List of Figures

Figure 2.1: Dividing a complex domain into a triangle and quadrilaterals	8
Figure 2.2: A pre-ordered structured triangular grid	8
Figure 2.3: A pre-ordered structured quadrilateral grid	9
Figure 2.4: Unstructured triangular mesh.	10
Figure 2.5: Unstructured quadrilateral mesh.	10
Figure 2.6: Quadtree decomposition of a simple 2D domain.	11
Figure 2.7: Delaunay criterion illustration.	13
Figure 2.8: Advancing front illustration.	14
Figure 2.9: Paving method applied to a square domain.	15
Figure 2.10: Splitting triangle method.	16
Figure 2.11: Combining triangle method, no triangle left in the domain	17
Figure 2.12: Combining triangle method, two triangles left in the domain	17
Figure 3.1: A simple 3D light frame wooden house	24
Figure 3.2: Showing detailed view of section M-M.	24
Figure 3.3: Typical FEM model generated in SAP 2000. The stud wall	
is modeled as roller supports	27
Figure 3.4: Typical FEM model generated in SAP 2000. The stud wall	
is modeled as spring supports	28
Figure 3.5: Free body diagram for maximum tie down force calculation (length	
units are in inches)	29
Figure 3.6: Stud wall modeled as roller support and tie down spring	
stiffness = 5,000 kips/in.	31
Figure 3.7: Stud wall modeled as roller support and tie down spring	
stiffness = 50,000 kips/in	32
Figure 3.8: Stud wall modeled as roller support and tie down spring	
stiffness = 500,000 kips/in	33
Figure 3.9: Stud wall modeled as spring support with stiffness = 76 kips/in.	
and tie down spring stiffness = 5 000 kins/in	34

Figure 3.10: Stud wall modeled as spring support with stiffness = 76 kips/in.	
and tie down spring stiffness = 50,000 kips/in	35
Figure 3.11: Stud wall modeled as spring support with stiffness = 76 kips/in.	
and tie down spring stiffness = 500,000 kips/in	36
Figure 3.12: Stud wall modeled as spring support with stiffness = 19 kips/in.	
and tie down spring stiffness = 5,000 kips/in	37
Figure 3.13: Stud wall modeled as spring support with stiffness = 19 kips/in.	
and tie down spring stiffness = 50,000 kips/in	38
Figure 3.14: Stud wall modeled as spring support with stiffness = 19 kips/in.	
and tie down spring stiffness = 500,000 kips/in	39
Figure 4.1: Interior domain lying on the left of initial generation front	43
Figure 4.2: Interior domain lying on the right of initial generation front	43
Figure 4.3: A node in 3D vector space.	44
Figure 4.4: Line segment AB.	44
Figure 4.5: Shortest distance between node N and line segment AB	.44
Figure 4.6: Generation front.	45
Figure 4.7: Area operator	45
Figure 4.8: Intersection operator.	46
Figure 4.9: Valid node set.	47
Figure 4.10: α quality of some example triangles.	48
Figure 4.11: Pseudo code for triangular element generation process.	50
Figure 4.12: Formula for NSF at any point P(x,y)	52
Figure 4.13: Domain with multiple openings and multiple constraint lines	53
Figure 4.14: Square shaped domain in xy-plane.	54
Figure 4.15: L-shaped domain in xy-plane.	54
Figure 4.16: Square-shaped domain with an opening in xy-plane	55
Figure 4.17: Square-shaped domain with a constraint line in xy-plane	.55
Figure 4.18: Square shaped domain with two openings and two constraint lines in	
xy-plane	56
Figure 4.19: Virginia Tech logo in xy-plane	56

Figure 4.20: A convex domain with an inside point lying to the left of all boundary	7
segments	57
Figure 4.21: A non-convex domain with an inside point lying to the left of all the	
boundary segments except for the one shown with dash style	58
Figure 4.22: Showing ray tracing method.	58
Figure 4.23: Rays intersecting vertices of the domain.	59
Figure 4.24: Rays overlapping edges of the domain	59
Figure 4.25: Showing solution to the problem of ray intersecting the vertices of	
boundary edges	60
Figure 4.26: Showing solution to the problem of ray being collinear with the bound	lary
edges	60
Figure 4.27: Showing line segments AB and CD.	61
Figure 4.28: Showing orientation of AB with respect to normal N	62
Figure 4.29: Showing distance of point from a line segment.	63
Figure 4.30: A simple quadrilateral domain	63
Figure 4.31: Boundary nodes named in continuous order	64
Figure 4.32: Showing subdivision of shorter segments from opposite edges	64
Figure 4.33: Dividing opposite edges into same number of subdivisions as the	
opposite shorter edges	65
Figure 4.34: Showing quadrilateral element generation process	66
Figure 4.36: Showing a skewed quadrilateral domain	67
Figure 5.1: Class xyz's attributes and methods (C++ interface)	69
Figure 5.2: Inherited class uvw's attributes and methods. All public	
and protected attribute and methods of class xyz also belongs to class	
uvw (C++ interface)	70
Figure 5.3: Showing polymorphism (operator overloading, C++ interface)	71
Figure 5.4: Basic architecture of the WoodFrameMesh program	74
Figure 5.5: Interface of KMDomainBldr class.	75
Figure 5.6: Interface of KMTxtFileReader class.	76
Figure 5.7: Interface of the KMDomain class	77
Figure 5.8: Interface for the KMFEModelBldr class	78

Figure 5.9: Interface for KMFEMeshGenerator class	79
Figure 5.10: Interface for the KMAFT class	80
Figure 5.11: Interface for the KMFEModel class.	81
Figure 5.12: Interface for the KMS2KFileWriter class.	81
Figure 5.13: Interface for the KMGeometricObject class	82
Figure 5.14: Interface for the KMSurfaceObject class.	83
Figure 5.15: Interface for the KMRestraintLineObject class	83
Figure 5.16: Interface for the KMSpringLineObject class	84
Figure 5.17: Interface of the KMFrameLineObject class	84
Figure 5.18: Interface for the KMNonLinearLinkLineObject class	84
Figure 5.19: Interface for the KMLoadLineObject class	85
Figure 5.20: Interface for the KMSpaceVector class	86
Figure 5.21: Interface for the KMNode class	86
Figure 5.22: Interface for the KMLineSegment class	8
Figure 5.23: Interface for the KMRestraint class	88
Figure 5.24: Interface for the KMSpring class	88
Figure 5.25: Interface for the KMShell class	89
Figure 5.26: Interface for the KMFrame class	89
Figure 5.27: Interface for the KMNonLinearLink class	90
Figure 5.28: Interface for the KMNodalLoad class	90
Figure 5.29: Interface for the KMMaterial class	91
Figure 5.30: Interface for the KMSection class	91
Figure 5.31: Interface for the KMFrameSection class	92
Figure 5.32: Interface for the KMShellSection class	92
Figure 5.33: Interface for the KMNonLinearLinkSection class	93
Figure 6.1: KSModelBuilder acting as interface between KSEcho and KSModel	98
Figure 6.2: Interface of a new derived element class	103
Figure 6.3: Interface for a new constraint derived class.	104
Figure 6.4: Interface of new section class.	105
Figure 6.5: Interface of new solver class.	106
Figure 6.6: Interface of new numberer class	107

Figure 6.7: Example showing addition of new code (show	wn in bold) in the
main program if a new numberer child class	is added108