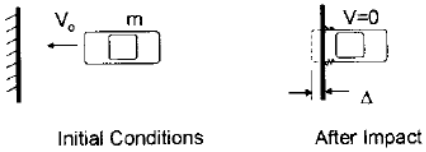
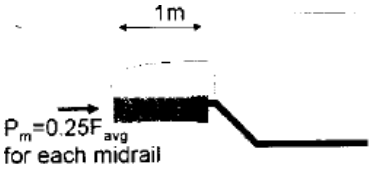
1. A 1000kg car impacts a rigid barrier at V_0 = 48 km/h. It is desired that the maximum deceleration level be a_{max} = 20g. The anticipated crush efficiency is η = 0.8. Assume fully plastic behavior.

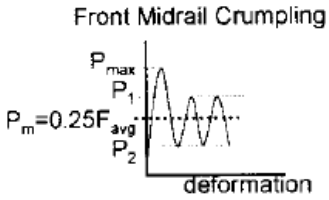


(1) What is the required crushable space Δ? (5 pts)

(2) What is the mean crush force which must be generated by the vehicle F_{avg}? (5 pts)

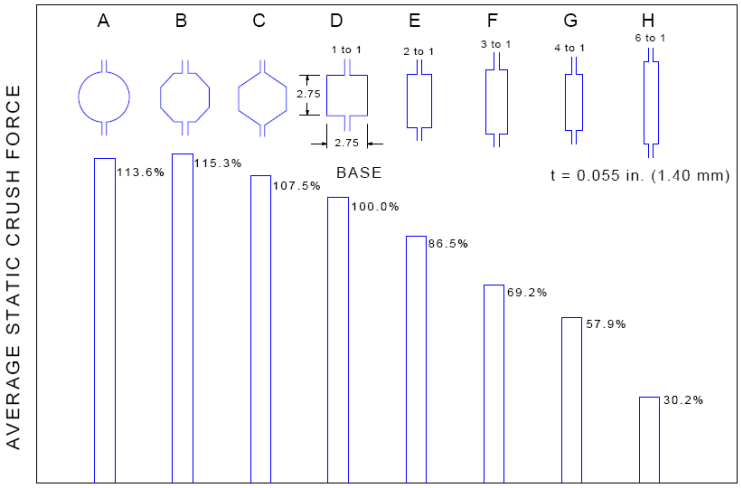
Assume that the two midrails will provide 25% of the average crumpling force F_{avg} required. The body will be tested statically for this force level. Material yield is σ_y = 207 N/mm^2.





$$P_m = 386 t^{1.86} b^{0.14} \sigma_Y^{0.57}$$

For same perimeter and thickness

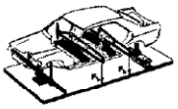


(3) Determine the size (*b*, *t*) of the square section required to generate 0.25 F_{avg} if the width to thickness ratio *b*/*t* = 60. What is the mass of the two rails(density = $7.83\times10^{-6}\ kg/mm^3$)? (10 pts)

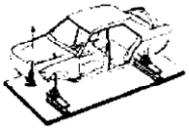
(4) A hexagonal section is being considered with the same *b*/*t* ratio. What is the resulting mass? (10 pts)

(5) Compare the two sections. What is preferred? (5 pts)

2. Typical bending and torsional requirements for a midsize vehicle: (10 pts)



Restraints at Suspension Attachments



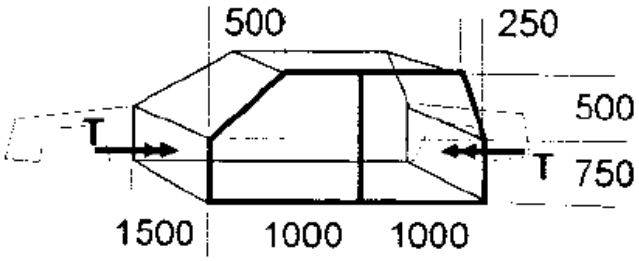
Restraints at Suspension Attachments

Bending Stiffness	Bending Strength	Torsion Stiffness	Torsion Strength
Nominal Value Stiffness = **(1)**	Nominal Value **(2)** no permanent deformation	Nominal Value Stiffness = **(3)**	Nominal Value **(4)** no permanent deformation

3. The sedan cab shown is loaded by a torque acting on the dash panel and a reaction torque acting on the rear panel as shown. For the dimensions in mm given.

(1) Label all force vectors using force equilibrium. (10 pts)

(2) Use moment equilibrium for each panel to relate unknown edge loads. This set of 7 equations can be expressed in matrix form as **AQ** = **T** where **A** is a square matrix of coefficients, **Q** is a column matrix of the edge loads, and **T** is a column matrix of applied torque. (20 pts)



4. Consider the impact of the vehicle(M_2) by a moving barrier(M_1). We can model each as a point mass with the impact being perfectly plastic. In this linear model, we are looking at motions lateral to the vehicle and will consider the lateral component of the barrier velocity as the initial impact velocity.

(1) Sketch the velocity-time histories for the barrier, the vehicle and the occupant based on the following figures. Indicate t_a, t_{final} and t_f in the time axis and corresponding V_a, V_{final} and V_f in the velocity axis. (15 pts)

(2) Specify Δ_0, Δ and a_{occ} (acceleration of occupant) in the histories. (10 pts)