Problem 1 (fatigue loading)
The figure shows a fluid-pressure linear actuator (hydraulic cylinder) in which $D = 4$, $t = 3/8$, $L = 12$ and $w = \frac{3}{4}$, all in inches. Both brackets as well as the cylinder are of steel. The actuator has been designed for a working pressure of 0 to 2500 psi. Six 3/8-inch SAE grade 5 coarse-thread bolts are used, tightened to 75 percent of proof load. The endurance limit for SAE grade 5 and 3/8 inch bolt is 18.6kpsi. The joint constant has been calculated as 0.2. (hint: you will need to find the bolt information from Table 8-1 and 8-9)

(a) Using the Goodman criterion, find the factor of safety guarding against a fatigue failure?
(b) What pressure would be required to cause total joint separation?

Problem 2 (Eccentric Loading)
Find the shear load on each of the three bolts for the connection shown in the figure.
### Table 8-2

Diameters and Area of Unified Screw Threads UNC and UNF

<table>
<thead>
<tr>
<th>Size Designation</th>
<th>Nominal Major Diameter in</th>
<th>Threads per Inch ( \ell )</th>
<th>Tensile-Stress Area ( A_s ), in²</th>
<th>Minor-Diameter Area ( A_m ), in²</th>
<th>Threads per Inch ( \ell )</th>
<th>Tensile-Stress Area ( A_s ), in²</th>
<th>Minor-Diameter Area ( A_m ), in²</th>
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<tbody>
<tr>
<td>0</td>
<td>0.3600</td>
<td>64</td>
<td>0.00213</td>
<td>0.00218</td>
<td>80</td>
<td>0.00180</td>
<td>0.00151</td>
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<td>0.00370</td>
<td>0.00310</td>
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<td>0.00278</td>
<td>0.00237</td>
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<td>0.00451</td>
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<td>0.00745</td>
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<td>0.01015</td>
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<td>0.01450</td>
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<td>0.02000</td>
<td>0.01750</td>
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<td>24</td>
<td>0.0242</td>
<td>0.0206</td>
<td>28</td>
<td>0.02580</td>
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<td>0.5160</td>
<td>20</td>
<td>0.0311</td>
<td>0.0269</td>
<td>28</td>
<td>0.03640</td>
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<td>0.0524</td>
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<tr>
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<td>16</td>
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<td>0.0678</td>
<td>24</td>
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<td>0.5000</td>
<td>13</td>
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<td>0.1890</td>
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<tr>
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<td>11</td>
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<td>0.202</td>
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<td>0.2400</td>
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<tr>
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<td>0.7500</td>
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<td>0.334</td>
<td>0.302</td>
<td>16</td>
<td>0.37300</td>
<td>0.3510</td>
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<tr>
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<td>0.8750</td>
<td>9</td>
<td>0.462</td>
<td>0.419</td>
<td>14</td>
<td>0.50900</td>
<td>0.4600</td>
</tr>
<tr>
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<td>1.0000</td>
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<td>0.606</td>
<td>0.551</td>
<td>12</td>
<td>0.66300</td>
<td>0.6250</td>
</tr>
<tr>
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<td>1.2500</td>
<td>7</td>
<td>0.969</td>
<td>0.890</td>
<td>12</td>
<td>1.07300</td>
<td>1.0240</td>
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<tr>
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<td>1.5000</td>
<td>6</td>
<td>1.405</td>
<td>1.294</td>
<td>12</td>
<td>1.58100</td>
<td>1.5210</td>
</tr>
</tbody>
</table>

*This table was compiled from ANSI B1.19. The minor diameter was found from the equation \( d_m = d - 1.519 \times 0.38 \), and the pitch diameter from \( D_p = d - 0.629 \times 0.38 \). The mean of the pitch diameter and the minor diameter was used to compute the tensile-stress area.

### Figure 8-3

(a) Square thread; (b) Acme thread
### Table 8-9

SAE Specifications for Steel Bolts

<table>
<thead>
<tr>
<th>SAE Grade No.</th>
<th>Size Range Inclusive, in</th>
<th>Minimum Proof Strength, kpsi</th>
<th>Minimum Tensile Strength, kpsi</th>
<th>Minimum Yield Strength, kpsi</th>
<th>Material</th>
<th>Head Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$\frac{1}{4}$-$\frac{1}{2}$</td>
<td>33</td>
<td>60</td>
<td>36</td>
<td>Low or medium carbon</td>
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</tr>
<tr>
<td>2</td>
<td>$\frac{1}{2}$-$\frac{3}{4}$</td>
<td>55</td>
<td>74</td>
<td>57</td>
<td>Low or medium carbon</td>
<td><img src="image" alt="Head Marking" /></td>
</tr>
<tr>
<td></td>
<td>$\frac{7}{8}$-$1\frac{1}{2}$</td>
<td>33</td>
<td>60</td>
<td>36</td>
<td></td>
<td><img src="image" alt="Head Marking" /></td>
</tr>
<tr>
<td>4</td>
<td>$\frac{1}{2}$-$1\frac{1}{2}$</td>
<td>65</td>
<td>115</td>
<td>100</td>
<td>Medium carbon, cold-drawn</td>
<td><img src="image" alt="Head Marking" /></td>
</tr>
<tr>
<td>5</td>
<td>$\frac{1}{4}$-$1$</td>
<td>85</td>
<td>120</td>
<td>92</td>
<td>Medium carbon, Q&amp;T</td>
<td><img src="image" alt="Head Marking" /></td>
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<tr>
<td></td>
<td>$1\frac{1}{4}$-$1\frac{1}{2}$</td>
<td>74</td>
<td>105</td>
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<td></td>
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<tr>
<td>6</td>
<td>$\frac{1}{2}$-$1$</td>
<td>85</td>
<td>120</td>
<td>92</td>
<td>Low-carbon martensite, Q&amp;T</td>
<td><img src="image" alt="Head Marking" /></td>
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<tr>
<td>7</td>
<td>$\frac{1}{2}$-$1\frac{1}{2}$</td>
<td>105</td>
<td>133</td>
<td>115</td>
<td>Medium-carbon alloy, Q&amp;T</td>
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<td>8</td>
<td>$\frac{1}{4}$-$1\frac{1}{2}$</td>
<td>120</td>
<td>150</td>
<td>130</td>
<td>Medium-carbon alloy, Q&amp;T</td>
<td><img src="image" alt="Head Marking" /></td>
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<tr>
<td>9</td>
<td>$\frac{1}{4}$-$1$</td>
<td>120</td>
<td>150</td>
<td>130</td>
<td>Low-carbon martensite, Q&amp;T</td>
<td><img src="image" alt="Head Marking" /></td>
</tr>
</tbody>
</table>

*Minimum strengths are strengths exceeded by 99 percent of testers.

ASTM specifications are listed in Table 8-10. ASTM threads are shorter because ASTM deals mostly with structures; structural connections are generally loaded in shear and the decreased thread length provides more shank area.

Specifications for metric fasteners are given in Table 8-11.

It is worth noting that all specification-grade bolts made in this country bear a manufacturer's mark or logo, in addition to the grade marking, on the bolt head. Such marks confirm that the bolt meets or exceeds specifications. If such marks are missing, the bolt may be imported; for imported bolts there is no obligation to meet specifications.

Bolts in fatigue axial loading fail at the fillet under the head, at the thread root, and at the first thread engaged in the nut. If the bolt has a standard shoulder under the