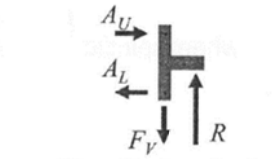
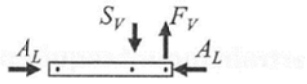
1. (2 pts each)

(1)	space frame	(2)	body on frame
(3)	body-frame integral (monocoque)	(4)	compartment
(5)	dash	(6)	strut
(7)	Mid rail	(8)	frame
(9)	panel	(10)	joints
(11)	brackets	(12)	Spot weld
(13)	shear	(14)	dent
(15)	shear	(16)	peel
(17)	yield	(18)	plate buckling
(19)	SS	(20)	SS

2. (3 pts each)



Knuckle free body



Lower arm free body

$$\sum F_x = 0 : A_U - A_L = 0 \rightarrow A_U = A_L$$

$$\sum F_y = 0 : S_V - A_V - R = 0 \rightarrow S_V = R + A_V$$

$$\sum \mathrm{M}_{@\,lowerarm,F_V} = 0 : \; bA_V - (b-\lambda b)S_V = 0 \rightarrow A_V = (1-\lambda)S_V$$

$$\rightarrow S_V = R + (1-\lambda)S_V \rightarrow \underline{S_V = \frac{1}{\lambda}R}$$

$$\sum \mathrm{M}_{@\,knuckle,F_V} = 0 : eR - dA_U = 0 \rightarrow A_U = \frac{e}{d}R$$

$$\underline{A_L = A_U = \frac{e}{d}R}$$

$$\underline{A_V = (1-\lambda)S_V = (1-\lambda)\frac{1}{\lambda}R = (\frac{1}{\lambda}-1)R}$$

3. (4 pts each)

Non-symmetrical nature of automotive beams

Local distortion of the section at the point of loading

Twisting of thin-walled members

Effect of spot welds on structural performance

4. (4 pts each) $\sigma_{cr} = \underbrace{k}\underbrace{\frac{E\pi^2}{12\left(1-\nu^2\right)}}\underbrace{\frac{1}{\left(b/t\right)^2}}$

Boundary conditions: flange curls, flanged holes

Normal stiffness of the plate: material, curved elements, foam filling

Width-to-thickness ratio: reducing width with beads and added edges (while maintaining moment of inertia)

5.

$$I=\frac{(1.5a)^2\,t(3a+1.5a)}{6}=\frac{27}{16}a^3t,\ \text{strength}\rightarrow\text{stiffness}\ (5\text{ pts})$$

$$\begin{cases} F_{\max}=\dfrac{4I\sigma_{design}}{Lc}\ \text{ where }\sigma_{design}=\begin{cases}\sigma_{yield}=207\ N/mm\\ \sigma_{buckle}=\dfrac{748355}{(a/t)^2}\ N/mm\end{cases}\ (5\text{ pts})\\ \rightarrow(\text{buckling})\,F_{\max}=\dfrac{4\dfrac{27}{16}a^3t\dfrac{748355}{(a/t)^2}}{2550(0.75a)}=2641t^3\geq 6670N\rightarrow t\geq 1.36mm\ (5\text{ pts})\\ k=\dfrac{48EI}{L^3}=\dfrac{48(207\times10^3)\dfrac{27}{16}a^3t}{(2550)^3}=1.375\times10^{-3}a^3\geq 6670\,N/mm\rightarrow a\geq 169.3mm\ (5\text{ pts}) \end{cases}$$

$$\rightarrow A=1151mm^2,(a/t)=124$$

$$\text{OR}\begin{cases} k=\dfrac{48EI}{L^3}\geq 6670\,N/mm\rightarrow I\geq 11.13\times10^6\,mm^4\\ F_{\max}=\dfrac{4I\sigma_{design}}{Lc}=\dfrac{4I\dfrac{748355}{(a/t)^2}}{2550(0.75a)}\geq 6670N\rightarrow a^3=2.74\times10^6t^2 \end{cases}\rightarrow I=\frac{(1.5a)^2\,t(3a+1.5a)}{6}=\frac{27}{16}a^3t=11.13\times10^6\rightarrow t=1.34$$

6.