Interactive Virtual Hands-on Manufacturing

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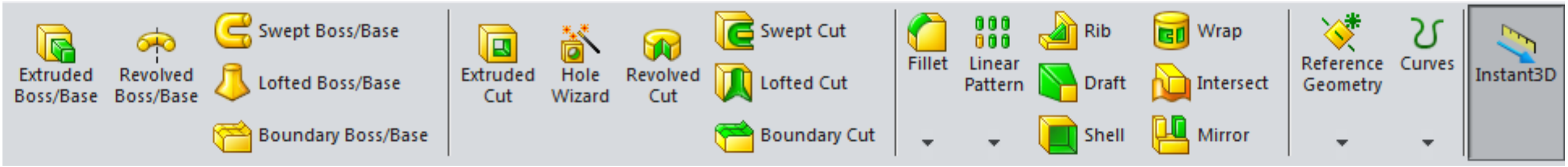
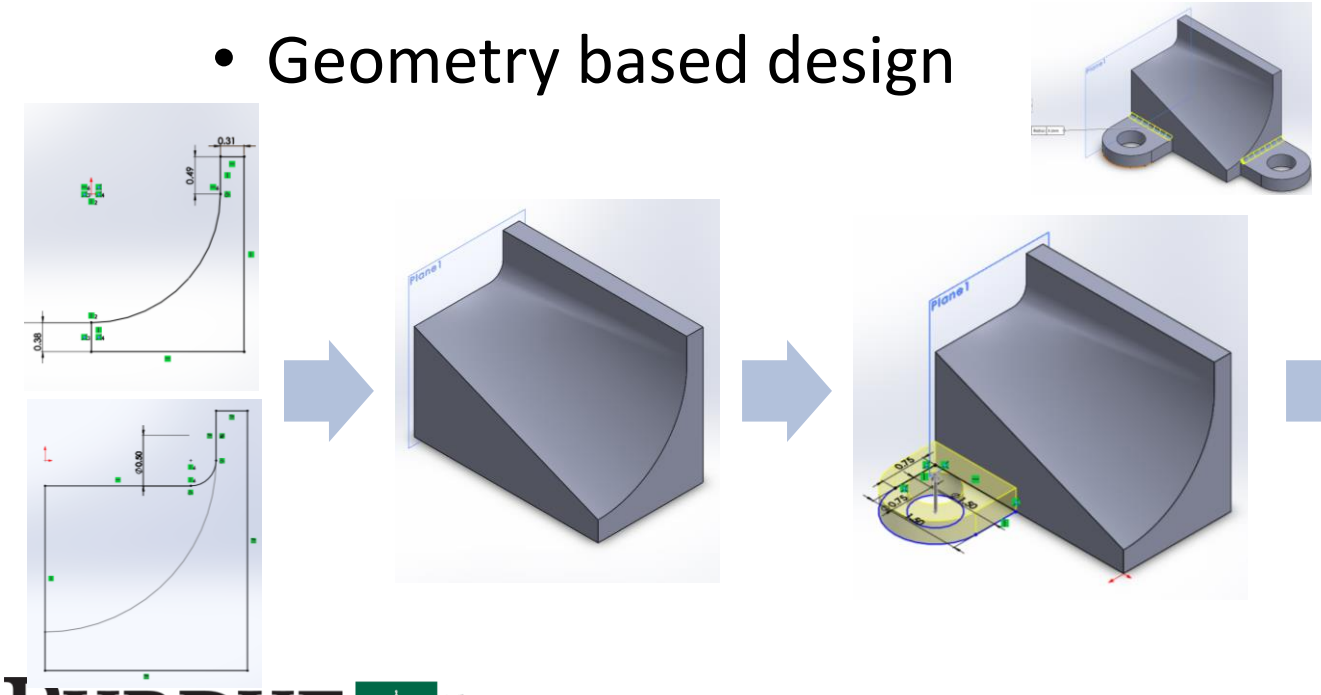
Current CAD Software

- A series of features in sequence to represent a desired solid model

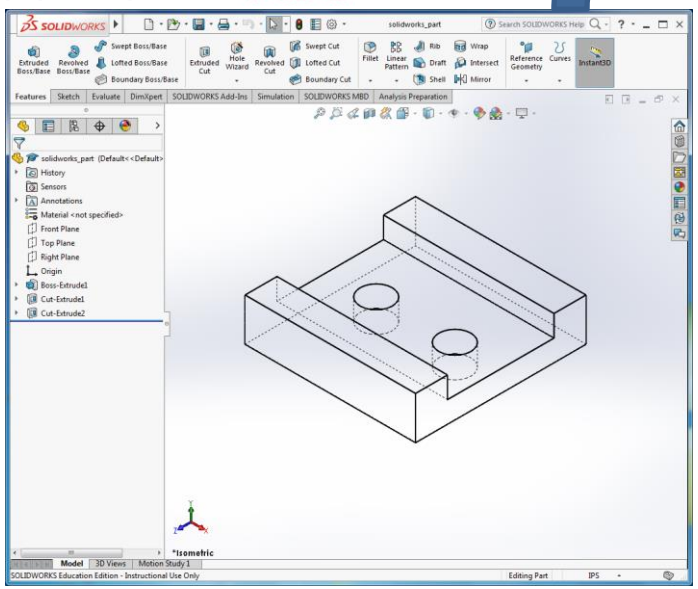


- Geometry based design

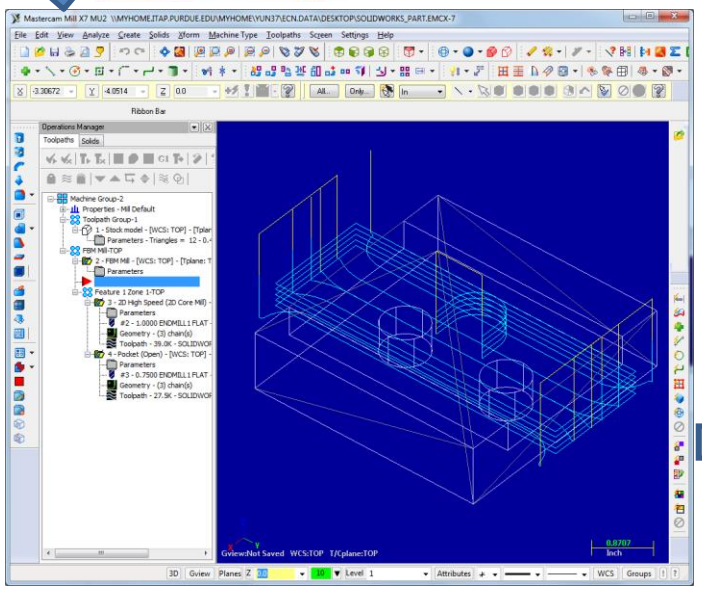


Current Design and Manufacturing

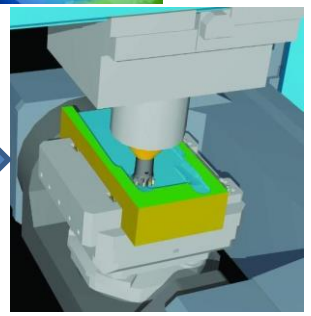
- Current design and manufacturing approach for part generation
- Well established CAD/CAM and verification software products



CAD



CAM



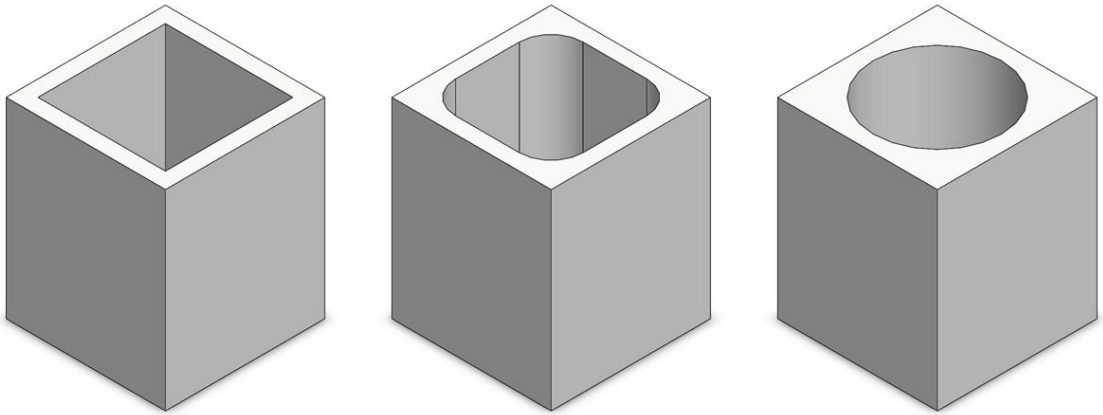
Verification

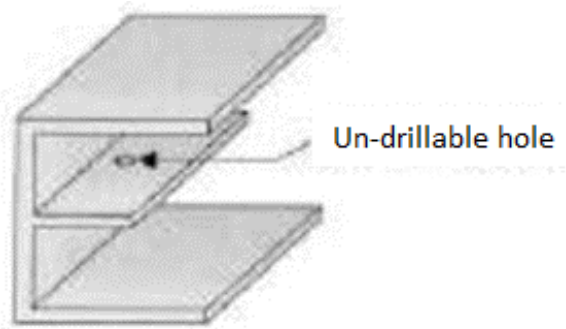
Post-processing for NC code generation

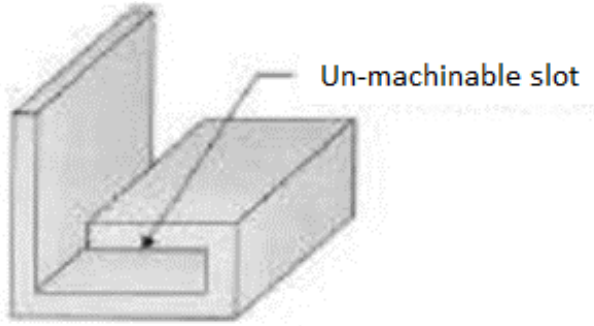
Part machining

Need for Manufacturing Integration

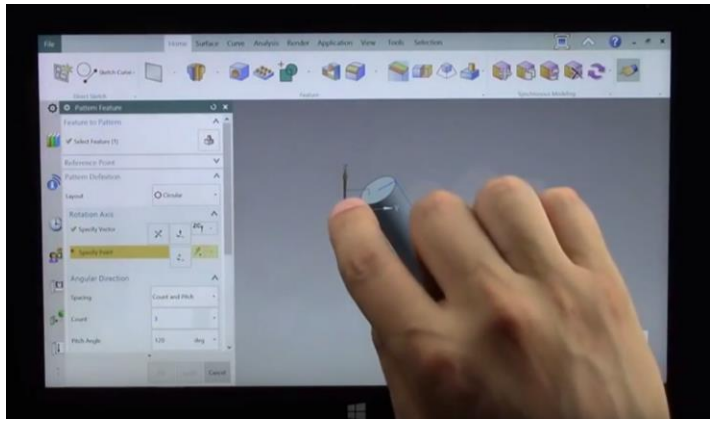
- CAD software does not take manufacturing into consideration
- Difficult to learn design for manufacturing





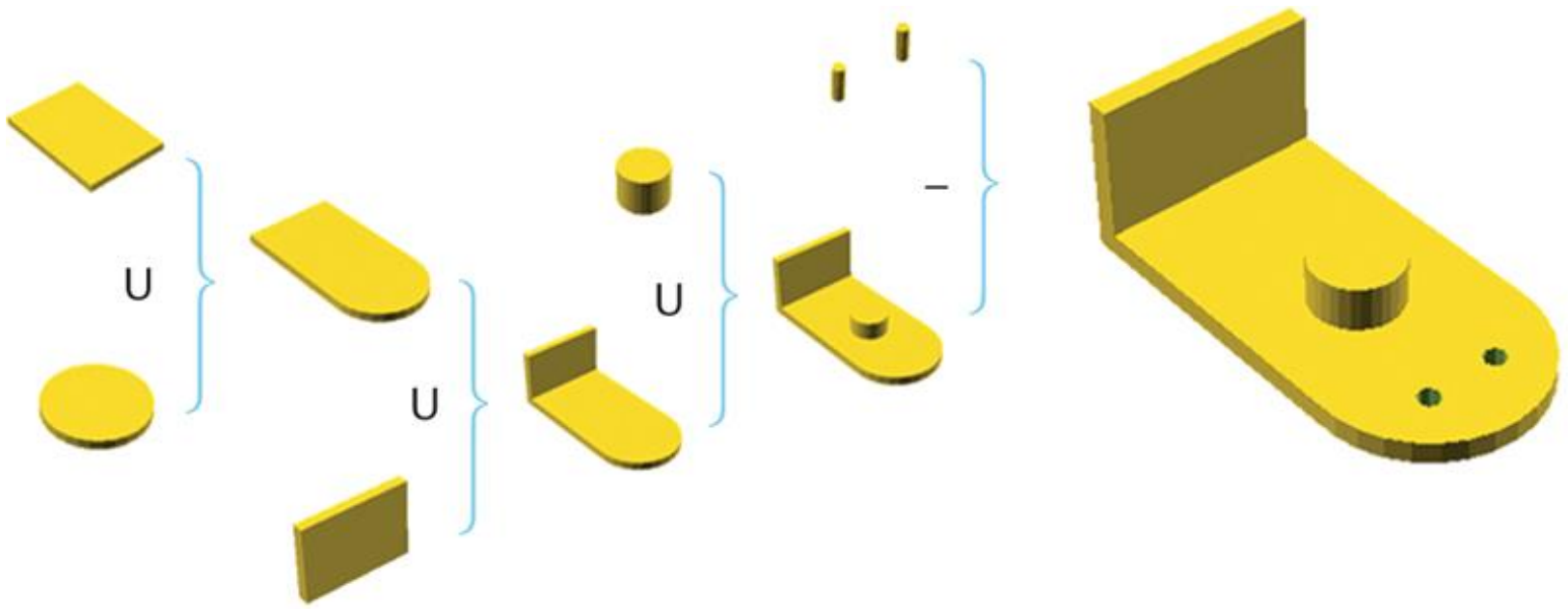


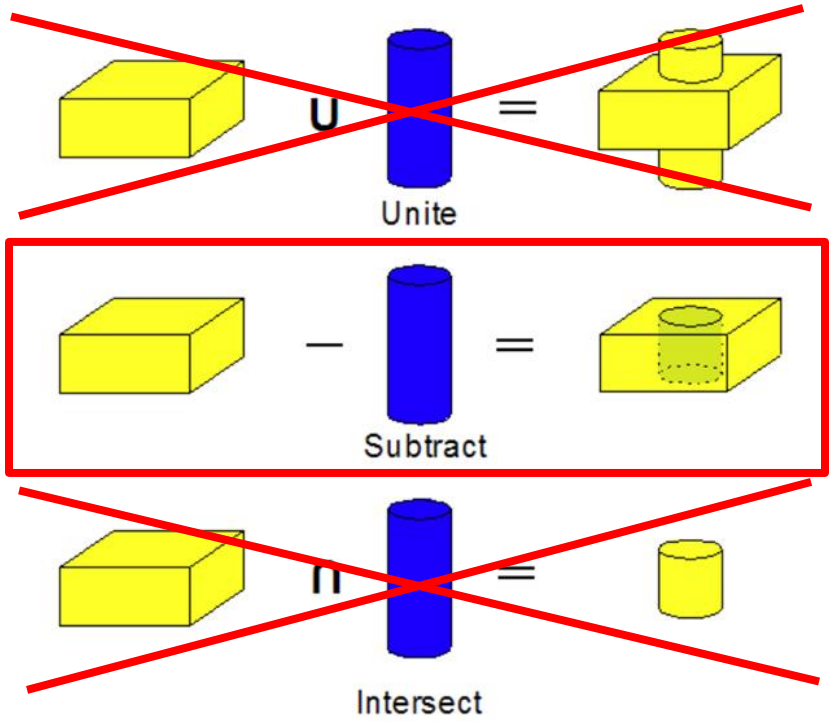
- No environment for interactive manufacturing (not just touch capability)



Manufacturing Perspective

- CAD software essentially uses a series of Boolean operations



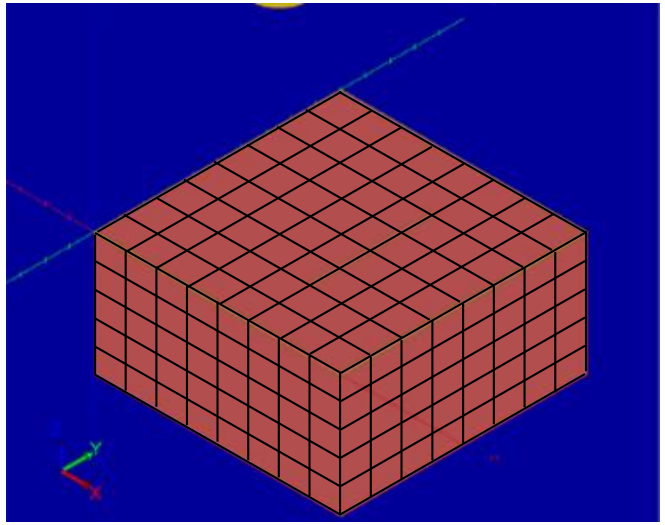


Can a part be generated using only Subtract Boolean operations?

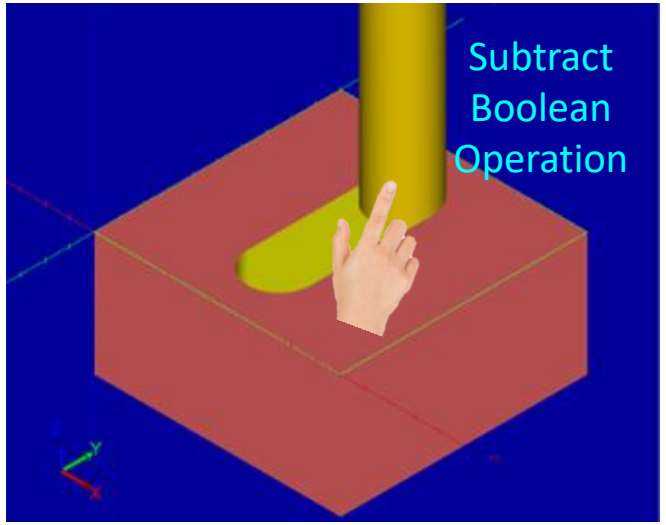
Can such Subtract Boolean operations be performed interactively by user?

Proposed Approach

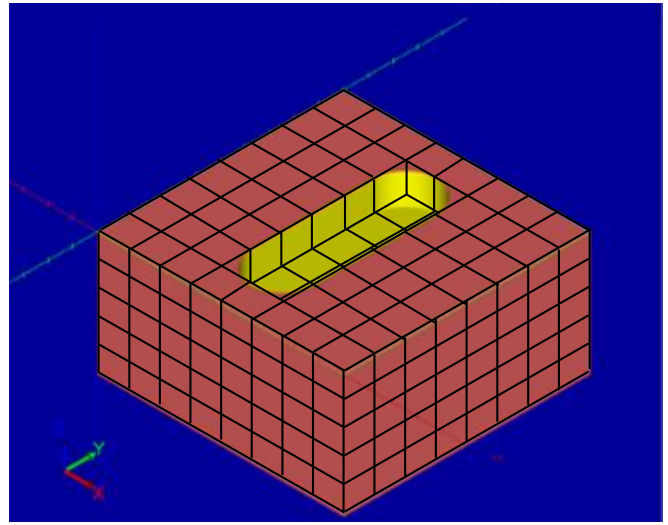
- Interactive virtual hands-on manufacturing
- Part design process is similar to manual machining process



Initial stock



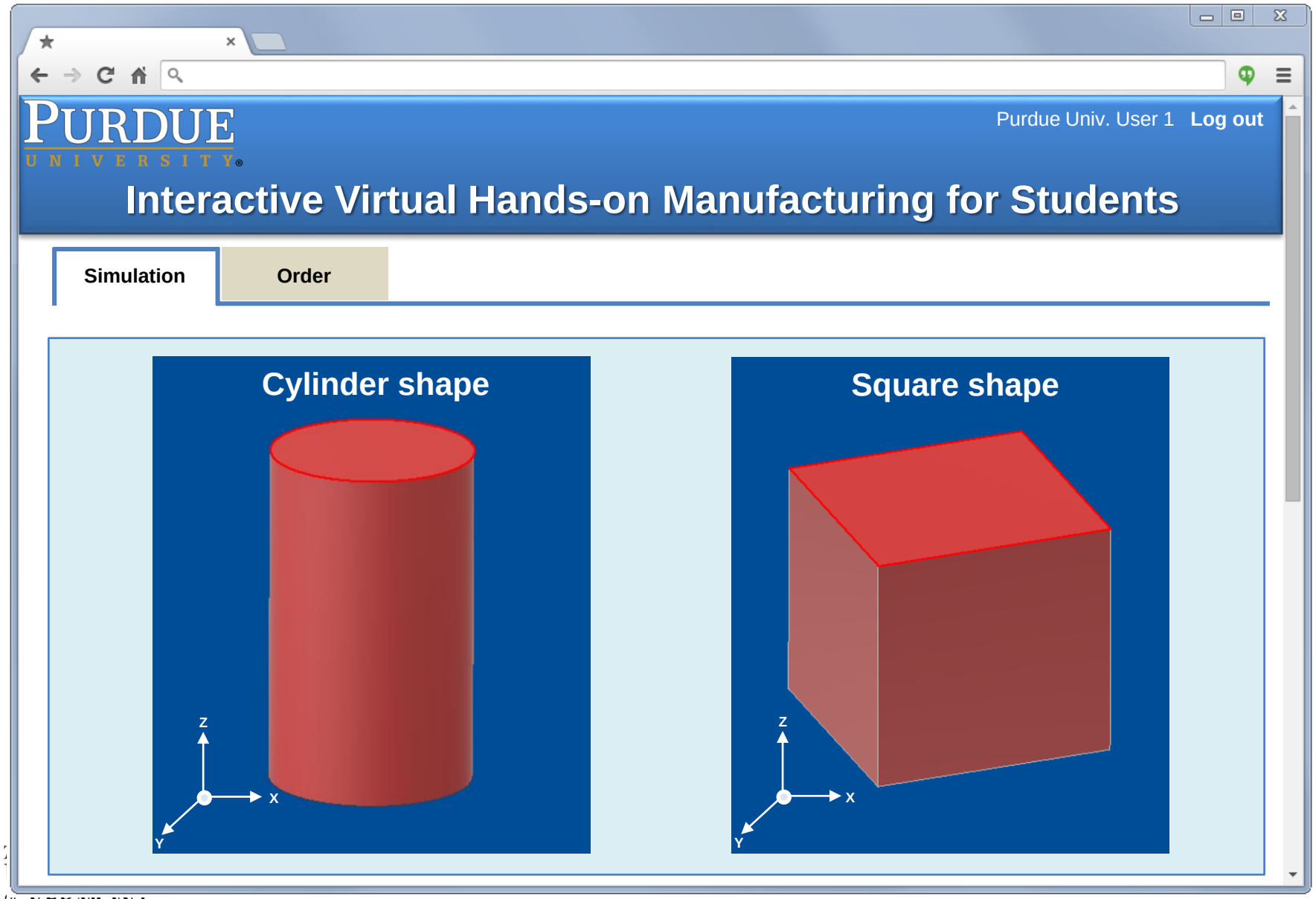
Tool trajectory by user



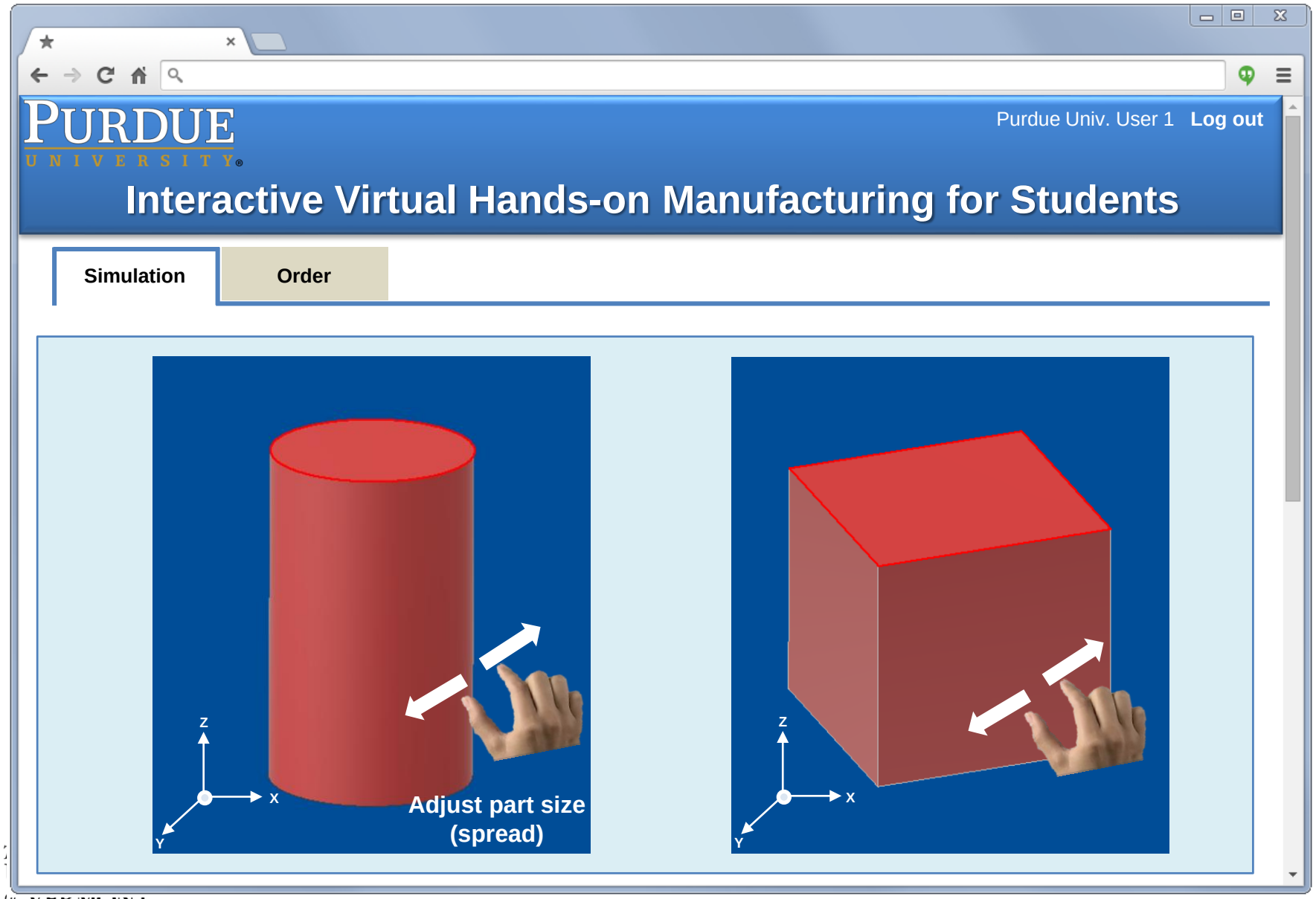
Final design

NC code

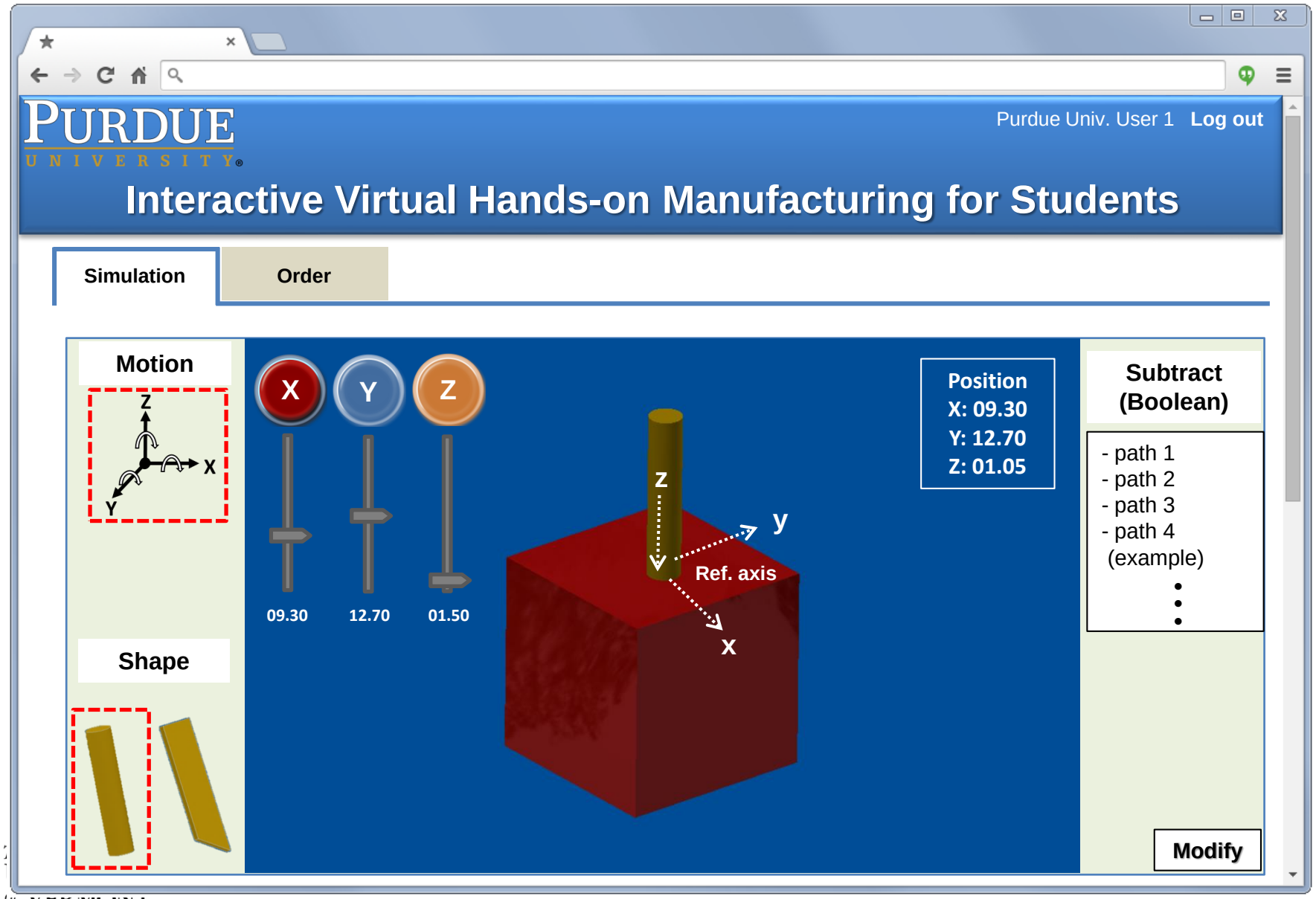
Software Interface Example



Software Interface Example

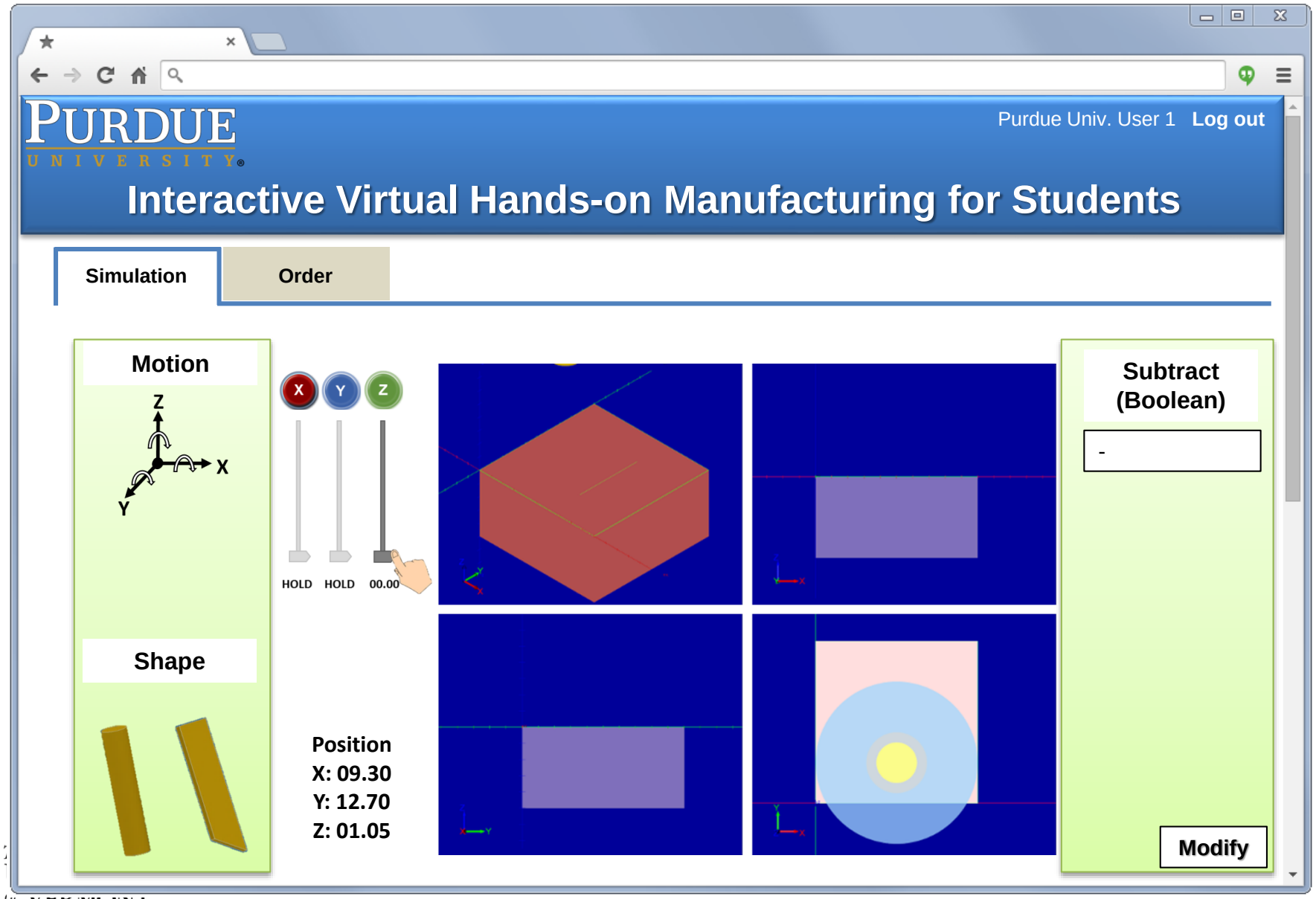


Software Interface Example



Software Interface Example

Operation Example: Straight Line



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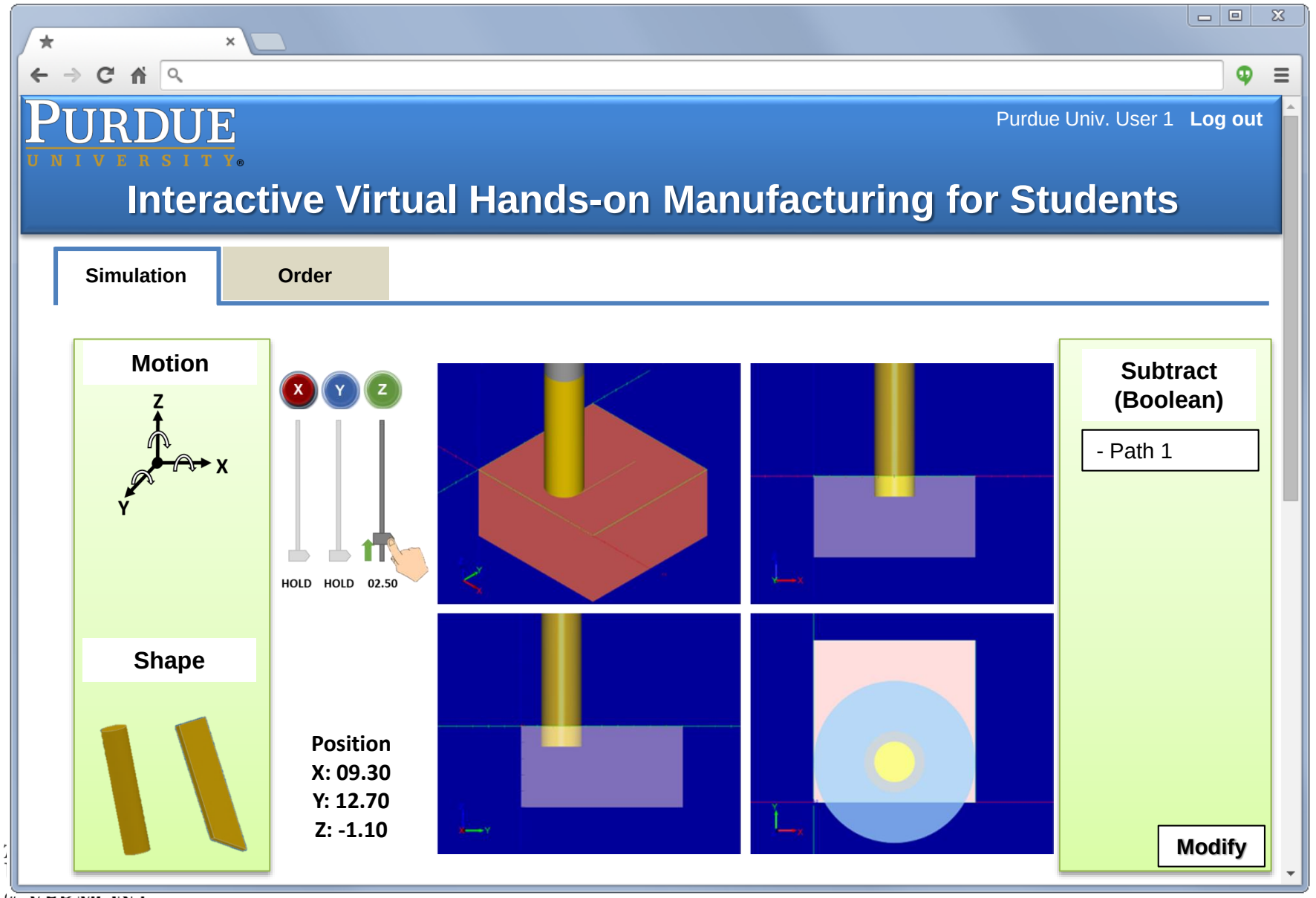

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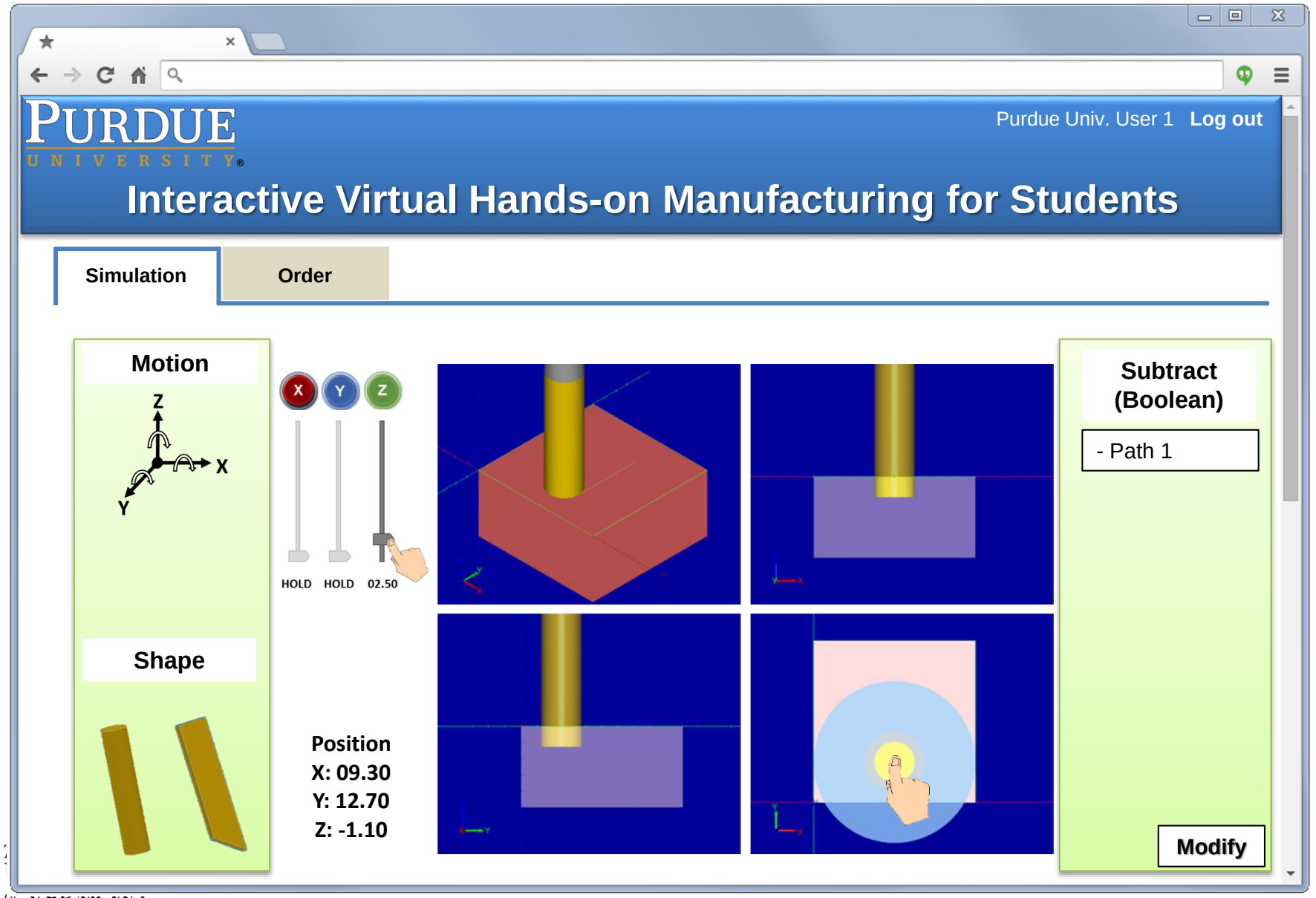

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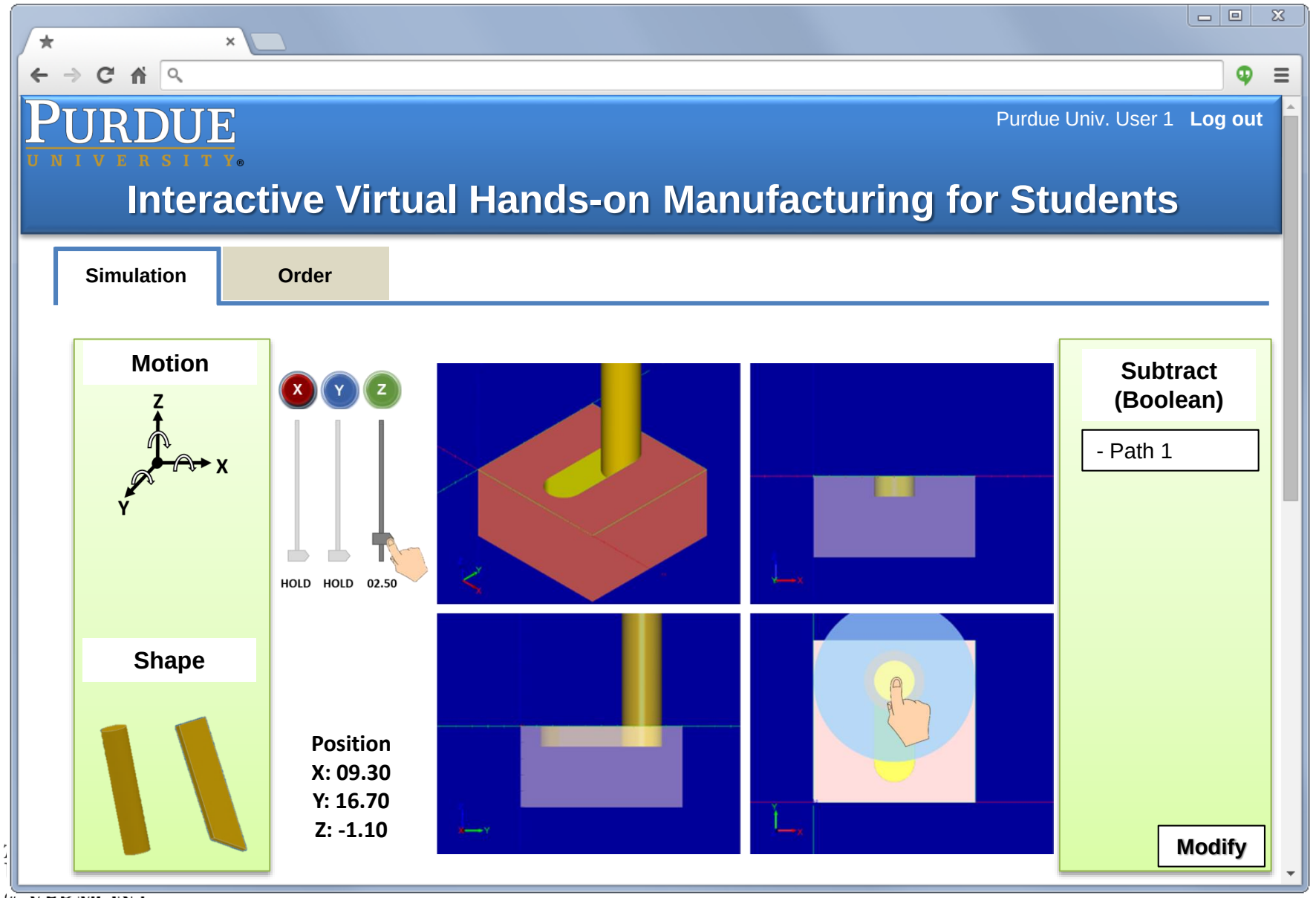
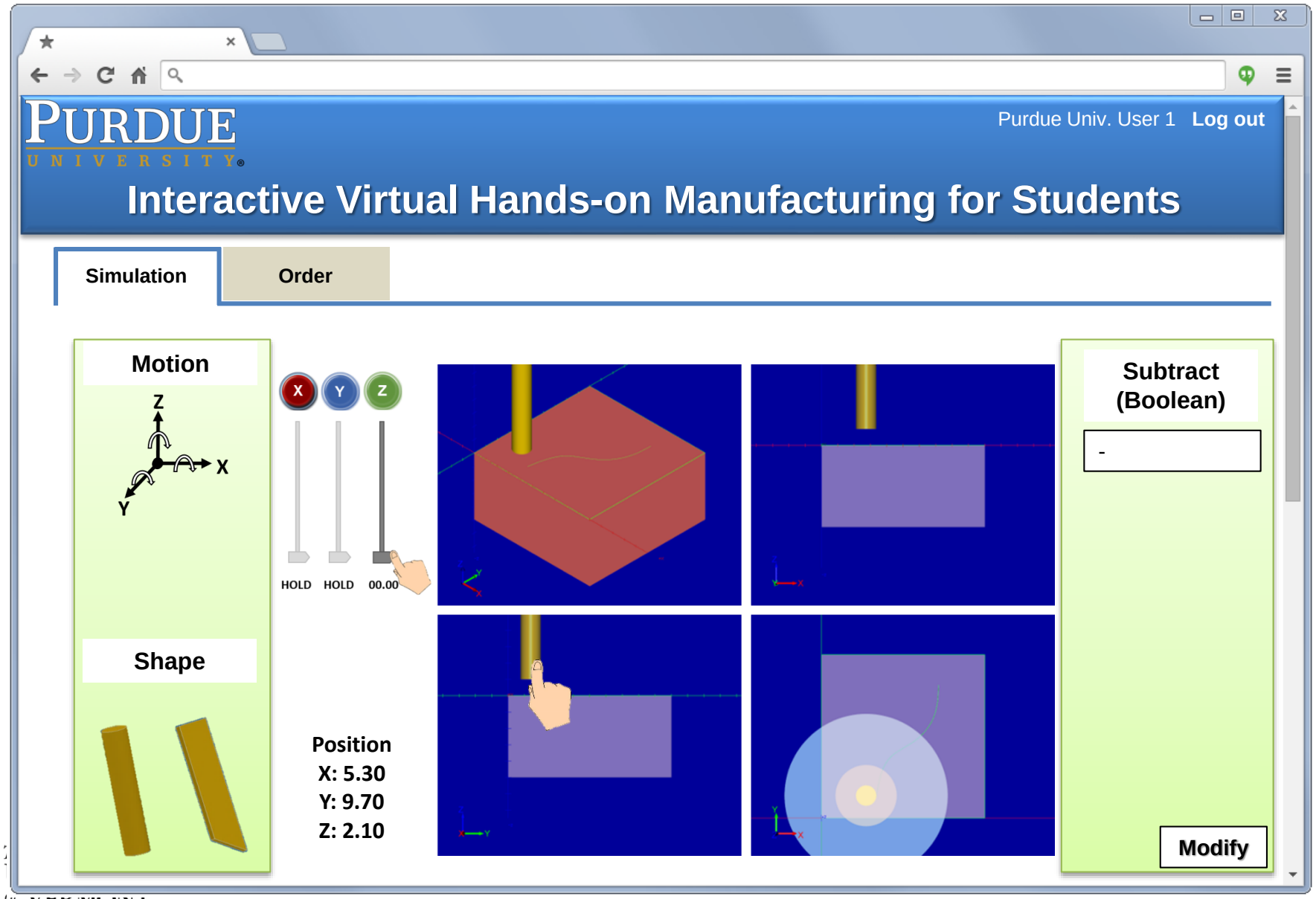


Operation Example: Curved Line



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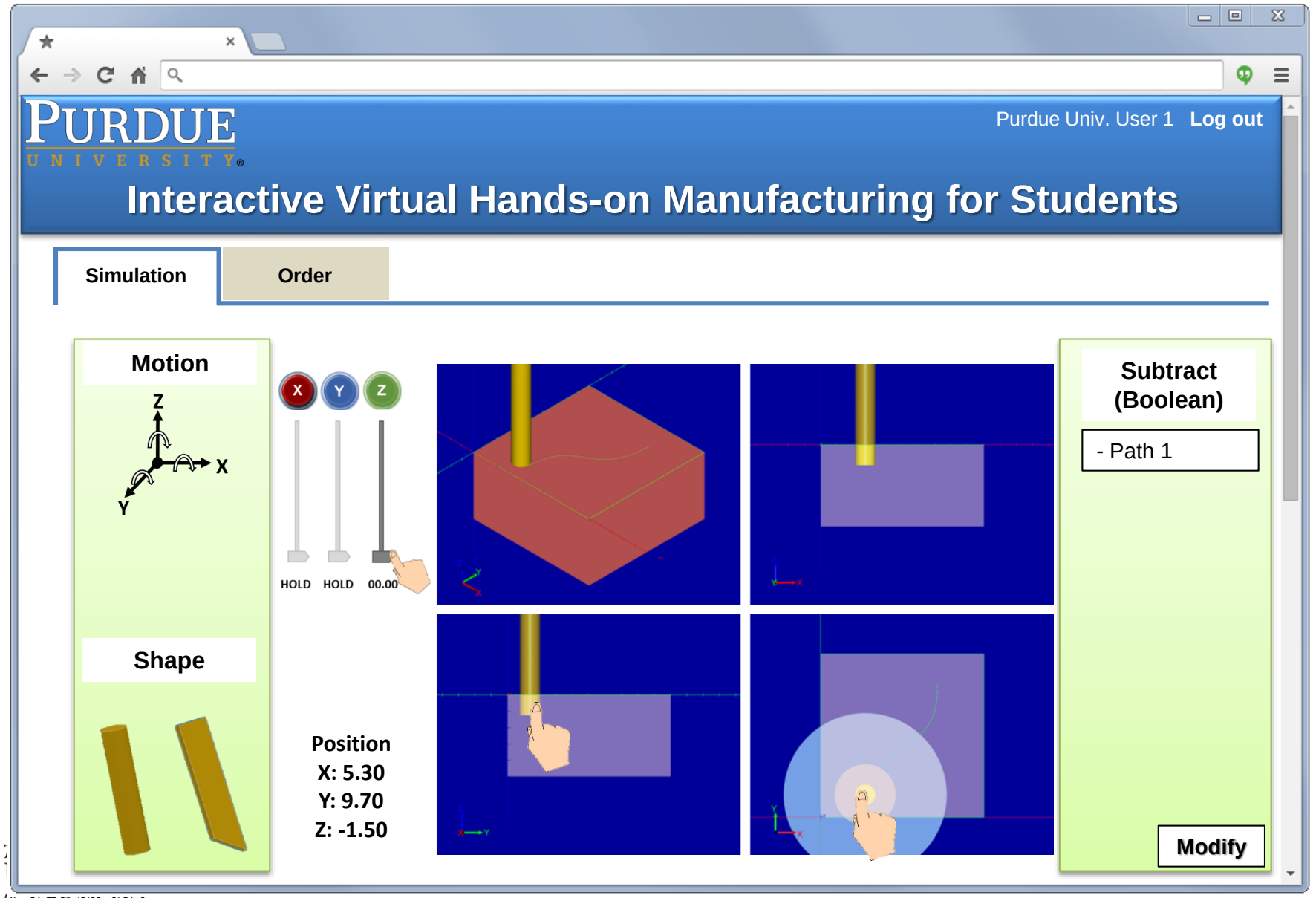

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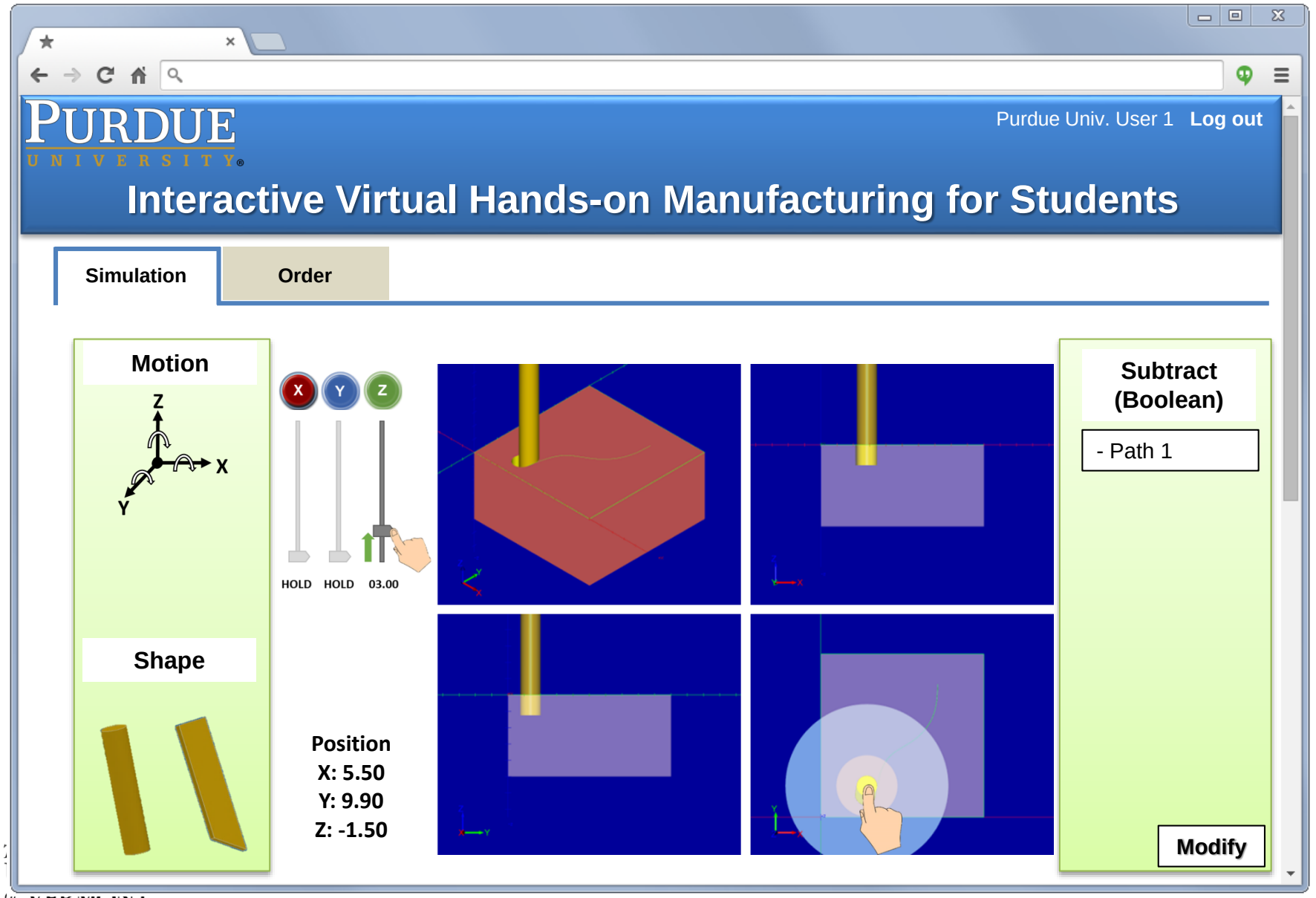

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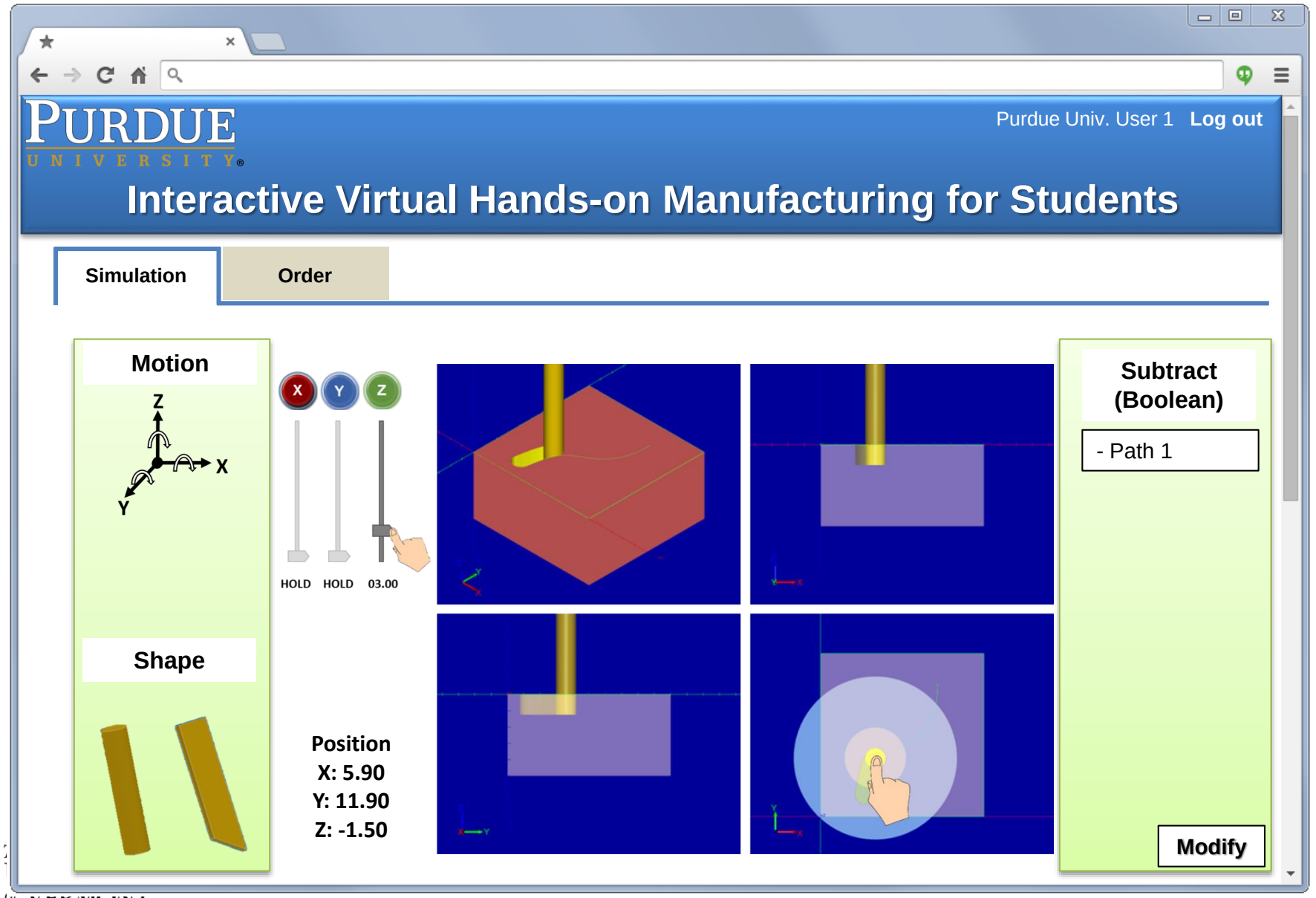

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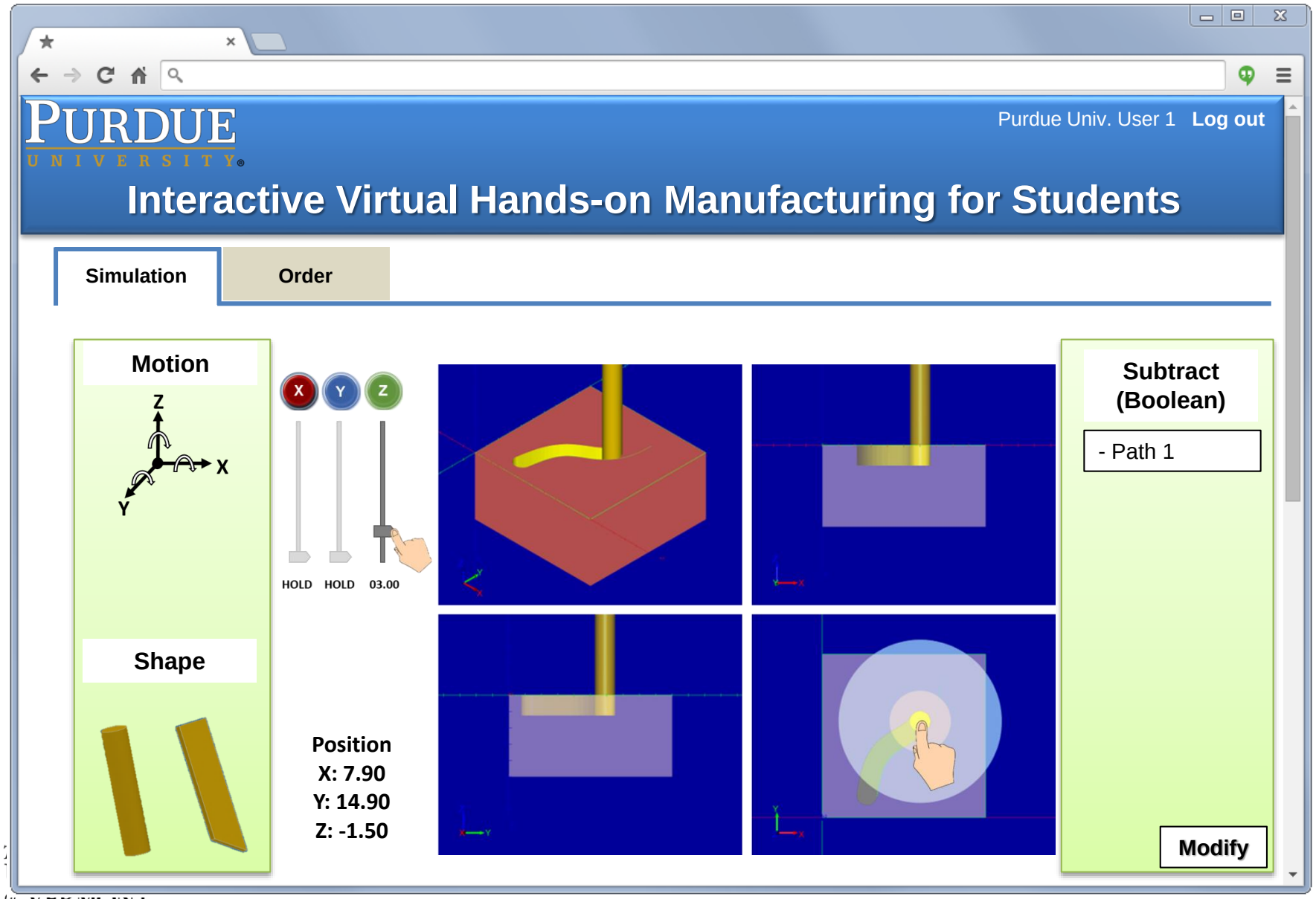

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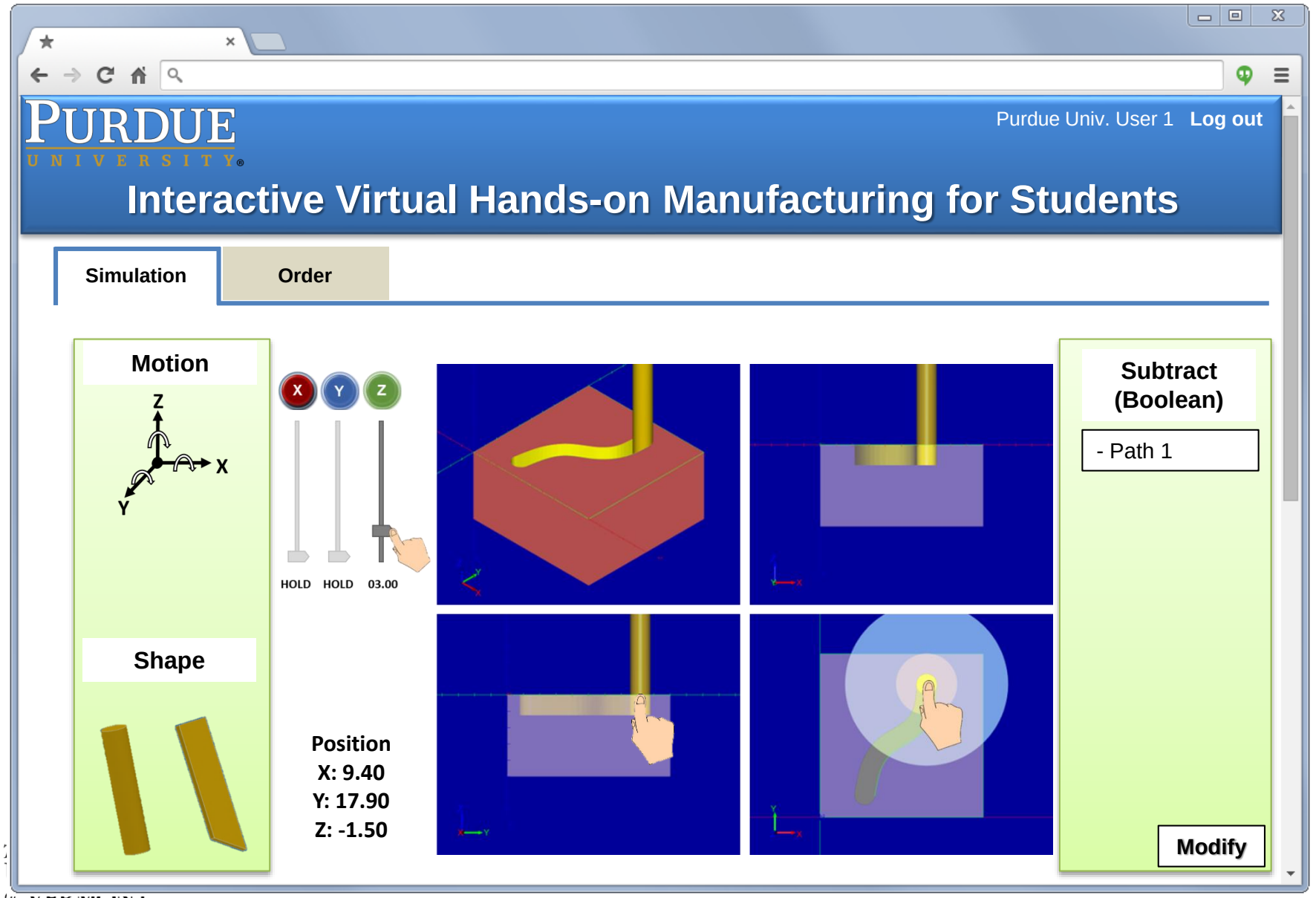

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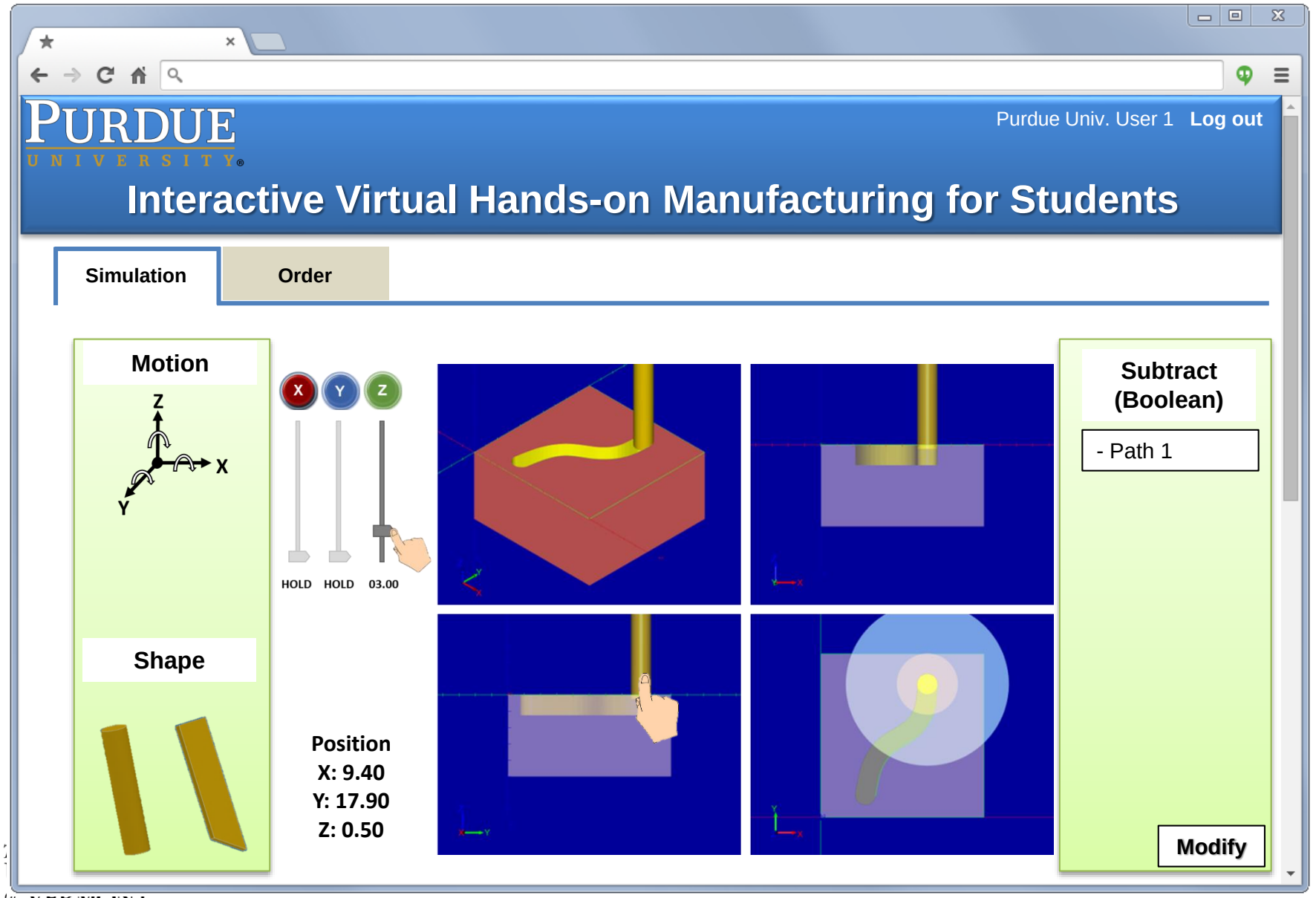
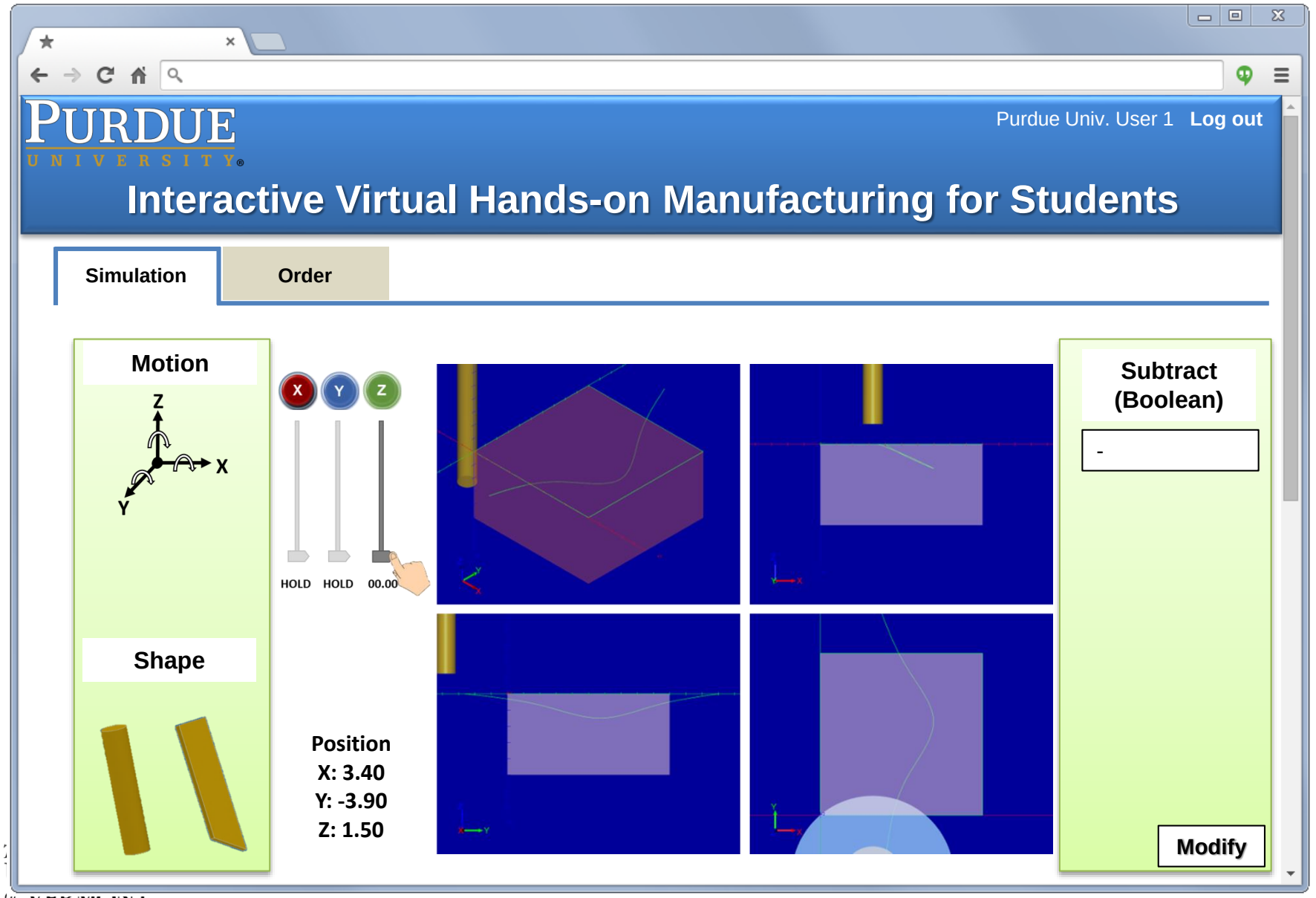


Operation Example: Freeform



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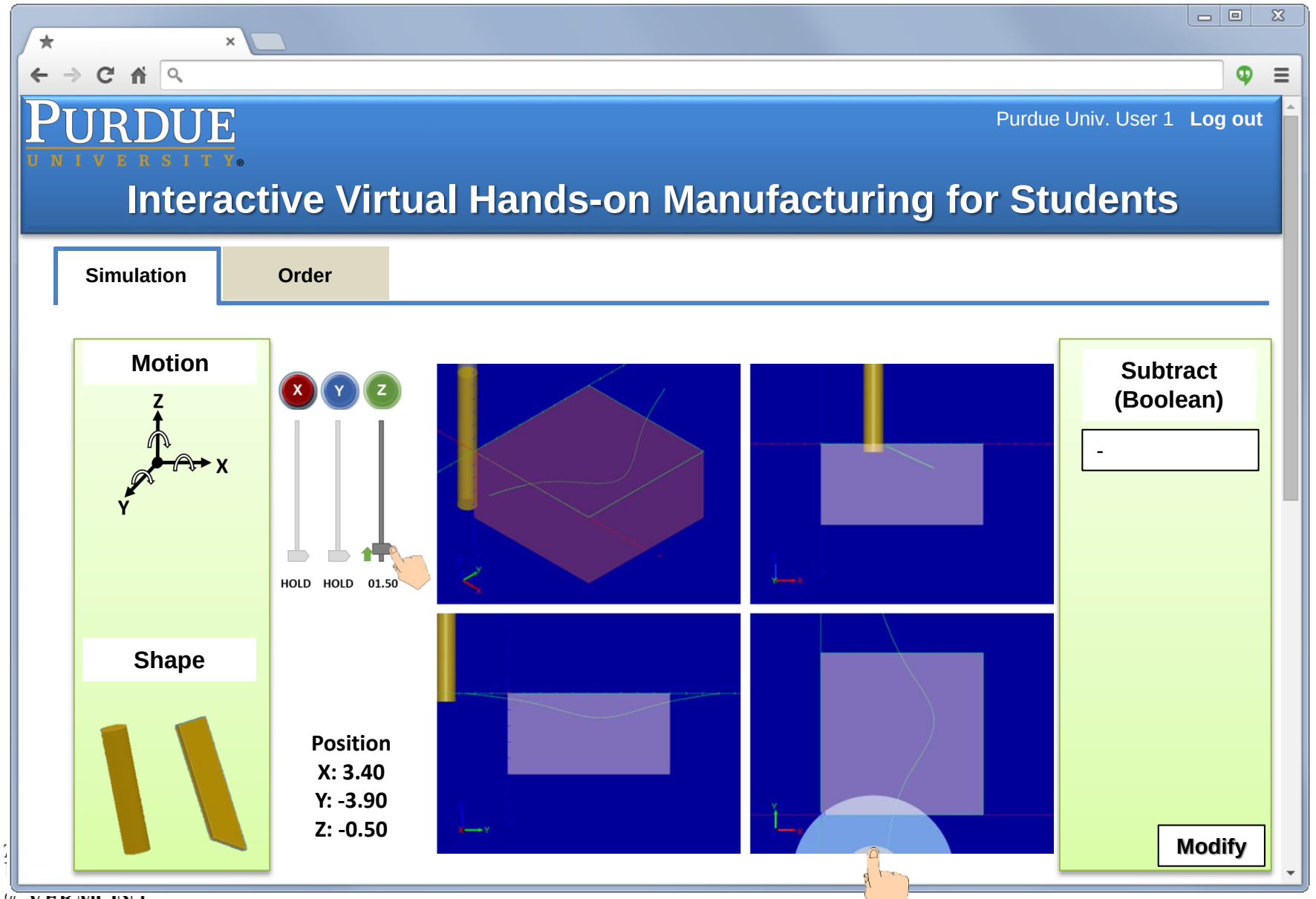

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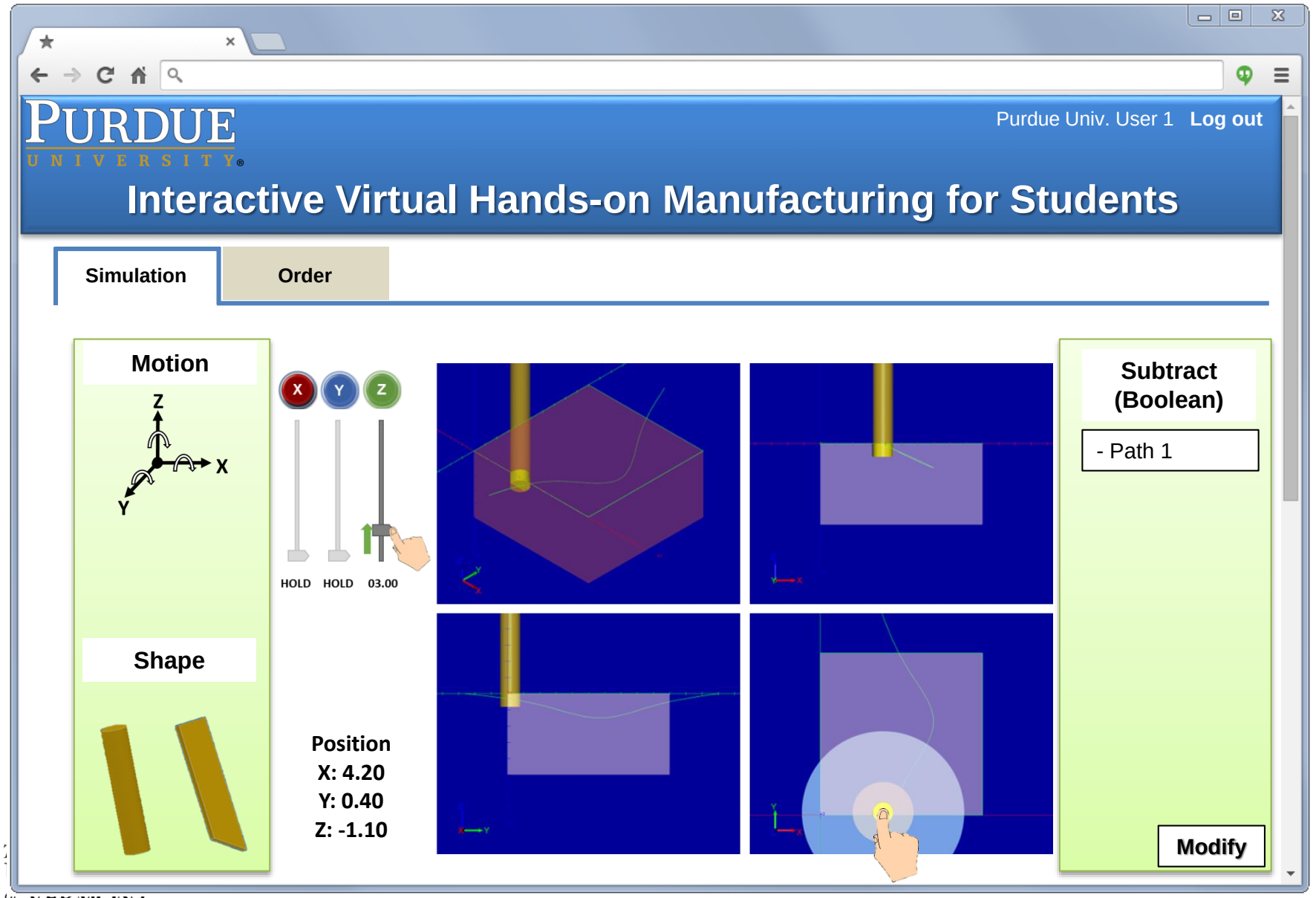

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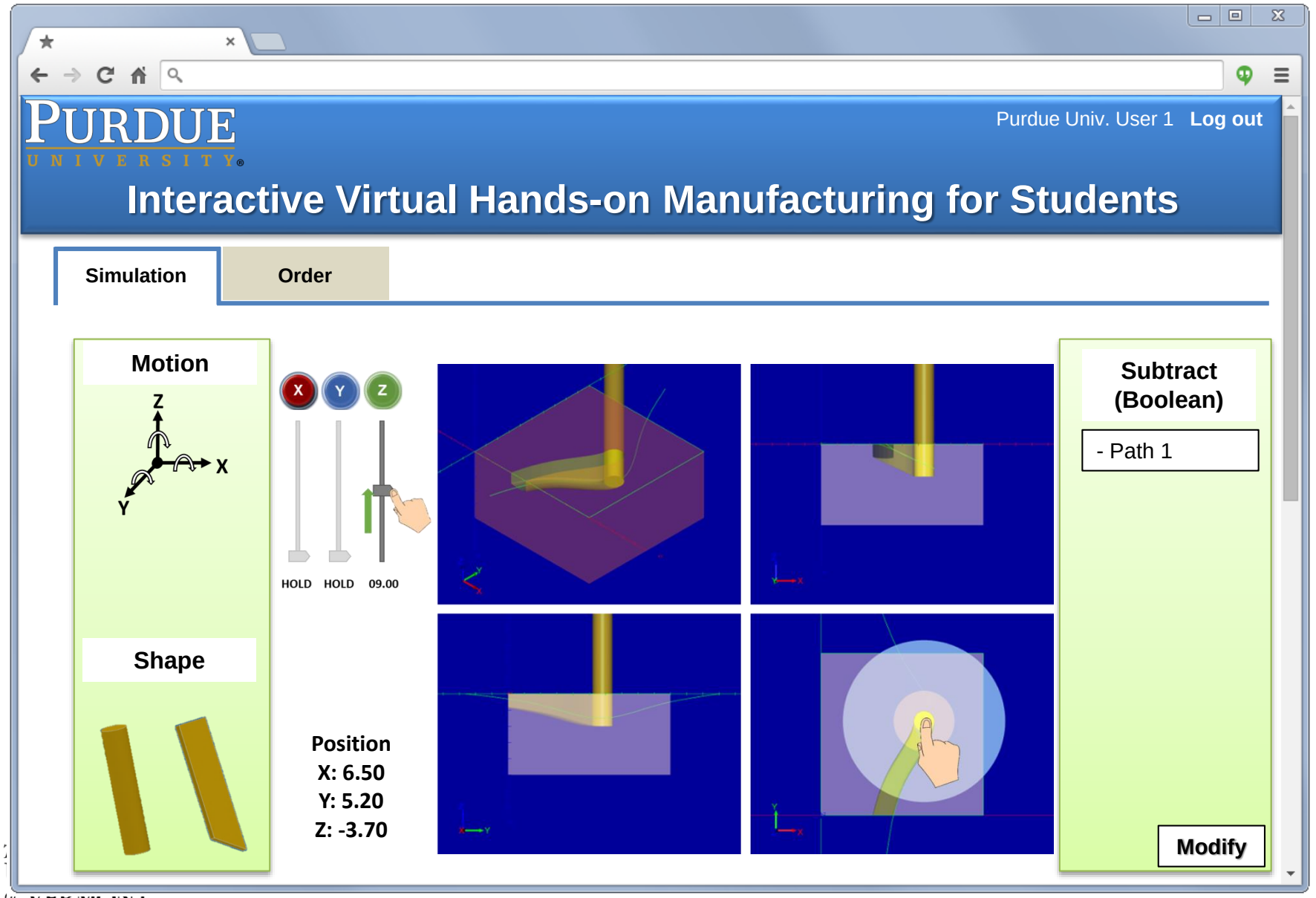

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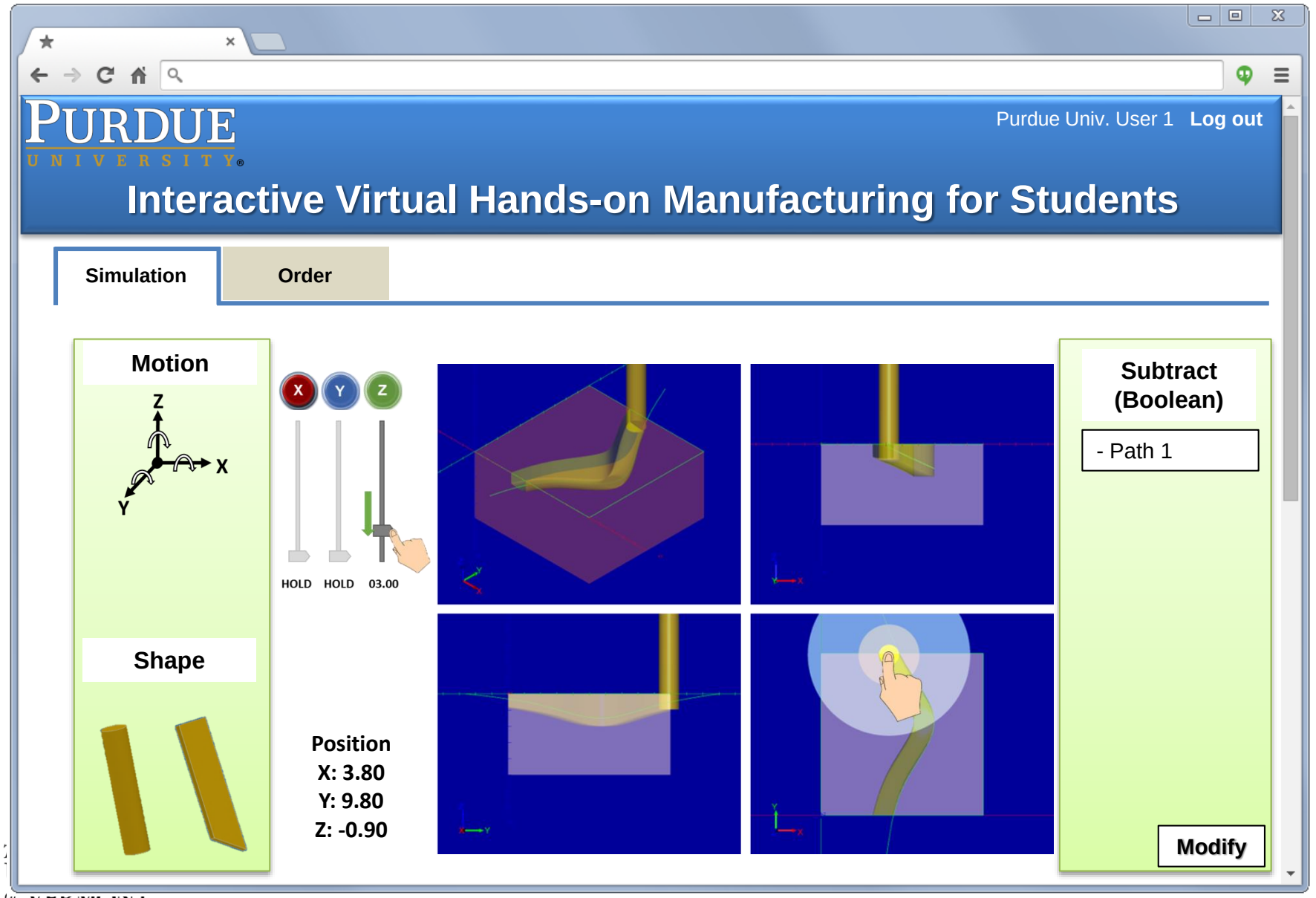

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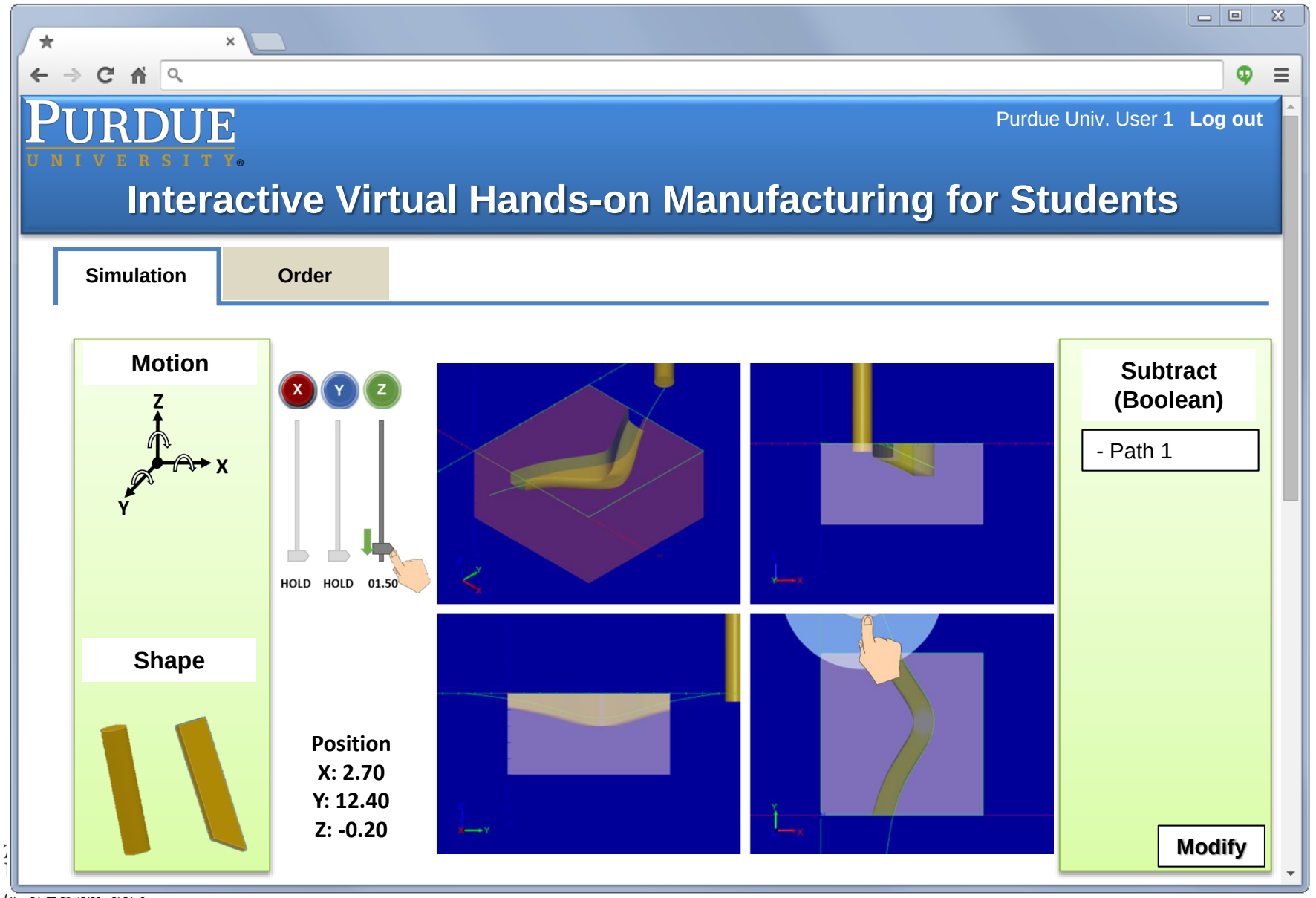
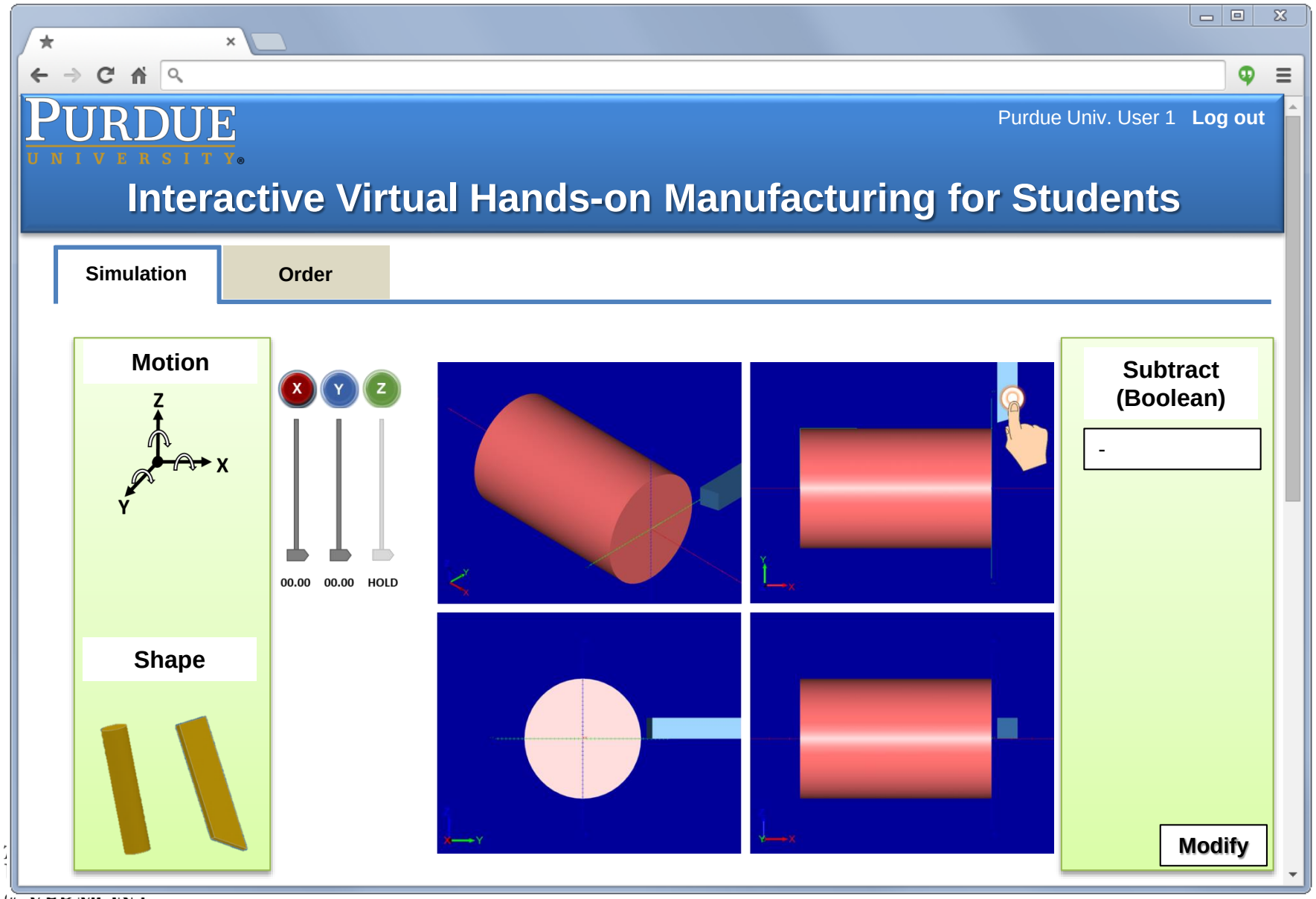
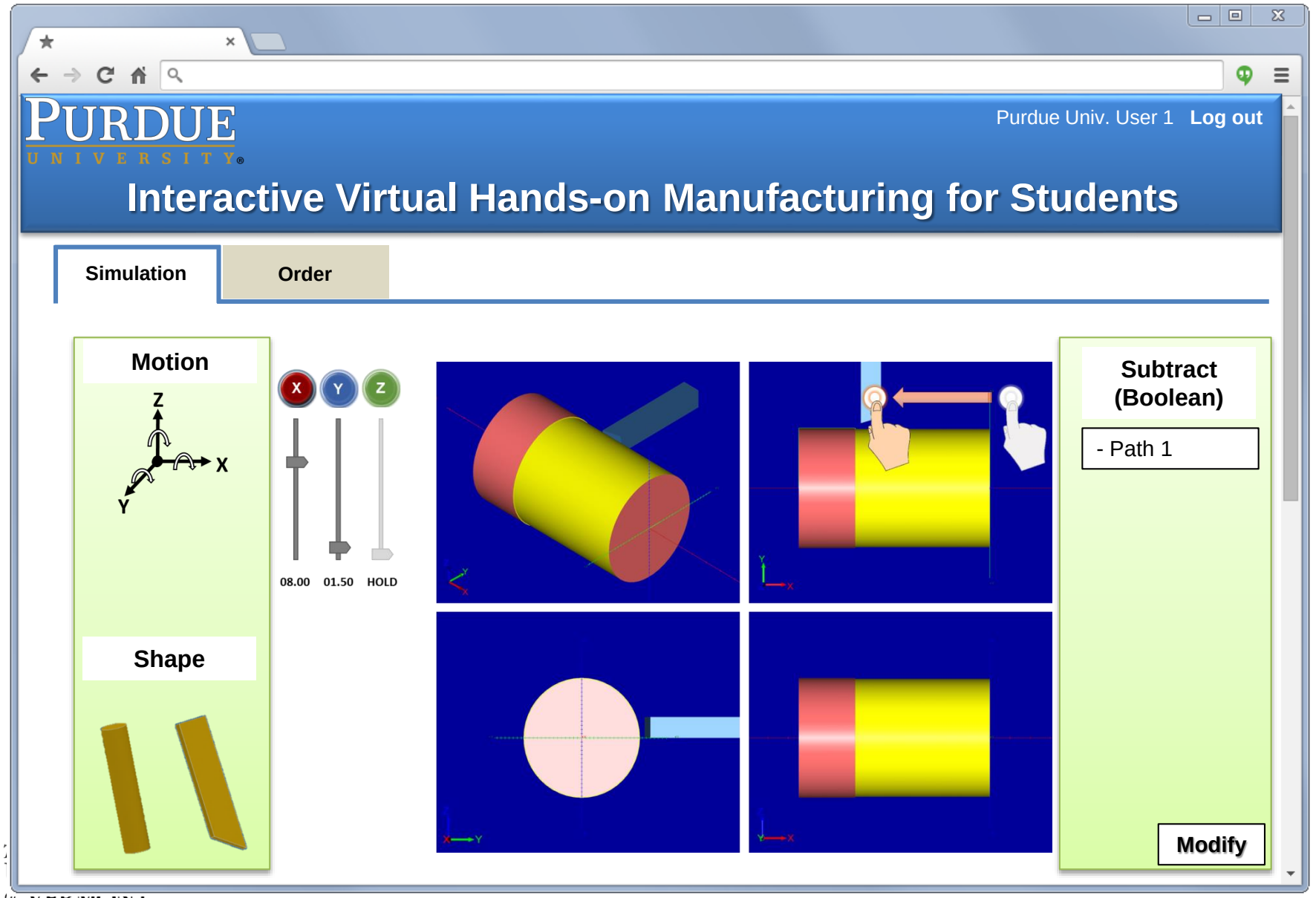


Operation Example: Turning



Operation Example: Turning



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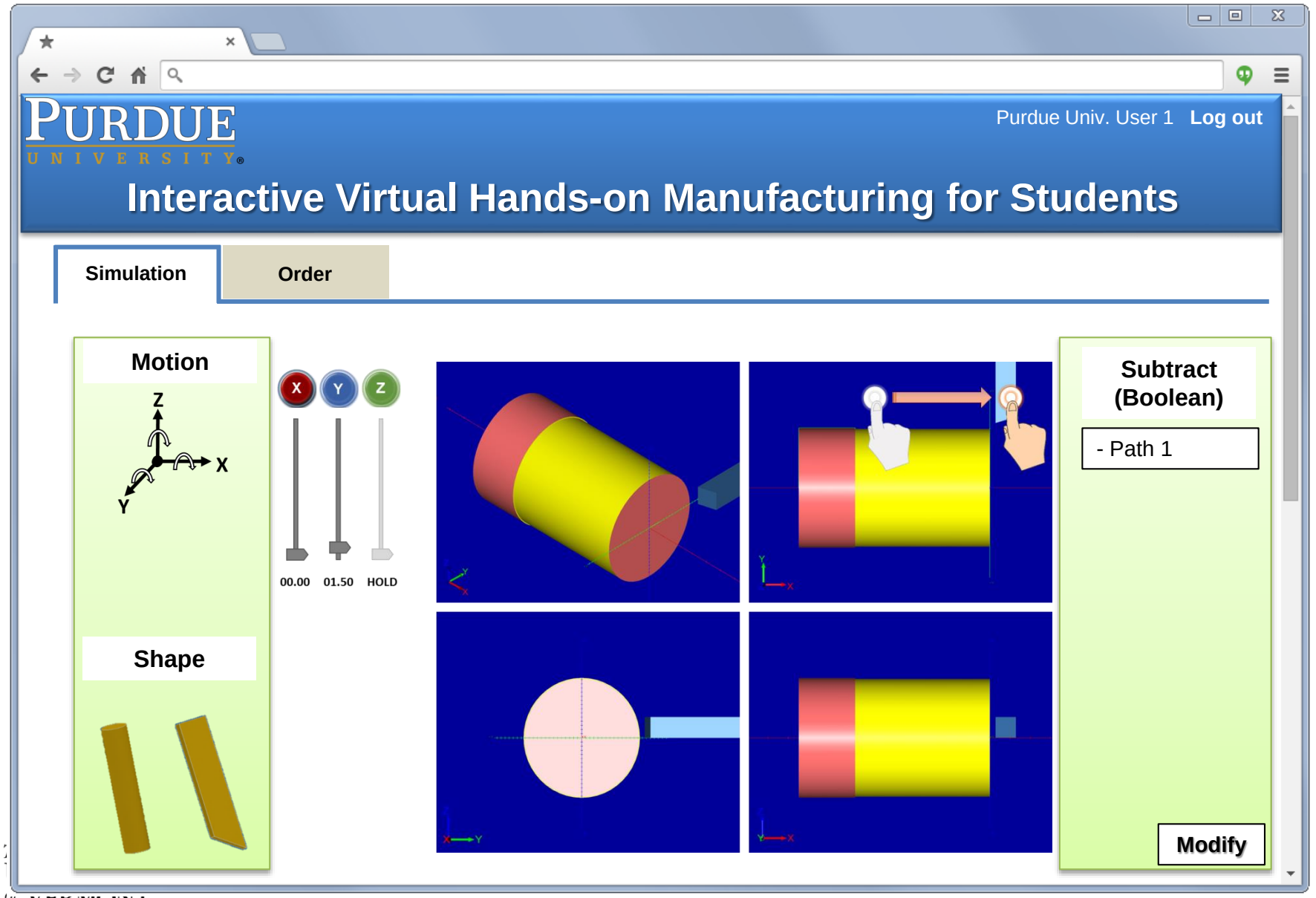

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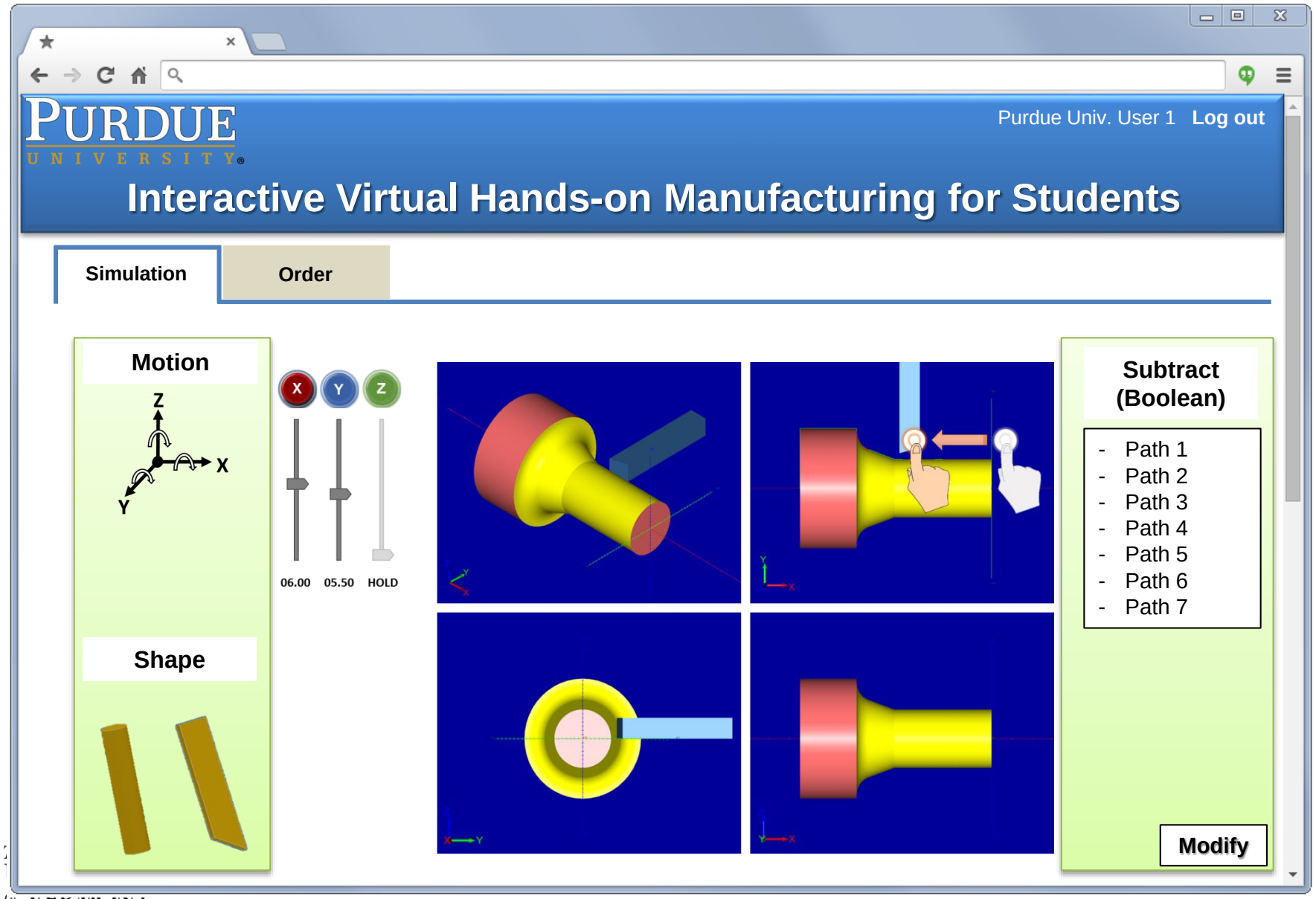

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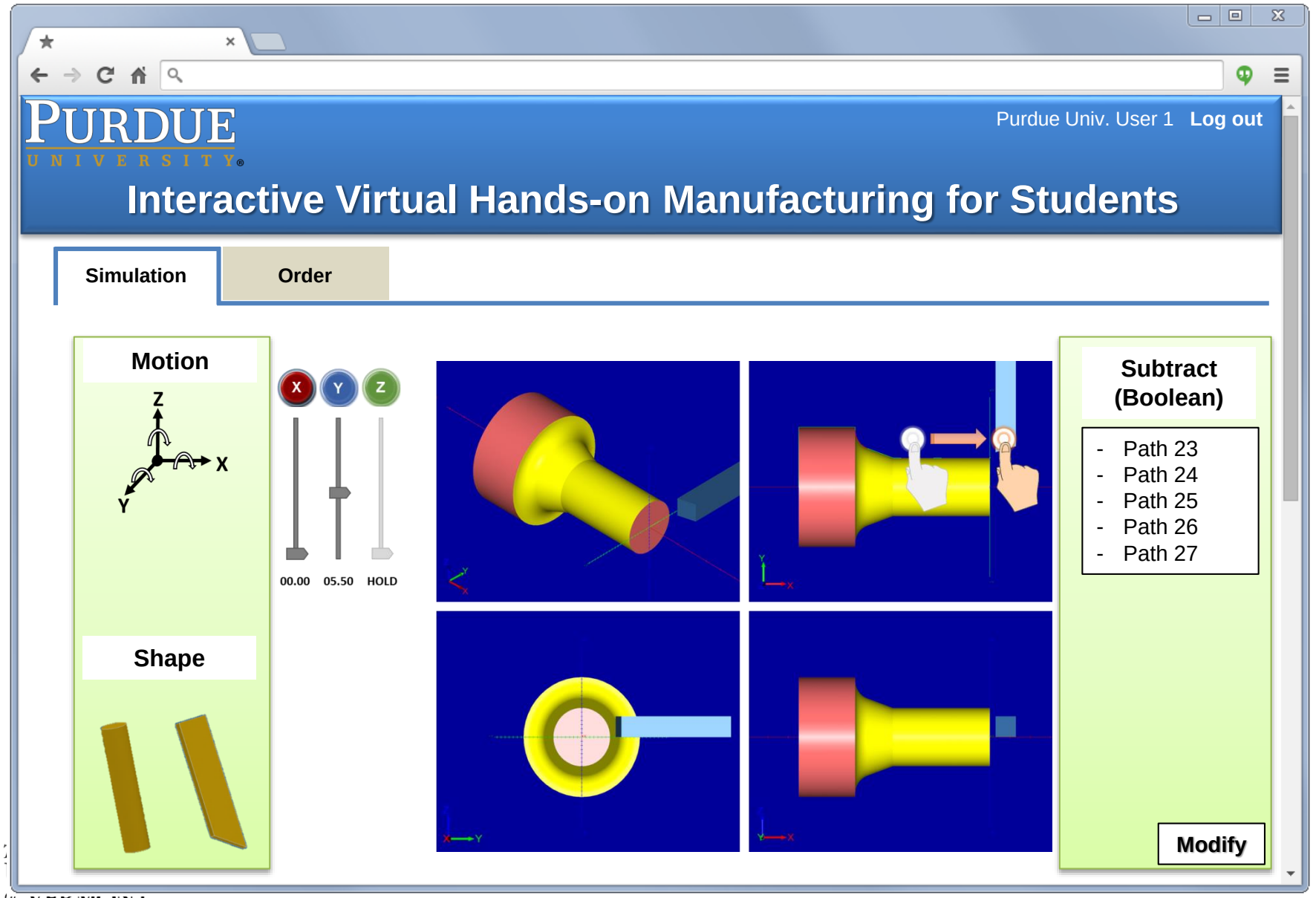

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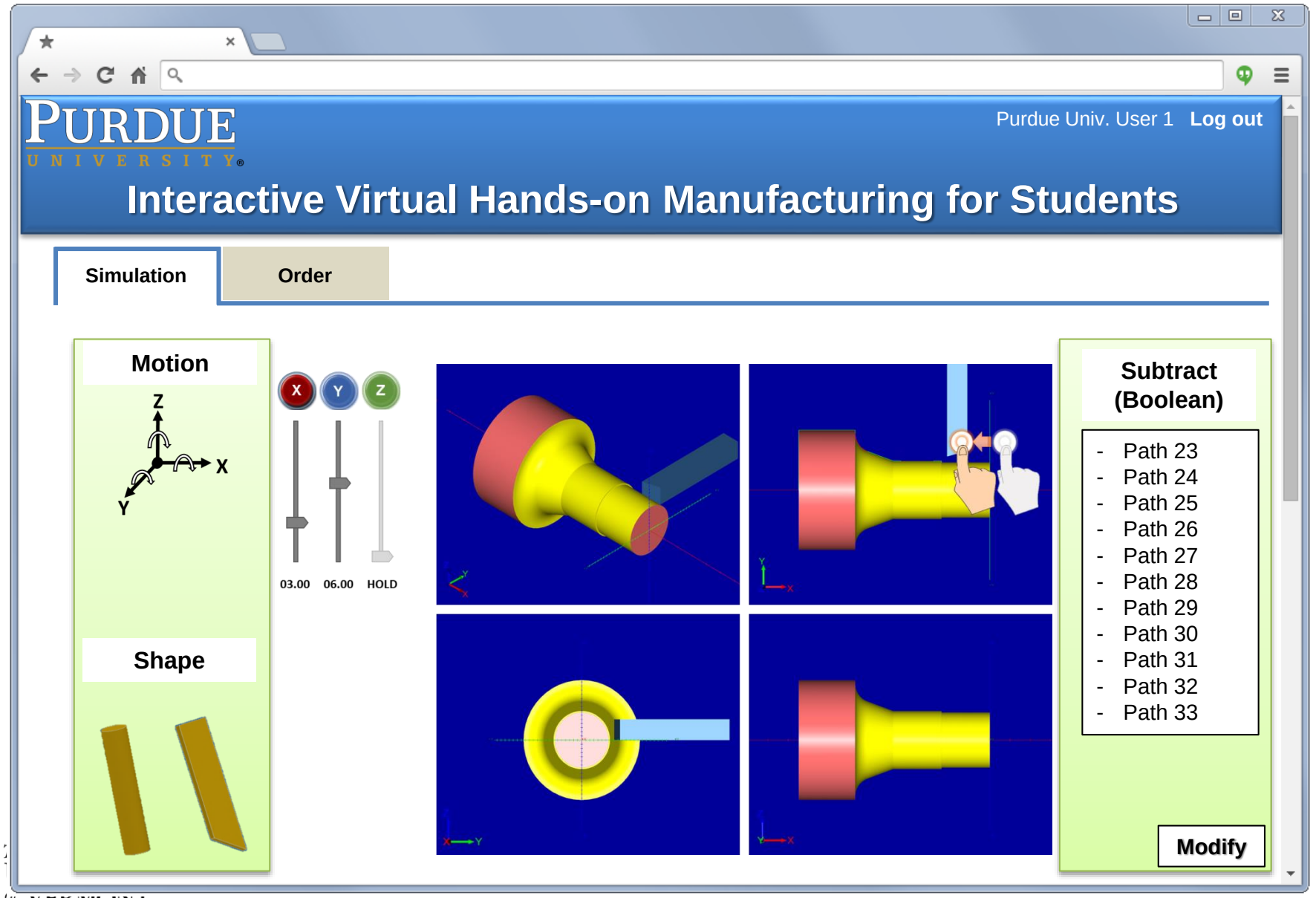

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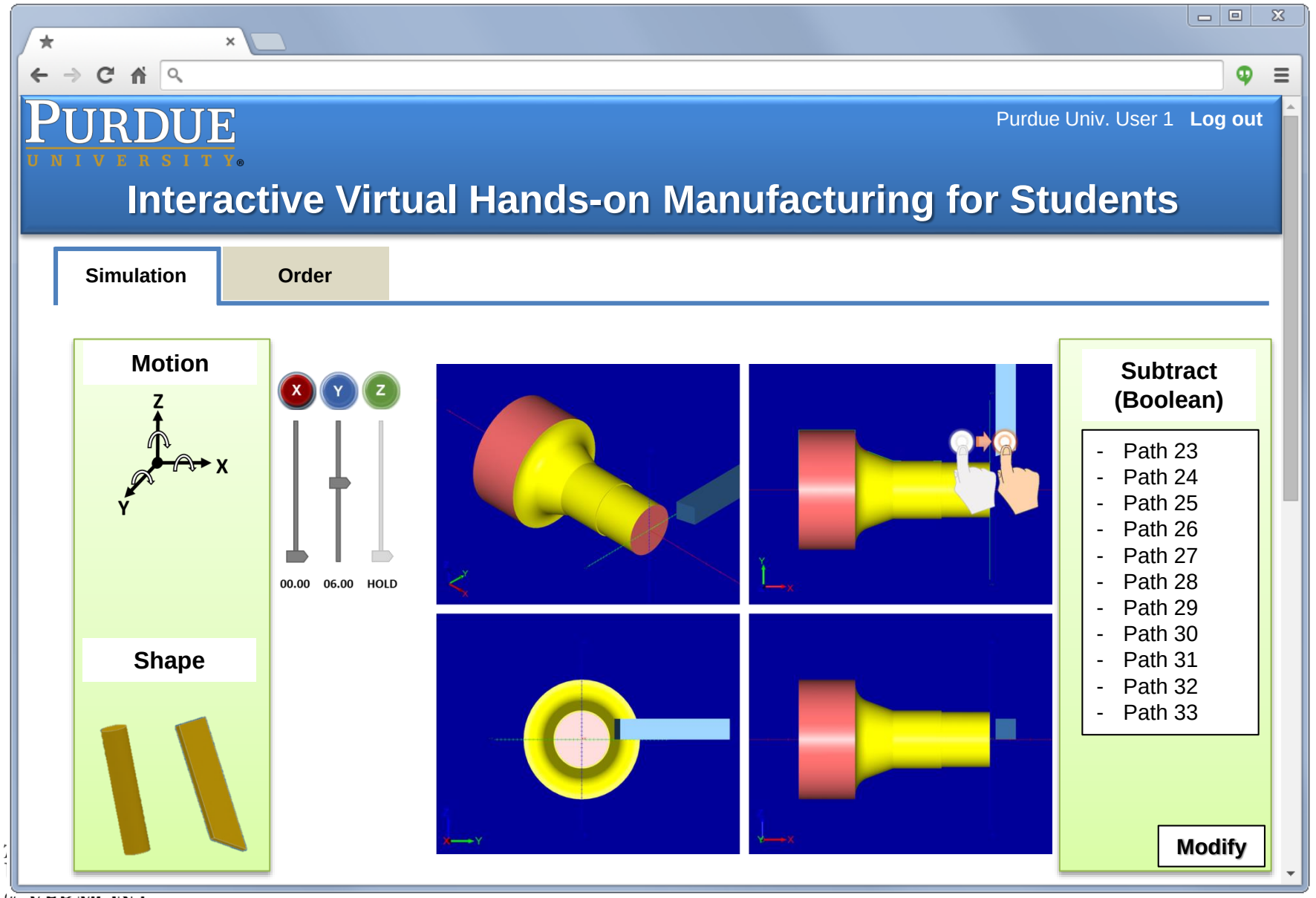

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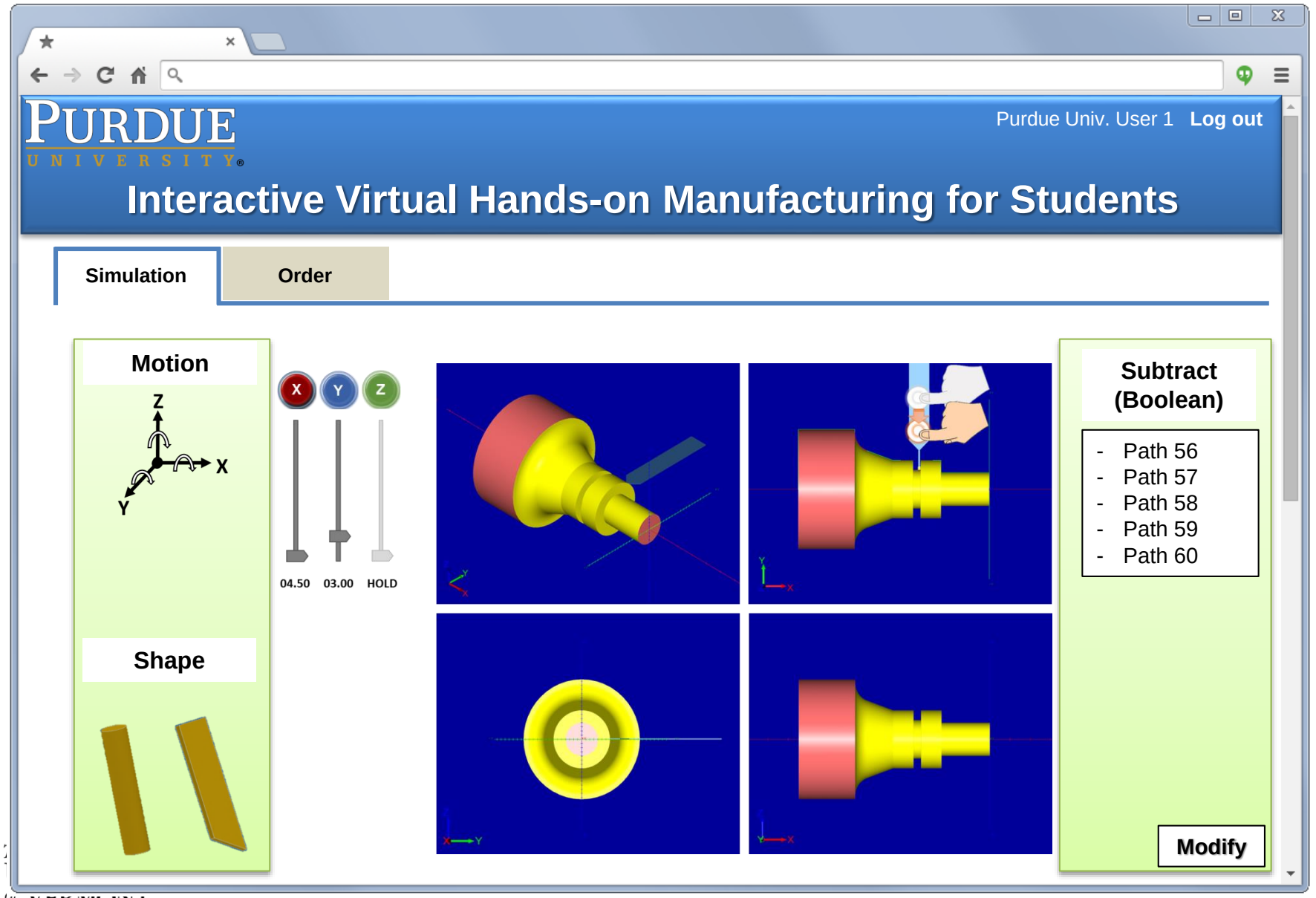

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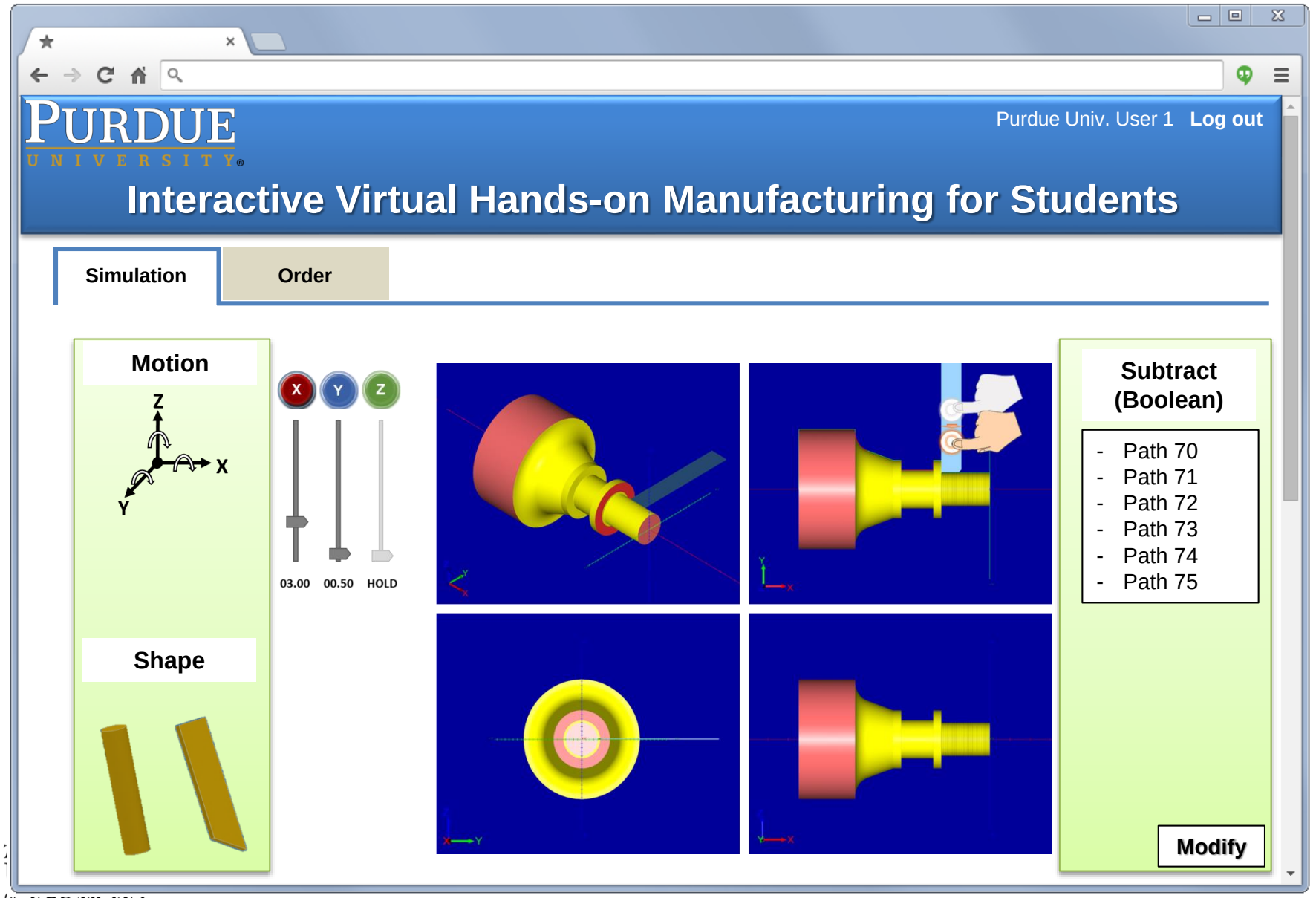
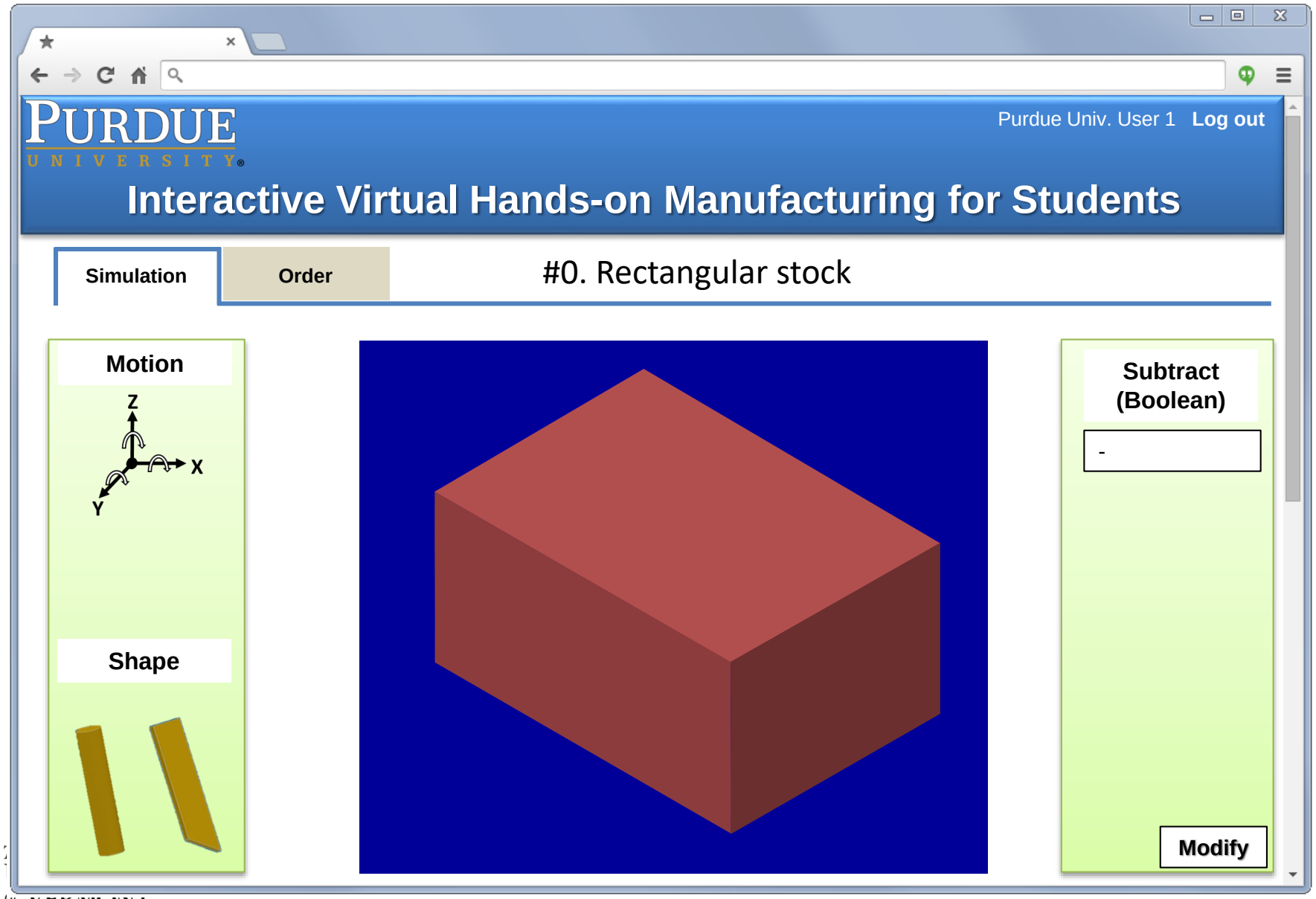


Part Generation Example



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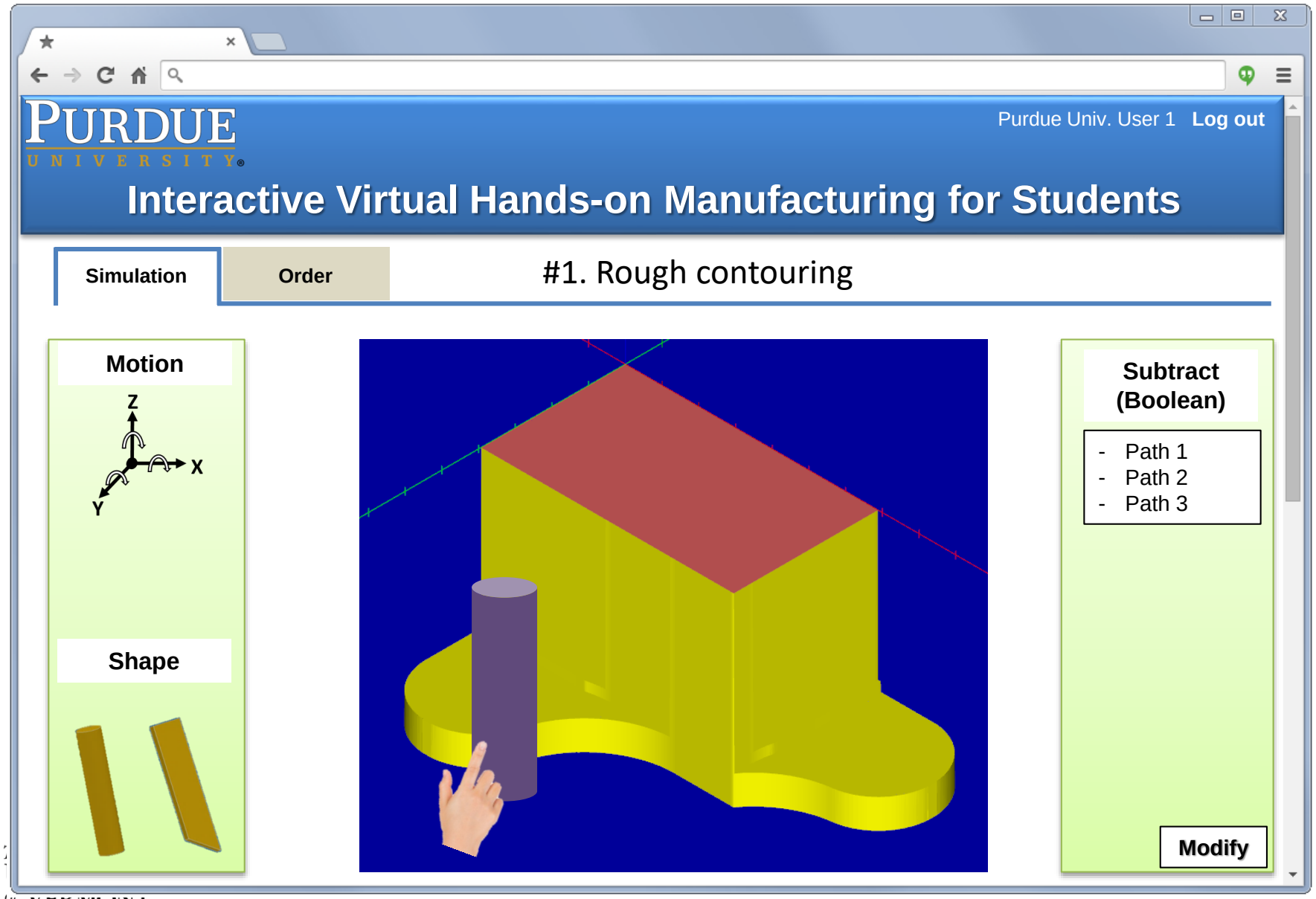
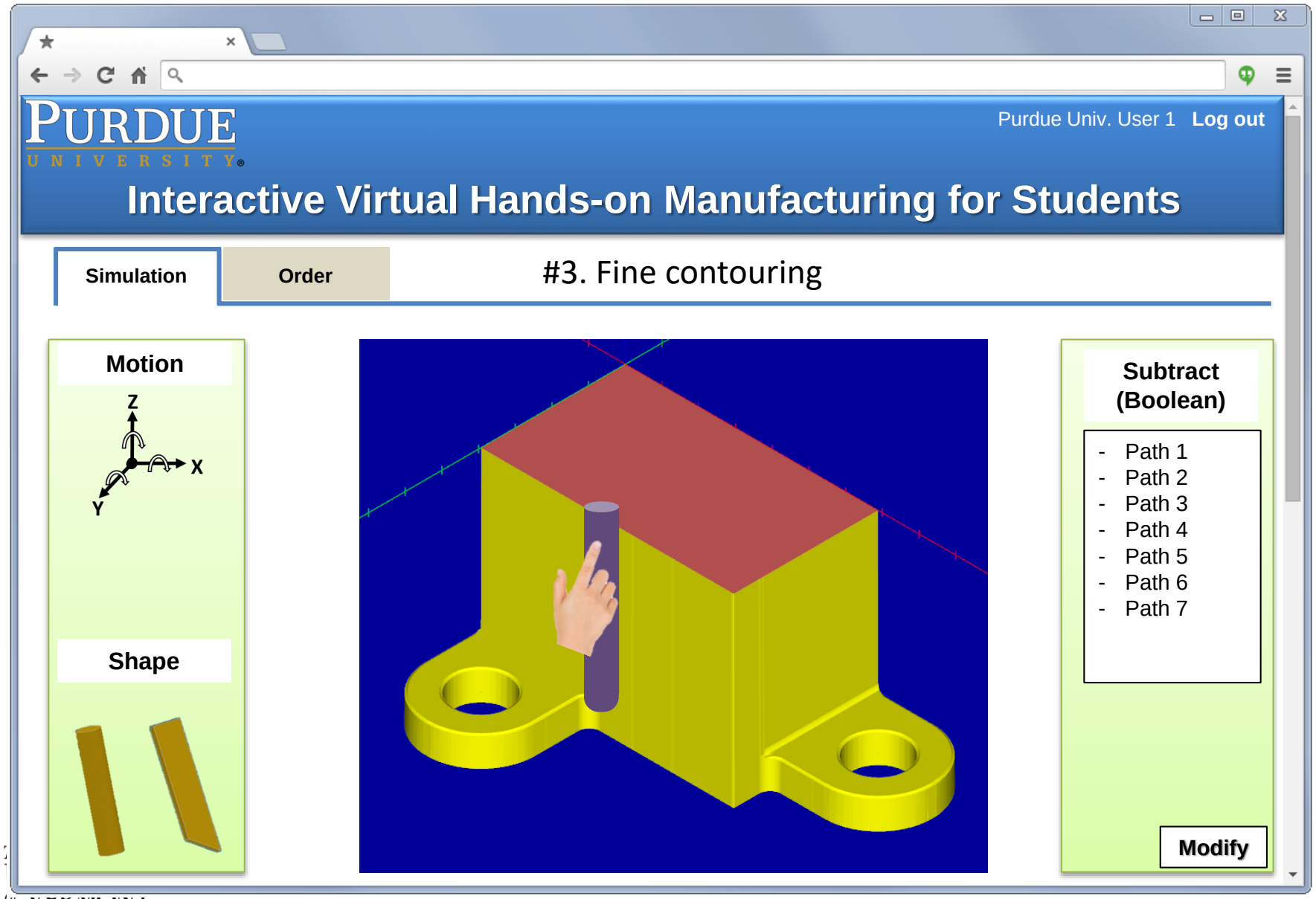


Operation Example: Turning

Operation Example: Turning



Operation Example: Turning

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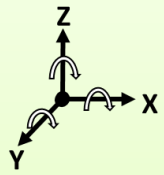
Purdue Univ. User 1 **Log out**

Interactive Virtual Hands-on Manufacturing for Students

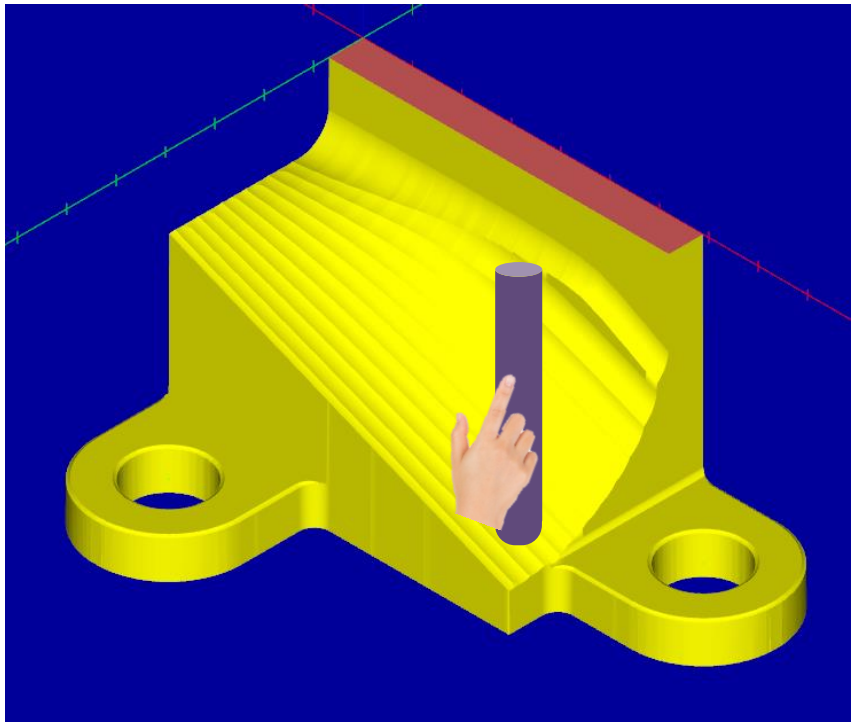
Simulation | **Order**

#4. Freeform contouring

Motion



Shape



Subtract (Boolean)

- Path 8
- Path 9
- Path 10
- Path 11
- Path 12
- Path 13
- Path 14
- Path 15
- Path 16
- Path 17
- Path 18
- Path 19

Modify

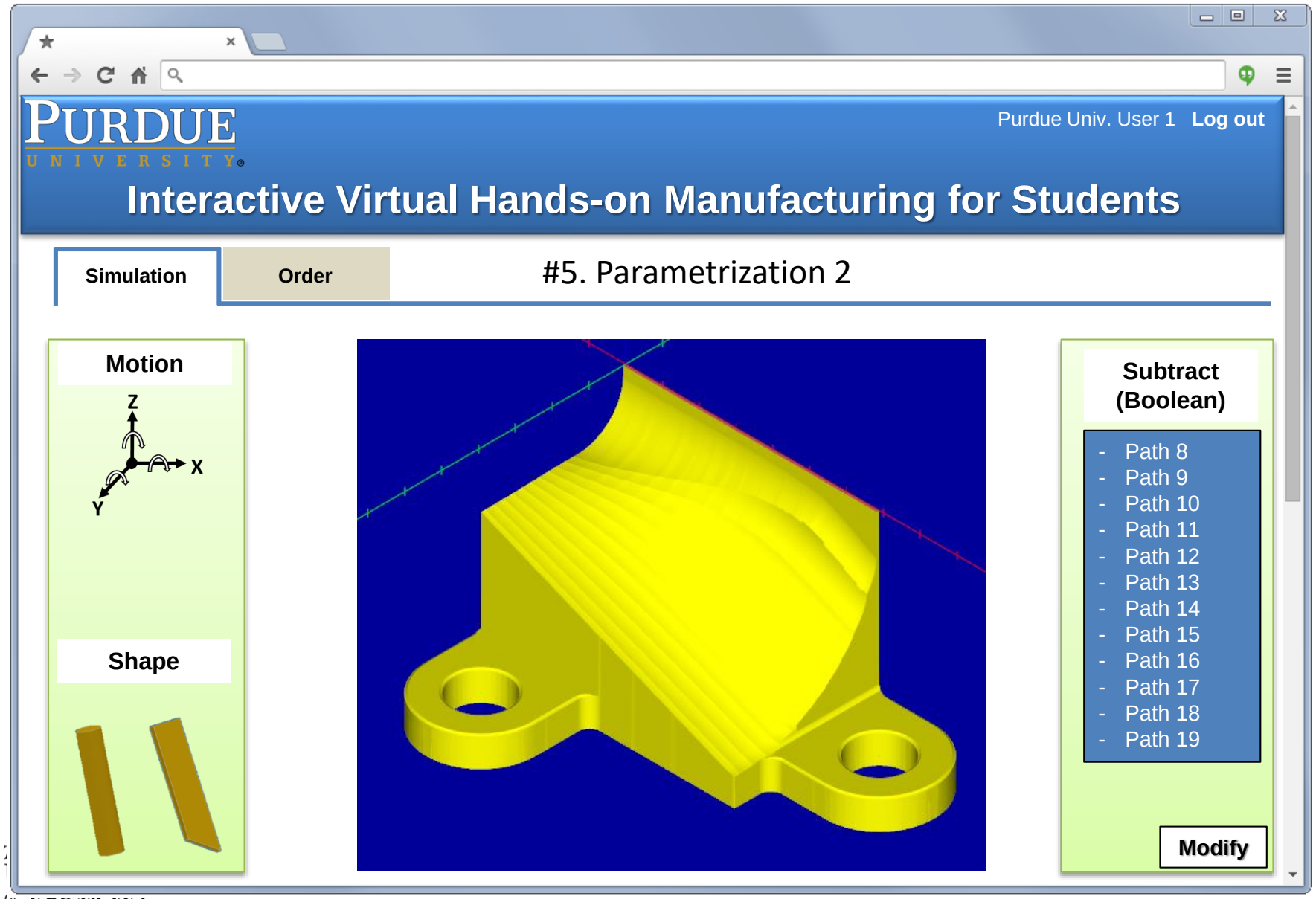
1. Select tool paths

3. Modify tool diameter (Φ3/4→1 in.)

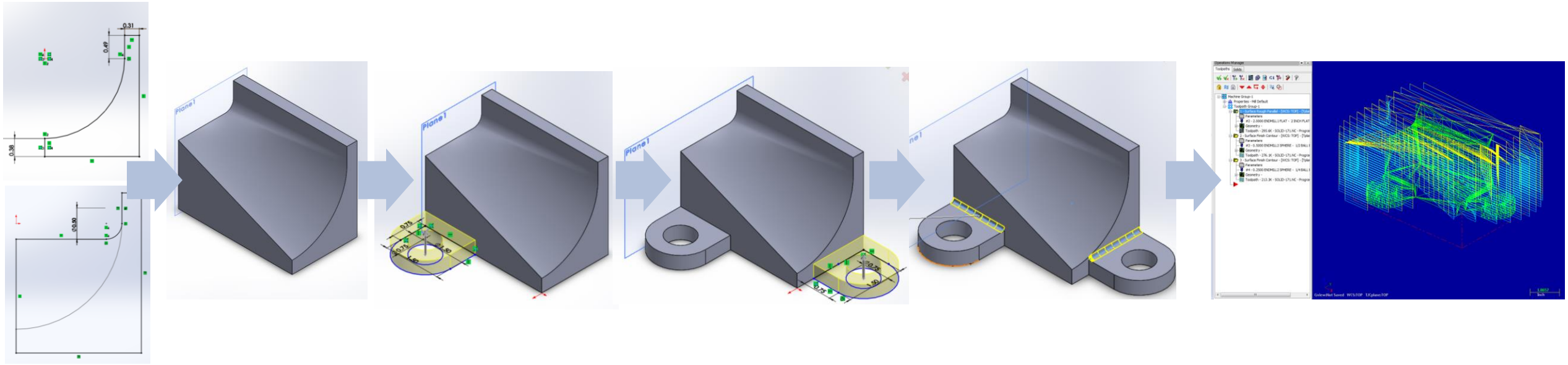
PURDUE UNIVERSITY

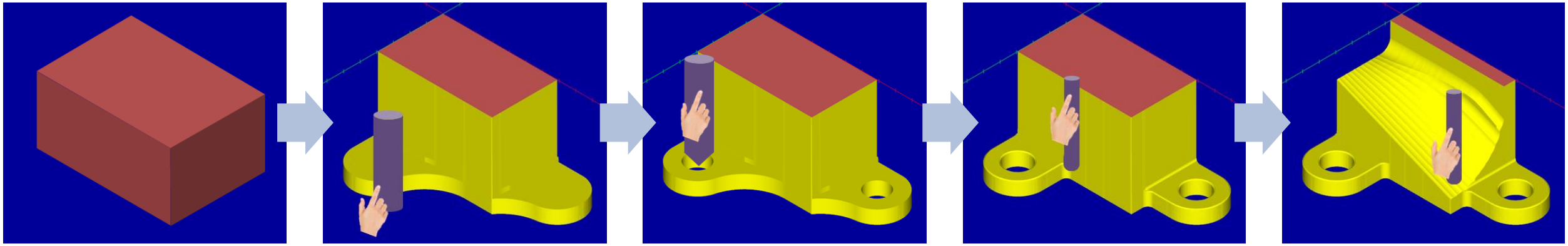
VERMONT

Operation Example: Turning



New Approach for CAD/CAM





Manufacturing Workflow

Conventional Design-to-Manufacture Workflow

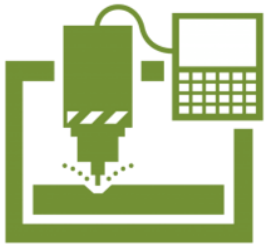
Customer

CAD Drawing

CAM Software

```
G03 X6.06066 Y6.0
G03 X5.00000 Y6.5
G00 Z20
/G00 X5 Y7.5
```

Part Program

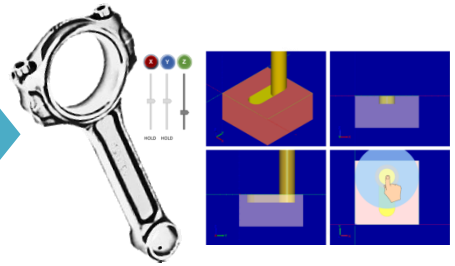


CNC Machine

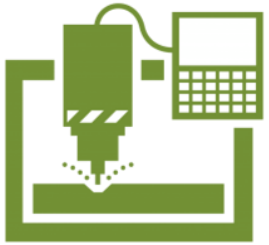
Cut Part

Streamlined Virtual Manufacturing Workflow

Customer



Interactive CAD

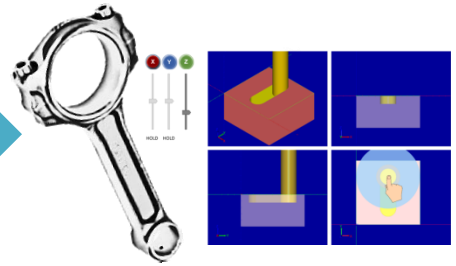


CNC Machine

Cut Part

Cybermanufacturing

Customer



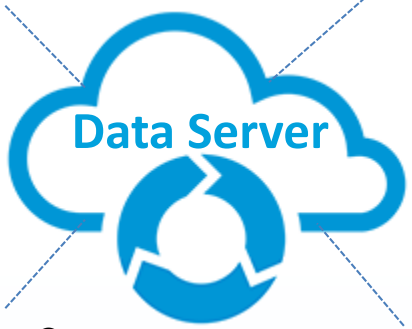
Virtual Manufacturing

- Final Design
- Machine Configuration
- Tool and Workpiece
- Quantity Information

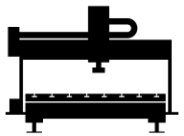
Upload

Shop A

Shop B

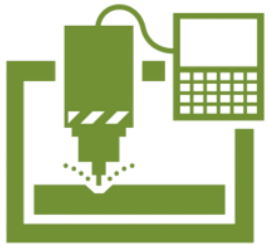


Shop C



Shop D

Provider Check

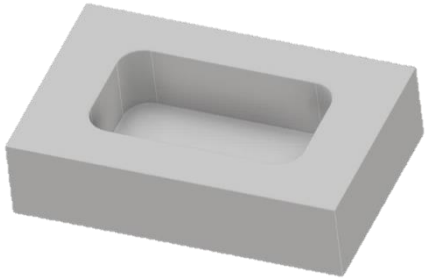


CNC Machine

Cut Part

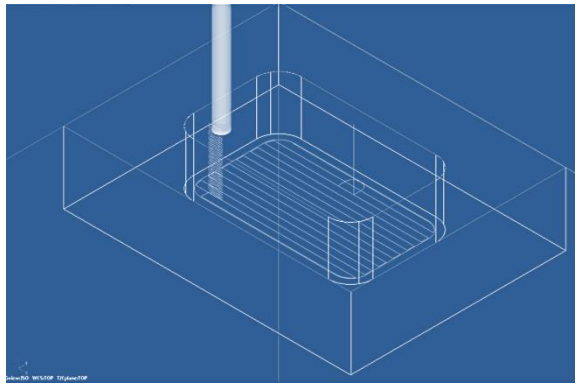
Delivery

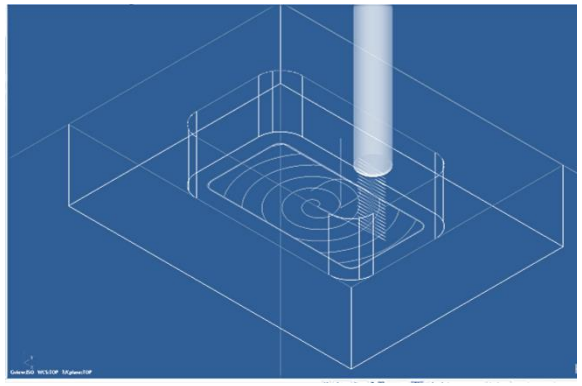
Good Manufacturing Designer



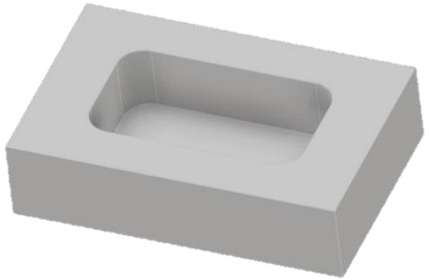
Target Part

Idea for parts



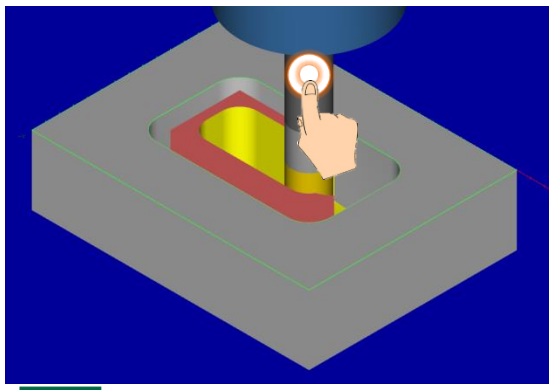


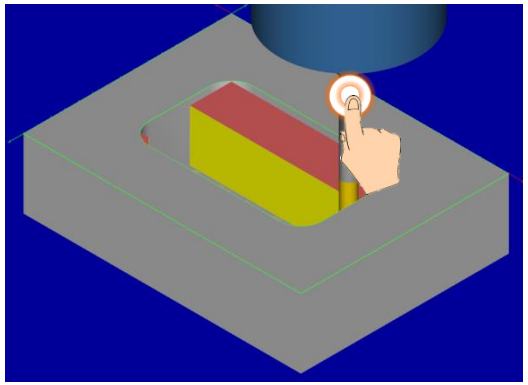
Good Manufacturing Designer

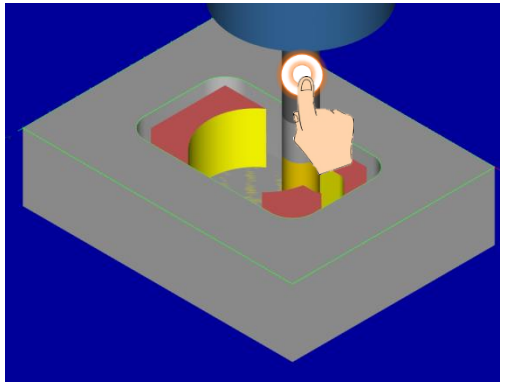


Target Part

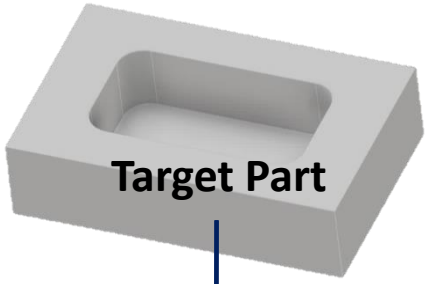
Virtual Manufacturing



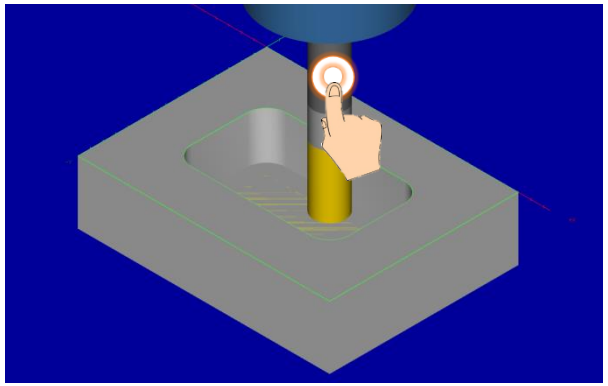




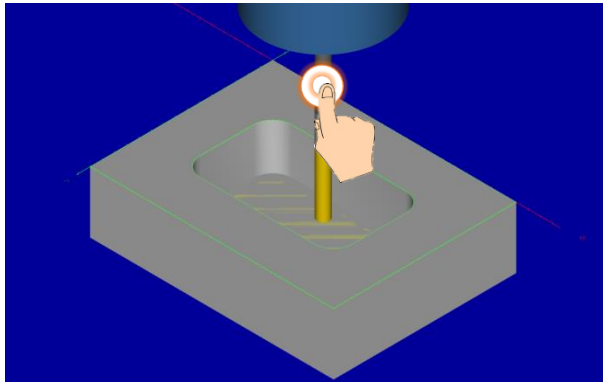
Good Manufacturing Designer



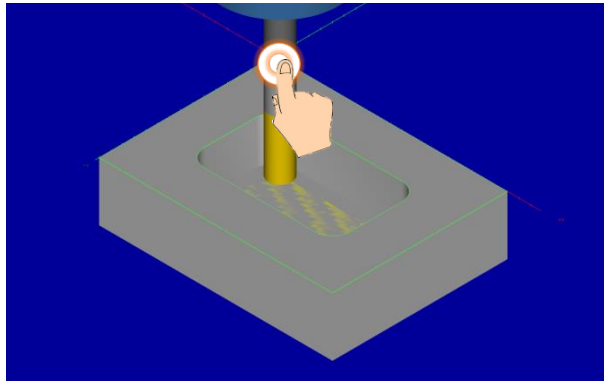
Virtual Manufacturing Results



Machining time : 39.0 sec
Part shape : Good



Machining time : 42.3 sec
Part shape : Normal



Machining time : 25.7 sec
Part shape : Good

Conclusion

- If the design process is similar to manufacturing, manufacturable parts can be readily designed
- Learning of manufacturing processes can be naturally obtained
- It provides a platform that allows innovative human inputs to manufacturing during the design process
- It can be a great tool for education and cybermanufacturing