is assembled (used by factory workers)
Work method sheet:	Shows in detail how a component is to be manufactured.
Routing Chart:	Graphical representation of the entire manufacturing process.

Manufacturability Review

(… or, can we make it?)

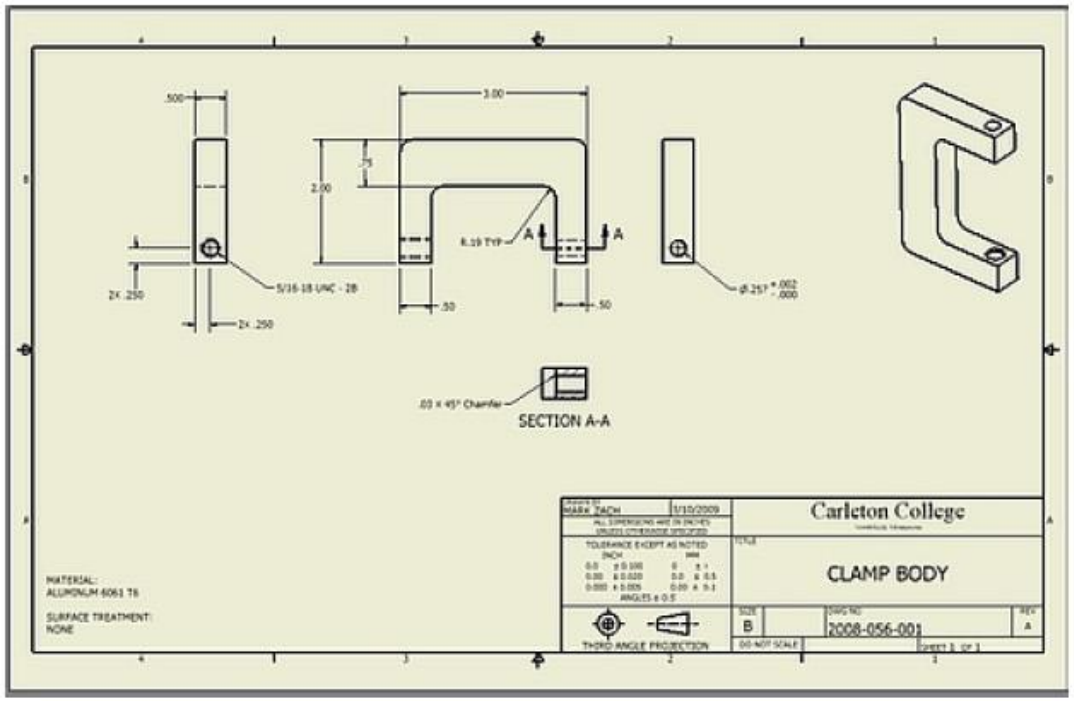
Example:
Design and make a G-clamp

- Manufacturability Review
  - Detailed & complete 2D Engineering drawing.
  - A Bill of Material and Exploded Assembly.
  - An Assembly Chart.
  - A Work Method Sheet for your component.
  - Routing Chart for your component.
  - Routing Chart for the product.



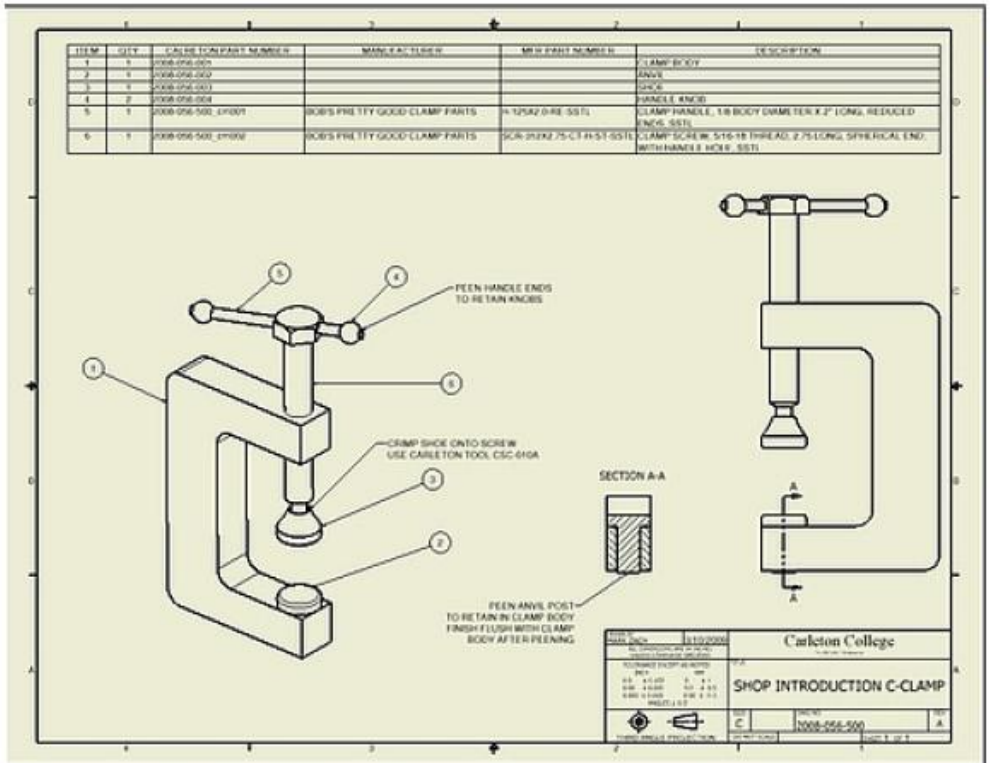
Case: Product – G Clamp

Engineering Drawing



Case: Product – G Clamp

Assembly Drawing & BOM



Item	Qty	Description
1	1	Clamp body
2	1	Lower Shoe
3	1	Clamp shoe
4	2	Handle ends
5	1	Handle
6	1	Clamp screw

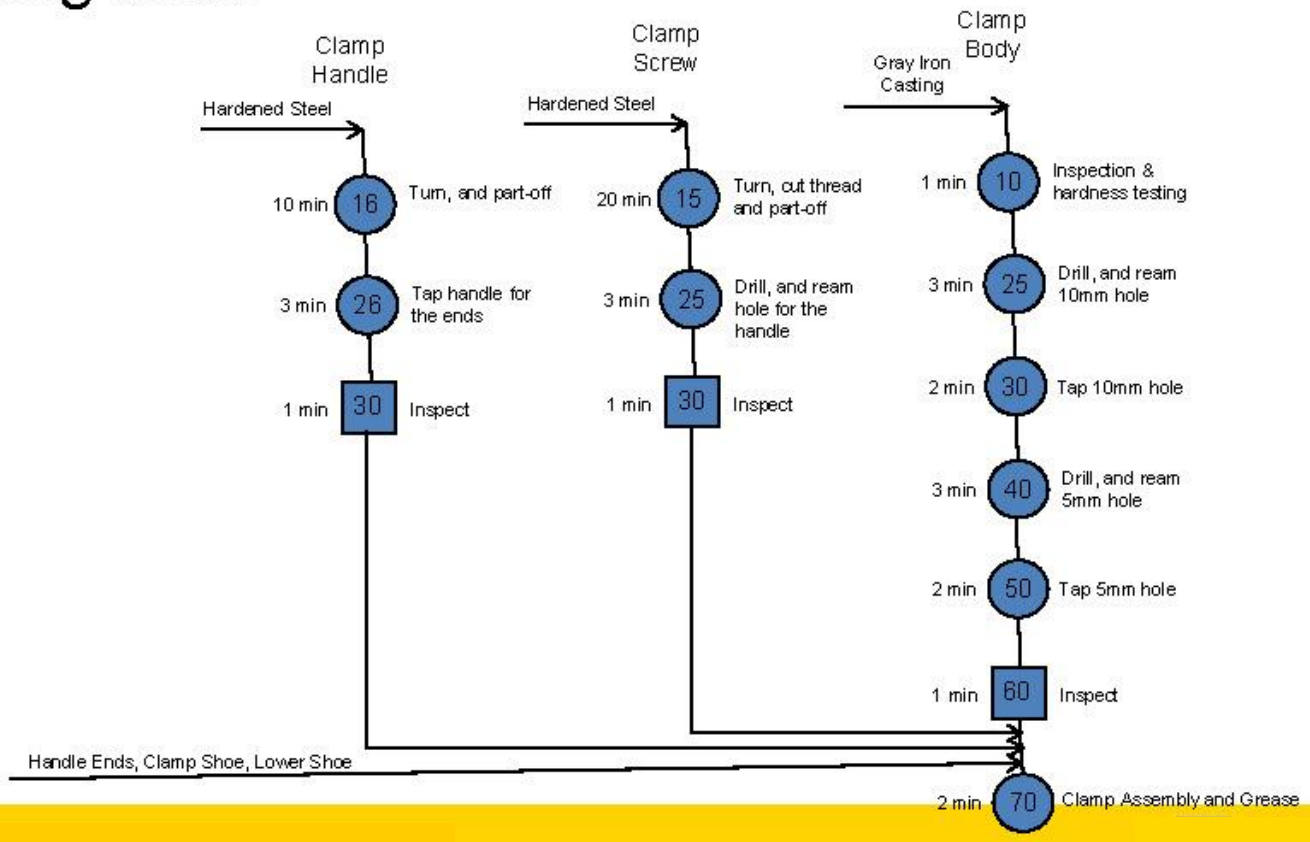
Case: Product – G Clamp

Work Method Sheet – for clamp body component

Part Name: Clamp Body **Part No:** 302 **Customer Name:** Midwest Valve Co. **Qty:** 100						
Op. #	**Process Description**	**Machine/Tools**	**Speed /Feed**	**Tooling**	**Time (min)**	**Risk Assesment**
10	Inspect casting, check hardness	Rockwell tester			1	
25	Drill 10mm hole for clamp screw	Drill press No.2	500 rpm	10 mm twist drill bit	3	
30	Tap M10 for the clamp screw hole	Drill press No.2	500 rpm	M10 tapping bit	2	
40	Drill 5 mm hole for lower shoe	Drill press No.2	500 rpm	5mm twist drill bit	3	
50	Tap M5 for the lower shoe hole hole	Drill press No.2	500 rpm	M5 tapping bit	2	
60	Inspect	Calipper			1	

Case: Product – G Clamp

Routing chart



Suggested approach

1. Finalise Engineering Drawing / Blue Print
2. Evaluate appropriate raw materials.
3. List component features E.g. Face, Hole, Slot etc.
4. List available resources E.g. Lathe, Mill, Bench Drill, Grinder etc.
5. Compare and match each component feature to available resources.
6. Determine machine requirements such as tooling and process parameters.
7. Calculate time requirements.
8. Create individual work method sheet and routing chart from this information.
9. Combine individual routing charts into product routing chart.

Some general workshop suggestions

1. Reduce component movement between machines and between work-holding devices
2. Perform delicate operations such as polishing last to avoid subsequent damage.
3. Include frequent inspections to avoid rework and scrap.

Consult with your TAFE teachers