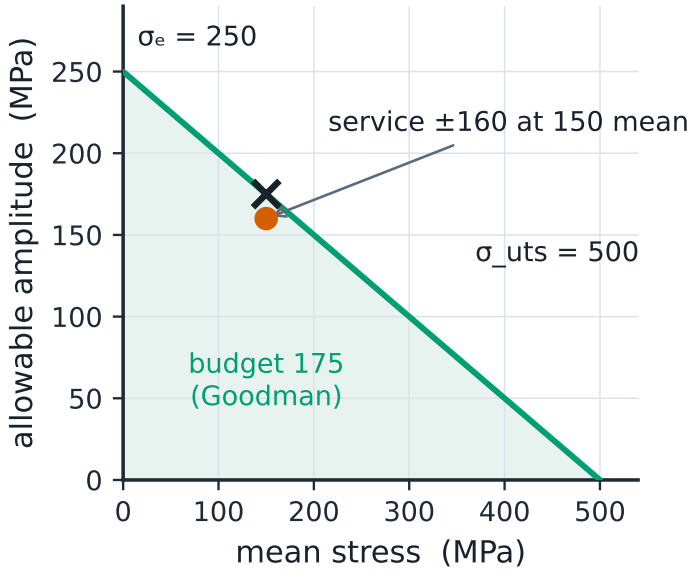
Exercise walk-through

4.4 Polymers, ceramics and composites

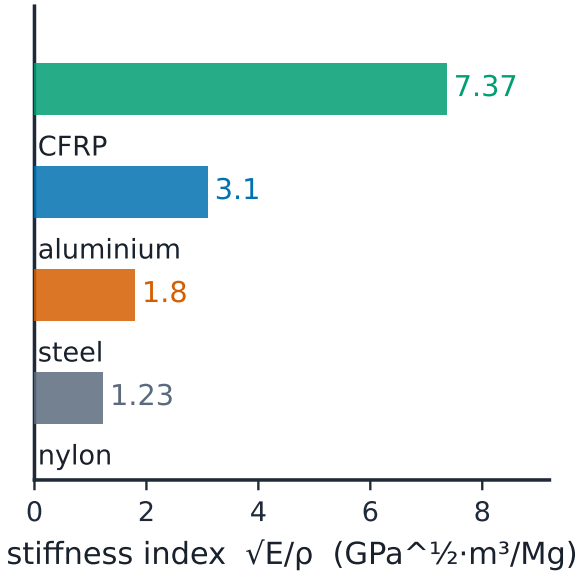
University Mechanical Engineering

Failure and selection: show the arithmetic

Goodman: the mean eats the budget



The index ranks; constraints eliminate



Goodman cuts 250 to **175** MPa at 150 mean; CFRP leads the stiffness index.

Selection in action: one method, two answers

1. **Rank** $\sqrt{E}/\rho$: CFRP 7.37 wins stiffness-per-mass at 2.4× aluminium.
2. **Eliminate** Plain nylon fails the T_g constraint; ceramics fail the survival probability at these loads.
3. **Split** The mount ships quenched-and-tempered steel (620 MPa, 16%); the carry-handle ships CFRP.

The project sheet, reproducible

1. **Structure** BCC 0.6802, FCC 0.7405; Hall-Petch 183.6 $\rightarrow$ 262.3 MPa for 50 $\rightarrow$ 10 µm.
2. **Certificate** Rod 191.0 MPa: 0.477 vs 1.364 mm; true ln 1.2 $=$ 0.1823; **toughness** 176 MJ/m^3.
3. **Choice** Routes 280/24, 260/26, 620/16, 950/8; Chvorinov 22.2 vs 50.0 s; Basquin 226.1 $\rightarrow$ 142.6; Goodman 175.0; index 7.37 / 3.10 / 1.80 / 1.23 - steel mount, CFRP handle.

Exercises 2.1·2.3

2.1 The modulus along the fibres (one decimal, GPa). [3]

2.2 The modulus across the fibres (two decimals, GPa) and the anisotropy ratio (two decimals). [4]

2.3 A ceramic has Weibull modulus $m = 8$ and characteristic strength 250 MPa: the survival probability at 200 MPa (three decimals). [4]

Exercises 2.1·2.3

2.1 The modulus along the fibres (one decimal, GPa). [3]

2.1

- $E_1 = 0.55 \times 230 + 0.45 \times 2.5 = 127.6$ GPa.

2.2 The modulus across the fibres (two decimals, GPa) and the anisotropy ratio (two decimals). [4]

2.2

- $E_2 = 230 \times 2.5/(0.55 \times 2.5 + 0.45 \times 230) = 575/104.9 = 5.48$ GPa.
- Ratio $127.6/5.48 = 23.3$.

2.3 A ceramic has Weibull modulus $m = 8$ and characteristic strength 250 MPa: the survival probability at 200 MPa (three decimals). [4]

2.3

- $P_s = \exp[-(200/250)^8] = \exp[-0.8^8] = \exp[-0.168] = 0.846$.

Exercise 2.4

2.4 One sentence each: why does a mount of nylon 6 need thermal certification, and why does a laminate datasheet quote moduli per direction? [3]

Exercise 2.4

2.4 One sentence each: why does a mount of nylon 6 need thermal certification, and why does a laminate datasheet quote moduli per direction? [3]

2.4

- Nylon's T_g (55°C) sits near service temperature: stiffness and creep change across the transition, so the spring rate must be re-read hot.
- E_1 and E_2 differ by more than an order of magnitude - one number would mislead in the other direction.