Static and Fatigue Failure

Step		Static			Fatigue				
1	Applied Loads	Include Tension (4.7), Shear (4.8), Bending (4.9), Torsion (4.12), Pressure (4.17), and Combined (4.13). See also Beam Deflection (4.10), Castigliano (4.11), Stress Concentrations (4.15), and Buckling (4.16) as appropriate.			Identify loads that vary with time.				
2	Internal Loads	Draw free body diagrams to identify internal forces and moments. (3.2) Use shear and moment diagrams to identify peak forces and moments. (App. D)			Draw free body diagrams to identify internal forces and moments. (3.2) Use shear and moment diagrams to identify peak forces and moments. (App. D) Graph loads versus time.				
3	Applied Stresses	Identify distribution of stress from Tension (4.7), Shear (4.8), Bending (4.9), Torsion (4.12), Pressure (4.17), and Combined (4.13).			Identify distribution of stress from Tension (4.7), Shear (4.8), Bending (4.9), Torsion (4.12), Pressure (4.17), Combined (4.13). Stress versus time must recognize mean stress and alternating stress.				
4	Critical Locations	At possible critical locations, show stress on element. Remember that Geometric Stress Concentrations (4.15) may force some locations to be critical.			At possible critical locations, show stress on element. Remember that Geometric Stress Concentrations (4.15) may force some locations to be critical. Stress versus time must recognize mean stress and alternating stress.				
5	Max Stresses at Critical Locations	Calculate principal stresses to obtain the maximum values of normal anc shear stress at the critical locations. (Mohr's Circle) (4.3, 4.5)			Calculate principal stresses to obtain the maximum values of normal and shear stress at the critical locations. (Mohr's Circle) (4.3, 4.5) Stress versus time must recognize mean stress and alternating stress.				
6	Failure Category	Ductile material where the yield strength is appreciably lower than the ultimate strength. (5.1)	Brittle material where tensile stress is primarily responsible for fracture. (5.2)	Linear elastic fracture mechanics (LEFM), (5.3), where a crack is primarily responsible for fracture.	Category I: Uniaxial stress, zero mean stress (Sec. 6.10)	Category II: Uniaxial stress, non-zero mean stress	Category III: Multi-axial stress, zero mean stress	Category IV: Multi-axial stress, non-zero mean stress	Crack Growth (Eq 6.4)
7	Effective Stress	Use von Mises to calculate uniaxial tension stress that would create the same distortional energy as the applied stresses. (Eq 5.7)	Use the Dowling effective stress (Eq 5.12)	Eq 5.14 K=f(a, stress)	Use von Mises to create effective alternating stress. Include Stress Concentration Factors (Neuber, Eq. 6.12).	Use von Mises to create effective mean and alternating stresses. Include Stress Concentration Factors (Neuber, Eq. 6.12).	Use von Mises (Eq 6.19) to create effective alternating stress. Include Stress Concentration Factors (Neuber, Eq. 6.12).	In-phase = simple = SINES or von Mises (with stress concentrations) ; Out-of-phase = complex = SEQA (can include stress concentrations).	Eq 6.3 delta K=f(a, stress)
8	Failure Envelope	Use distortion energy, aka von Mises-Hencky, on principal stress plot.	Use modified Mohr cutoffs on principal stress graph.	Stress intensity factor = fracture toughness.	Use Modified Endurance Limit	Use Modified Goodman Diagram including modified fatigue strength.	Use effective stress at desired point on S-N Diagram.	Use Modified Goodman Diagram including modified fatigue strength.	When crack length = critical crack length.
9	Safety Factor	Eq 5.8 $N=S_y$/sig-prime	Eq 5.12 $N=S_{ut}$/sig-one (in 1st quadrant)	Eq 5.15 $N_{fm}=K_c/K$	Eq 6.14 $N_f=S_n$/sig-prime	Eq 6.18 Case 1-4	Eq 6.20 $N_f=S_n/sig_a$-prime	Eq 6.18 Case 1-4	Eq 6.4 Integrate da/dN=A(delta-K)^n ; then set N_f = (N to critical crack)/(N for Life Required)