Université de Technologie de Belfort-Montbéliard – UTBM
Mechanical Engineering and Design Department – GMC
CP51 Class: Product Lifecycle Management and Design for 'X'
Final Examination, Spring 2013

This final exam is based on 3 parts. Part 1 consists of a set of questions and represents a total of 10 points. Part 2 and Part 3 are application cases and represent 4 points and 6 points respectively. As a reminder, the use of English language for answering is needed.

Part 1: Questions (10 pts)

1. What is the definition of PLM? (1 pt)
2. Define PDM and MPM, and their role in the PLM strategy. (2 pts)
3. What are the main functionalities of a PLM system? (1 pt)
4. What are the key features (mechanisms) enabling collaboration between design engineers and process engineers? (1 pt)
5. Describe briefly a engineering change management (ECM) process? Then, explain how ECM is implemented within Notixia? (1 pt)
6. What are the differences between "bottom-up" and "top-down" modelling approaches in geometric modelling phase? (1 pt)
7. Explain an emergent modelling approach which promotes collaborative and top-down modelling in the extended enterprise context. List the advantages of such an approach. (1 pt)
8. What is the main issue of simulation data management? (1 pt)
9. What does DFA mean? Give at least 5 DFA rules among the 20 DFA guidelines. (1 pt)

Part 2: Skeleton-based modelling (4 pts)

By considering the following case study (See Figure 1), you have to define the final skeleton-based model. This model will be assembly-oriented (skeletons structure and assembly relationships). It is requested to develop this model in a step-by-step way. As appendix, Tables 1 and 2 have been introduced in order to provide guidelines.

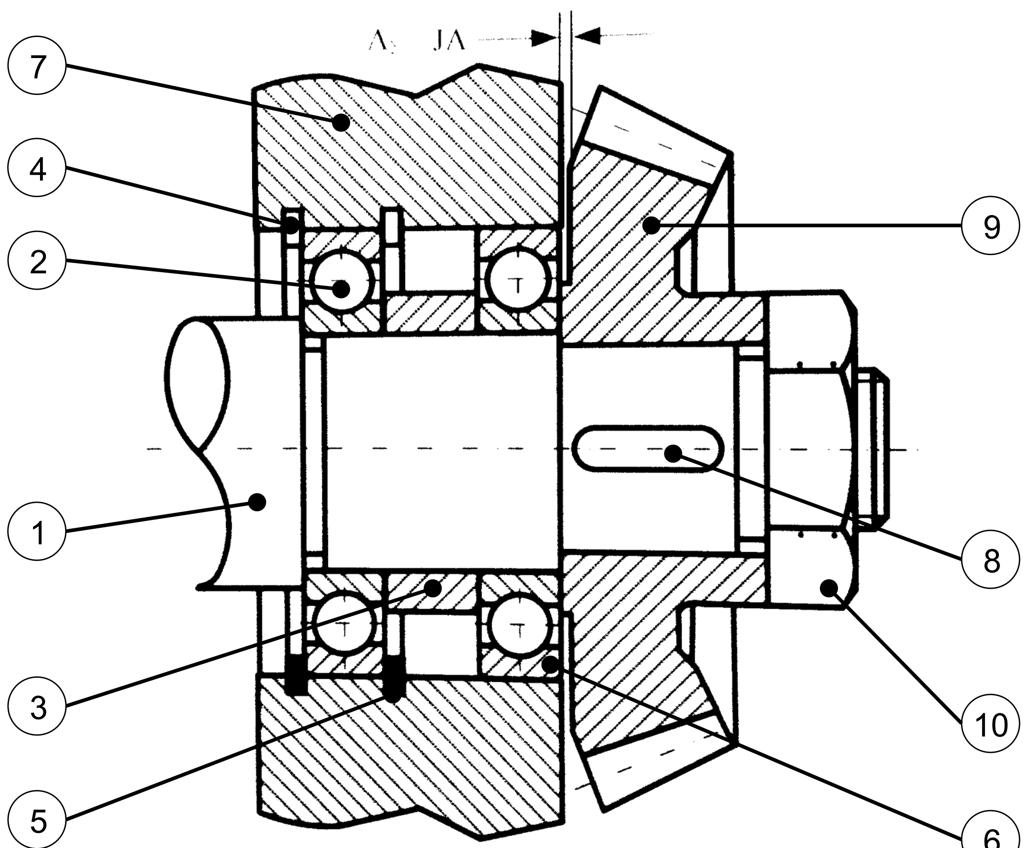

Figure 1: Mechanical assembly as a case study for Part 2.

Part 3: Design For Assembly (6 pts)

In the following case study (See Figure 2), you have to improve the product design by considering specific DFA rules. Figure 2 shows a simple sub-assembly used in the construction of a gas-flow meter. The objective is to analyse the design by using the Boothroyd-Dewhurst method with the intention of using the information obtained to create a new, easier-to-assemble, less expensive sub-assembly. In this analysis only manual assembly will be considered. For the redesign of an existing product, it will be assumed that the functional parts must have the same dimensions and be made of the same materials.

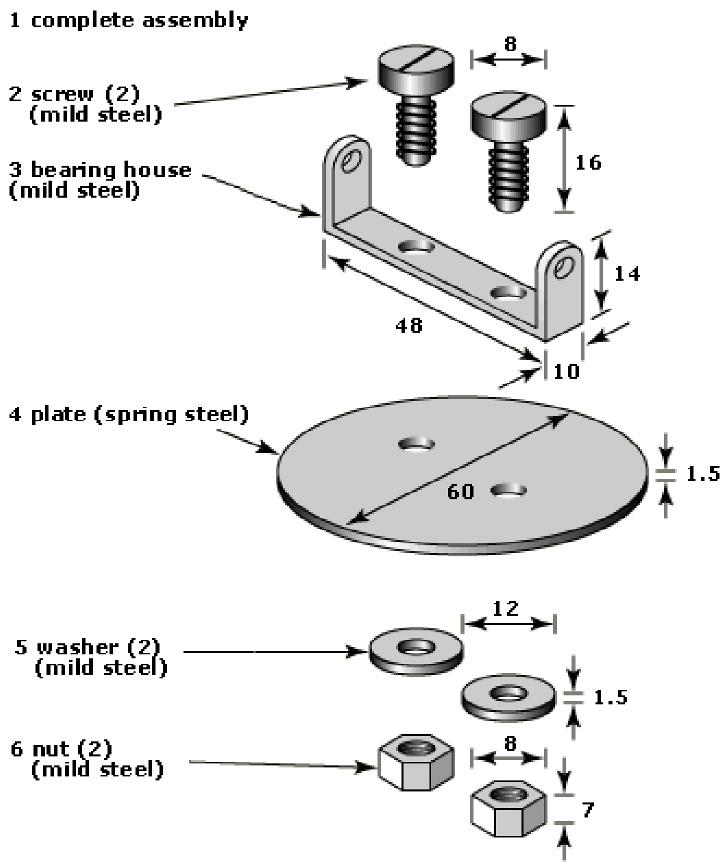

Figure 2: Case study for Part 3.

You will find below the DFA worksheet (Figure 3) to be filled according to geometric properties of each part of the case study and estimated times tables in Figures 4 to 9.

1	2	3	4	5	6	7	8	9
Component	Component ID	Instance number of the component in the product	Associated cell reference of the handling time of the component	Manual handling time (s)	Associated cell reference of the insertion time of the component	Manual insertion time (s)	Is this component essential to the product ?	Assembly time (s) (3)*[(5)+(7)]
	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	10							
Product Name:	Minimum number of component (Nmin) =							
	Total assembly time (Ttotal) =							
	Boothroyd & Dewhurst DFA Efficiency =3*Nmin/Ttotal							

Figure 3: DFA Worksheet.

Table 1
Skeleton entities definition based on kinematic pairs.

Kinematic pair	Constraint	Assembly skeleton		
		Entity	Constraint	Assembly axis
Rigid	Coordinate system/coordinate system	Coordinate system	/	Any
Revolute	Axis–axis and Plane–plane	Line, Plane	Perpendicular	Rotation axis
Prismatic	Axis–axis and Plane–plane	Line, plane	Perpendicular	Translation axis
Screw	Axis–axis and Plane–plane	Line, plane	Perpendicular	Rotation axis
Cylindrical	Axis–axis	Line	/	Translation/rotation axis
Spherical	Point–point	Point	/	Any
Planar	Plane–plane	Plane	/	Perpendicular to the plane
Point-contact	Point–plane	Point, plane	Coincidence	Perpendicular to the plane
Line-contact	Line–plane	Line, plane	Coincidence	Perpendicular angle
Curve-contact	Curve–curve	Curve	/	Translation axis

Table 2
Skeleton entities definition based on technological pairs.

Technological pair	Constraint	Assembly skeleton		
		Entity	Constraint	Assembly axis
Gluing	Coordinate system/coordinate system	Coordinate system	/	Any
Welding	Coordinate system/coordinate system	Coordinate system	/	Any
Screwing	Axis–axis and plane–plane	Line, plane	Perpendicular	Rotation axis
Riveting	Axis–axis and plane–plane	Line, plane	Perpendicular	Rotation Axis
Cotter	Axis–axis and plane–plane	Line, plane	Perpendicular	Translation axis
Pin	Axis–axis and plane–plane	Line, plane	Perpendicular	Rotation axis
Gear-rack	Curve–curve	Lines, curve	Distance	Rotation axis
Gear–gear	Axis–axis and curve–curve	Lines, curve	Distance	Rotation axis

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MANUAL HANDLING–ESTIMATED TIMES (seconds)

Key: ONE HAND

Parts can be grasped and manipulated by one hand without the aid of grasping tools			Parts are easy to grasp and manipulate					Parts present handling difficulties (1)				
			Thickness >2 mm			Thickness ≤2 mm		Thickness >2 mm			Thickness ≤2 mm	
			Size >15 mm	6 mm ≤ size >15 mm	Size <6 mm	Size >6 mm	Size ≤6 mm	Size >15 mm	6 mm ≤ size ≤15 mm	Size <6 mm	Size >6 mm	Size ≤6 mm
			0	1	2	3	4	5	6	7	8	9
	$(\alpha + \beta) < 360°$	0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98
	$360° \le (\alpha + \beta) < 540°$	1	1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38
	$540° \le (\alpha + \beta) < 720°$	2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7
	$(\alpha + \beta) = 720°$	3	1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4

Figure 4: Manual Handling-estimated times – One Hand

ONE HAND with GRASPING AIDS

Parts can be grasped and manipulated by one hand but only with the use of grasping tools				Parts need tweezers for grasping and manipulation								Parts need standard tools other than tweezers	Parts need special tools for grasping and manipulation
				Parts can be manipulated without optical magnification				Parts require optical magnification for manipulation					
				Parts are easy to grasp and manipulate		Parts present handling difficulties (1)		Parts are easy to grasp and manipulate		Parts present handling difficulties (1)			
				Thickness >0.25 mm	Thickness ≤0.25 mm	Thickness >0.25 mm	Thickness ≤0.25 mm	Thickness >0.25 mm	Thickness ≤0.25 mm	Thickness >0.25 mm	Thickness ≤0.25 mm		
				0	1	2	3	4	5	6	7	8	9
	$\alpha \le 180°$	$0 \le \beta \le 180°$	4	3.6	6.85	4.35	7.6	5.6	8.35	6.35	8.6	7	7
	$\alpha \le 180°$	$\beta = 360°$	5	4	7.25	4.75	8	6	8.75	6.75	9	8	8
	$\alpha = 360°$	$\alpha \le \beta \le 180°$	6	4.8	8.05	5.55	8.8	6.8	9.55	7.55	9.8	8	9
	$\alpha = 360°$	$\beta = 360°$	7	5.1	8.35	5.85	9.1	7.1	9.55	7.85	10.1	9	10

Figure 5: Manual Handling-estimated times – One Hand with Grasping Aids

TWO HANDS for MANIPULATION		Parts present no additional handling difficulties					Parts present additional handling difficulties (e.g. sticky, delicate, slippery, etc.) (1)				
		$\alpha \leq 180°$			$\alpha = 360°$		$\alpha \leq 180°$			$\alpha = 360°$	
		Size >15 mm	6 mm ≤ size ≤ 15 mm	Size <6 mm	Size >6 mm	Size ≤6 mm	Size >15 mm	6 mm ≤ size ≤ 15 mm	Size <6 mm	Size >6 mm	Size ≤6 mm
		0	1	2	3	4	5	6	7	8	9
Parts severely nest or tangle or are flexible but can be grasped and lifted by one hand (with the use of grasping tools if necessary) (2)	8	4.1	4.5	5.1	5.6	6.75	5	5.25	5.85	6.35	7

TWO HANDS or assistance required for LARGE SIZE		Parts can be handled by one person without mechanical assistance									Two persons or mechanical assistance required for parts manipulation
		Parts do not severely nest or tangle and are not flexible								Parts severely nest or tangle or are flexible (2)	
		Part weight <10 lb				Parts are heavy (>10 lb)					
		Parts are easy to grasp and manipulate		Parts present other handling difficulties (1)		Parts are easy to grasp and manipulate		Parts present other handling difficulties (1)			
		$\alpha \leq 180°$	$\alpha = 360°$	$\alpha \leq 180°$	$\alpha = 360°$	$\alpha \leq 180°$	$\alpha = 360°$	$\alpha \leq 180°$	$\alpha = 360°$		
		0	1	2	3	4	5	6	7	8	9
Two hands, two persons or mechanical assistance required for grasping and transporting parts	9	2	3	2	3	3	4	4	5	7	9

Figure 6: Manual Handling-estimated times – Two Hands

MANUAL INSERTION–ESTIMATED TIMES (seconds)

Key: PART ADDED but NOT SECURED

		Alter assembly no holding down required to maintain orientation and location (3)				Holding down required during subsequent processes to maintain orientation at location (3)			
		Easy to align and position during assembly (4)		Not easy to align or position during assembly		Easy to align and position during assembly (4)		Not easy to align or position during assembly	
		No resistance to insertion	Resistance to insertion (5)	No resistance to insertion	Resistance to insertion (5)	No resistance to insertion	Resistance to insertion (5)	No resistance to insertion	Resistance to insertion (5)
		0	1	2	3	6	7	8	9
Addition of any part (1) where neither the part itself nor any other part is finally secured immediately: Part and associated tool (including hands) can easily reach the desired location	0	1.5	2.5	2.5	3.5	5.5	6.5	6.5	7.5
Addition of any part (1) where neither the part itself nor any other part is finally secured immediately: Part and associated tool (including hands) cannot easily reach the desired location: Due to obstructed access or restricted vision (2)	1	4	5	5	6	8	9	9	10
Addition of any part (1) where neither the part itself nor any other part is finally secured immediately: Part and associated tool (including hands) cannot easily reach the desired location: Due to obstructed access and restricted vision (2)	2	5.5	6.5	6.5	7.5	9.5	10.5	10.5	11.5

Figure 7: Manual Insertion-estimated times – Part Added but not Secured

PART SECURED IMMEDIATELY		No screwing operation or plastic deformation immediately after insertion (snap/press fits, circlips, spire nuts, etc.)		Plastic deformation immediately after insertion						Screw tightening immediately after insertion	
				Plastic bending or torsion			Rivetting or similar operation				
					Not easy to align or position during assembly			Not easy to align or position during assembly			
		Easy to align and position with no resistance to insertion (4)	Not easy to align or position during assembly and/or resistance to insertion (5)	Easy to align and position during assembly (4)	No resistance to insertion	Resistance to insertion (5)	Easy to align and position during assembly (4)	No resistance to insertion	Resistance to insertion (5)	Easy to align and position with no torsional resistance (4)	Not easy to align or position and/or torsional resistance (5)
Addition of any part (1) where the part itself and/or other parts are being finally secured immediately		0	1	2	3	4	5	6	7	8	9
Part and associated tool (including hands) can easily reach the desired location and the tool can be operated easily	3	2	5	4	5	6	7	8	9	6	8
Part and associated tool (including hands) cannot easily reach desired locaton or tool cannot be operated easily — Due to obstructed access or restricted vision (2)	4	4.5	7.5	6.5	7.5	8.5	9.5	10.5	11.5	8.5	10.5
Part and associated tool (including hands) cannot easily reach desired locaton or tool cannot be operated easily — Due to obstructed access and restricted vision (2)	5	6	9	8	9	10	11	12	13	10	12

Figure 8: Manual Insertion-estimated times – Part Immediately Secured

SEPARATE OPERATION		Mechanical fastening processes (part(s) already in place but not secured immediately after insertion)				Non-mechanical fastening processes (part(s) already in place but not secured immediately after insertion)				Non-fastening processes	
		None or localized plastic deformatiion				Metallurgical processes					
							Additional material required				
		Bending or similar process	Rivetting or similar processes	Screw tightening or other processes	Bulk plastic deformation (large proportion of part is plastically deformed during fastening)	No additional material required (e.g. resistance, friction welding etc.)	Soldering processes	Weld/braze processeses	Chemical processes (e.g. adhesive bonding, etc.)	Manipulation of parts or sub-assembly (e.g. orienting, fitting or adjustment of parts(s), etc.)	Other processes (e.g. liquid insertion, etc.)
Assembly processes where all solid parts are in place		0	1	2	3	4	5	6	7	8	9
	9	4	7	5	12	7	8	12	12	9	12

Figure 9: Manual Insertion-estimated times – Separate Operation

 End of exam.