

EN1740 Computer Aided Visualization and Design

Spring 2012

4/17/2012 - Lecture A

Brian C. P. Burke

Last Time:

- Group Project Overview
- Tolerance Analysis
 - CETOL
- Intro to GD&T

Tonight:

- Intro to GD&T
- Motion analysis with Pro/E

Geometric Dimensioning and Tolerancing (GD&T)

Position tolerance requires Datums, Basic Dim's and Tolerance

Fig. 8-7 & 8-8, B. A. Wilson, GD&T App. And Intr., 2010

Datums establish how to measure the part, *Basic dimensions* state theoretical location & *Position Tolerances* state allowances

BCB – Apr. 17, 2012

Geometric Dimensioning and Tolerancing (GD&T)

Principal Advantage

- Key advantages of position tolerances:
 - Clarity Part is located and removes ambiguity
 - Increase tolerance zone
 - Bonus tolerances from material modifiers
 - Go/No-Go Gaging

Fig. 8-23, B. A. Wilson, GD&T App. And Intr., 2010 Fig. 8-24, B. A. Wilson, GD&T App. And Intr., 2010

Geometric Dimensioning and Tolerancing (GD&T)

Example

Fig. 8-1, B. A. Wilson, GD&T App. And Intr., 2010

BCB – Apr. 17, 2012



EXERCISE - Design Tolerance Analysis

Tolerance study with GD&T

- Get tol_blocks.zip from Supporting Materials page
- Open blocks.asm
- Apply position tol's to hole and pin
- Analyze affect of tolerance on gap between plate and block





EXERCISE - Design Tolerance Analysis

Set Datums

- This will establish the datum feature references
- Set FRONT datum as A (Primary datum)
 - Select FRONT
 - RMB > Properties
 - Change name to A
 - Select last type
 - Placement > On Datum
 - OK
- Repeat setting RIGHT as B and TOP as C





EXERCISE - Design Tolerance Analysis

Set Datums

- Repeat for other postblock.prt
 - Set FRONT as A
 - Set RIGHT as B
 - Set TOP as C



EXERCISE - Design Tolerance Analysis

Set Basic Dimensions

- Set the dimensions that locate the hole as Basic on B-BLOCK.prt
- Repeat for post on POST-BLOCK.prt

	Properties Dimension Text Text Style	
	Value and tolerance	Format
	Tolerance mode Nominal	Decimal
	Nominal value 1.500	C Fractional
	Upper tolerance 0.001	Number of decimal places
B-BLUCK (Active) - Pro/ENGINEER Education Edition Elle Edit View Insert Analysis Info Applications Iools Window H	Lower tolerance 0.001	An and an affirm and a
] D 2 ² B B A A A A A X M A B B B		
		Degrees
	Display	Dual dimension
sprt	O Inspection	Position 💿 Below
<u>/</u> /B <u>/</u> /C	O Neither	U To right
Z7 A → PRT_(Show as linear dimension	Dual decimal places
B-mf ² Extru 	Text orientation	
	(As Is)	Witnessline display
	Chamfer style Ordinate Style	Show Erase Default
Round	ANSI 🗹	
	Move Move Text Edit Attach Or	rient Text Symbol
•	Restore Values	OK Cancel
	XX+01 XXX+001	 ○○ <li< th=""></li<>
	ANG.+-0.5	I &

Dimension Properties

EN1740, S2012

X

EXERCISE - Design Tolerance Analysis

Create GD&T Feature Control Frame

- Create a position tolerance for the hole on B-BLOCK.prt
 - Insert > Annotation > Geometric Tolerance
- Click Specify Tol from Menu Manager
- From Type pick Feature, Select hole
- From Placement pick dimension and select the hole diameter



EXERCISE - Design Tolerance Analysis

Create GD&T Feature Control Frame

- Set the datum references for the position tolerance
 - A as primary
 - B as secondary
 - C as tertiary

B-BLOCK (Activ	🧾 Geon	netric To	lerance	×
Elle Edit Alem I	—		Mode Refs Datum Refs To Value Symbols Additional Text	OK
	$\overline{\mathbf{O}}$	10/	Datum References	Cancel
Br Carl I Show ▼ Sett	$\check{\frown}$	$\overline{\bigcirc}$	Primary Secondary Tertiary	New Gtol
B-BLOCK.I	1 1	<u> </u>	Basid 🛛 🔄 💽 💽 💽	
— [] B — [] C — [] A	\leq	Ļ	Compound none	Copy From
→ PRT_(→ Sketcl 田→ ☆ Extru		$ \oplus $		_
Extru	O	=	Composite Tolerance	
Emergina Hole J Emergina Patter Patter Round	ø	\$ \$	Value 0.001 Datum Reference None 💌	Move
Patter → Round → Round	STATUS	: complete		
- Insert				
				A C
				3
				Ø
		X		Â
				6
		×	x x + x x x x + 0. x x x + 0. x x x + 0.	01 001 5
لالك التحر			Smat	- 8

BCB – Apr. 17, 2012

EXERCISE - Design Tolerance Analysis

Create GD&T Feature Control Frame

• Set tolerance value to .010

📕 Geometric To	plerance	×	
$-\Box$	Model Refs Datum Refs Tol Value Sympols Additional Text	OK	
$\cap \mathcal{M}$	Tolerance Value	Cancel	
	✓ Overall Tolerance 0.010	New Gtol	
	Name gp0		
$\leq \perp$	Per Unit Tolerance	Copy From	
// 🕀	Value/Unit 0.001		×
	Unit Length 0.001		
<u> </u>	Material Condition RFS(no symbol)	Move	¢
STATUS: complete	a.		r,
			0
			A A
		6	P
		0 4	<u>0</u> 7
		á	8
	× **		
		r G	р Д
		d	戸目
		X.X+-0.1	
<u>∢</u> >⊴		X,XX+-0.01 K,XXX+-0.001 ANG,+-0.5	
	Smart		

EN1740, S2012

BCB – Apr. 17, 2012

EXERCISE - Design Tolerance Analysis

Create GD&T Feature Control Frame

- Turn on the diameter symbol
- Click OK
- Done Return



EXERCISE - Design Tolerance Analysis

Finish Tolerance

- Change the tolerance type on the dimension to symmetric
- The dimension should appear as shown



EXERCISE - Design Tolerance Analysis

One more time...

• Repeat the process of setting a position tolerance for the mating feature on post-block.prt



BCB – Apr. 17, 2012

EXERCISE - Design Tolerance Analysis

Analyze gap between edges

- Start a new CETOL analysis (Analysis > CETOL)
- Select horizontal basic dimension and position tolerance from each component
- MMB when done



EXERCISE - Design Tolerance Analysis

Analyze gap between edges

• Take a look at the results for the default design objective of <u>+</u>.010

Measurement Table						đ
ame	Nominal	Tolerance	Ср	<u>6</u>	Attachment	
- HI CETOL_1	0.02	0.020 ±0.010	_	_	Center	
🗄 🗾 Post-Block						
- Feature1						
↔ d11	3	⊕ Ø0.01	1	1		
En Peature						
POST-BLOCK/B-BL					Center	
	2.98	⊕ Ø001	1	-1		
Feature2	2170	1.9 1.0 0.0 1				
lvsis Results						
lysis Results						
lysis Results Measure Variation					Stat Contribs WC Contribs Sensitivities	
lysis Results Measure Variation					Stat Contribs WC Contribs Sensitivities	1
lysis Results Measure Variation igma _= 4.2426					Stat Contribs WC Contribs Sensitivities	
lysis Results Measure Variation igma = 4.2426 & Vield = 99.9978					Stat Contribs WC Contribs Sensitivities	1
lysis Results Measure Variation igma = 4.2426 &Yield = 99.9978 PMU = 22.264					Stat Contribs WC Contribs Sensitivities	1
lysis Results Measure Variation igma = 4.2426 & Yield = 99,9978 IPMU = 22.264					Stat Contribs WC Contribs Sensitivities	1
lysis Results Measure Variation igma = 4.2426 &Yield = 99,9978 IPMU = 22.264					Stat Contribs WC Contribs Sensitivities Name Statistical ContributionPOST-BLOCK:d11	
lysis Results Measure Variation igma = 4.2426 &Yield = 99.9978 PMU = 22.264 0.01			0.0:	3	Stat Contribs WC Contribs Sensitivities Name Statistical Contribution .POST-BLOCK:d11 50.00 % .B-BLOCK:d14 50.00 %	1
Ilysis Results Measure Variation iigma = 4.2426 &Yield = 99.9978 JPMU = 22.264 0.01			0.02	3	Stat Contribs WC Contribs Sensitivities Name Statistical Contribution POST-BLOCK:d11 50.00 % B-BLOCK:d14 50.00 %	2
Ilysis Results Measure Variation iigma = 4.2426 &Yield = 99.9978 PMU = 22.264 0.01			0.0	3	Stat Contribs WC Contribs Sensitivities Name Statistical Contribution .POST-BLOCK:d11 50.00 % .B-BLOCK:d14 50.00 %	(
lysis Results Measure Variation igma = 4.2426 &Yield = 99.9978 PMU = 22.264 0.01	0.02		0.0:	3	Stat Contribs WC Contribs Sensitivities Name Statistical Contribution POST-BLOCK:d11 50.00 % B-BLOCK:d14 50.00 %	1
lysis Results Measure Variation igma = 4.2426 &Yield = 99.9978 PMU = 22.264 0.01	0.02		0.03	3	Stat Contribs WC Contribs Sensitivities Name Statistical Contribution .POST-BLOCK:d11 50.00 % .B-BLOCK:d14 50.00 %	ć
lysis Results Measure Variation igma = 4.2426 &Yield = 99.9978 PMU = 22.264 0.01 0.01 Dimension Loop Dia	0.02		0.0	3 1.03	Stat Contribs WC Contribs Sensitivities Name Statistical Contribution POST-BLOCK:d11 50.00 % B-BLOCK:d14 50.00 %	6
Ilysis Results Measure Variation iigma = 4.2426 &Yield = 99,9978 PMU = 22.264 0.01 0.01 Dimension Loop Dia	0.02 gram		0.0	3 	Stat Contribs WC Contribs Sensitivities Name Statistical Contribution POST-BLOCK:d11 50.00 % B-BLOCK:d14 50.00 % sis Results	

BCB – Apr. 17, 2012

Motion Analysis

- Using capabilities in Pro/E we can:
 - Visualize mechanism motion
 - Analyze kinematic results
 - Export animation of mechanism





EXERCISE - Motion Analysis

Open the assembly

- Download pist-crank.asm from the Supporting Materials page of the web site
- Open the assembly



EXERCISE - Motion Analysis

Switch to the Mechanism Application

• Applications > Mechanism



BCB – Apr. 17, 2012

EXERCISE - Motion Analysis

Examine current constraints

- View > Highlight Bodies
 - Green highlighting means a body is grounded (has no available DOF's)
 - Other colors are not significant except to differentiate bodies
 - There are a finite number of colors available...may repeat if necessary
- Need to "un-ground" the components to allow motion



EXERCISE - Motion Analysis

Redefine model constraints

- Switch back to the Standard Application
- We will need to Edit Definition for each component in the assembly
- Start with:

crank-shaft_one_pist.prt



EXERCISE - Motion Analysis

Redefine model constraints

- Examine the constraints currently applied:
 - The first constraint aligns the center axis
 - The next two align planes
- Delete the two planar constraints
 - Select constraint > RMB > Delete



EXERCISE - Motion Analysis

Redefine model constraints

- With just the axis alignment constraint remaining, click the convert icon
 - This icon converts the assembly constraints to mechanism constraints



EXERCISE - Motion Analysis

Redefine model constraints

- Drop down the constraint-type menu
- Look at the available types of motion in the list after a co-axial constraint has been established
- Select Pin

🛄 PIST-	ERANK	(Active) - Pro/EN	GINEE	R Educatio	on Edition					
<u>F</u> ile <u>E</u> di	t <u>V</u> iew	<u>I</u> nsert	<u>A</u> nalysis	I <u>n</u> fo	Application	ns <u>T</u> ools	<u>M</u> anikin	<u>W</u> indow	<u>H</u> elp		
] B ø	98	B (1 G	n	° Å	ħĈ			040 80	3•]	2
	×××	×××	<u>₹</u> \?								
🗳 🔶	Select a p	oint or p	olanar surfa	ice on a	one part.						
	1		> 🔀 Рі	n	•	/s Au	itomatic	~		- NOTI	DEFINE
	Placeme	nt Mo	ve User D)efined							
80 1	E Conr	ection_"	l (Pi 📈 Pi	gia 1	Co	nstraint En	abled				
Shor	- Tra	angline	" Sli 	der linder	:tr	aint Type		_			
🔲 PIS'	S	elect co	mpo 🔥 Pl	anar	ог	natic	▼ FI	ip.			
		elect as:	semt 🌮 Ba	all eld	et		_				
			Be	aring		Coincident	•	NOT DI			
7			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	eneral)OF							
•			💫 SI	ot			1-1				
	New S	et			Conne	ction Defin	ition Not C	omplete.			

EXERCISE - Motion Analysis

Redefine model constraints

- Return to Placement
 dialog
- Notice the system is prompting for the next DOF
 - In this case, a Translation constraint
 - Select the RIGHT plane of the crank shaft
 - Select the ASM_RIGHT plane from the assembly

🧮 PIST-CRANK (Active) - Pro/ENGINEER	Education Edition
<u>File E</u> dit <u>V</u> iew Insert <u>A</u> nalysis I <u>n</u> fo A	pplications <u>T</u> ools <u>M</u> anikin <u>W</u> indow <u>H</u> elp
C & E & Q Q M (> X 昏昏昏腔腔的口•] 🖂
] ∠ , /, ×× ¥∗ ⊐ <u></u> , №	
Select a point or planar surface on on	e part.
函 🕞 🏷 🔀 Pin	🔹 🖌 🛛 Automatic 🖃 🔲 🕶 NOT DEF
Placement Move Flexibility Pr	operties
B □ I Sho PIS PIS PIS PIS Select component item Select assembly item	Constraint Enabled Constraint Type Automatic Flip Offset Coincident NOT DEF
New Set	Connection Definition Not Complete.

EXERCISE - Motion Analysis

Redefine model constraints

- The system then prompts for the next DOF
 - Connection is labeled Rotation Axis
 - It's actually looking for a reference plane to use as a 0 deg rotation reference
 - Select the TOP plane from the crank shaft
 - Select the ASM_TOP plane from the assembly
- Click Done



BCB – Apr. 17, 2012

EXERCISE - Motion Analysis

Redefine model constraints

• Notice the Connection Icon next to the part file name in the model tree



EXERCISE - Motion Analysis

Redefine model constraints

- Now edit the definition of the *rod.prt*
- Delete the two planar constraints
 - Notice this leaves the axis alignment
- Convert the constraint to a Pin type connection

🛄 PIST-CRANK (Active) - Pro/ENGINEER I	Education Edition
<u>File E</u> dit <u>V</u> iew Insert <u>A</u> nalysis Info A	pplications <u>T</u> ools <u>M</u> anikin <u>W</u> indow <u>H</u> elp
C & E 🛔 4, 6, 🛛 🖍 🤇	> X 昏昏昏茫茫的口•
🛛 🗸 🏑 🛪 🎘 🖓 🖓 🖉	
Select a point or planar surface on one	e part.
🗹 🕒 🏷 📈 Pin	📕 🖌 🛛 Automatic 🔄 🔲 🕶 NO
Placement Move Flexibility Pro	operties
B [□ Connection_1 (Pin)	Constraint Enabled
Shor Translation	Constraint Type
Select component item	Automatic Flip
Select assembly item	Offset
	Coincident 🔽 NOT DEF
¥.	
↓ ↓ ↓	
New Set	Status
	Connection Definition Not Complete.

EXERCISE - Motion Analysis

Redefine model constraints

- For the Translation constraint
 - Select the back surface of the rod
 - Select the RIGHT plane of the crank shaft
- Do not specific a Rotation Axis
 - Already done with crank shaft
 - Notice the status of the part is Connection Definition Complete



EXERCISE - Motion Analysis

Redefine model constraints

- Before we can redefine the piston constraints we need to add a datum axis
- Drag the Insert Here tab under the rod
- Click the Create Axis icon
- Click the RIGHT plane on the rod
- Holding the Ctrl key, click ASM_FRONT plane
- Click OK



BCB – Apr. 17, 2012

EXERCISE - Motion Analysis

Redefine model constraints

- Resume the rest of the assembly features
 - Drag the Insert Here tag down to the bottom of the tree
- Edit the piston component
 - Remove all constraints but the axis



EXERCISE - Motion Analysis

Redefine model constraints

- Convert the original constraint to a Pin connection
 - Edit the Translation constraint
 - Select the RIGHT datum from the piston
 - Select the RIGHT datum from the rod

🛄 PIST-CRANK (Active) - Pro/ENGINEER	Education Edition
<u>Eile E</u> dit <u>V</u> iew <u>I</u> nsert <u>A</u> nalysis I <u>n</u> fo a	Applications <u>T</u> ools <u>M</u> anikin <u>W</u> indow <u>H</u> elp
068844	◇ X 🖻 🛱 🟥 💒 🗰 🗆 - 🛛 🐎 💖 🏷 🔍 🔍 🖾 🖆 🕾 🗍 🗇
∠ 2 /	
Select a point or planar surface on ot	her part.
📓 🕒 🏷 📈 Pin	💽 🌠 🗐 Align 🔄 🔲 🔹 NOT DEFINE 💌 🌠 STATUS : Connection Definition Complete.
Placement Move Flexibility P	roperties
Bo Connection_2 (Pin)	Constraint Enabled
Shor Translation	Constraint Type
	Aign Fip
	Status FRONT
	Connection Definition Complete.
	Translation
	Axis alignment
	, PISTON PIN

EXERCISE - Motion Analysis

Redefine model constraints

- We need to add an addition connection for the piston
 - Click New Set
 - Change connection type to Cylinder
 - Select the Cylinder axis on the piston
 - Select the datum axis we created earlier in the exercise
- Click Done



EXERCISE - Motion Analysis

Redefine model constraints

• Suppress the piston-pin and the piston-ring in the model tree

• SAVE

- Switch applications back to Mechanism
- View > Highlight Bodies
- Notice no green left





EXERCISE - Motion Analysis

Run the model

- As another check, run the model
 - Edit > (Re)connect
 - Click Run
- There should be a message saying it was successful

Click Yes





EXERCISE - Motion Analysis

Drag the mechanism through its motion

- Click Drag
- Click on the end face of the crank shaft
- Rotate the mechanism
- LMB Done.



BCB – Apr. 17, 2012