1. The thin-walled open cross-section shown in the figure (not to scale) is transmitting torque $T$. The angle of twist per unit length is $\theta$, which can be found by using the following equation:

$$T = \frac{G\theta}{3} \sum_{i=1}^{3} L_i c_i^3,$$

where for this case, $i = 1, 2, 3$, $L_i$ represents the leg length, $c_i$ represents the leg width, and $G$ is the shear modulus. The values of these variables in this case can be found in the table below.

In addition, the maximum of the shear stress $r_{\text{max}}$ can be found by using the following equation:

$$r_{\text{max}} = G\theta c_{\text{max}},$$

where $c_{\text{max}}$ is the maximum value of $c_1$, $c_2$, and $c_3$ in this case. Consider the allowable shear stress to be 36 MPa,

(a) Determine the angle of twist per unit length $\theta$. (15%)

(b) Determine the torque $T$ transmitted by the entire section. (10%)

(本题佔分 25%)

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<table>
<thead>
<tr>
<th>$c_1$</th>
<th>$L_1$</th>
<th>$c_2$</th>
<th>$L_2$</th>
<th>$c_3$</th>
<th>$L_3$</th>
<th>$G$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mm</td>
<td>20 mm</td>
<td>3 mm</td>
<td>30 mm</td>
<td>2 mm</td>
<td>25 mm</td>
<td>80 GPa</td>
</tr>
</tbody>
</table>
2. The cold-drawn AISI 1040 steel bar shown in the figure (not to scale) is subjected to a static load of 24 kN. The yield strength of cold-drawn AISI 1040 is 490 MPa.
(a) Determine the maximum tensile stress $\sigma_{\text{max}}$ in the bar due to the stress concentration effect. (15%)
(b) Determine the yielding factor of safety. (10%)
(本题佔分 25%)

Axial tension

$$
\begin{align*}
\sigma_{\text{max}} &= \sigma_A = K_t \sigma_{\text{y}}, \\
\sigma_{\text{yourn}} &= P/[l(D - d)] \\
K_t &= 3.000 - 3.140(d/D) + 3.667(d/D)^2 - 1.527(d/D)^3 \\
& \text{for } 0 \leq d/D \leq 1
\end{align*}
$$
3. The 10 kg slider is released from rest at position A and slides in a vertical plane along the circular rod with a constant frictional force 20 N. The attached spring has a stiffness of 300 N/m and has an unstretched length of 0.5 m.

![Diagram of a slider on a circular rod]

When the slider passes position B, please determine
(a) The velocity of the slider at the position B (15%)
(b) The acceleration of the slider at the position B (10%)
(本題佔分 25%)

4. A car is traveling along a circular curve that has a radius of 50 m. If it starts from rest at \( t = 0 \) and is increasing uniformly at 2 m/s\(^2\). Please determine
(a) The magnitude of its acceleration at \( t = 5 \) second (10%)
(b) The time needed for its acceleration to reach 8 m/s\(^2\) (15%)
(本題佔分 25%)