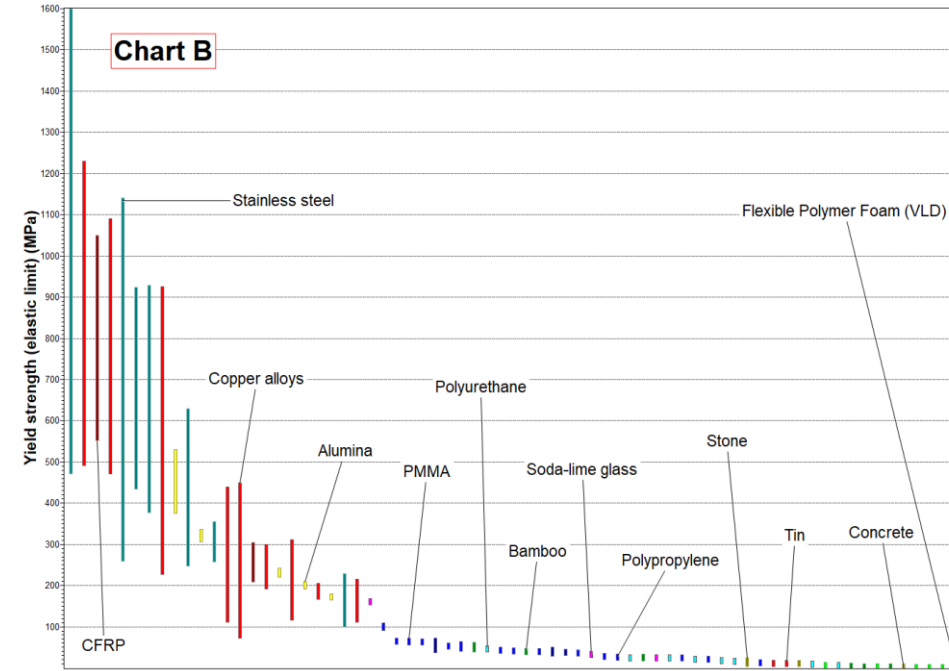
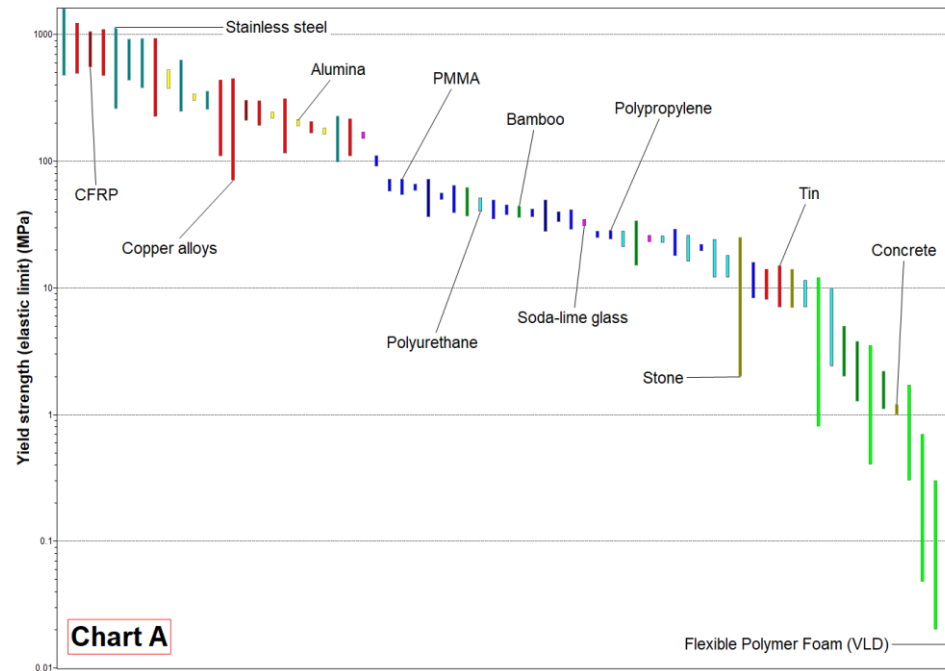




Materials Selection with Ashby Charts Homework Assignment Solutions

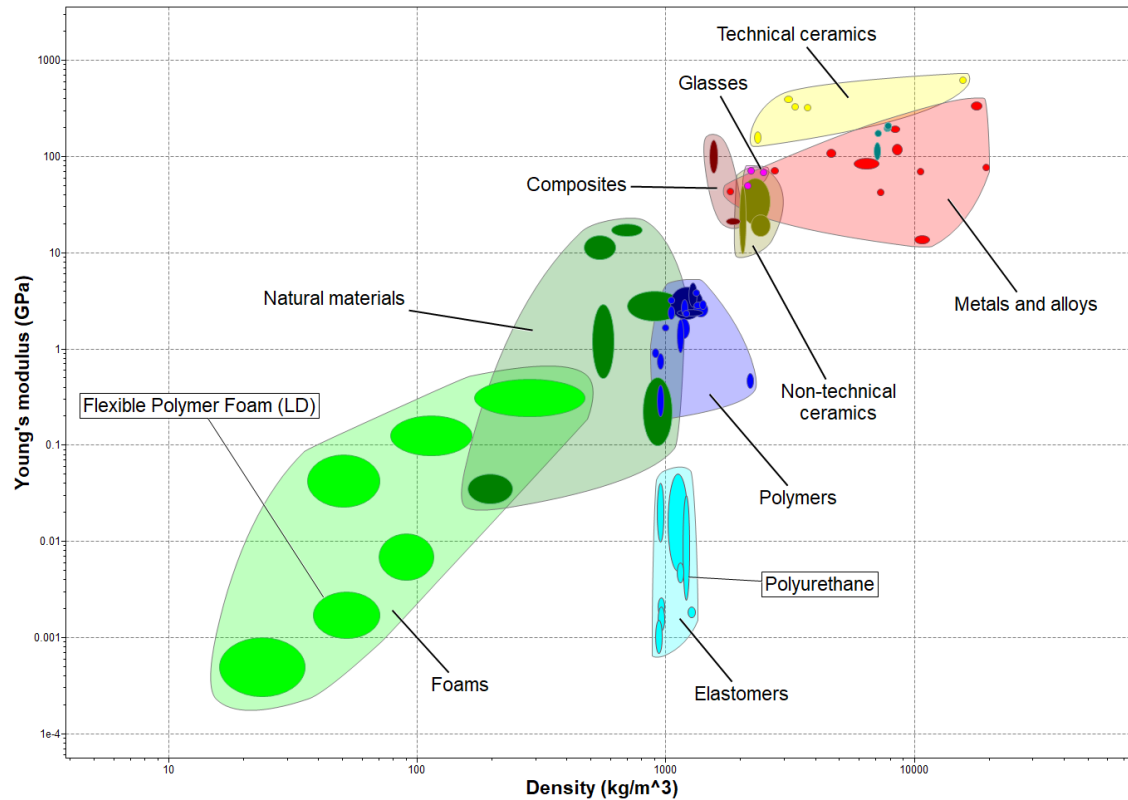
Kaitlin Tyler and Claes Fredriksson

1. Take a look at the two property bar charts below. What is the difference between them? Is one easier to read? Why or why not?



Answer: Chart A uses Logarithmic scale for the Y-axis, while Chart B uses a linear scale. Chart A is significantly easier to read because of this, particularly for lower values of Yield Strength, such as for polymers and foams

2. Why are ceramics and metals in the upper right quadrant of this chart?

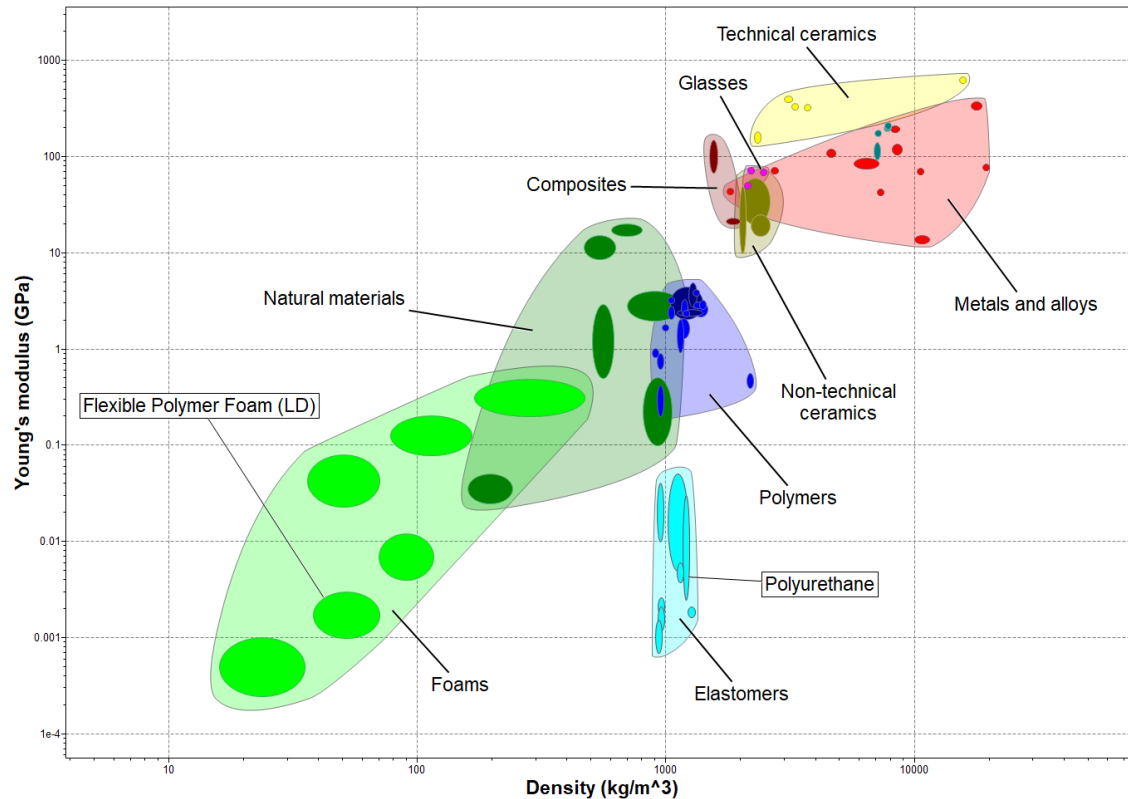


Answer:

Metals and ceramics have high density due to two factors: the atoms that make up the material generally have higher atomic mass and the arrangement of the atoms is highly ordered (or crystalline), which packs more closely.

The bonds found in metallic and ceramic materials (metallic and covalent bonds) are very strong, which leads to a high Young's Modulus

3. Two materials are highlighted on this chart- a Flexible Polymer Foam and Polyurethane. Why is the flexible polymer foam less dense than the bulk matrix material, polyurethane?



Answer:

Foams are a hybrid material, meaning they are made of two or more components. Generally, the second component in foams is air. Air is significantly less dense than solid material, so the hybrid air/polyurethane foam is lighter than solid polyurethane.

4. In the course, we discussed ranking materials for selection based on the design needs of the product.

For bar charts, we are focusing on maximizing or minimizing our single material property. For bubble charts, we are focusing on different quadrants of the chart.

For the set of products listed below, identify the area within each provided chart where we should focus our selection efforts. Do the areas of focus change across the set of products? Why or why not?

Three charts were provided, with a total of five material properties to focus on:

1. Young's Modulus (Stiffness)
2. Yield Strength (Strength)
3. Fracture Toughness (Resistance to breaking)
4. Density (Weight)
5. Price

Looking at the list of properties we have data for in our property charts, we can determine if we want a high value, a low value, a moderate value, or if we have no preference.

(a) Bicycles: a child's bike vs. a competitive racing bike

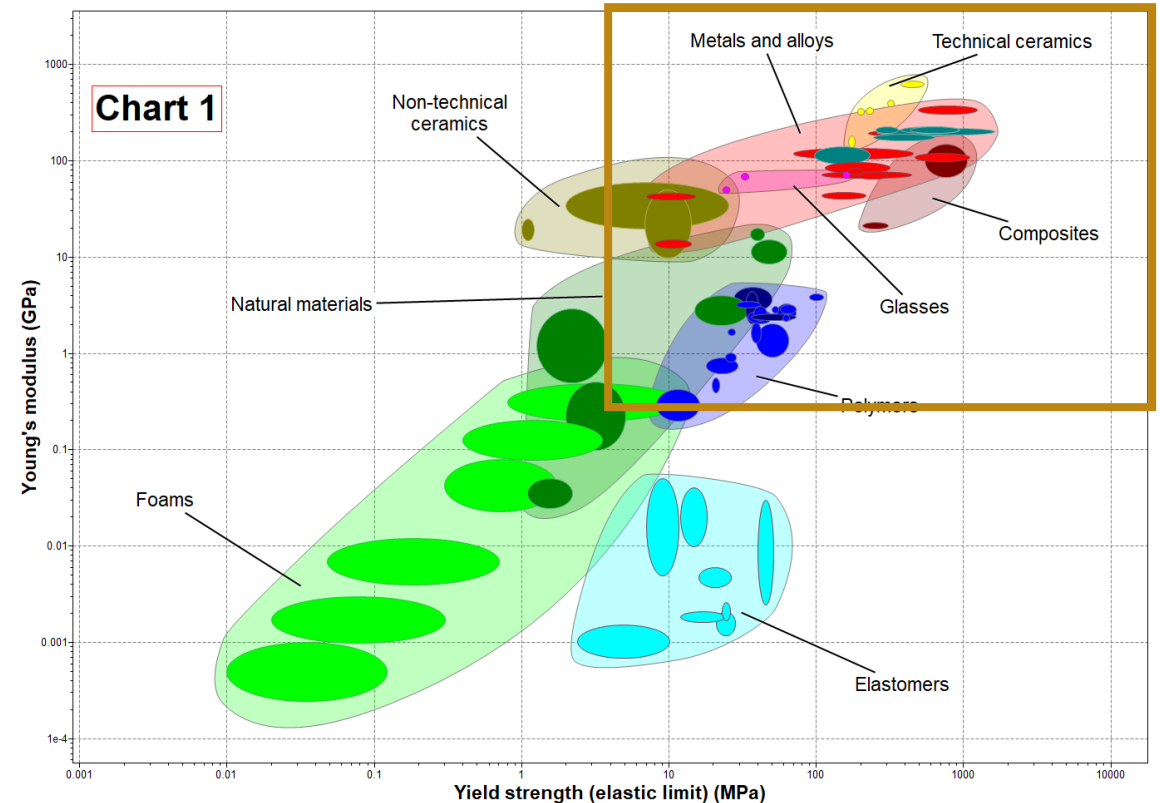
Below are the values for each property for both a child's bike and a racing bike. Then we can identify the portions of the relevant charts where these values might lie.

Property	Child's Bike	Racing Bike
Young's Modulus (Stiffness)	High	High
Yield Strength (Strength)	High	High
Fracture Toughness (Resistance to breaking)	High	High
Density (Weight)	--	Low
Price	Low	--

(a) Bicycles: a child's bike vs. a competitive racing bike

Property	Child's Bike	Racing Bike
Young's Modulus (Stiffness)	High	High
Yield Strength (Strength)	High	High
Fracture Toughness (Resistance to breaking)	High	High
Density (Weight)	--	Low
Price	Low	--

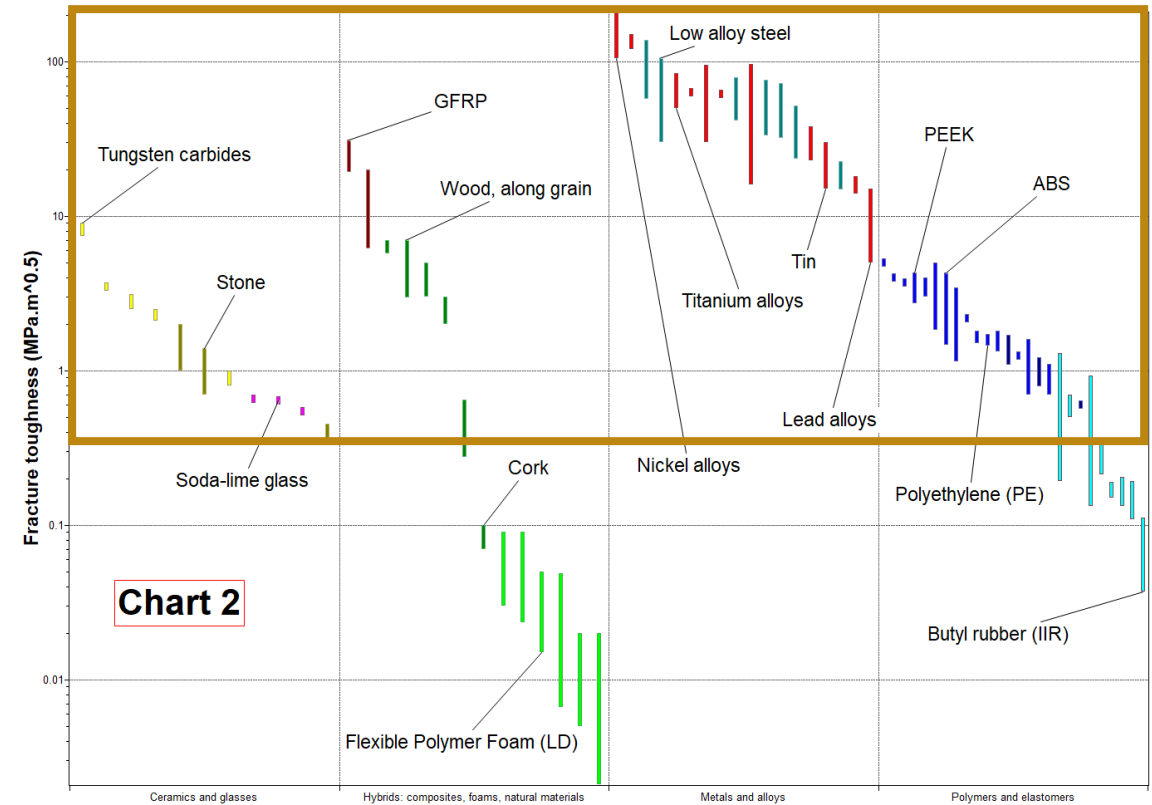
Both bikes need high stiffness and strength to avoid bending in the frame and to be able to support the rider. That means both bikes need materials in the upper righthand quadrant, where metals, ceramics, and composites are found.



(a) Bicycles: a child's bike vs. a competitive racing bike

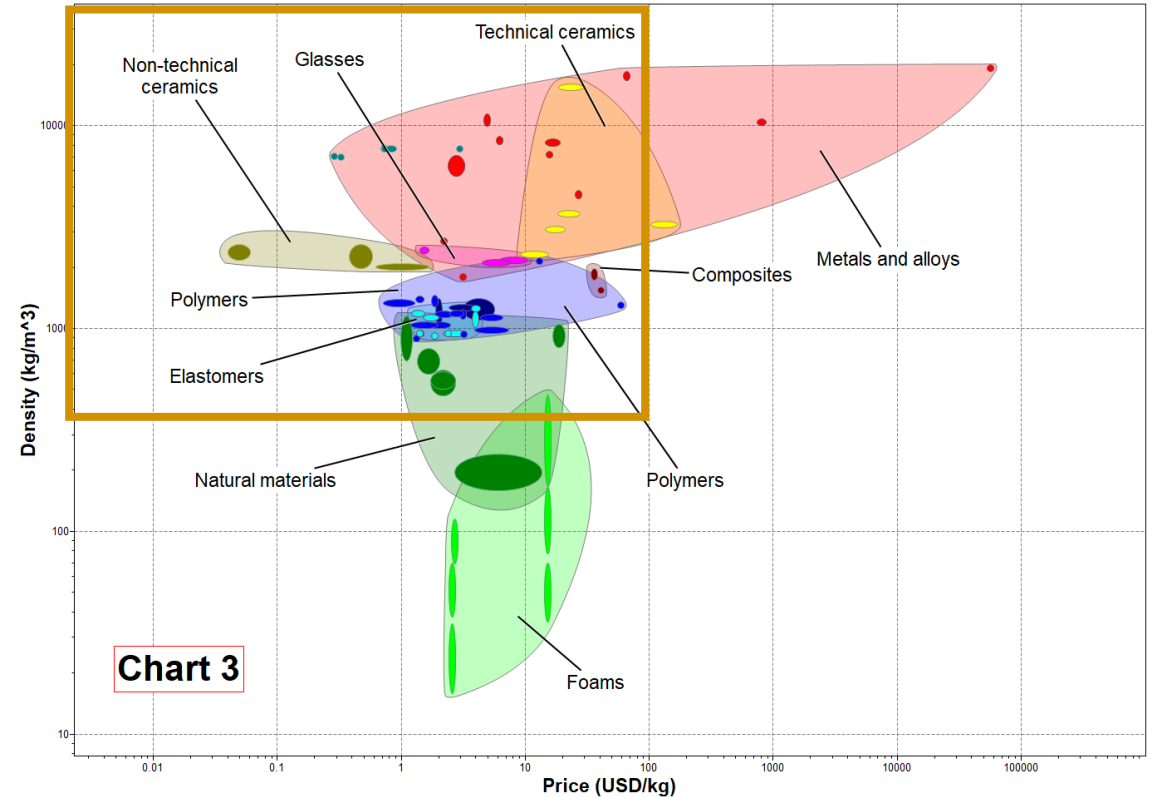
Property	Child's Bike	Racing Bike
Young's Modulus (Stiffness)	High	High
Yield Strength (Strength)	High	High
Fracture Toughness (Resistance to breaking)	High	High
Density (Weight)	--	Low
Price	Low	--

Both bikes need a high fracture toughness to avoid breaking during use. Once again, ceramics, metals, and composites fall into the category with high fracture toughness.



(a) Bicycles: a child's bike vs. a competitive racing bike

Property	Child's Bike	Racing Bike
Young's Modulus (Stiffness)	High	High
Yield Strength (Strength)	High	High
Fracture Toughness (Resistance to breaking)	High	High
Density (Weight)	--	Low
Price	Low	--



A child's bike should be cheap, but the weight is less of a concern. Whereas for a racing bike, price is no object but it needs to be lightweight for speed.

Considering our material choices from before, we can focus on the upper lefthand quadrant. Steel, commonly used in children's bikes, is the cheapest metal whereas carbon fiber composites, commonly used in racing bikes, is the least dense material. So while the same quadrant is used, the end material choice is different. This makes sense because, at the end of the day, both are still bikes and have the same general use.

(b) Plates: Disposable plates vs. fine china plates

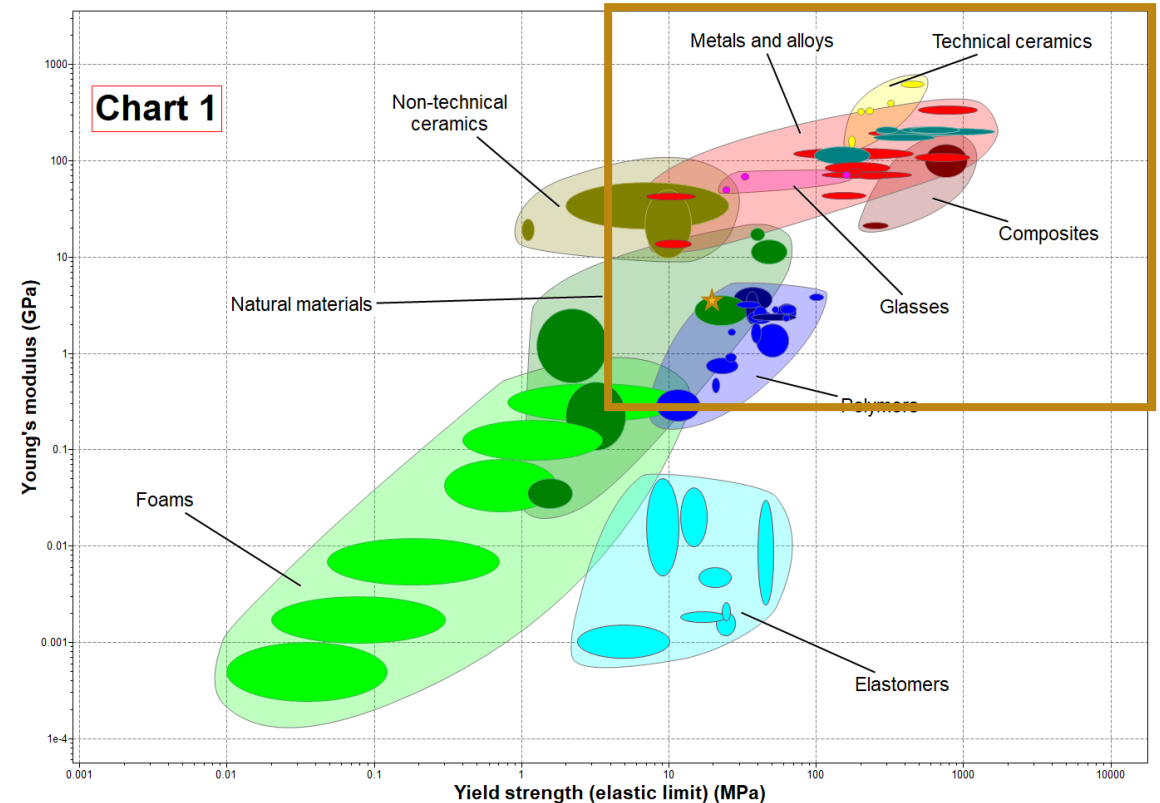
Below are the values for each property for our different plates. Then we can identify the portions of the relevant charts where these values might lie.

Property	Disposable Plates	Fine China Plates
Young's Modulus (Stiffness)	Moderate	High
Yield Strength (Strength)	Moderate	High
Fracture Toughness (Resistance to breaking)	Low/Moderate	Low/Moderate
Density (Weight)	Low	--
Price	Low	--

(b) Plates: Disposable plates vs. fine china plates

Property	Disposable Plates	Fine China Plates
Young's Modulus (Stiffness)	Moderate	High
Yield Strength (Strength)	Moderate	High
Fracture Toughness (Resistance to breaking)	Low/ Moderate	Low/ Moderate
Density (Weight)	Low	--
Price	Low	--

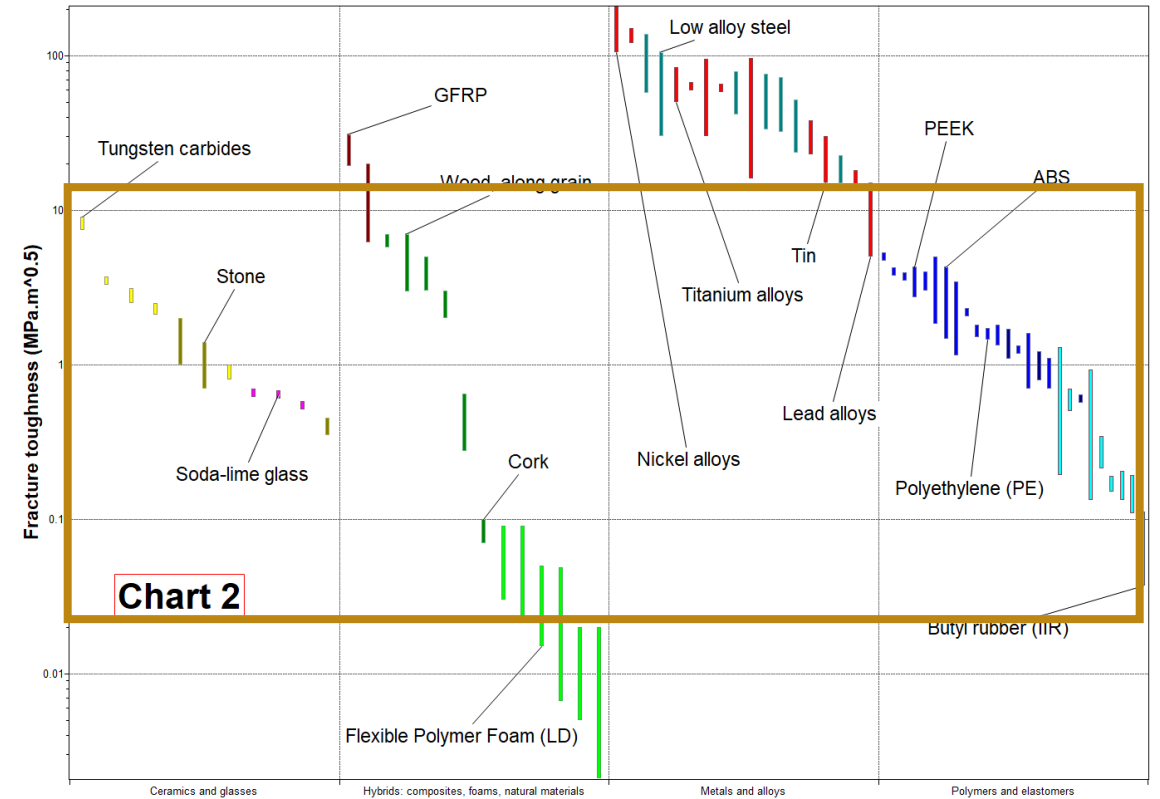
Fine china plates need to be stiff and strong, so focused on is on the upper righthand quadrant. Most disposable plates are made of paper, which is noted by the starred bubble. This also fits in the upper righthand quadrant, which makes sense. We still want some amount of stiffness and strength.



(b) Plates: Disposable plates vs. fine china plates

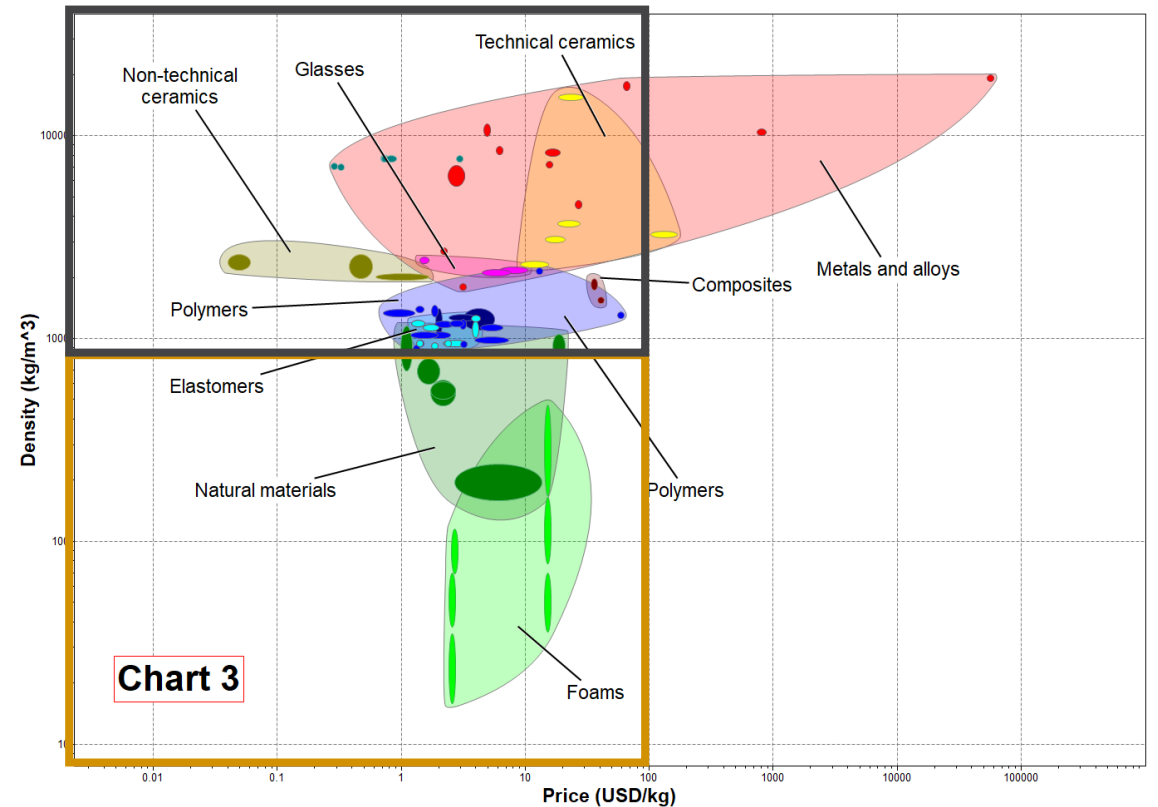
Property	Disposable Plates	Fine China Plates
Young's Modulus (Stiffness)	Moderate	High
Yield Strength (Strength)	Moderate	High
Fracture Toughness (Resistance to breaking)	Low/ Moderate	Low/ Moderate
Density (Weight)	Low	--
Price	Low	--

While we do not want our plates to break during use, they do not need to have exceptionally high fracture toughness. Therefore, we can focus in the middle of our chart



(b) Plates: Disposable plates vs. fine china plates

Property	Disposable Plates	Fine China Plates
Young's Modulus (Stiffness)	Moderate	High
Yield Strength (Strength)	Moderate	High
Fracture Toughness (Resistance to breaking)	Low/ Moderate	Low/ Moderate
Density (Weight)	Low	--
Price	Low	--



Disposable plates need to be lightweight and cheap, so they can be carried to picnics and camping. Whereas fine china is usually purchased once and used for a lifetime (or more!) and the weight is less of a factor, though one still needs to be able to pick up the plate.

For this case, we must focus our attention in two different quadrants. Disposable plates are in the lower lefthand corner, while fine china is in the upper lefthand corner.

© 2022 ANSYS, Inc. All rights reserved.

Use and Reproduction

The content used in this resource may only be used or reproduced for teaching purposes; and any commercial use is strictly prohibited.

Document Information

This solution set is to accompany the Ansys Innovation Course titled “Materials Selection using Ashby Charts”.

If any errors are found, please contact the Ansys Academic Development Team at education@ansys.com.