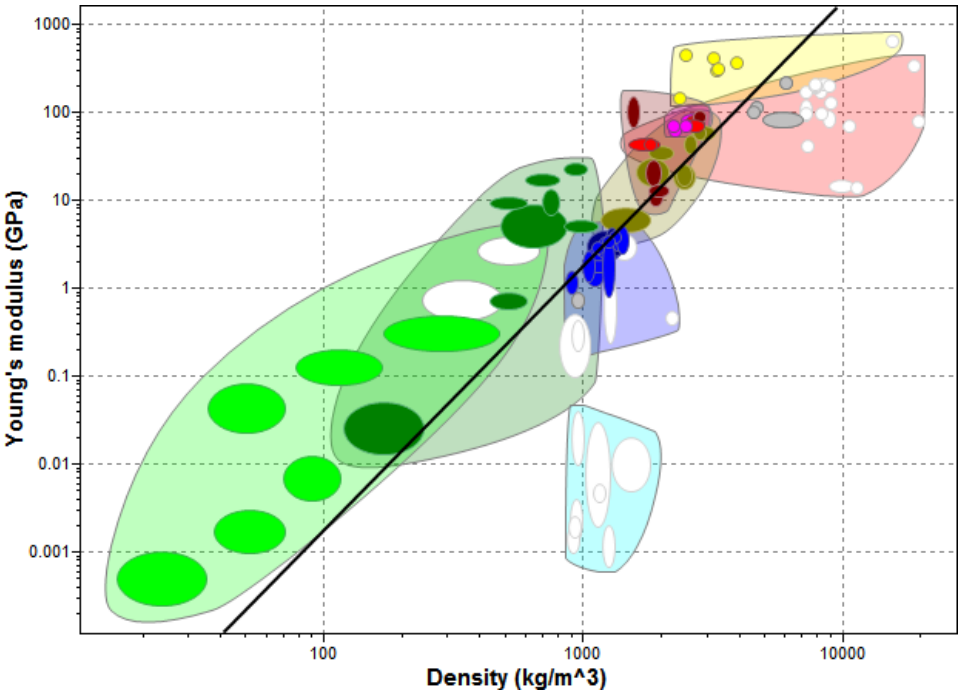
CES EduPack 2016

User Manual & Getting Started Guide

January 2016



GRANTA
MATERIAL INSPIRATION

Table of Contents

1 Introduction

CES EduPack supports and enhances the teaching and learning of materials, engineering, design and sustainability. It provides a comprehensive database of materials and process information, powerful materials software tools, and a range of supporting textbooks, lectures, projects, and exercises.

CES EduPack is a curriculum-wide resource with specialist Editions for specific disciplines, and three levels of the database and software to suit varying needs in all years of undergraduate study and postgraduate teaching. It is continually developed based on feedback from the global user community.

The CES EduPack software provides engaging ways for students to explore and understand the world of materials.

- **Become familiar with materials space**—with powerful tools to browse and search the information in CES EduPack databases.
- **Visualize properties**—charting tools help to develop understanding of how material families behave.
- **Match materials to applications**—for example, by applying a structured approach to materials selection; helps students to relate their learning to the world around them.
- **Dig into the underlying science**—encourage students to get to grips with the scientific principles through textbook-style 'science note' information and textbook links.
- **Evaluate environmental impact with the Eco Audit Tool**—explore key eco design concepts; try ‘what if' scenarios.
- **Additional tools** are also available, such as the innovative Synthesizer Tool which allows investigation into the benefits of using hybrid materials.

1.1 Where to find help

You will be surprised at all the additional help and resources that can be accessed from CES EduPack.

Getting Started

The Installation Guide is the starting point for anyone that has not yet installed CES EduPack.

If you have any questions or issues at this stage, you can refer to our Student FAQs.

Or the Educator FAQs.

Learning How CES EduPack Works

The **User Manual and Getting Started Guide**, as well as the Video Tutorials, are the best way to learn about the core functionality of the software.

The **In-Software Help** is accessed from the **Help** menu, or by pressing the **F1** key. As well as explaining the core functionality, it also includes useful references like the Tables of Materials Indices and glossaries of materials terms.

Further Learning

The Case Studies were created by Professor Mike Ashby and follow the material selection methodology outlined in his book, *Materials Selection in Mechanical Design*. They can be completed using CES EduPack.

You can find interactive case studies to practice your skills, ready-made Eco Audit project files, and fun databases on Granta's Teaching Resources Website.

The **Student Resources** page in the software help provides a helpful table of resources so you can find information easily.

The online books CES InDepth and CES Concepts explain the concepts of selection methodology and the CES EduPack databases.

2 Installation

This part of the User Manual provides instructions for registering and installing your copy of the CES EduPack system.

2.1 System Requirements

To install CES EduPack 2016 you will need:

- A compatible Microsoft® Windows® operating system;
  - Windows Vista 32-bit or 64-bit SP2,
  - Windows 7 32-bit or 64-bit,
  - Windows 8 32-bit or 64-bit,
  - Windows 10 32-bit or 64-bit.
- 4 GB of RAM.
- 4 GB of available hard disk space.
- Microsoft .NET Framework Client version 4.0 and ReportViewer 2010 SP1. For the French language installation you will also require the French language packs for both of these. If these are not already installed on your PC, you will be given the option to add them automatically to the CES EduPack installation process.
- Administrator rights.
- Internet access, if you wish to use the web-based search, the online resources, or connect to datasheets from external databases, where applicable.

2.2 License options

Students

If you are a student installing this on your own computer, then you should have been given a license key and access to the files to install CES EduPack 2016. Please ask your instructor for a license key if you do not have one.

For the Student FAQ page, please go to:
www.grantadesign.com/education/support/FAQs/students.htm

Educators

Enrollment licenses are licenses for a group of students for a limited period of time. You and your students will need the license key on the Software License Agreement to install CES EduPack 2016.

Lab licenses are perpetual licenses for a fixed number of computers. You or your IT department will need the license key on the Software License Agreement to install CES EduPack 2016.

For the Educators FAQ page, please go to:
www.grantadesign.com/education/support/FAQs/educators.htm

Network Administrators

Please follow this link for information on installing the software over a network:
www.grantadesign.com/education/network.

For the Network Administration FAQ page please go to:
www.grantadesign.com/education/support/FAQs/network.htm.

2.3 Running the CES EduPack 2016 setup wizard

If you have installed a previous version or evaluation copy of CES EduPack, we recommend that you uninstall it before installing this version. To do so, use **Programs and Features** in Windows Control Panel to uninstall the software.

To install CES EduPack 2016, copy the files onto your computer. Run ***setup.exe*** and follow the instructions in the setup wizard. You can click Cancel to quit the installation at any point.

You can find a video of the installation process at:
www.grantadesign.com/education/resources/videotutorials/2016/index.htm.

3 Databases

Different databases are available depending on your installation.

The databases are split into *Introductory* – Level 1 and 2 databases – and *Advanced* – Level 3 databases – with different editions to cover specific areas of study e.g. Aerospace and Sustainability.

There are video Database Tours, to give you more information on the different levels and databases: www.grantadesign.com/education/resources/videotutorials/2016/index.htm.

3.1 Databases for Rational Materials Selection

The MaterialUniverse and ProcessUniverse data tables are used with CES EduPack to create high quality databases that you won't find elsewhere. They are designed for like-to-like comparisons across the whole spectrum of material and processing possibilities. Typical material databases do not allow this - the most common reasons being: 'holes in the data'; and different properties reported for different materials. This makes it difficult to compare different classes of materials.

Universe data tables solve the problem by conforming to strict database design principles. These principles are reviewed below, with reference to the MaterialUniverse data table.

Complete spectrum represented

The MaterialUniverse data table contains a representation of virtually every commercial engineering material in every class. This means that you can be sure that you have considered all material possibilities for any particular application.

Each material represented only once

Multiple instances of the same material from different producers are consolidated into one representative record. This reduces the complexity of the engineer's search for the best material.

Property ranges

Properties of real materials are seldom exact - there are inevitable variations from batch to batch and manufacturer to manufacturer. These variations are captured in a Universe data table by a range. The range may be small for a property such as density, but relatively large for price or toughness.

Complete property set

In a Universe data table, there is a value for every property on the datasheet. If a value is not known experimentally, it has been estimated using intelligent estimating techniques. These estimates are based on well-established correlations between material properties, using fundamental physics.

Quality checks

Granta has examined hundreds of material datasets over the years from various sources and, without exception, they contain errors - sometimes by as much as 1000%! To minimize errors in the Universe data tables, strict data checking procedures are used. These include checks that properties for specific material classes fall within acceptable ranges, and powerful science-based checks on the correlations between properties.

Normalization

All properties are presented in the same unit system, which can be chosen by the user. Properties that are reported in different ways for different materials classes are equivalenced to enable comparison.

Hierarchy

The carefully-constructed record hierarchy allows simple and rapid navigation to all records in the data table.

References

The reference source is given at the bottom of the datasheet, to encourage students to question and research where the data comes from.

The Result

Applying these principles required a great amount of work in data collection and processing. The MaterialUniverse data table represents over 50 man-years of effort spread over a 20 year period. The rewards of this effort are immediate and numerous with the MaterialUniverse and ProcessUniverse databases used in combination with the CES EduPack software.

4 Getting Started with CES EduPack

The exercises in this section give an overview of CES EduPack and will teach you how to use the core functionality. There is a comprehensive help file within the software that provides further guidance, as well as containing case studies and tutorials.

4.1 Main tools in CES EduPack

The main tools in CES EduPack are:

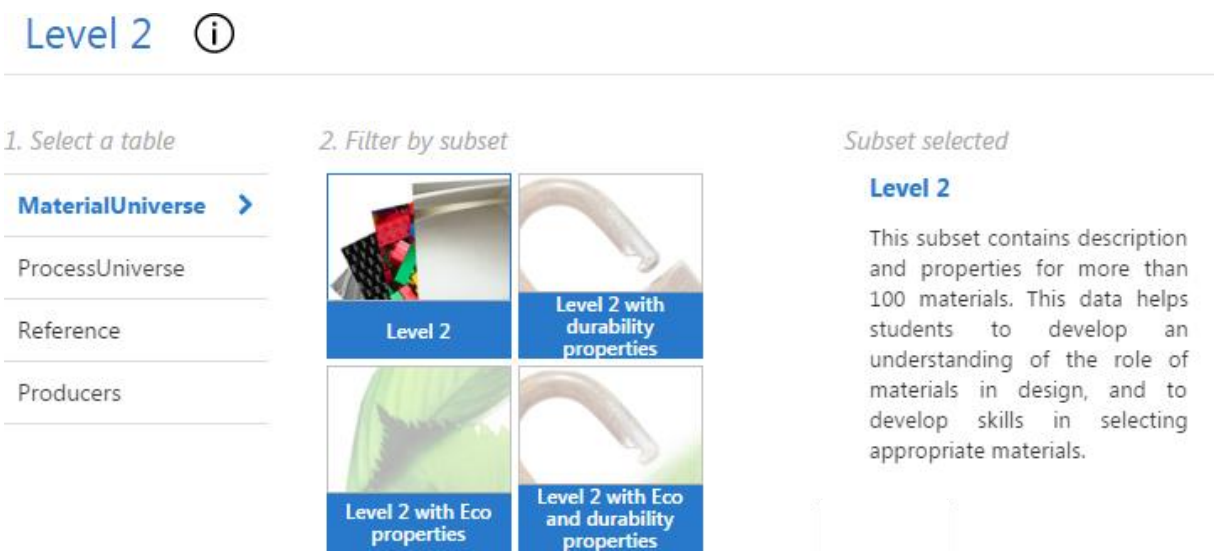
BROWSE	Explore the database and retrieve records via a hierarchical index or tree.
SEARCH	Find information via a full-text search of records.
SELECT	The central hub of CES EduPack, used to apply the Rational Material Selection methodology. A powerful selection engine that identifies records that meet an array of design criteria and enables trade-offs between competing objectives.
CHART	Create charts and add formatting and labels to illustrate your point.
ECO AUDIT	Quickly estimate the environmental impact of a product over its entire lifecycle and study *What If* design scenarios. The enhanced version also accounts for Secondary, Joining, and Finishing processes, and allows you to apply the same *What If* scenarios to the economic cost.
SYNTHESIZER TOOL	Predict performance of materials by modelling new hybrid materials, or modelling part cost of a design; compare these results with existing records.

The following exercises cover the use and functionality of these tools.

4.2 Browsing and Searching

Exercise 1 — Opening a Database

On starting CES EduPack, the **Databases** window will appear, showing all installed databases. The following exercises use the MaterialUniverse and ProcessUniverse tables which are found within all Granta material databases. After clicking on a database name in the **Databases** window to select it, the Homepage then opens to show a list of the available tables and a graphic for each subset.



Click a subset name to show its description. Use the information icon next to the database name to view a detailed description. There are also links to online resources, for both students and educators, from the home page.

❖ Select Edu Level 2 database

> **Note:** Unless otherwise stated, all exercises and screenshots in this guide were produced using Edu Level 2 database. Results and images may differ if you complete these exercises using a different database.

❖ Select different subsets and read about the available data and applications

Click a subset in the Homepage to select it. The information displayed is for the currently-selected subset.

❖ Change to the PROCESSUNIVERSE table

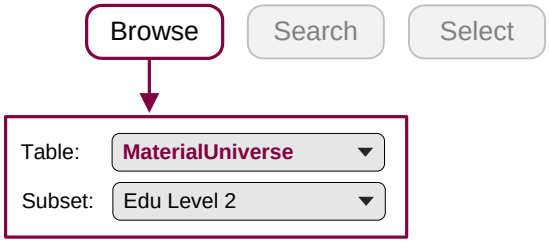
Click **ProcessUniverse** and notice that the Browse tree in the left panel updates.

❖ Close the HOME PAGE

Click the cross at the top of the Home page tab. This page can be reopened at any time by clicking **Home** on the main toolbar.

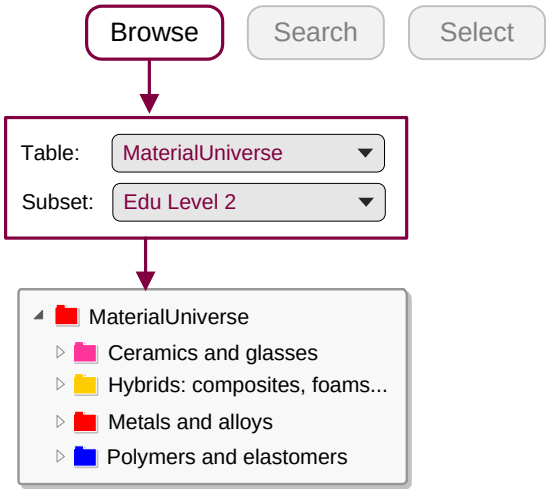
❖ Change to the MATERIALUNIVERSE table

With the Homepage closed, navigate to different tables using the Table list in the Browse window.



Exercise 2 — Browse Material Records

❖ Select the Table ***MaterialUniverse*** and the Subset ***Edu Level 2***.



❖ Find the record for STAINLESS STEEL

Double-click on a folder in the browse tree to view the records and folders below it. Find the record for CONCRETE

❖ Open the GENERIC record for POLYPROPYLENE (Level 3 Databases only)

Generic records are records at the folder level. They provide general information on the material, rather than data on a specific variant. They have their own icon: .

❖ Open a POLYPROPYLENE record

Double-click the record name in the tree to view the datasheet.

Click hyperlinked attribute names. In Level 1 and Level 2 databases, this will bring up a Science Note, giving details of the underlying science and calculations for the attribute. In Level 3 databases, this will bring up the design note, which provides background information on properties, test notes, and selection guidelines. From a design note, there will also be a link to the corresponding Science Note.

Right-click the datasheet to see a context menu with further actions, for example, locate in Browse tree, copy the datasheet, print the datasheet, and export the data to an FE package format.

- ❖ Find PROCESSES that can shape POLYPROPYLENE using the ProcessUniverse Link at the bottom of the datasheet.

Part of the Polypropylene Level 2 datasheet:

Polymers and elastomers > Polymers > Thermoplastics >

Description

Image

Caption

1. Polypropylene samples showing texture and transparency. © Chris Lefteri 2. Polypropylene glasses. © Thinkstock

The material

Polypropylene, PP, first produced commercially in 1958, is the younger brother of polyethylene - a very similar molecule with similar price, processing methods and application. Like PE it is produced in very large quantities (more than 30 million tons per year in 2000), growing at nearly 10% per year, and like PE its molecule-lengths and side-branches can be tailored by clever catalysis, giving precise control of impact strength, and of the properties that influence molding and drawing. In its pure form polypropylene is flammable and degrades in sunlight. Fire retardants make it slow to burn and stabilizers give it extreme stability, both to UV radiation and to fresh and salt water and most aqueous solutions.

Composition (summary) ⓘ

(CH2-CH(CH3))n

General properties

Density	ⓘ	890	-	910	kg/m^3
Price	ⓘ	* 1.96	-	2.24	USD/kg
Date first used	ⓘ	1957			

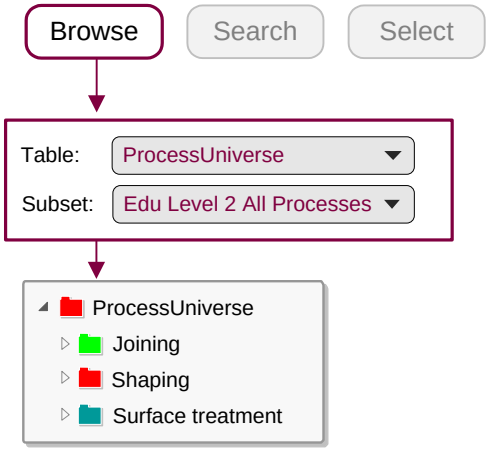
Mechanical properties

Young's modulus	ⓘ	0.896	-	1.55	GPa
Shear modulus	ⓘ	0.316	-	0.548	GPa
Bulk modulus	ⓘ	2.5	-	2.6	GPa
Poisson's ratio	ⓘ	0.405	-	0.427	
Yield strength (elastic limit)	ⓘ	20.7	-	37.2	MPa
Tensile strength	ⓘ	27.6	-	41.4	MPa
Compressive strength	ⓘ	25.1	-	55.2	MPa

For more information on the property and to drill down to the underlying science, click ⓘ to view the science note.

Exercise 3 — Browse Process Records

- Browse ProcessUniverse: Edu Level 2 All Processes



- Find the record for INJECTION MOLDING, THERMOPLASTICS

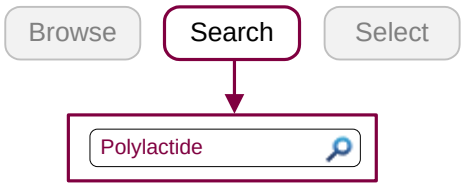
- Find the record for VAPOR METALLIZING (PVD)

- Find the record for FRICTION WELDING (METALS)

- Find materials that can be DIE CAST, using the link to the MaterialUniverse at the bottom of the datasheet for DIE CASTING

Exercise 4 — Searching

❖ Find the material POLYLACTIDE



❖ Find the materials used as CUTTING TOOLS

❖ Find the process VACUUM ASSISTED RTM

The folder name is also included in the search. If the term appears in a folder name, all records under that folder will be returned; for example, a search for **ceramics** would return all records in the folder named **Ceramics and glasses**.

❖ Enter the search term ALUM*

Records containing the term **Alumina** or **Aluminum** or **Alumino** are returned.

Advanced searches

The following search operators are available:

AND	Finds records containing both the search terms, so **steel AND alloy** returns only records containing both the words **steel** and **alloy**
OR	Finds records containing either search term, so **steel OR alloy** returns all records that contain **steel**, **alloy**, or **both**
NOT	Finds records containing the first search term, but not the second, so **steel NOT alloy** returns only records with the word **steel** but without the word **alloy**
Phrase Search	Finds the exact search term, so **"steel alloy"** will return only records containing the exact phrase **steel alloy**
Parentheses	Used to group search terms, so **iron AND (ore OR cast)** will return the records containing **iron** and containing either **ore**, **cast**, or **both**
Wildcards	Use **?** as a wildcard single character, or ***** as a wildcard representing any number of characters (cannot be used as the first character in a search string)

Note: AND operators are automatically added when a search has two or more terms and no other operators have been entered.

Exercise 5 — Find Supporting Information

You will need an internet connection for this exercise.

CES EduPack translates the material ID to search strings compatible with a group of high-quality material and process information sources, and delivers the search results. Many of the sources require a subscriber-based password. The ASM source is particularly recommended.

❖ Search the web to find more information on PET

With the PET datasheet open, click **Tools > Search Web**.

4.3 Creating property charts

Bar charts and bubble charts are a great way to visualize and communicate material properties, as well as being a key tool to support systematic materials selection.

Exercise 6 — Create a bar chart

❖ Select MATERIALUNIVERSE: EDU LEVEL 2

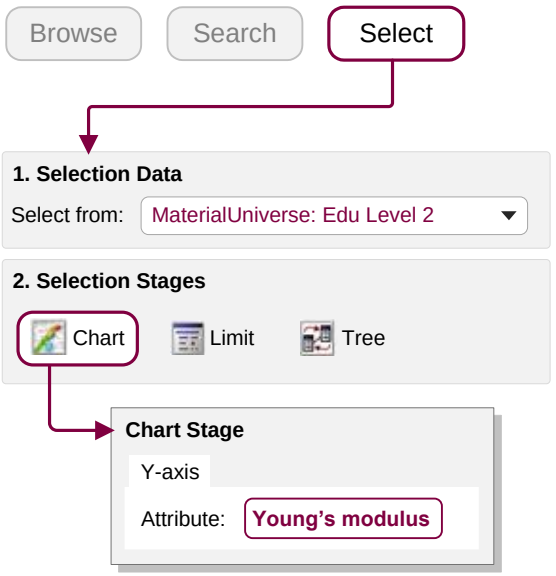
Click **Chart/Select**, and then select **MaterialUniverse: Edu Level 2 subset**.

❖ Make a bar chart of YOUNG'S MODULUS (E)

Under Selection Stages, click **Chart**.

Set the y-axis attribute to **Young's modulus**, then click **OK**.

For a bar chart, you do not set an x-axis: leave x-axis set to <None>.



❖ Explore the chart

Click **Zoom in** and then drag to zoom in on an area of the chart.

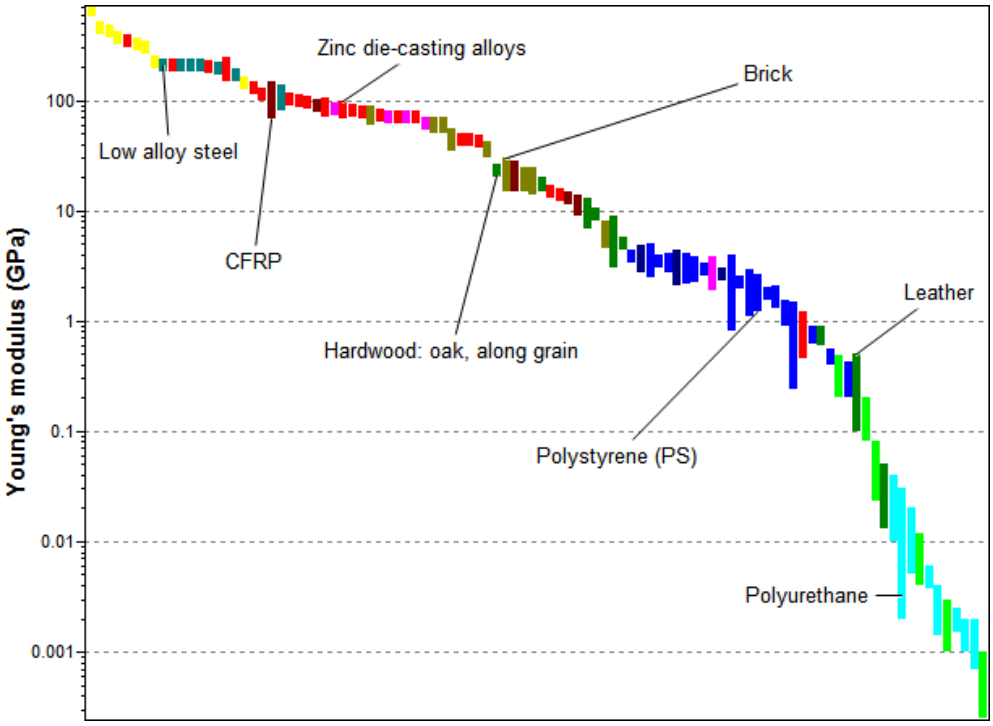
Click **Zoom out** to zoom out.

Click **Autoscale** to zoom back to view the whole chart again.

❖ Label records on the chart

Click a record in the chart and then drag to add and position a new data label.

To delete a data label, select it and press DELETE. To delete all labels in the chart, press CTRL+A and then press DELETE.



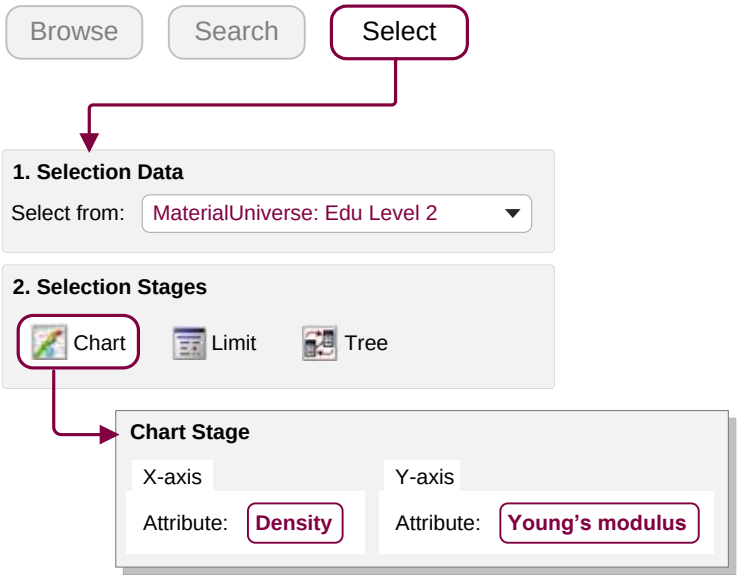
Exercise 7 — Create a bubble chart

❖ Make a bubble chart plotting YOUNG'S MODULUS (E) against DENSITY (ρ)

Under Selection Stages, click **Chart**.

Set the y-axis to **Young's modulus** and set the x-axis to **Density**.

Leave the Axis Settings as default values to create a log-log plot.



❖ Display family envelopes

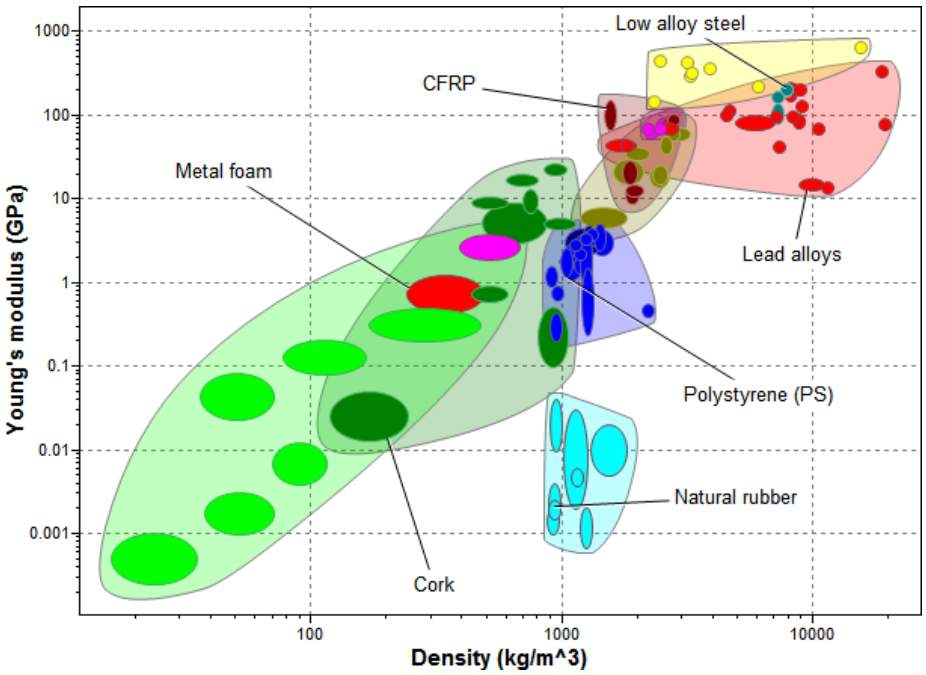
Click  to look at how data for a given family of materials cluster together.

❖ Label records on the chart

Zoom in and label some records (click over a record and drag).

Try adding labels from the Results list: select a record in the list, right-click and select **Label** on the shortcut menu, then then drag the label where you want it on the chart.

If the new label isn't visible at the current zoom, click **Autoscale** to display the whole chart again.



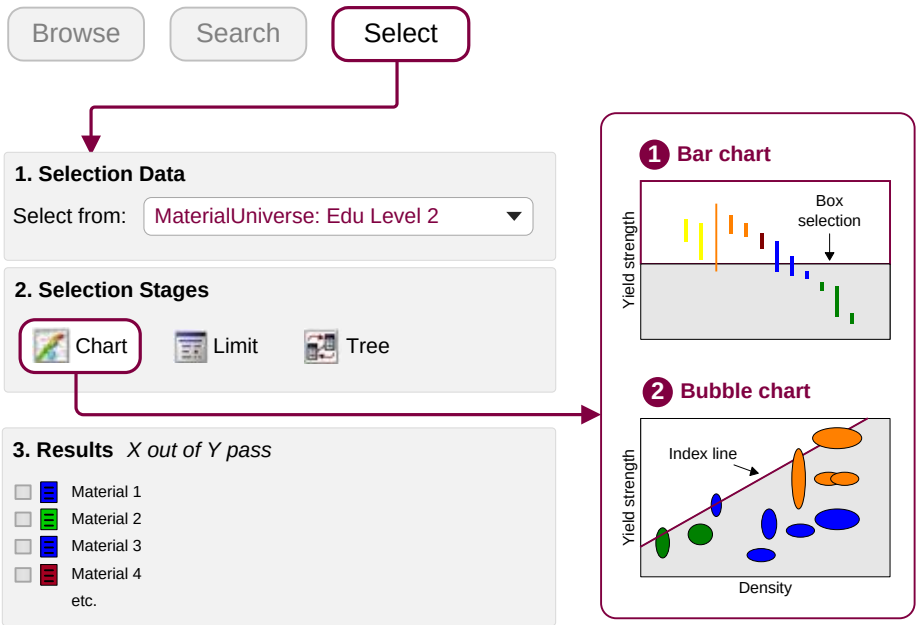
❖ Delete this stage

Select the stage in the Selection Stages list and press DELETE.

4.4 Filtering and Screening

Exercise 8 — Selection Using a Chart Stage

When plotted on a Chart Stage, records can also be filtered using the **Index line** and **Box selection** tools. This provides a more qualitative approach to filtering.

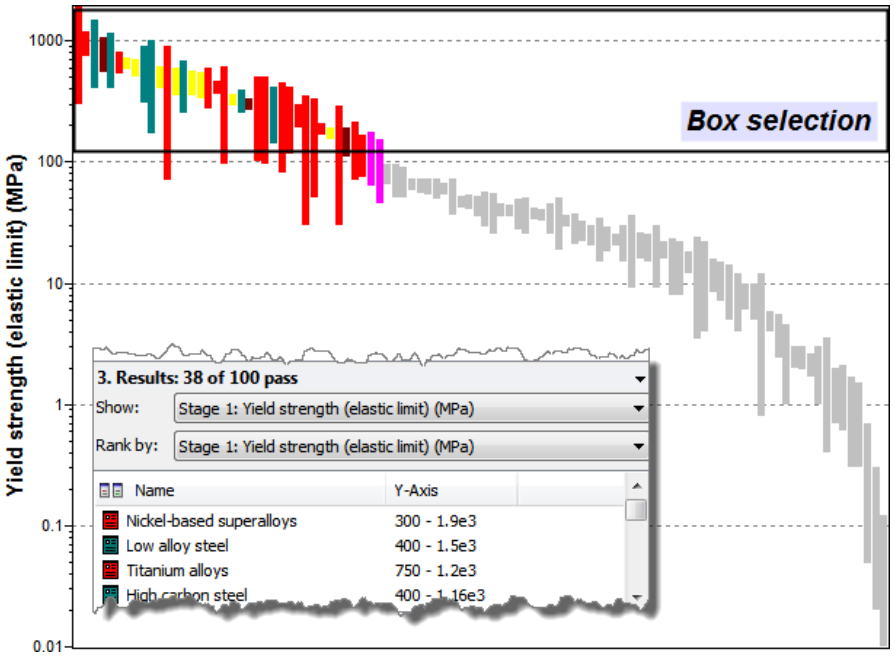


❖ Make a Bar Chart of YIELD STRENGTH (σ_y)

Set the y-axis to **Yield strength (elastic limit)**.

❖ Use a Box selection to identify materials with high values of YIELD STRENGTH

Click **Box selection**  , then drag to define the selection box.



❖ Add DENSITY (ρ) to the x-axis

Click **Chart Settings** then click the X-Axis tab and select **Density** as the axis attribute.

❖ Use an INDEX LINE to identify materials with high values of the specific strength σ_y / ρ

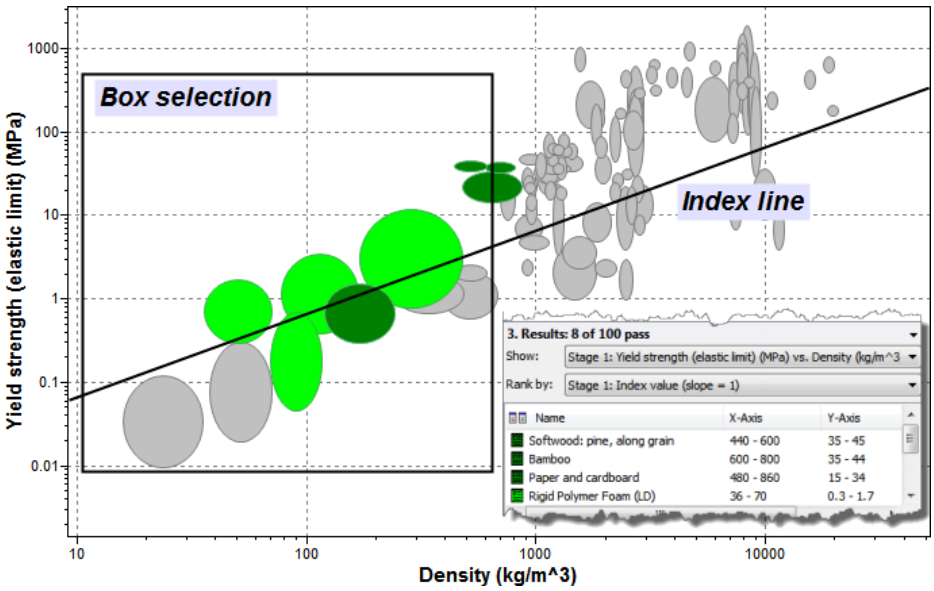
Click **Index and display lines** .

The objective of the line is set to **Maximize the index** by default, which will result in selection of materials above the line, for high values of σ_y / ρ.

Click **OK** and then click the chart to position the line through a particular point.

Drag the line upwards to refine the selection to fewer materials.

❖ Add a Box selection to the chart to identify materials with low DENSITY that maximize the index.



❖ Rank the results by specific strength (YIELD STRENGTH / DENSITY)

Show: Stage 1: Yield strength v. Density

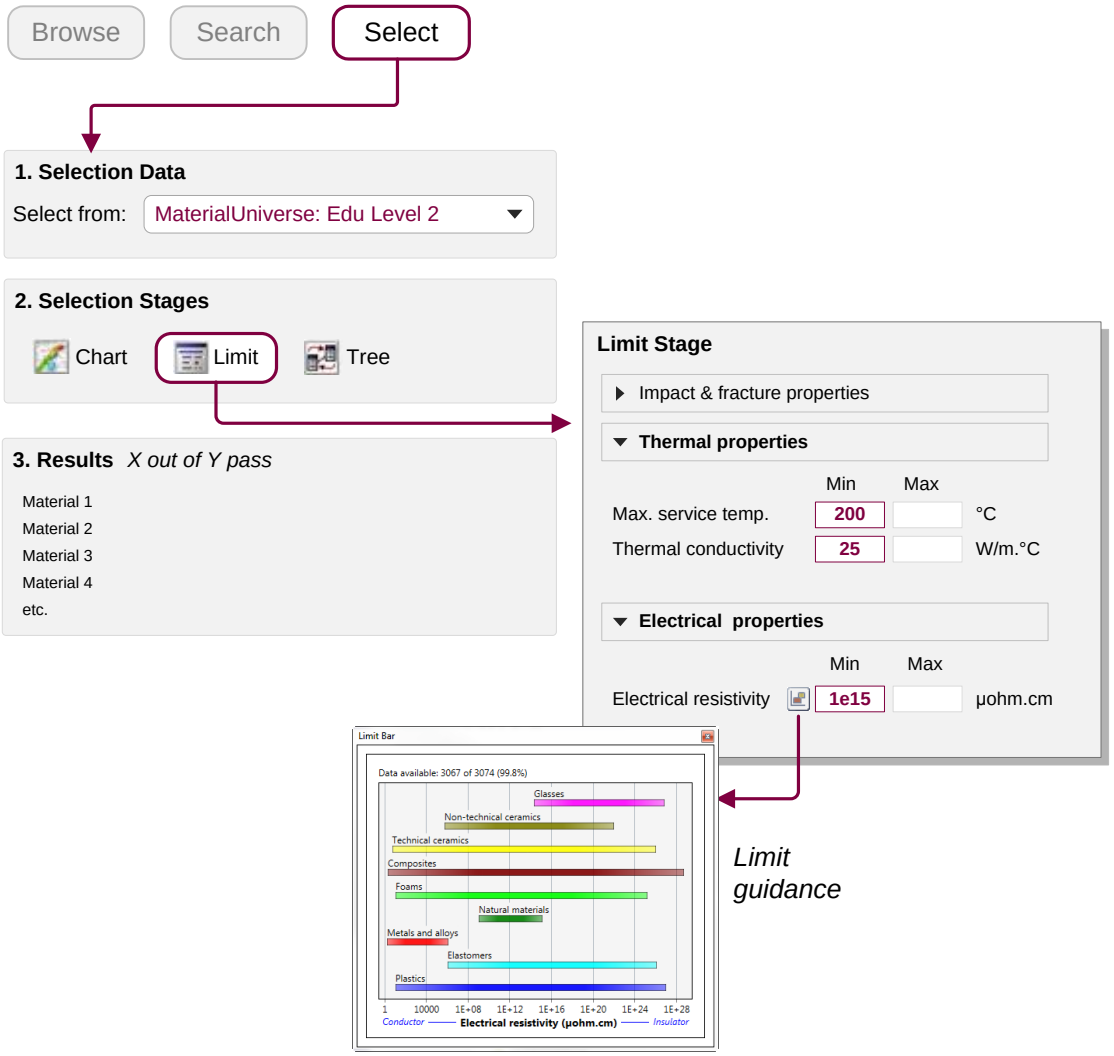
Rank by: Stage 1: Index value.

Example results: Softwood, Bambo, Paper.

❖ Delete this stage

Select the stage in the Selection Stages list and press DELETE.

Exercise 9 — Selection Using a Limit Stage



❖ Select materials with specific thermal and electrical properties.

Create a new Limit Stage with the following criteria:

MAX. SERVICE TEMPERATURE	> 200 °C
THERMAL CONDUCTIVITY	> 25 W/m.°C
ELECTRICAL RESISTIVITY	> 1e15 µohm.cm

Example results: Aluminum nitride, Alumina, Silicon nitride.

Use the limit bars for guidance on suitable values. Enter the limits – minimum or maximum as appropriate – and click **Apply**.

You can change the units on the datasheet by clicking the **Units** tab under **Tools > Settings**.

❖ Filter the results further to select only materials with non-opaque TRANSPARENCY.

Under Optical Properties, in the Transparency list, select Translucent, Transparent, and Optical quality.

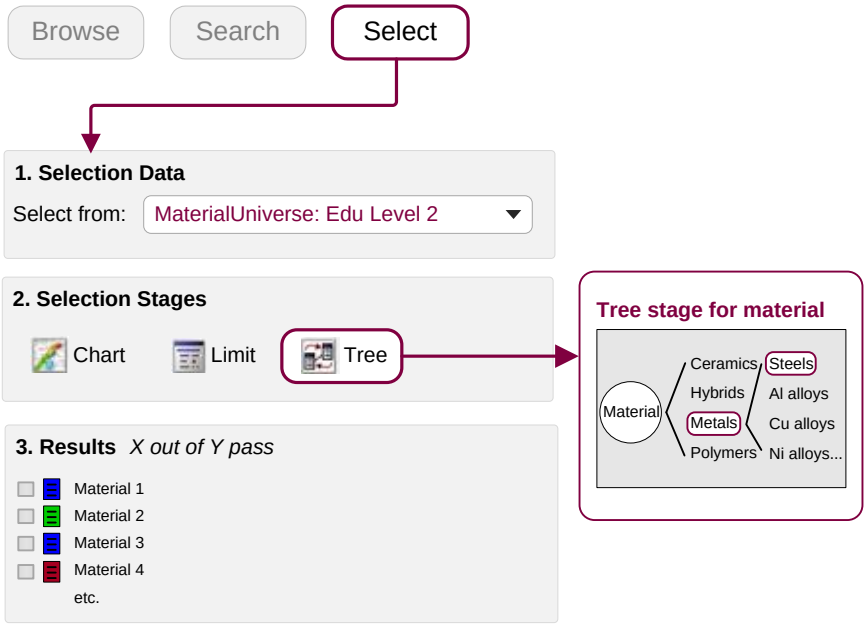
Click Apply.

Example results: Alumina and Silicon Nitride.

❖ Delete this stage.

Selection Using a Tree Stage

Using a Tree Selection Stage, you can filter records based on their links to records in other data tables, or based on the database hierarchy (tree).



❖ Find materials that can be MOLDED

Under Selection Stages, click **Tree**. In the Tree Stage window, select ProcessUniverse, navigate to Molding, and click **Insert**, then click **OK**.

❖ Click **Show** to see a list of the materials in MaterialUniverse to which this process is linked.

❖ Delete this stage.

❖ Find processes to join STEELS

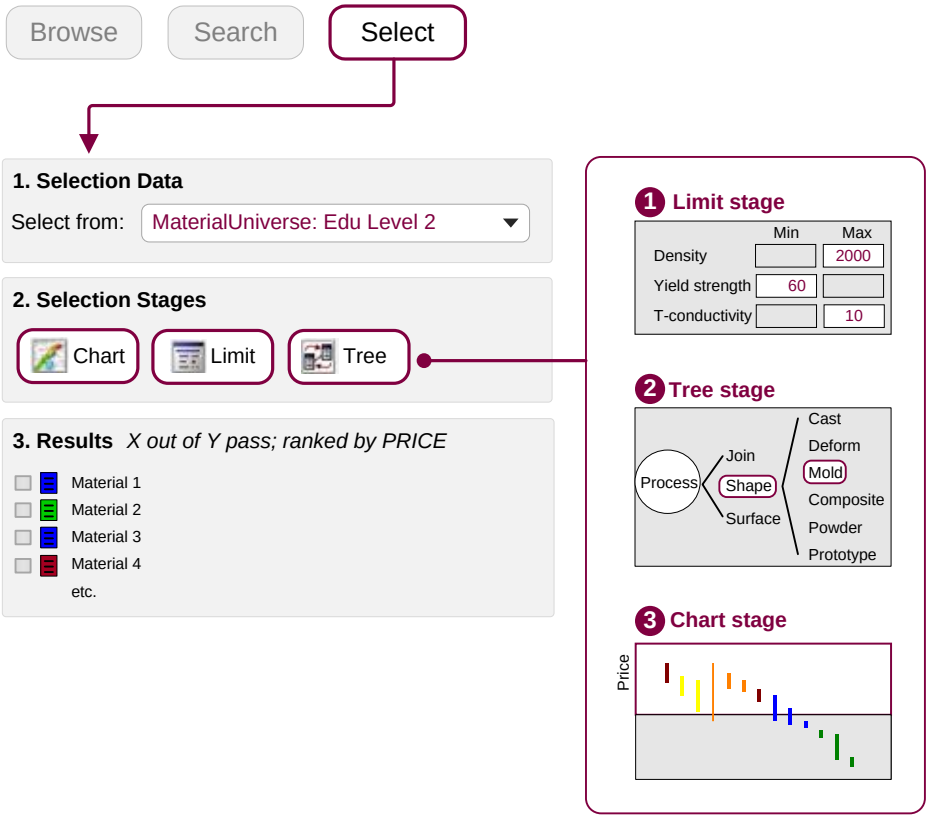
In the Selection Project pane, under Selection Data, select *ProcessUniverse: Joining*.

Under Selection Stages, click **Tree**. Select *MaterialUniverse*, expand *Metals and alloys*, select *Ferrous*, and then click **Insert** followed by **OK**.

❖ Delete this stage.

4.5 Putting it all together

Exercise 10 — Combining Filtering and Charting Tools



❖ Choose the data source.

Select from: MaterialUniverse: Edu Level 2.

❖ Select materials with specific physical, mechanical, and thermal properties.

Add a Limit Stage with the following criteria:

DENSITY	< 2000 kg/m^3
YIELD STRENGTH (Elastic limit)	> 60 MPa
THERMAL CONDUCTIVITY	< 10 W/m.°C

❖ Filter the results to find those that can be THERMOFORMED

Add a Tree Stage and select ProcessUniverse > Shaping > Molding > Thermoplastic molding > Thermoforming.

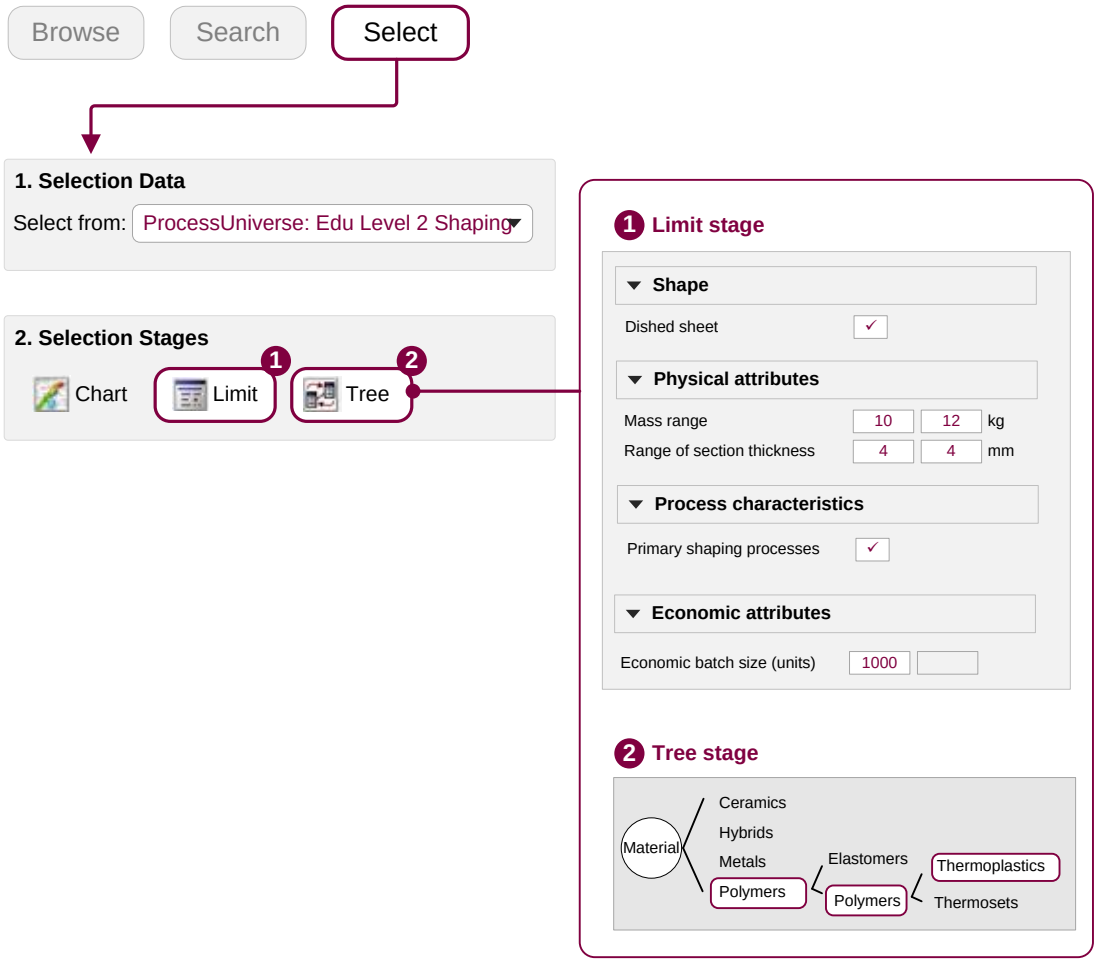
❖ Rank the results by PRICE and find the three cheapest materials

Add a Chart Stage with a bar chart of Price. On the Chart Stage, all materials that fail one or more stages are grayed out. The Results window by default lists the materials that pass all stages.

In the **Rank by** list, select *Stage 3: Price*.

4.6 Process Selection

Exercise 11 — Selecting Processes



❖ Choose the data source

Select from: ProcessUniverse: Edu Level 2 Shaping.

❖ Find PRIMARY SHAPING PROCESSES to make a component with specific shape, physical, and economic properties.

Add a Limit Stage with five criteria:

SHAPE	Dished sheet
MASS	10 - 12 kg
SECTION THICKNESS	4 mm
PROCESS CHARACTERISTICS	Primary shaping process
ECONOMIC BATCH SIZE	> 1000

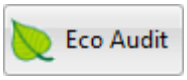
❖ Filter the results to only include THERMOPLASTIC materials

Add a Tree Stage and select MaterialUniverse - Polymers and Elastomers - Polymers - Thermoplastics.

Example results: Rotational molding, Compression molding, Thermoforming.

4.7 Eco Audit

The Eco Audit Tool is not available in the Bio-Engineering Edition of CES EduPack.



The Eco Audit Tool estimates the energy used and CO_2 produced during five key life phases of a product (material, manufacture, transport, use, and end of life), and identifies which phase has the dominant contribution. This is the starting point for eco-aware product design, as it identifies which parameters need to be targeted to reduce the eco-footprint of the product.

A brand of bottled mineral water is sold in 1 liter PET bottles with polypropylene caps. A bottle weighs 40 grams; the cap 1 gram. Bottles and caps are molded, filled, and transported 550 km from the French Alps to England by 14 tonne truck, refrigerated for 2 days and then sold. The overall life of the bottle is one year.

An example product file for this case study is installed with CES EduPack in the Samples folder, with the filename Bottle PET - Level 2.prd.

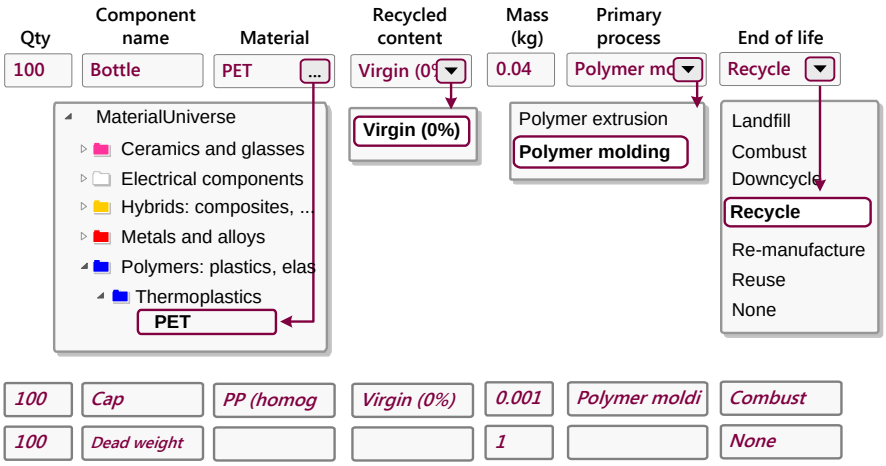
Product Definition

The following example shows how the example product file has been created.

For an explanation of the calculations used at each stage, click Help in the heading.

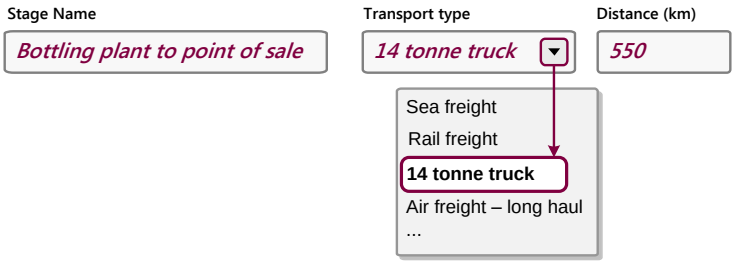
1. Material, manufacture, and end of life

Bill of materials (BoM) and primary processing method.



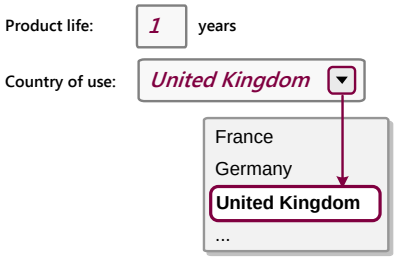
2. Transport

Transportation from site of manufacture to point of sale.



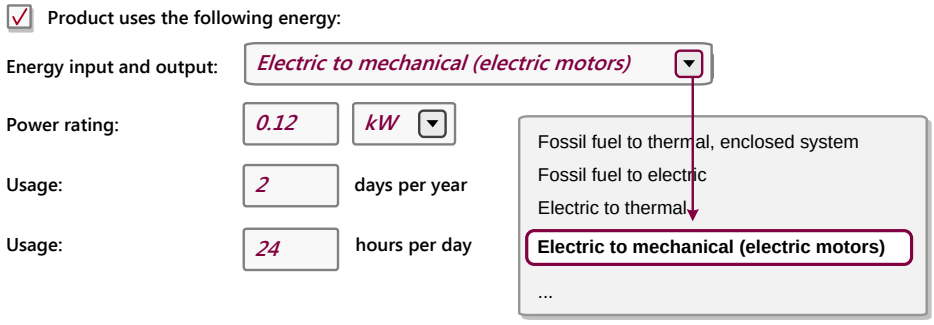
3. Use

Product Life and Location Use



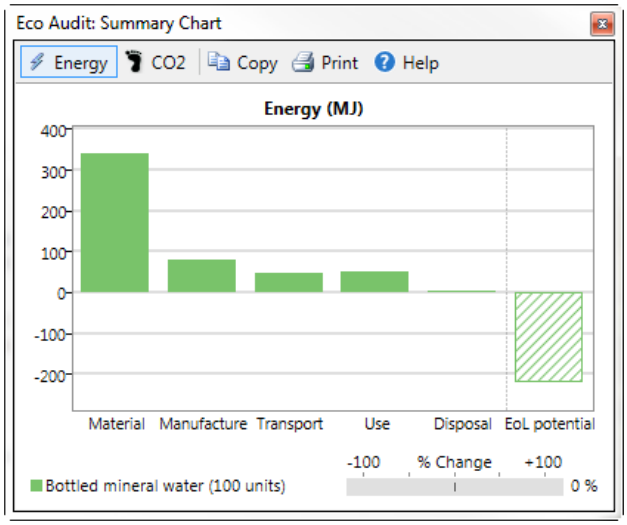
Static Mode

Energy used to refrigerate product at point of sale (average energy required to refrigerate 100 bottles at 4°C = 0.12kW).



4. Report

Summary chart enables rapid identification of the dominant life phase. Toggle between views of energy usage or CO_2 footprint.



The chart shows that, in this project, Material is the dominant life phase. Each life phase can be clicked to show guidance on strategies to reduce its impact.

Detailed report provides a component-by-component breakdown of each life phase, enabling the main contributors to the dominant life phase to be identified.

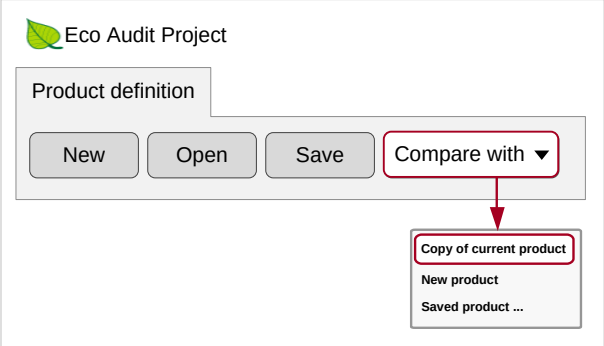
Exercise 12 — Compare Eco Audit Projects

❖ Open the *Bottle PET - Level 2* product file.

Click **Open** and locate the sample product file *Bottle PET - Level 2.prd*, located in the Samples folder in your CES EduPack installation folder. For example:
C:\Program files (x86)\CES EduPack 2016\Samples\eco_audit\en\Bottle PET - Level 2.prd

❖ Create a copy of this product for comparison

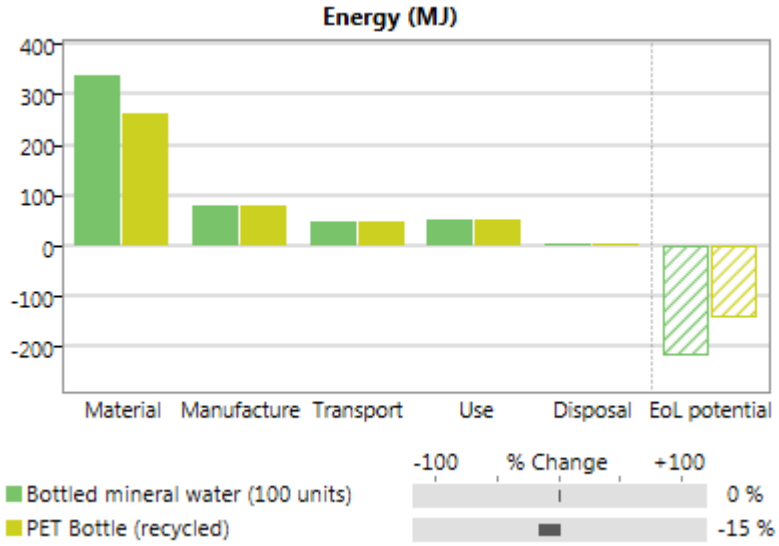
Click **Compare with** and select **Copy of current product**.



❖ Set the following values in for the new product:

NAME	PET Bottle (Recycled)
RECYCLED CONTENT	35%

❖ Generate the SUMMARY CHART



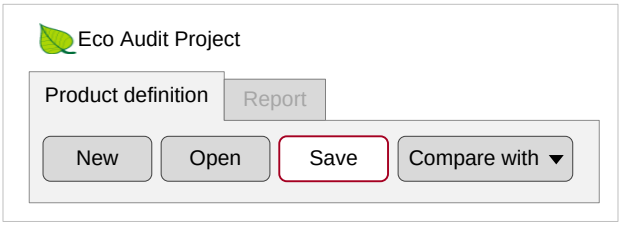
The first life energy (not including EoL potential) is reduced by 15%.

> **Note:** The chart can be copied into a document or printed using Copy and Print at the top of the chart window.

Exercise 13 — Saving and Exporting

Eco Audit projects do not form part of a selection project and therefore need to be saved separately.

❖ SAVE the product definition

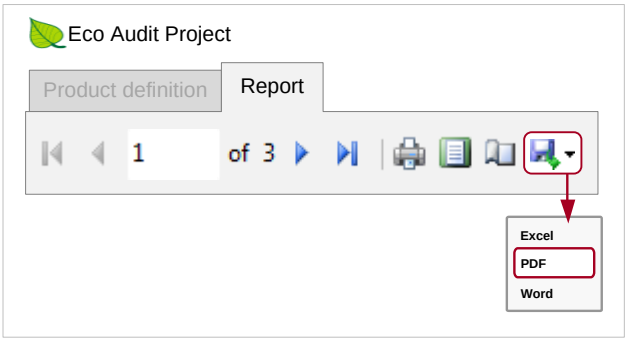


❖ GENERATE the Eco Audit report

Click the **Report** tab (or click **Detailed Report** on the Product definition tab).

❖ EXPORT the report as a PDF

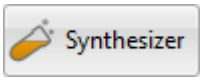
You will require a PDF reader such as Adobe Reader to view the exported report.



Note: The Level 3 Eco Design and Level 3 Sustainability databases contain an enhanced version of the Eco Audit tool, containing options to include a secondary process and cost analysis in the audit. Please read the in-software help, or the online teaching resources for information on how to get started with these advanced features.

4.8 Synthesizer Tool

The Synthesizer Tool is only available in some advanced editions of CES EduPack.



The Synthesizer Tool is designed for use in the early stage of product development. It consists of two types of models: hybrid models, for estimating the performance of novel materials and structures; and the part cost estimator, for calculating the cost of a component based on the material and process chain.

Synthesized records produced using the Synthesizer Tool can then be compared with existing records in the MaterialUniverse database using selection stages.

Exercise 14 — Hybrid Model: Sandwich Panels Model

Hybrid materials and structures combine the benefits of two or more materials to produce new materials that exhibit unique combinations of properties. For example, both composite materials and sandwich panels are commonly used to create strong, lightweight structures.

Note: You will need a Level 3 database for this exercise.

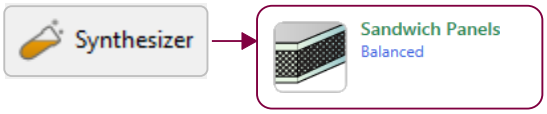
❖ Make a BUBBLE CHART of YOUNG'S MODULUS (E) against DENSITY (ρ) using MaterialUniverse: All bulk materials

As in Exercise 7.

❖ Use the SANDWICH PANELS MODEL to create synthesized records for a family of hybrid materials

Click **Synthesizer** on the toolbar (or click **Tools > Synthesizer** on the menu bar).

Select the *Sandwich Panels – Balanced* model.



❖ Set the SOURCE RECORD values

FACE-SHEET	Aluminum, 6061, wrought, T6
CORE	Polymethacrylimide foam (rigid, 0.200)

Click **Browse** and locate the records in the tree.

❖ Leave the default values for MODEL VARIABLES and MODEL PARAMETERS, and set the following RECORD NAMING values:

FACE-SHEET	Al
CORE	Rohacell

❖ CREATE the synthesized records

Click **Create** and then **Finish**. The new synthesized records will be shown in the Results list and on the Chart Stage.

Note: Click the help icon in the Synthesizer Tool dialog to view further information about the current model type, including details of the calculations used.

❖ Plot an INDEX LINE corresponding to a lightweight, stiff panel in bending $E^{1/3}/\rho$

Click **Index and display lines**, enter a slope of 3, and maximize the index.

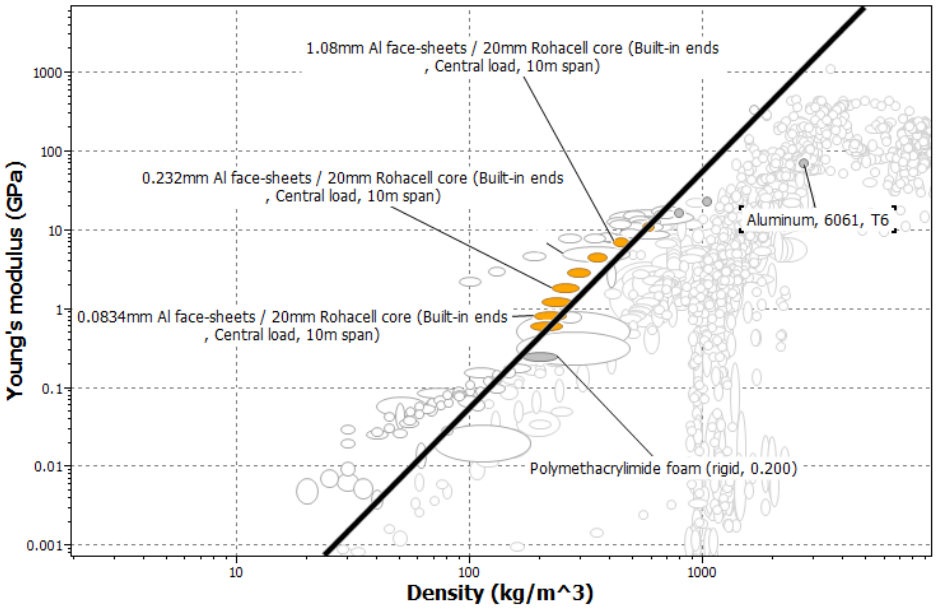
❖ Add labels to the source records and some of the synthesized records

You can select individual records on the chart and drag to place a label.

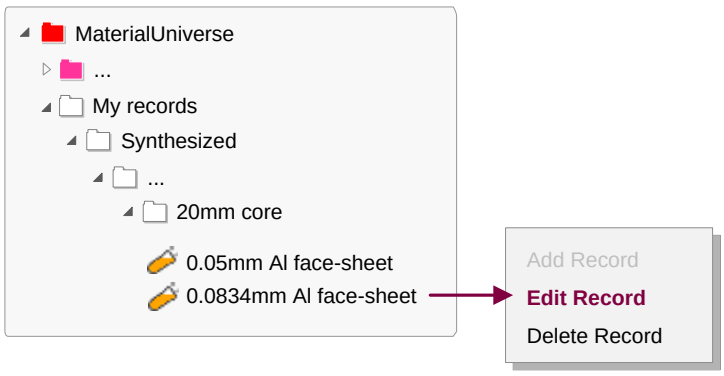
You can also add labels from the Results list: select one or more records in the Results list, right-click and select **Label** on the shortcut menu, then then drag the labels where you want them on the chart.

Click  **Highlight synthesized records** to help you identify the synthesized records on the chart.

Use the Zoom controls  and  to zoom in to the area of interest on the chart.



Synthesized records appear on the Browse tree under *My Records* and may be edited or deleted in a similar way to User Defined records.

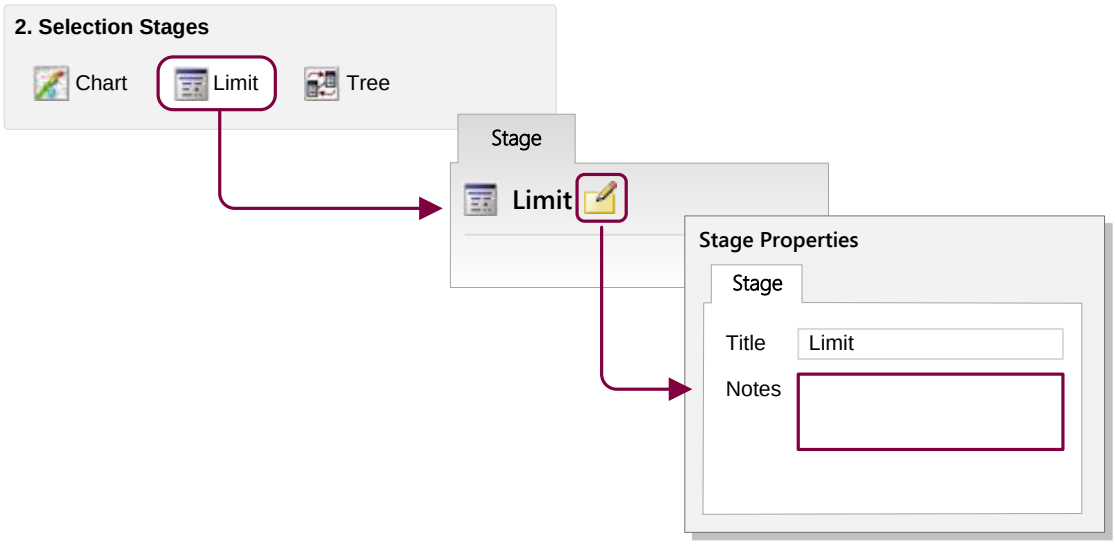


4.9 Saving, Copying, and Report Writing

Exercise 15 — Adding Comments and Saving a Project

You can add comments to a selection project as a reminder of why you have applied certain constraints and objectives. Comments are displayed on mouse-over in the selection report, and are saved in the project file.

Comments can be added to all selection stages in a project.



❖ Click **Notes** in the stage window heading, then enter some comments

❖ Save the project

On the **File** menu, click **Save Project**. Give the project a filename and directory location; the project will be saved with the file extension *.ces*.

Exercise 16 — Exporting and Copying

Charts, records, and results lists can be copied and pasted into a document in another application such as Microsoft® Word, Microsoft Excel, Microsoft Powerpoint, or Notepad.

❖ Copy a chart into a document

To copy a chart to the clipboard: in the chart window, right-click the chart and select **Copy** on the shortcut menu, or press CTRL+C.

You can then paste the chart image from the clipboard into your document.

❖ Copy a datasheet into a document

To copy a datasheet to the clipboard: open the datasheet, then right-click the datasheet, and select **Copy** on the shortcut menu, or press CTRL+C.

You can then paste the data from the clipboard into your document.

❖ Copy results into a document

To copy results to the clipboard, use SHIFT+click or CTRL+click to highlight the records you want, then right-click and select **Copy** on the shortcut menu, or press CTRL+C.

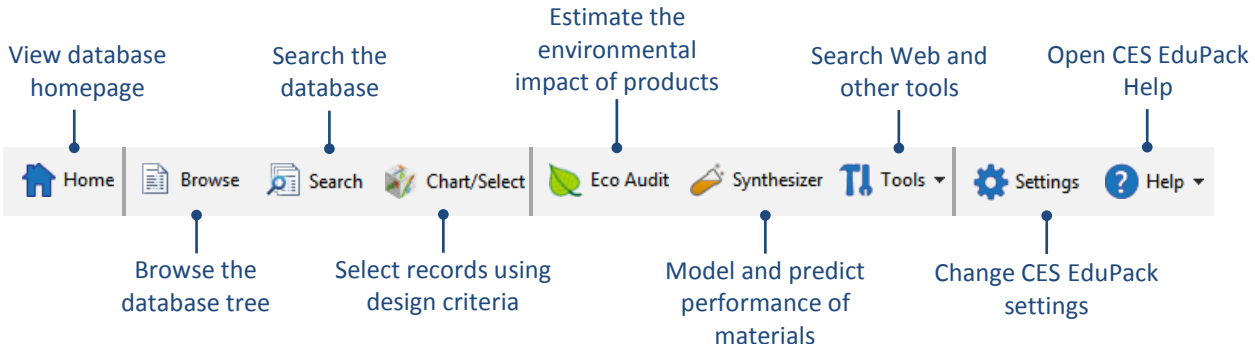
To select all results in the list, right-click and select **Select All** on the shortcut menu, or press CTRL+A.

You can then paste the results from the clipboard into your document.

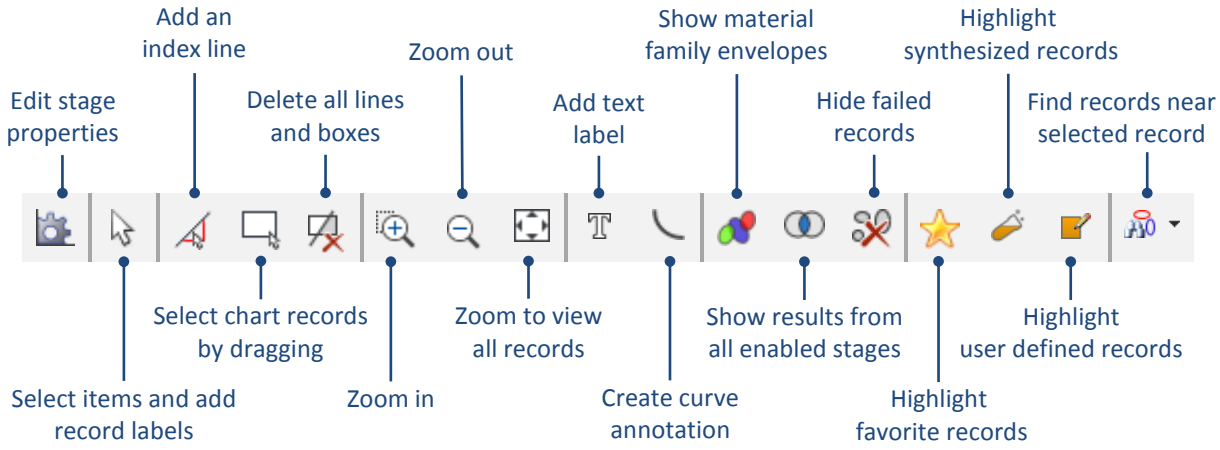
❖ Try editing the document you have created

5 Toolbars and general information

5.1 Standard toolbar



5.2 Chart Stage toolbar



5.3 CES EduPack file types

*.gdb	Granta Database file
*.ces	CES Project file
*.cet	Selection Template file
*.frl	Favorites file
*.prd	Eco Audit Product Definition file

5.4 Options for Preferred Currency and Units

Settings	Database options	
	Preferred Currency	Preferred Unit System
<Automatic>	The Regional Setting from the operating system for currency is used to view data. This will appear as: <Automatic - Regional Currency> For example: <Automatic - GBP>.	The Regional setting from the operating system for unit system is used to view data. This will appear as: <Automatic - Regional Units> For example: <Automatic - Metric>.
<None>	Data is displayed using the same currency as it is stored with in the database.	Numeric data is displayed using the same units as the data is stored with in the database.
Named setting	Named currency is used to display data.	Named unit system is used to display data.

5.5 Physical Constants and Conversion of Units

Physical Constants

Absolute zero temperature	-273.2°C
Acceleration due to gravity, g	9.807 m/s^2
Avogadro's number N_A	6.022 x 10^{23}
Base of natural logarithm, e	2.718
Boltzmann's constant, k_B	1.381 x 10^{-23} J/K
Faraday's constant, F	9.648 x 10^4 C/mol
Gas constant, R	8.314 J/mol/K
Plank's constant, h	6.626 x 10^{-34} Js
Speed of light in a vacuum, c	2.998 x 10^8 m/s
Volume of perfect gas at STP	22.41 x 10^{-3} m^3/mol

Conversion of units

Angle, θ	1 rad	57.30°
Density, ρ	1 lb/ft^3	16.03 kg/m^3
Diffusion coefficient, D	1 cm^2/s	1.0 x 10^{-4} m^2/s
Energy, U	See below	
Force, F	1 kgf 1 lbf 1 dyne	9.807 N 4.448 N 1.0 x 10^{-5} N
Length, l	1 ft 1 inch 1 Å	304.8 mm 25.40 mm 0.1 nm
Mass, M	1 tonne 1 short ton 1 long ton 1 lb mass	1000 kg 908 kg 1107 kg 0.454 kg
Power, P	See below	
Stress, σ	See below	
Specific Heat, Cp	1 cal/gal.°C 1 Btu/lb.°F	4.188 kJ/kg.°C 4.187 kJ/kg.°C
Stress Intensity, K_{1c}	1 ksi $\sqrt{in}$	1.10 $MN/m^{3/2}$
Surface Energy, γ	1 erg/cm^2	1 mJ/m^2
Temperature, T	1°F	0.556K
Thermal Conductivity, λ	1 cal/s.cm.°C 1 Btu/h.ft.°F	418.8 W/m.°C 1.731 W/m.°C
Volume, V	1 Imperial gall 1 US gall	1.546 x 10^{-3} m^3 3.785 x 10^{-3} m^3
Viscosity, η	1 poise 1 lb ft.s	0.1 $N.s/m^2$ 0.1517 $N.s/m^2$

Conversion of Units - Stress and Pressure

	MPa	**dyn/cm^2**	**lb/in^2**	**kgf/mm^2**	**bar**	**long ton/in^2**
MPa	1	10^{7}	1.45×10^{2}	0.102	10	6.48×10^{-2}
dyn/cm^2	10^{-7}	1	1.45×10^{-5}	1.02×10^{-8}	10^{-6}	6.48×10^{-9}
lb/in^2	6.89×10^{-3}	6.89×10^{4}	1	703×10^{-4}	6.89×10^{-2}	4.46×10^{-4}
kgf/mm^2	9.81	9.81×10^{7}	1.42×10^{3}	1	98.1	63.5×10^{-2}
bar	0.10	10^{6}	14.48	1.02×10^{-2}	1	6.48×10^{-3}
long ton/in^2	15.44	1.54×10^{8}	2.24×10^{3}	1.54	1.54×10^{2}	1

Conversion of Units - Energy

	J	**erg**	**cal**	**eV**	**Btu**	**ft lbf**
J	1	10^{7}	0.239	6.24×10^{18}	9.48×10^{-4}	0.738
erg	10^{-7}	1	2.39×10^{-8}	6.24×10^{11}	9.48×10^{-11}	7.38×10^{-8}
cal	4.19	4.19×10^{7}	1	2.61×10^{19}	3.97×10^{-3}	3.09
eV	1.60×10^{-19}	1.60×10^{-12}	3.38×10^{-20}	1	1.52×10^{-22}	1.18×10^{-19}
Btu	1.06×10^{3}	1.06×10^{10}	2.52×10^{2}	6.59×10^{21}	1	7.78×10^{2}
ft lbf	1.36	1.36×10^{7}	0.324	8.46×10^{18}	1.29×10^{-3}	1

Conversion of Units – Power

	kW (kJ/s)	**erg/s**	**hp**	**ft lbf/s**
kW (kJ/s)	1	10^{-10}	1.34	7.38×10^{2}
erg/s	10^{-10}	1	1.34×10^{-10}	7.38×10^{-8}
hp	7.46×10^{-1}	7.46×10^{9}	1	15.50×10^{2}
ft lbf/s	1.36×10^{-3}	1.36×10^{7}	1.82×10^{-3}	1

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