- https://mdmf.hkust.edu.hk/
  - Open the presentation PDF at “Useful Links” -> “Seminar Materials” -> “MDMF(CWB) - Lattice Workshop - 20221205-01.pdf”.
  - Download the STEP CAD file to be used in workshop at:
  - https://gohkust-my.sharepoint.com/:u:/g/personal/empatlam_ust_hk/EYTROL_YYKJEuBOSDoUnMGwB3I1Dlay-CnjDcMf-xgk8rQ?e=gvLdFC
- If you do not have an Autodesk Account, then please create one at:
  - https://accounts.autodesk.com/
  - Use your registration email account (i.e. the registered HKUST email) as the Autodesk Account name.
- https://fusion.online.autodesk.com

Design for Additive Manufacturing

13 Dec 2022

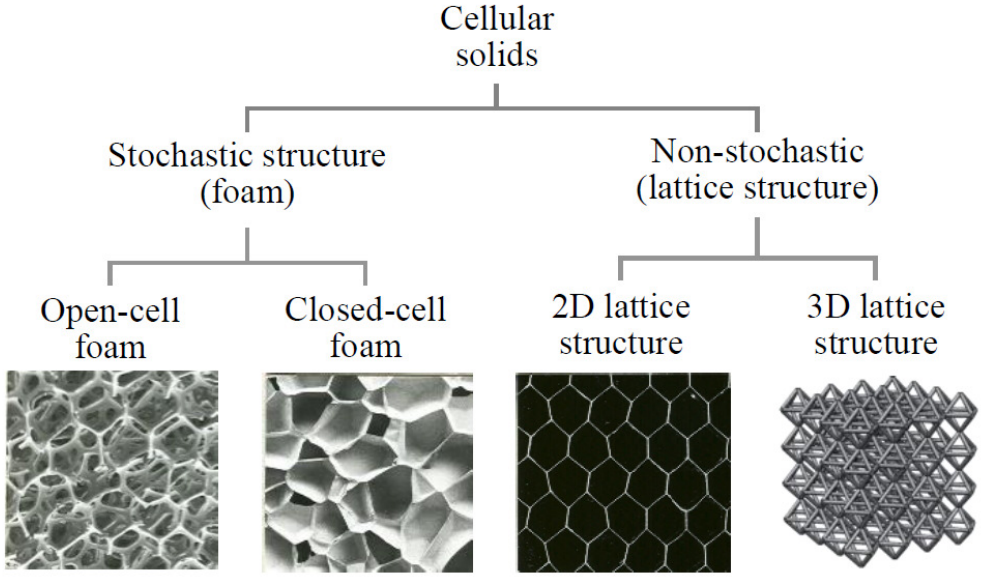
Lattice Workshop

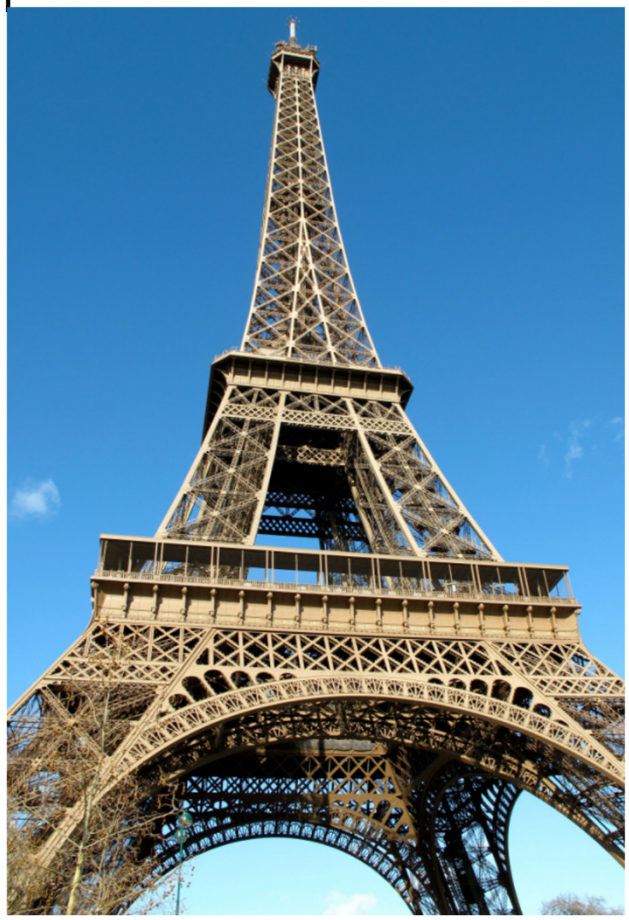
Contents

1. What is Lattice Structure
2. Lattice Structure – Terminology
3. Types of Lattice
4. Tools for generating lattice structure (Fusion 360 – Product Design Extension)
5. Workflow of Fusion 360 – Volumetric Lattice

1. What is Lattice Structure

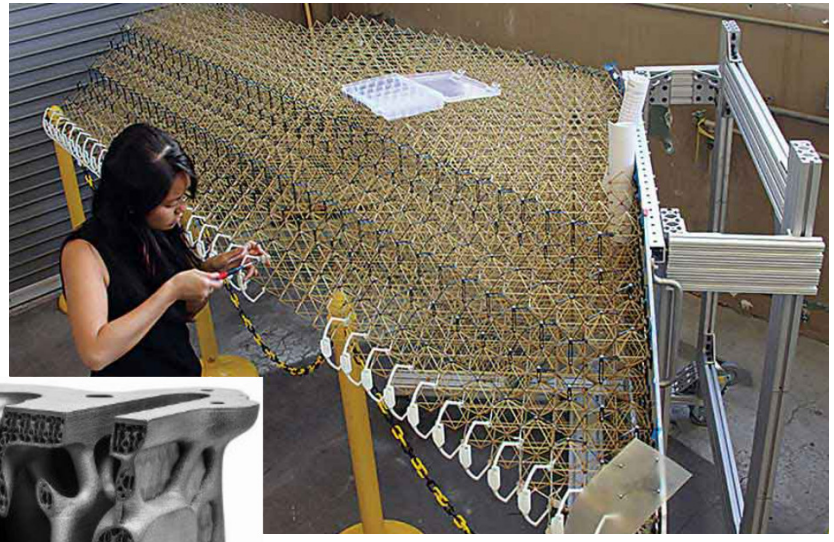
- An engineering or architectural structure made of a network of crosshatch sections.
- Formed by an array of spatial periodic unit cells with edges and faces.
  - Two- and three-dimensional lattice structures





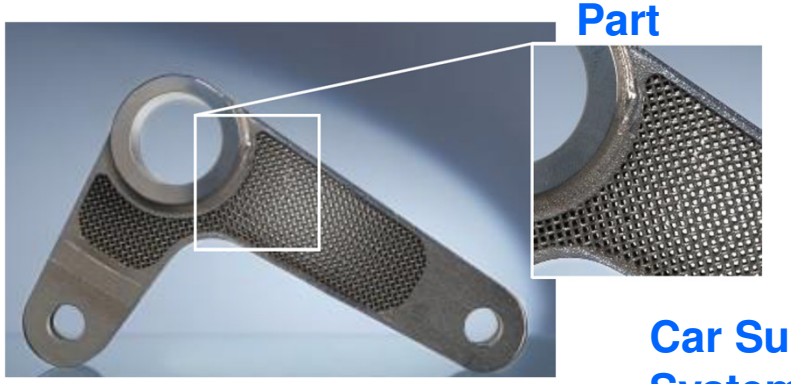
1. What is Lattice Structure

- Lightweight structure
  - High strength-to-weight ratio

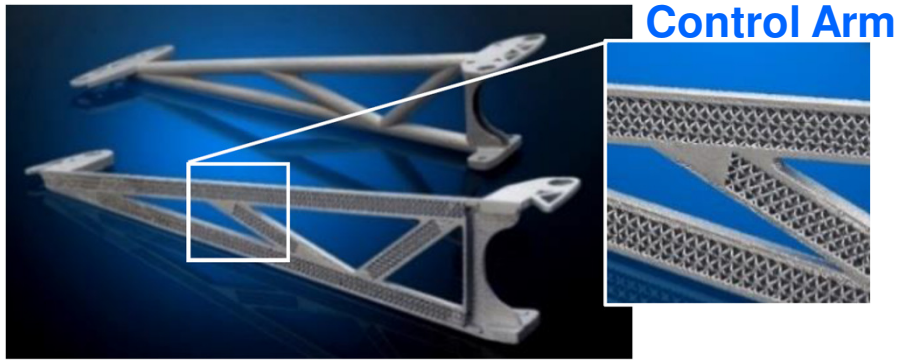


Aircraft Wing Structure

Helicopter Part



Car Suspension System - Control Arm



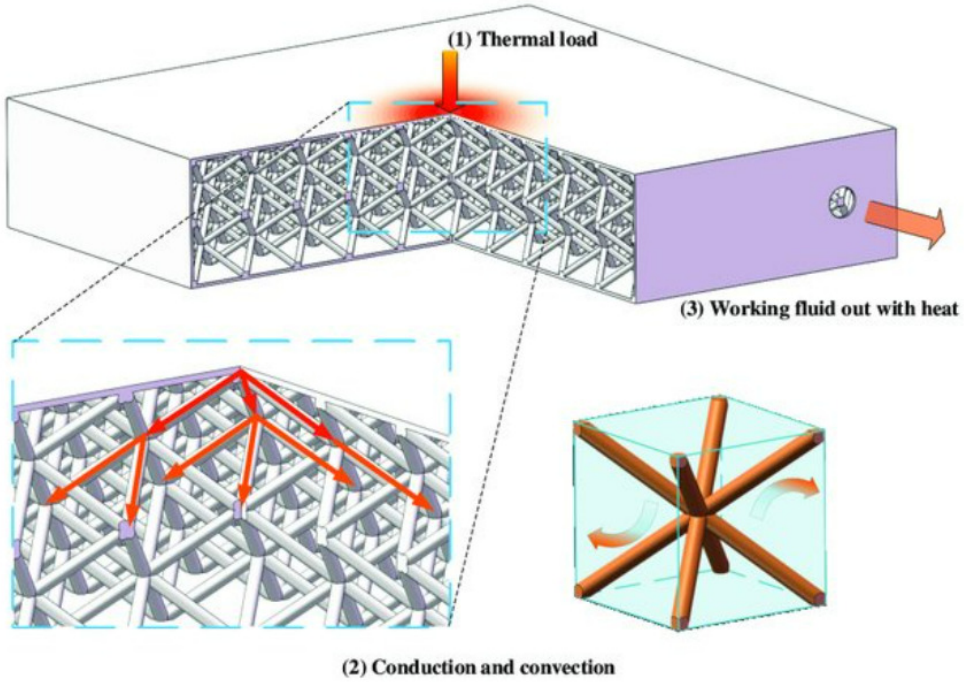
Cylinder Head

1. What is Lattice Structure

- Height exchanger
  - Large surface area

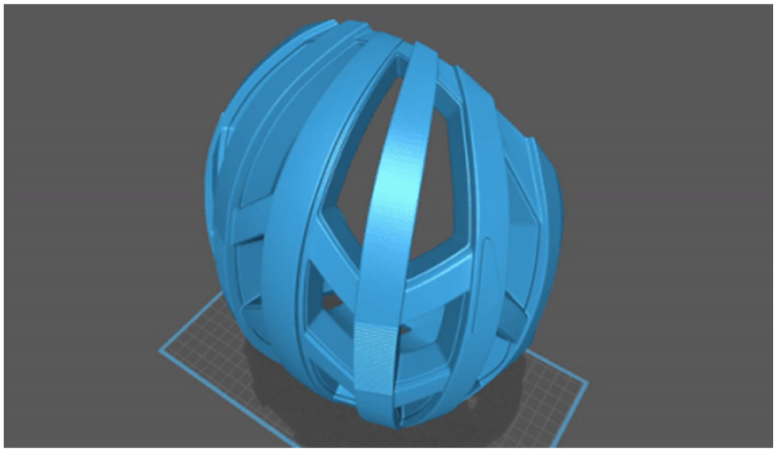
Combustion Chamber

Heat Exchanger



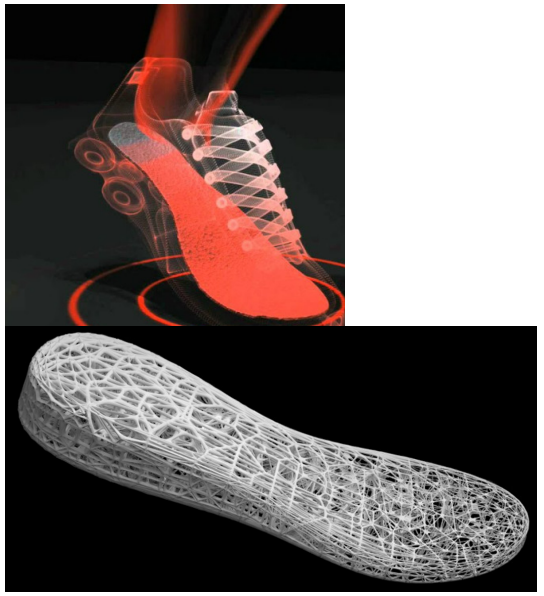
1. What is Lattice Structure

- Energy absorber
  - Ability to undergo great deformation at a relatively low stress level.
  - Prevent products from collisions and dropping by absorbing impact energy.
  - Reduce vibrations and dampening because of their ability to withstand and recover large strains.



Helmet

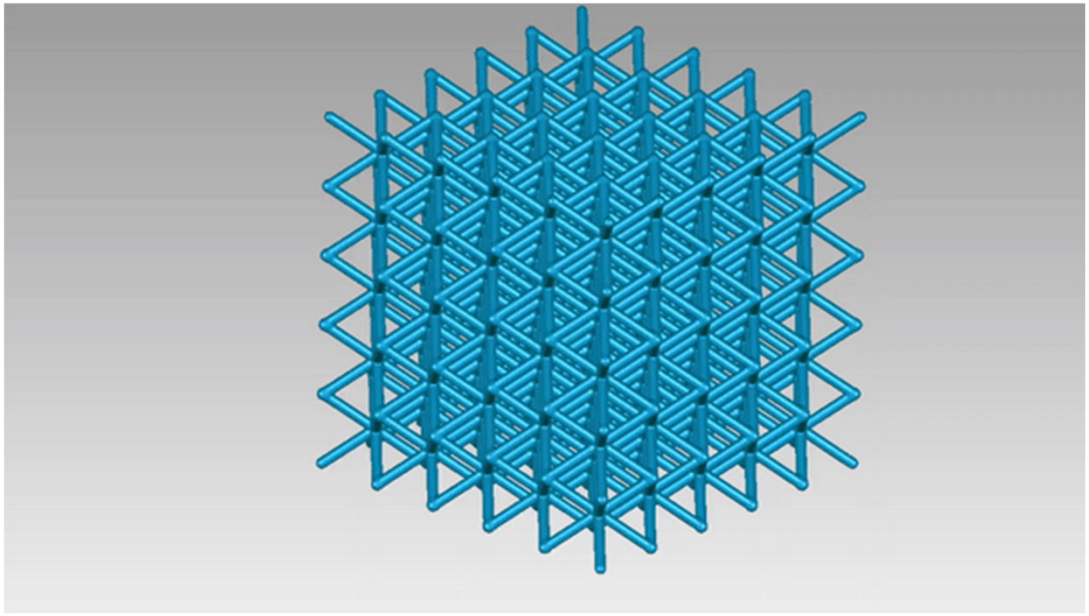
Vibration-absorbing Structure



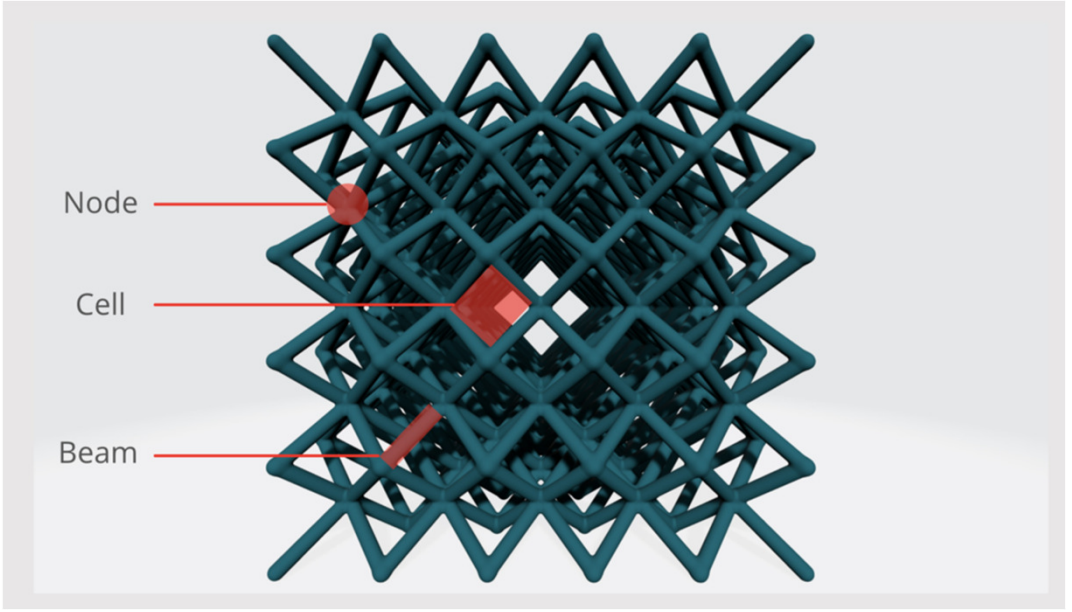
Impact Absorbing Insole

2. Lattice Structure – Terminology

- Lattice structures are topologically ordered, three-dimensional open-celled.



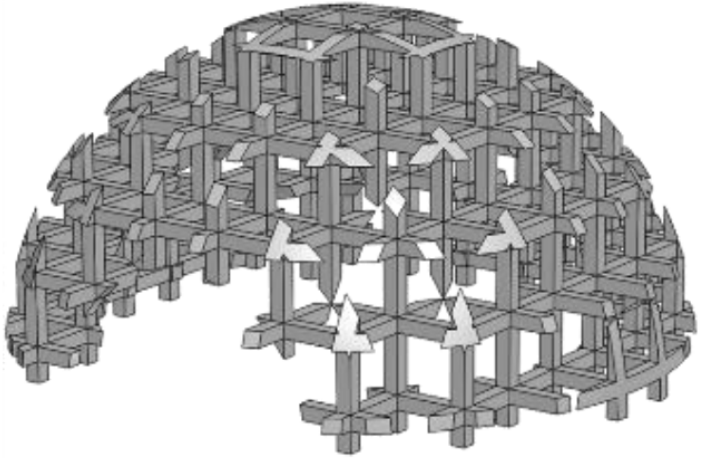
Lattice Structure



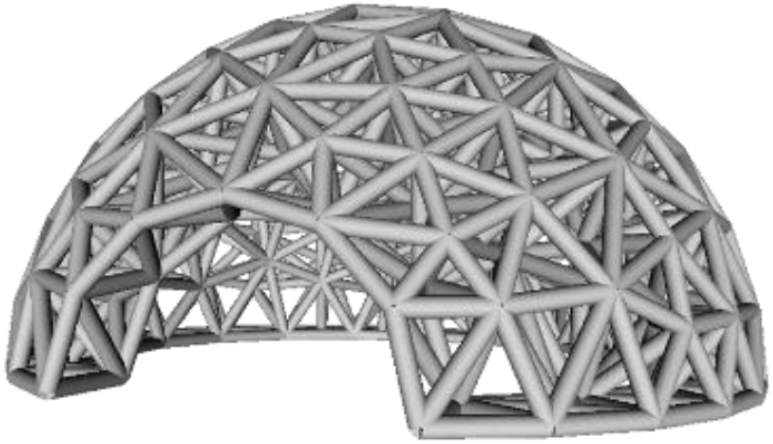
Lattice Structure - Terminology

2. Lattice Structure – Terminology

- Direct patterning
  - Unit cells are translationally repeated.
- Conformal patterning:
  - Unit cells are repeated conforming to a given shape geometry.
  - Retains the integrity of the unit cell.
  - A better approach to stiffen or strengthen the desired structure.
  - Can distribute the load evenly throughout the whole structure.

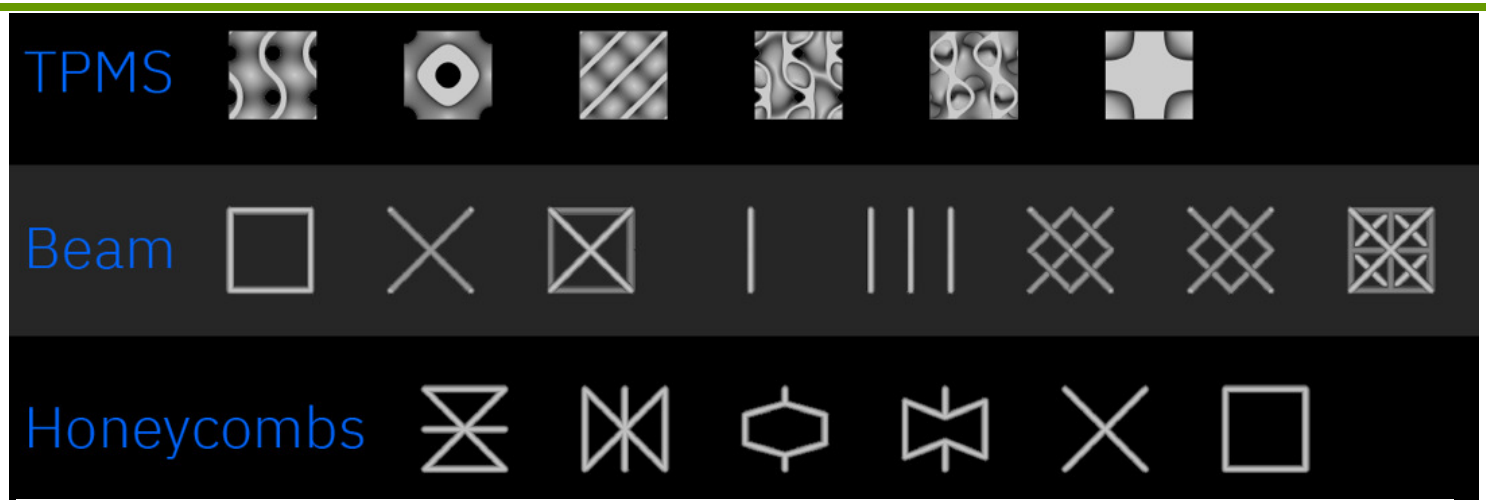


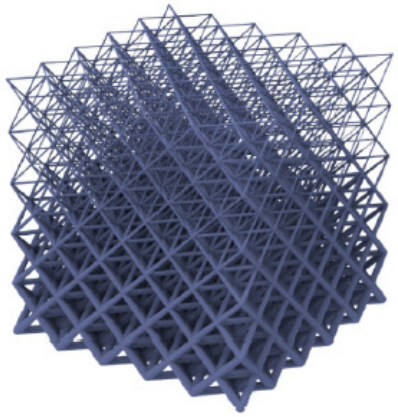
Direct patterning



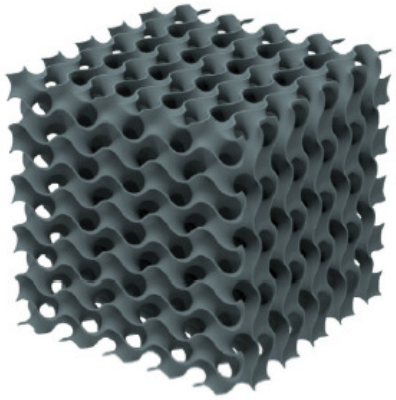
Conformal patterning

3. Types of Lattice

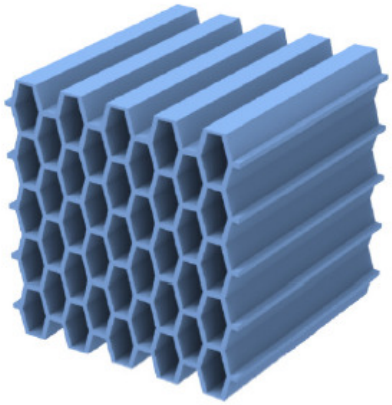




Beam



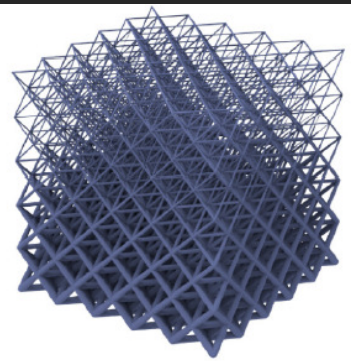
TPMS



Honeycomb

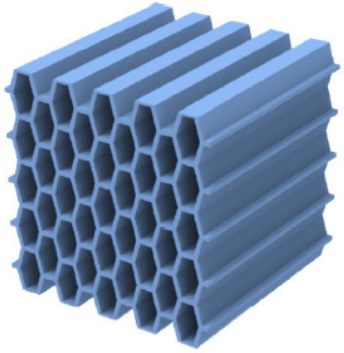
3. Types of Lattice

- Beam structure
  - Lattice with a triangular, square profile, and hexagonal cells.
  - High stiffness-to-weight, or be elastic and compliant
  - Light weight and energy-absorbing structure
  - Excellent damage tolerance



  - Better to print strut-based lattice with cell size < 5mm
    - Avoid serious deformation and struts' distortion

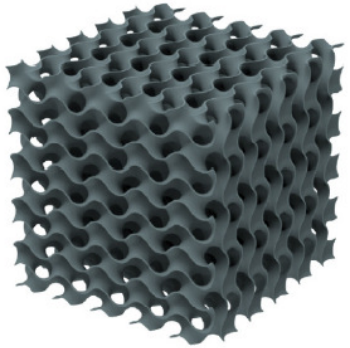
- Honeycomb structure
  - High stiffness in a specific direction

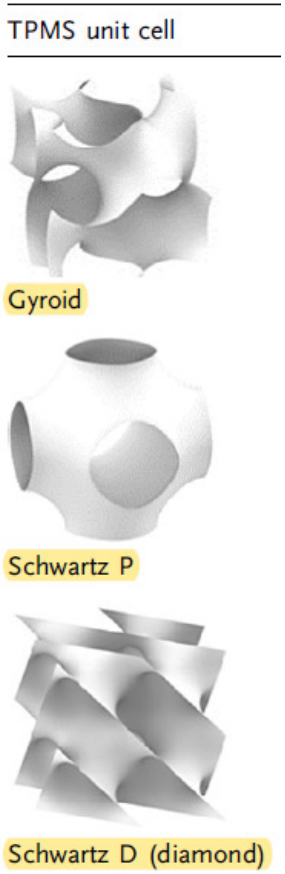


3. Types of Lattice

- TPMS (Triply Periodic Minimal Surfaces)
  - Surface-based lattice
  - All-around good mechanical properties
  - Biomorphic geometry, makes TPMS favorable for:
    - Orthopedic implant
    - Tissue-engineering applications

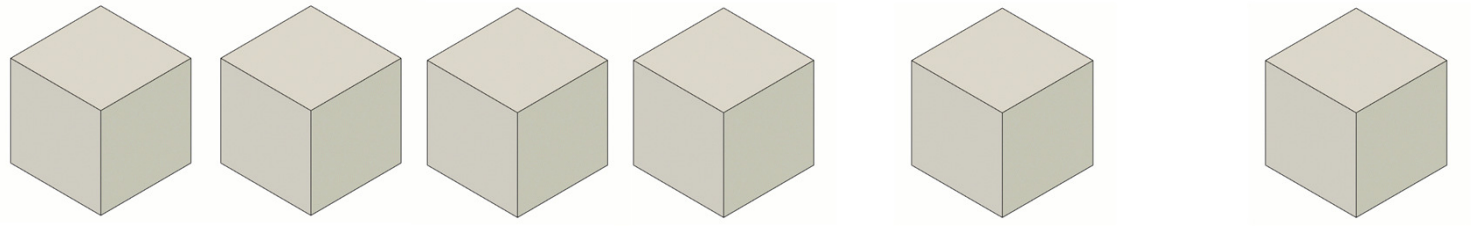
  - TPMS lattices of larger overhanging structures remains feasible
    - Cell walls' inclination varies between layers
    - Providing a self-support property





4. Tools for generating lattice structure (Fusion 360 – Product Design Extension)

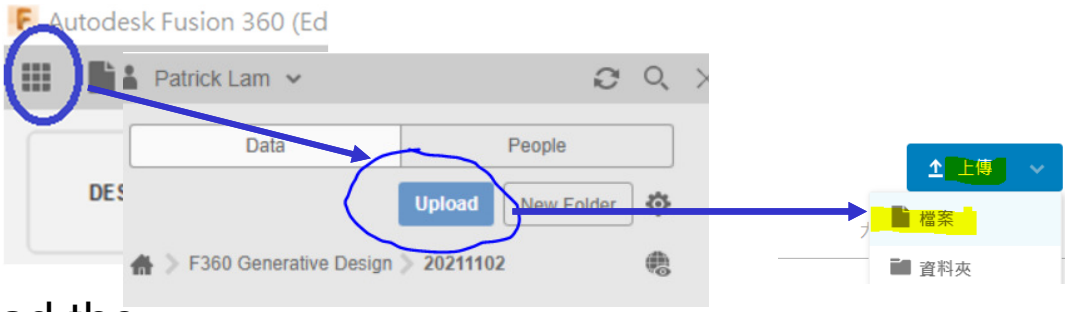
- Fusion 360 – Product Design Extension provides a set of advanced 3D design and modeling tools that:
  - Enable an automated approach to creating complex product designs.
  - Improve product performance and prepare your design for manufacturing with intelligent feature settings and guidance.
  - **Volumetric Lattice** tool to select a body and specify the cell shape, size, and density of the lattice.
    - **Hollow out** parts while maintaining their shape and meeting their mechanical specifications.
    - Supports multiple cell types:
      - Gyroid, Cross, X-Cell, 2.5D X-Cell, Schwarz P, and Schwarz D.



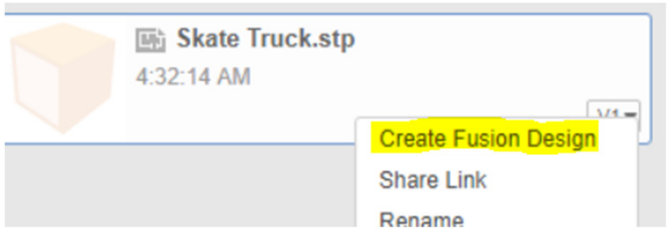
Import Data

5. Workflow of Fusion 360 – Volumetric Lattice

- To use online Fusion 360:
  - https://fusion.online.autodesk.com.



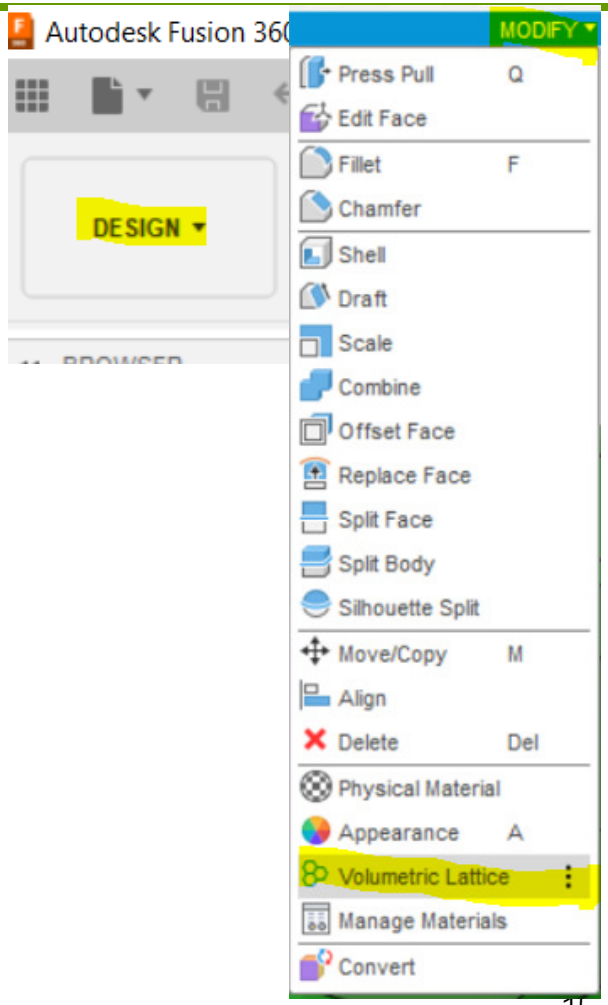
- Data uploading
  - Show the Data Panel
  - After creating your folder, then Upload the STEP file “Skate Truck.stp”
  - Right click the uploaded file and select “Create Fusion Design” to create the model as a Fusion360 model.
  - Then right click the created fusion design model, and select “Open” to open the Fusion360 model.



Volumetric Lattice

5. Workflow of Fusion 360 – Volumetric Lattice

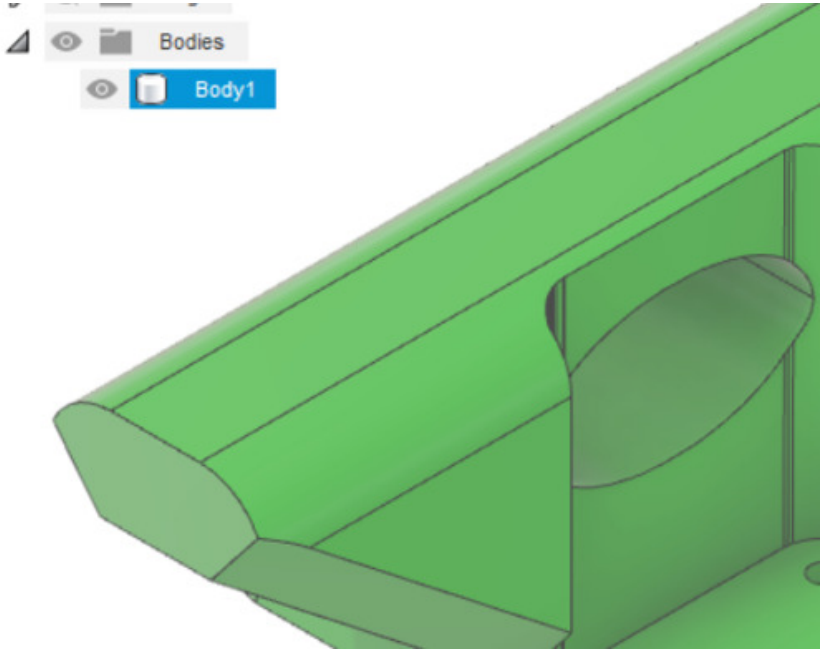
- Change Workspace to “Design”
- Define Volumetric Lattice
  - Ribbon “Modify” > “Volumetric Lattice”
    - At the first time of using “Volumetric Lattice”, you will be asked to start the trial of “Product Design Extension”.
    - Please answer “Yes” to this trial.

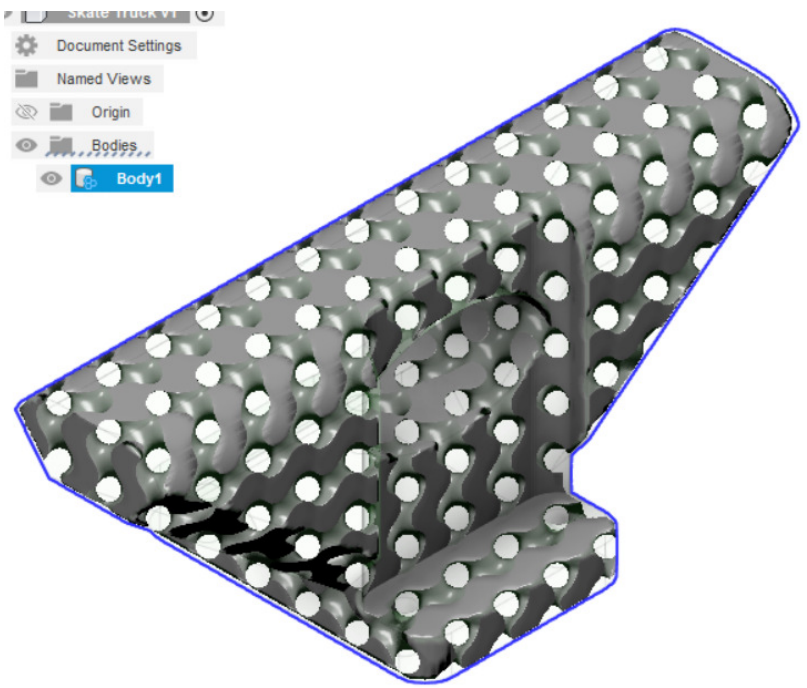


Volumetric Lattice

5. Workflow of Fusion 360 – Volumetric Lattice

- Define Volumetric Lattice
  - After selecting “Volumetric Lattice”
  - Select solid for generating volumetric lattice:
    - Select Body1 from “Bodies”
  - Default lattice type “Gyroid” is applied

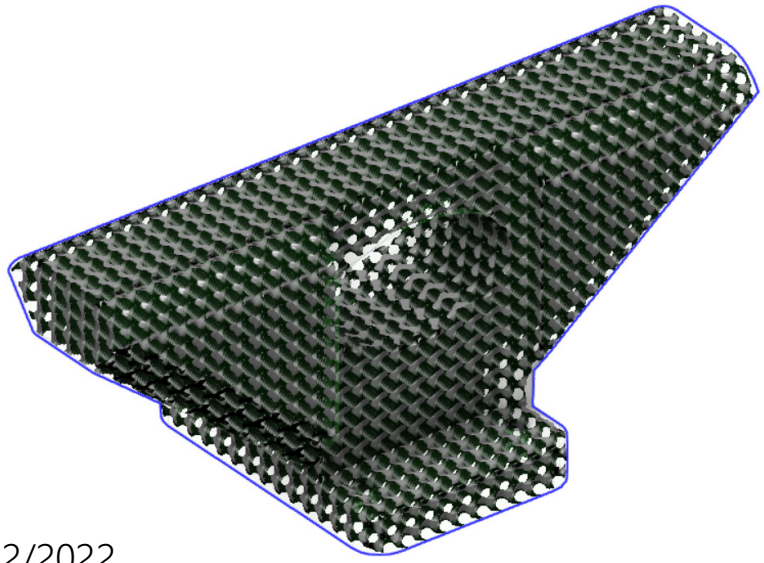


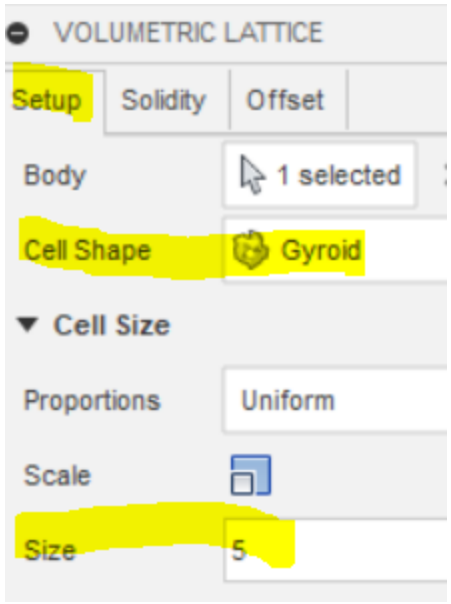


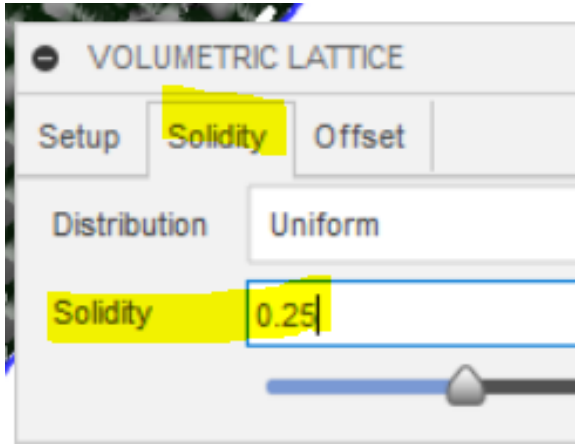
Volumetric Lattice

5. Workflow of Fusion 360 – Volumetric Lattice

- Select “Setup”
  - Change “Cell Shape” to “Gyroid”
  - Change “Size” to 5mm
- Select “Solidify”
  - Change “Solidify” to 0.25



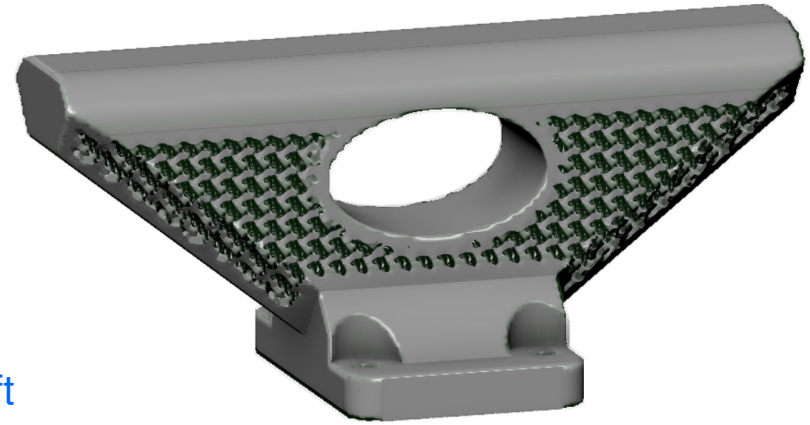


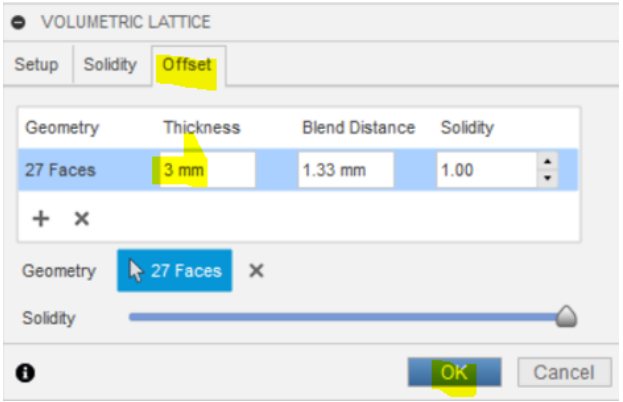


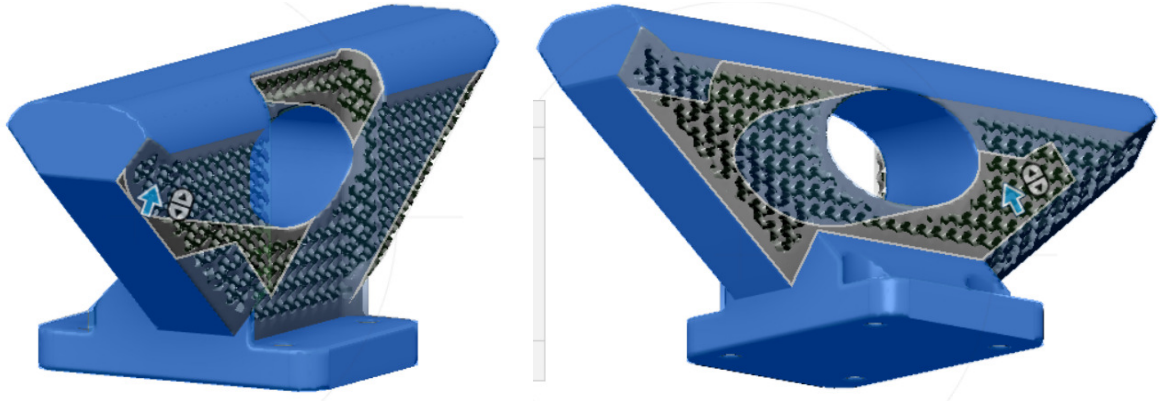
Volumetric Lattice

5. Workflow of Fusion 360 – Volumetric Lattice

- To specify the surfaces that does not need to apply lattice (say, for joining or supporting purpose):
- Select “Offset”
  - Pick all the surface that need to be kept
  - Tips:
    - Pan: Hold Middle Mouse Button
    - Rotate: SHIFT + Hold Middle Mouse Button
    - Zoom In / Out: Scroll Middle Mouse Button
    - Select by “Crossing Window”: Drag from right to left
  - Change “Thickness” to 3mm



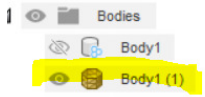


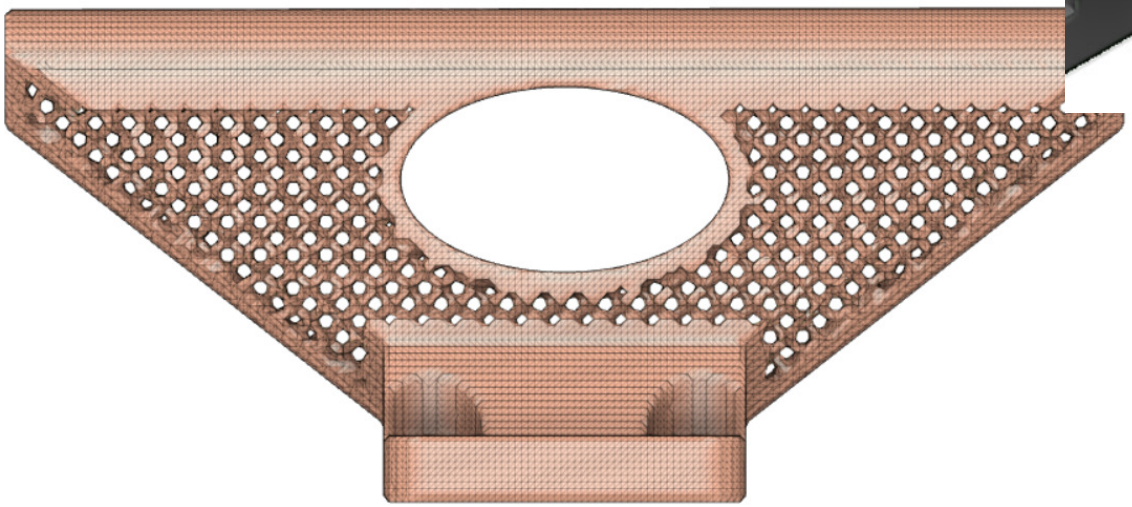


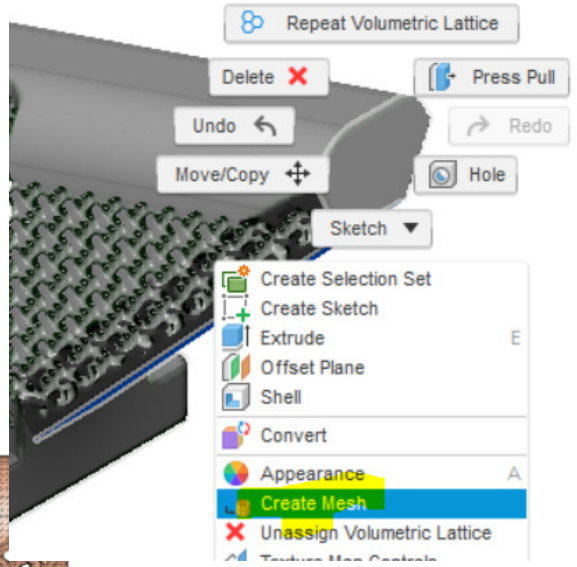
Volumetric Lattice

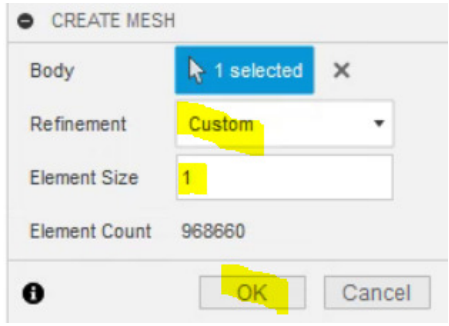
5. Workflow of Fusion 360 – Volumetric Lattice

- To create the mesh model of body with volumetric lattice:
  - Right click “Body1”
    - Select “Create Mesh”
    - Change “Refinement” to “Custom”
    - Change “Element Size” to 1
    - Click “OK”





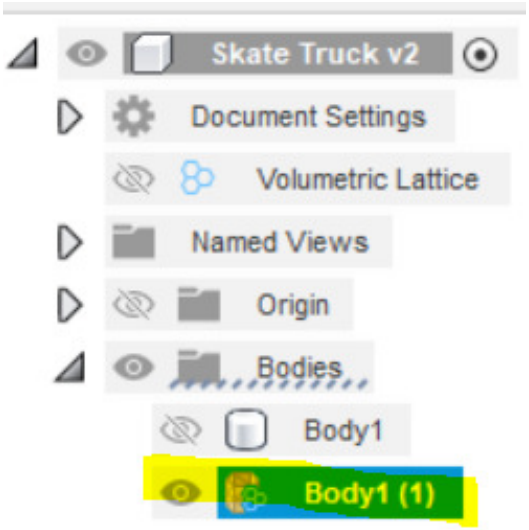


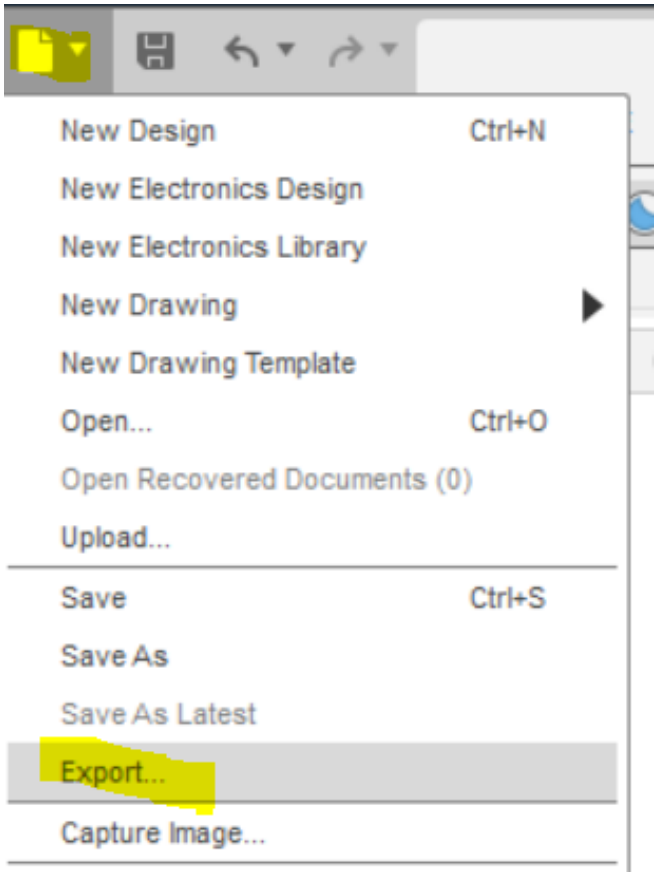


Volumetric Lattice

5. Workflow of Fusion 360 – Volumetric Lattice

- To generate the STL file of body with volumetric lattice:
  - While the mesh model “Body1(1)” is selected
  - Select “Export…” under File icon

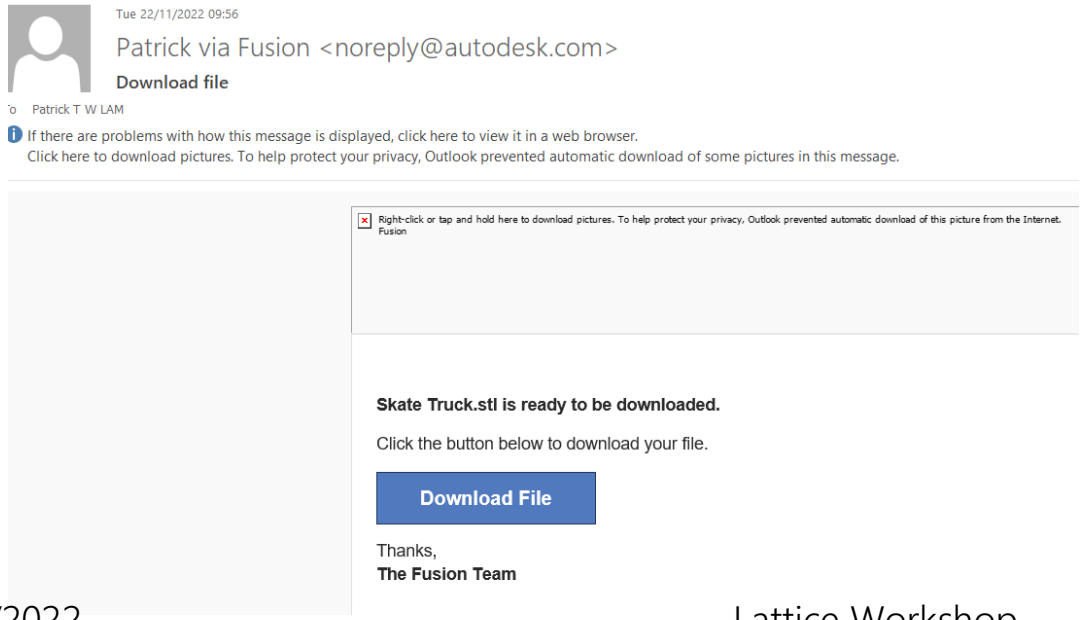


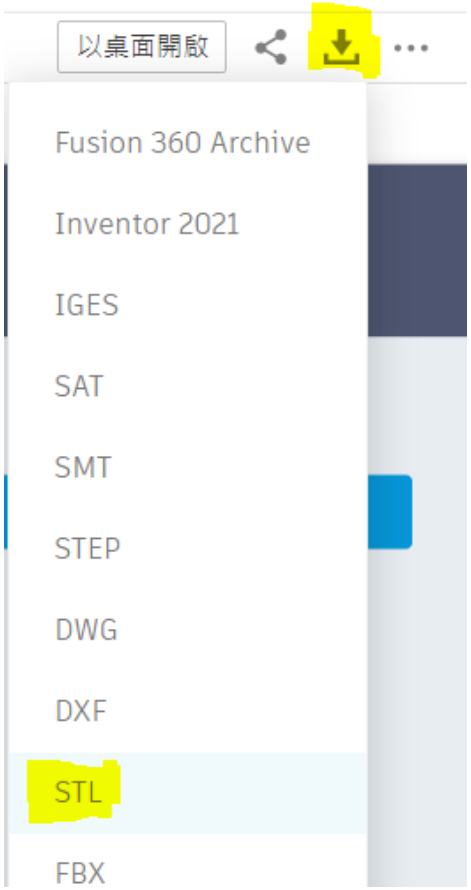


Volumetric Lattice

5. Workflow of Fusion 360 – Volumetric Lattice

- To generate the STL file of body with volumetric lattice:
  - Select “Download Icon” at top right hand corner
  - Select “STL” at the drop down list
    - File generation will be done at background.
  - You will be informed by email once the STL file is ready for download.






THANK
YOU!