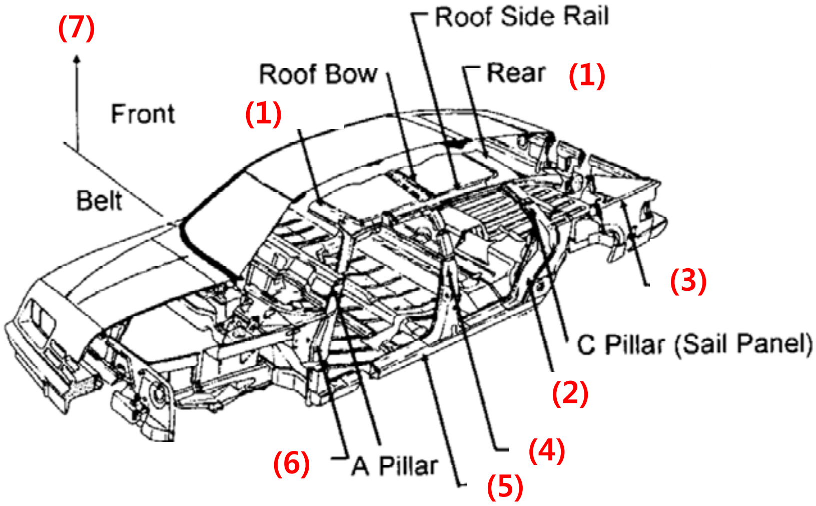
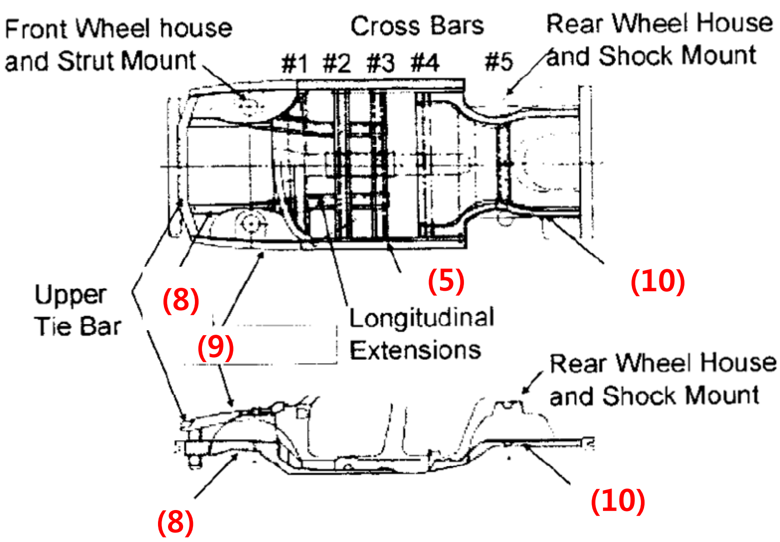
1. Fill in the part names. (2 pts each)





2. For a flat plate with simply supported edge constraint ($\nu = 0.3$), (10 pts)

(1) For mild steel $\sigma_{\text{yield}} = 207\left[\text{N/mm}^2\right]$ and $E = 207{,}000\left[\text{N/mm}^2\right]$, what is the numerical b/t ratio at which σ_{yield} and σ_{critical} be equal?

(2) Explain the failure mechanism in terms of b/t ratio.

(3) A typical aluminum alloy has $\sigma_{\text{yield}} = 345\left[\text{N/mm}^2\right]$ and $E = 69{,}000\left[\text{N/mm}^2\right]$ what is b/t ratio where σ_{yield} and σ_{critical} are equal?

3. An untreated thin-walled section performs so poorly under a point load. Describe several strategies to reduce the local distortion so that the idealized beam stiffness is more fully utilized. (10 pts)

4. Describe techniques to inhibit plate buckling. (10 pts)

5. Consider the steering column mounting beam. ($E = 207{,}000\left[\mathrm{N}/\mathrm{mm}^2\right]$, $G = 78{,}000\left[\mathrm{N}/\mathrm{mm}^2\right]$) We can view this beam with non-symmetrical section as a cantilever with a downward vertical tip load. [centroid (35.5, 35.5), principal axes: u, v] (30 pts)

(1) Determine the tip deflection. ($\delta = Fl^3/3EI$)

(2) Determine the stress at a specific point A where the beam joins the restraining structure. ($\sigma_z = My/I_x$)

Consider again the steering column mounting beam, but now under a pure torque of $T = 25\times10^4\left[\mathrm{N}\cdot\mathrm{mm}\right]$.

(3) Determine the angle of rotation.

(4) Determine the shear stress.

Consider again the steering column mounting beam, but now, rather than a closed section, there is a very thin slot.

(5) Determine the angle of rotation.

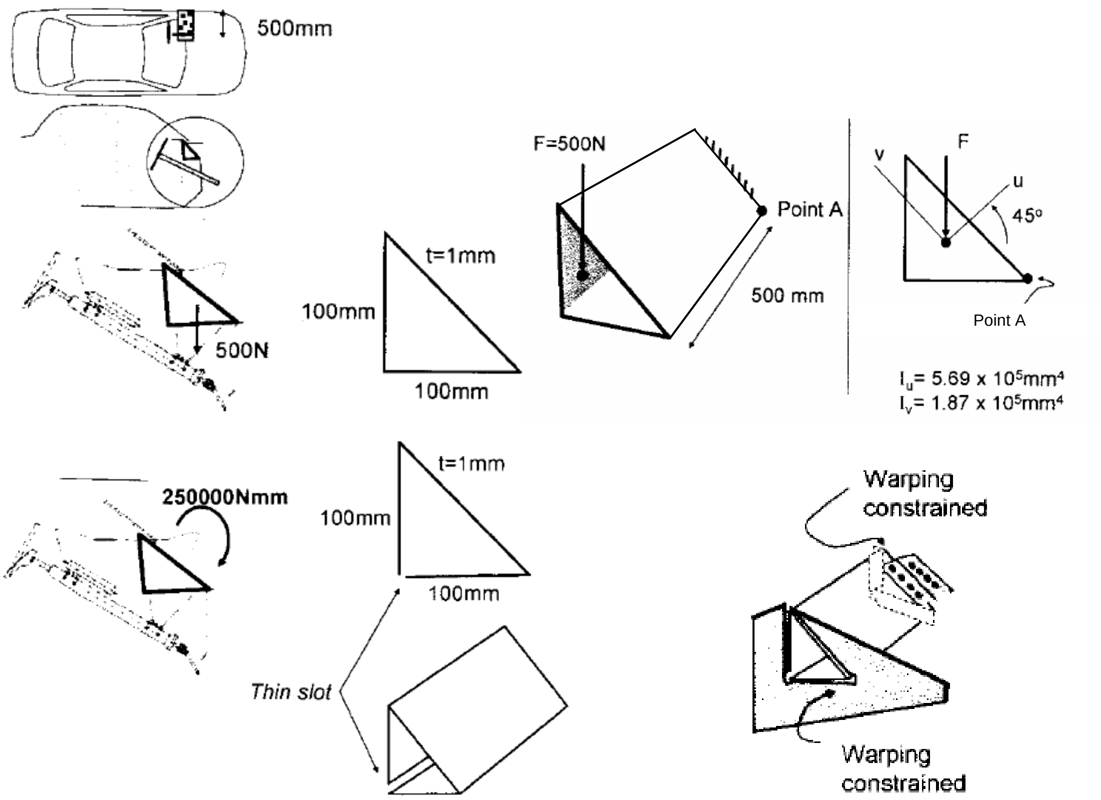
(6) Determine the shear stress.

(7) Describe what happened if torsion members with open section are used.

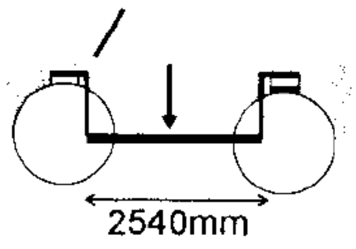
Previously unrestrained warping is allowed in the calculation of angle of rotation, now both ends from out-of-plane deflection are constrained by adding a very stiff mounting bracket to each end.

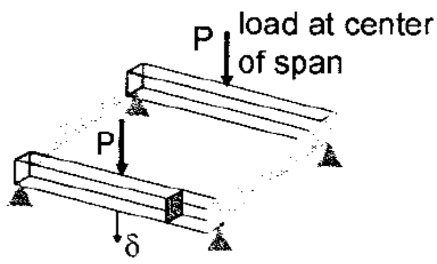
(8) Determine the angle of rotation. ($C_w = 1.4\times10^9\left[\mathrm{mm}^6\right]$)

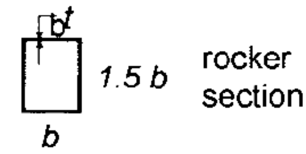
(9) Describe advantages and disadvantages of the constraining warping.



6. Consider a highly idealized convertible. The bending performance of this vehicle is provided by the two rocker sections, which act as center-loaded simply supported beams. The specified bending stiffness requirement for the vehicle is 3335 [N/mm] and strength requirement is 3335 [N]. We wish to determine the mild steel rocker section width *b*, and thickness, *t*, which meets both strength and stiffness requirements at a minimum mass. (20 pts)





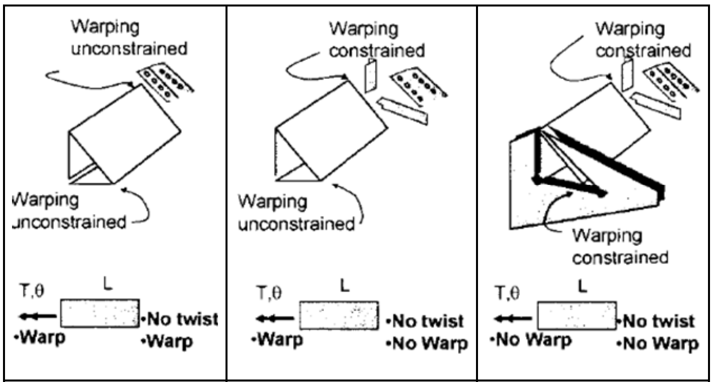


$$\delta = \frac{FL^3}{48EI}$$

[Reference Sheet]

Torsion of members with closed/open section

	closed section	open section
Angle of rotation	$\theta = \dfrac{TL}{GJ_{eff}}$	
Shear stress	$\tau = \dfrac{T}{2At}$	$\tau = \dfrac{Tt}{J_{eff}}$
Constant thickness	$J_{eff} = \dfrac{4A^2 t}{S}$	$J_{eff} = \dfrac{1}{3} t^3 S$
Non-uniform thickness	$J_{eff} = 4A^2 \Big/ \sum_i \dfrac{S_i}{t_i}$	$J_{eff} = \dfrac{1}{3} \sum_i t_i^3 S_i$



$\theta = \dfrac{TL}{GJ}$	$\theta = \dfrac{TL}{GJ}\left(1 - \dfrac{\tanh kL}{kL}\right)$	$\theta = \dfrac{TL}{GJ}\left(1 - \dfrac{\tanh kL/2}{kL/2}\right)$

$$k = \sqrt{\frac{JG}{C_w E}}$$

plate bending stiffness:

$$D = \frac{Et^3}{12\left(1-\nu^2\right)}$$

critical compressive plate buckling stress:

$$\sigma_{cr} = \frac{D\pi^2}{tb^2} k$$

Case	Boundary Condition	Loading	k
(a)	ss ss ss ss	Compression	4.0
(b)	ss fixed fixed ss	Compression	6.97
(c)	ss ss free ss	Compression	0.425
(d)	ss fixed free ss	Compression	1.277
(e)	ss fixed ss ss	Compression	5.42
(f)	ss ss ss ss	Shear	5.34
(g)	ss fixed free ss	Shear	8.98
(h)	ss ss ss ss	Bending	23.9
(i)	fix fixed fixed fix	Bending	41.8