1. In the $\sigma'_a$ versus $\sigma'_m$ plane, carefully draw the lines and write the equations for the following fatigue failure criteria:
   (a) Soderberg line, (b) modified Goodman line, (c) ASME-elliptic line, (d) Gerber line, and (e) Langer yield line.

2. A shaft has the properties $S_e = 300$ MPa, $S_y = 480$ MPa, and $S_{ut} = 620$ MPa. The shaft is subjected to an alternating bending stress of 120 MPa, an alternating torsional stress of 90 MPa, and a steady torsional stress of 80 MPa. Find the factor of safety $n_y$ guarding against a static failure.

3. For the shaft in Problem 2, find the factor of safety $n_f$ guarding against a fatigue failure using (a) modified Goodman line, (b) ASME-elliptic line, (c) Gerber line.

1. (SMAG Lines from GA to MS and equations) $1 \times 5 = 5$

2. $\sigma'_{\text{max}} = 317.96$ MPa, $n_y = S_y / \sigma'_\text{max} = 1.5096$, $n_y = 1.51$

3. 
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   \sigma'_a = \frac{1}{\sqrt{2}} \left[ 2\sigma_a^2 + 6\tau_a^2 \right]^{1/2} = 196.723 \text{ MPa}
   
   \sigma'_m = \frac{1}{\sqrt{2}} \left[ 6\tau_s^2 \right]^{1/2} = 138.564 \text{ MPa}
   
   (a) Modified Goodman line: $n_f = 1.14$
   
   (b) ASME-elliptic line: $n_f = 1.40$
   
   (c) Gerber line: $n_f = 1.38$