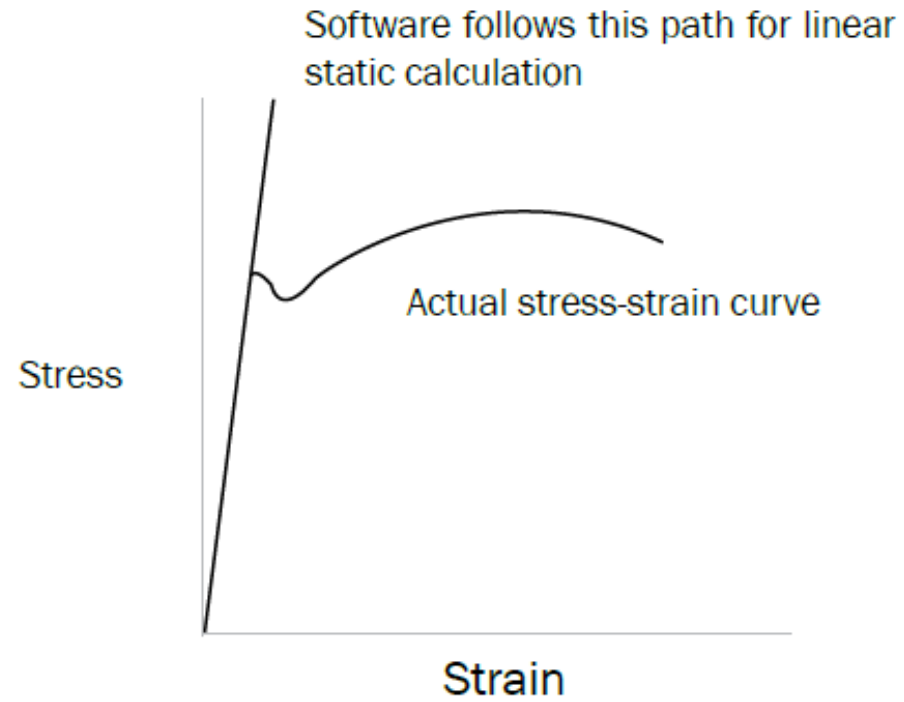


Types of analysis

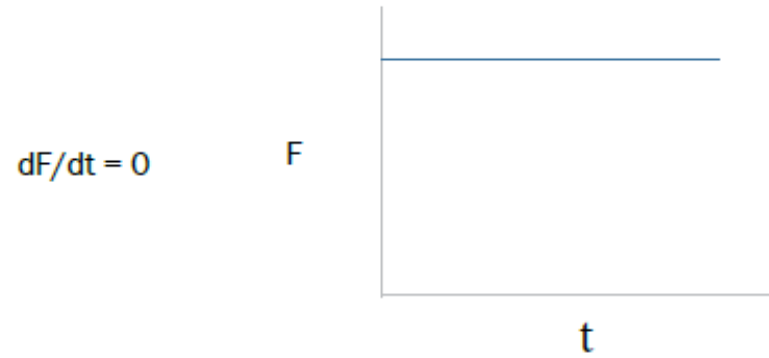
- | | | | |
|----|------------------------|-----|------------------|
| 1) | Linear static analysis | 6) | Fatigue analysis |
| 2) | Nonlinear analysis | 7) | Optimization |
| 3) | Dynamic analysis | 8) | CFD analysis |
| 4) | Buckling analysis | 9) | Crash analysis |
| 5) | Thermal analysis | 10) | NVH analysis |

1) Linear Static Analysis



There are two conditions for static analysis:

1) Force is static meaning there is no variation with respect to time (dead weight)

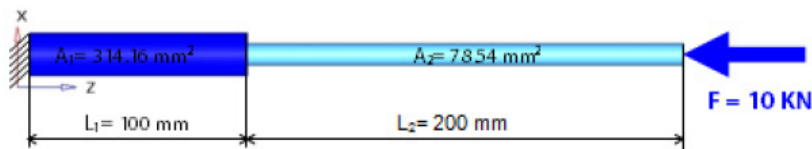


2. Equilibrium condition - $\sum \text{Force} = 0$, $\sum \text{Moments} = 0$

$$\sum F_x = 0 \quad \sum M_x = 0$$

$$\sum F_y = 0 \quad \sum M_y = 0$$

$$\sum F_z = 0 \quad \sum M_z = 0$$



Material Steel
 $E = 210 \text{ GPa}$

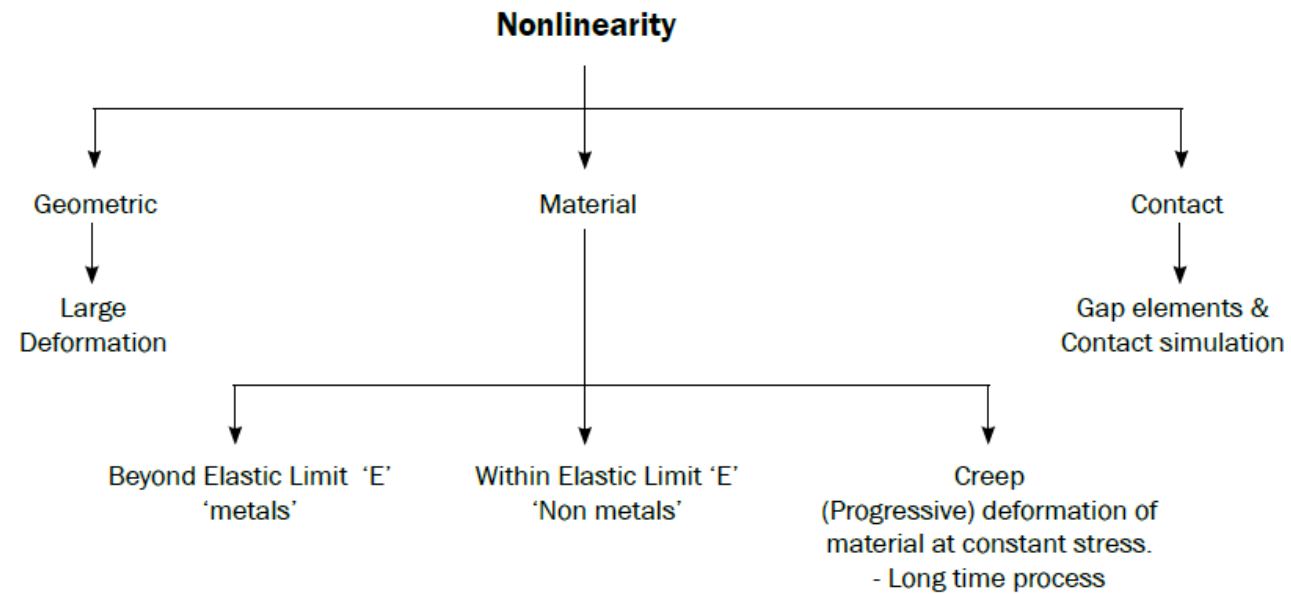


$$\mathbf{F} = \mathbf{K}\mathbf{x}$$



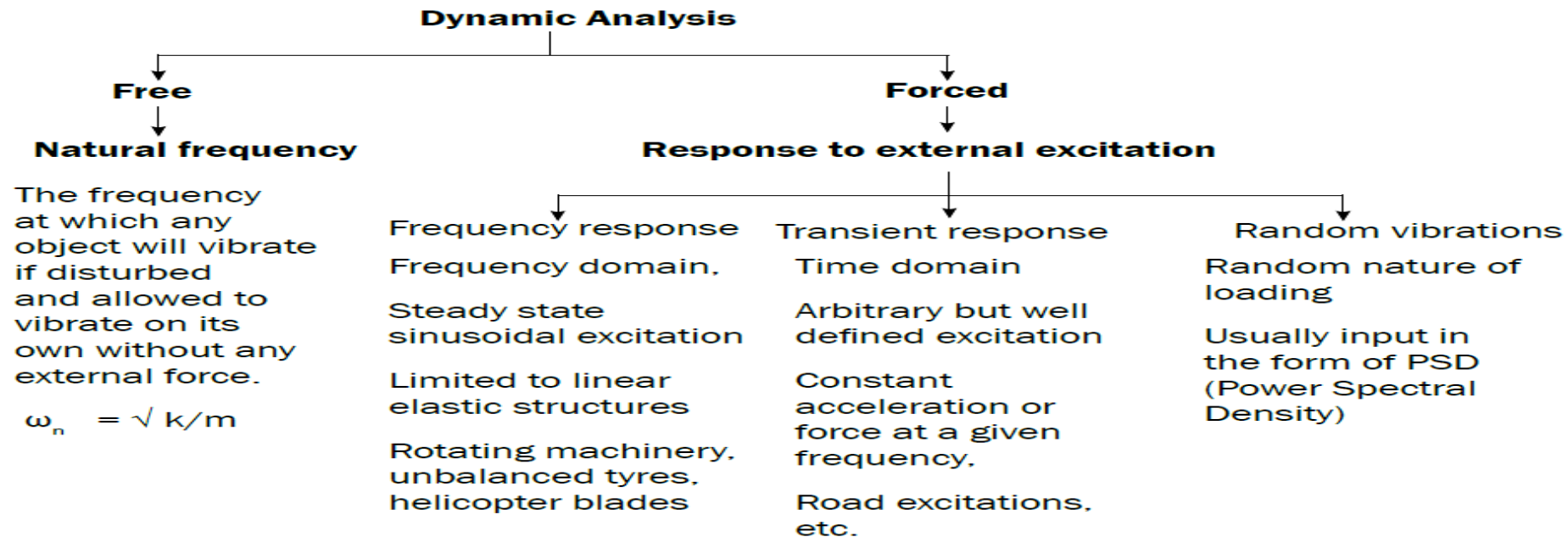
$$\mathbf{K} = \begin{bmatrix} \frac{AE}{L} & -\frac{AE}{L} \\ -\frac{AE}{L} & \frac{AE}{L} \end{bmatrix}$$

2) Nonlinear Analysis



3) Dynamic Analysis

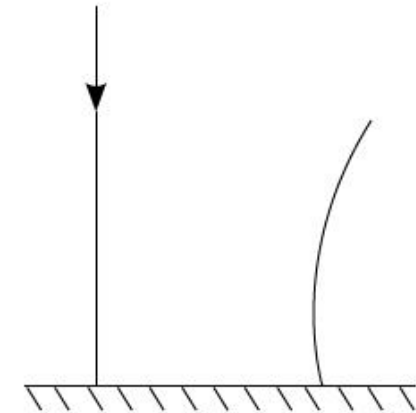
- Loads are a function of time
 - Response is time dependent
- a. Linear dynamics – force increases linearly with position, e.g. a mass and a linear spring
- b. Non – Linear dynamics - force does not increase linearly with position, e.g. a mass and a non-linear spring



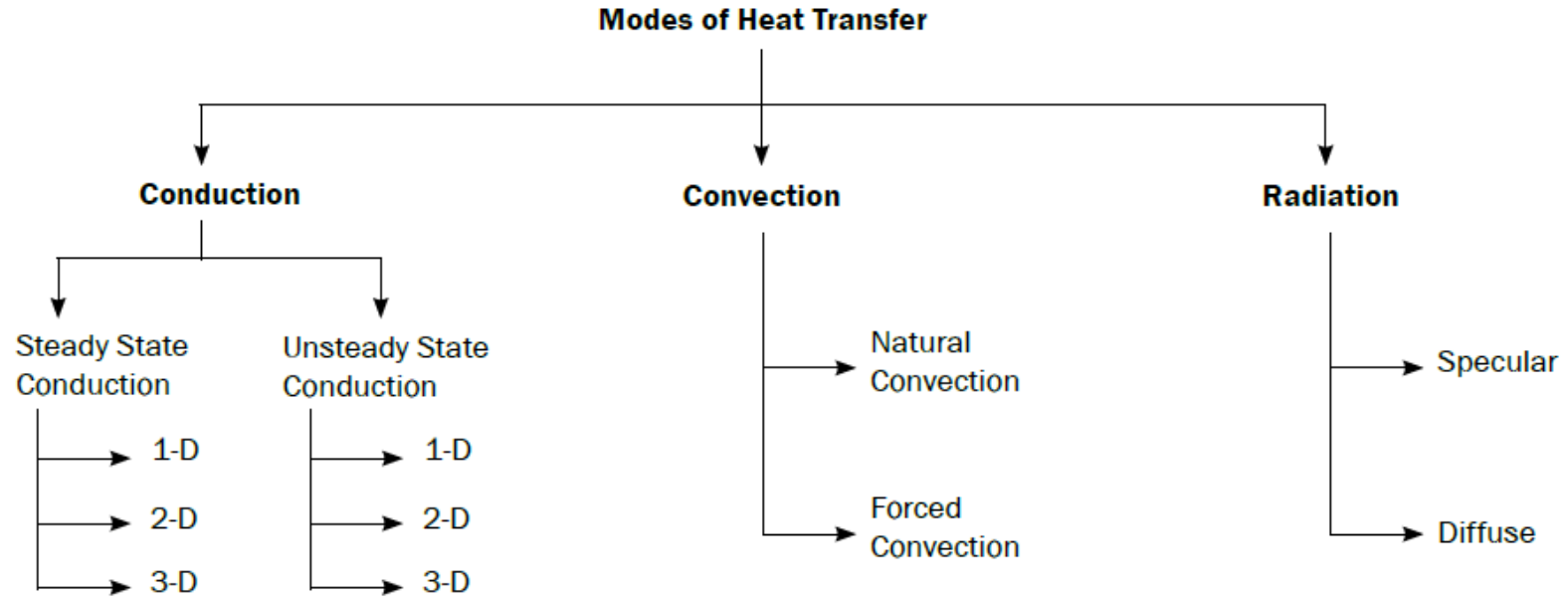
4) Linear Buckling Analysis

Some key aspects:

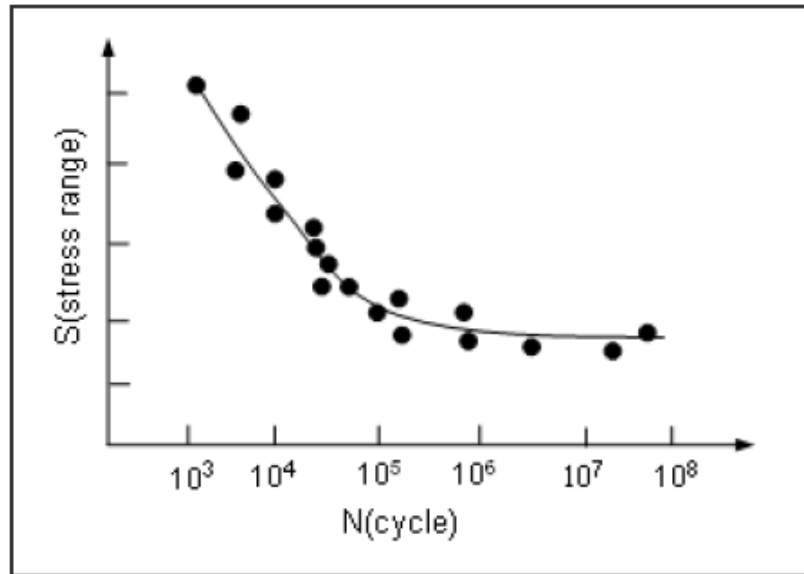
- Applicable for only compressive load
- Slender beams and sheet metal parts
- Bending stiffness $\ll$ Axial stiffness
- Large lateral deformation



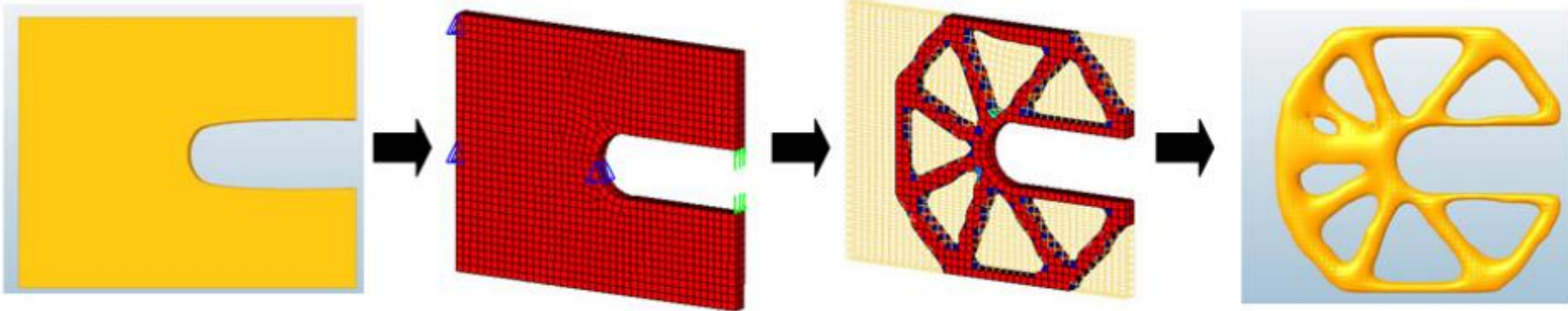
5) Thermal Analysis



3) Fatigue Analysis



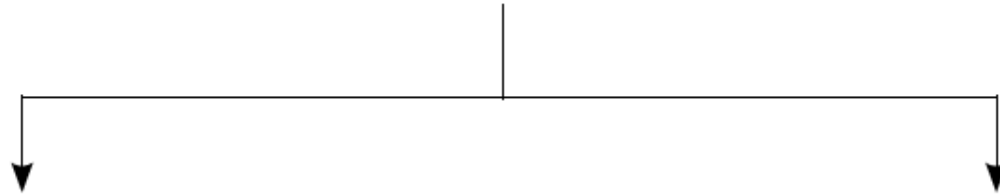
7) Optimization



1. Topology
2. Topography
3. Size
4. Shape
5. Composite

8) Computational Fluid Dynamics (CFD)

Fluid Mechanics



Fluid Statics (Hydrostatics)

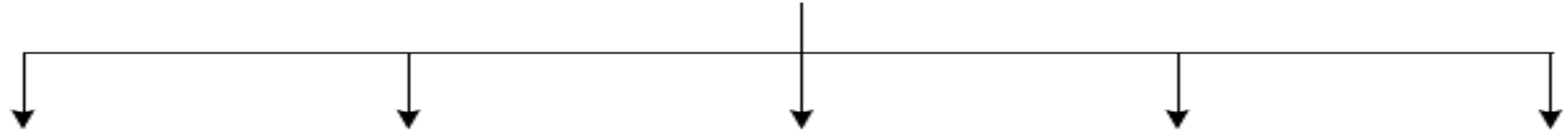
- Fluid at rest
- Easy from a calculation point of view
- No variation with respect to time, less realistic results
- Linear equations
- Civil engineering: Dam design

Fluid Dynamics

- Fluid in motion
- Calculations are more complex
- Variation with respect to time considered
- Nonlinear equations
- Aerospace, automobile, marine and valves

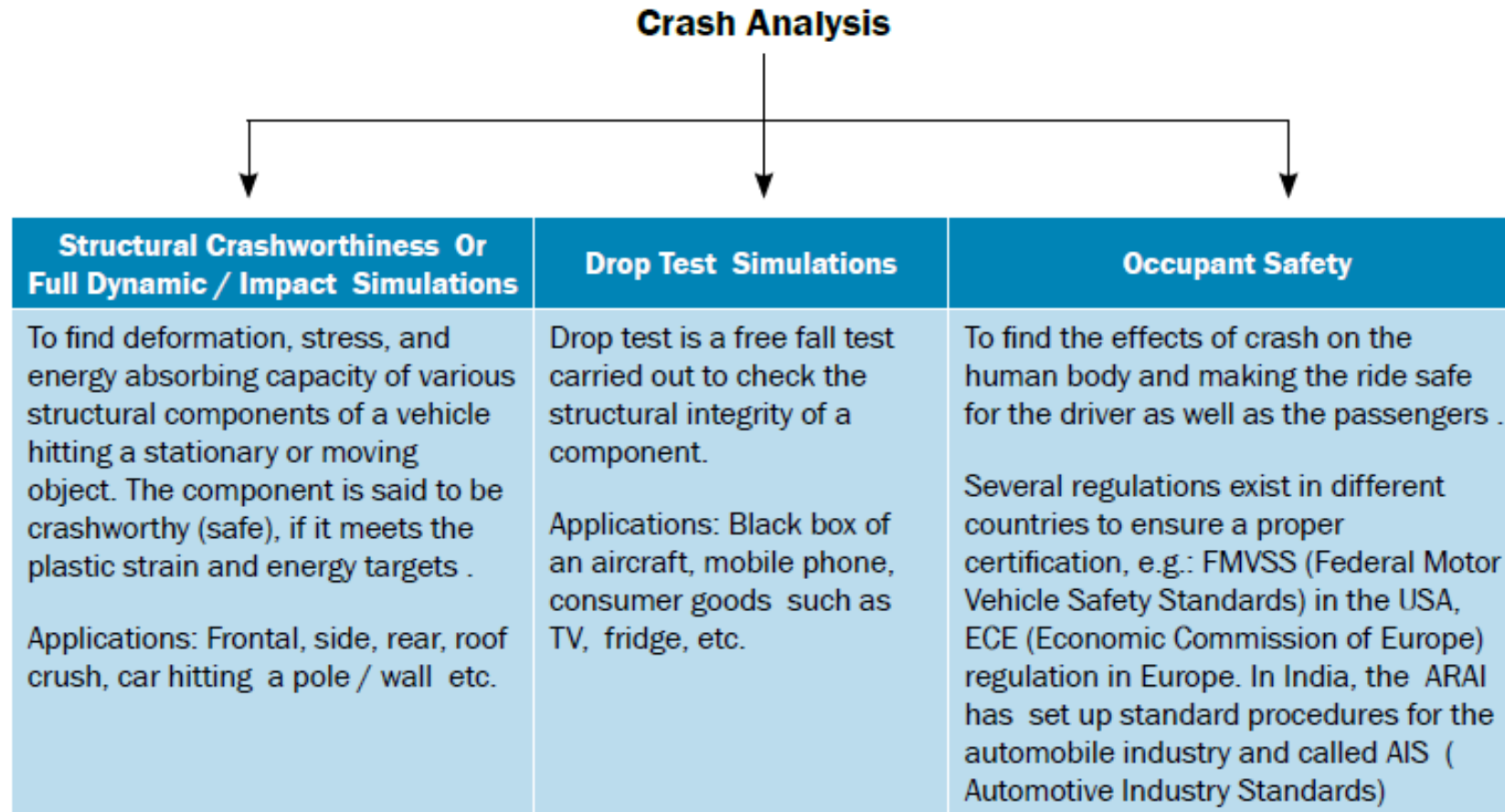
8) Computational Fluid Dynamics (CFD) (cont.)

Flow Classification



Viscosity	Dimensions	Turbulent/ Laminar	Compressibility	Velocity
Inviscid: no viscosity	1D: e.g. flow through a nozzle	- Laminar: Reynolds's number < 2300. - Flow through a water tap at low velocities	Incompressible: high density fluids flowing at sub sonic velocity (mach number < 1) e.g. water, oil	Sub Sonic $M < 1.0$
Viscid: Viscous flow. Most common	2D: e.g. flow through a pipe or over an airfoil	- Turbulent: Reynold's number > 2300. - Flow through a water tap at higher velocities	Compressible: low density fluids flowing at sonic or supersonic velocity e.g. discontinuities like shock and expansion waves	Trans sonic $0.85 < M < 1.20$ Represents weak shocks
	3D: e.g. flow through a valve, flow over an automobile, aircraft, or missile			Super sonic $1.20 < M < 4.0$ Hypersonic $M > 6.0$ e.g. Space shuttle entering earth's atmosphere.

9) Crash Analysis



10) Noise, Vibration And Harshness, NVH

Sound Radiation Or Scattering Or Uncoupled Problems	Coupled Or Vibroacoustics Problems
How much sound pressure is felt at a certain distance from the vibrating source.	When there is a clear interaction and transmission of the vibrations through a structure.
e.g. How much sound pressure is felt from a exhaust at a certain distance.	e.g. How a door mirror vibrates due to the engine vibrations.
Solved using B.E.M	Solved using F.E.M.

Notes adapted from/further reading

Practical Aspects of Finite Element Simulation – Altair University