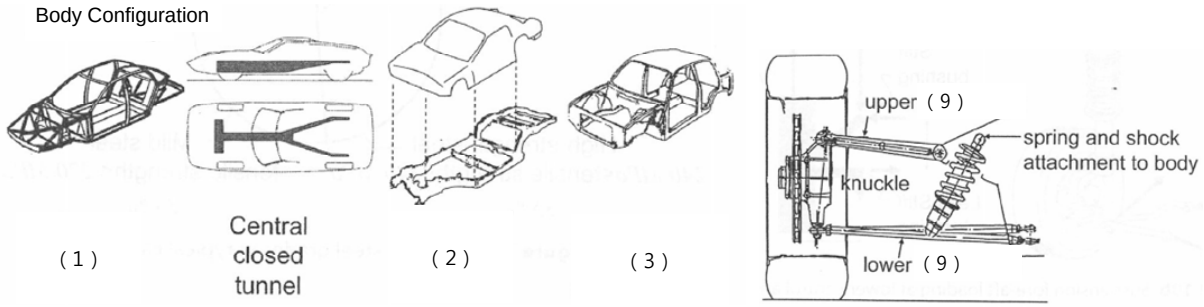
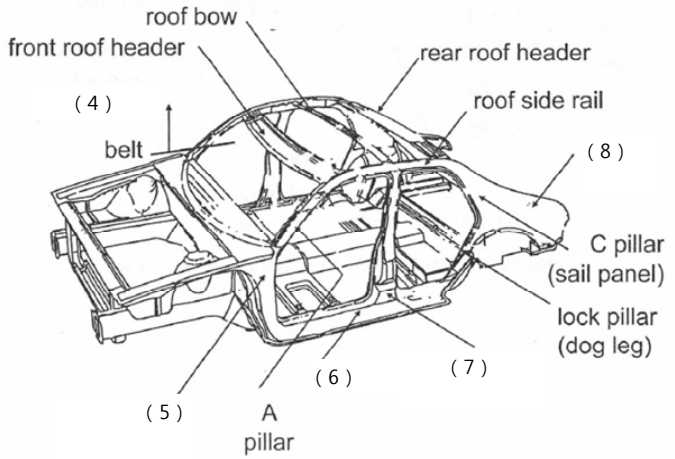
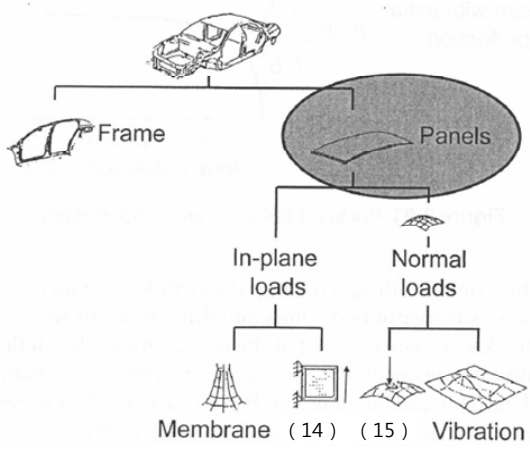
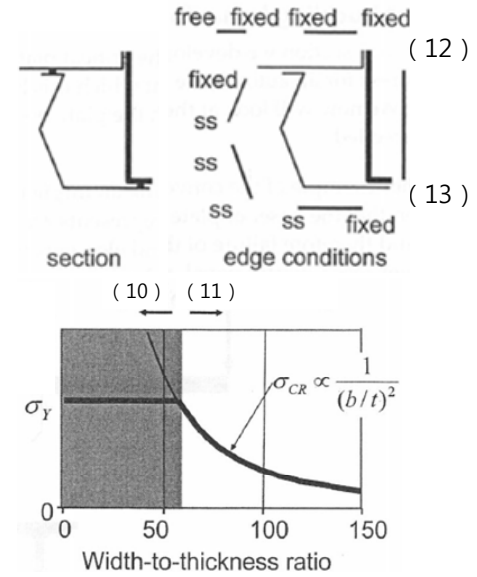
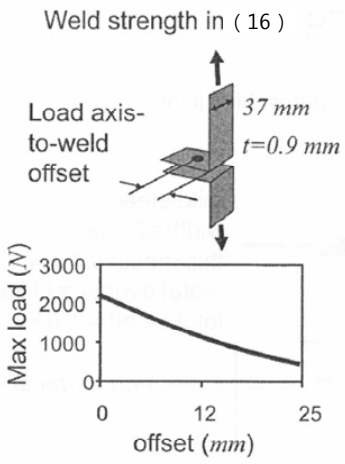
1. Fill in the blanks.

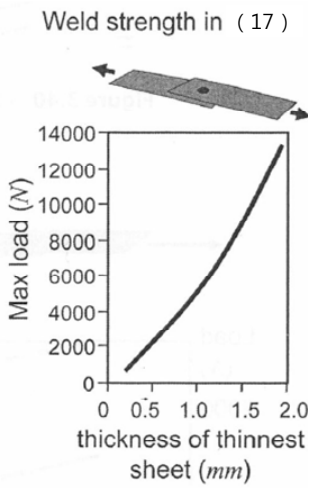












* In the (18) category, he deformations are small and elastic and are characterized by (18)–the ratio of applied load per unit of deformation.

* The (19) category is characterized by the onset of a small permanent deformation. The requirement is stated as the lowest load at which a permanent deformation first appears.

* The (20) category is characterized by very large permanent deformations where the amount of energy absorbed by the structure during deformation is of interest.

2. Describe the strategies to establish the bending stiffness and torsion stiffness requirements, respectively. (10 pts)

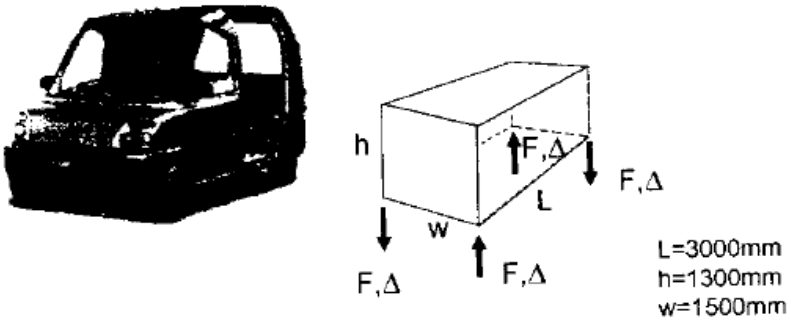
3. The shear panel at the intersection of the beams is relatively highly loaded in shear and can be prone to shear buckling. Also the bar elements at the front and rear of the B pillar are relatively highly loaded in compression and can be prone to compressive buckling. Describe means to solve both of these concerns. (10 pts)

4. Consider the van box model for torsion.

(1) Determine the shear loads in each panel when F = 8000N. (10 pts)

(2) Show that the torsional stiffness of box is $K = \frac{T}{\theta} = (2wh)^2 \frac{1}{\sum_{\text{all surfaces}} \left[\frac{ab}{(Gt)}\right]_i}$. (10 pts)

(3) Determine the torsional stiffness if all panels are perfectly flat panels 1mm thick. (G=80,000N/mm^2) (5 pts)



5. Consider the steering column mounting beam. ($E = 207,000\left[\mathrm{N/mm^2}\right]$, $G = 78,000\left[\mathrm{N/mm^2}\right]$) 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] (25 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 $T = 25\times10^4\left[\mathrm{N\cdot mm}\right]$.

(3) Determine the angle of rotation.

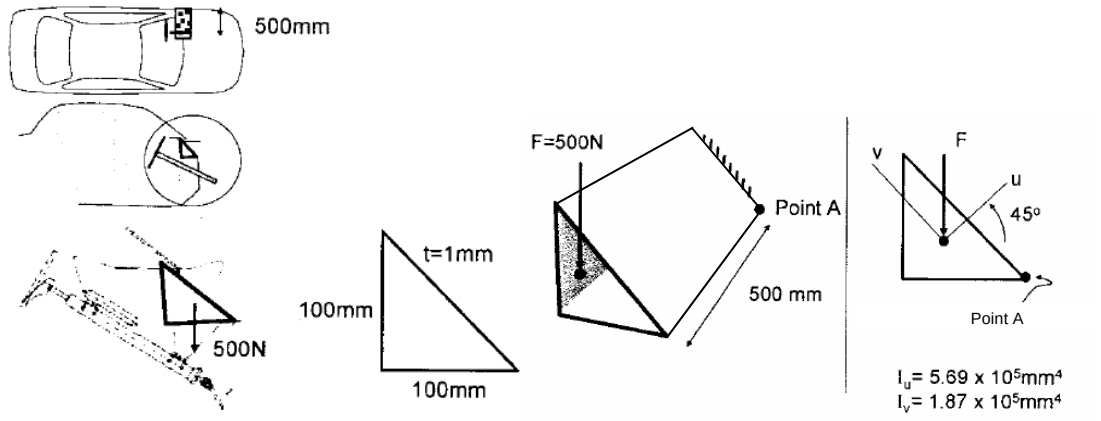
(4) Determine the shear stress.

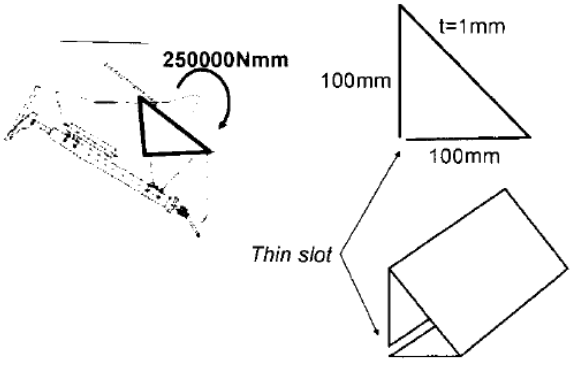
Consider again the steering column mounting beam, but now, rather than a closed section, there is a very thin slot.

(5) Determine the angle of rotation.

(6) Determine the shear stress.

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





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