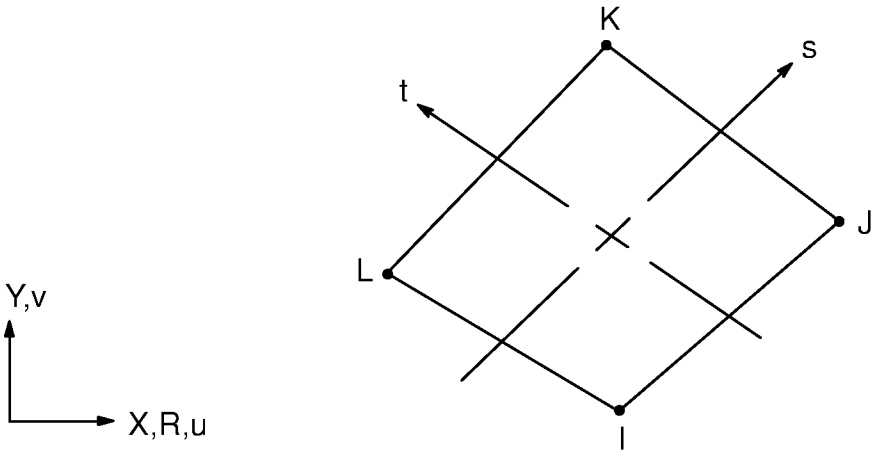
14.13 PLANE13 — 2–D Coupled–Field Solid



Matrix or Vector	Geometry	Shape Functions	Integration Points
Magnetic Potential Coefficient Matrix	Quad	Equation (12.6.5–9)	2 x 2
	Triangle	Equation (12.6.1–9)	1 if planar, and 3 if axisymmetric
Thermal Conductivity Matrix	Quad	Equation (12.6.5–20)	Same as coefficient matrix
	Triangle	Equation (12.6.1–20)	
Stiffness Matrix	Quad	Equations (12.6.5–1) and (12.6.5–2) and, if modified extra shapes are included (KEYOPT(2)=0) and element has 4 unique nodes) equations (12.6.6–1) and (12.6.6–2).	Same as coefficient matrix
	Triangle	Equations (12.6.1–1) and (12.6.1–2)	

Matrix or Vector	Geometry	Shape Functions	Integration Points
Mass Matrix	Quad	Equations (12.6.5–1) and (12.6.5–2)	Same as coefficient matrix
	Triangle	Equations (12.6.1–1) and (12.6.1–2)	Same as coefficient matrix
Specific Heat Matrix	Same as conductivity matrix. Matrix is diagonalized as described in Section 13.2		Same as coefficient matrix
Damping (Eddy Current) Matrix	Quad	Equations (12.6.5–9) and (12.6.5–21)	Same as coefficient matrix
	Triangle	Equations (12.6.1–9) and (12.6.1–21)	Same as coefficient matrix
Stress Stiffness Matrix	Same as mass matrix.		Same as coefficient matrix
Convection Surface Matrix and Load Vector	Same as conductivity matrix		2
Permanent Magnet and Applied Current Load Vector	Same as coefficient matrix		Same as coefficient matrix
Thermal and Magnetic Force Load Vector	Same as stiffness matrix		Same as coefficient matrix
Pressure Load Vector	Same as mass matrix specialized to the face		2

Load Type	Distribution
Current Density	Bilinear across element
Current Phase Angle	Bilinear across element
Heat Generation	Bilinear across element
Pressure	Linear along each face

References: Wilson(38), Taylor, et al (49), Silvester, et al (72),Weiss, et al (94), Garg, et al (95)

14.13.1 Other Applicable Sections

Chapter 2 describes the derivation of structural element matrices and load vectors as well as stress evaluations. Chapter 6 describes the derivation of thermal element matrices and load vectors as well as heat flux evaluations. Section 5.2 and 5.3 discuss the magnetic vector potential method, which is used by this element. Section 13.1 describes integration point locations. The diagonalization of the specific heat matrix is described in Section 13.2. Section 14.42 provides additional information on the element coordinate system, extra displacement shapes, and stress calculations.