

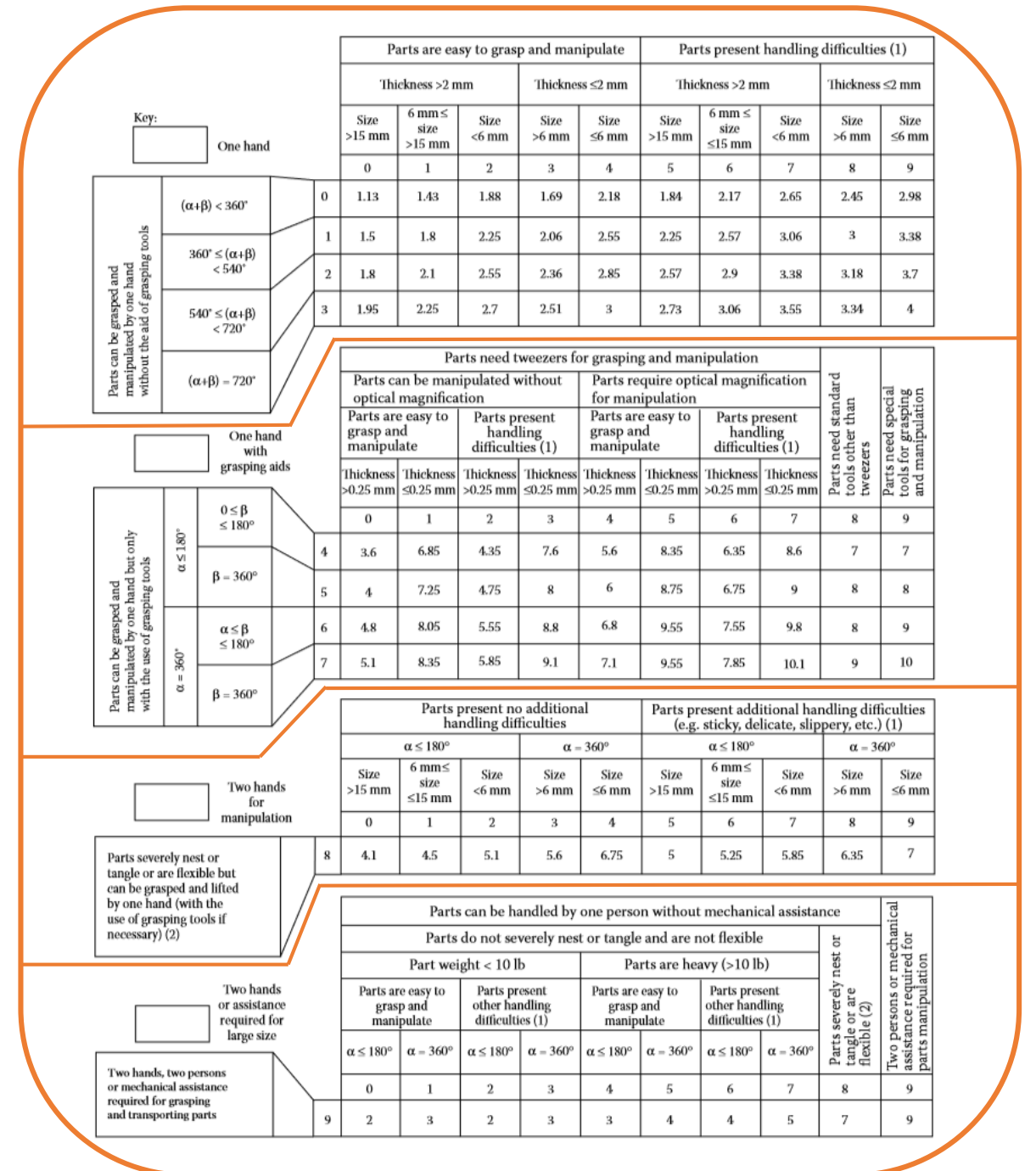
Classifications for Manual Assembly

Classifications for Manual Assembly Evaluation Charts

A systematic arrangement of part features in order of increasing handling difficulty levels.

The part features which affect manual handling time significantly are:

- Size
- Thickness
- Weight
- Nesting
- Fragility
- Flexibility
- Slipperiness
- Stickiness
- Necessity of using:
 - Two hands
 - Grasping tools
 - Optical magnification
 - Mechanical assistance



Classifications for Manual Assembly Evaluation Charts

The classification numbers are determined by two digits.

- Each digit is assigned a value 0-9

The first digit of the system is divided into 4 main groupings.

		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			
Key:			0	1	2	3	4	5	6	7	8	9		
Parts can be grasped and manipulated by one hand without the aid of grasping tools	(α+β) < 360°	0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98		
	360° ≤ (α+β) < 540°	1	1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38		
	540° ≤ (α+β) < 720°	2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7		
	(α+β) = 720°	3	1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4		
Parts need tweezers for grasping and manipulation														
Parts can be manipulated without optical magnification						Parts require optical magnification for manipulation						Parts need standard tools other than tweezers	Parts need special tools for grasping and 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	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			
Parts can be grasped and manipulated by one hand but only with the use of grasping tools	α ≤ 180°	0 ≤ β ≤ 180°	4	3.6	6.85	4.35	7.6	5.6	8.35	6.35	8.6	7	7	
		β = 360°	5	4	7.25	4.75	8	6	8.75	6.75	9	8	8	
	α = 360°	α ≤ β ≤ 180°	6	4.8	8.05	5.55	8.8	6.8	9.55	7.55	9.8	8	9	
		β = 360°	7	5.1	8.35	5.85	9.1	7.1	9.55	7.85	10.1	9	10	
Parts present no additional handling difficulties														
α ≤ 180°					α = 360°					α ≤ 180°			α = 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	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			
	Parts can be handled by one person without mechanical assistance													
Parts do not severely nest or tangle and are not flexible												Parts severely nest or tangle or are flexible (2)	Two persons or mechanical assistance required for parts manipulation	
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)					
α ≤ 180°	α = 360°	α ≤ 180°	α = 360°	α ≤ 180°	α = 360°	α ≤ 180°	α = 360°	α ≤ 180°	α = 360°	α ≤ 180°	α = 360°	8	9	
		0	1	2	3	4	5	6	7	8	9			
		2	3	2	3	3	4	4	5	7	9			

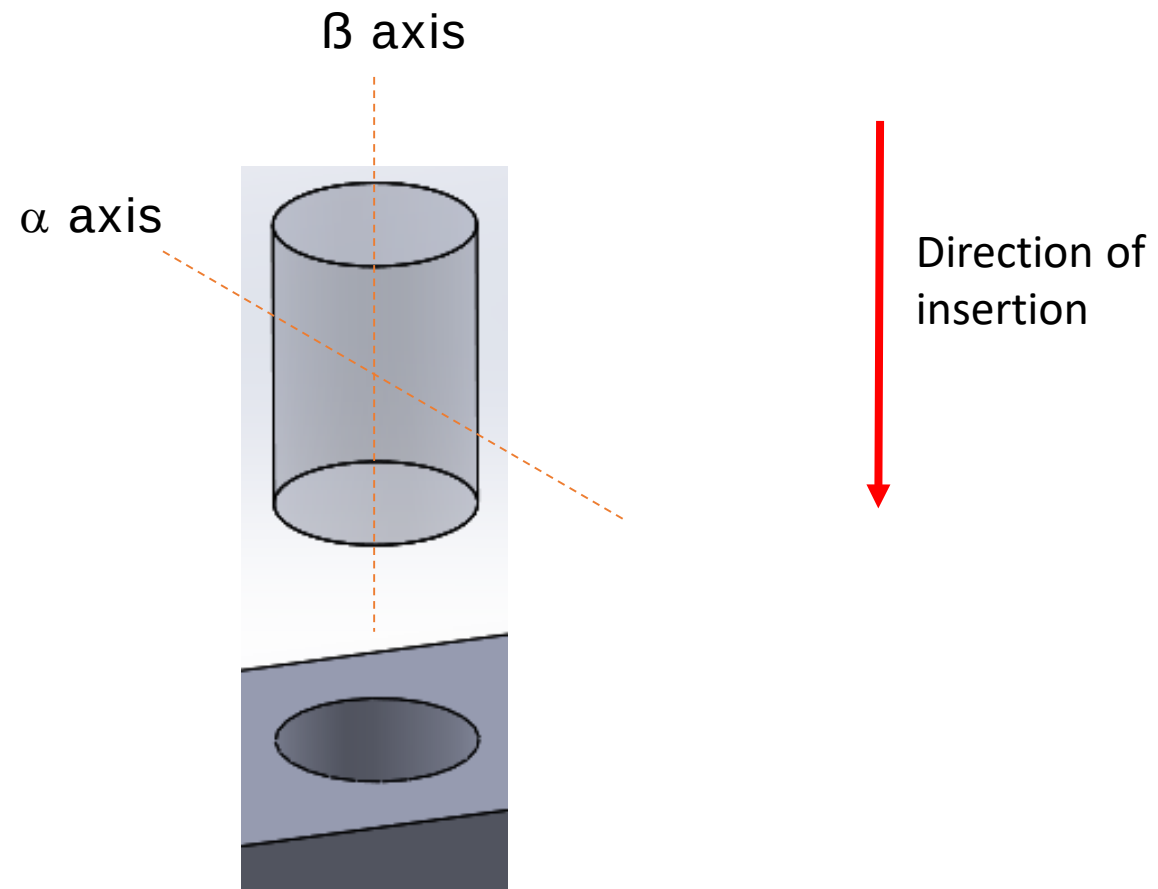
Classifications for Manual Assembly Evaluation Charts

First digit of 0-3	Parts of nominal size and weight that are easy to grasp and manipulate with one hand (without the aid of tools)
First digit of 4-7	Parts that require grasping tools to handle due to their size
First digit of 8	Parts which severely nest or tangle in bulk
First digit of 9	Parts which require two hands, two persons or mechanical assistance in handling.

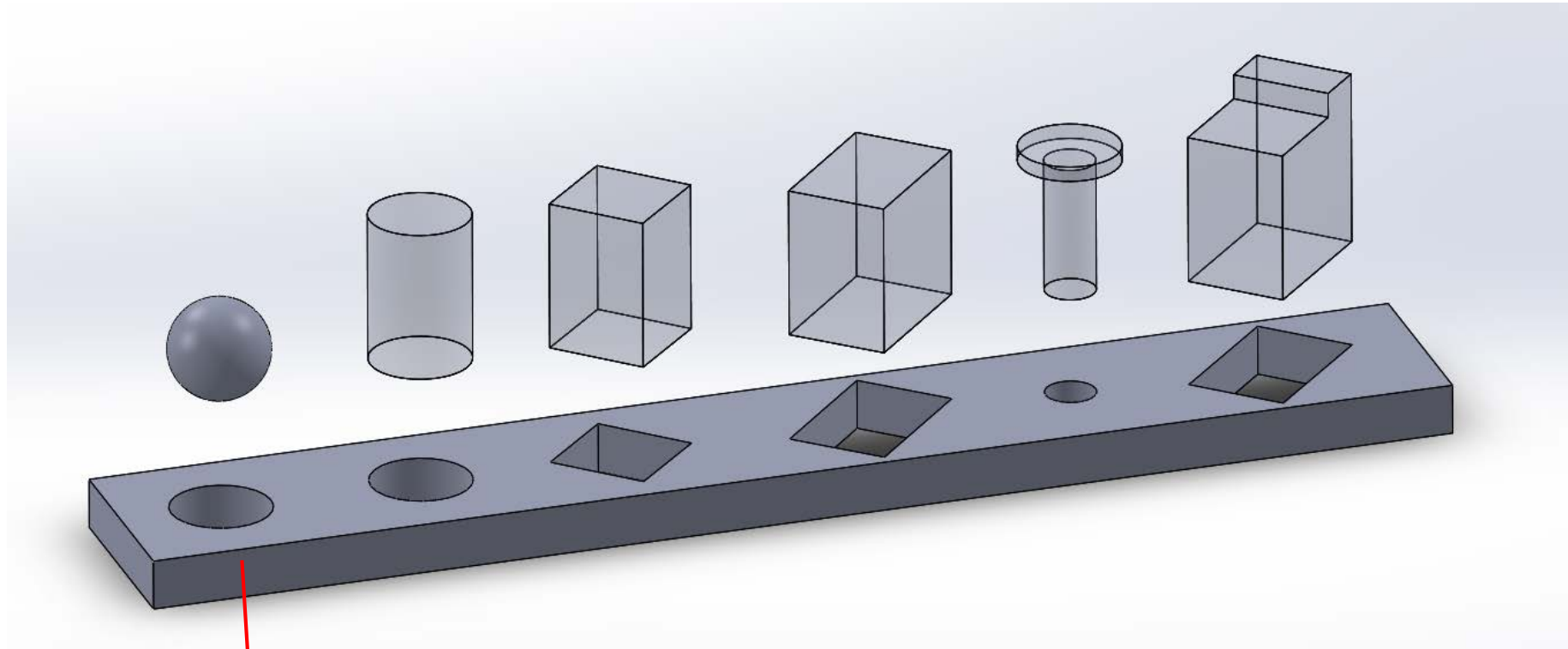
Key: One hand		Parts are easy to grasp and manipulate					Parts present handling difficulties (1)					
		Thickness >2 mm			Thickness ≤2 mm		Thickness >2 mm			Thickness ≤2 mm		
		Size >15 mm	6 mm ≤ size >15 mm	Size <6 mm	Size >6 mm	Size ≤6 mm	Size >15 mm	6 mm ≤ size ≤15 mm	Size <6 mm	Size >6 mm	Size ≤6 mm	
Parts can be grasped and manipulated by one hand without the aid of grasping tools	$(\alpha + \beta) < 360^\circ$	0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98
	$360^\circ \leq (\alpha + \beta) < 540^\circ$	1	1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38
	$540^\circ \leq (\alpha + \beta) < 720^\circ$	2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7
	$(\alpha + \beta) = 720^\circ$	3	1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4
Parts can be grasped and manipulated by one hand with grasping aids	Parts need tweezers for grasping and manipulation											
	Parts can be manipulated without optical magnification				Parts require optical magnification for manipulation				Parts need standard tools other than tweezers	Parts need special tools for grasping and 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				
Parts can be grasped and manipulated by one hand but only with the use of grasping tools	$0 \leq \beta \leq 180^\circ$	0	1	2	3	4	5	6	7	8	9	
	$\beta = 360^\circ$	4	3.6	6.85	4.35	7.6	5.6	8.35	6.35	8.6	7	7
	$\alpha \leq \beta \leq 180^\circ$	5	4	7.25	4.75	8	6	8.75	6.75	9	8	8
	$\beta = 360^\circ$	6	4.8	8.05	5.55	8.8	6.8	9.55	7.55	9.8	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)	$\alpha = 360^\circ$	7	5.1	8.35	5.85	9.1	7.1	9.55	7.85	10.1	9	10
Two hands for manipulation	Parts present no additional handling difficulties					Parts present additional handling difficulties (e.g. sticky, delicate, slippery, etc.) (1)					Parts severely nest or tangle or are flexible (2)	Two persons or mechanical assistance required for parts manipulation
	$\alpha \leq 180^\circ$		$\alpha = 360^\circ$			$\alpha \leq 180^\circ$		$\alpha = 360^\circ$				
	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		
Two hands or assistance required for large size	8	4.1	4.5	5.1	5.6	6.75	5	5.25	5.85	6.35	7	
Two hands, two persons or mechanical assistance required for grasping and transporting parts	Parts can be handled by one person without mechanical assistance											
	Parts do not severely nest or tangle and are not flexible											
	Part weight < 10 lb				Parts are heavy (>10 lb)				Parts severely nest or tangle or are flexible (2)	Two persons or mechanical assistance required for parts manipulation		
	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)					
$\alpha \leq 180^\circ$	$\alpha = 360^\circ$	$\alpha \leq 180^\circ$	$\alpha = 360^\circ$	$\alpha \leq 180^\circ$	$\alpha = 360^\circ$	$\alpha \leq 180^\circ$	$\alpha = 360^\circ$					
Two hands, two persons or mechanical assistance required for grasping and transporting parts	0	1	2	3	4	5	6	7	8	9		
	2	3	2	3	3	4	4	5	7	9		

Key: One hand				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
Parts can be grasped and manipulated by one hand without the aid of grasping tools	(α+β) < 360°		0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98
	1		1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38	
	2		1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7	
	3		1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4	
	(α+β) = 720°		Groups 1 & 2 are further sub-divided into categories representing the amount of orientation required, based on the symmetry of the part.										

α & β Orientation

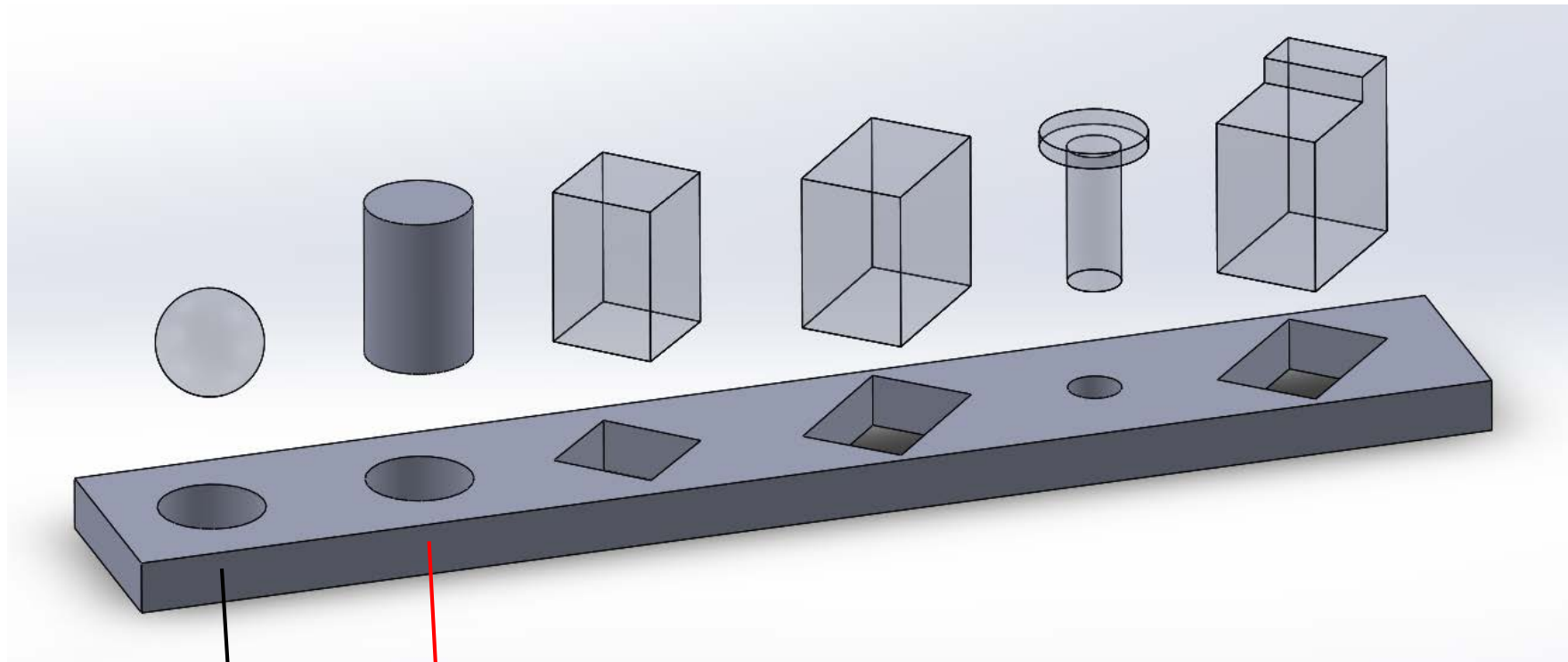


α & β Orientation



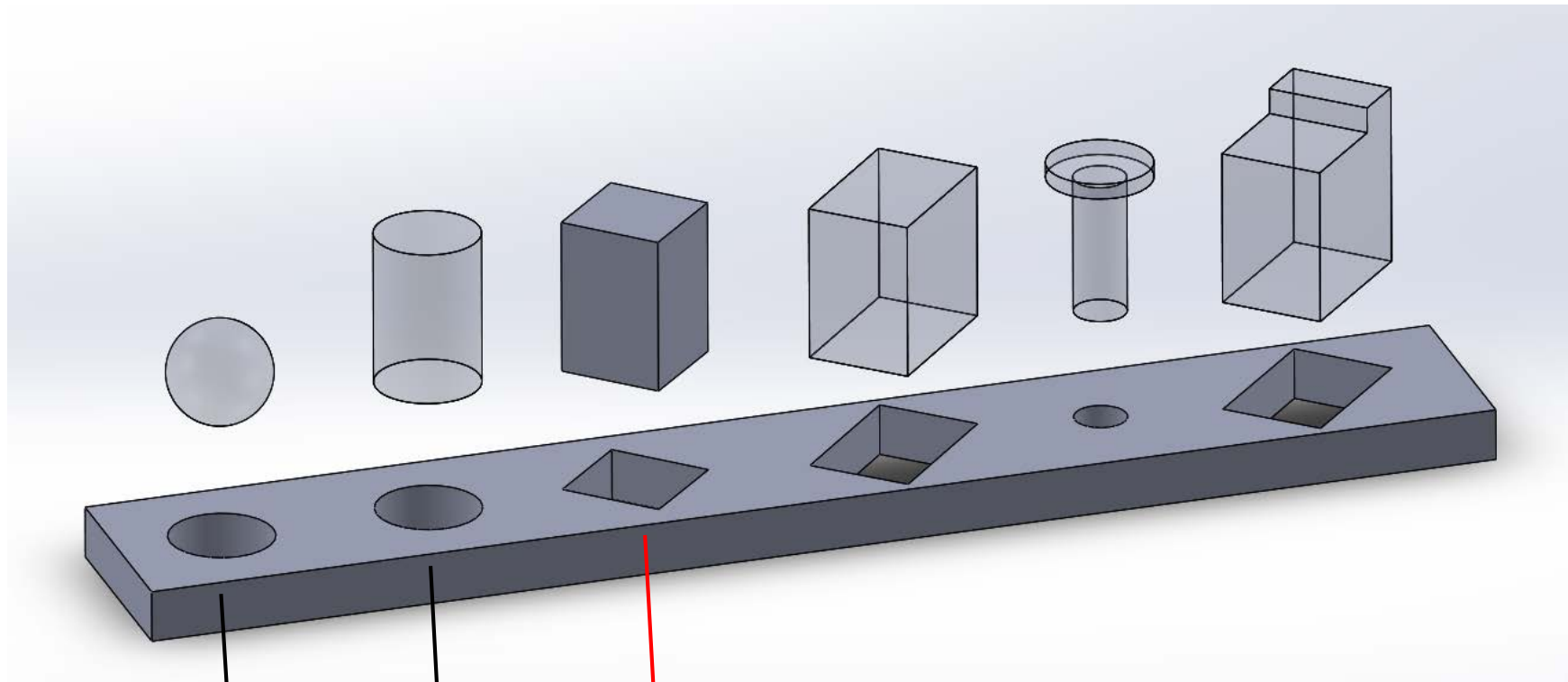
α	0					
β	0					

α & β Orientation



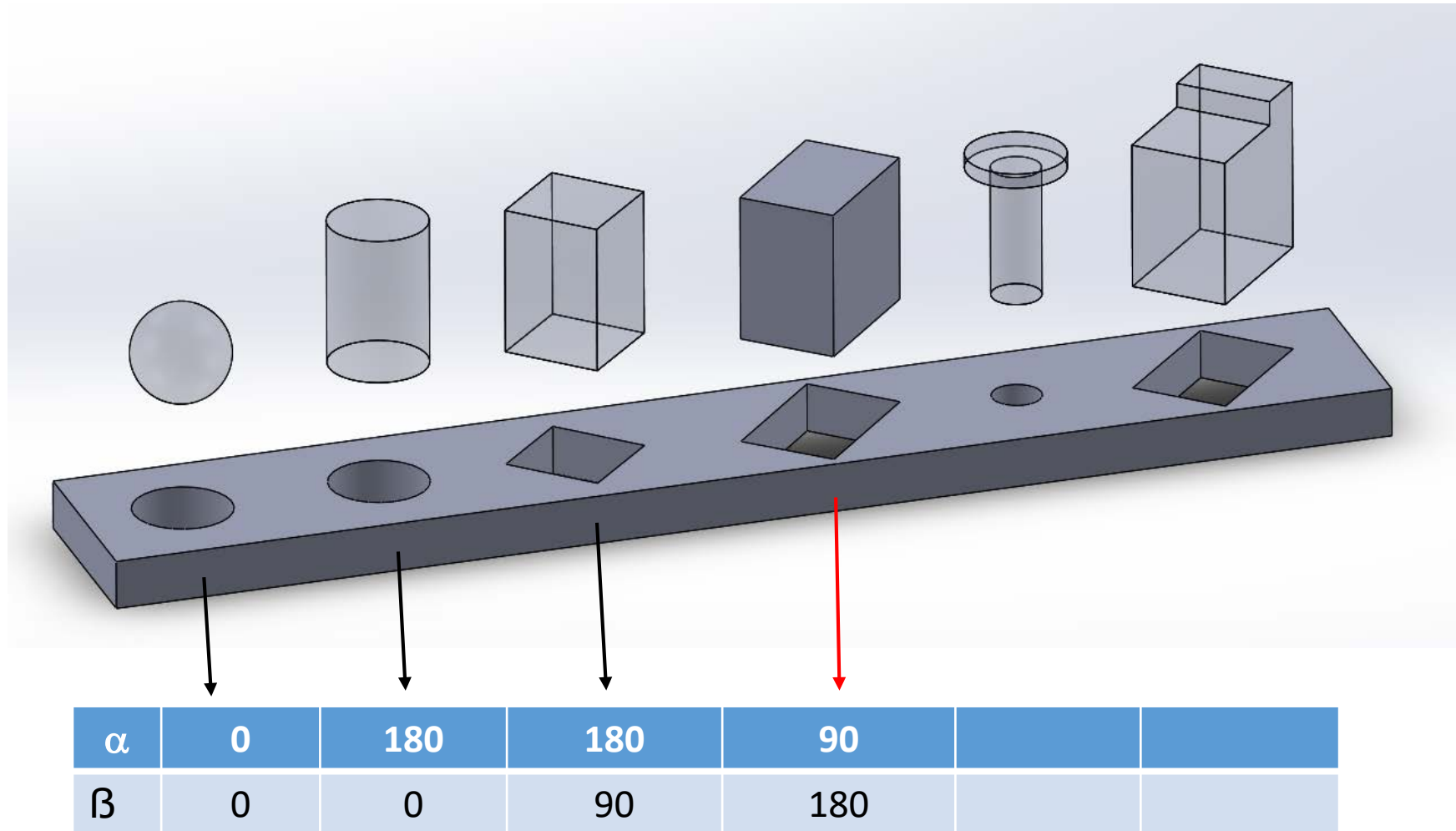
α	0	180				
β	0	0				

α & β Orientation

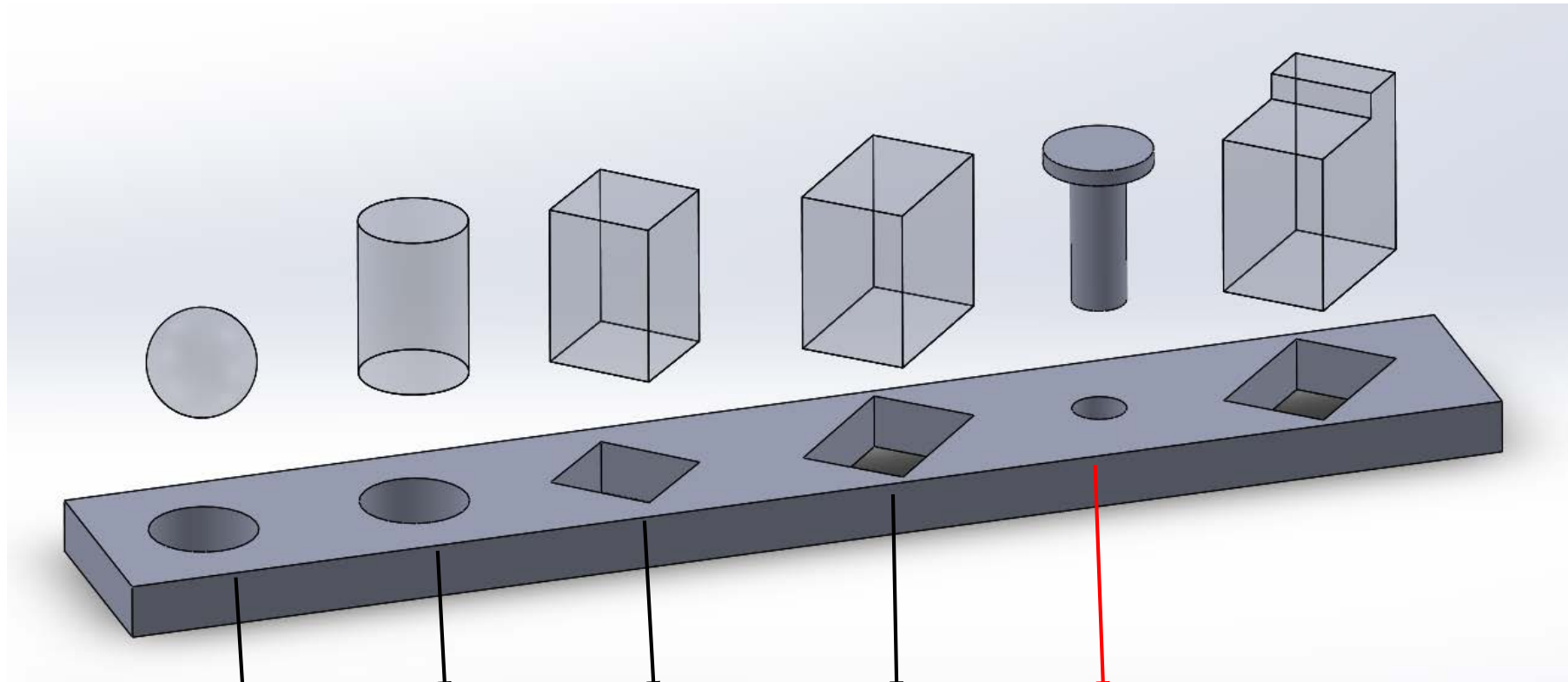


α	0	180	180			
β	0	0	90			

α & β Orientation

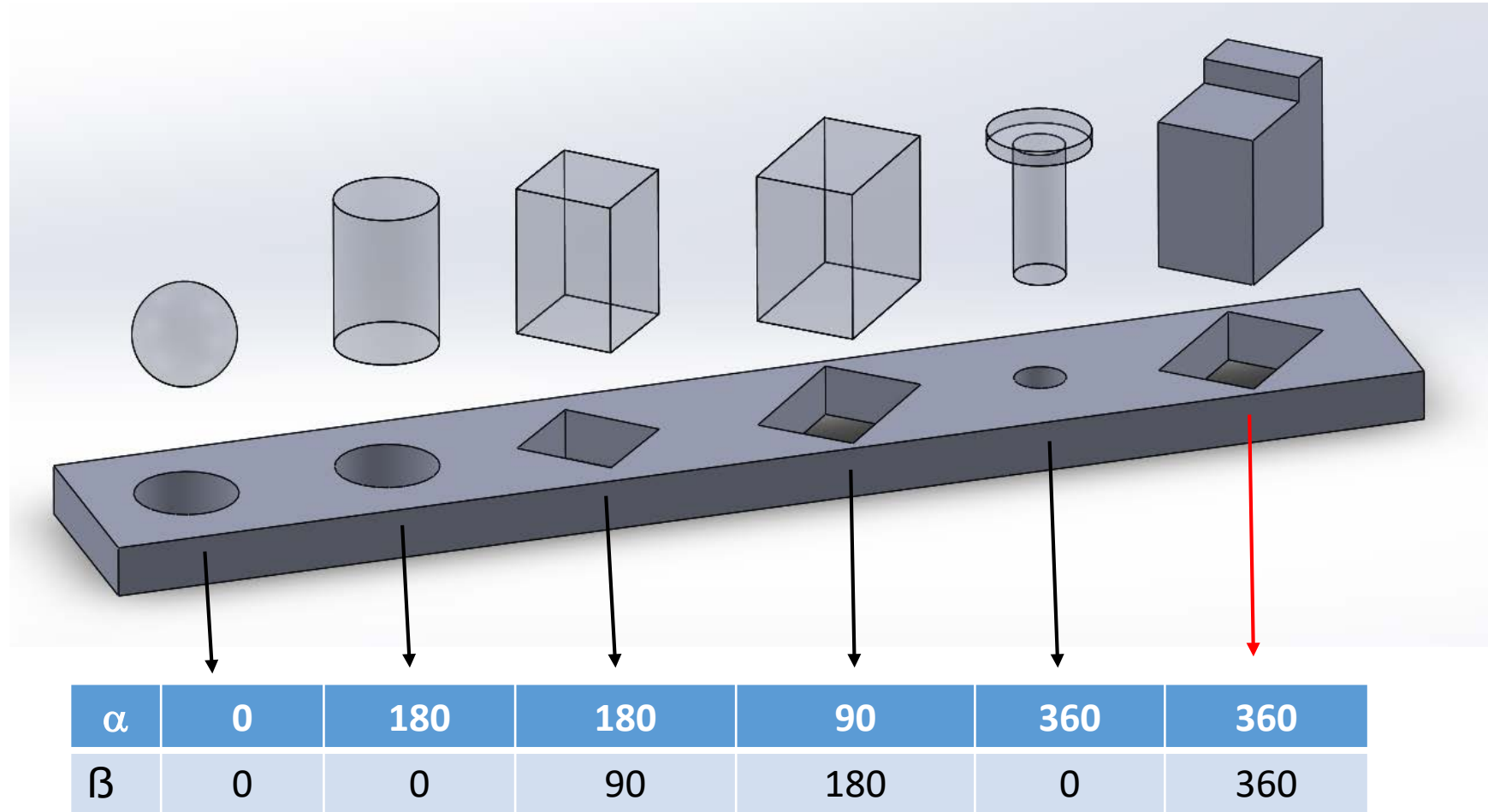


α & β Orientation



α	0	180	180	90	360	
β	0	0	90	180	0	

α & β Orientation



Key:

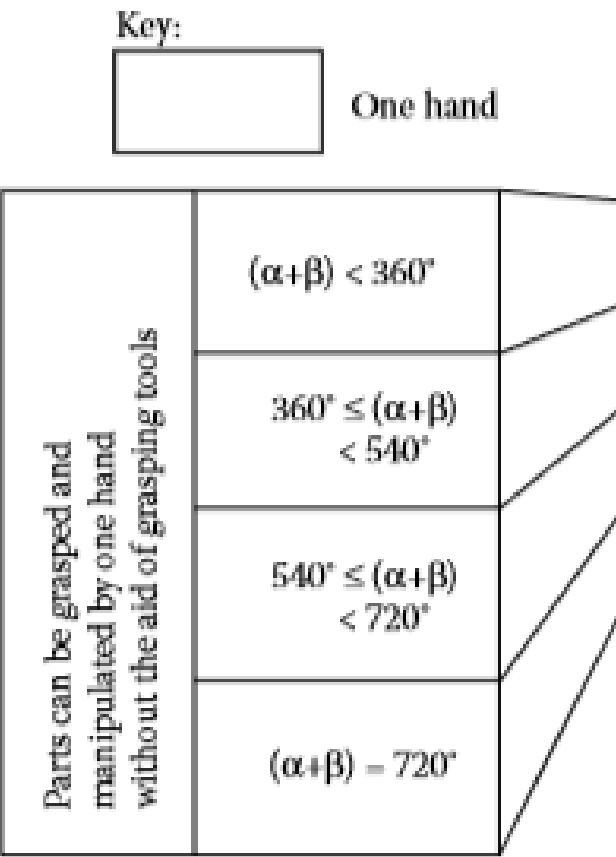


One hand

Parts can be grasped and manipulated by one hand without the aid of grasping tools	$(\alpha + \beta) < 360^\circ$	
	$360^\circ \leq (\alpha + \beta) < 540^\circ$	
	$540^\circ \leq (\alpha + \beta) < 720^\circ$	
	$(\alpha + \beta) = 720^\circ$	

	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
0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98
1	1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38
2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7
3	1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4

The second digit of the handling code is based on flexibility, slipperiness, stickiness, fragility and nesting characteristics of the part. The second digit also depends on the group divisions of the first digit (as defined on the following slide).



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	
1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98	
1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38	
1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7	
1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4	

Parts need tweezers for grasping and manipulation			Standard handling	Special handling
Parts can be manipulated without optical magnification		Parts require optical magnification for manipulation		
Parts are easy to grasp and manipulate	Parts are easy to grasp and manipulate	Parts are easy to grasp and manipulate		

- For a first digit of 0-3
- The 2nd digit classifies the size and thickness of the part
- For a first digit of 4-7
- and the necessity for optical magnification during the handling process
- For a first digit of 8
- The second digit classifies the size and symmetry of the part
- For a first digit of 9
- The second digit classifies the symmetry, weight and interlocking characteristics of parts in bulk

Key: One hand				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	
Parts can be grasped and manipulated by one hand without the aid of grasping tools	(α+β) < 360°	0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98		
	360° ≤ (α+β) < 540°		1	1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38	
			2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7	
			3	1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4	
	(α+β) = 720°													
Parts need tweezers for grasping and manipulation													Standard handling	Special handling
Parts can be manipulated without optical magnification					Parts require optical magnification for manipulation									
Parts are easy to grasp and manipulate					Parts are easy to grasp and manipulate									

For a first digit of 4-7

The 2nd digit classifies the size and symmetry of the part

4-7

and the necessity for optical magnification during the handling process

For a first digit of 8

The second digit classifies the size and symmetry of the part

For a first digit of 9

The second digit classifies the symmetry, weight and interlocking characteristics of parts in bulk

Parts can be grasped and manipulated by one hand but only with the use of grasping tools	$\alpha \leq 180^\circ$	$0 \leq \beta \leq 180^\circ$		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				
	$\beta = 360^\circ$	4	3.6	6.85	4.35	7.6	5.6	8.35	6.35	8.6	7	7	
		5	4	7.25	4.75	8	6	8.75	6.75	9	8	8	
$\alpha = 360^\circ$	$\alpha \leq \beta \leq 180^\circ$	6	4.8	8.05	5.55	8.8	6.8	9.55	7.55	9.8	8	9	
		7	5.1	8.35	5.85	9.1	7.1	9.55	7.85	10.1	9	10	
$\beta = 360^\circ$													

One hand with grasping aids

For a first digit of 4-7

One hand
with
grasping aids

For a first digit of 4-7

The 2nd digit classifies the size and symmetry of the part

Two hands for manipulation			Parts present no additional handling difficulties					Parts present additional handling difficulties (e.g. sticky, delicate, slippery, etc.) (1)					
			$\alpha \leq 180^\circ$			$\alpha = 360^\circ$		$\alpha \leq 180^\circ$			$\alpha = 360^\circ$		
			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

For a first digit of 8

For a first digit of 8
The second digit classifies the size and symmetry of the part

Two hands or assistance required for large size Two hands, two persons or mechanical assistance required for grasping and transporting parts		Parts can be handled by one person without mechanical assistance								Parts severely nest or tangle or are flexible (2)	Two persons or mechanical assistance required for parts manipulation
		Parts do not severely nest or tangle and are not flexible									
		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)			
		$\alpha \leq 180^\circ$	$\alpha = 360^\circ$	$\alpha \leq 180^\circ$	$\alpha = 360^\circ$	$\alpha \leq 180^\circ$	$\alpha = 360^\circ$	$\alpha \leq 180^\circ$	$\alpha = 360^\circ$		
		0	1	2	3	4	5	6	7	8	9
	9	2	3	2	3	3	4	4	5	7	9

For a first digit of 9

The second digit classifies the symmetry, weight and interlocking characteristics of parts in bulk