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## PTC Product Focus

### Pro/Engineer Behavioral Modeling Extension (BMX)

#### Introduction

Behavioral Modeling (BMX) technology was introduced with Pro/Engineer 2000i and has been continually developed over the past three releases. BMX enables Pro/Engineer users to solve real world engineering problems. The technology was so revolutionary that PTC received several awards including an INDUSTRYWEEK Technology of the Year Award and the Computer Graphics World Innovation Award, both in 1999. BMX is commonly overlooked though it is relatively simple to use. Why? Probably the misconception that such a powerful tool is also complex.

#### Core Capabilities

Behavioral Modeling increases the power and value of Pro/Engineer design intent exponentially by allowing the user to achieve critical design objectives automatically. With BMX, Pro/Engineer users no longer design by trial and error. With BMX, the redundant task of modifying dimensions and testing results can be eliminated instantly. The potential impact on user productivity is remarkable.

Behavioral Modeling turns on the following functions within Pro/Engineer:

**Analysis Feature** – The ability to save any standard analysis as a model tree feature.

**Motion Analysis** – Run a predefined MDX/MDO analysis and return results.

**Mechanica Analysis** – Run a predefined Mechanica analysis and return results.

**Excel Analysis** – Export and Import design parameters to Microsoft Excel.

**User-Defined Analysis** – A datum construction group used to build a non-standard analysis.

**Sensitivity** – Graph the relationship between driving parameters and resultant measures.

**Feasibility** – Modify model parameters to meet specified design criteria.

**Optimization** – Identify the optimal design that meets the specified criteria and single goal.

**Multi-Objective Design Study** – Identify the design solution set that meets the specified criteria and multiple goals.

In addition, Analysis Features can be created on the fly after analyzing any geometric property by selecting the ‘Add Feature’ button. The analysis feature is then inserted in the model tree.

The Sensitivity Study is used when the relationship between driving parameters and measurable results needs to be investigated. The result of this study is purely graphical. It does not result in changes to the part geometry.

A Feasibility Study is used to determine if the design criteria is possible by modification to the specified parameters. The result of this study is modified Pro/Engineer geometry, if the design criteria are achieved. Graphical results are optional.

An Optimization Study combines the functionality of the Feasibility Study with the ability to target a specific goal, such as minimum mass. With this option, BMX not only ensures the design criteria is achieved, it also determines the optimal combination of parameters to achieve the goal specified. The result is optimized model geometry. Graphical results are optional.

The Multi-Object Design Study is used when multiple goals exist that need to be evaluated against one another. The result of this study is a solution set that explores the design space that achieves the specified goals. The results can be displayed graphically. The ‘optimal’ design solution set can be objectively chosen from the graphical display.

## Potential Use Cases

When would a Pro/Engineer user choose to use BMX? When design criteria dictate measurable, quantifiable objectives. Here is a sampling of the standard measures that can be saved as an Analysis Feature:

Category	Measurement Examples
Measure	Length, Distance, Angle, Area, ...
Model Analysis	Mass, Volume, Inertia, Clearance, ...
Curve Analysis	Curvature, Radius, Deviation, ...
Surface Analysis	Gaussian Curvature, Deviation, Draft, ...

Whenever a measurable objective, or even conflicting objectives are required, BMX can be used to automate the solution. Any of the measurement examples listed above can be used to drive an exact solution.

## Recent Enhancements

The ‘out of the box’ power of BMX was dramatically enhanced with the release of Pro/Engineer Wildfire. The primary enhancements to Behavioral Modeling include:

1. [Mechanica Analysis](#)
2. [Mechanism Dynamics Analysis](#)

### 3. [Global Optimization Option](#)

The Mechanics Analysis feature enables BMX to execute an existing Mechanics study within the context of a BMX solution. This allows the designer to incorporate both geometric and simulation properties, such as stress, in a BMX solution. All Mechanics calculated results are available within the BMX analysis. Please Note: The Mechanics study will recalculate during model regeneration unless the regeneration option 'Only Design Study' is set.

Mechanism Dynamics Analysis is a function of the Motion Analysis feature in Pro/Engineer. [Mechanism Dynamics](#) (MDO) is included in the current 'Flexible Engineering' package, Flex3C, and is based on Mechanics Motion technology. MDO enables kinematic assemblies (MDX) to be analyzed for dynamic performance. With Wildfire, MDO forces and measures can be used within a BMX solution. Please Note: The Motion Analysis study will recalculate during model regeneration unless the regeneration option 'Only Design Study' is set.

The new Global Optimization Option overcomes a limitation from prior versions that BMX could potentially focus (get stuck) in a local maxima or minima during an Optimization Study, thereby missing the true optimal result. This was not an issue when the solution space had a discrete max and min, as represented by Figure 1. However, multiple maxima or minima, as in Figure 2, could result in an incorrect Optimization result. With Pro/Engineer Wildfire, users can force BMX to explore the complete design space, ensuring the true optimal design solution is returned.

Figure 1

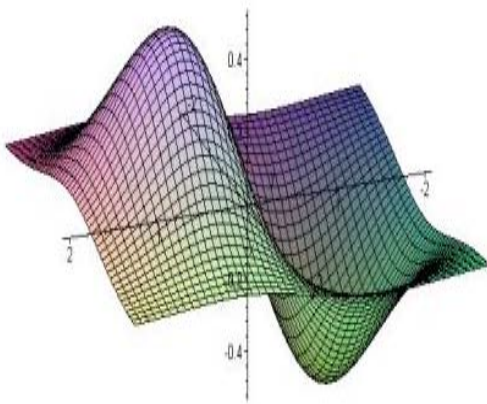
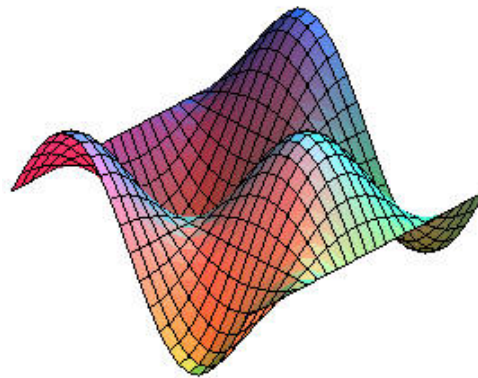


Figure 2



## Licensing Information

Many PTC customers already own BMX through the premier 'Flexible Engineering' packages offered with Pro/Engineer Version 2000i<sup>2</sup> through Wildfire. If your license pack is an older premier package, upgrading to a 'Flexible Engineering' package is the most cost effective option to obtain BMX. For 'Foundation' customers, BMX is also available as an optional design extension.

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## PTC Product Focus

### ProjectLink/Wildfire Integration in 6.2.6 DSU5

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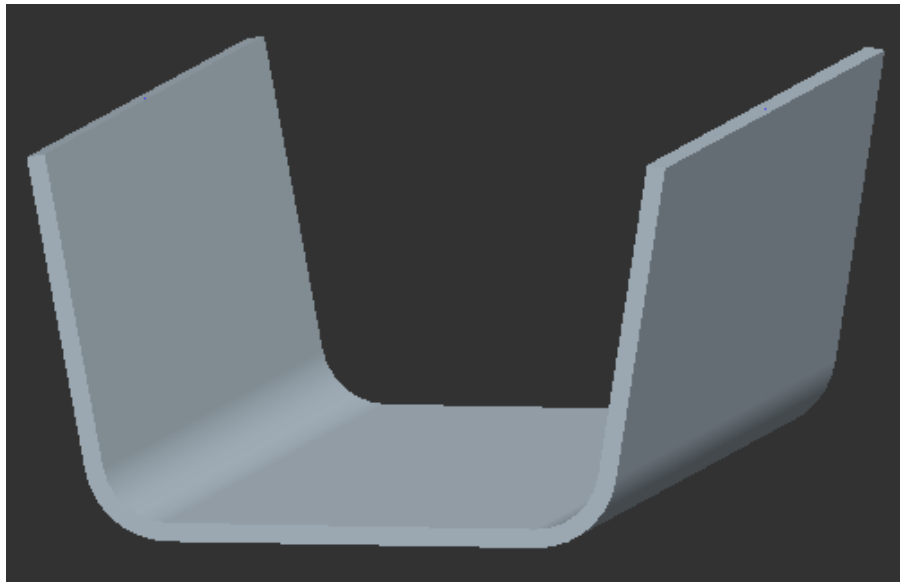
## Tips of the Week

### Solving Engineering Problems w/ BMX




Think you are ready to give BMX a try? Here is a basic exercise to get you started. Learning a few basic procedures can enable users to explore the power of BMX. Note: These instructions were created using Pro/Engineer Wildfire.

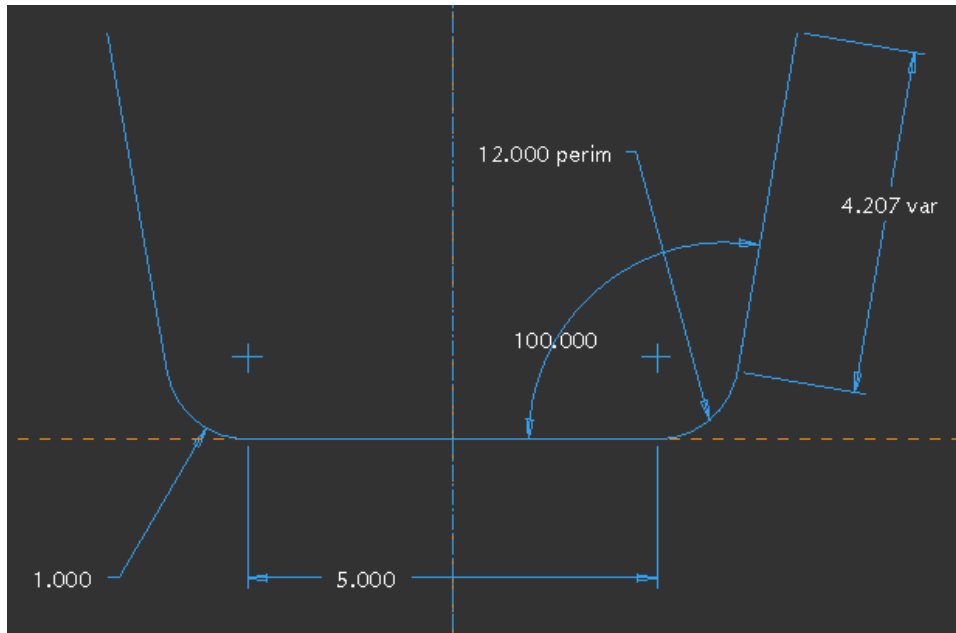
#### Problem Description

Imagine you are issued the task of creating a channel that maximizes flow area similar to the design shown below. You must use a strip of stock material, 12 inches in width. The length is unspecified. It must have a flat bottom, 2 inches wide minimum, and 1 inch nominal corner radii. What is the optimum design?



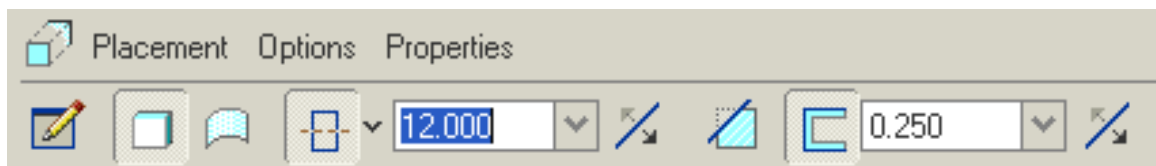
## Model Creation

1. Launch Pro/Engineer and create a new part model.
2. Create an extrusion using the Extrude Tool .
3. Select the Thin Protrusion option .
4. Select the internal sketch icon  to enter sketcher and create the following sketch:




Note: The perimeter dimension shown was created by selecting sketch entities, then Edit > Convert To > Perimeter. Specify the dimension to be driven by the perimeter dimension.



5. Complete the feature by filling in the dashboard as shown:



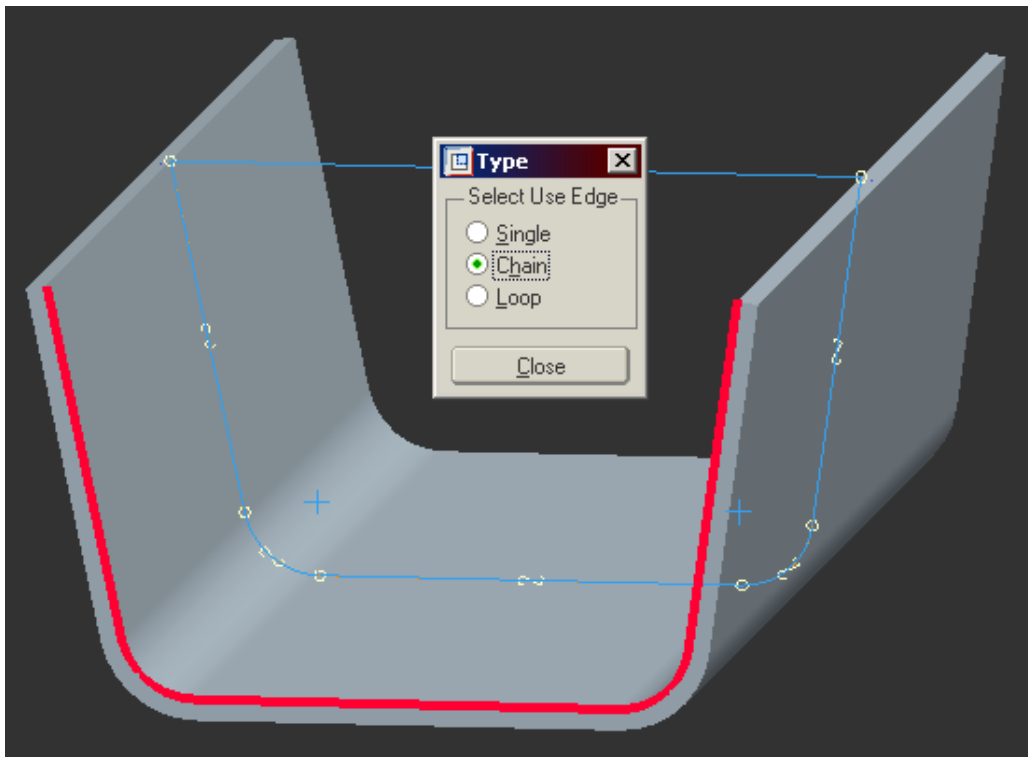
This will result in a thin protrusion, symmetric about the sketch plane, with a .25 material thickness.


6. Use the toggle offset icon  so that the sketch is the mid-plane of the solid body.

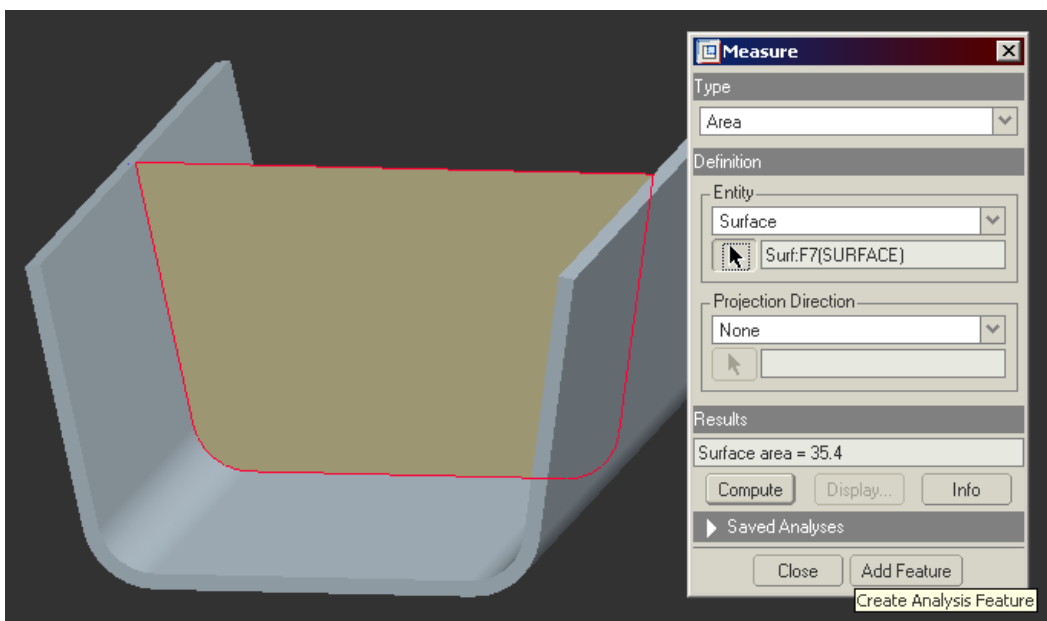
We intend to analyze the effect of changes in bend angle and leg lengths on the cross sectional area of our channel. Therefore we will create a flat surface to measure the area with.

7. Create a new Datum Curve .
8. Reference the inner edges of the solid body with the Use Edge  function.

9. Insert a line between the endpoints to close the loop.



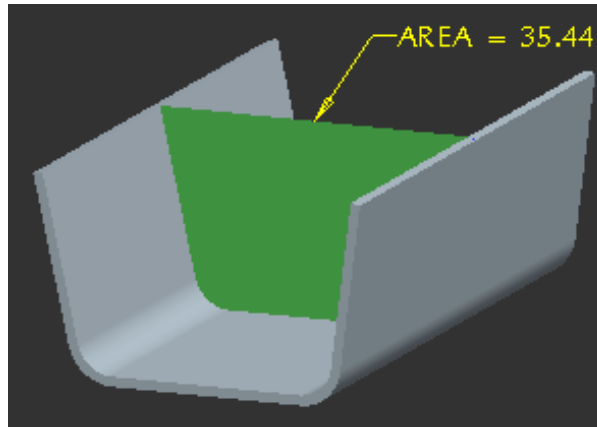
10. Create a Flat Surface using the Fill Tool  or Edit > Fill. The previous datum curve must be selected prior to using this function (object-action).
11. Measure the area of the flat surface with the Analysis > Measure > Area function.
12. Select the flat surface to analyze and 'Compute' the result.



13. Use the 'Add Feature' option to create the Analysis Feature.
14. Name the analysis 'FLOW\_AREA'. The Analysis Feature will appear in the model tree.

Optional Step: Create a 3D note that displays the area value.

15. Select the 'FLOW\_AREA' feature. Use RMB > Setup Note.
16. In the 'text' field enter: AREA = &AREA:FID\_FLOW\_AREA
17. Select 'Place' > Done and select the leader location on the model.



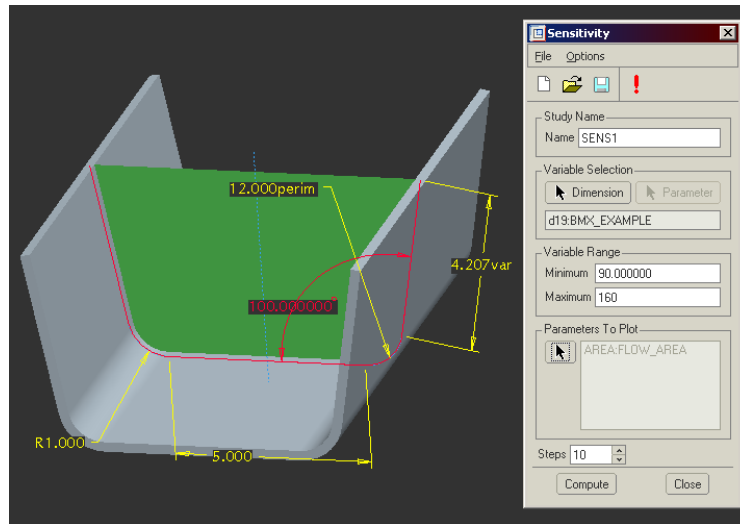
The Analysis Feature 'FLOW\_AREA' will be used in several BMX studies. Remember, an Analysis Feature is recalculated with the rest of a Pro/Engineer model during regeneration. The result is therefore always up to date.



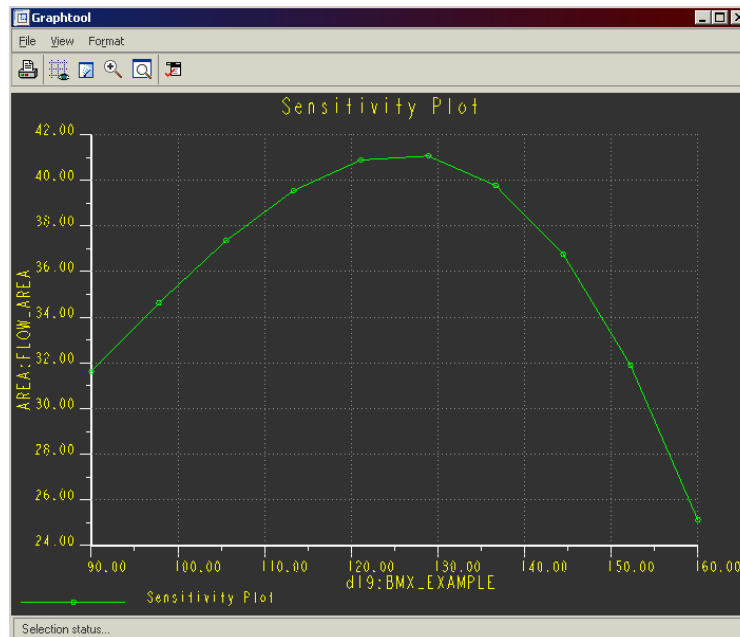
## Sensitivity Analysis

Use a Sensitivity Analysis to investigate the relationship between the included angle and the cross-sectional area.

1. Use Analysis > Sensitivity Analysis to open the dialog.
2. Select the 'Dimension' button. Pick the included angle from the thin protrusion.
3. Select to plot the AREA:FLOW\_AREA values from the list.



4. Compute. The resulting graph should look like the following:



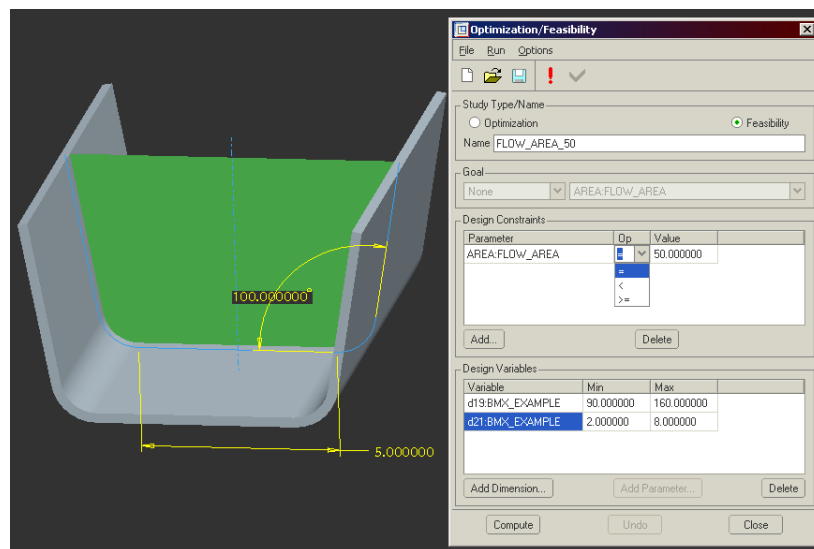
From the graph we can determine a maximum area of 41 in<sup>2</sup> is found just below 130 degrees. Is this the best solution for the model? Increase the 5.00 leg length and re-

run the analysis.

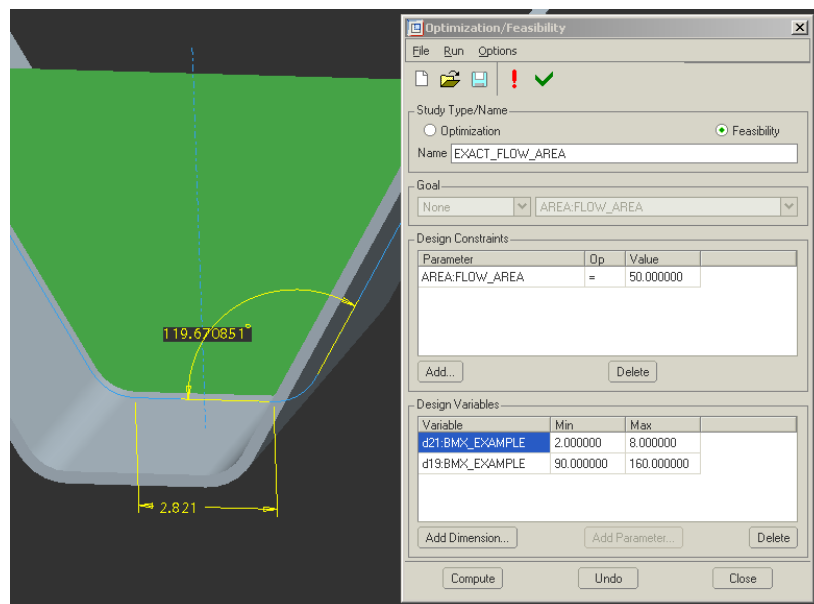
## Feasibility Analysis

Use a Feasibility Analysis to determine if a cross-sectional area of 50 in<sup>2</sup> is possible.

1. Use Analysis > Feasibility/Optimization to open the dialog.
2. Select the Feasibility radio button.
3. Under Design Constraints, set the AREA:FLOW\_AREA value to 50 in<sup>2</sup>.
4. Under Design Variables, Select the included angle and bottom leg length dimensions. Set the minimum and maximum values as shown.





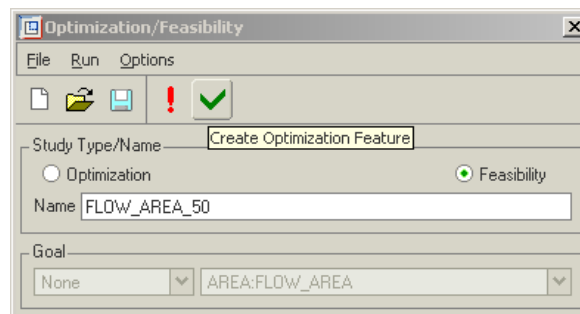
5. Select 'Compute' to run the analysis.



Is the result above the only solution that satisfies the Design Criteria? A Feasibility Study only processes until it determines that the objectives are met.

## Feasibility Extra

A Feasibility Study can be saved as an Analysis Feature in the model tree using the  icon. In effect, the Pro/Engineer model would always satisfy the specified Design Criteria by recalculating the solution during regeneration. Using the save button  from the dialog will save the analysis definition in the active model, but will not create an Analysis Feature.

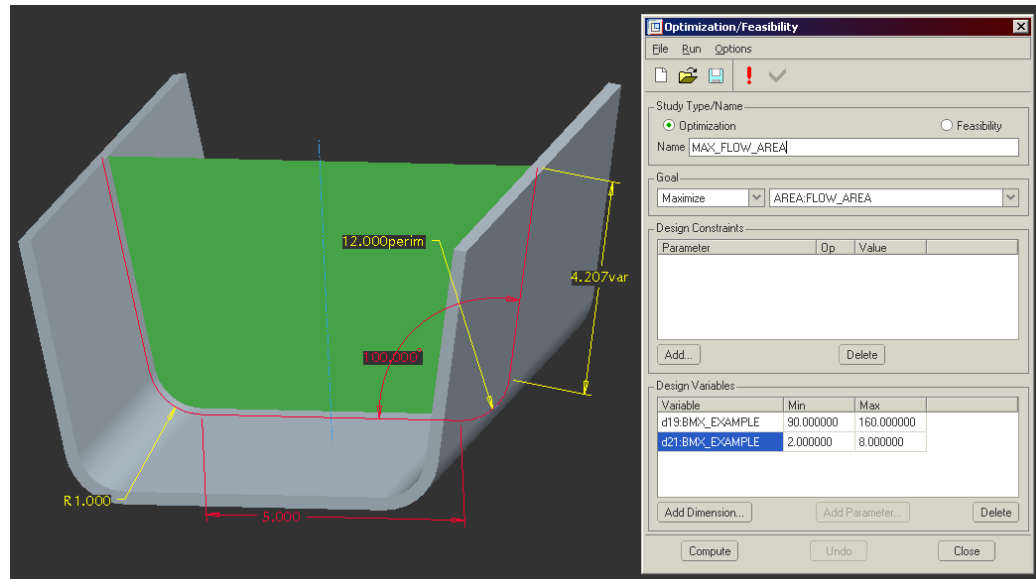


Close the Feasibility dialog. Notice Pro/Engineer prompts you to keep the results. Select Cancel.

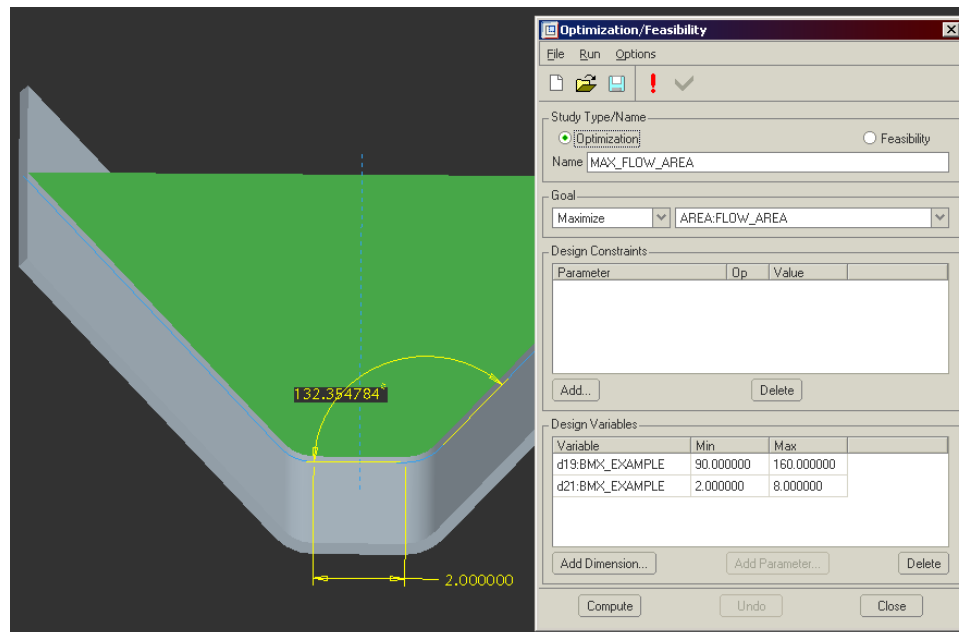
## Optimization Analysis

Use an Optimization Analysis to determine the maximum cross-sectional area possible within the design constraints.

1. Use Analysis > Feasibility/Optimization to open the dialog.
2. Select the Optimization radio button.
3. Under the Goal option, select to Maximize the AREA:FLOW\_AREA.
4. Use the same Design Variable setup as in the Feasibility Analysis.



5. Select 'Compute' to run the analysis.



Is the result different from the Feasibility Study? Why? Is the optimum result what you expected?

Also notice that with an Optimization Analysis, you can combine Goals and Design Constraints. This becomes important when you have multiple, possibly conflicting, constraints for the design.

## Summary

BMX is extremely powerful once you have a basic understanding of the tool. When measurable design objectives exist, use BMX to find the optimum solution. The examples above are intended as a sampling of BMX functionality. Remember, anything you can analyze can be saved as an Analysis Feature in Pro/Engineer, including assembly analyses. For example, use BMX to solve component locations to satisfy COG constraints. Plus, with Pro/Engineer Wildfire, you can combine Pro/Mechanica results or dynamic Motion Analysis results in the BMX solution. BMX is design power for real world engineering problems.

## Challenge

Now it is time to test your understanding of BMX. In your design process, what design challenges can be automated using the tools and procedures described above? Have you encountered a design problem that required trial and error to obtain a 'close enough' solution? Try BMX on one of your previous designs today.

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## Tips of the Week

### Speedy Activity Creation

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<http://www.ptc.com/go/engineering/index.htm>

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June 8 - 11, 2003                      Orlando, FL  
Pro/USER International Conference  
<http://www.prouser.org/>

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<http://www.ptc.com/services/edserv/index.htm>

PTC

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- 1) Inform you on events related to PTC products (user groups, conferences, training schedules, etc.)
- 2) Educate you on products that are available at PTC
- 3) Tips & Techniques using PTC Products

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