

## A

Absolute differentiation 120  
 Absolute scalar field 43  
 Absolute tensor 45,46,47,48  
 Acceleration 121, 190, 192  
 Action integral 198  
 Addition of systems 6, 51  
 Addition of tensors 6, 51  
 Adherence boundary condition 294  
 Aelotropic material 245  
 Affine transformation 86, 107  
 Airy stress function 264  
 Almansi strain tensor 229  
 Alternating tensor 6,7  
 Ampere's law 176,301,337,341  
 Angle between vectors 80, 82  
 Angular momentum 218, 287  
 Angular velocity 86,87,201,203  
 Arc length 60, 67, 133  
 Associated tensors 79  
 Auxiliary Magnetic field 338  
 Axis of symmetry 247

## B

Basic equations elasticity 236, 253, 270  
 Basic equations for a continuum 236  
 Basic equations of fluids 281, 287  
 Basis vectors 1,2,37,48  
 Beltrami 262  
 Bernoulli's Theorem 292  
 Biharmonic equation 186, 265  
 Bilinear form 97  
 Binormal vector 130  
 Biot-Savart law 336  
 Bipolar coordinates 73  
 Boltzmann equation 302,306  
 Boundary conditions 257, 294  
 Bulk modulus 251  
 Bulk coefficient of viscosity 285

## C

Cartesian coordinates 19,20,42, 67, 83  
 Cartesian tensors 84, 87, 226

Cauchy stress law 216  
 Cauchy-Riemann equations 293,321  
 Charge density 323  
 Christoffel symbols 108,110,111  
 Circulation 293  
 Codazzi equations 139  
 Coefficient of viscosity 285  
 Cofactors 25, 26, 32  
 Compatibility equations 259, 260, 262  
 Completely skew symmetric system 31  
 Compound pendulum 195,209  
 Compressible material 231  
 Conic sections 151  
 Conical coordinates 74  
 Conjugate dyad 49  
 Conjugate metric tensor 36, 77  
 Conservation of angular momentum 218, 295  
 Conservation of energy 295  
 Conservation of linear momentum 217, 295  
 Conservation of mass 233, 295  
 Conservative system 191, 298  
 Conservative electric field 323  
 Constitutive equations 242, 251,281, 287  
 Continuity equation 106,234, 287, 335  
 Contraction 6, 52  
 Contravariant components 36, 44  
 Contravariant tensor 45  
 Coordinate curves 37, 67  
 Coordinate surfaces 37, 67  
 Coordinate transformations 37  
 Coulomb law 322  
 Covariant components 36, 47  
 Covariant differentiation 113,114,117  
 Covariant tensor 46  
 Cross product 11  
 Curl 21, 173  
 Curvature 130, 131, 134, 149  
 Curvature tensor 134, 145  
 Curvilinear coordinates 66, 81  
 Cylindrical coordinates 18, 42, 69

## D

Deformation 222  
 Derivative of tensor 108  
 Derivatives and indicial notation 18, 31  
 Determinant 10, 25, 32, 33  
 Dielectric tensor 333  
 Differential geometry 129  
 Diffusion equation 303  
 Dilatation 232  
 Direction cosines 85  
 Displacement vector 333  
 Dissipation function 297  
 Distribution function 302  
 Divergence 21, 172  
 Divergence theorem 24  
 Dot product 5  
 Double dot product 50, 62  
 Dual tensor 100  
 Dummy index 4, 5  
 Dyads 48,62,63  
 Dynamics 187

## E

e Permutation symbol 6, 7, 12  
 $\epsilon\delta$  identity 12  
 Eigenvalues 179,189  
 Eigenvectors 179,186  
 Einstein tensor 156  
 Elastic constants 248  
 Elastic stiffness 242  
 Elasticity 211,213  
 Electrostatic field 322,333  
 Electric flux 327  
 Electric units 322  
 Electrodynamics 339  
 Electromagnetic energy 341  
 Electromagnetic stress 341,342  
 Elliptic coordinates 72  
 Elliptical cylindrical coordinates 71  
 Enthalpy 298  
 Entropy 300  
 Epsilon permutation symbol 83  
 Equation of state 300

Equilibrium equations 273,300  
 Elastic constants 243,248  
 Equipotential curves 325  
 Euler number 294  
 Euler-Lagrange equations 192  
 Eulerian angles 201, 209  
 Eulerian form 287  
 Eulerian system 227  
 Eulers equations of motion 204

## F

Faraday's law 176,301, 340  
 Field lines 324, 327  
 Field electric 322  
 First fundamental form 133,143  
 Fourier law 297, 299  
 Free indices 3  
 Frenet-Serret formulas 131, 188  
 Froude number 294  
 Fluids 281

## G

Gas law 300  
 Gauss divergence theorem 24, 330  
 Gauss equations 138  
 Gauss's law for electricity 176,301,328  
 Gauss's law for magnetism 176,301,341  
 Gaussian curvature 137,139, 149  
 Geodesics 140, 146  
 Geodesic curvature 135, 140  
 General tensor 48  
 Generalized  $e - \delta$  identity 84, 104  
 Generalized Hooke's law 242  
 Generalized Kronecker delta 13, 31  
 Generalized stress strain 242  
 Geometry in Riemannian Space 80  
 Gradient 20, 171  
 Gradient basis 37  
 Green's theorem 24  
 Group properties 41, 54  
 Generalized velocity 121  
 Generalized acceleration 121

## H

Hamiltonian 208  
 Heat equation 316  
 Hexagonal material 247  
 Higher order tensors 47, 93  
 Hooke's law 212, 242, 252  
 Hydrodynamic equations 283

## I

Ideal fluid 283  
 Idemfactor 50  
 Incompressible material 231  
 Index notation 1, 2, 14  
 Indicial notation 1, 2, 14, 24  
 Inner product 52  
 Inertia 30  
 Integral theorems 24  
 Intrinsic derivative 120  
 Invariant 43  
 Inviscid fluid 283  
 Isotropic material 248  
 Isotropic tensor 104

## J

Jacobian 17, 30, 40, 101, 127  
 Jump discontinuity 330

## K

Kronecker delta 3, 8, 13, 31, 76  
 Kinetic energy 201  
 Kinematic viscosity 302

## L

Lagrange's equation of motion 191, 196  
 Lagrangian 209  
 Laplacian 174  
 Linear form 96  
 Linear momentum 209, 287  
 Linear transformation 86  
 Linear viscous fluids 284  
 Lorentz transformation 57  
 Lame's constants 251

## M

Magnitude of vector 80  
 Magnetostatics 334, 338  
 Magnetic field 334  
 Magnetization vector 337  
 Magnetic permeability 337  
 Material derivative 234, 288  
 Material symmetry 244, 246  
 Maxwell equations 176, 339  
 Maxwell transfer equation 308  
 Maximum, minimum curvature 130, 140  
 Mean curvature 137, 148  
 Metric tensor 36, 65  
 Meusnier's Theorem 150  
 Mixed tensor 49  
 Mohr's circle 185  
 Moment of inertia 30, 184, 200  
 Momentum 217, 218  
 Multilinear forms 96, 98  
 Multiplication of tensors 6, 51

## N

Navier's equations 254, 257  
 Navier-Stokes equations 288, 290  
 Newtonian fluids 286  
 Nonviscous fluid 283  
 Normal curvature 135, 136  
 Normal plane 188  
 Normal stress 214  
 Normal vector 130, 132  
 Notation for physical components 92

## O

Oblate Spheroidal coordinates 75  
 Oblique coordinates 60  
 Oblique cylindrical coordinates 102  
 Order 2  
 Orthogonal coordinates 78, 86  
 Orthotropic material 246  
 Outer product 6, 51  
 Osculating plane 188

## P

Parallel vector field 122  
 Pappovich-Neuber solution 263  
 Parabolic coordinates 70  
 Parabolic cylindrical coordinates 69  
 Particle motion 190  
 Pendulum system 197, 210  
 Perfect gas 283, 299  
 Permutations 6  
 Phase space 302  
 Physical components 88, 91, 93  
 Piezoelectric 300  
 Pitch, roll, Yaw 209  
 Plane Couette flow 315  
 Plane Poiseuille flow 316  
 Plane strain 263  
 Plane stress 264  
 Poisson's equation 329  
 Poisson's ratio 212  
 Polar element 273  
 Polarization vector 333  
 Polyads 48  
 Potential energy 191  
 Potential function 323  
 Poynting's vector 341  
 Pressure 283  
 Principal axes 183  
 Projection 35  
 Prolated Spheroidal coordinates 74  
 Pully system 194, 207

## Q

Quotient law 53

## R

Radius of curvature 130, 136  
 Range convention 2, 3  
 Rate of deformation 281, 286  
 Rate of strain 281

Rayleigh impulsive flow 317  
 Reciprocal basis 35, 38  
 Relative scalar 127  
 Relative tensor 50, 121  
 Relative motion 202  
 Relativity 151  
 Relative motion 155  
 Reynolds number 294  
 Ricci's theorem 119  
 Riemann Christoffel tensor 116, 129, 139, 147  
 Riemann space 80  
 Rectifying plane 188  
 Rigid body rotation 199  
 Rotation of axes 85, 87, 107  
 Rules for indices 2

S

Scalar 40, 43  
 Scalar invariant 43, 62, 105  
 Scalar potential 191  
 Scaled variables 293  
 Second fundamental form 135, 145  
 Second order tensor 47  
 Shearing stresses 214  
 Simple pulley system 193  
 Simple pendulum 194  
 Skew symmetric system 3, 31  
 Skewed coordinates 60, 102  
 Solid angle 328  
 Space curves 130  
 Special tensors 65  
 Spherical coordinates 18, 43, 56, 69, 103, 194  
 Stokes flow 318  
 Stokes hypothesis 285  
 Stokes theorem 24  
 Straight line 60  
 Strain 218, 225, 228  
 Strain deviator 279

- Stress 214  
 Stress deviator 279  
 Strong conservative form 298  
 Strouhal number 294  
 St Venant 258  
 Subscripts 2  
 Subtraction of tensors 51, 62  
 Summation convention 4, 9  
 Superscripts 2  
 Surface 62, 131  
 Surface area 59  
 Surface curvature 149  
 Surface metric 125, 133  
 Susceptibility tensor 333  
 Sutherland formula 285  
 Symmetric system 3, 31, 51, 101  
 Symmetry 243  
 System 2, 31
- T  
 Tangential basis 37  
 Tangent vector 130  
 Tensor and vector forms 40, 150  
 Tensor derivative 141  
 Tensor general 48  
 Tensor notation 92, 160  
 Tensor operations 6, 51, 175  
 Test charge 322  
 Thermodynamics 299  
 Third fundamental form 146  
 Third order systems 31  
 Toroidal coordinates 75, 103  
 Torus 124  
 Transformation equations 17, 37, 86  
 Transitive property 45, 46  
 Translation of coordinates 84  
 Transport equation 302  
 Transposition 6  
 Triad 50  
 Trilinear form 98  
 Triple scalar product 15
- U  
 Unit binormal 131, 192  
 Unit normal 131, 191  
 Unit tangent 131, 191  
 Unit vector 81, 105
- V  
 Vector identities 15, 20, 315  
 Vector transformation 45, 47  
 Vector operators 20, 175  
 Vector potential 188  
 Velocity 95, 121, 190, 193  
 Velocity strain tensor 281  
 Viscosity 285  
 Viscosity table 285  
 Viscous fluid 283  
 Viscous forces 288  
 Viscous stress tensor 285  
 Vorticity 107, 292
- W  
 Wave equation 255, 269  
 Weighted tensor 48, 127  
 Weingarten's equation 138, 153  
 Work 191, 279  
 Work done 324
- Y  
 Young's modulus 212