ITS A MATERIAL WORLD: bringing material science and mechanical engineering to a laborartory exercise

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*In the chapter entitled «*The Return to Alchemy*» in Tim Ingold›s book* Making, *he quotes art historian James Elkins, «...I need to take a course in forgetting chemistry» The quote indicates an emphasis in both archaeological and conservation science on chemistry as opposed to material science.To understand some of the basic mechanical properties of materials, a simple exercise was developed that helps conservators learn what information is gained by* handling *materials, and, ultimately, how that handling relates to a stress-strain graph.*

The exercise employs rods of identical dimensions of metals, glass, plastics, composites and woods. The first part of the exercise involves ranking the materials by density by the «feel» in the hand; the second, bending - but not breaking - each rod to rank them for stiffness (elastic modulus); the third, bending to either complete failure or plastic deformation to determine if the material is brittle, ductile-malleable (or something else), and, to estimate the bending (flexural) strength or yield strength of the material.This kind of information about materials acquired through the senses is called **apprehensive knowledge**.

The exercise now turns to gaining **comprehensive knowledge** - *understood in through the mind. Students now determine the actual density of each material by measurement, find bending strength data, and, for each material set constructing a graph of bending strength* vs. *density, and, elastic modulus* vs. *density .*

Some of the learnings that derive from this exercise are that there is little or no correlation between elastic modulus and density for metals and a close correlation for woods. In addition, a material can have a low modulus and be brittle (acrylic) and a low elastic modulus and high bending strength (most woods). Finally, both the **apprehensive and comprehensive knowledges** *are used to understand stress-strain graphs.*

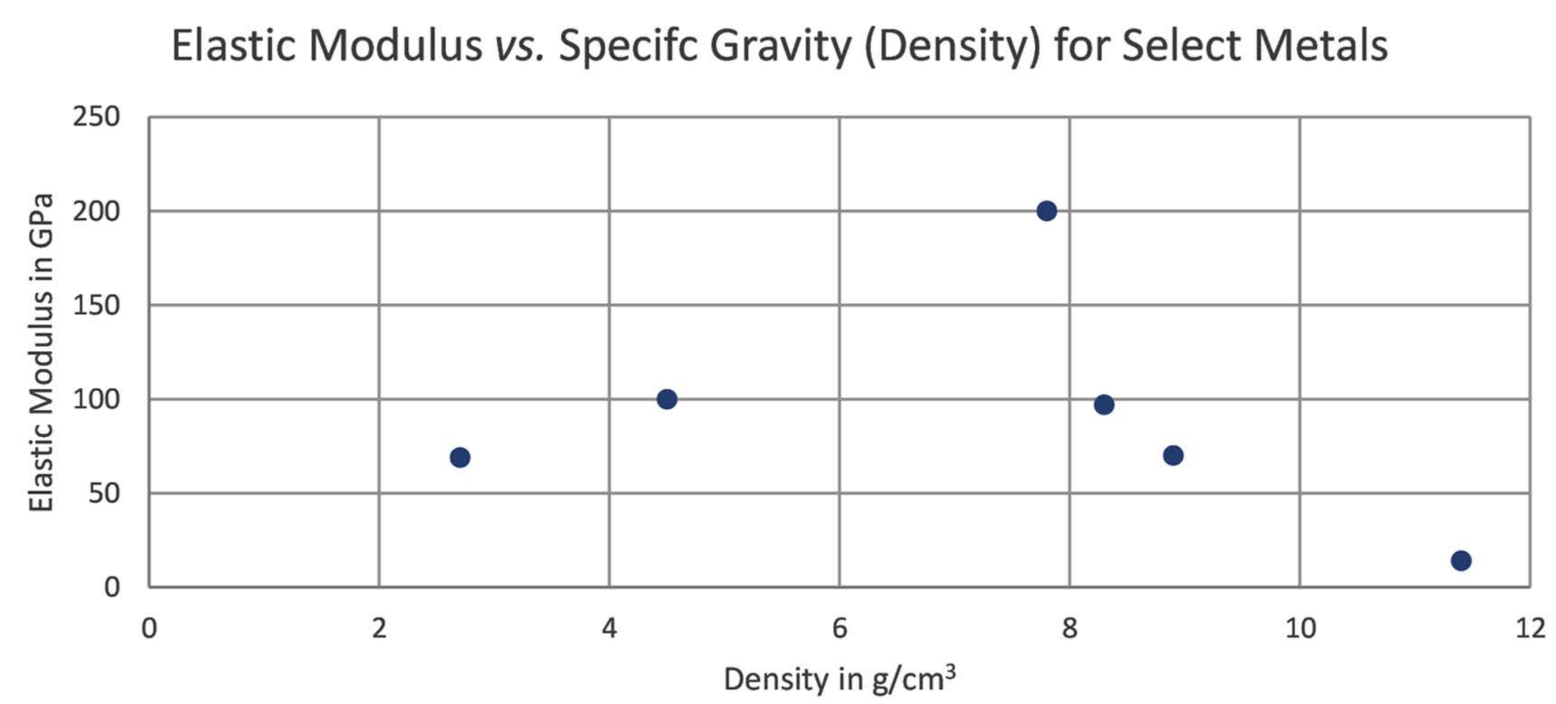

Figure 1. *The graph indicates of poor correlation between elastic modulus and density for select metals.*

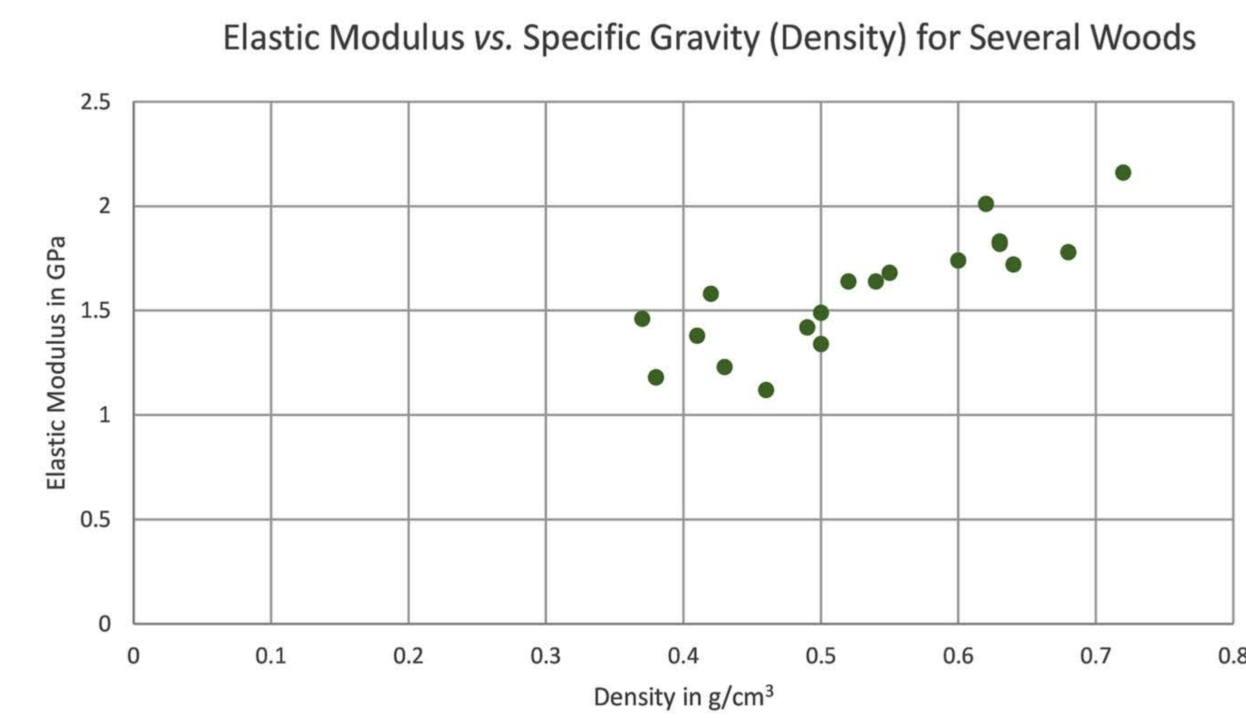

Figure 2. *The graph indicates a relatively good correlation between elastic modulus and density of many woods.*

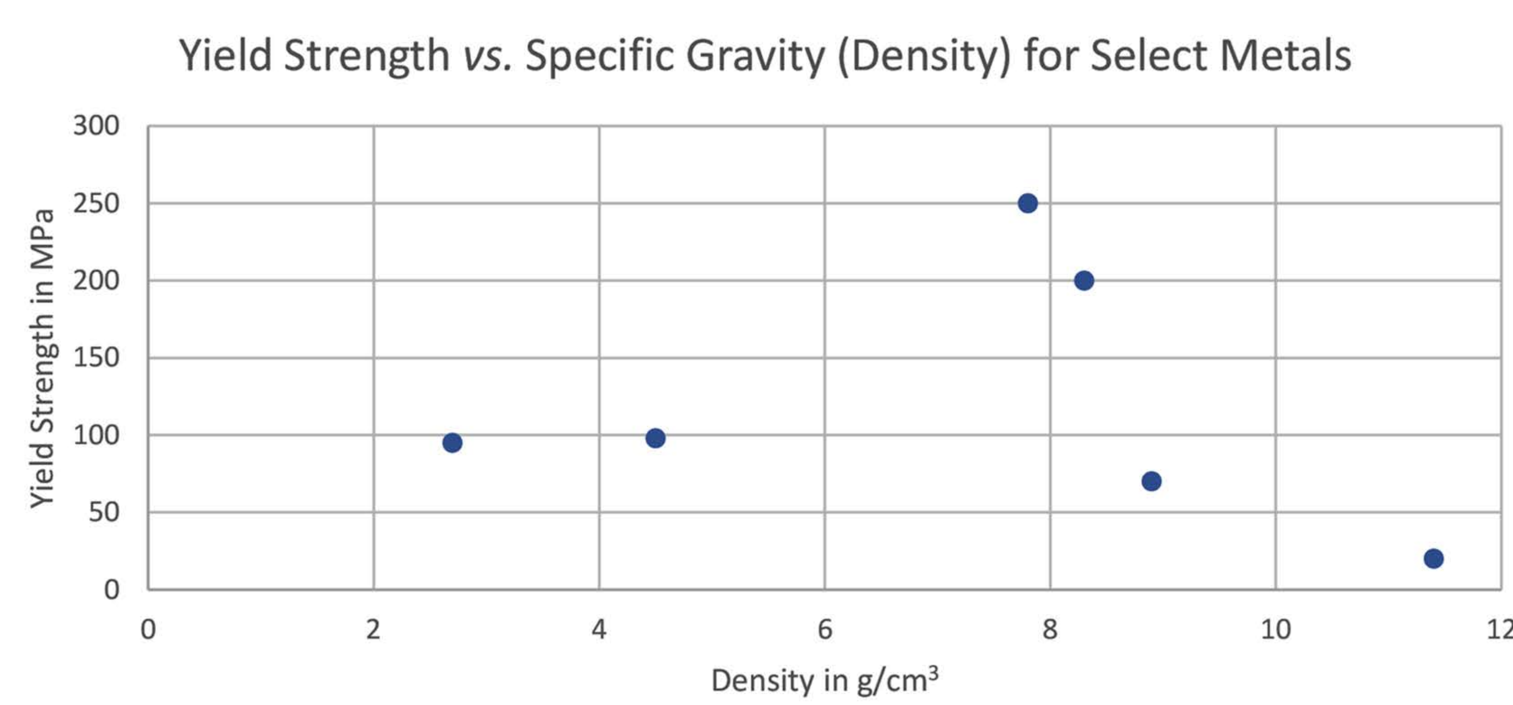

Figure 3. *The graph indicates a poor correlation between yield strength and density for select metals.*

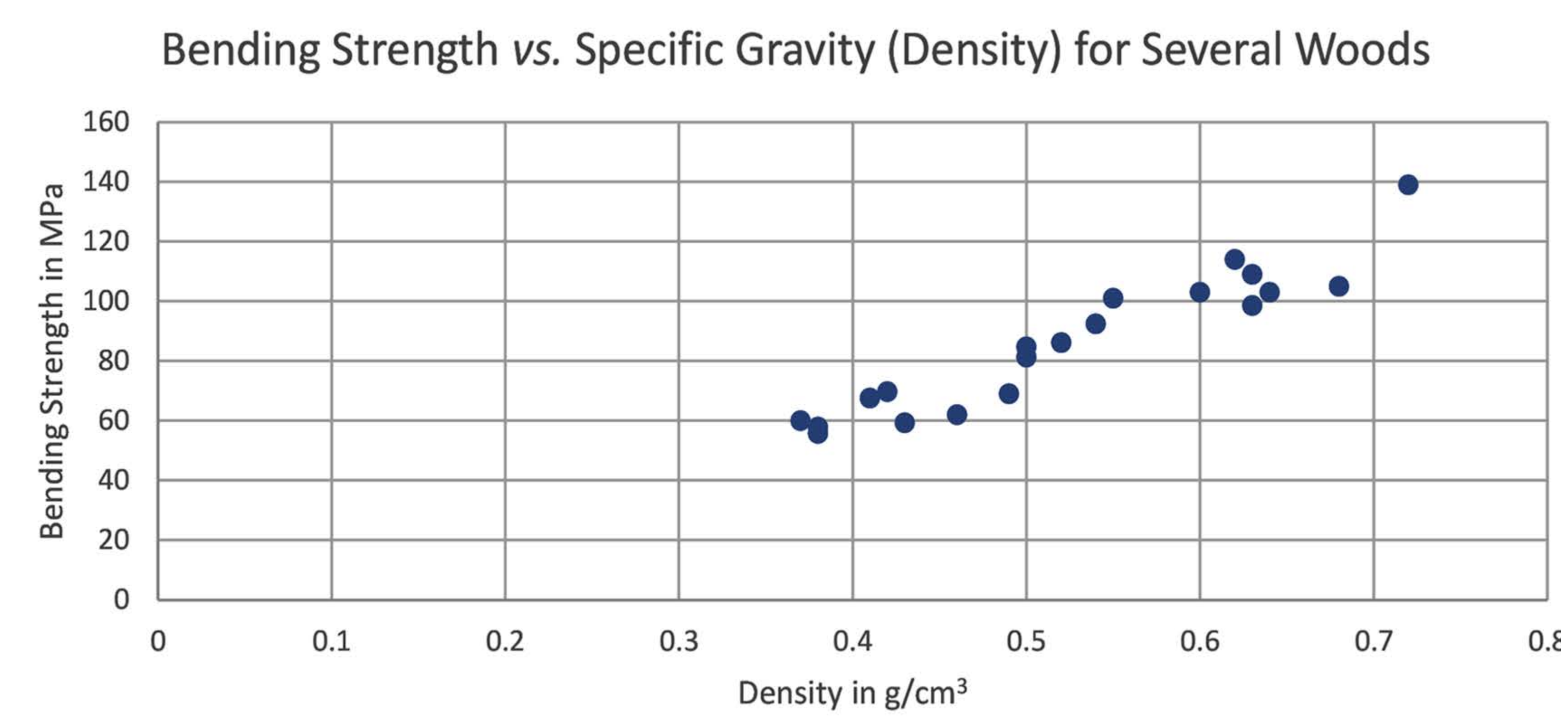

Figure 4. *The graph indicates a very good correlation between bending strength and density for many woods.*

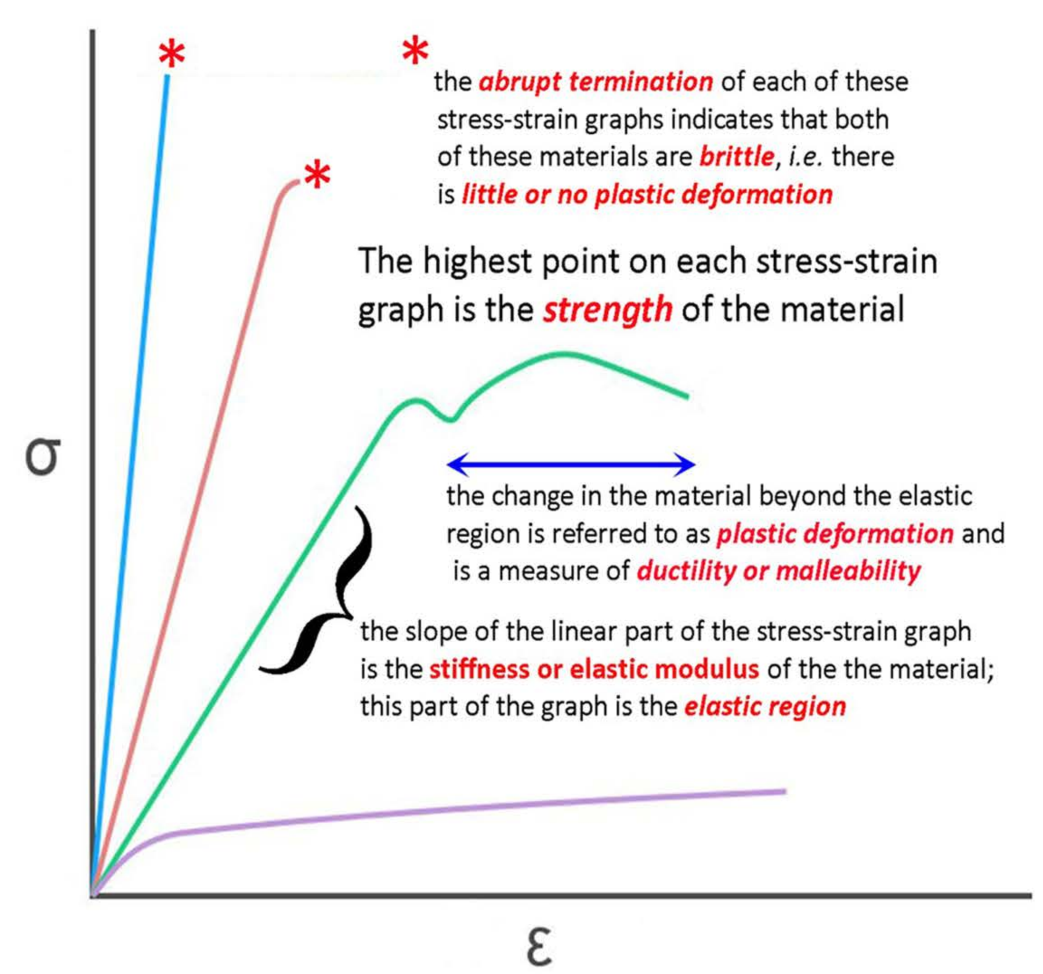

Figure 5. *The ultimate goal of the exercise is the learn to interpret a stress-strain graph and understand the information it provides. The graph and related texts in the figure on the left provide information about materials with fundamentally different properties. The blue and red-orange lines indicate* **brittle materials** *- the lines end abruptly with little or no extension to the right after failure. The materials are also high in strength - the termination is high up in the graph - and they have high elastic moduli - the slopes of the straight-line part of the graphs are also high. These graphs would indicate materials like stone or terracotta. The green line indicates of* **ductile-malleable material** *(ductile if the test is performed in tension and malleable if in compression). These materials - such as most metals - exhibit signficant plastic (permanent and irreversible) deformation after the yield point. The elastic modulus and strengths are less than the materials expressed in the blue and re-orange lines.The violet line indicates a brittle material with a low elastic modulus such as an unreinforced acrylic.*