1. (2 pts each)

(1)	space frame	(2)	body on frame
(3)	body-frame integral (monocoque)	(4)	greenhouse
(5)	hinge pillar	(6)	rocker
(7)	B pillar	(8)	quarter panel
(9)	control arm	(10)	yield
(11)	plate buckling	(12)	ss
(13)	ss	(14)	shear
(15)	dent	(16)	peel
(17)	shear	(18)	stiffness
(19)	strength	(20)	energy absorption

2. (5 pts each)

(1) Bending stiffness: H point bending test (slope of load-deflection curve), resonant frequency as with a simple beam

(2) Torsion stiffness: torsion test (slope of couple vs. angular rotation), good handling property (K_body = 10*(K_roll)), solid structural feel (high fundamental natural frequency of the body twisting mode)

3. (5 pts each)

(1) Use rib pattern (V rib pattern increases the shear buckling stress to the panel while the vertical ribs provide a path for the compressive load)

(2) Increase the span (provide a filleted transition)

4.

$$(1)\ \ (10\text{ pts})\begin{cases} F_w = \dfrac{Fw}{2h} = \dfrac{(8000N)(1500mm)}{2(1300mm)} = 4615.4N \\ F_h = \dfrac{F}{2} = 4000N \\ F_L = \dfrac{FL}{2h} = \dfrac{(8000N)(3000mm)}{2(1300mm)} = 9230.8N \end{cases}$$

$$(2)\ \ (10\text{ pts})\begin{cases} e = \int \dfrac{\tau\gamma}{2}dV = \int \dfrac{\tau^2}{2G}dV = \dfrac{(q/t)^2}{2G}(abt) = q^2\dfrac{ab}{2(Gt)} \\ \dfrac{1}{2}T\theta = \sum\limits_{\text{all surfaces}} \dfrac{1}{2}q^2\left[\dfrac{ab}{(Gt)}\right]_i \xrightarrow{q=\frac{F}{2h}=\frac{T/w}{2h}=\frac{T}{2wh}} \dfrac{1}{2}T\theta = \sum\limits_{\text{all surfaces}} \dfrac{1}{2}\left(\dfrac{T}{2wh}\right)^2\left[\dfrac{ab}{(Gt)}\right]_i \\ \theta = T\left(\dfrac{1}{2wh}\right)^2 \sum\limits_{\text{all surfaces}}\left[\dfrac{ab}{(Gt)}\right]_i \rightarrow K = \dfrac{T}{\theta} = (2wh)^2\dfrac{1}{\sum\limits_{\text{all surfaces}}\left[\dfrac{ab}{(Gt)}\right]_i} \end{cases}$$

$$(3)\ \ (5\text{ pts})\begin{cases} \text{Front \& Rear: } \dfrac{ab}{Gt} = \dfrac{(1300mm)(1500mm)}{80000N/mm^2} = 24.375 \\ \text{Top \& Bottom: } \dfrac{ab}{Gt} = \dfrac{(1500mm)(3000mm)}{80000N/mm^2} = 56.25 \\ \text{Right \& Left: } \dfrac{ab}{Gt} = \dfrac{(1300mm)(3000mm)}{80000N/mm^2} = 48.75 \end{cases}$$

$$K = \frac{T}{\theta} = (2wh)^2\frac{1}{\sum\limits_{\text{all surfaces}}\left[\dfrac{ab}{(Gt)}\right]_i} = 4(1500mm)^2(1300mm)^2\frac{1}{2(24.375+56.25+48.75)}$$

$$= 5.88E10[Nmm/rad] = 1.03E6[Nm/°]$$

5. (4 pts each*6 +1)

$$(1)\ \ \delta_u = \frac{F_u l^3}{3EI_v} = \frac{(500N\sin 45°)(500mm)^3}{3\left(207\times10^3 N/mm^2\right)\left(1.87\times10^5 mm^4\right)} = 0.38mm$$

$$\delta_v = \frac{F_v l^3}{3EI_u} = \frac{(500N\cos 45°)(500mm)^3}{3\left(207\times10^3 N/mm^2\right)\left(5.69\times10^5 mm^4\right)} = 0.125mm$$

$$\delta = \sqrt{(\delta_u)^2 + (\delta_v)^2} = 0.4mm$$

$$(2)\ \ \sigma_u = -\frac{M_u v}{I_u} = -\frac{(-500N\cos 45°\times500mm)(-70.7mm)}{5.69\times10^5 mm^4} = -22N/mm^2$$

$$\sigma_v = -\frac{M_v v}{I_v} = -\frac{(-500N\sin 45°\times500mm)(20.7mm)}{1.87\times10^5 mm^4} = +19.57N/mm^2$$

$$\sigma_A = \sigma_u + \sigma_v = -2.43N/mm^2$$

(3) $J_{eff} = \dfrac{4A^2}{\oint \frac{dS}{t}} = \dfrac{4A^2 t}{S} = \dfrac{4\left(\frac{1}{2}100^2\,mm^2\right)^2 (1mm)}{(100+100+141.4mm)} = 2.929\times10^5\,mm^4$

$\theta = \dfrac{Tl}{GJ_{eff}} = \dfrac{(25\times10^4\,Nmm)(500mm)}{\left(78\times10^3\,N/mm^2\right)\left(2.929\times10^5\,mm^4\right)} = 5.47\times10^{-3}\,rad\,(0.312°)$

(4) $\tau = \dfrac{T}{2At} = \dfrac{25\times10^4\,Nmm}{2\left(\frac{1}{2}100^2\,mm^2\right)(1mm)} = 25N/mm^2$

(5) $J_{eff} = \dfrac{1}{3}t^3 S = \dfrac{1}{3}(1mm)^3(100+100+141.4mm) = 113.8mm^4$

$\theta = \dfrac{Tl}{GJ_{eff}} = \dfrac{(25\times10^4\,Nmm)(500mm)}{\left(78\times10^3\,N/mm^2\right)\left(113.8mm^4\right)} = 14.1rad\,(803°)$

(6) $\tau = \dfrac{Tt}{J_{eff}} = \dfrac{(25\times10^4\,Nmm)(1mm)}{113.8mm^4} = 2197N/mm^2$

(7) It is beyond the linearity assumptions, however we learn that not only is the section very flexible, but the shear stress is quite high compared to the closed section.