# Useful Terminology

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| **Term** | **Definition** |
| Vector | Collection of scalars |
| Cartesian vector | Euclidean vector defined using Cartesian coordinates |
| Norm | Magnitude of a vector |
| Cartesian tensor | Generalization of a vector |
| Orthogonal tensor | Represents the rotation of a vector or coordinate system |
| Field | Function in the space |
| Surface traction | Internal force per unit area  Force intensity acting on a cut plane |
| Stress tensor | Completely characterizes the state of stress at a given point |
| Cauchy’s lemma | Surface tractions acting on opposite sides of the same surface are equal in magnitude and opposite in direction |
| Hydrostatic/mean stress | Related to the change in volume  Frame indifference |
| Stress deviator | Related to the change in shape  Trace-free |
| Principal stresses | Three mutually perpendicular planes on which the normal stress attains an extremum value  Shear stresses vanish  Global maximum, minimum and intermediate normal stress |
| Strain | Change in length divided by original length |
| Proportional limit | The greatest stress for which the stress is still proportional to the strain |
| Elastic limit | The greatest stress without resulting in any permanent strain on release of stress |
| Young’s modulus | Slope of the linear portion of the stress-strain curve |
| Yield stress | Stress required to produce 0.2% plastic strain |
| Strain hardening | Region where more stress is required to deform the material |
| Ultimate stress | Maximum stress the material can resist |
| Necking | Reduction of the cross section of the specimen during deformation |
| Principle of minimum potential energy | For all displacements that satisfy boundary conditions, if they exist, make the total potential energy stationary |
| Virtual displacement | Small arbitrary perturbation of the real displacement |
| Jacobian matrix | Used to relate the derivatives of shape functions between physical and reference coordinates |
| Geometric nonlinearity | Represent cases when relations among kinematic quantities are nonlinear |
| Material nonlinearity | Represent cases when the relation between stress and strain is nonlinear |
| Kinematic nonlinearity | Displacement boundary conditions depend on deformations of the structure |
| Force nonlinearity | Occurs when the applied forces depend on deformation |
| Lagrangian strain | Uses undeformed geometry as a reference  Symmetric  Approaches the infinitesimal strain when the displacement gradient is small |
| Eulerian strain | Uses deformed geometry as a reference  Symmetric  Approaches the infinitesimal strain when the displacement gradient is small |
| Dilatation | Volume-changing deformation |
| Distortion | Volume-preserving deformation |
| Cauchy stress tensor | Refers to the current deformed geometry as a reference for both force and area  True stress |
| Piola-Kirchhoff stress tensor | Refers to the force in the current geometry and the area in the initial geometry |
| Constitutive theory | Describes the macroscopic behaviour of a material between deformation and internal force caused by deformation |
| Principle of minimum potential energy | The displacement field in the equilibrium minimizes the potential energy |

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| **Symbol/Equation** | **Name** | **Definition** |
|  | Kronecker delta symbol |  |
|  | Dyadic product | Increases the rank by 1 |
|  | Contraction | Double inner product |
|  | Trace | Part of the contraction operator in which a pair of indices is under the inner product |
|  | Permutation |  |
|  | Dual vector of a skew tensor | Skew tensor defined using a vector with the permutation symbol |
|  | Gradient |  |
|  | Variational equation |  |
|  | Deformation gradient |  |
|  | Neo-Hookean model | Good correlation with experimental data up to 40% strain in uniaxial tension and 90% strain in simple shear |
|  | Mooney-Rivlin model | Good up to 100% strain of the tensile test, but has difficulty in describing compression |
|  | Yeoh model | Corresponds well with experiments for large strain |
|  | Ogden model | Good correlation with test data in simple tension up to 700% |