

## Muddy Card Responses Lecture M1

There was relatively little mud on this lecture - which is perhaps not surprising given the subject matter.

**There were various direct and oblique comments regarding my PRS question on the cost of a human life.** I acknowledge that I was being deliberately provocative in having you put a dollar amount on a human life. Clearly the real answer is that "it all depends on the situation and context". However I hope that it was a useful exercise in asking you to think about the question of "how safe is safe enough". If every engineering system was designed and operated on the basis that a human life is literally priceless then modern civilization would grind to a halt! "How safe is safe enough" is a recurring question that practicing engineers have to answer, either explicitly or implicitly.

There were various comments about a human life being priceless, which when it is our own, or someone who we are close to is certainly the case, however, the cold reality of engineering systems is that people are not willing to pay infinite costs to ensure safety.

The idea that safety is a requirement in its own right came up from a couple of responses. I have some sympathy with this, but at some point someone has to perform a safety assessment of the structure and evaluate whether it is worth improving the safety of the structure by implementing certain engineering improvements.

**Were there any important concepts beside the cost of safety and weight that I should take away from this lecture.** It was actually a rather concept rich lecture:

Objectives of structural engineering

Concept of structural integrity

Concept of trading between design options on the basis of cost (which can be used to factor in weight and safety)

The three great principles of solid mechanics: constitutive behavior, equilibrium and compatibility.

**Have I ever seen Fight Club** - no!

**Is it true that if the cost of life is smaller than the cost of a recall that the company will not recall a product and will accept human loss of life because it means less of a loss.**

Absolutely, although one needs to understand that in most product recall cases there is a matter of statistics that one needs to account for. Generally the safety issues concerned are very unlikely to occur, and so the company will run a cost/benefit assessment to determine if a recall is necessary.

**Lighter weight materials often cost more than heavier materials, so wouldn't decreasing weight be likely to increase cost?** Good point. Two key ideas here. One, the actual direct cost of the material is small compared to the total cost of the overall structure. One needs to factor in manufacturing and assembly costs as well. Secondly, the trade between less dense and more dense materials will depend very much on the application. In a fighter aircraft at

\$3,000/kg it makes sense to use a lot of composite materials (which are relatively expensive) whereas on an automobile at \$10/kg it does not.

**Has the cost per lb of aircraft (commercial and/or military) increased faster than inflation over the years?** Military aircraft definitely has - this is a result of the same inflationary pressures that affect health care. No-one would ever make do with a lower quality product than absolutely the best that they can afford. This continues to push technology to improve performance. In contrast the cost of air transportation has steadily decreased - while the performance (speed) has not changed significantly in 40 years.

**Why were the springs in equilibrium while the force was being applied?** So long as the structure was not accelerating, static equilibrium must have been maintained. We will discuss the concept of equilibrium more on Friday.

**What understanding of mathematics will we need for materials and structures?** You will need to understand material covered in 18.01, 18.02 and 18.03.

**Why would each leg be governed by  $F=k\delta$ ?** You defined the applied force as  $F$  so wouldn't you need to take its dot product with each leg's direction. My apologies, this was sloppy on my part, I should not have used  $F$  as the force applied to the overall structure. The spring forces are different from the applied force.

**Will this class be primarily focused on 8.01 Material such as force and analysis?** The M&S part of Unified will rely on knowledge of the basic concepts of mechanics introduced in 8.01, particularly the idea of static equilibrium of forces and moments. We will go much further than this though.

**Are any modern, high performance aircraft using wood construction?** Not that I am aware of. The chief problem with wood is that it is not as stable as metal when it comes to temperature and environmental variations. Also wood is porous, so its use as pressure vessels (pressurized fuselages) is problematic.

**Please post concept questions and don't remain impartial, root for the Red Sox and enjoy the mayhem when they win.** I will post the concept questions, and I will reserve judgement on the Sox!

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**What about weight and reproducibility as objectives for structural engineering?** My contention would be that these both have a cost associated with them, and therefore are included by the statement of "minimizing cost"

**Why is a human life worth more now than a few years ago?** Basically just inflation. At least in the US people are earning more, so the amount that companies are sued for when an accident happens is also going up.