

# Geoscript Groovy Cookbook

Jared Erickson

# Table of Contents

Geometry Recipes.....	1
Creating Geometries .....	1
Processing Geometries .....	7
Reading and Writing Geometries .....	10
Creating Bounds.....	12
Getting Bounds Properties.....	14
Processing Bounds .....	17
Projection Recipes .....	27
Creating Projections .....	27
Getting Projection Properties .....	29
Using Projections .....	30
Using Geodetic .....	31
Using Decimal Degrees.....	32
Spatial Index Recipes .....	36
Using STRtree .....	36
Using Quadtree.....	37
Using GeoHash .....	38
Viewer Recipes .....	42
Drawing geometries .....	42
Plotting geometries .....	46
Plot Recipes .....	49
Processing Charts .....	49
Creating Bar Charts.....	53
Creating Pie Charts .....	55
Creating Box Charts .....	56
Creating Curve Charts .....	56
Creating Regression Charts.....	58
Creating Scatter Plot Charts .....	59
Feature Recipes .....	60
Creating Fields .....	60
Creating Schemas .....	61
Getting Schema Properties .....	62
Getting Schema Fields .....	63
Modifying Schemas.....	64
Creating Features from a Schema .....	67

# Geometry Recipes

## Creating Geometries

*Create a Point with an XY*

```
Point point = new Point(-123,46)
```



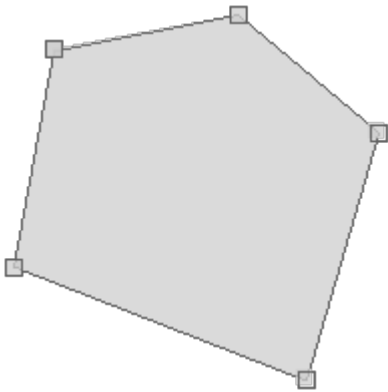
*Create a LineString from Coordinates*

```
LineString lineString = new LineString(  
    [3.1982421875, 43.1640625],  
    [6.7138671875, 49.755859375],  
    [9.7021484375, 42.5927734375],  
    [15.3271484375, 53.798828125]  
)
```



### Create a Polygon from a List of Coordinates

```
Polygon polygon = new Polygon([[  
    [-101.35986328125, 47.754097979680026],  
    [-101.5576171875, 46.93526088057719],  
    [-100.12939453125, 46.51351558059737],  
    [-99.77783203125, 47.44294999517949],  
    [-100.45898437499999, 47.88688085106901],  
    [-101.35986328125, 47.754097979680026]  
]])
```



### Create a MultiPoint with a List of Points

```
MultiPoint multiPoint = new MultiPoint([  
    new Point(-122.3876953125, 47.5820839916191),  
    new Point(-122.464599609375, 47.25686404408872),  
    new Point(-122.48382568359374, 47.431803338643334)  
])
```



### Create a MultiLineString with a List of LineStrings

```
MultiLineString multiLineString = new MultiLineString([
    new LineString (
        [-122.3822021484375, 47.57837853860192],
        [-122.32452392578125, 47.48380086737799]
    ),
    new LineString (
        [-122.32452392578125, 47.48380086737799],
        [-122.29705810546874, 47.303447043862626]
    ),
    new LineString (
        [-122.29705810546874, 47.303447043862626],
        [-122.42889404296875, 47.23262467463881]
    )
])
```



### Create a MultiPolygon with a List of Polygons

```
MultiPolygon multiPolygon = new MultiPolygon(  
    new Polygon ([[  
        [-122.2723388671875, 47.818687628247105],  
        [-122.37945556640624, 47.66168780332917],  
        [-121.95373535156249, 47.67093619422418],  
        [-122.2723388671875, 47.818687628247105]  
    ]]),  
    new Polygon ([[  
        [-122.76672363281249, 47.42437092240516],  
        [-122.76672363281249, 47.59505101193038],  
        [-122.52227783203125, 47.59505101193038],  
        [-122.52227783203125, 47.42437092240516],  
        [-122.76672363281249, 47.42437092240516]  
    ]]),  
    new Polygon ([[  
        [-122.20367431640624, 47.543163654317304],  
        [-122.3712158203125, 47.489368981370724],  
        [-122.33276367187499, 47.35371061951363],  
        [-122.11029052734374, 47.3704545156932],  
        [-122.08831787109375, 47.286681888764214],  
        [-122.28332519531249, 47.2270293988673],  
        [-122.2174072265625, 47.154237057576594],  
        [-121.904296875, 47.32579231609051],  
        [-122.06085205078125, 47.47823216312885],  
        [-122.20367431640624, 47.543163654317304]  
    ]])  
    ])  
)
```



### Create a CircularString with a List of Points

```
CircularString circularString = new CircularString([  
    [-122.464599609375, 47.247542522268006],  
    [-122.03613281249999, 47.37789454155521],  
    [-122.37670898437499, 47.58393661978134]  
])
```



Create a *CircularRing* with a List of Points

```
CircularRing circularRing = new CircularRing([
    [-118.47656249999999, 41.508577297439324],
    [-109.6875, 57.51582286553883],
    [-93.8671875, 42.032974332441405],
    [-62.57812500000001, 30.14512718337613],
    [-92.10937499999999, 7.36246686553575],
    [-127.265625, 14.604847155053898],
    [-118.47656249999999, 41.508577297439324]
])
```



## Create a CompoundCurve with a List of CircularStrings and LineStrings

```
CompoundCurve compoundCurve = new CompoundCurve([
    new CircularString([
        [27.0703125, 23.885837699862005],
        [5.9765625, 40.17887331434696],
        [22.5, 47.98992166741417],
    ]),
    new LineString([
        [22.5, 47.98992166741417],
        [71.71875, 49.15296965617039],
    ]),
    new CircularString([
        [71.71875, 49.15296965617039],
        [81.5625, 39.36827914916011],
        [69.9609375, 24.5271348225978]
    ])
])
```





```
CompoundRing compoundRing = new CompoundRing([
    new CircularString([
        [27.0703125, 23.885837699862005],
        [5.9765625, 40.17887331434696],
        [22.5, 47.98992166741417],
    ]),
    new LineString([
        [22.5, 47.98992166741417],
        [71.71875, 49.15296965617039],
    ]),
    new CircularString([
        [71.71875, 49.15296965617039],
        [81.5625, 39.36827914916011],
        [69.9609375, 24.5271348225978]
    ]),
    new LineString([
        [69.9609375, 24.5271348225978],
        [27.0703125, 23.885837699862005],
    ])
])
```



## Processing Geometries

Get the area of a Geometry

```
Polygon polygon = new Polygon([[
    [-124.80, 48.92],
    [-126.21, 45.33],
    [-114.60, 45.08],
    [-115.31, 51.17],
    [-121.99, 52.05],
    [-124.80, 48.92]
]])
double area = polygon.area
println area
```

62.4026

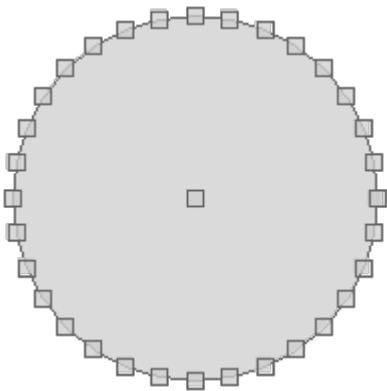
### *Get the length of a Geometry*

```
LineString lineString = new LineString([-122.69, 49.61], [-99.84, 45.33])  
double length = lineString.length  
println length
```

23.24738479915536

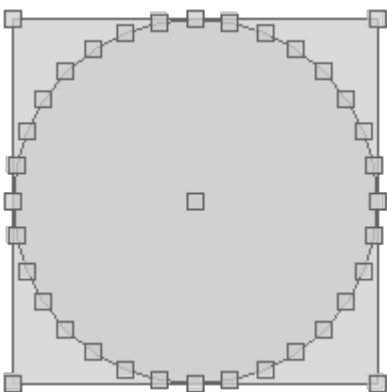
### *Buffer a Point*

```
Point point = new Point(-123,46)  
Geometry bufferedPoint = point.buffer(2)
```



### *Get Bounds from a Geometry*

```
Point point = new Point(-123,46)  
Polygon polygon = point.buffer(2)  
Bounds bounds = polygon.bounds
```



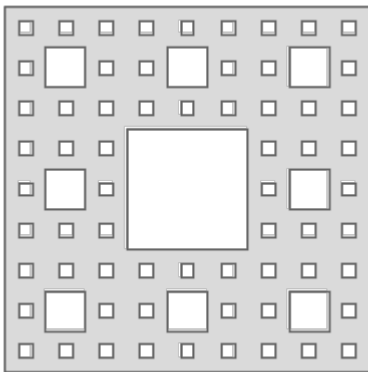
### *Create a Geometry of a String*

```
Geometry geometry = Geometry.createFromText("Geo")
```

# GEO

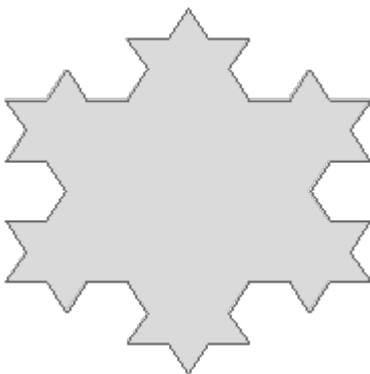
*Create a Sierpinski Carpet in a given Bounds and with a number of points*

```
Bounds bounds = new Bounds(21.645,36.957,21.676,36.970, "EPSG:4326")  
Geometry geometry = Geometry.createSierpinskiCarpet(bounds, 50)
```



*Create a Koch Snowflake in a given Bounds and with a number of points*

```
Bounds bounds = new Bounds(21.645,36.957,21.676,36.970, "EPSG:4326")  
Geometry geometry = Geometry.createKochSnowflake(bounds, 50)
```



# Reading and Writing Geometries

The `geoscript.geom.io` package has several Readers and Writers for converting `geoscript.geom.Geometry` to and from strings.

## WKT

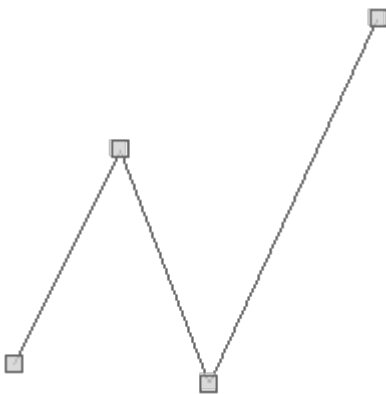
*Read a Geometry from WKT using the `WktReader`*

```
String wkt = "POINT (-123.15 46.237)"
WktReader reader = new WktReader()
Geometry geometry = reader.read(wkt)
```



*Read a Geometry from WKT using the `Geometry.fromWKT()` static method*

```
String wkt = "LINESTRING (3.198 43.164, 6.7138 49.755, 9.702 42.592, 15.327 53.798)"
Geometry geometry = Geometry.fromWKT(wkt)
```



*Get the WKT of a Geometry*

```
Geometry geometry = new Point(-123.15, 46.237)
String wkt = geometry.wkt
println wkt
```

```
POINT (-123.15 46.237)
```

*Write a Geometry to WKT using the WktWriter*

```
Geometry geometry = new LineString(  
    [3.198, 43.164],  
    [6.713, 49.755],  
    [9.702, 42.592],  
    [15.32, 53.798]  
)  
WktWriter writer = new WktWriter()  
String wkt = writer.write(geometry)  
println wkt
```

```
LINESTRING (3.198 43.164, 6.713 49.755, 9.702 42.592, 15.32 53.798)
```

## GeoJSON

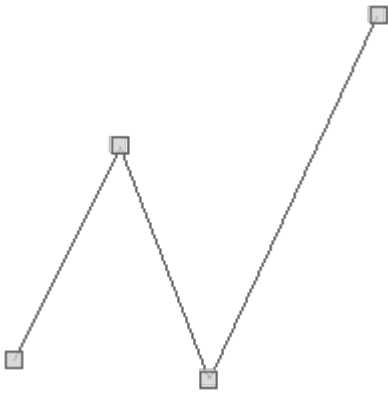
*Read a Geometry from GeoJSON using the GeoJSONReader*

```
String json = '{"type":"Point","coordinates":[-123.15,46.237]}'  
GeoJSONReader reader = new GeoJSONReader()  
Geometry geometry = reader.read(json)
```



*Read a Geometry from GeoJSON using the Geometry.fromGeoJSON() static method*

```
String json =  
'{"type":"LineString","coordinates":[[3.198,43.164],[6.713,49.755],[9.702,42.592],[15.  
32,53.798]]}'  
Geometry geometry = Geometry.fromGeoJSON(json)
```



*Get the GeoJSON of a Geometry*

```
Geometry geometry = new Point(-123.15, 46.237)
String json = geometry.geoJSON
println json
```

```
{"type":"Point","coordinates":[-123.15,46.237]}
```

*Write a Geometry to GeoJSON using the GeoJSONWriter*

```
Geometry geometry = new LineString(
    [3.198, 43.164],
    [6.713, 49.755],
    [9.702, 42.592],
    [15.32, 53.798]
)
GeoJSONWriter writer = new GeoJSONWriter()
String json = writer.write(geometry)
println json
```

```
{"type":"LineString","coordinates":[[3.198,43.164],[6.713,49.755],[9.702,42.592],[15.32,53.798]]}
```

## Creating Bounds

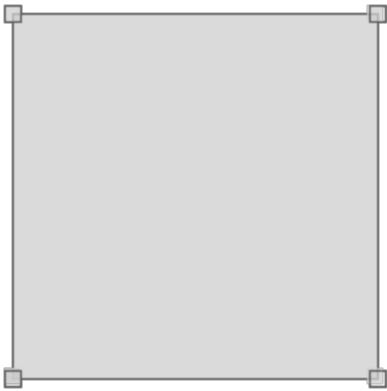
*Create a Bounds from four coordinates (minx, miny, maxx, maxy) and a projection.*

```
Bounds bounds = new Bounds(-127.265, 43.068, -113.554, 50.289, "EPSG:4326")
```



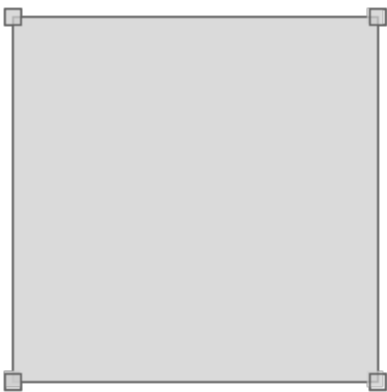
Create a *Bounds* from four coordinates (*minx*, *miny*, *maxx*, *maxy*) without a projection. The projection can be set later.

```
Bounds bounds = new Bounds(-127.265, 43.068, -113.554, 50.289)
bounds.proj = new Projection("EPSG:4326")
```



Create a *Bounds* from a string with commas delimiting *minx*, *miny*, *maxx*, *maxy* and projection values.

```
Bounds bounds = Bounds.fromString("-127.265,43.068,-113.554,50.289,EPSG:4326")
```



Create a *Bounds* from a string with spaces delimiting *minx*, *miny*, *maxx*, *maxy* and projection values.

```
Bounds bounds = Bounds.fromString("12.919921874999998 40.84706035607122 15.99609375  
41.77131167976407 EPSG:4326")
```



## Getting Bounds Properties

*Create a Bounds and view it's string representation*

```
Bounds bounds = new Bounds(-127.265, 43.068, -113.554, 50.289, "EPSG:4326")
String boundsStr = bounds.toString()
println boundsStr
```

```
(-127.265,43.068,-113.554,50.289,EPSG:4326)
```

*Get the minimum x coordinate*

```
double minX = bounds.minX
println minX
```

```
-127.265
```

*Get the minimum y coordinate*

```
double minY = bounds.minY
println minY
```

```
43.068
```

*Get the maximum x coordinate*

```
double maxX = bounds.maxX
println maxX
```

```
-113.554
```



*Get the maximum y coordinate*

```
double maxY = bounds.maxY  
println maxY
```

50.289

*Get the Projection*

```
Projection proj = bounds.proj  
println proj.id
```

EPSG:4326

*Get the area*

```
double area = bounds.area  
println area
```

99.007131000000004

*Get the width*

```
double width = bounds.width  
println width
```

13.710999999999999

*Get the height*

```
double height = bounds.height  
println height
```

7.2210000000000004

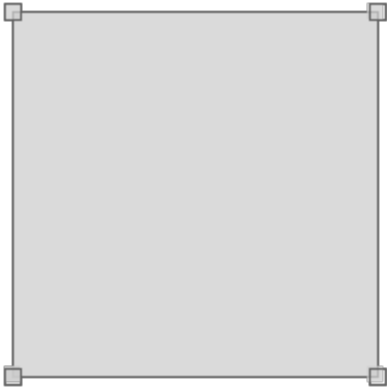
*Get the aspect ratio*

```
double aspect = bounds.aspect  
println aspect
```

1.8987674837280144

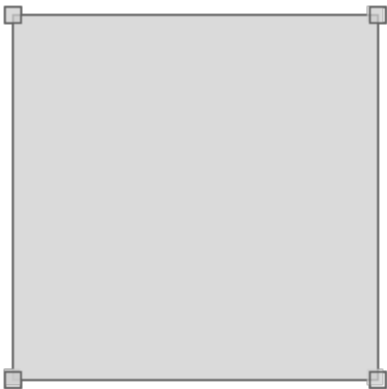
*A Bounds is not a Geometry but you can get a Geometry from a Bounds*

```
Bounds bounds = new Bounds(-122.485, 47.246, -122.452, 47.267, "EPSG:4326")
Geometry geometry = bounds.geometry
```



*You can also get a Polygon from a Bounds*

```
Bounds bounds = new Bounds(-122.485, 47.246, -122.452, 47.267, "EPSG:4326")
Polygon polygon = bounds.polygon
```



*Get the four corners from a Bounds as a List of Points*

```
Bounds bounds = new Bounds(-122.485, 47.246, -122.452, 47.267, "EPSG:4326")
List<Point> points = bounds.corners
```



## Processing Bounds

*Reproject a Bounds from one Projection to another.*

```
Bounds bounds = new Bounds(-122.485, 47.246, -122.452, 47.267, "EPSG:4326")  
println bounds
```

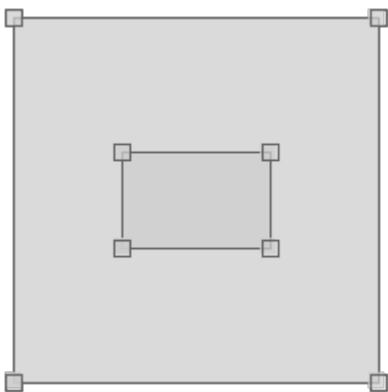
```
(-122.485,47.246,-122.452,47.267,EPG:4326)
```

```
Bounds reprojectedBounds = bounds.reproject("EPSG:2927")  
println reprojectedBounds
```

```
(1147444.7684517875,703506.223164177,1155828.120242509,711367.9403610165,EPG:2927)
```

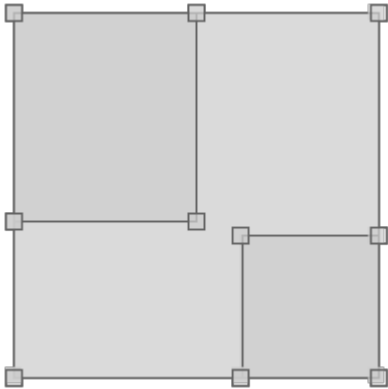
*Expand a Bounds by a given distance*

```
Bounds bounds1 = new Bounds(-127.265, 43.068, -113.554, 50.289, "EPSG:4326")  
Bounds bounds2 = new Bounds(-127.265, 43.068, -113.554, 50.289, "EPSG:4326")  
bounds2.expandBy(10.1)
```



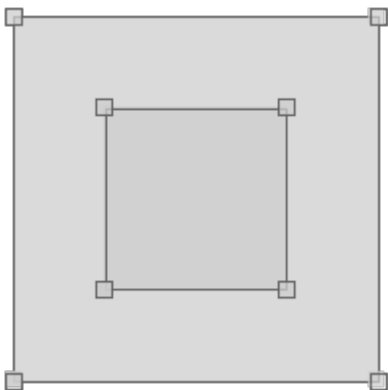
### *Expand a Bounds to include another Bounds*

```
Bounds bounds1 = new Bounds(8.4375, 37.996162679728116, 19.6875, 46.07323062540835, "EPSG:4326")
Bounds bounds2 = new Bounds(22.5, 31.952162238024975, 30.937499999999996, 37.43997405227057, "EPSG:4326")
bounds1.expand(bounds2)
```



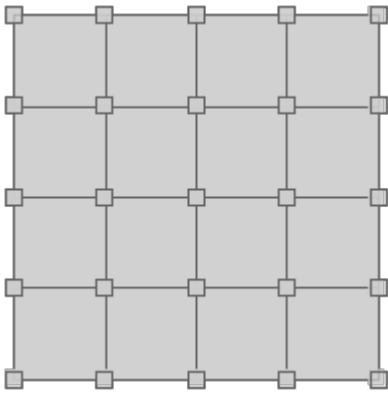
### *Scale an existing Bounds some distance to create a new Bounds*

```
Bounds bounds1 = new Bounds(-127.265, 43.068, -113.554, 50.289, "EPSG:4326")
Bounds bounds2 = bounds1.scale(2)
```



### *Divide a Bounds into smaller tiles or Bounds*

```
Bounds bounds = new Bounds(-122.485, 47.246, -122.452, 47.267, "EPSG:4326")
List<Bounds> subBounds = bounds.tile(0.25)
```



Calculate a quad tree for this Bounds between the start and stop levels. A Closure is called for each new Bounds generated.

```
Bounds bounds = new Bounds(-180, -90, 180, 90, "EPSG:4326")
bounds.quadTree(0,2) { Bounds b ->
    println b
}
```

```
(-180.0,-90.0,180.0,90.0,EPG:4326)
(-180.0,-90.0,0.0,0.0,EPG:4326)
(-180.0,0.0,0.0,90.0,EPG:4326)
(0.0,-90.0,180.0,0.0,EPG:4326)
(0.0,0.0,180.0,90.0,EPG:4326)
```

Determine whether a Bounds is empty or not. A Bounds is empty if it is null or it's area is 0.

```
Bounds bounds = new Bounds(0,10,10,20)
println bounds.isEmpty()
```

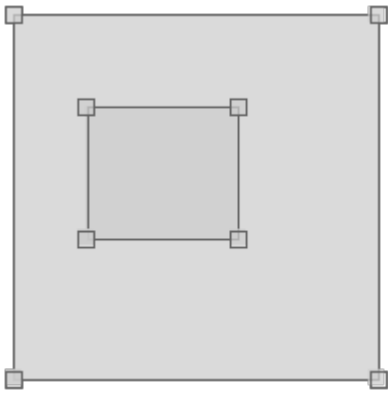
false

```
Bounds emptyBounds = new Bounds(0,10,10,10)
println emptyBounds.isEmpty()
```

true

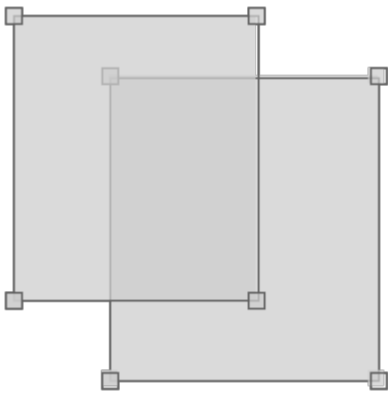
Determine if a Bounds contains another Bounds

```
Bounds bounds1 = new Bounds(-107.226, 34.597, -92.812, 43.068)
Bounds bounds2 = new Bounds(-104.326, 37.857, -98.349, 40.913)
println bounds1.contains(bounds2)
```



true

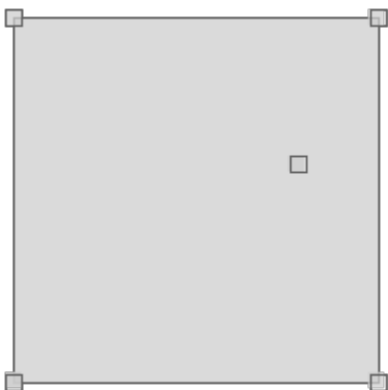
```
Bounds bounds3 = new Bounds(-112.412, 36.809, -99.316, 44.777)
println bounds1.contains(bounds3)
```



false

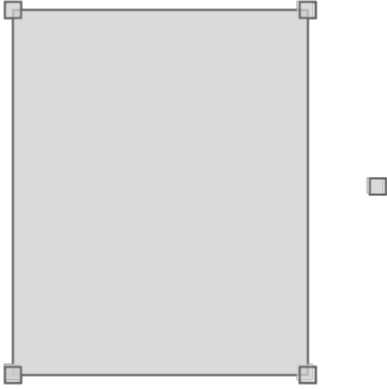
*Determine if a Bounds contains a Point*

```
Bounds bounds = new Bounds(-107.226, 34.597, -92.812, 43.068)
Point point1 = new Point(-95.976, 39.639)
println bounds.contains(point1)
```



true

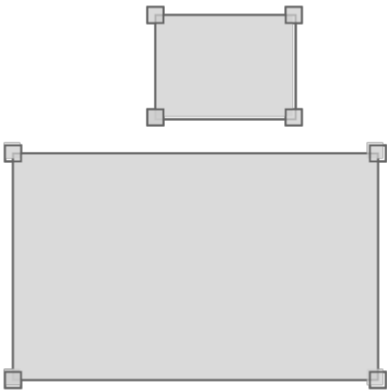
```
Point point2 = new Point(-89.384, 38.959)
println bounds.contains(point2)
```



true

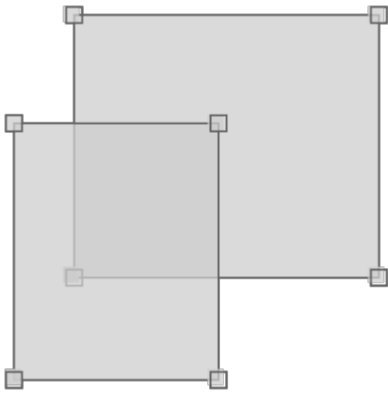
*Determine if two Bounds intersect*

```
Bounds bounds1 = new Bounds(-95.885, 46.765, -95.788, 46.811)
Bounds bounds2 = new Bounds(-95.847, 46.818, -95.810, 46.839)
println bounds1.intersects(bounds2)
```



false

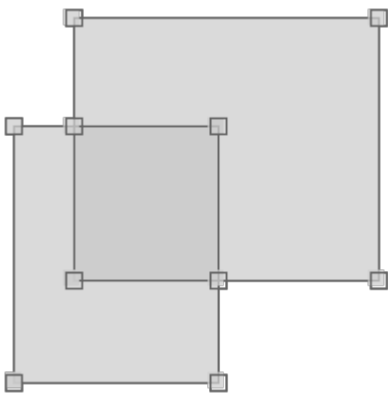
```
Bounds bounds3 = new Bounds(-95.904, 46.747, -95.839, 46.792)
println bounds1.intersects(bounds3)
```



true

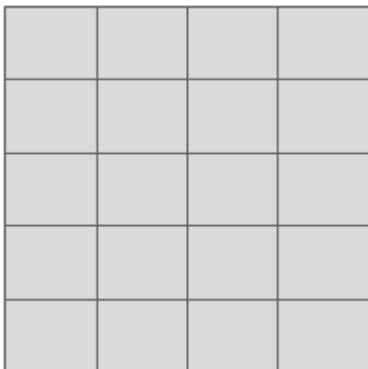
*Calculate the intersection between two Bounds*

```
Bounds bounds1 = new Bounds(-95.885, 46.765, -95.788, 46.811)
Bounds bounds2 = new Bounds(-95.904, 46.747, -95.839, 46.792)
Bounds bounds3 = bounds1.intersection(bounds2)
```



*Generate a grid from a Bounds with a given number of columns and rows and the polygon shape. Other shapes include: polygon, point, circle/ellipse, hexagon, hexagon-inv).*

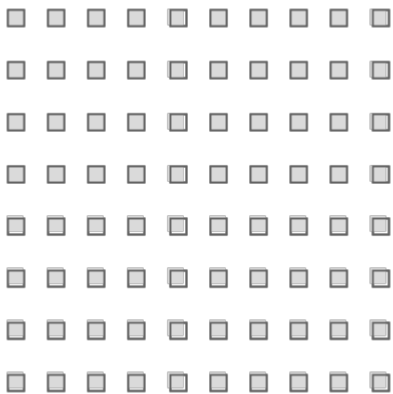
```
Bounds bounds = new Bounds(-180,-90,180,90,"EPSG:4326")
Geometry geometry = bounds.getGrid(5,4,"polygon")
```





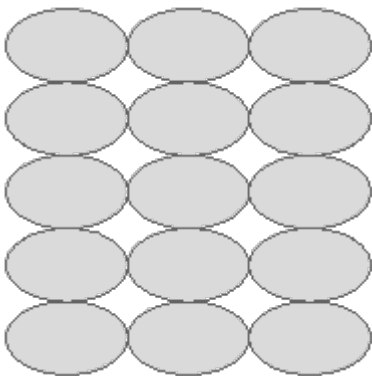
Generate a grid from a Bounds with a given number of columns and rows and a point shape. A Closure that is called with a geometry, column, and row for each grid cell that is created.

```
Bounds bounds = new Bounds(-180,-90,180,90,"EPSG:4326")
List geometries = []
Geometry geometry = bounds.generateGrid(10,8,"point") { Geometry g, int col, int row
->
    geometries.add(g)
}
```



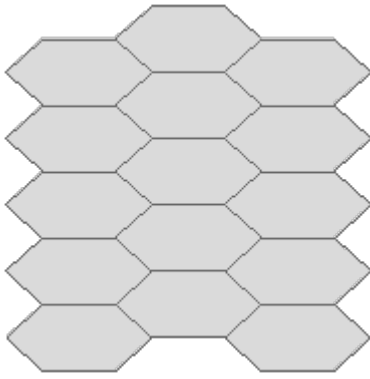
Generate a grid from a Bounds with a given cell width and height and a circle/ellipse shape.

```
Bounds bounds = new Bounds(-180,-90,180,90,"EPSG:4326")
Geometry geometry = bounds.getGrid(72.0,72.0,"circle")
```



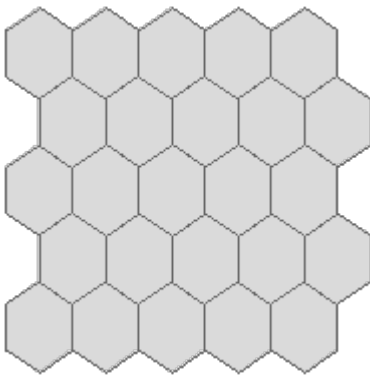
Generate a grid from a Bounds with a given cell width and height and a hexagon shape. A Closure is called with a geometry, column, and row for each grid cell generated.

```
Bounds bounds = new Bounds(-180,-90,180,90,"EPSG:4326")
List geometries = []
Geometry geometry = bounds.generateGrid(72.0,72.0,"hexagon") { Geometry g, int col,
int row ->
    geometries.add(g)
}
```



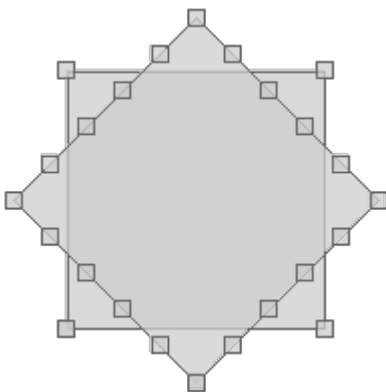
*Generate a grid from a Bounds with a given cell width and height and an inverted hexagon shape.*

```
Bounds bounds = new Bounds(-180,-90,180,90,"EPSG:4326")
Geometry geometry = bounds.getGrid(5,5,"hexagon-inv")
```



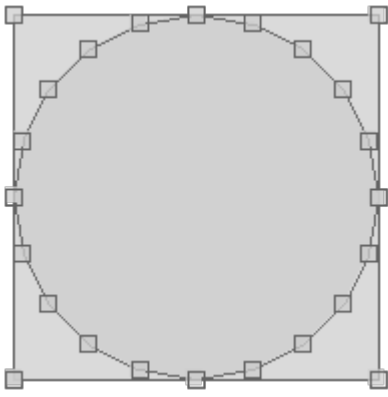
*Create a rectangle from a Bounds with a given number of Points and a rotation angle in radians.*

```
Bounds bounds = new Bounds(0,0,20,20)
Polygon polygon = bounds.createRectangle(20,Math.toRadians(45))
```



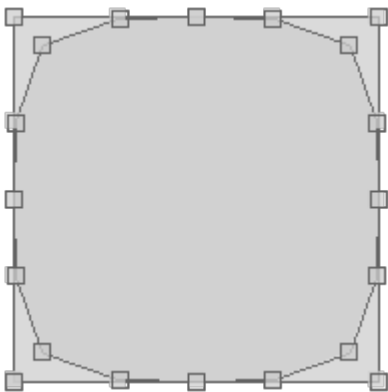
*Create an ellipse from a Bounds. The default number of points is 20 and the default rotation angle in radians is 0.*

```
Bounds bounds = new Bounds(0,0,20,20)
Polygon polygon = bounds.createEllipse()
```



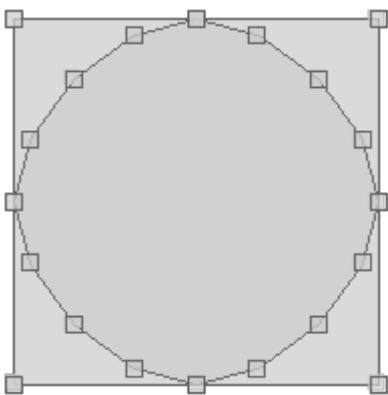
Create a squircle from a Bounds. The default number of points is 20 and the default rotation angle in radians is 0.

```
Bounds bounds = new Bounds(0,0,20,20)
Polygon polygon = bounds.createSquircle()
```



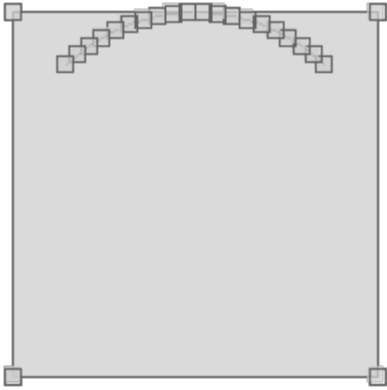
Create a super circle from a Bounds with a given power. The default number of points is 20 and the default rotation angle in radians is 0.

```
Bounds bounds = new Bounds(0,0,20,20)
Polygon polygon = bounds.createSuperCircle(1.75)
```



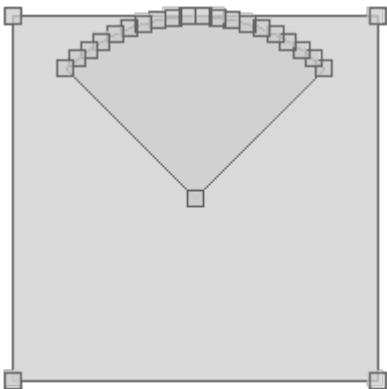
Create an arc from a Bounds with a start angle and angle extent. The default number of points is 20 and the default rotation angle in radians is 0.

```
Bounds bounds = new Bounds(0,0,20,20)
LineString lineString = bounds.createArc(Math.toRadians(45), Math.toRadians(90))
```



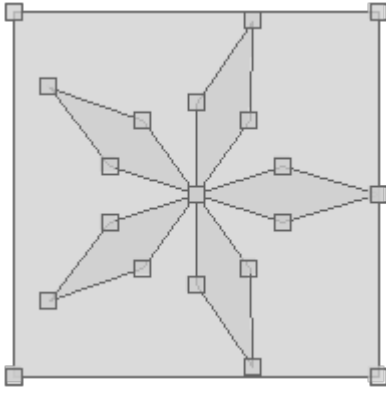
Create an arc polygon from a Bounds with a start angle and angle extent. The default number of points is 20 and the default rotation angle in radians is 0.

```
Bounds bounds = new Bounds(0,0,20,20)
Polygon polygon = bounds.createArcPolygon(Math.toRadians(45), Math.toRadians(90))
```



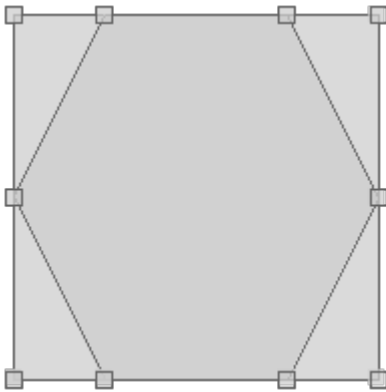
Create a sine star from a Bounds with a number of arms and an arm length ratio. The default number of points is 20 and the default rotation angle in radians is 0.

```
Bounds bounds = new Bounds(0,0,20,20)
Polygon polygon = bounds.createSineStar(5, 2.3)
```



Create a hexagon from a Bounds that is either inverted (false) or not (true).

```
Bounds bounds = new Bounds(0,0,20,20)
Polygon polygon = bounds.createHexagon(false)
```



## Projection Recipes

### Creating Projections

Create a Projection from an EPSG Code

```
Projection proj = new Projection("EPSG:4326")
println proj.wkt
```

```
GEOGCS["WGS 84",
  DATUM["World Geodetic System 1984",
    SPHEROID["WGS 84", 6378137.0, 298.257223563, AUTHORITY["EPSG","7030"]],
    AUTHORITY["EPSG","6326"]],
  PRIMEM["Greenwich", 0.0, AUTHORITY["EPSG","8901"]],
  UNIT["degree", 0.017453292519943295],
  AXIS["Geodetic longitude", EAST],
  AXIS["Geodetic latitude", NORTH],
  AUTHORITY["EPSG","4326"]]
```

### Create a Projection from a WKT Projection String

```
Projection proj = new Projection("GEOGCS[\"WGS 84\",  
DATUM[\"World Geodetic System 1984\",  
SPHEROID[\"WGS 84\", 6378137.0, 298.257223563, AUTHORITY[\"EPSG\", \"7030\"]],  
AUTHORITY[\"EPSG\", \"6326\"]],  
PRIMEM[\"Greenwich\", 0.0, AUTHORITY[\"EPSG\", \"8901\"]],  
UNIT[\"degree\", 0.017453292519943295],  
AXIS[\"Geodetic longitude\", EAST],  
AXIS[\"Geodetic latitude\", NORTH],  
AUTHORITY[\"EPSG\", \"4326\"]\"")
```

```
GEOGCS[\"WGS 84\",  
DATUM[\"World Geodetic System 1984\",  
SPHEROID[\"WGS 84\", 6378137.0, 298.257223563, AUTHORITY[\"EPSG\", \"7030\"]],  
AUTHORITY[\"EPSG\", \"6326\"]],  
PRIMEM[\"Greenwich\", 0.0, AUTHORITY[\"EPSG\", \"8901\"]],  
UNIT[\"degree\", 0.017453292519943295],  
AXIS[\"Geodetic longitude\", EAST],  
AXIS[\"Geodetic latitude\", NORTH],  
AUTHORITY[\"EPSG\", \"4326\"]]
```

### Create a Projection from well known name

```
Projection proj = new Projection("Mollweide")  
println proj.wkt
```

```
PROJCS[\"Mollweide\",  
GEOGCS[\"WGS84\",  
DATUM[\"WGS84\",  
SPHEROID[\"WGS84\", 6378137.0, 298.257223563]],  
PRIMEM[\"Greenwich\", 0.0],  
UNIT[\"degree\", 0.017453292519943295],  
AXIS[\"Longitude\", EAST],  
AXIS[\"Latitude\", NORTH]],  
PROJECTION[\"Mollweide\"],  
PARAMETER[\"semi-minor axis\", 6378137.0],  
PARAMETER[\"Longitude of natural origin\", 0.0],  
UNIT[\"m\", 1.0],  
AXIS[\"Easting\", EAST],  
AXIS[\"Northing\", NORTH]]
```

### Get a List of all supported Projections (this is really slow)

```
List<Projection> projections = Projection.projections()
```

```
EPSG:4326  
EPSG:4269  
EPSG:26918  
EPSG:2263  
EPSG:2927  
...
```

## Getting Projection Properties

*Get the id*

```
Projection proj = new Projection("EPSG:4326")  
String id = proj.id
```

```
EPSG:4326
```

*Get the srs*

```
String srs = proj.srs
```

```
EPSG:4326
```

*Get the epsg code*

```
int epsg = proj.epsg
```

```
4326
```

*Get the WKT*

```
String wkt = proj.wkt
```

```
GEOGCS["WGS 84",  
  DATUM["World Geodetic System 1984",  
    SPHEROID["WGS 84", 6378137.0, 298.257223563, AUTHORITY["EPSG","7030"]],  
    AUTHORITY["EPSG","6326"]],  
  PRIMEM["Greenwich", 0.0, AUTHORITY["EPSG","8901"]],  
  UNIT["degree", 0.017453292519943295],  
  AXIS["Geodetic longitude", EAST],  
  AXIS["Geodetic latitude", NORTH],  
  AUTHORITY["EPSG","4326"]]
```

*Get the Bounds in the native Projection*

```
Bounds bounds = proj.bounds
```

```
(-180.0, -90.0, 180.0, 90.0, EPSG:4326)
```

*Get the Bounds in the EPSG:4326*

```
Bounds geoBounds = proj.geoBounds
```

```
(-180.0, -90.0, 180.0, 90.0, EPSG:4326)
```

## Using Projections

*Transform a Geometry from one projection to another using the Projection static method with strings*

```
Geometry epsg4326Geom = new Point(-122.440, 47.245)
Geometry epsg2927Geom = Projection.transform(epsg4326Geom, "EPSG:4326", "EPSG:2927")
println epsg2927Geom
```

```
POINT (1158609.2040371667 703068.0661327887)
```

*Transform a Geometry from one projection to another using the Projection static method with Projections*

```
Projection epsg4326 = new Projection("EPSG:4326")
Projection epsg2927 = new Projection("EPSG:2927")
Geometry epsg4326Geom = new Point(-122.440, 47.245)
Geometry epsg2927Geom = Projection.transform(epsg4326Geom, epsg4326, epsg2927)
println epsg2927Geom
```

```
POINT (1158609.2040371667 703068.0661327887)
```

*Transform a Geometry from one projection to another using two Projections*

```
Projection fromProj = new Projection("EPSG:4326")
Projection toProj = new Projection("EPSG:2927")
Geometry geom = new Point(-122.440, 47.245)
Geometry projectedGeom = fromProj.transform(geom, toProj)
println projectedGeom
```



```
POINT (1158609.2040371667 703068.0661327887)
```

*Transform a Geometry from one projection to another using a Projections and a String*

```
Projection fromProj = new Projection("EPSG:4326")
Geometry geom = new Point(-122.440, 47.245)
Geometry projectedGeom = fromProj.transform(geom, "EPSG:2927")
println projectedGeom
```

```
POINT (1158609.2040371667 703068.0661327887)
```

## Using Geodetic

*Create a Geodetic object with an ellipsoid*

```
Geodetic geodetic = new Geodetic("wgs84")
println geodetic
```

```
Geodetic [SPHEROID["WGS 84", 6378137.0, 298.257223563]]
```

*Calculate the forward and back azimuth and distance between the given two Points.*

```
Geodetic geodetic = new Geodetic("clrk66")
Point bostonPoint = new Point(-71.117, 42.25)
Point portlandPoint = new Point(-123.683, 45.52)
Map results = geodetic.inverse(bostonPoint, portlandPoint)
double forwardAzimuth = results.forwardAzimuth
println forwardAzimuth
```

```
-66.52547810974724
```

```
double backAzimuth = results.backAzimuth
println backAzimuth
```

```
75.65817457195088
```

```
double distance = results.distance
println distance
```

```
4164050.4598800642
```

*Calculate a new Point and back azimuth given the starting Point, azimuth, and distance.*

```
Geodetic geodetic = new Geodetic("clrk66")
Point bostonPoint = new Point(-71.117, 42.25)
Map results = geodetic.forward(bostonPoint, -66.531, 4164192.708)
Point point = results.point
println point
```

```
POINT (-123.6835797667373 45.516427795897236)
```

```
double azimuth = results.backAzimuth
println azimuth
```

```
75.65337425050724
```

*Place the given number of points between starting and ending Points*

```
Geodetic geodetic = new Geodetic("clrk66")
Point bostonPoint = new Point(-71.117, 42.25)
Point portlandPoint = new Point(-123.683, 45.52)
List<Point> points = geodetic.placePoints(bostonPoint, portlandPoint, 10)
points.each { Point point ->
    println point.wkt
}
```

```
POINT (-75.41357382496236 43.52791689304304)
POINT (-79.8828640042499 44.63747566950249)
POINT (-84.51118758826816 45.565540142641005)
POINT (-89.27793446221685 46.300124344169255)
POINT (-94.15564606698499 46.83102721803566)
POINT (-99.11079892605703 47.15045006457598)
POINT (-104.10532353179985 47.25351783423774)
POINT (-109.09873812691617 47.13862709798196)
POINT (-114.05062990603696 46.80756425557422)
POINT (-118.92312608779855 46.26537395700513)
```

## Using Decimal Degrees

### Create a new DecimalDegrees from a longitude and latitude

```
DecimalDegrees decimalDegrees = new DecimalDegrees(-122.525619, 47.212023)
println decimalDegrees
```

-122° 31' 32.2284" W, 47° 12' 43.2828" N

### Create a new DecimalDegrees from a Point

```
DecimalDegrees decimalDegrees = new DecimalDegrees(new Point(-122.525619,47.212023))
println decimalDegrees
```

POINT (-122.52561944444444 47.212022222222224)

### Create a new DecimalDegrees from a Longitude and Latitude string

```
DecimalDegrees decimalDegrees = new DecimalDegrees("-122.525619, 47.212023")
println decimalDegrees
```

-122° 31' 32.2284" W, 47° 12' 43.2828" N

### Create a new DecimalDegrees from two strings with glyphs

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122\u00B0 31' 32.23\" W",
"47\u00B0 12' 43.28\" N")
println decimalDegrees
```

-122° 31' 32.2300" W, 47° 12' 43.2800" N

### Create a new DecimalDegrees from two strings

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31m 32.23s W", "47d 12m
43.28s N")
println decimalDegrees
```

-122° 31' 32.2300" W, 47° 12' 43.2800" N

Create a new `DecimalDegrees` from a single Degrees Minutes Seconds formatted string

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31m 32.23s W, 47d 12m 43.28s N")
println decimalDegrees
```

-122° 31' 32.2300" W, 47° 12' 43.2800" N

Create a new `DecimalDegrees` from a single Decimal Degree Minutes formatted string with glyphs

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122\u00B0 31.5372' W, 47\u00B0 12.7213' N")
println decimalDegrees
```

-122° 31' 32.2320" W, 47° 12' 43.2780" N

Create a new `DecimalDegrees` from a single Decimal Degree Minutes formatted string

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31.5372m W, 47d 12.7213m N")
println decimalDegrees
```

-122° 31' 32.2320" W, 47° 12' 43.2780" N

Get degrees minutes seconds from a `DecimalDegrees` object

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31m 32.23s W", "47d 12m 43.28s N")
Map dms = decimalDegrees.dms
println "Degrees: ${dms.longitude.degrees}"
println "Minutes: ${dms.longitude.minutes}"
println "Seconds: ${dms.longitude.seconds}"
```

Degrees: -122  
Minutes: 31  
Seconds: 32.22999999998388

```
println "Degrees: ${dms.latitude.degrees}"
println "Minutes: ${dms.latitude.minutes}"
println "Seconds: ${dms.latitude.seconds}"
```

```
Degrees: 47
Minutes: 12
Seconds: 43.280000000006396
```

*Convert a DecimalDegrees object to a DMS String with glyphs*

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31m 32.23s W", "47d 12m 43.28s N")
println decimalDegrees.toDms(true)
```

```
-122° 31' 32.2300" W, 47° 12' 43.2800" N
```

*Convert a DecimalDegrees object to a DMS String without glyphs*

```
println decimalDegrees.toDms(false)
```

```
-122d 31m 32.2300s W, 47d 12m 43.2800s N
```

*Get degrees minutes from a DecimalDegrees object*

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31m 32.23s W", "47d 12m 43.28s N")
Map dms = decimalDegrees.ddm
println "Degrees: ${dms.longitude.degrees}"
println "Minutes: ${dms.longitude.minutes}"
```

```
Degrees: -122
Minutes: 31.5371666666666398
```

```
println "Degrees: ${dms.latitude.degrees}"
println "Minutes: ${dms.latitude.minutes}"
```

```
Degrees: 47
Minutes: 12.72133333333344
```

*Convert a DecimalDegrees object to a DDM String with glyphs*

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31m 32.23s W", "47d 12m 43.28s N")
println decimalDegrees.toDdm(true)
```

```
-122° 31.5372' W, 47° 12.7213' N
```

*Convert a `DecimalDegrees` object to a DDM String without glyphs*

```
println decimalDegrees.toDdm(false)
```

```
-122d 31.5372m W, 47d 12.7213m N
```

*Get a Point from a `DecimalDegrees` object*

```
DecimalDegrees decimalDegrees = new DecimalDegrees("122d 31m 32.23s W", "47d 12m  
43.28s N")  
Point point = decimalDegrees.point
```

```
POINT (-122.52561944444444 47.212022222222224)
```

## Spatial Index Recipes

### Using STRtree

*Create a STRtree spatial index*

```
STRtree index = new STRtree()
```

*Insert Geometries and their Bounds*

```
index.insert(new Bounds(0,0,10,10), new Point(5,5))  
index.insert(new Bounds(2,2,6,6), new Point(4,4))  
index.insert(new Bounds(20,20,60,60), new Point(30,30))  
index.insert(new Bounds(22,22,44,44), new Point(32,32))
```

*Get the size of the index*

```
int size = index.size  
println size
```

```
4
```

### *Query the index*

```
List results = index.query(new Bounds(1,1,5,5))
results.each { Geometry geometry ->
    println geometry
}
```

```
POINT (4 4)
POINT (5 5)
```

## Using Quadtree

### *Create a Quadtree spatial index*

```
Quadtree index = new Quadtree()
```

### *Insert Geometries and their Bounds*

```
index.insert(new Bounds(0,0,10,10), new Point(5,5))
index.insert(new Bounds(2,2,6,6), new Point(4,4))
index.insert(new Bounds(20,20,60,60), new Point(30,30))
index.insert(new Bounds(22,22,44,44), new Point(32,32))
```

### *Get the size of the index*

```
int size = index.size
println size
```

```
4
```

### *Query the index with a Bounds*

```
List results = index.query(new Bounds(1,1,5,5))
results.each { Geometry geometry ->
    println geometry
}
```

```
POINT (30 30)
POINT (32 32)
POINT (5 5)
POINT (4 4)
```

### *Query the entire index*

```
List allResults = index.queryAll()
allResults.each { Geometry geometry ->
    println geometry
}
```

```
POINT (30 30)
POINT (32 32)
POINT (5 5)
POINT (4 4)
```

### *Remove an item from the index*

```
Geometry itemToRemove = allResults[0]
boolean removed = index.remove(itemToRemove.bounds, itemToRemove)
println "Removed? ${removed}"
println "Size = ${index.size}"
```

```
Removed = true
Size = 3
```

## Using GeoHash

### *Encode a Point as a String*

```
GeoHash geohash = new GeoHash()
Point point = new Point(112.5584, 37.8324)
String hash = geohash.encode(point)
println hash
```

```
ww8p1r4t8
```

### *Decode a Point from a String*

```
GeoHash geohash = new GeoHash()
Point point = geohash.decode("ww8p1r4t8")
println point
```

```
POINT (112.55838632583618 37.83238649368286)
```



### *Encode a Point as a Long*

```
GeoHash geohash = new GeoHash()  
Point point = new Point(112.5584, 37.8324)  
long hash = geohash.encodeLong(point)  
println long
```

```
4064984913515641
```

### *Decode a Point from a Long*

```
GeoHash geohash = new GeoHash()  
Point point = geohash.decode(4064984913515641)  
println point
```

```
POINT (112.55839973688126 37.83240124583244)
```

### *Decode a Bounds from a String*

```
GeoHash geohash = new GeoHash()  
Bounds bounds = geohash.decodeBounds("ww8p1r4t8")  
println bounds
```

```
(112.55836486816406,37.83236503601074,112.5584077835083,37.83240795135498)
```

### *Decode a Bounds from a Long*

```
GeoHash geohash = new GeoHash()  
Bounds bounds = geohash.decodeBounds(4064984913515641)  
println bounds
```

```
(112.55836486816406,37.83236503601074,112.5584077835083,37.83240795135498)
```

### Find neighboring geohash strings

```
GeoHash geohash = new GeoHash()
String hash = "dqcjg"
String north    = geohash.neighbor(hash, GeoHash.Direction.NORTH)
String northwest = geohash.neighbor(hash, GeoHash.Direction.NORTHWEST)
String west     = geohash.neighbor(hash, GeoHash.Direction.WEST)
String southwest = geohash.neighbor(hash, GeoHash.Direction.SOUTHWEST)
String south    = geohash.neighbor(hash, GeoHash.Direction.SOUTH)
String southeast = geohash.neighbor(hash, GeoHash.Direction.SOUTHEAST)
String east     = geohash.neighbor(hash, GeoHash.Direction.EAST)
String northeast = geohash.neighbor(hash, GeoHash.Direction.NORTHEAST)
String str = ""
    | ${northwest} ${north} ${northeast}
    | ${west} ${hash} ${east}
    | ${southwest} ${south} ${southeast}
    |"".stripMargin()
println str
```

```
dqcjt dqcjw dqcjx
dqejm dqcjg dqcjr
dqcjj dqcjm dqcjp
```

### Find neighboring geohash longs

```
GeoHash geohash = new GeoHash()
long hash = 1702789509
long north    = geohash.neighbor(hash, GeoHash.Direction.NORTH)
long northwest = geohash.neighbor(hash, GeoHash.Direction.NORTHWEST)
long west     = geohash.neighbor(hash, GeoHash.Direction.WEST)
long southwest = geohash.neighbor(hash, GeoHash.Direction.SOUTHWEST)
long south    = geohash.neighbor(hash, GeoHash.Direction.SOUTH)
long southeast = geohash.neighbor(hash, GeoHash.Direction.SOUTHEAST)
long east     = geohash.neighbor(hash, GeoHash.Direction.EAST)
long northeast = geohash.neighbor(hash, GeoHash.Direction.NORTHEAST)
String str = ""
    | ${northwest} ${north} ${northeast}
    | ${west} ${hash} ${east}
    | ${southwest} ${south} ${southeast}
    |"".stripMargin()
println str
```

```
1702789434 1702789520 1702789522
1702789423 1702789509 1702789511
1702789422 1702789508 1702789510
```

### Find all neighboring geohash strings

```
GeoHash geohash = new GeoHash()
String hash = "dqcjg"
Map neighbors = geohash.neighbors(hash)
String north    = neighbors[GeoHash.Direction.NORTH]
String northwest = neighbors[GeoHash.Direction.NORTHWEST]
String west     = neighbors[GeoHash.Direction.WEST]
String southwest = neighbors[GeoHash.Direction.SOUTHWEST]
String south    = neighbors[GeoHash.Direction.SOUTH]
String southeast = neighbors[GeoHash.Direction.SOUTHEAST]
String east     = neighbors[GeoHash.Direction.EAST]
String northeast = neighbors[GeoHash.Direction.NORTHEAST]
String str = ""
            | ${northwest} ${north} ${northeast}
            | ${west} ${hash} ${east}
            | ${southwest} ${south} ${southeast}
            |"".stripMargin()
println str
```

```
dqcjt dqcjw dqcjx
dqejm dqcjg dqcjr
dqcyj dqcjm dqcjp
```

### Find all neighboring geohash longs

```
GeoHash geohash = new GeoHash()
Long hash = 1702789509
Map neighbors = geohash.neighbors(hash)
Long north    = neighbors[GeoHash.Direction.NORTH]
Long northwest = neighbors[GeoHash.Direction.NORTHWEST]
Long west     = neighbors[GeoHash.Direction.WEST]
Long southwest = neighbors[GeoHash.Direction.SOUTHWEST]
Long south    = neighbors[GeoHash.Direction.SOUTH]
Long southeast = neighbors[GeoHash.Direction.SOUTHEAST]
Long east     = neighbors[GeoHash.Direction.EAST]
Long northeast = neighbors[GeoHash.Direction.NORTHEAST]
String str = ""
            | ${northwest} ${north} ${northeast}
            | ${west} ${hash} ${east}
            | ${southwest} ${south} ${southeast}
            |"".stripMargin()
println str
```

```
1702789434 1702789520 1702789522
1702789423 1702789509 1702789511
1702789422 1702789508 1702789510
```

*Find all geohashes as strings within a Bounds*

```
GeoHash geohash = new GeoHash()
List<String> bboxes = geohash.bboxes(new Bounds(120, 30, 120.0001, 30.0001), 8)
bboxes.each { String hash ->
    println hash
}
```

```
wtm6dtm6
wtm6dtm7
```

*Find all geohashes as longs within a Bounds*

```
GeoHash geohash = new GeoHash()
List<Long> bboxes = geohash.bboxesLong(new Bounds(120, 30, 120.0001, 30.0001), 40)
bboxes.each { long hash ->
    println hash
}
```

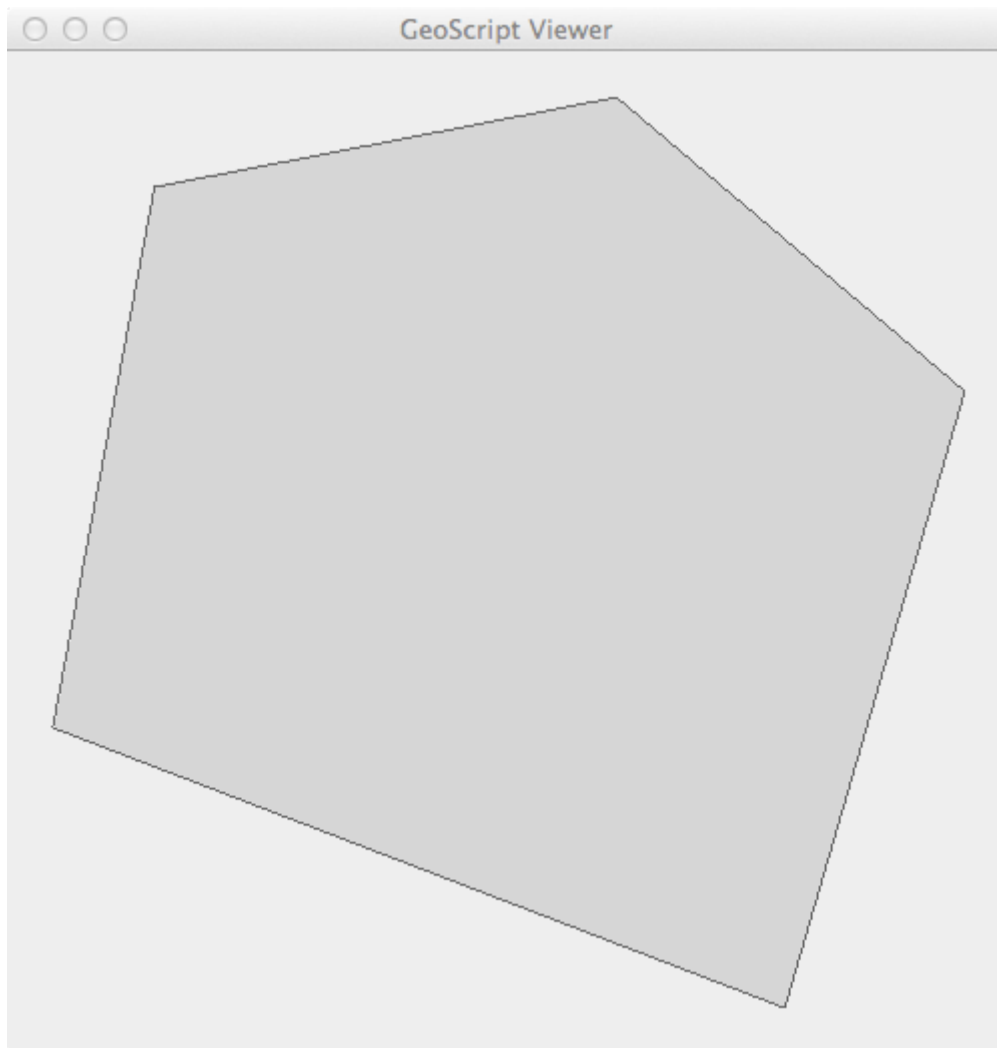
```
989560464998
989560464999
```

## Viewer Recipes

### Drawing geometries

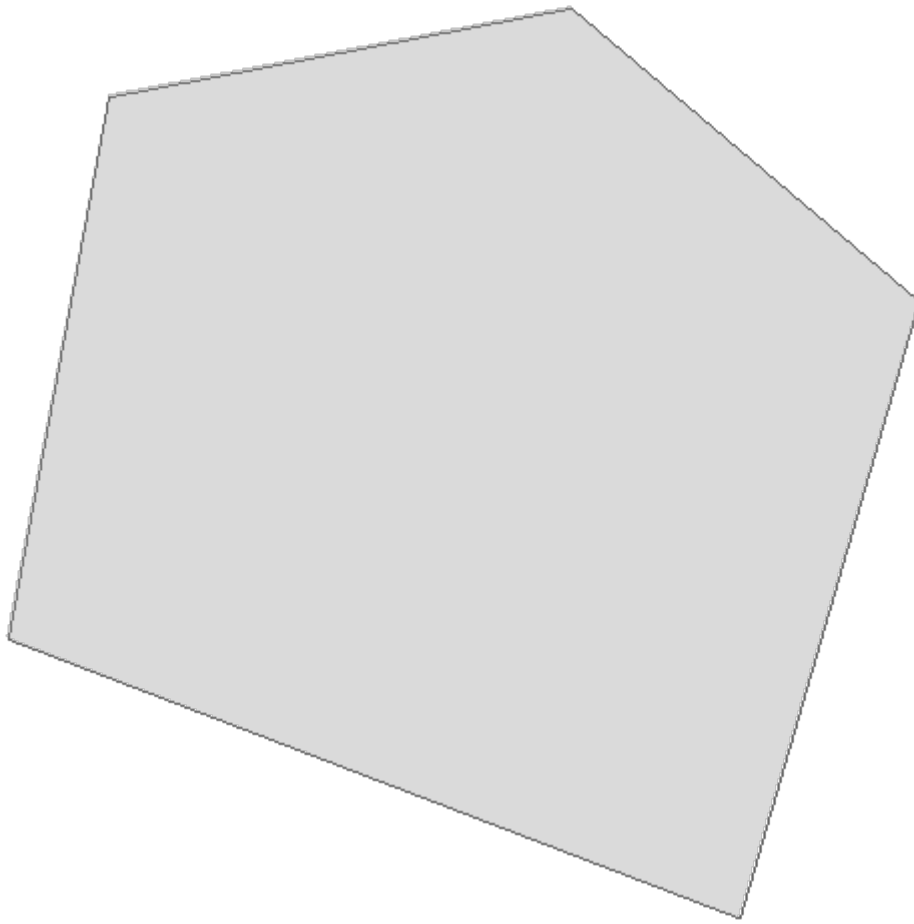
*Draw a geometry in a simple GUI*

```
Polygon polygon = new Polygon([[
    [-101.35986328125, 47.754097979680026],
    [-101.5576171875, 46.93526088057719],
    [-100.12939453125, 46.51351558059737],
    [-99.77783203125, 47.44294999517949],
    [-100.45898437499999, 47.88688085106901],
    [-101.35986328125, 47.754097979680026]
]])
Viewer.draw(polygon)
```



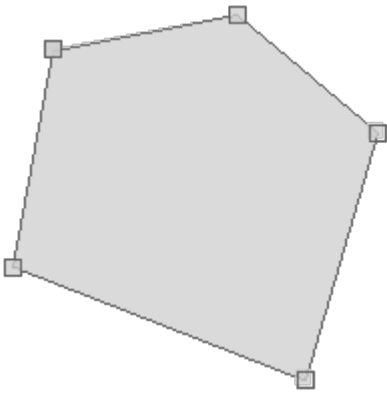
*Draw a geometry to an image*

```
Polygon polygon = new Polygon([[  
    [-101.35986328125, 47.754097979680026],  
    [-101.5576171875, 46.93526088057719],  
    [-100.12939453125, 46.51351558059737],  
    [-99.77783203125, 47.44294999517949],  
    [-100.45898437499999, 47.88688085106901],  
    [-101.35986328125, 47.754097979680026]  
]])  
BufferedImage image = Viewer.drawToImage(polygon)
```



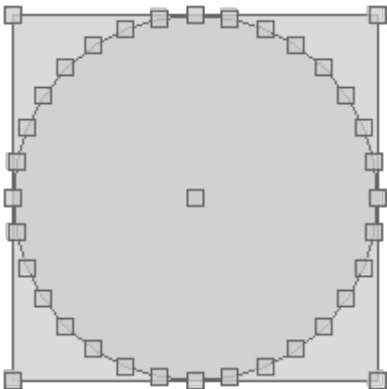
*Draw a geometry to an image with options*

```
Polygon polygon = new Polygon([[
    [-101.35986328125, 47.754097979680026],
    [-101.5576171875, 46.93526088057719],
    [-100.12939453125, 46.51351558059737],
    [-99.77783203125, 47.44294999517949],
    [-100.45898437499999, 47.88688085106901],
    [-101.35986328125, 47.754097979680026]
]])
BufferedImage image = Viewer.drawImage(
    polygon,
    size: [200,200],
    drawCoords: true,
    fillCoords: true,
    fillPolys: true
)
```



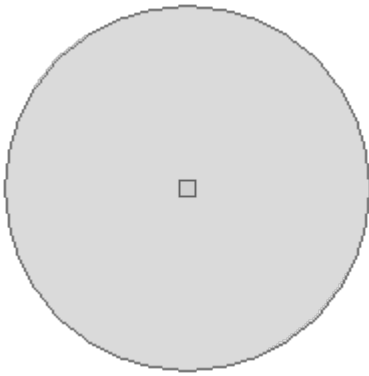
*Draw a List of geometries to an image*

```
Point point = new Point(-123.11, 47.23)
Geometry buffer = point.buffer(4)
Geometry bounds = buffer.bounds.geometry
BufferedImage image = Viewer.drawToImage(
    [bounds, buffer, point],
    size: [200,200],
    drawCoords: true,
    fillCoords: true,
    fillPolys: true
)
```



*Draw a List of Geometries to a File*

```
Point point = new Point(-123.11, 47.23)
Geometry buffer = point.buffer(4)
File file = new File("geometry.png")
Viewer.drawToFile([buffer, point], file, size: [200,200])
```

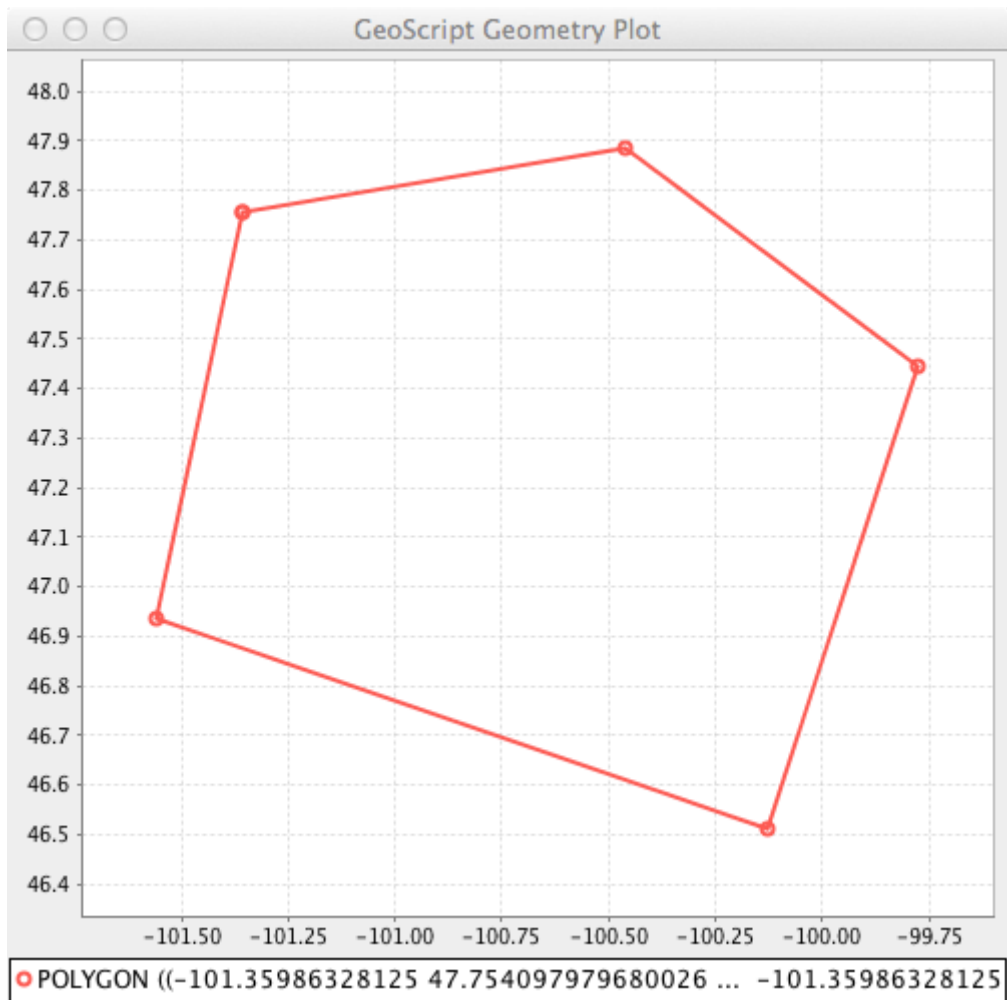


## Plotting geometries

*Plot a geometry in a simple GUI*

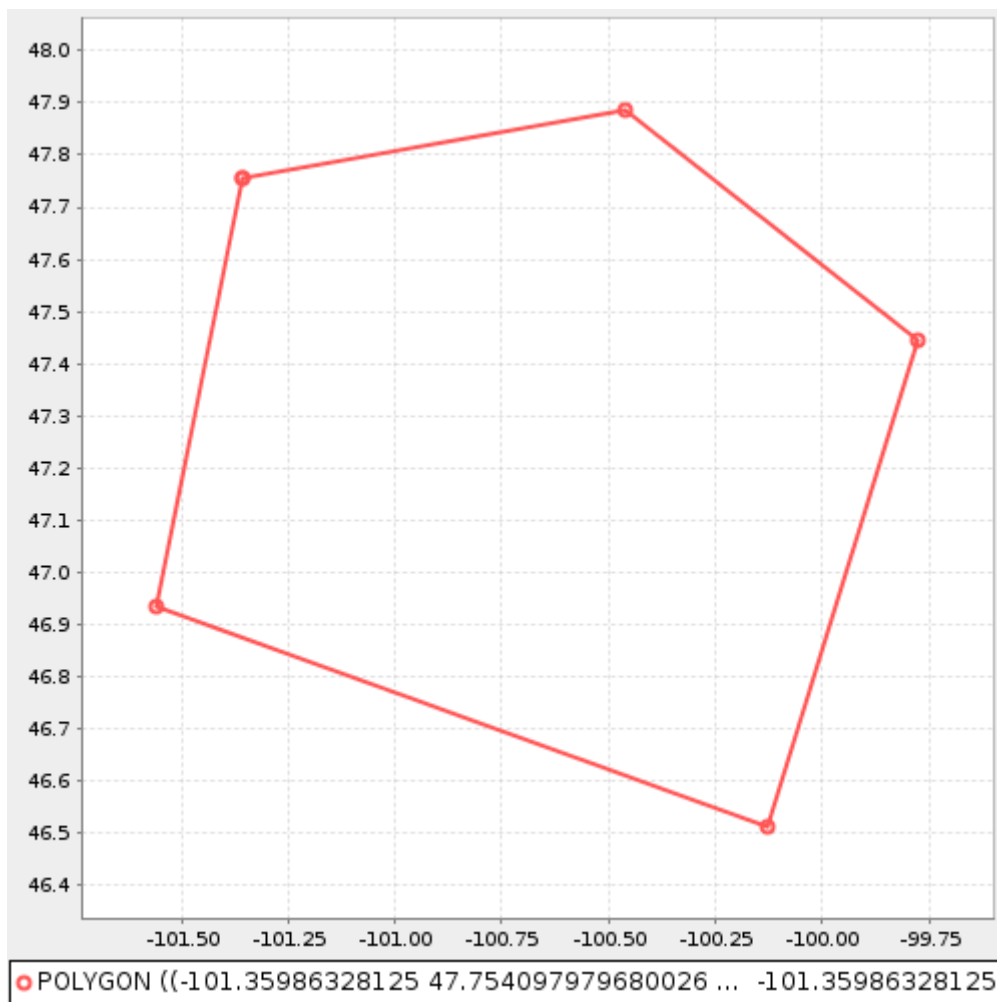
```
Polygon polygon = new Polygon([[
    [-101.35986328125, 47.754097979680026],
    [-101.5576171875, 46.93526088057719],
    [-100.12939453125, 46.51351558059737],
    [-99.77783203125, 47.44294999517949],
    [-100.45898437499999, 47.88688085106901],
    [-101.35986328125, 47.754097979680026]
]])
Viewer.plot(polygon)
```





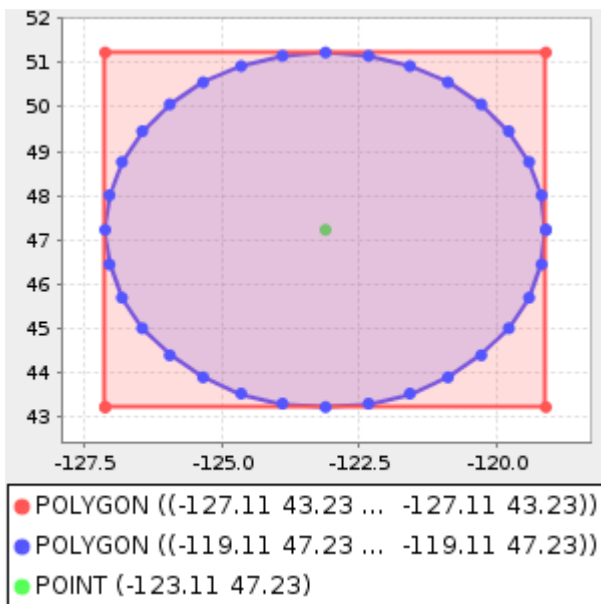
*Plot a Geometry to an image*

```
Polygon polygon = new Polygon([[
    [-101.35986328125, 47.754097979680026],
    [-101.5576171875, 46.93526088057719],
    [-100.12939453125, 46.51351558059737],
    [-99.77783203125, 47.44294999517949],
    [-100.45898437499999, 47.88688085106901],
    [-101.35986328125, 47.754097979680026]
]])
BufferedImage image = Viewer.plotToImage(polygon)
```



*Plot a List of Geometries to an image*

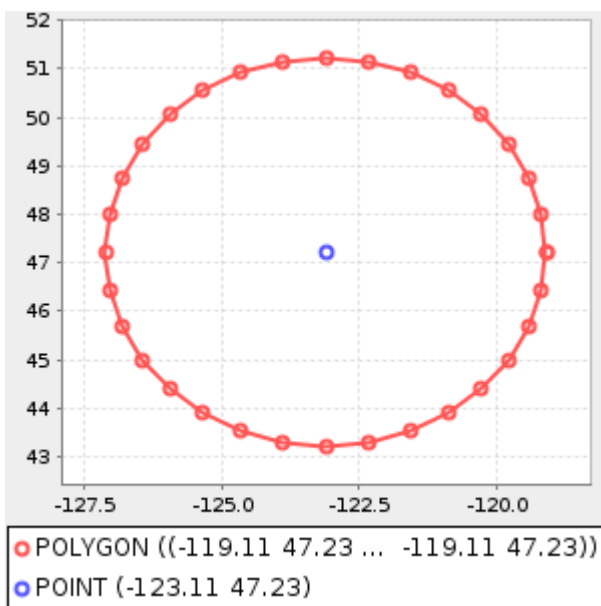
```
Point point = new Point(-123.11, 47.23)
Geometry buffer = point.buffer(4)
Geometry bounds = buffer.bounds.geometry
BufferedImage image = Viewer.plotToImage(
    [bounds, buffer, point],
    size: [300,300],
    drawCoords: true,
    fillCoords: true,
    fillPolys: true
)
```



*Plot a Geometry to a File*

```

Point point = new Point(-123.11, 47.23)
Geometry buffer = point.buffer(4)
File file = new File("geometry.png")
Viewer.plotToFile([buffer, point], file, size: [300,300])
  
```

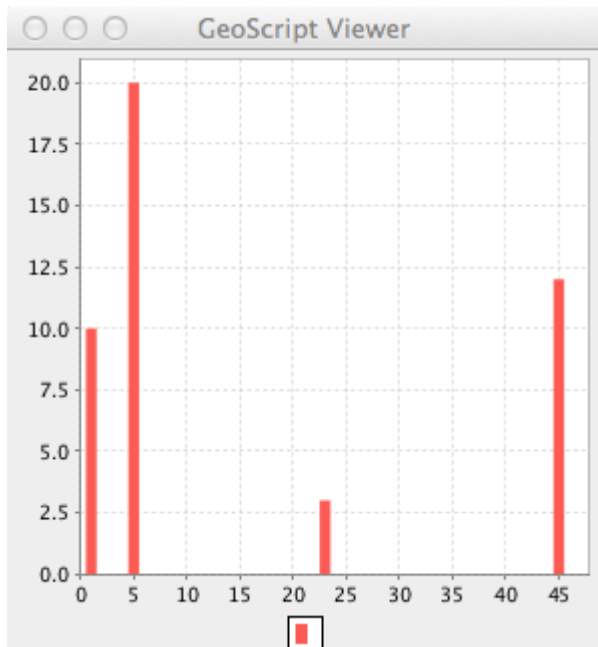


## Plot Recipes

## Processing Charts

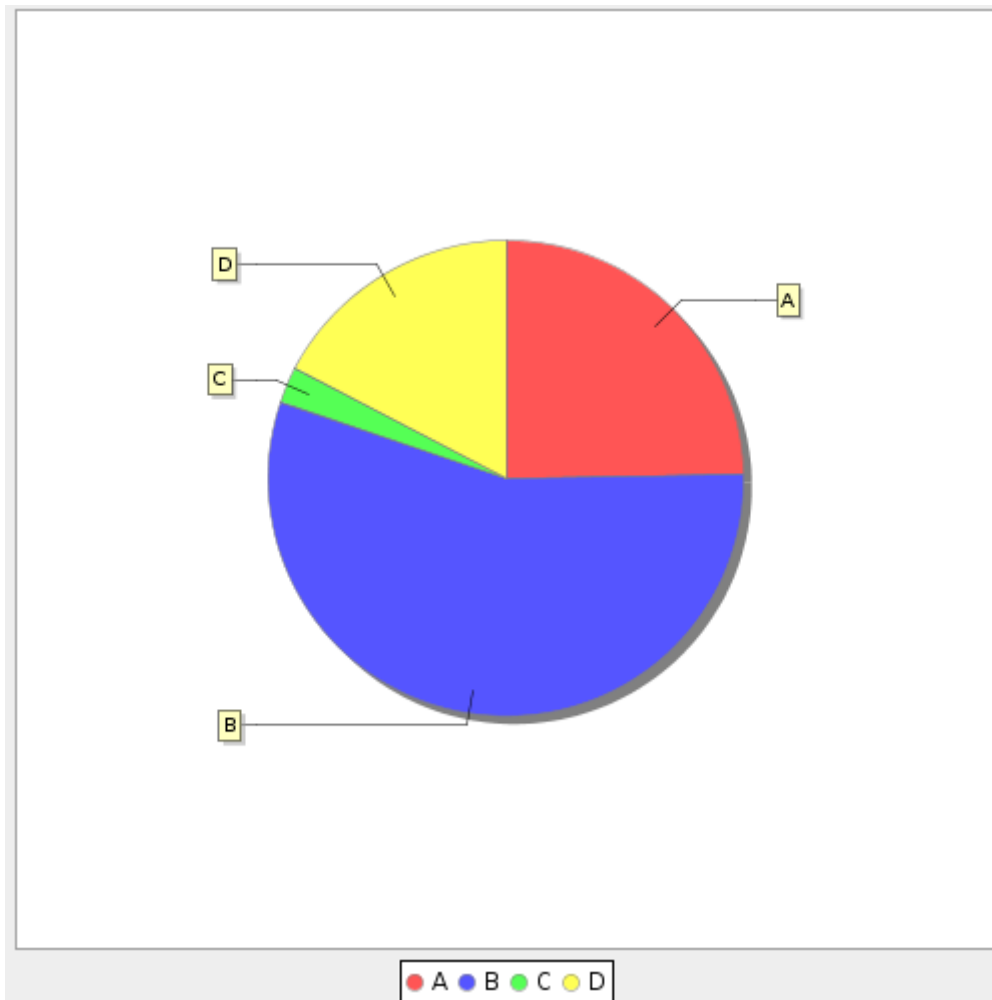
### Show a chart in a GUI

```
List data = [  
    [1,10],[45,12],[23,3],[5,20]  
]  
Chart chart = Bar.xy(data)
```



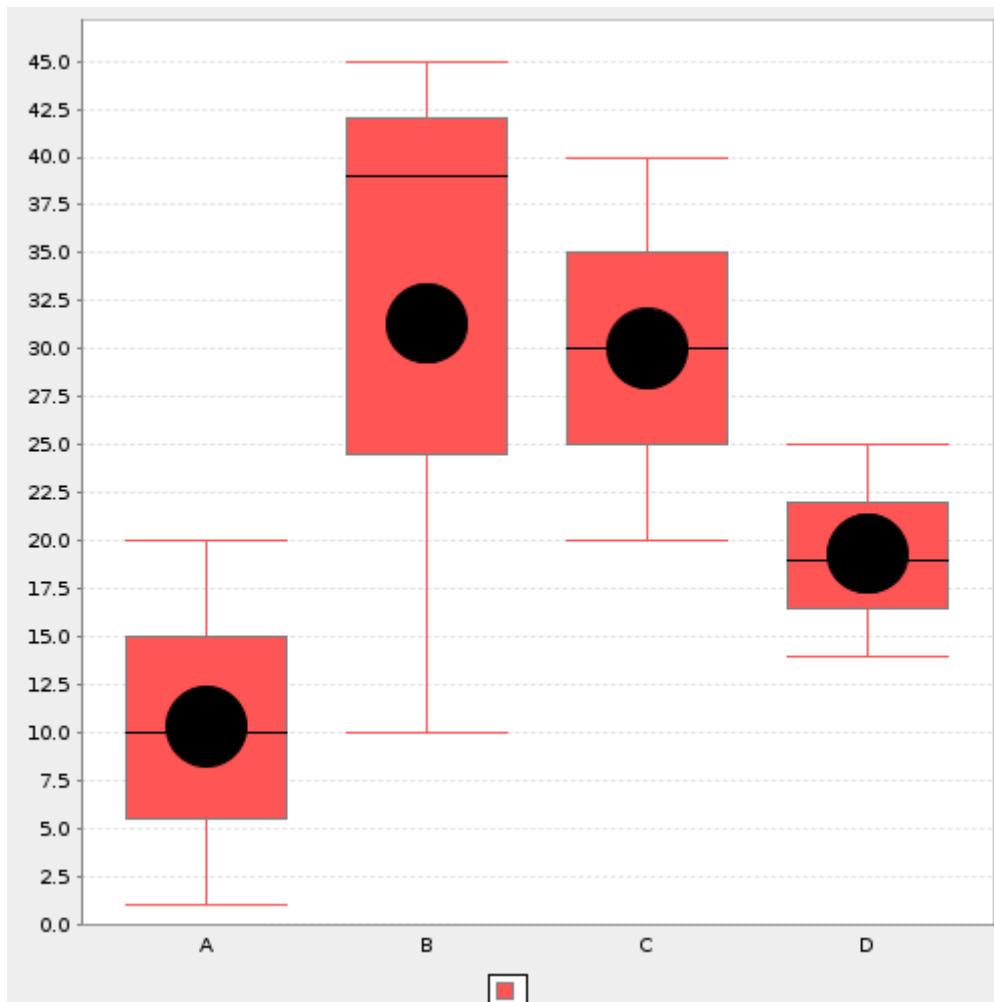
### Get an image from a chart

```
Map data = [  
    "A":20,"B":45,"C":2,"D":14  
]  
Chart chart = Pie.pie(data)  
BufferedImage image = chart.image
```



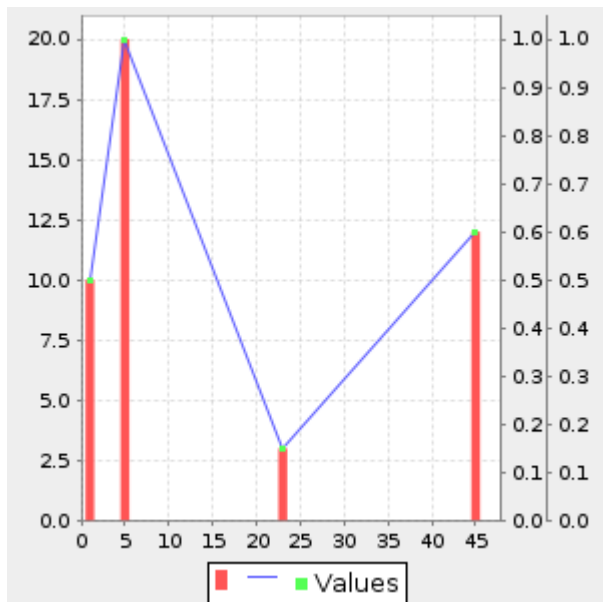
*Save a chart to a file*

```
Map data = [  
    "A": [1, 10, 20],  
    "B": [45, 39, 10],  
    "C": [40, 30, 20],  
    "D": [14, 25, 19]  
]  
Chart chart = Box.box(data)  
File file = new File("chart.png")  
chart.save(file)
```



### Overlay multiple charts

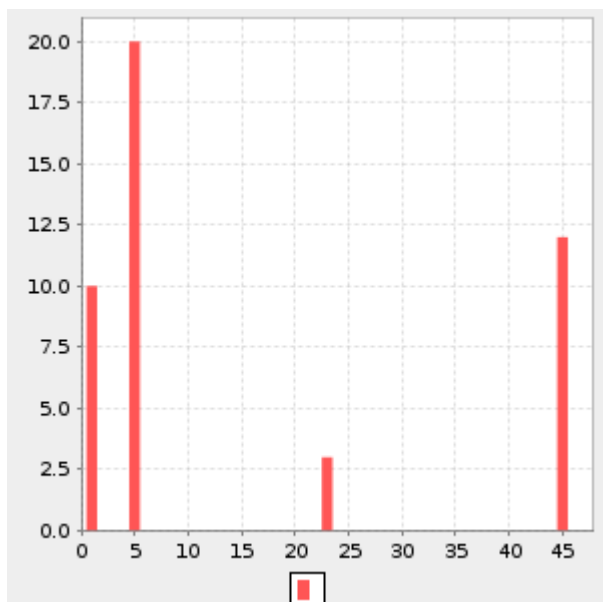
```
List data = [
    [1,10],[45,12],[23,3],[5,20]
]
Chart chart1 = Bar.xy(data)
Chart chart2 = Curve.curve(data)
Chart chart3 = Regression.linear(data)
chart1.overlay([chart2,chart3])
```



## Creating Bar Charts

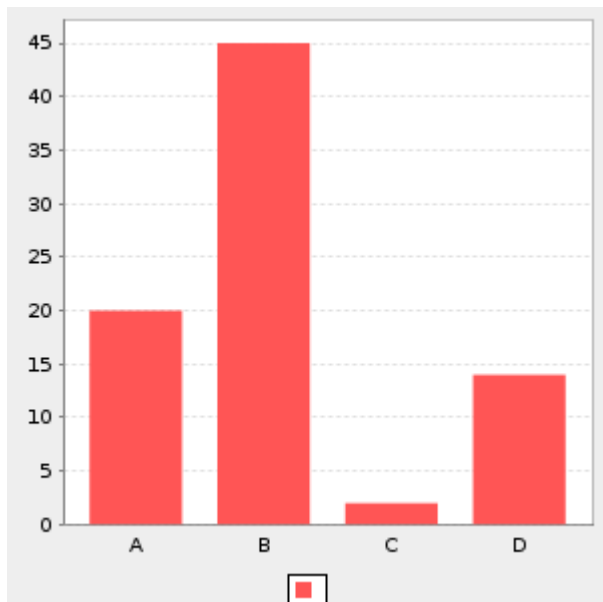
*Create a basic bar chart*

```
List data = [
  [1,10],[45,12],[23,3],[5,20]
]
Chart chart = Bar.xy(data)
```



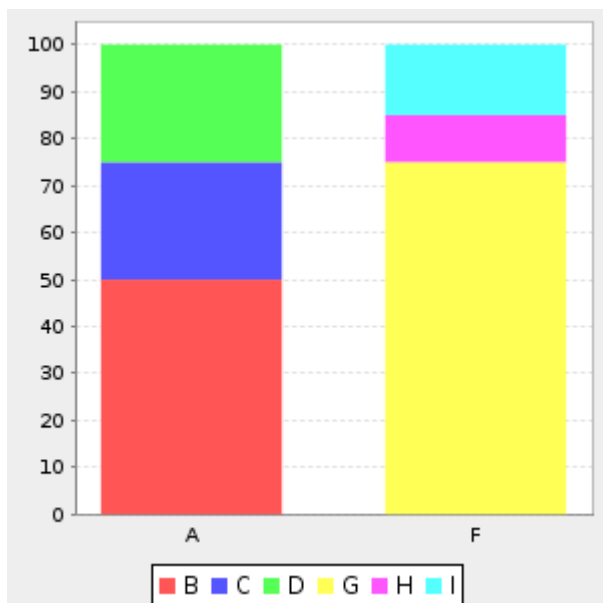
*Create a bar chart with categories*

```
Map data = [
  "A":20,"B":45,"C":2,"D":14
]
Chart chart = Bar.category(data)
```



Create a stacked bar chart with two series of data

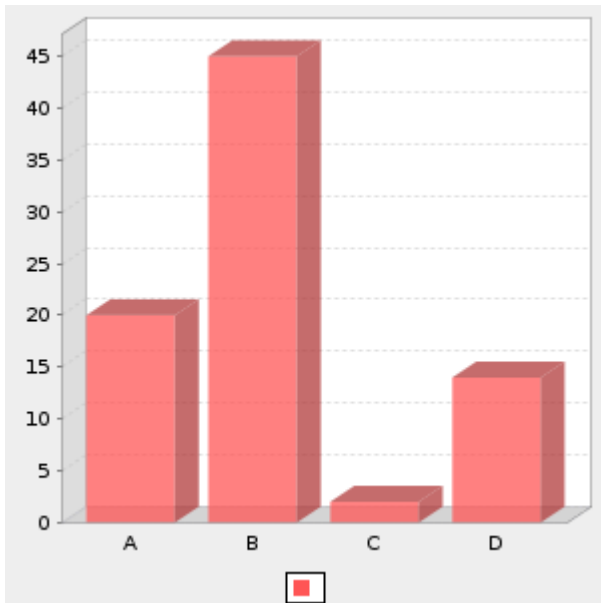
```
Map data = [
  "A": ["B":50,"C":25,"D":25],
  "F": ["G":75,"H":10,"I":15]
]
Chart chart = Bar.category(data, stacked: true)
```



Create a 3D bar chart with categories

```
Map data = [
  "A":20,"B":45,"C":2,"D":14
]
Chart chart = Bar.category(data, trid: true)
```

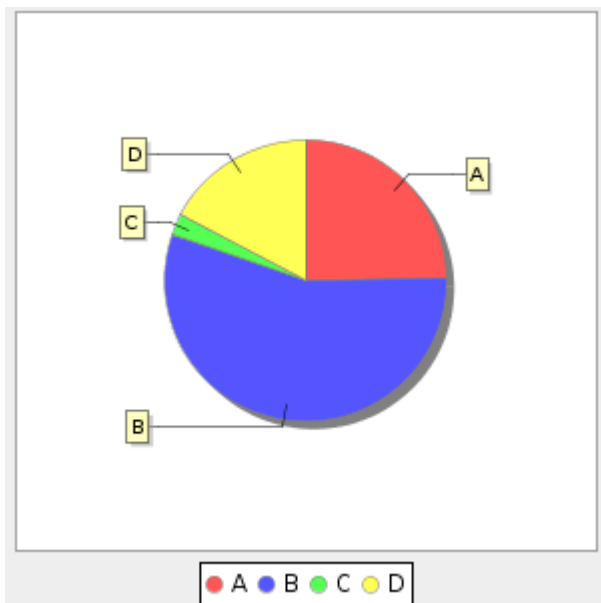




## Creating Pie Charts

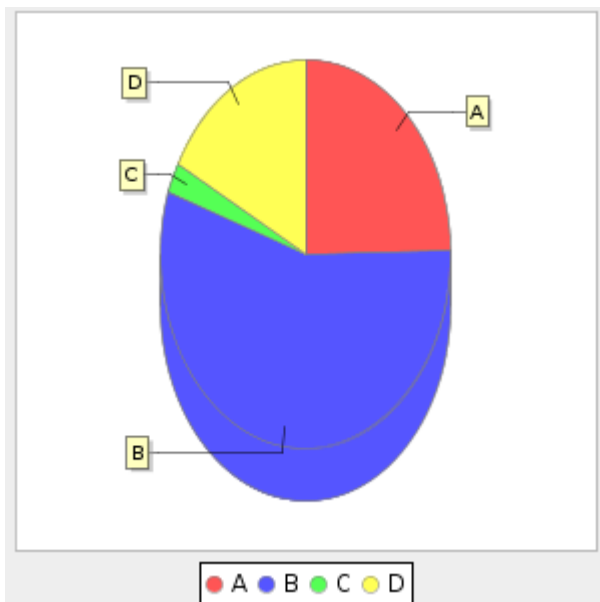
*Create a pie chart*

```
Map data = [  
  "A":20,"B":45,"C":2,"D":14  
]  
Chart chart = Pie.pie(data)
```



*Create a 3D pie chart*

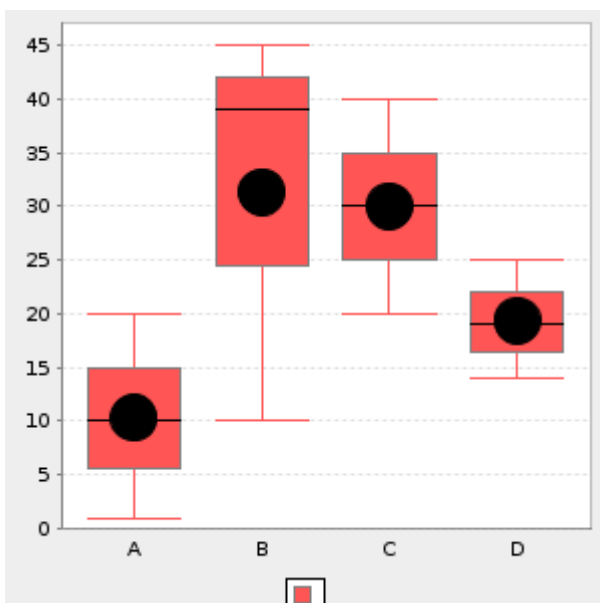
```
Map data = [  
  "A":20,"B":45,"C":2,"D":14  
]  
Chart chart = Pie.pie(data, trid: true)
```



## Creating Box Charts

Create a box chart

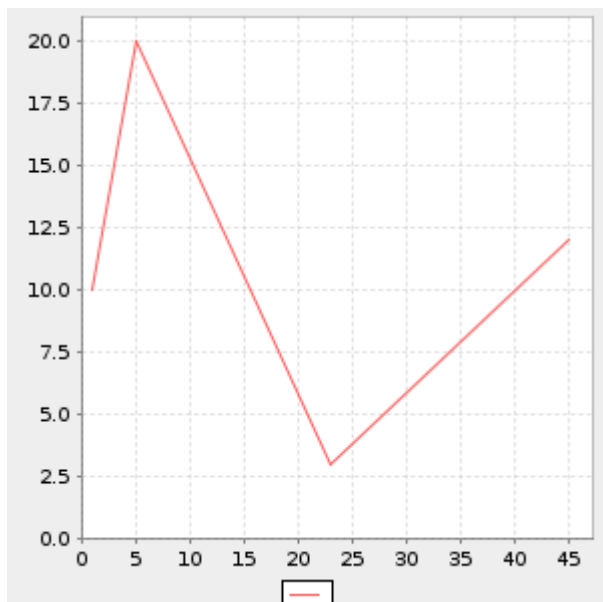
```
Map data = [
  "A": [1, 10, 20],
  "B": [45, 39, 10],
  "C": [40, 30, 20],
  "D": [14, 25, 19]
]
Chart chart = Box.box(data)
```



## Creating Curve Charts

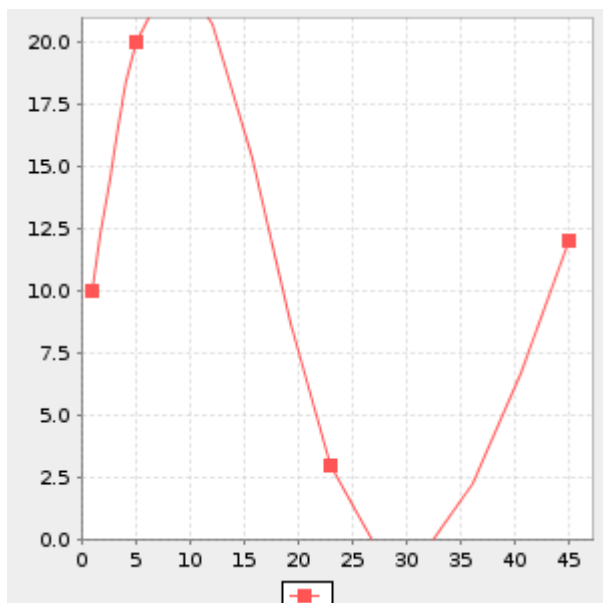
### Create a curve chart

```
List data = [  
    [1,10],[45,12],[23,3],[5,20]  
]  
Chart chart = Curve.curve(data)
```



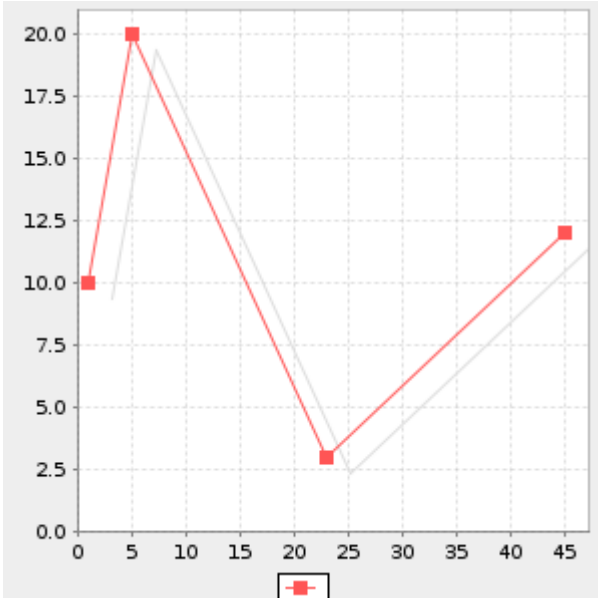
### Create a smooth curve chart

```
List data = [  
    [1,10],[45,12],[23,3],[5,20]  
]  
Chart chart = Curve.curve(data, smooth: true)
```



### Create a 3D curve chart

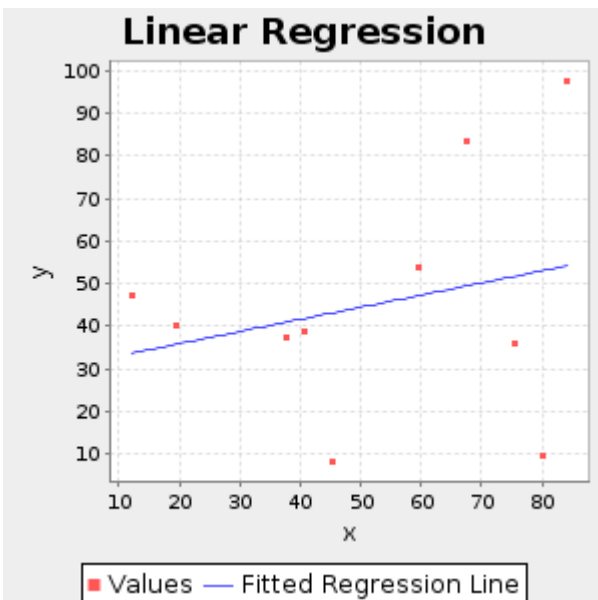
```
List data = [  
    [1,10],[45,12],[23,3],[5,20]  
]  
Chart chart = Curve.curve(data, trid: true)
```



## Creating Regression Charts

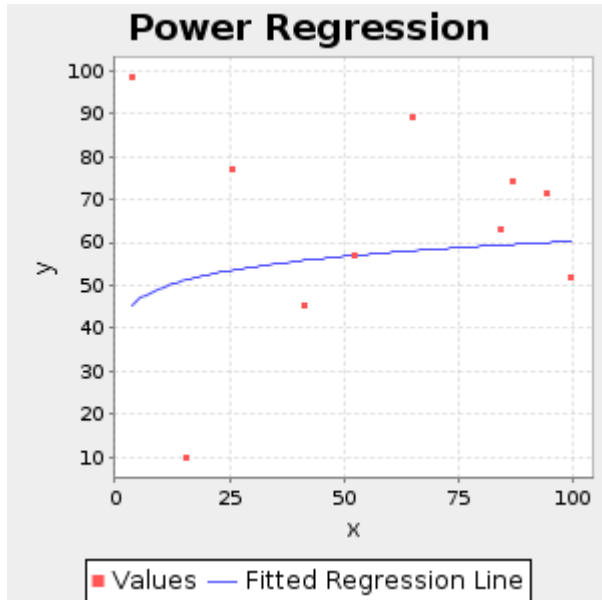
### Create a linear regression chart

```
MultiPoint mulitPoint = Geometry.createRandomPoints(new Bounds(0,0,100,100).geometry,  
10)  
List data = mulitPoint.geometries.collect{ Point pt ->  
    [pt.x, pt.y]  
}  
Chart chart = Regression.linear(data)
```



### Create a power regression chart

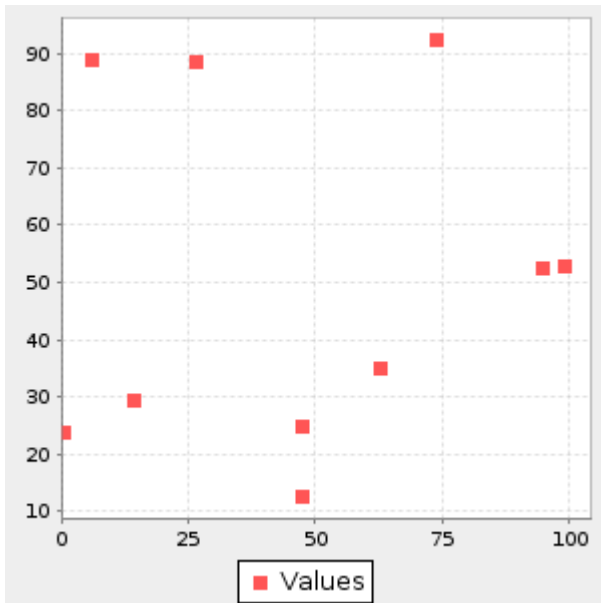
```
MultiPoint multPoint = Geometry.createRandomPoints(new Bounds(0,0,100,100).geometry,  
10)  
List data = multPoint.geometries.collect{ Point pt ->  
    [pt.x, pt.y]  
}  
Chart chart = Regression.power(data)
```



## Creating Scatter Plot Charts

### Create a scatter plot chart

```
MultiPoint multPoint = Geometry.createRandomPoints(new Bounds(0,0,100,100).geometry,  
10)  
List data = multPoint.geometries.collect{ Point pt ->  
    [pt.x, pt.y]  
}  
Chart chart = Scatter.scatterplot(data)
```



# Feature Recipes

## Creating Fields

*Create a Field with a name and a type*

```
Field field = new Field("name", "String")
println field
```

```
name: String
```

*Create a Geometry Field with a name and a geometry type and an optional projection*

```
Field field = new Field("geom", "Point", "EPSG:4326")
println field
```

```
geom: Point(EPSG:4326)
```

*Create a Field with a List of Strings (name, type, projection)*

```
Field field = new Field(["geom", "Polygon", "EPSG:4326"])
println field
```

```
geom: Polygon(EPSG:4326)
```

*Create a Field from a Map where keys are name, type, proj*

```
Field field = new Field([
    "name": "geom",
    "type": "LineString",
    "proj": new Projection("EPSG:4326")
])
println field
```

```
geom: LineString(EPSG:4326)
```

*Access a Field's properties*

```
Field field = new Field("geom", "Point", "EPSG:4326")
println "Name = ${field.name}"
println "Type = ${field.typ}"
println "Projection = ${field.proj}"
println "Is Geometry = ${field.geometry}"
```

```
Name = geom
Type = Point
Projection = "EPSG:4326"
Is Geometry = true
```

## Creating Schemas

*Create a Schema from a list of Fields*

```
Schema schema = new Schema("cities", [
    new Field("geom", "Point", "EPSG:4326"),
    new Field("id", "Integer"),
    new Field("name", "String")
])
println schema
```

```
cities geom: Point(EPSG:4326), id: Integer, name: String
```

### Create a Schema from a list of Lists

```
Schema schema = new Schema("cities", [
    ["geom", "Point", "EPSG:4326"],
    ["id", "Integer"],
    ["name", "String"]
])
println schema
```

```
cities geom: Point(EPSG:4326), id: Integer, name: String
```

### Create a Schema from a list of Maps

```
Schema schema = new Schema("cities", [
    [name: "geom", type: "Point", proj: "EPSG:4326"],
    [name: "id", type: "Integer"],
    [name: "name", type: "String"]
])
println schema
```

```
cities geom: Point(EPSG:4326), id: Integer, name: String
```

### Create a Schema from a string

```
Schema schema = new Schema("cities", "geom:Point:srid=4326,id:Integer,name:String")
println schema
```

```
cities geom: Point(EPSG:4326), id: Integer, name: String
```

## Getting Schema Properties

### Get the Schema's name

```
Schema schema = new Schema("cities", [
    new Field("geom", "Point", "EPSG:4326"),
    new Field("id", "Integer"),
    new Field("name", "String")
], "https://github.com/jericks/geoscript-groovy-cookbook")
String name = schema.name
println name
```

```
cities
```



### *Get the Schema's geometry Field*

```
Field geomField = schema.geom
println geomField
```

```
geom: Point(EPsg:4326)
```

### *Get the Schema's Projection*

```
Projection proj = schema.proj
println proj
```

```
EPsg:4326
```

### *Get the Schema's URI*

```
String uri = schema.uri
println uri
```

```
https://github.com/jericks/geoscript-groovy-cookbook
```

### *Get the Schema's specification string*

```
String spec = schema.spec
println spec
```

```
geom:Point:srid=4326,id:Integer,name:String
```

## Getting Schema Fields

### *Get the Schema's Fields*

```
Schema schema = new Schema("cities", [
    new Field("geom", "Point", "EPsg:4326"),
    new Field("id", "Integer"),
    new Field("name", "String")
])
List<Field> fields = schema.fields
fields.each { Field field ->
    println field
}
```

```
geom: Point(EPsg:4326)
id: Integer
name: String
```

### *Get a Field*

```
Field nameField = schema.field("name")
println nameField
```

```
name: String
```

### *Get a Field*

```
Field idField = schema.get("id")
println idField
```

```
id: Integer
```

### *Check if a Schema has a Field*

```
boolean hasArea = schema.has("area")
println "Has area Field? ${hasArea}"

boolean hasGeom = schema.has("geom")
println "Has geom Field? ${hasGeom}"
```

```
false
true
```

## Modifying Schemas

### *Change the projection of a Schema*

```
Schema schema = new Schema("cities", [
    new Field("geom", "Point", "EPsg:4326"),
    new Field("id", "Integer"),
    new Field("name", "String")
])
Schema reprojectedSchema = schema.reproject("EPsg:2927", "cities_spws")
```

```
cities_spws geom: Point(EPsg:2927), id: Integer, name: String
```

### *Change the geometry type of a Schema*

```
Schema schema = new Schema("cities", [  
    new Field("geom", "Point", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String")  
])  
Schema polygonSchema = schema.changeGeometryType("Polygon", "cities_buffer")
```

```
cities_buffer geom: Polygon(EPSG:4326), id: Integer, name: String
```

### *Change a Field definition of a Schema*

```
Schema schema = new Schema("cities", [  
    new Field("geom", "Point", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String")  
])  
Schema guidSchema = schema.changeField(schema.field('id'), new Field('guid', 'String'),  
    'cities_guid')
```

```
cities_guid geom: Point(EPSG:4326), guid: String, name: String
```

### *Change Field definitions of a Schema*

```
Schema schema = new Schema("cities", [  
    new Field("geom", "Point", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String")  
])  
Schema updatedSchema = schema.changeFields(  
    [  
        (schema.field('id')) : new Field('guid', 'String'),  
        (schema.field('name')) : new Field('description', 'String')  
    ], 'cities_updated')
```

```
cities_updated geom: Point(EPSG:4326), guid: String, description: String
```

### Add a Field to a Schema

```
Schema schema = new Schema("countries", [  
    new Field("geom", "Polygon", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String")  
])  
Schema updatedSchema = schema.addField(new Field("area", "Double"), "countries_area")
```

countries\_area geom: Polygon(EPSG:4326), id: Integer, name: String, area: Double

### Add a List of Fields to a Schema

```
Schema schema = new Schema("countries", [  
    new Field("geom", "Polygon", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String")  
])  
Schema updatedSchema = schema.addFields([  
    new Field("area", "Double"),  
    new Field("perimeter", "Double"),  
], "countries_areaperimeter")
```

countries\_areaperimeter geom: Polygon(EPSG:4326), id: Integer, name: String, area: Double, perimeter: Double

### Remove a Field from a Schema

```
Schema schema = new Schema("countries", [  
    new Field("geom", "Polygon", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String"),  
    new Field("area", "Double")  
])  
Schema updatedSchema = schema.removeField(schema.field("area"), "countries_updated")
```

countries\_updated geom: Polygon(EPSG:4326), id: Integer, name: String

### *Remove a List of Fields from a Schema*

```
Schema schema = new Schema("countries", [  
    new Field("geom", "Polygon", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String"),  
    new Field("area", "Double")  
])  
Schema updatedSchema = schema.removeFields([  
    schema.field("area"),  
    schema.field("name")  
], "countries_updated")
```

```
countries_updated geom: Polygon(EPSG:4326), id: Integer
```

## Creating Features from a Schema

### *Create a Feature from a Schema with a Map of values*

```
Schema schema = new Schema("cities", [  
    new Field("geom", "Point", "EPSG:4326"),  
    new Field("id", "Integer"),  
    new Field("name", "String")  
])  
Feature feature = schema.feature([  
    id: 1,  
    name: 'Seattle',  
    geom: new Point( -122.3204, 47.6024)  
], "city.1")  
println feature
```

```
cities.city.1 geom: POINT (-122.3204 47.6024), id: 1, name: Seattle
```

Create a Feature from a Schema with a List of values. The order of the values must match the order of the Fields.

```
Schema schema = new Schema("cities", [
    new Field("geom", "Point", "EPSG:4326"),
    new Field("id", "Integer"),
    new Field("name", "String")
])
Feature feature = schema.feature([
    new Point(-122.3204, 47.6024),
    1,
    'Seattle'
], "city.1")
println feature
```

```
cities.city.1 geom: POINT (-122.3204 47.6024), id: 1, name: Seattle
```

Create a Feature from a Schema with another Feature.

```
Schema schema = new Schema("cities", [
    new Field("geom", "Point", "EPSG:4326"),
    new Field("id", "Integer"),
    new Field("name", "String")
])
Feature feature1 = new Feature([
    id: 1,
    name: 'Seattle',
    geom: new Point(-122.3204, 47.6024)
], "city.1", schema)
println feature1
Feature feature2 = schema.feature(feature1)
println feature2
```

```
cities.city.1 geom: POINT (-122.3204 47.6024), id: 1, name: Seattle
cities.city.1 geom: POINT (-122.3204 47.6024), id: 1, name: Seattle
```

Create an empty Feature from a Schema.

```
Schema schema = new Schema("cities", [
    new Field("geom", "Point", "EPSG:4326"),
    new Field("id", "Integer"),
    new Field("name", "String")
])
Feature feature = schema.feature()
println feature
```

```
cities.fid-24da3124_159c349ab9d_-8000 geom: null, id: null, name: null
```