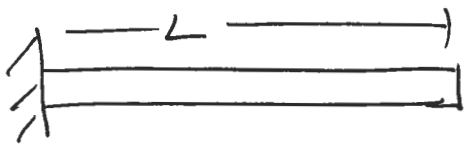

M22 $\delta = \dfrac{2ML^2}{\pi R^4 E}$ Mass, $m = \rho \pi R^2 L$

R is the free variable, ∴ eliminate

$$R = \sqrt{\frac{m}{\rho \pi L}}$$

$$\Rightarrow \delta = \frac{2ML^2}{\pi E}\left(\frac{\rho \pi L}{m}\right)^2$$

$$\text{Mass} = \pi\left(\frac{2M}{\pi\delta}\right)^{\frac{1}{2}} \cdot \left(L^3\right)\left(\frac{\rho}{E^{\frac{1}{2}}}\right)$$

F G M

Minimize $\left(\dfrac{\rho}{E^{\frac{1}{2}}}\right)$, Maximize $\dfrac{E^{\frac{1}{2}}}{\rho}$. ⟸

	ρ (Mg/m³)	E (GPa)	$E^{1/2}/\rho$
6) Steel	7.9	203	1.8
Al	2.8	71	3.0
Ti	4.5	120	2.4
CFRP	1.5	230	10.11 ⟸
HDPE	0.96	1.1	1.1
Wood	0.6	12	5.8
SiC	3.0	410	6.8

Choose CFRP

c) choose material comparable in bending stiffness to bone - match $E^{1/2}/\rho$

18 GPa, $\rho = 1.55$

Draw line of constant $E^{1/2}/\rho$ on graph

possibilities

- low modulus GFRP, CFRP, KFRP composites
  - Cement
  - Rock, stone
  - Ti alloys ⇐
  - ZrO_2

Choose Ti - these are used!