• A complete description of the general state of stress at a point consists of:
  
  – normal stresses in three directions, \( \sigma_x \) (or \( \sigma_{11} \)), \( \sigma_y \) (or \( \sigma_{22} \)) and \( \sigma_z \) (or \( \sigma_{33} \)),
  
  – shear stresses on three planes, \( \tau_x \) (or \( \sigma_{12} \ldots \)), \( \tau_y \) (or \( \sigma_{23} \ldots \)), and \( \tau_z \) (or \( \sigma_{31} \ldots \)).
• The stress, $\sigma_x$ in the x-direction produces 3 strains:
  – longitudinal strain (extension) along the **x-axis** of:
    \[ \varepsilon_x = \frac{\sigma_x}{E} \]  
    \hspace{1cm} \text{(6.7)}
  – transverse strains (contraction) along the **y and z -axes**, which are related to the Poisson’s ratio:
    \[ \varepsilon_y = \varepsilon_z = -\nu \varepsilon_x = -\frac{\nu \sigma_x}{E} \]  
    \hspace{1cm} \text{(6.8)}
Properties of $\nu$

- Absolute values of $\nu$ are used in calculations.

- The value of $\nu$ is about:
  - 0.25 for a perfectly isotropic elastic materials.
  - 0.33 for most metals.
• In order to determine the total strain produced along a particular direction, we can apply the principle of superposition.

• For Example, the resultant strain along the x-axis, comes from the strain contribution due to the application of $\sigma_x$, $\sigma_y$ and $\sigma_z$.
  
  $\nabla$

  $\sigma_x$ causes: $\frac{\sigma_x}{E}$          in the x-direction  

  $\sigma_y$ causes: $-\frac{\nu \sigma_y}{E}$          in the x-direction  

  $\sigma_z$ causes: $-\frac{\nu \sigma_z}{E}$          in the x-direction  

  Applying the principle of superposition (x-axis):

$$\varepsilon_x = \frac{1}{E} \left[ \sigma_x - \nu(\sigma_y + \sigma_z) \right]$$  \hspace{1cm} (6.9a)
The situation can be summarized by the following table:

<table>
<thead>
<tr>
<th>Stress</th>
<th>Strain in the x direction</th>
<th>Strain in the y direction</th>
<th>Strain in the z direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma_x )</td>
<td>( \varepsilon_x = \frac{\sigma_x}{E} )</td>
<td>( \varepsilon_y = -\frac{\nu \sigma_x}{E} )</td>
<td>( \varepsilon_z = -\frac{\nu \sigma_x}{E} )</td>
</tr>
<tr>
<td>( \sigma_y )</td>
<td>( \varepsilon_x = -\frac{\nu \sigma_y}{E} )</td>
<td>( \varepsilon_y = \frac{\sigma_y}{E} )</td>
<td>( \varepsilon_z = -\frac{\nu \sigma_y}{E} )</td>
</tr>
<tr>
<td>( \sigma_z )</td>
<td>( \varepsilon_x = -\frac{\nu \sigma_z}{E} )</td>
<td>( \varepsilon_y = -\frac{\nu \sigma_z}{E} )</td>
<td>( \varepsilon_z = \frac{\sigma_z}{E} )</td>
</tr>
</tbody>
</table>