# Contents


## Chapter 1 2D GRAPHICS

### 1.1 Representations of points and polygons

**Conversion between real and complex representations**

C2R(CP), R2C(RP), RegPoly(N,R)

### 1.2 Bounding boxes and rectangles

**Bounding box of a polygon** BBox(P) Rec(W)

**A suitable frame for drawing a polygon** Frame(P)

**Is a point z inside or outside of a rectangle with diagonal D?**

Inside(z,D) Outside(z,D) PointsInside(P,D)

**Bounding boxes for polygons with possibly infinitely distant points**

$\phi \equiv 10^{20}$ $\omega \equiv 10^{100}$ FBox(P) FFrame(P)

### 1.3 Drawing graphs of functions

**Three types of function graphs**

**Point on the graph of f at the parameter value x** GPt(f,x,type)

**The vectors of point coordinates on the graph of f corresponding to a vector x of parameter values** Graph(f,x,type)

**A vector of parameter values with constant distance**

Ma2Vec(Ma) Ma2Ve Vec(I) Arc(R,I) Arcn(R,I) EvenGraph(f,I,type)

Dot(z,w) Cross(z,w) Angle(z,w,u) MaxAng(P) MaxEdgeLen(P)

MaxAngle(f,x,type) MaxEdgeLength(f,x,type) Smooth(f,x,v,d,type)

SmoothOut(f,x,a,p,type) AdaptiveGraph(f,I,a,p,type)

## 1.4 Several polygons in the same plot

**Drawing a small number of polygons**

**Drawing a series of polygons with same number of vertices**

CTangentVector(f,x,type) TangentVector(f,x,type) Tangents(f,I,S,type)

Sierpinski's triangle

**Binary array operations generalized to nested arrays** ArrayOp(f,V) ArrayOpN(f,V,N)

**Drawing a series of polygons with varying number of vertices.**

Augment(A,B) ArrayAugment(A) RemoveFirst(x) Join(P,Q) ArrayJoin(A)

## 1.5 Shading a rectangle

**Shading of a rectangle**

Sh(W,H,d,α) Sha(W,H,d,α) Shad(W,H,d,α) Shade(Z,d,α)

**Drawing a plain histogram** Histogram(int,x,type)

**Drawing a shaded histogram** SHistogram(int,x,d,a,type)

## 1.6 Text on 2D graphs

**Drawing circle segments - auxiliary functions** Seg(n,N) Segment(z1,z2,n,N)

**Drawing a character** DrawCh(M,N)

**Making a font based on a table of arrays** Font(array,N,factor)

**Drawing a text** Width(P) Height(P) WriteString_(S,sp,fo)

**Subscripts and superscripts** WriteString(S,sp,fo)

**A general text writing function** Italic(z,t) Write(S,ap,it,sp,wi,he,ha,va,an,fo)

**Writing a fraction** WriteFrac(nom,den,sp,fo)

WriteFraction(nom,den,ap,sp,wi,he,ha,va,an,fo)

**Writing a matrix of texts at a matrix of positions** WriteMatrices(T,P,wr)

**Writing text over multiple lines**

Decompose(T) WriteMultipleLines(T,ap,it,sp,wi,he,ha,va,an,fo)

**The characters in Font01.xmcd**

**The characters in Font02.xmcd**

**The characters in Font03.xmcd**

## 1.7 Naming vertices, edges and faces of a polytop

**Naming the vertices of a polygon** Rep(x) VertexNames(P,N,d,wr,type)

**Naming the edges of a polygon** EdgeNames(P,E,N,d,wr,type)

**Face numbers on plane graphs** FacePolygon(V,f) FaceNames(V,F,N,d,write,type)

## 1.8 Writing a table DrawTable(M,wr,d,dx,dy)

## 1.9 Permutation groups and multiplication tables

**Representation of permutations** o(M,x)

**Removing trivial columns in a permutation matrix** RemoveTriv(A)

**One row representations of cyclic permutations** One2Two(A)

**Normalised representation of permutations** ν(A)

**Group operation on permutations** ⊗(A,B)

**The inverse of a permutation.** Inv(A)

**Decomposing a permutation into cycles** ToCycles(M)

**Multiplication table of a permutation group** tt(x,V,T) MultTable(D,V,T)

**Drawing the multiplication table** MultTab(D,V,T,write)

## 1.10 Drawing electric circuits

**Library of electronic components**

Resistance1(a,b,N) Resistance2(a,b) Emf1(a,b1,b2) PlusSign(c,R)

Emf2(a,b1,b2) Capacitance(a,b) Meter1(R,N) Meter(R,N,letter,or,fo)

AltEmf(R,N) Inductance(a,b,N,M) ArrowHead(h) Key(a,t)

Key2(a,R,t,N) Arrow(z1,z2,h) DrawArrows(Ma,h) Loop(z,R,N)

DrawLoops(Ma,R,NN) DrawBranch(z1,z2,Ma,T)

**Drawing an electric circuit** DrawCircuit(C)

## 1.11 Line and polygon clipping

**Line clipping with Liang-Barsky's method** MaxInMinOut(P,Z)

**Liang-Barsky's algorithm** LiangBarsky(P,Z,type)

**Clipping a polygon along a rectangle** CutOutside(P,Z) PolyClip(P,Z,type)

**Horizontal shading of a polygon** floor5(x) Floor5(C) HShade(P,h)

**Oblique shading of a polygon** OShade(P,h,a)

**Clipping along a convex polygon** PMaxInMinOut(P,Q) PLiangBarsky(P,Q,type)

PolyLiangBarsky(P,Q,type)

**Clipping a shading** ShLiangBarsky(S,Q,type) SLiangBarsky(PS,Q,type)

**Polygon clip with Sutherland-Hodgman's algorithm**

**Sutherland-Hodgeman's method for polygon clip**

Between(P1,P2,Z,n) Intersect(P1,P2,Z,m) Save(v,z)

**Sutherland-Hodgman's algorithm** ClipTop(P,A,Z) ClipBottom(P,A,Z) ClipRight(P,A,Z)
ClipLeft(P,A,Z) SHClip(Poly,Z)

## 1.12 Venn Diagrams

## 1.13 Plane graphs

**Drawing a simple plane graph** DrawGraph(G,N,R)

**Plane graphs including circular arcs** DrawCGraph(G,N,R,n)

**Drawing a directed graph** ArrowHead(a) UDEdge(n,N,a,t)

ULoop(N,a) DEdge(z1,z2,n,N,a,t) DLoop(z1,z2,N,a) DrawDiGraph(G,N1,R,n,N,a)

## 1.14 Logical circuits

**The intersection of and arc and a straight line** Int(y)

**Logical circuit symbols** AND OR NOT BOX NEG Symbol DrawLCircuit(L)

## 1.15 Graphs and polytopes

**Plane graphs** DrawEdges(P)

**Plane polytopes** Polygons(P) DrawPolygons(P) Polytope(V,F)

EdgeEqual(x,y) RemoveEqualEdges(C) Edges(F) PDraw(P)

**Shading a polytope** ShadePolytope(P,d)

**Triangles** Rep(x) Inside3(x,P) IO3(Q,T)

**Triangulating plane polytopes** PFacePolygon(V,f) DrawFace(V,f) CompNo(x,y)

Leftmost(V,f) Cyclic(f,n) LeftOrder(V,f) Split1(P,S) Split(P,S) Empty(X)

Push(x,X) Pop(X) Triangulate(P,S) DrawTriangulation(P,S) TFacePolygons(Q)

ClipInside(P,Q) ClipOutside(P,Q) TriangleClip(P,Q,inout)

## 1.16 2D mappings

**Complex formulation** Mirror(M,t) Reflect(M,a,t) Scale(P,C,c)

**Real formulation** C2RM(CP) RM2C(RP) Rot(v) RTrans(M,x) Refl RScale(x)

HTrans(tx,ty) HRot(u) HReflectlX HScale(t) Car2Hom(M) Hom2Car(M)

PolygonFunction(f,M)

**Iterated function systems** Collage(Polygon,ifs) Collage2(PolyMatrix,ifs)

**Tilings** Tiling(M,F,G)

## 1.17 3D Polytopes

**Conversion between real and complex polytope representations** RM2C(M) C2RM(C)

**Conversion between vector of index vectors and matrices representing the faces**

M2A(M) A2M(V) Cube(s) House(s)

**Drawing a 3D polytope** PDraw(P3D,Proj) PXY PXZ PYZ XYZProj(P)

**Joining two polytopes** PolytopeJoin(P1,P2) PolytopeArrayJoin(PA)

**Mapping a 3D polytope** PolytopeMap(Po,F) PolytopeMmul(Po,M)

PolytopeTranslate(P,X)RotZ(t) PolytopeRotZ(P,t) RotX(t) PolytopeRotX(P,t)

RotY(t) PolytopeRotY(P,t) RotN(n,t) PolytopeRotN(P,n,t) Scale(t) PolytopeScale(P,t)

**Homogeneous coordinates** Car2Hom(M) Hom2Car(M) HTranslate3(x) MC2H(M)

HScale(t) HRotZ(t) HRotX(t) HRotY(t) HRotN(n,t)

## 1.18 Projections

**Orthographic projections into an oblique plane**

RotAB(a,b) HRotAB(a,b) HOPro(F,N,u) OrthoPro(P,F,N,u) OrthoProj(P,F,N,u)

**Isometric projection** IsoProj(P)

**Perspective projections** PerspZ(d) PersZ(d) PerZ(P,d)

**Perspective depth transformation** DepthPZ(d) DepthPerZ(M,d) DepthPersZ(P,d)

**General perspective projections** NormalizePosition(F,N,U,d) HPerspec(F,N,U,d)

HDepthPerspec(F,N,U,d) HDepthPerspect(F,N,U,d) VPer(V,F,N,U,d)

Per(P,F,N,U,d) VDepthPer(V,F,N,U,d) DepthPer(P,F,N,U,d)

## 1.19 Back and front faces

BackFront(P,F,N,U) Back(P,F,N,U) Front(P,F,N,U) DrawBack(P,F,N,U)

DrawFront(P,F,N,U) Draw(P,F,N,U) DrawPerspPolytope(P,F,N,U,d)

DrawPerspFront(P,F,N,U,d) DrawPerspBack(P,F,N,U,d)

DrawPersp(P,F,N,U,d)

**Examples in X01_19_01**

Cube(s) House(s) Tetrahedron(s) Octahedron(s) Dodecahedron(s) Icosahedron(s)

RD(t) I(N) Prism(N,s,h) AntiPrism(N,s,h) RegularAntiPrism(N,s) DiPyramid(N,s,h)

RegularDiPyramid(N,s) GEDipyramid(N,R,h1,h2,h3) RegGEDipyramid(N,s)

TriAugTriPrism(s,H) QuasiPrism1(N,R,H QuasiPrism2(N,R,H,t)

QuasiPrism3(N,R,H,d) QuasiPrism4(N,R,H,d) Catalan6(R,h) Mason(R)

## 1.20 Drawing non-convex polytopes

**Rectangle intersection** RIntersect(r1,r2)

**The intersection between two straight lines** LIntersect(P,Q) Cross(z,w)

Intersect3(T,U) LIntersect2(P,Q) DepthOrder(P,T1,T2,F,N,U)

**Establishing depth order for a polytope** DepthList(P,F,N,U)

**Five ways that a line segment and a triangle can intersect** LineTriangleIntersect(L,T)

HLDraw(P,F,N,U) HLPerspDraw(P,F,N,U,d) An extra example

# Chapter 2 SURFACE PLOTS

## 2.1 Net maps

**Mappings of coordinate matrix triples = nets** row(A,n) NetRow(A,n) NetCol(A,n)

**Mappings of nets** NetMap3(M,f) NetMap2(M,f) Prism(sx,sy,sz)

NetTranslate3(M,x) NetTranslate2(M,x) NetTranslate(M,x) VNet(NetArray,NetMap)

NetsTranslate2(MA,x) NetsTranslate3(MA,x) NetsTranslate(MA,x)

NetScale(M,x) NetScaleV(M,x) NetsScale(AM,x) NetsScaleV(AM,x)

NetMmul(M,T) NetsMmul(NA,T) RotZ(α) NetRotZ(M,α) NetsRotZ(NA,α)

RotY(α) NetRotY(M,α) NetsRotY(NA,α) RotX(α) NetRotX(M,α)

NetsRotX(NA,α) RotN(n,t) NetRotN(M,n,α) NetsRotN(NA,N,α) RotAB(a,b)

NetRotAB(M,a,b) NetsRotAB(NA,a,b) Netaugment(M1,M2) NetAugment(VM)

Augment(MX) Netstack(R,S) NetStack(MX) Stack(MX)

## 2.2 Drawing filled plane areas

NGon(P,h) RegPolyE(N,E,F) RegularPolygon(N,E,F,h) Netjoin(R,S,depth)
NetsWindow(N,d) VNetJoin(MX,d) NetJoin(MX,d) Tiles(Mf,A,M,N,d)
Coord(V,f) FillSubMotif(V,f,h) StrokeSubMotif(V,f,h) FillMotif(V,F,h,d)
StrokeMotif(V,F,h,d) FillTiling(V,Ff,A,M,N,h,d) StrokeTiling(V,Ff,A,M,N,h,d)
Tiles2(Mf,A,M,N,d) FillTiling2(V,Ff,A,M,N,h,d) StrokeTiling2(V,Ff,A,M,N,h,d)
IFS1(M,T,α,d)

## 2.3 More examples of surfaces given as nets.

VI2Surface(V,I) Prism0(x,y,z) Prism(x,y,z) Cube0(s) Cube(s)
CylinderS(P,H) RegPolygon(N,R) Cone(P,T) GenCone(P,T) RevSurf(P,a,A,N,ax)
AddV2M(V,M) O3 PE(B,a,b,c) Parallelepiped(B,a,b,c) ParallelEpiped(M)
TH(B,a,b,c) Tetrahedron(B,a,b,c) TetraHedron(M) Octahedron(s) ConstVec(N,a)
PrismS(N,R,h) RegularPrismS(N,R)

## 2.4 Triangular nets

id(x,y) QuadrangularNet(a,A,M,b,B,N) TriangNet1(M) TriangularNet1(M)
TriangNet2(MM) TriangularNet2(M) TriangNet3(MM) TriangularNet3(M) TriangNet4(MM)
TriangularNet4(M) TriangNet5(MM) TriangularNet5(M) TriangularNet(M,i)
TriangleNet(a,A,M,b,B,N,n) Create3Mesh(f,a,A,M,b,B,N,g,n)
CreateTriMesh(f,a,A,M,b,B,N,n)

## 2.5 Uniform cubic B-splines

b(u) Bsp(u,p) RepEnd(z,n) Close(z) BSpline(u,M)

## 2.6 Cylinders and tubes

Edges(P) UnitV(x) Tangents(P,C) NP(a,b) PrincipalNormals(P,C)
BiNormals(P,C) GenCyl(P,EX,EY,X,Y) TubeConst(P,EX,EY,R) RegPolygon(N,R)
Tube1(P,N,R,C) Space2Mat(XYZ) SpacePolygon(F,a,A,M) CPNormals(P,C)
CBiNormals(P,C) Tube2(P,M,R,C) XBase(P,C) YBase(P,C) Tube3(P,N,R,C)

## 2.7 Drawing knots

Star(M,R1,R2) StarKnot(P,M,R1,R2) Rectangle(a,b)

RecKnot(P,a,b) ParameterKnot(P,R,a,A,M) PolarKnot(P,r,a,A,M)

VarKnot1(P,R,f) Rot(t) VarKnot2(P,R,α) VarKnot3(P,R,α,f)

## 2.8 Knots using varying number of vertices

Polygon1(N,R) Star1(N,R1,R2) GenTube4(H,CS1,CS2,M,EX,EY)

Polygon2(N,R) Star2(N,R1,R2) NewHXY(H,K,P1,P2)

GridTube(H,p,N,R,r)

## 2.9 Using fast Fourier transform to draw knots

Ff(V,k,t) FF(M,k,t)

## 2.10 Drawing a series of surfaces as one item

MatrixExtend(M,n) RowEqu(X1,X2) JoinSurfaces(M1,M2,P)

**Three dimensional IFSs** IFS3(M,T,α)

# Chapter 3 3D POLYGON MESHES

## 3.1 3D Polygon meshes

M2A(M) A2M(V) UnitV(x) FNormal(V,f) FCenter(V,f) Center(V) FNormals(P)

FCenters(P) Face(V,f,d,h) Faces(P,d,h) Cube(s) QuadSurface(P,d,h) House(s)

Gon(V,f) Gons(P) GonSurface(P,d) Tetrahedron(s) Octahedron(s) Dodecahedron(s)

Icosahedron(s) RD(t) I(N) Prism(N,s,h) RegularPrism(N,s)

AntiPrism(N,s,h) RegularAntiPrism(N,s) DiPyramid(N,s,h) RegularDiPyramid(N,s)

GEDipyramid(N,R,h1,h2,h3) RegGEDipyramid(N,s) TriAugTriPrism(s,H)

QuasiPrism1(N,R,H) QuasiPrism2(N,R,H,t) QuasiPrism3(N,R,H,d)

QuasiPrism4(N,R,H,d) Catalan6(R,h) Mason(R) MeshMap(P,f) MeshTranslate(P,x)

MeshMmul(P,M) MeshScale(P,x) MeshRotZ(P,α) MeshRotY(P,α) MeshRotX(P,α)

MeshRotAB(P,a,b) MeshRotN(P,n,t)

## 3.2 Auxiliary vector functions

in(x,y) CoNo(x,y) CompNo(x,y) ClNo(x,y) ColNo(x,y)

Common(x,y) DelComp(x,m) Volume(P,A,B,C) ang(A,B,C)

## 3.3 Edges of a polygon mesh

EdgeEqual(x,y) RemoveEqualEdges(E) Edges(S) EdgeInFace(e,f) EdgeNo(e,E)

VertexFaceNos(P,n) FaceNos(P) Dual(P) RightOrder(e,f) EdgeFacesNo(e,S)

EdgeFacesNos(S) VertexEdgeNos(P,n) EdgeNos(P)

## 3.4 Truncating the vertices a polygon mesh

VertexTruncate(P,t) VertexTruncate1(P,t,d,h) VertexTruncate2(P,t,d,h)

VertexTruncate3(P,t,d) VertexTruncate4(P,t,d)

## 3.5 The edge dual of a polygon mesh

EdgeDual(P) EdgeDual1(P,d,h) EdgeDual2(P,d,h) EdgeDual3(P,d) EdgeDual4(P,d)

## 3.6 Edge truncated polygon meshes

LongIndex(L,i,j) EdgeTruncate(P,h) EdgeTruncate1(P,h1,d,h)

EdgeTruncate2(P,h1,d,h) EdgeTruncate3(P,h1,d) EdgeTruncate4(P,h1,d)

EdgeLength(P) FaceCenterDistance(P) BestH(P)

## 3.7 Edge and vertex truncated polygon meshes

LongIndex(L,i,j) ang(A,B,C) Mod(x,y) EdgeVertexCut(P,s,t)

EdgeVertexCut1(P,s,t,d,h) EdgeVertexCut2(P,s,t,d,h) EdgeVertexCut3(P,s,t,d)

EdgeVertexCut4(P,s,t,d) S2T(s,n) T2S(t,n) BestS(D,n) BestS(D,n)

FaceCenterDistance(P) EdgeLength(P) RegS(P) RegT(P)

## 3.8 Star polyhedra

Center(V) StarFace(V,f,x,y,d) StarFaces(P,x,y,d) HFaceCenter(V,f,h)

HFaceCenters(P,h) StarSurface(P,x,y,d) GenStarFaces(P,X,Y,d)

GSurface(P,X,Y,d) GenStarVertexTrunc(P,u,v,t,d) GenStarEdgeTrunc(P,u,v,w,t,d)

GenStarEdgeVertexTrunc(P,u,v,w,s,t,d) FaceCenterOnSphere(P) SphereCenters(P)

Star2Mesh(P,t)

## 3.9 Drawing arrays of polygons meshes

ScaleMesh(P,C,t) Cylinder(P,Q,m,r,n) JoinArray(SA,C) JoinArrayC(SA,C,Ce)

QuadSurfaces(PA,d,h) GonSurfaces(PA,d) QuadSurfacesC(PA,Ce,d,h)

GonSurfacesC(PA,Ce,d) SurfaceGrid(FA,P,path) CylinderGrid(P,path,m,r,n)

Nonneg(x) SurfaceGrids(FA,P,paths) CylinderGrids(P,paths,m,r,n)

Corners(P,t,u,r) FaceSkeleton(P,s,n) Skeleton(P,s)

# Chapter 4 TESSELLATIONS

## 4.1 Regular tessellations

Tiles4(Mf,A,M,N,d) Tiles42(Mf,A,M,N,d) FillTiling4(V,Ff,A,M,N,h,d)

FillTiling42(V,Ff,A,M,N,h,d) StrokeTiling4(V,Ff,A,M,N,h,d)

StrokeTiling42(V,Ff,A,M,N,h,d) I(N)

## 4.2 Semiregular tessellations

***Example 1. Tiling ($3^3$,$4^2$)*** ***Example 2. The tiling (4,$3^2$,4,3)*** ***Example 3. The tiling (6,$3^4$)***

***Example 4. The tiling (3,6,3,6)*** ***Example 5. The tiling (3,$12^2$)*** ***Example 6. Tiling (4,6,12,6)***

***Example 7. Tiling (6,4,3,4)*** ***Example 8. Tiling($6^2$,4)***

## 4.3 Tiling a surface

Reference: Def04_01

Tile2Def(X,A,M,N,D) Mod(x,y) T2D(X,A,M,N,D,type)

NetsMap(VN,f) Torus(U,R,r) Sphere(U,R)

## 4.4 Surfaces

CCylinder(x,R,H) DefCyl(R,H,C) SurfRev(U,f,ax) L(P) UnitV(x) Perp(x)

PPoint(t,de,P) SurfRevP(U,P,ax) CSurfRev(U,f,ax,a,A) Def(f,a,A) Du(f,u,v)

Dv(f,u,v) SNormal(f,u,v) Surface3D(U,f) Torus2D(u,v,R,r1,r2)

PolSurf(U,f,ax,N) CPolSurf(U,f,ax,a,A,N) PCoord(t,P)

PPolSurf(U,P,f,ax,N) DefPPolSurf(P,a,A) CPPolSurf(U,P,f,ax,a,A,N)

DefCPPolSurf(P,f,a,A) Pol2Surf(U,P,Q,ax) Pol2SurfVar(U,P,Q,ax)

Func2Surf(U,f,g,ax) Func3Surf(U,f,g,h)

## 4.5 Tiling a tube around a differentiable space curve

UnitV(x) kv D(f,t) T(f,t) NX(f,t) NY(f,t) TubeFunction(U,f,R)

**Tiling a knot using discrete methods**

## 4.6 Plane isometries

Trans(x,t) Rotate(x,t) Rotation(x,a,t) Mi Mir(x) Ref(t) Refl(x,t)

Reflect(x,a,t) Glideref(x,a,b,d) Cell(A) Flag(A) I2 row(A,n) Rows(A)

Affine(M,T,L) MapDiagram(F,A) T2(M) Ma(M) Mb(M) Ga(M) Gb(M)

Trd(M) T4(M) Md(M) Gd(M) Hex Fl TriC Tri HexMapDiagram(F)

T3(M) T32(M) T6(M) T62(M) RE(M) RA(M)

## 4.7 Writing an integer on a 2D graph

Reference: Def04_06

τ1 Δ υ Join2Polygons(M1,M2) JoinPolygons(MA) DrawInteger(x,P,s)

VertexNumbers(P,s) Embed(P,h) Digits(h) StrokeInteger(x,P,s,he,de)

StrokeVertexNumbers(P,s,he,de) μ ν FilledDigits(h) FillInteger(x,h,d)

## 4.8 Lattices and their symmetries

DrawMotif(Mf,A,s) DrawMotifImage(Mf,F,A,s) ColNo(x,M)

NoRepAugment(M1,M2) ExtendPoints(V,F) IndexMap(M,f,F) Polygon(M,f)

## 4.9 The rectangular lattice

***Symmetry type pg*** ***Symmetry type pmm*** ***Symmetry type pmg***

## 4.10 Symmetry type cm ***Symmetry type cmm***

## 4.11 The square lattice

***Symmetry type p4*** ***Symmetry type p4m*** ***Symmetry type p4m***

## 4.12 The hexagonal lattice

***Symmetry type p3*** ***Symmetry type p3m1*** ***Symmetry type p31m***

***Symmetry type p6*** ***Symmetry type p6m***

## 4.13 Tiling a 3D Polygon Mesh

FaceNormal(V,f) XY2Face(R,V,f,O,EX) DrawOnAllFaces(R,P)

DrawOnFaces(R,P,O,EX)

## 4.14 Ribbon tilings

NGon3D(P) FillSubMotif3D(V,f) StrokeSubMotif3D(V,f) FillMotif3D(V,F,d)

StrokeMotif3D(V,F,d) FillTiling3D(V,Ff,A,M,N,d) StrokeTiling3D(V,Ff,A,M,N,d)

FillTiling3D2(V,Ff,A,M,N,d) StrokeTiling3D2(V,Ff,A,M,N,d)

***Escher's ribbon designs (Doris Schattschneider [1] p. 48)***

Z(M) R(M) S(M) DrawRibbonMotifs(d) RibbonPattern(C,B,A,M,N,d)

# Chapter 5 RECURSIVE CURVES

## 5.1 Recursive curves **Basic definitions**

s0 O l Turn(s,m) Move(s,m) StateArray(st,sh) StateMatrix(st,sh) sh1

FinalState(sh) Polygon(st,sh) Shape(P) Polyg(sh) vK4 ShExp(n,v) ones(n)

Reg(n) star vK4 vK3 s5 vK8 vK18 vK32 vK50 Peano9 Cesaro

Sierpinski Peano7 PeanoGosper s15 s16 s17 s18 s19 s20 s21 s22

## 5.2 Functions defined on shapes

TLength(sh) TTurn(sh) EMove(sh) EWalk(sh) Closed(sh) ETurn(sh) shape2(sh)

FDim(sh) Fdim(sh) Amplitude(sh) NormAmp(sh) TTurning(s) div(x,y) NRev(s)

MaxStep(sh) NormMaxStep(sh) dist1(z,p1,p2) dist2(z,p1,p2) dist3(x,P)

dist4(P1,P2) dist5(P1,P2) d(s1,s2)

## 5.3 Operations on shapes

o(c,sh) ¤(sh,c) Normal(sh) ⊕(sh1,sh2) ∑(Sh) •(n,sh) Sub(sh,m,n)

AtomicSub(sh) Ins(sh1,sh2,i) ⊗(s1,s2) ↑(s,n) Π(s,S) ∪(S1,S2) ◊(n,S)

conj(S) ´(s) ¬(S) Cutoff(s,t) CutOffClosed(s,t)

## 5.4 Drawing an array of shapes

PolygonArray(Sh,St) PolyArray(Init,sh,St,n) PolyArrayF(Init,St,n,F) div(x,y)

Grid(n,cols,Xd,Yd) PolygonGrid(Sh,cols,Xd,Yd) PolyGrid(Init,sh,n,cols,Xd,Yd)

PolyGridF(Init,sh,n,cols,Xd,Yd) Count(x,n) TreeProd(sh,S,Ind) TreeP(sh1,sh2,Ind)

## 5.5 Examples of fractal curves

Von Koch's three segment snowflake curve
Von Koch's four segment snowflake curve
Inward Von Koch Island
Von Koch's eight segment curve
Von Koch eighteen segment curve
Von Koch's thirty-two segment curve
Von Koch's fifty segment curve
Levy's curve
The Peano curve
The Modified Peano Curve:
The Gosper curve:
Non-standard example:
Example 13 Example 14
Example 15 Example 16

## 5.6 Showing more iterations

**Example 1. Von Koch's 3 segment curve.** **Example 2. Von Koch's 4 segment curve**
**Example 3. The inward von Koch island.** **Example 4. Von Koch's 8 segment curve.**
**Example 5. Von Koch's 18 segment curve.** **Example 6. Von Koch's 32 segment curve.**
**Example 7. Von Koch's 50 segment curve.** **Example 8. Levy's curve.**
**Example 9. The Peano curve** **Example 10. The modified Peano curve**
**Example 11. The Cesaro Triangle Curve** **Example 12. The modified Cesaro curve**

## 5.7 Examples of shapes using the multishape product Π.

**Example 1. The dragon curve** **The modified Dragon curve**
**Example 2. The Polya Triangle Curve.** **The modified Polya Triangle curve:**
**Example 3. The Sierpinski Triangle curve with generator Sierpinski.**

## 5.8 Fractal curves using more complicated recursion

**Example 1. The Peano-Gosper Curve**
**Example 2. Peano Seven Segment Snowflake Curves**
**Example 3. The Peano thirteen segment snowflake curve**
**Example 4. The Hilbert curve**

## 5.9 Examples of trees using the tree product

**Example 1. A tree of triangles** **Example 2. A ternary tree**
**Example 3. A quaternary tree** **Example 4. The H fractal tree**
**Example 5. The modified H fractal tree.** **Example 6. A tree of squares**
**Example 7. A tree of almost squares.** **Example 8. A Pythagorean tree**
**Example 9. An alternating Pythagorean tree** **Example 10. A bronchial system tree**

## 5.10 3D shapes

·(a,b) E I J K E1 E2 E3 S(q) VS(q) V(q) IS(a)
IV(x) _(q) Inv(q) NQ(q) M(q) M0(q) MU(q) MU0(q) Exp(V,θ)
qRot(V,θ) QRot(a,b) s0 Turn(st,m) Move(st,m) Matrix(sh) StateArray(st,sh)
StateMatrix(st,sh) Polygon(st,sh) O l FinalState(sh) qReg(n,V) SH(p,N,M)