M13 Need to consider possibility of buckling in compressive members of truss

Material selection

achieve certain (required) buckling load while minimizing mass

$$P_{crit} = \frac{\pi^2 E I}{L^2} \qquad \text{~~mass~~ mass} = \pi R^2 L \rho$$

assume circular cross-section $\therefore\ I = \frac{\pi R^4}{4}$

~~mass~~ rewrite $R = \sqrt{\frac{M}{\pi L \rho}}$ & $R^4 = \left(\frac{M}{\pi L \rho}\right)^2$

$$\therefore\ P_{crit} = \frac{\pi^2 E}{L^2} \cdot \frac{\pi}{4} \cdot \left(\frac{M}{\pi L \rho}\right)^2 = M^2 \quad \frac{\pi}{4L^4} \quad \frac{E}{\rho^2}$$

F G M

maximize E/ρ^2 for highest buckling load for given mass

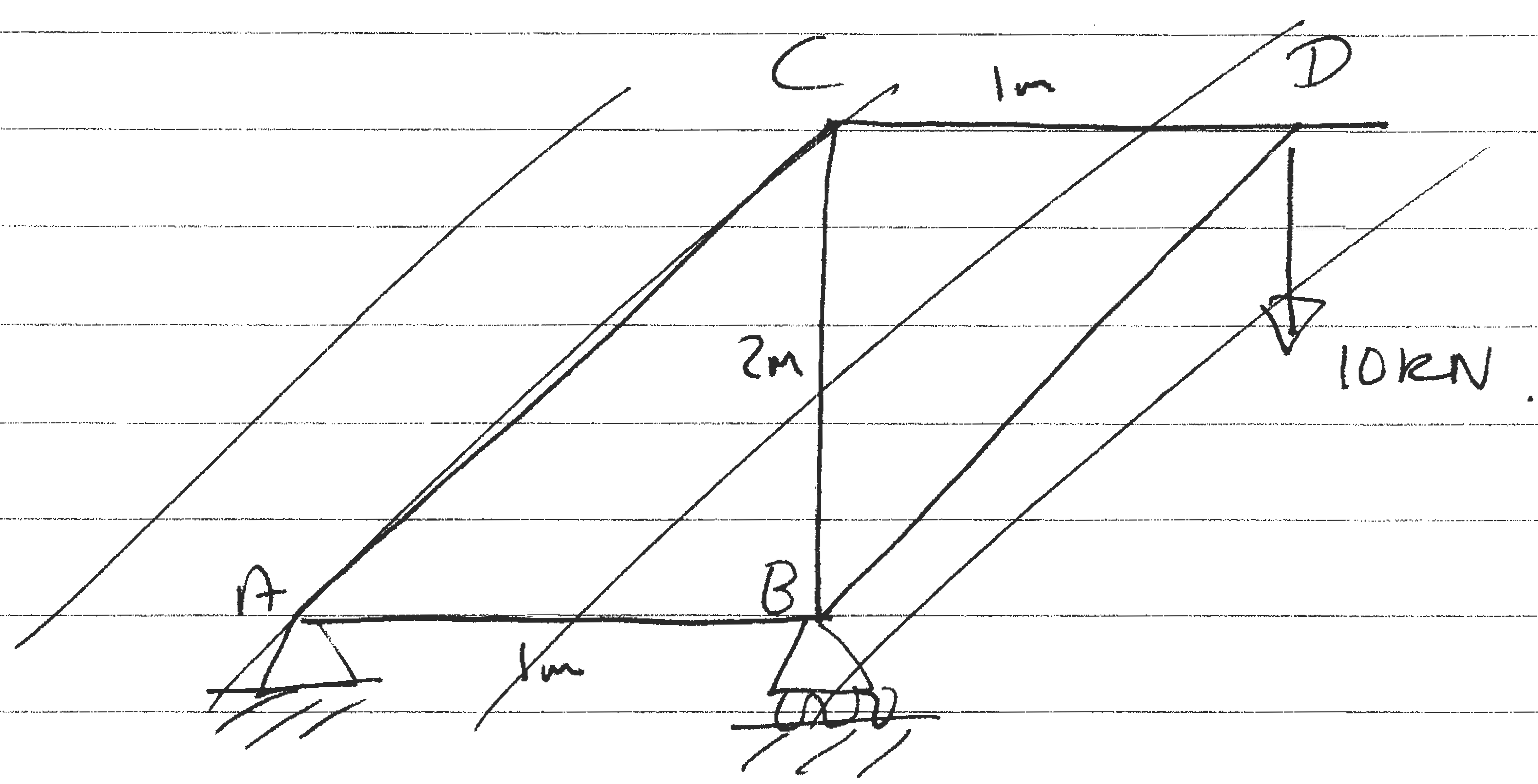
(previously maximize σ_f/ρ)

Reranking materials

	σ_f/ρ	E/ρ^2
Steel	28×10^3	3.3×10^3
Al	125×10^3	9.0×10^3
Ti	188×10^3	5.9×10^3
CFRP	466×10^3	31×10^3
Wood	50×10^3	33×10^3
SiC	100×10^3	45×10^3

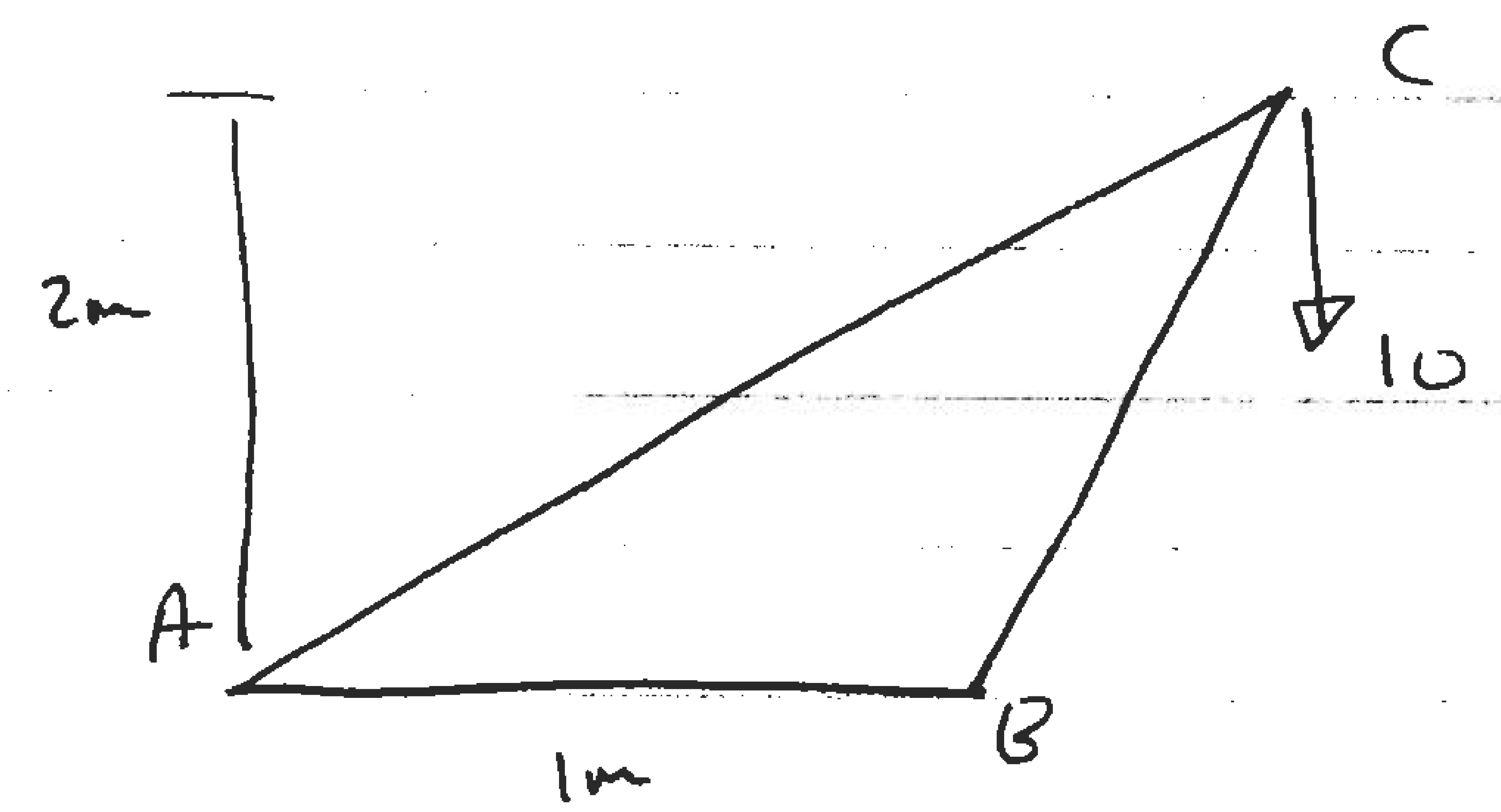
CFRP still looks very good. - high E/ρ^2
Wood might be better in buckling dominated design.

Reconsider design



Costs

Reconsider design.



$F_{AB} = -10$ kN.

$F_{BC} = -22.4$ kN.

BC is the longest member at highest compressive force

∴ only need to consider this.

Assume that it is a simply supported column.

$$P_{crit} = \frac{\pi^2 E I}{L^2}$$ given circular cross-section

$$I = \frac{\pi R^4}{4}$$

$$\therefore P_{crit} = \frac{\pi^2 E \pi R^4}{4 L^2}$$ $L = \sqrt{5}$ m

$$R = \sqrt[4]{\frac{P_{crit} \times 4L^2}{\pi^3 E}} = \sqrt[4]{\frac{22.4\times10^3 \times 4 \times 5}{\pi^3 \times 70\times10^9}}$$

$= 0.021$ m.

∴ area $= \pi R^2 = 0.0014 = 1430\ mm^2$ (cf $32\ mm^2$ before

∴ mass increases by $\frac{1430}{32} = 44.7$ Now ~~weights~~ weighs

$0.29 \times 44.7 = 13.0$ kg!