Prob. 3.3

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Plot the longitudinal tensile strength of a E-glass/epoxy unidirectionally-
reinforced composite, as a function of the volume fraction Vf.
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The necessary numerical parameters for the fiber and matrix are

	S-glass	epoxy
σ_f, GPa	4.5	0.06
E, GPa	85.5	2.4
ε_f	0.053	0.025

The values for ε_f were obtained by assuming linearity; then $\varepsilon_f = \sigma_f / E$. Data for S-glass is from Table 1 (p. 3-2); data for a typical epoxy resin are from published sources.

Since here the matrix breaking strain is less than the fiber breaking strain, the situation is the converse of that which led to Fig. 1.37. If we assume the composite fails when the fibers break, the matrix will already have failed and only the fibers are holding the load. The composite strength is then

sigma[b,1]:=V[f]*sigma[fb];

$$\sigma_{b,1} := V_f \sigma_{fb}$$

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This is obviously not correct at very low volume fractions, where the stress transmitted by both fiber and matrix at the breaking strain of the matrix is

sigma[b,2]:=V[f]*E[f]*epsilon[mb]+(1-V[f])*sigma[mb];

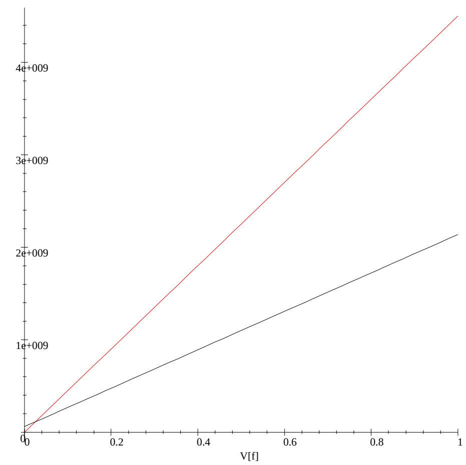
$$\sigma_{b,2} := V_f E_f \varepsilon_{mb} + \left(1 - V_f\right) \sigma_{mb}$$

Numerical parameters:

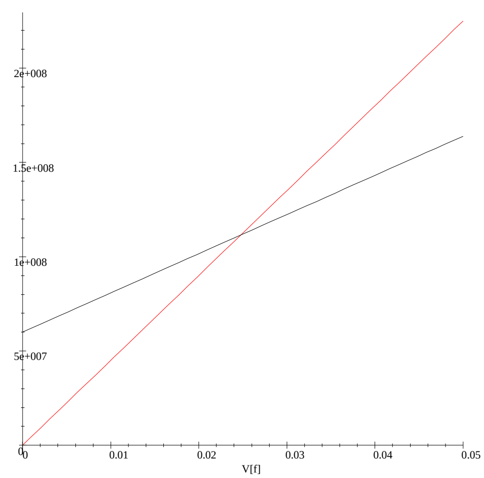
Digits:=4;unprotect(E);E[f]:=85.5e9;epsilon[mb]:=.025;sigma[mb]:=.06e9;sigma[fb]:=4.5e9;

Plotting these two relations, over full and reduced scales of V_f: :

plot({sigma[b,1],sigma[b,2]},V[f]=0..1);



plot({sigma[b,1],sigma[b,2]},V[f]=0..0.05);



Whichever curve is greater for a given V_f should predict the composite strength.