MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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2.002 MECHANICS AND MATERIALS II
EXAMPLE PROBLEM

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Two steels commonly used in the ground vehicle industry are SAE 1015 and SAE 1045. (SAE: Society of Automotive Engineers) Compositions include:

Material	C	Mn	S	Si	P	Fe
1015	0.14%	0.47%	0.025%	0.037%	0.0004%	bal.
1045	0.48%	0.71%	0.025%	0.20%	0.14%	bal.

The 1015 steel is normalized, leading to a Brinnel hardness of $H_B = 80$, and the 1045 is quenched and tempered (at 500^oF), leading to $H_B = 500$. Monotonic stress-strain properties are:

Material	E (ksi)	$(\sigma_y)_{0.2\%}$ (ksi)	UTS (ksi)	ϵ_f	σ_f (ksi)	n
1015	30×10^3	33	60	1.14	105	0.26
1045	30×10^3	245	265	0.71	330	0.047

and cyclic properties include:

Material	$(\sigma'_y)_{0.2\%}$ (ksi)	n'	K' (ksi)	σ'_f (ksi)	ϵ'_f	b	c
1015	35	0.22	137	120	0.95	-0.11	-0.64
1045	185	0.12	–	330	0.25	-0.08	-0.68

(a) On an appropriate log-log plot, construct the strain amplitude/reversals to failure curves for each of the two steels.

(b) Which material is "better" for low cycle fatigue?

(c) Which material is "better" for high cycle fatigue?

(d) Which material cyclically hardened?

(e) Which material cyclically softened?

A design application calls for the material to sustain repeated "blocks" of cyclic straining. Each block of straining consists of the following number of reversals at the specified amplitude:

1 "block" of loading

Strain-Amplitude (ϵ_a)	# of Reversals ($2N$)
0.002	120
0.005	54
0.01	10

(a) Estimate the number of these blocks,"B_f", required to cause fatigue failure in both the 1015 and 1045 steels. Which material would you choose for long fatigue life in this application?

(b) The loading block is altered by eliminating the 10 reversals of $\epsilon_a = 0.01$, but retaining the same number of reversals at the other two strain amplitudes. *Now* how many blocks of life would there be for each material, and which would you choose to design with?

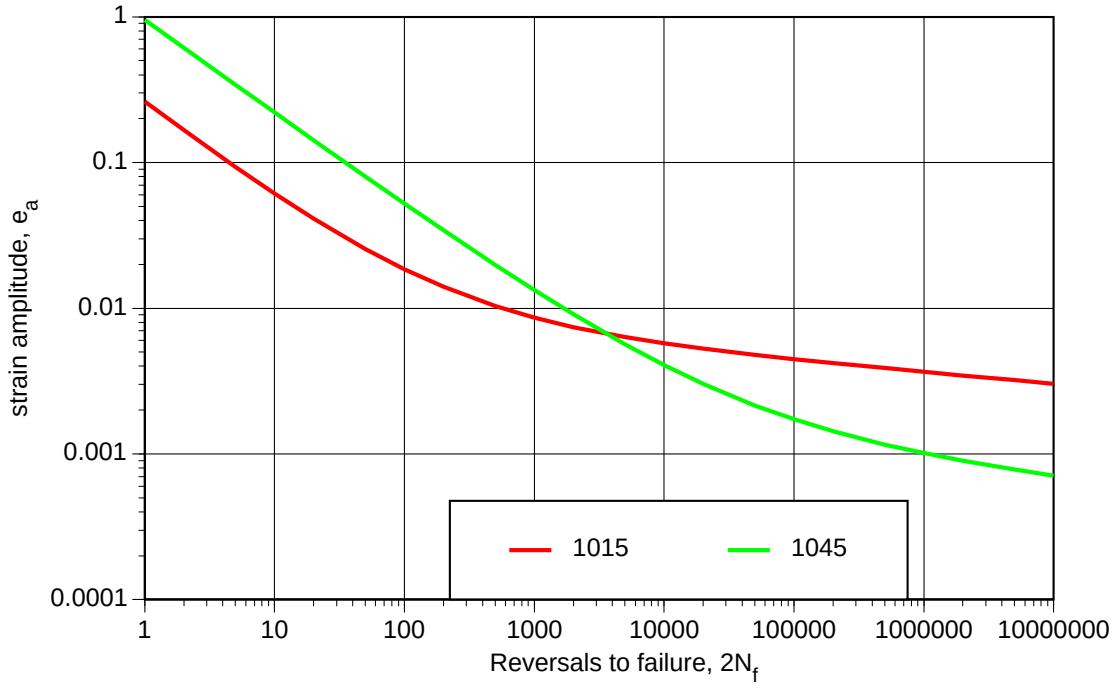

Figure 1: Strain amplitude ϵ_a vs. reversals to failure $2N_f$ for SAE 1015 and 1045 steels.