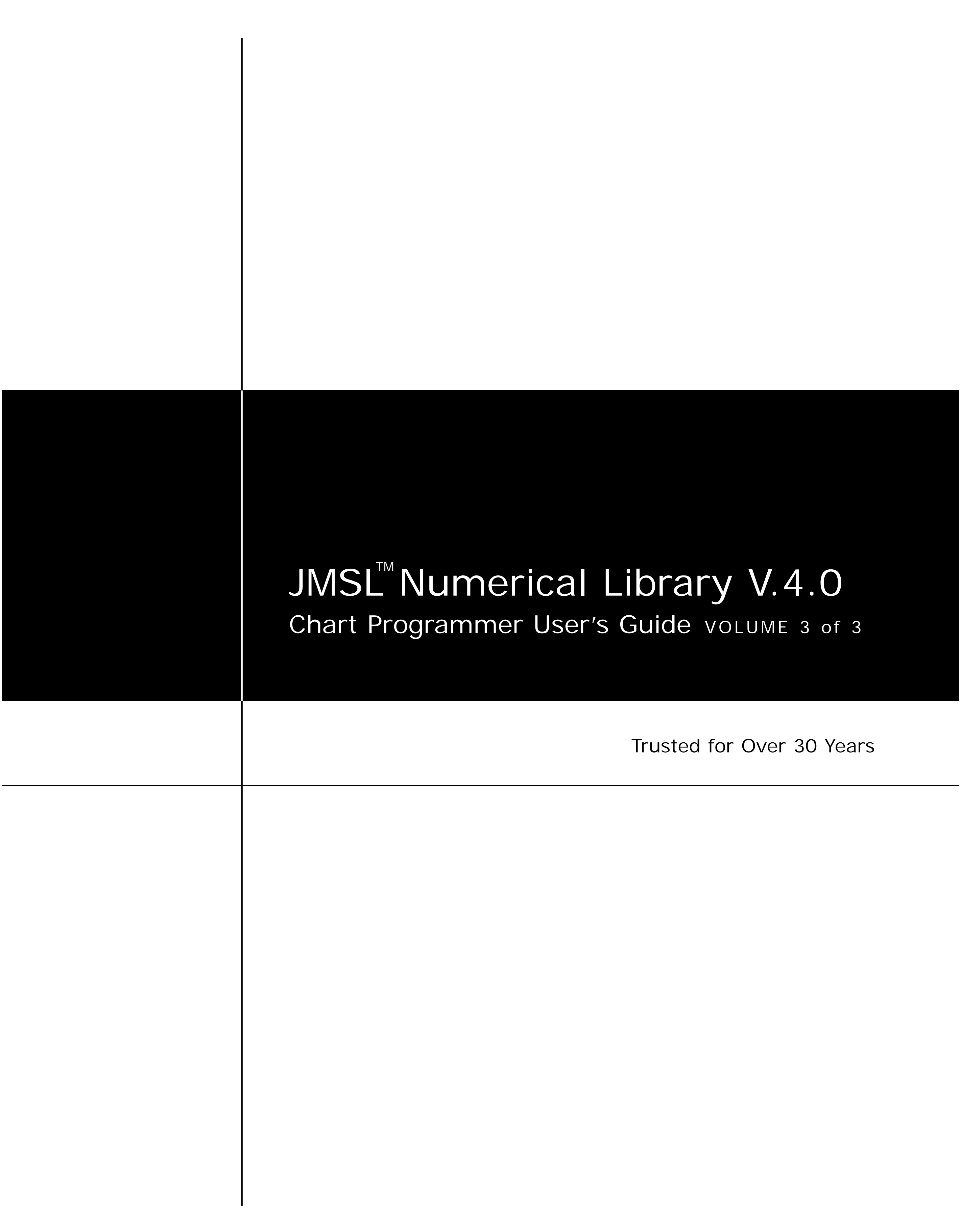
Chart Programmer User's Guide

VERSION 4.0


JMSL™ Numerical Library V.4.0
Chart Programmer User's Guide VOLUME 3 of 3
Trusted for Over 30 Years

Visual Numerics Corporate Headquarters
2500 Wilcrest Drive
Houston, TX 77042

USA Contact Information

Toll Free:	800.222.4675
Houston, TX:	713.784.3131
Westminster, CO:	303.379.3040
Email:	info@vni.com
Web site:	www.vni.com

Visual Numerics has Offices Worldwide
USA • UK • France • Germany •Mexico
Japan • Korea • Taiwan
For contact information, please visit
www.vni.com/contact

© 1970-2006 Visual Numerics, Inc. All rights reserved.
Visual Numerics and PV-WAVE are registered trademarks of Visual Numerics, Inc. in the U.S. and other countries. IMSL, JMSL, JWAVE, TS-WAVE and Knowledge in Motion are trademarks of Visual Numerics, Inc. All other company, product or brand names are the property of their respective owners.

IMPORTANT NOTICE: Information contained in this documentation is subject to change without notice. Use of this document is subject to the terms and conditions of a Visual Numerics Software License Agreement, including, without limitation, the Limited Warranty and Limitation of Liability. If you do not accept the terms of the license agreement, you may not use this documentation and should promptly return the product for a full refund. This documentation may not be copied or distributed in any form without the express written consent of Visual Numerics..

Contents

Preface ix

What's in this Manual ix

Technical Support xi

JMSL CHART 2D Programmer's Guide Part 1 - 15

Chapter 1: Introduction - Chart 2D 1

Overview 1

Implicitly Created Nodes 4

Adding a Chart to an Application 8

Chapter 2: Charting 2D Types 9

Scatter Plot 10

Simple Scatter Plot 10

Complex Scatter Plot 12

Line Plot 14

Simple Line Plot 14

Mixed Line and Marker Plot 16

Area Plot 18

Simple Area Plot 18

Painted Area Example 20

Attribute Reference 21

Function Plot 22

Example 22

Histogram Example 23

Spline Chart 24

Log and SemiLog Plot 26

SemiLog Plot 26

Log-Log Plot 28

Error Bar Plot 30

Vertical Error Bars 30

Horizontal Error Bars 32

Mixed Error Bars 34
High-Low-Close Plot. 36
Example 37
Candlestick Chart 40
Example 41
Pie Chart 44
Example 44
Box Plot 46
Example 46
Bar Chart 53
Simple Bar Chart 53
Grouped Bar Chart. 55
Stacked Grouped Bar Chart. 57
Legend 59
Attribute BarGap 61
Attribute BarWidth 61
Contour Chart. 62
Example 62
Heatmap. 64
Example 64
Histogram 66
Example 66
Polar Plot 69
Example 70
Dendrogram Chart 72
Example 72

Chapter 3: 2D Drawing Elements 77

Line Attributes 78
Attribute LineColor 78
Attribute LineWidth. 78
Attribute LineDashPattern 78
Samples 78
Marker Attributes 79
Attribute MarkerType 79
Attribute MarkerColor 80
Attribute MarkerSize. 80

Attribute MarkerThickness 80
Attribute MarkerDashPattern 80
Samples 80
Fill Area Attributes 81
FillOutlineType 81
FillOutlineColor 81
FillType 81
FillColor 81
Gradient 81
FillPaint 84
Text Attributes 85
Attribute Font 85
Attribute FontName 85
Attribute FontSize 85
Attribute FontStyle 85
Samples 86
Attribute TextAngle 86
Attribute TextColor 86
Attribute TextFormat 86
Attribute Title 87
Labels 88
Attribute LabelType 88
Data Point Labeling Example 88
Annotation 91
AxisXY 93
. . . . 94
Axis Layout 95
Transform 96
Autoscale 96
Background 119
Solid Color Background 119
Gradient Color Background 121
Pattern Background 123
Legend 125
Simple Legend Example 125
Legend Example 127
Colormaps 129

Tool Tips . . . 130
Example . . . 130
Chapter 4: XML . . . 131
Chart XML Syntax . . . 131
Syntax Example . . . 134
Attribute Tags . . . 135
Array Tags . . . 136
Array Tag Examples . . . 137
Creating a Chart from XML . . . 137
Interacting with an XML Created Chart . . . 138
Enumerated Types in Chart XML Files . . . 138
Marker Types . . . 138
Fill Types . . . 139
Text Alignments . . . 139
Font Styles . . . 139
Axis Parameters . . . 139
Autoscale Parameters . . . 140
Axis Transforms . . . 140
Data Node Types . . . 140
Label Types . . . 140
Bar Types . . . 140
Creating Charts from General XML Files Using XSLT . . . 141
Example . . . 141
XML Examples . . . 147
Chapter 5: Actions . . . 173
Picking . . . 173
Example . . . 174
Zoom . . . 176
Example . . . 176
Printing . . . 182
Printing from JFrameChart . . . 182
Printable Interface . . . 182
Pageable . . . 182
Serialization . . . 184
Example . . . 184

Appendix A: Web Server Application **187**
Overview—Web Servlets 187
Generating a Chart with a JSP 188
Generating Charts with Client-side Imagemaps 190
Servlet Deployment 193
Appendix B: Writing a Chart as a Bitmap Image File **195**
Using the ImageIO Class 195
Using the Java Advanced Imaging API 196
Using the Scalable Vector Graphics (SVG) API 198
Appendix C: Picture-in-Picture **201**
JMSL CHART 3D Programmer's Guide Part 2 - - - - - - - - - - - - - - - - - - **205**
Chapter 6: Introduction - Chart 3D **207**
Java3D. 207
Overview 207
Chapter 7: Charting 3D Types **211**
Scatter Plot 212
Fisher Iris Data Set 212
Tube Plot 216
Spiral Example. 216
Surface Plot 218
Shaded Surface 218
Chapter 8: 3D Drawing Elements **221**
Line Attributes 222
Attribute LineColor 222
Attribute ColorFunction 222
Attribute LineWidth 222
Tube Attributes. 223
Attribute LineColor 223
Attribute ColorFunction 223
Marker Attributes 224
Attribute MarkerType 224
Attribute MarkerColor. 225
Attribute MarkerSize 225
Attribute MarkerPulsingCycle 225

Attribute MarkerPulsingCycleOffset 225
Attribute MarkerPulsingMinimumScale 225
Attribute MarkerPulsingMaximumScale 225
Attribute MarkerRotatingCycle 225
Attribute MarkerRotatingCycleOffset 225
Attribute MarkerRotatingAxis 226
Fill Attributes. 227
Attribute FillColor 227
Attribute ColorFunction 227
Attribute Material 227
Text Attributes 228
Attribute FontName 228
Attribute FontSize. 228
Attribute FontStyle 228
Attribute TextColor 228
Attribute TextFormat 228
Labels. 230
Attribute LabelType 230
AxisXYZ 231
Axis Layout. 232
Transform. 232
Autoscale 232
Background 236
Lights 237
Color Map Legend 238
Appendix D: 3D: Drawing to the Canvas 239
Appendix E: Java 3D 241
Using the Chart 3D with Swing 241
Video Card Drivers. 241
System Properties 242
Index I-1

Preface

The *JMSL Numerical Library Chart Programmer's Guide* explains how to create 2D and 3D charting with JMSL.

What's in this Manual

The JMSL Numerical Library Chart Programmer's Guide is presented as Part 1: Chart 2D and Part 2: Chart 3D.

Part 1: Chart 2D contains the following sections:

"Introduction - Chart 2D" — Provides an overview of the scope of the most commonly used 2D charting.

"Charting 2D Types" — Describes the JMSL 2D Charts.

"2D Drawing Elements" — This chapter discusses the JMSL chart drawing elements.

"XML" — This chapter explains JMSL XML features.

"Actions" — This chapter discusses actions available in 2D charting.

"Web Server Application" — Describes JMSL and web servlets.

"Writing a Chart as a Bitmap Image File" — Describes the ways to save bitmaps images.

"Picture-in-Picture" — Describes the picture-in-picture effects.

Part 2: Chart 3D contains the following sections:

"Introduction - Chart 3D" — Provides an overview of the scope of the most commonly used 3D charting.

"Charting 3D Types" — Describes the JMSL 3D Charts.

“3D Drawing Elements” — This chapter discusses the JMSL chart drawing elements.

“3D: Drawing to the Canvas” — Describes how to use JMSL to draw to a canvas.

“Java 3D” — Describes JMSL Chart 3D package.

Technical Support

If you have problems installing, unlocking, or running your software, contact Visual Numerics Technical Support by calling:

Office Location	Phone Number
North American IMSL Family Technical Support and Corporate Headquarters Houston, Texas	713-784-3131
North America PV-WAVE Family Technical Support Westminister, Colorado	303-379-3033
France	+33-1-46-93-94-20
Germany	+49-711-67400-260
Japan	+81-3-5211-7760
Korea	+82-2-3273-2632
Mexico	+52-55-5514-9730
Taiwan	+88-622-727-2255
United Kingdom	+44-118-925-5910

Users outside the U.S., France, Germany, Japan, Korea, Mexico, Taiwan, and the U.K. can contact their local agents.

Please be prepared to provide the following information when you call for consultation during Visual Numerics business hours:

- The name and version number of the product. For example, JMSL 4.0.
- The type of system on which the software is being run. For example, SPARCstation, IBM RS/6000, HP 9000 Series 700.
- The operating system and version number. For example, HP-UX 11.0 or IRIX 6.5.3.
- A detailed description of the problem.

FAX and E-mail Inquiries

Contact Visual Numerics Technical Support staff by sending a FAX to:

Office Location	FAX Number
North American IMSL Family Technical Support Houston, Texas	713-781-9260
North American PV-WAVE Family Technical Support Westminster, Colorado	303-379-2140
France	+33-1-46-93-94-39
Germany	+49-711-67400-456
Japan	+81-3-5211-7769
Korea	+82-2-3273-2634
Mexico	+52-55-5514-5880
Taiwan	+88-622-727-6798
United Kingdom	+44-118-925-5912

or by sending E-mail to:

Office Location	E-mail Address
Visual Numerics Corporate Headquarters Houston, Texas	`info@vni.com`
North American IMSL Family Technical Support Houston, Texas	`support@vni.com`
North American PV-WAVE Family Technical Support Westminster, Colorado	`support@vni.com`
France	`support@vni-paris.fr`
Germany	`support@visual-numerics.de`
Japan	`support@vnij.co.jp`
Korea	`support@vni.co.kr`
Mexico	`avadillo@mail.internet.com.mx`
Taiwan	`support@vni.com.tw`
United Kingdom	`support@vniuk.co.uk`

Electronic Services

Service	Address
General e-mail	`info@vni.com`
Support e-mail	`support@vni.com`
World Wide Web	`http://www.vni.com`
VNI Forums	`http://forums.vni.com`
Anonymous FTP	`ftp.boulder.vni.com`
FTP Using URL	`ftp://ftp.boulder.vni.com/VNI/`

JMSL CHART 2D

Programmer's Guide

Part 1

Chapter 1: Introduction - Chart 2D

The *JMSL Numerical Library Chart Programmer's Guide* is an overview and discussion of the JMSL charting package. It is intended to be used in conjunction with the online *Javadoc*-generated Reference Manual.

This guide is both an introductory tutorial on the charting package and a "cookbook" for creating common chart types. The Reference Manual contains the complete details of the classes.

NOTE: Charts in the printed version of this manual appear in black and white. If you are reading this manual in print and wish to see the charts in color, please open the Acrobat Reader file:

/manual/chartpg

If you do not have Acrobat Reader installed on your machine, you can download it for free at:

`http://www.adobe.com/products/acrobat/readstep2.html`

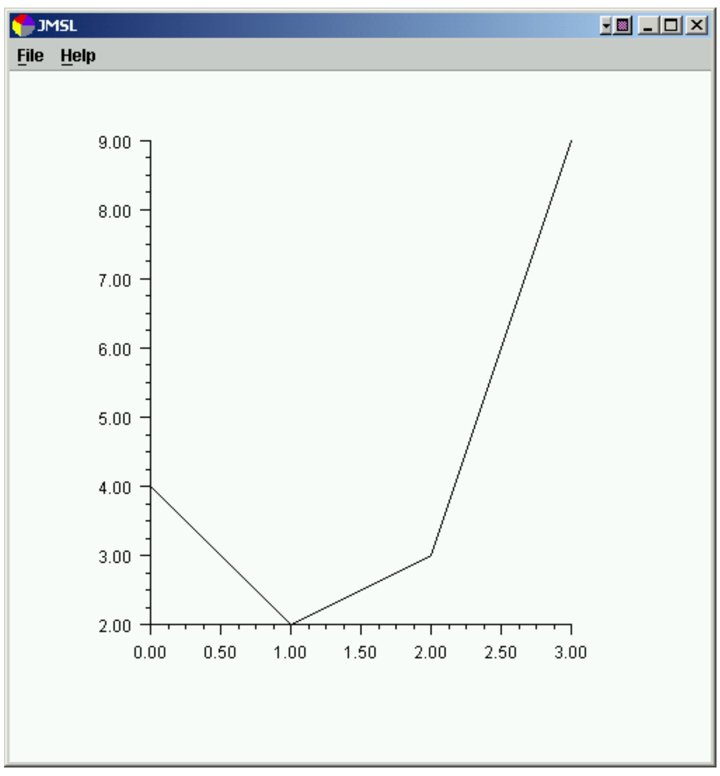
Or you may also view the *Guide* in color from our Web site at:

`http://www.vni.com/products/jmsl/chartpg/index.html`

Overview

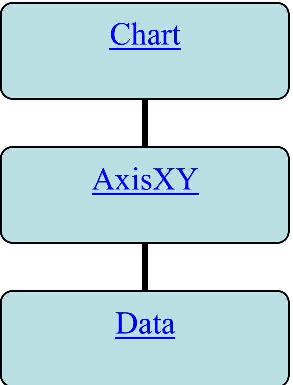
The JMSL chart package is designed to allow the creation of highly customizable charts using Java. A JMSL chart is created by assembling ChartNodes into a tree. This chart tree is then rendered to the screen or printer.

The following class is a simple example of the use of the JMSL chart package. The chart is displayed in a Swing frame. The code to create the chart is all in the constructor. The JMSL class JFrameChart extends the Swing class JFrame and creates a Chart object.




```
import com.imsl.chart.*;

public class Intro1 extends JFrameChart {

    public Intro1() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);
    }

    public static void main(String argv[]) {
        new Intro1().setVisible(true);
    }
}
```

The above example created and assembled three nodes into the following tree. The root Chart node is created by the JFrameChart class.



The general pattern of the ChartNode class, and classes derived from it, is to have constructors whose first argument is the parent ChartNode of the ChartNode being created.

The root node of the tree is always a Chart object. It is usually constructed within JFrameChart or JPanelChart, which handle the repainting of the chart within Swing. If a Chart object is explicitly created, and used within a Swing GUI, then its `paint(Graphics)` method must be called from the container's `paint(Graphics)` or `paintComponent(Graphics)` methods.

Chart nodes can contain attributes, such as FillColor and LineWidth. Attributes are inherited via the chart tree. For example, when a Data node is being painted, its LineWidth attribute determines the thickness of the line. If this attribute is set in the data node being drawn, that is the value used. If it is not set, then its parent node (an AxisXY node in the above example) is queried. If it is not set there, then *its* parent is queried. This continues until the root node is reached after which a default value is used. Note that this inheritance is not the same as Java class inheritance.

Attributes are set using setter methods, such as `setLineWidth(double)` and retrieved using getter methods, such as `getLineWidth(double)`.

Implicitly Created Nodes

Some chart nodes automatically create additional nodes, as their children, when they are created. These nodes can be accessed via `get` methods. For example, the code

```
chart.getBackground().setFillColor(java.awt.Color.green);
```

changes the background color. The method `getBackground` retrieves the Background node from the chart object and the method `setFillColor` sets the Background object's FillColor attribute to `Color.green`.

In the following diagram, the nodes automatically created are shown in light green (to view in color see the online documentation).

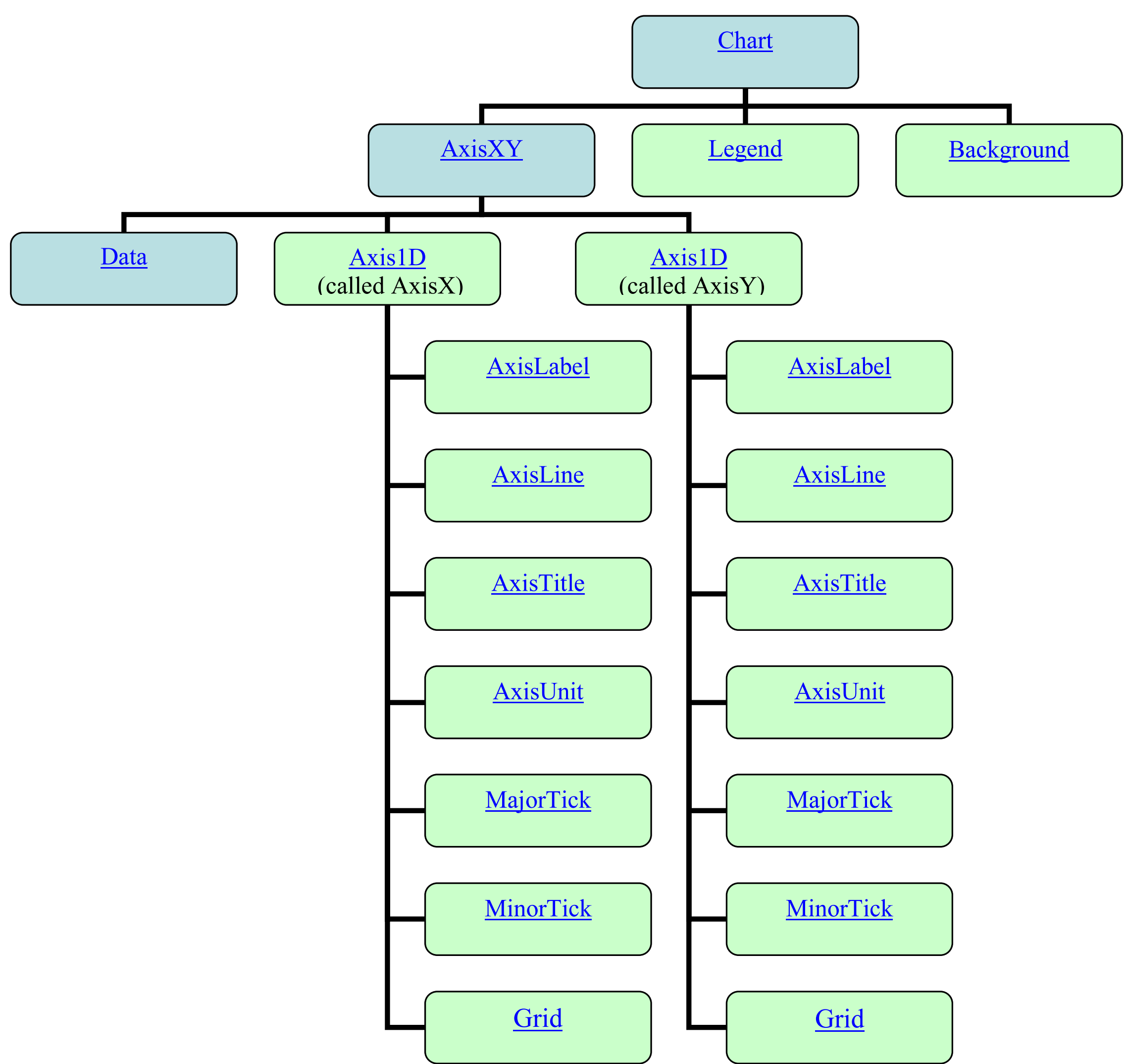


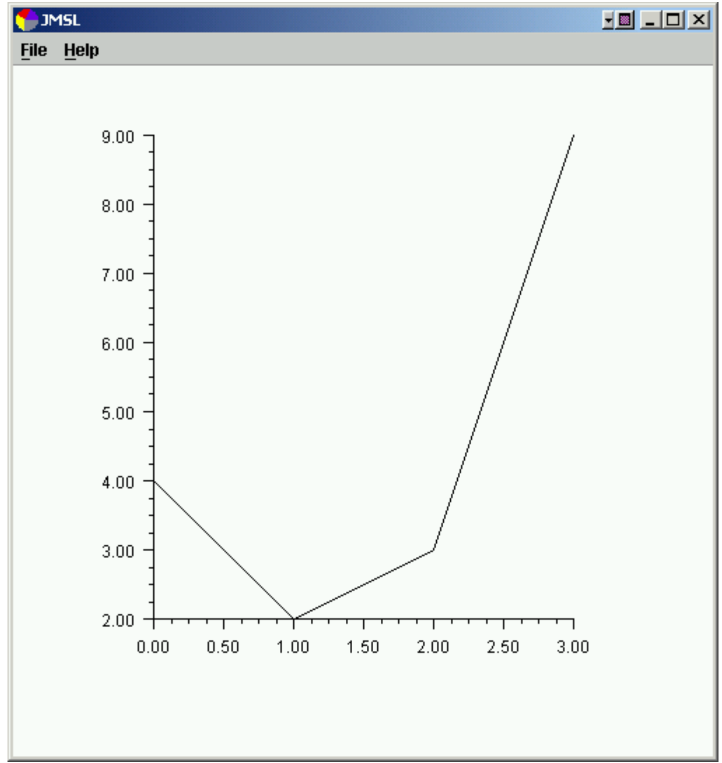
Chart
AxisXY
Legend
Background
Data
Axis1D
(called AxisX)
Axis1D
(called AxisY)
AxisLabel
AxisLine
AxisTitle
AxisUnit
MajorTick
MinorTick
Grid
AxisLabel
AxisLine
AxisTitle
AxisUnit
MajorTick
MinorTick
Grid

Method calls can be chained together. For example, the following sets the thickness of the major tick marks on the y-axis.

```
axis.getAxisX().getMajorTick().setLineWidth(2.0);
```

where `axis` is an `AxisXY` object.

A customized version of the above chart can be obtained by changing its constructor as in the following.



```
import com.imsl.chart.*;

public class Intro2 extends JFrameChart {

    public Intro2() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);

   chart.getBackground().setFillColor(java.awt.Color.green);
        axis.getAxisX().getMajorTick().setLineWidth(2.0);
    }

    public static void main(String argv[]) {
        new Intro2().setVisible(true);
    }
}
```

Adding a Chart to an Application

For simplicity, most of the examples in this manual use the JFrameChart class. JFrameChart is useful for quickly building an application that is a chart. The class JPanelChart is used to build a chart into a larger application. It extends Swing's JPanel class and can be used wherever a JPanel can be used. The following code shows a JPanelChart being created, added to a JFrame, and having a chart tree added to the JPanelChart. (The generated chart is very similar to that shown at the beginning of this chapter.)

```
import com.imsl.chart.*;

public class SampleJPanel extends javax.swing.JFrame {
    private JPanelChart jPanelChart;

    public SampleJPanel() {
        this.setSize(500, 500);
        jPanelChart = new JPanelChart();
        getContentPane().add(jPanelChart);

        Chart chart = jPanelChart.getChart();
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);
    }

    public static void main(String argv[]) {
        new SampleJPanel().setVisible(true);
    }
}
```

Chapter 2: Charting 2D Types

This chapter describes these JMSL charting types:

- "Scatter Plot" on page 10
- "Line Plot" on page 14
- "Function Plot" on page 22
- "Log and SemiLog Plot" on page 26
- "Error Bar Plot" on page 30
- "High-Low-Close Plot" on page 36
- "Candlestick Chart" on page 40
- "Pie Chart" on page 44
- "Box Plot" on page 46
- "Bar Chart" on page 53
- "Contour Chart" on page 62
- "Heatmap" on page 64
- "Histogram" on page 66
- "Polar Plot" on page 69
- "Dendrogram Chart" on page 72

Scatter Plot

This section describes the construction of scatter charts. The markers can be formatted using the Marker Attributes (see page 79).

It is also possible to mix lines and markers (see "Mixed Line and Marker Plot" on page 16).

Simple Scatter Plot

The `JFrameChart` class is used to create a frame containing a Chart node. The Chart node is the root of the tree to which an AxisXY node is added. A Data node is then created as the child of the axis node. The Data node is created using an array of *y*-values. The *x*-values default to 0, 1, ….

The DataType attribute is set to DATA_TYPE_MARKER to make this a scatter plot.

The look of the markers is controlled by the marker attributes. In this example the MarkerType attribute is set to MARKER_TYPE_FILLED_SQUARE. The MarkerColor attribute is set to blue (to view plot in color see online documentation).

9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
0.00 1.00 2.00 3.00 4.00

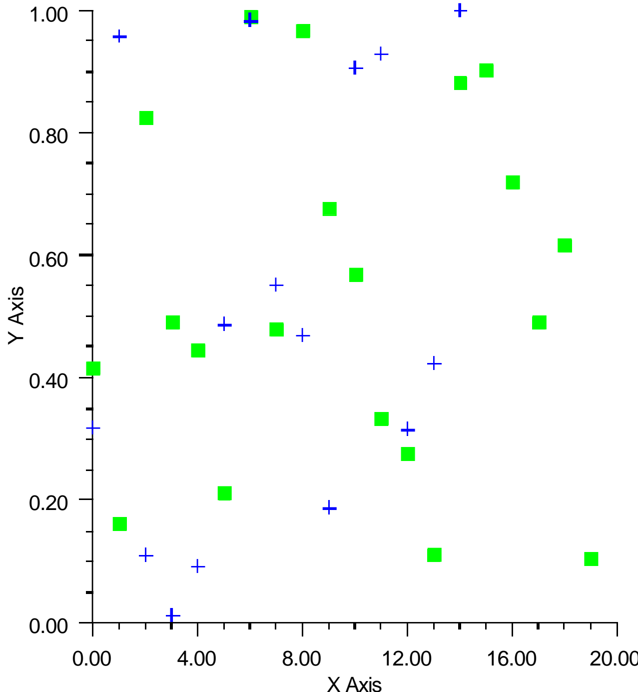
```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleSimpleScatter extends JFrameChart {

    public SampleSimpleScatter() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        double y[] = {8, 3, 5, 2, 9};
        Data data1 = new Data(axis, y);
        data1.setDataType(Data.DATA_TYPE_MARKER);
        data1.setMarkerType(Data.MARKER_TYPE_FILLED_SQUARE);
        data1.setMarkerColor(Color.blue);
    }

    public static void main(String argv[]) {
        new SampleSimpleScatter().setVisible(true);
    }
}
```

Complex Scatter Plot

This example shows a scatter plot with two data sets. The Data nodes are created using random *y*-values generated by Random. The *x*-values default to 0, 1, ….

The axes are labeled by setting the AxisTitle attribute for the *x* and *y* axes.

The DataType attribute is set in the axis node. The axis node does not itself use this attribute, but from there it is inherited by the child Data nodes.



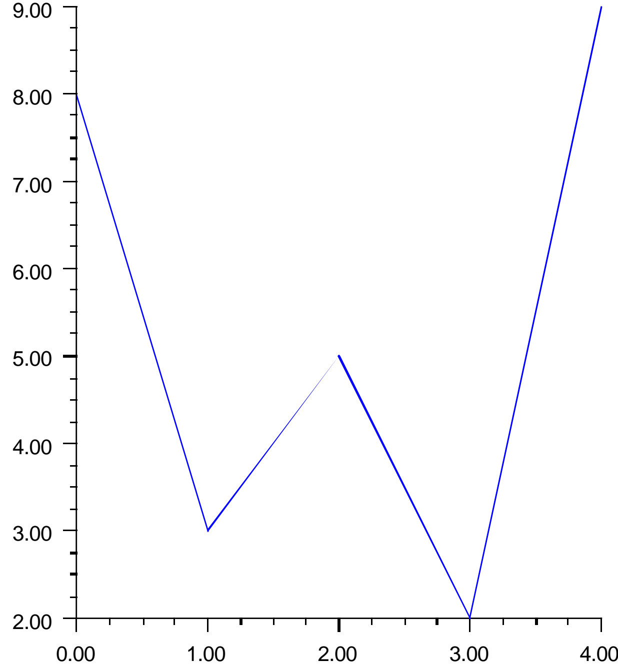
```
import com.imsl.chart.*;
import java.awt.Color;
import com.imsl.stat.Random;

public class SampleScatter extends JFrameChart {

    public SampleScatter() {
        Random r = new Random(123457);

        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        axis.getAxisX().getAxisTitle().setTitle("X Axis");
        axis.getAxisY().getAxisTitle().setTitle("Y Axis");
        axis.setDataType(Data.DATA_TYPE_MARKER);

        // Data set 1
        double y1[] = new double[20];
        for (int k = 0;  k < y1.length;  k++)  y1[k] = r.nextDouble();
        Data data1 = new Data(axis, y1);
        data1.setDataType(Data.DATA_TYPE_MARKER);
        data1.setMarkerType(Data.MARKER_TYPE_FILLED_SQUARE);
        data1.setMarkerColor(Color.green);

        // Data set 2
        double y2[] = new double[15];
        for (int k = 0;  k < y2.length;  k++)  y2[k] = r.nextDouble();
        Data data2 = new Data(axis, y2);
        data2.setMarkerType(Data.MARKER_TYPE_PLUS);
        data2.setMarkerColor(Color.blue);
    }

    public static void main(String argv[]) {
        new SampleScatter().setVisible(true);
    }
}
```

Line Plot

A line plot consists of points connected by lines. The lines can be formatted using the Line Attributes (see page 78).

Simple Line Plot

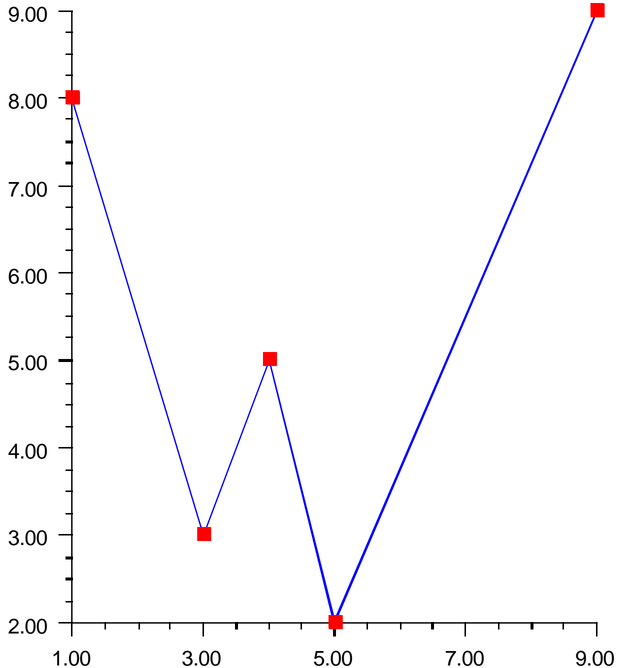
This example shows a simple line plot. The Data node is created using an array of *y*-values. The *x*-values default to 0, 1, …. The DataType attribute is set to DATA_TYPE_LINE to make this a line chart. The look of the line is controlled by the line attributes. Here the LineColor attribute is set to blue.



```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleSimpleLine extends JFrameChart {

    public SampleSimpleLine() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        double y[] = {8, 3, 5, 2, 9};
        Data data1 = new Data(axis, y);
        data1.setDataType(Data.DATA_TYPE_LINE);
        data1.setLineColor(Color.blue);
    }

    public static void main(String argv[]) {
        new SampleSimpleLine().setVisible(true);
    }
}
```

Mixed Line and Marker Plot

The DataType attribute can be set using "or" syntax to combine types. In this example, it is set to DATA_TYPE_LINE | DATA_TYPE_MARKER. This example also explicitly sets both the `x` and the `y` values of the data points. Note that the `x` values do not have to be uniformly spaced.



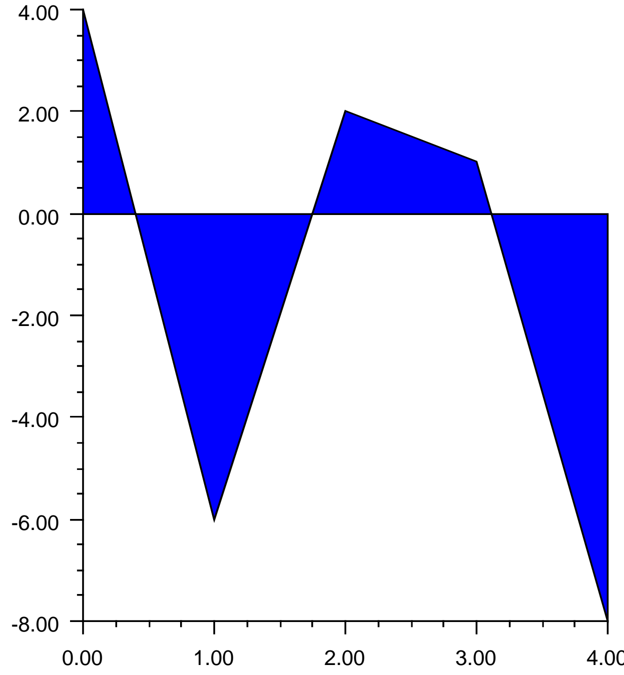
```
import com.imsl.chart.*;

public class SampleLineMarker extends JFrameChart {

    public SampleLineMarker() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        double x[] = {1, 3, 4, 5, 9};
        double y[] = {8, 3, 5, 2, 9};
        Data data = new Data(axis, x, y);
        data.setDataType(Data.DATA_TYPE_LINE | Data.DATA_TYPE_MARKER);
        data.setLineColor("blue");
        data.setMarkerColor("red");
        data.setMarkerType(Data.MARKER_TYPE_FILLED_SQUARE);
    }

    public static void main(String argv[]) {
        new SampleLineMarker().setVisible(true);
    }
}
```

Area Plot

Area plots are similar to line plots, but with the area between the line and a reference line filled in. An area plot is created if the DATA_TYPE_FILL bit is on in the value of the DataType attribute. The default reference line is *y*=0. The location of the reference line can be changed from 0 by using `setReference(double)`. The Fill Area Attributes determine how the area is filled (see page 81).

Simple Area Plot

This example draws a simple area plot. The default value of the FillType attribute is FILL_TYPE_SOLID. The example sets the FillColor attribute to blue. So the area between the line and *y*=0 is solid blue.



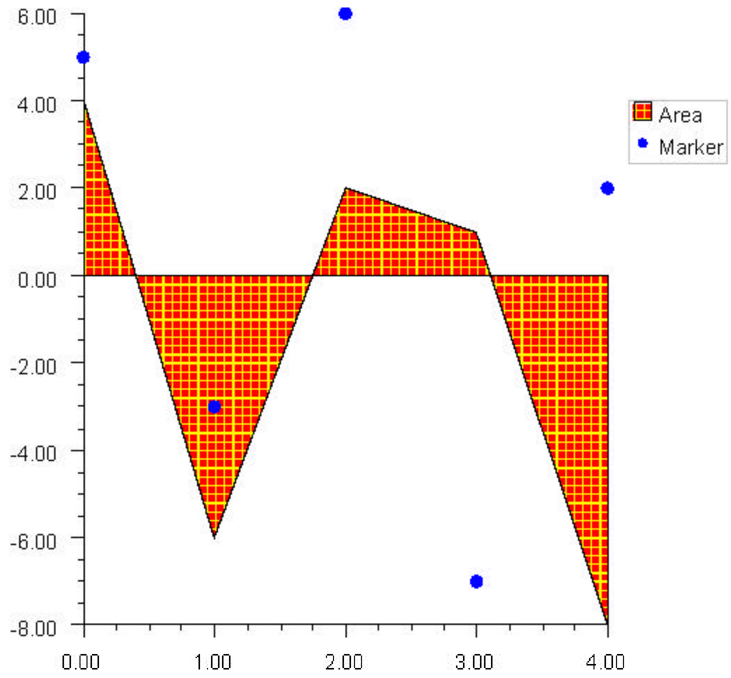
```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleArea extends JFrameChart {

    public SampleArea() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        double y[] = {4, -6, 2, 1, -8};
        Data data = new Data(axis, y);
        data.setDataType(Data.DATA_TYPE_FILL);
        data.setFillColor(Color.blue);
    }

    public static void main(String argv[]) {
        new SampleArea().setVisible(true);
    }
}
```

Painted Area Example

This example shows an area chart filled in with a painted texture. The texture is created by a static method `FillPaint.crosshatch`.

A second data set is plotted as a set of markers.

The Legend node is painted in this example and has entries for both the filled area data set and the marker data set.



```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleAreaPaint extends JFrameChart {

    public SampleAreaPaint() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        chart.getLegend().setPaint(true);

        double y1[] = {4, -6, 2, 1, -8};
        Data data1 = new Data(axis, y1);
        data1.setTitle("Area");
        data1.setDataType(Data.DATA_TYPE_FILL);
        data1.setFillType(Data.FILL_TYPE_PAINT);
        data1.setFillPaint(FillPaint.crosshatch
        (10,5,Color.red,Color.yellow));

        double y2[] = {5, -3, 6, -7, 2};
        Data data2 = new Data(axis, y2);
        data2.setTitle("Marker");
        data2.setDataType(Data.DATA_TYPE_MARKER);
        data2.setMarkerColor(Color.blue);
        data2.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);
    }

    public static void main(String argv[]) {
        new SampleAreaPaint().setVisible(true);
    }
}
```

Attribute Reference

The attribute Reference defines the reference line. If its value is a, then the reference line is $y = a$. Its default value is 0.

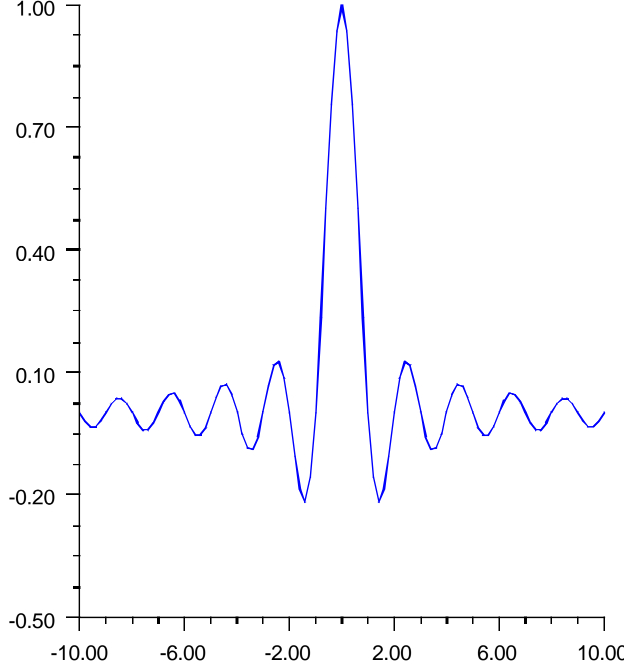
Function Plot

A function plot shows the value of a function $f(x)$ over an interval $[a,b]$. The function must be defined as an implementation of the ChartFunction interface. A Data node constructor creates a line chart from the function. The look of the function is controlled by the line attributes.

The ChartFunction interface requires that the function name be `"f"`, that the function has a single double argument and that it returns a double.

Example

This example plots the sinc function on the interval [-10,10]. The sinc function is defined to be $\sin(\pi x)/\pi x$. In this example, sinc is an anonymous inner class that implements ChartFunction. This is required by the function Data constructor. In the code, the case $x=0$ is handled specially to avoid returning NaN.



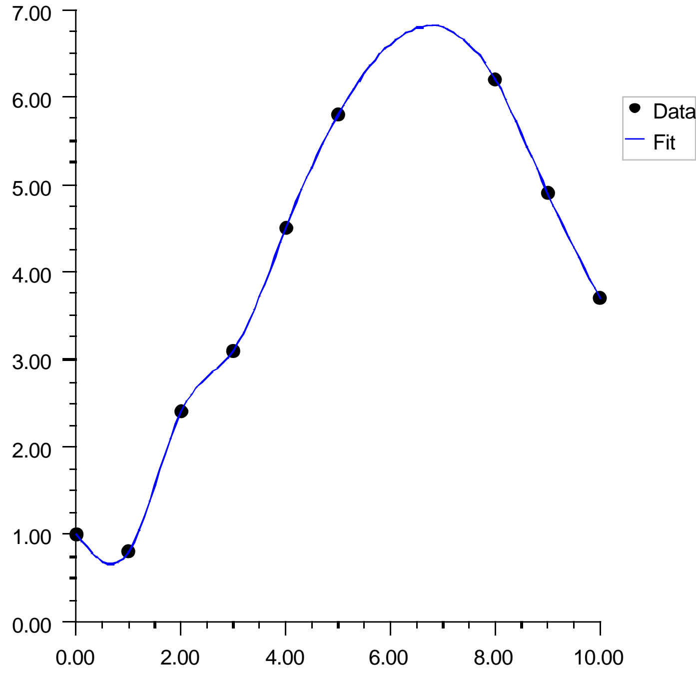
```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleFunction extends JFrameChart {

    public SampleFunction() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        ChartFunction sinc = new ChartFunction() {
            public double f(double x) {
                if (x == 0.0) return 1.0;
                return Math.sin(Math.PI*x) / (Math.PI*x);
            }
        };
        Data data = new Data(axis, sinc, -10.0, 10.0);
        data.setLineColor(Color.blue);
    }

    public static void main(String argv[]) {
        new SampleFunction().setVisible(true);
    }
}
```

Histogram Example

For another example of a ChartFunction, see "Histogram" on page 66.

Spline Chart

This example shows raw data points, as markers, and their fit to a shape preserving spline. The spline is computed using CsShape found in the JMSL Math package (which extends Spline). The `ChartSpline` class wraps the Spline into a Chart-Function. This example also enables the Legend.



```
import com.imsl.chart.*;
import com.imsl.math.CsShape;
import java.awt.Color;

public class SampleSpline extends JFrameChart {

    public SampleSpline() {
        try {
            Chart chart = getChart();
            AxisXY axis = new AxisXY(chart);
            chart.getLegend().setPaint(true);

            double x[] = {0, 1, 2, 3, 4, 5, 8, 9, 10};
            double y[] = {1.0, 0.8, 2.4, 3.1, 4.5, 5.8, 6.2, 4.9, 3.7};
            Data dataMarker = new Data(axis, x, y);
            dataMarker.setTitle("Data");
            dataMarker.setDataType(Data.DATA_TYPE_MARKER);
            dataMarker.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);

            CsShape spline = new CsShape(x, y);
           Data dataSpline = new Data(axis, new ChartSpline(spline), 0., 10.);
            dataSpline.setTitle("Fit");
            dataSpline.setLineColor(Color.blue);
        } catch (com.imsl.IMSLException e) {
            e.printStackTrace();
        }
    }

    public static void main(String argv[]) {
        new SampleSpline().setVisible(true);
    }
}
```

Log and SemiLog Plot

In a semilog plot the y-axis is logarithmically scaled, while the x-axis is linearly scaled. In a log-log plot both axes are logarithmically scaled.

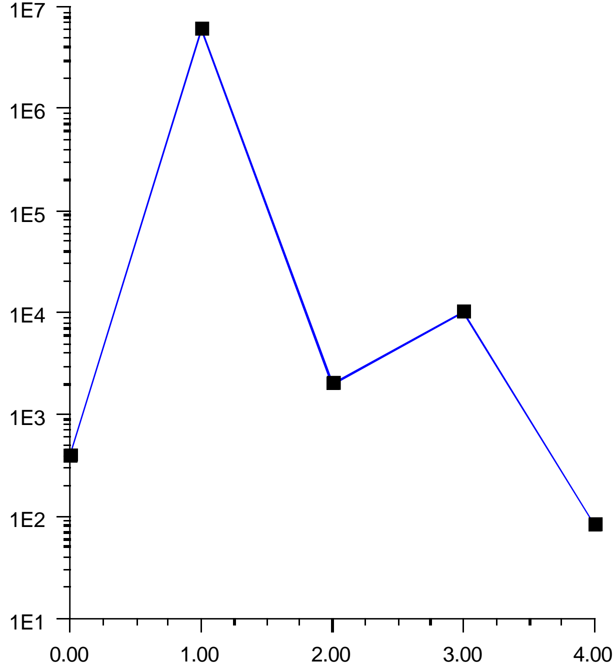
SemiLog Plot

In this example data is plotted as lines and markers on a semilog axis.

To set up the y-axis as a logarithmic axis,

- The Transform attribute is set to TRANSFORM_LOG.
- The Density attribute is set to 9. Density is the number of minor ticks between major ticks. It is 9 because base 10 is used and the major tick marks are not counted.

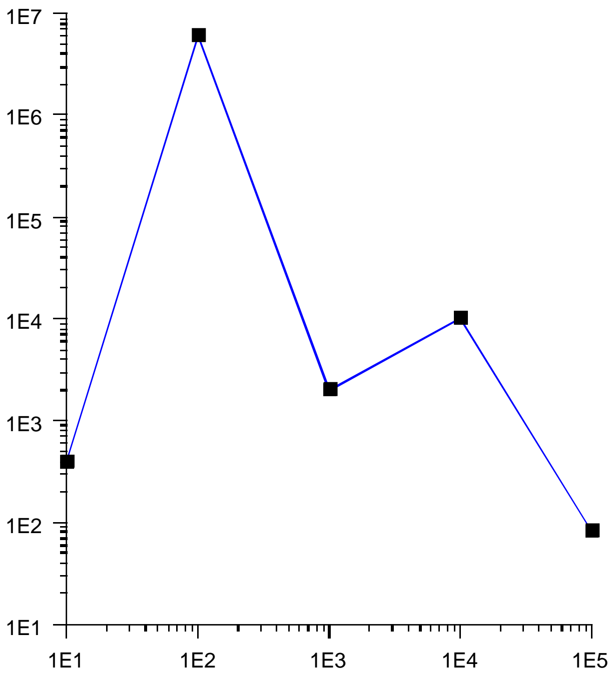
The TextFormat, used by AxisLabel, is changed to use scientific notation (see "Text Attributes" on page 85). The default decimal format would result in large numbers written with many zeros.



```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleSemiLog extends JFrameChart {

    public SampleSemiLog() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        axis.getAxisY().setTransform(axis.TRANSFORM_LOG);
        axis.getAxisY().setDensity(9);
        axis.getAxisY().setTextFormat(new java.text.DecimalFormat("0.E0"));

        double y[] = {4e2, 6e6, 2e3, 1e4, 8e1};
        Data data = new Data(axis, y);
        data.setDataType(Data.DATA_TYPE_LINE | Data.DATA_TYPE_MARKER);
        data.setLineColor(Color.blue);
        data.setMarkerType(Data.MARKER_TYPE_FILLED_SQUARE);
    }

    public static void main(String argv[]) {
        new SampleSemiLog().setVisible(true);
    }
}
```

Log-Log Plot

A log-log plot is set up in much the same way as a semilog plot, except that the changes must be made to both the *x*-axis and the *y*-axis. In this example, the changes are made to the axis node and inherited by both the *x* and *y*-axis nodes.



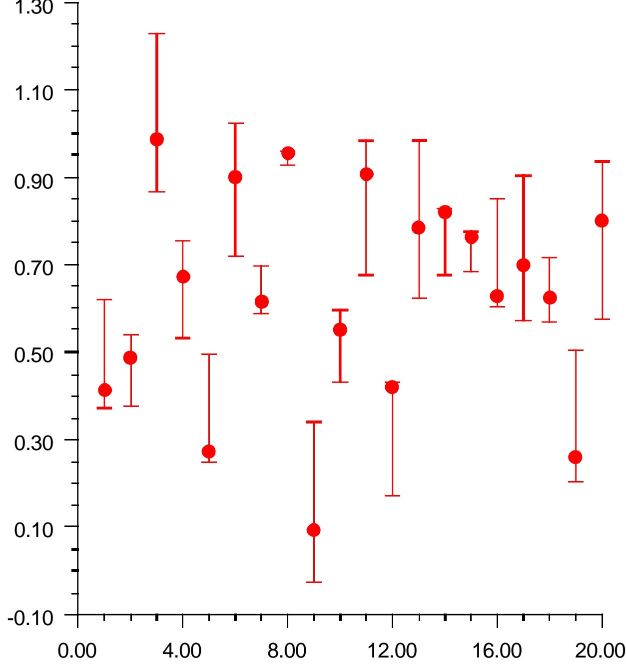
```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleLogLog extends JFrameChart {

    public SampleLogLog() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        axis.setTransform(axis.TRANSFORM_LOG);
        axis.setDensity(9);
        axis.setTextFormat(new
   java.text.DecimalFormat("0.E0"));

        double x[] = {1e1, 1e2, 1e3, 1e4, 1e5};
        double y[] = {4e2, 6e6, 2e3, 1e4, 8e1};
        Data data = new Data(axis, x, y);
        data.setDataType(Data.DATA_TYPE_LINE |
   Data.DATA_TYPE_MARKER);
        data.setLineColor(Color.blue);
        data.setMarkerType(Data.MARKER_TYPE_FILLED_SQUARE);
    }

    public static void main(String argv[]) {
        new SampleLogLog().setVisible(true);
    }
}
```

Error Bar Plot

Error bars are used to indicate the estimated error in a measurement. Errors bars indicate the uncertainty in the *x* and/or *y* values.

Vertical Error Bars

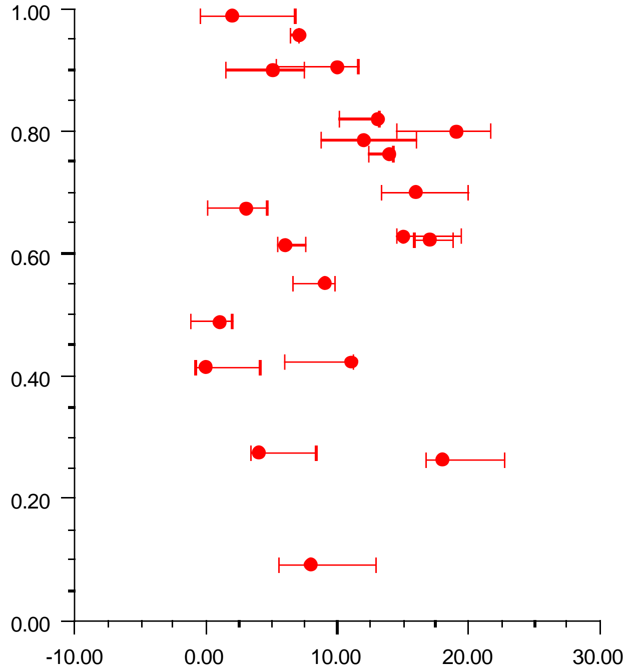
The most common error bar plot is one in which the errors are in the *y*-values. This example shows such an error bar plot. Note that the values of the low and high arguments are absolute *y* values, not relative or percentage values.



```
import com.imsl.chart.*;
import java.awt.Color;
import com.imsl.stat.Random;

public class SampleErrorBar extends JFrameChart {

    public SampleErrorBar() {
        Random r = new Random(123457);

        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        // Generate a random data set, with random errors
        int n = 20;
        double x[] = new double[n];
        double y[] = new double[n];
        double low[] = new double[n];
        double high[] = new double[n];
        for (int k = 0;  k < n;  k++) {
            x[k] = k + 1;
            y[k] = r.nextDouble();
            low[k] = y[k] - 0.25*r.nextDouble();
            high[k] = y[k] + 0.25*r.nextDouble();
        }

        ErrorBar data = new ErrorBar(axis, x, y, low, high);
        data.setDataType(data.DATA_TYPE_ERROR_Y | data.DATA_TYPE_MARKER);
        data.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);
        data.setMarkerColor(Color.red);
    }

    public static void main(String argv[]) {
        new SampleErrorBar().setVisible(true);
    }
}
```

Horizontal Error Bars

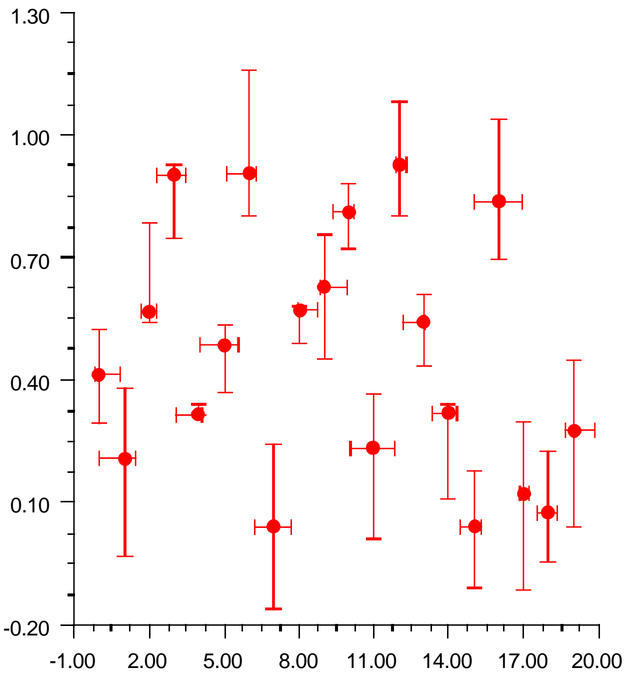
It is also possible to have horizontal error bars, indicating errors in *x*, as shown in this example.



```
import com.imsl.chart.*;
import java.awt.Color;
import com.imsl.stat.Random;

public class SampleHorizontalErrorBar extends JFrameChart {

    public SampleHorizontalErrorBar() {
        Random r = new Random(123457);

        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        // Generate a random data set, with random errors in x
        int n = 20;
        double x[] = new double[n];
        double y[] = new double[n];
        double low[] = new double[n];
        double high[] = new double[n];
        for (int k = 0;  k < n;  k++) {
            x[k] = k;
            y[k] = r.nextDouble();
            low[k] = x[k] - 5.*r.nextDouble();
            high[k] = x[k] + 5.*r.nextDouble();
        }

        ErrorBar data = new ErrorBar(axis, x, y, low, high);
        data.setDataType(data.DATA_TYPE_ERROR_X | data.DATA_TYPE_MARKER);
        data.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);
        data.setMarkerColor("red");
    }

    public static void main(String argv[]) {
        new SampleHorizontalErrorBar().setVisible(true);
    }
}
```

Mixed Error Bars

To show errors in both *x* and *y*, it is necessary to create both vertical and horizontal error bar objects. This example shows such a chart.




```
import com.imsl.chart.*;
import java.awt.Color;
import com.imsl.stat.Random;

public class SampleMixedErrorBar extends JFrameChart {

    public SampleMixedErrorBar() {
        Random r = new Random(123457);

        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        // Generate a random data set, with random errors in x
        int n = 20;
        double x[] = new double[n];
        double y[] = new double[n];
        double xlow[] = new double[n];
        double xhigh[] = new double[n];
        double ylow[] = new double[n];
```

```
        double yhigh[] = new double[n];
        for (int k = 0;  k < n;  k++) {
            x[k] = k;
            y[k] = r.nextDouble();
            xlow[k] = x[k] - r.nextDouble();
            xhigh[k] = x[k] + r.nextDouble();
            ylow[k] = y[k] - 0.25*r.nextDouble();
            yhigh[k] = y[k] + 0.25*r.nextDouble();
        }

        ErrorBar dataY = new ErrorBar(axis, x, y, ylow, yhigh);
        dataY.setDataType(dataY.DATA_TYPE_ERROR_Y | dataY.DATA_TYPE_MARKER);
        dataY.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);
        dataY.setMarkerColor("red");

        ErrorBar dataX = new ErrorBar(axis, x, y, xlow, xhigh);
        dataX.setDataType(dataY.DATA_TYPE_ERROR_X);
        dataX.setMarkerColor("red");
    }

    public static void main(String argv[]) {
        new SampleMixedErrorBar().setVisible(true);
    }
}
```

High-Low-Close Plot

High-Low-Close plots are used to show stock prices. They are created using the HighLowClose class.

The markers can be formatted using the attribute MarkerColor.

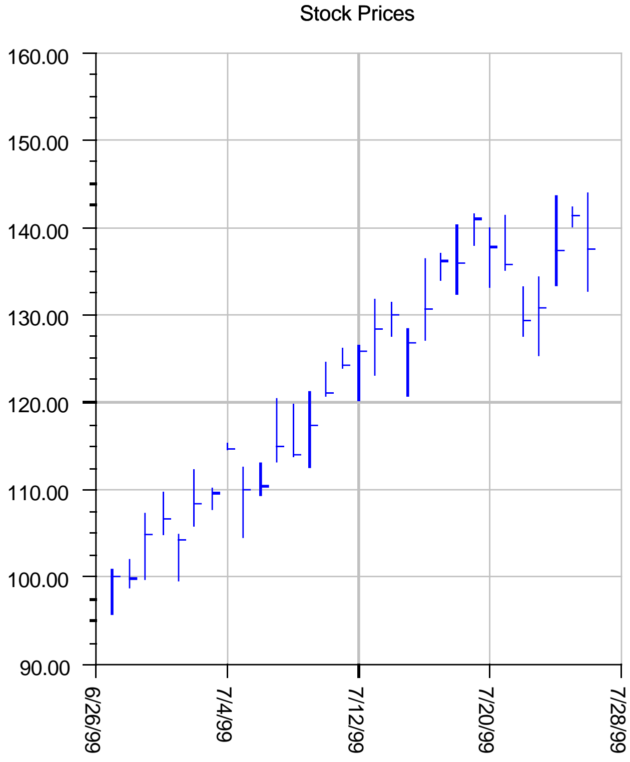
In a high-low-close plot the vertical line represents the high and low values. The close value is represented by a “tick” to the right. The open value, if present, is represented by a tick to the left.

The `setupDateAxis` method will configure the *x*-axis for dates. This turns off autoscaling of the axis.

In a high-low-close chart the *x*-values are the number of milliseconds since the epoch (January 1, 1970). This is the standard Java convention for representing dates as numbers.

Example

In this example, random security prices are computed in the `createData` method. The time axis is prepared by calling `setDateAxis`.



```
import com.imsl.chart.*;
import java.text.DateFormat;
import java.util.*;

public class SampleHighLowClose extends JFrameChart {
    private double high[], low[], close[];

    public SampleHighLowClose() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        // Date is June 27, 1999
        Date date = new GregorianCalendar(1999,
        GregorianCalendar.JUNE, 27).getTime();

        int n = 30;
        createData(n);

        //Create an instance of a HighLowClose Chart
      HighLowClose hilo = new HighLowClose(axis, date, high,
   low, close);
        hilo.setMarkerColor("blue");

        //Set the HighLowClose Chart Title
        chart.getChartTitle().setTitle("Stock Prices");

        // Setup the x axis
        Axis1D axisX = axis.getAxisX();

        //Set the text angle for the X axis labels
        axisX.getAxisLabel().setTextAngle(270);
        //Change the text format to the local date format
        DateFormat df =
   DateFormat.getDateInstance(DateFormat.SHORT);
        axisX.getAxisLabel().setTextFormat(df);

        // Setup the time axis
        hilo.setDateAxis("Date(SHORT)");

        // Turn on grid and make it light gray
        axisX.getGrid().setPaint(true);
        axisX.getGrid().setLineColor("lightgray");
        axis.getAxisY().getGrid().setPaint(true);
        axis.getAxisY().getGrid().setLineColor("lightgray");
    }
```

```
    private void createData(int n) {
        high = new double[n];
        low = new double[n];
        close = new double[n];
        Random r = new Random(123457);
        for (int k = 0;  k < n;  k++) {
            double f = r.nextDouble();
            if (k == 0) {
                close[0] = 100;
            } else {
                close[k] = (0.95+0.10*f)*close[k-1];
            }
            high[k] = close[k]*(1.+0.05*r.nextDouble());
            low[k] = close[k]*(1.-0.05*r.nextDouble());
        }
    }

    public static void main(String argv[]) {
        new SampleHighLowClose().setVisible(true);
    }
}
```

Candlestick Chart

Candlesticks are used to show stock price. Each candlestick shows the stock's high, low, opening and closing prices.

The Candlestick constructors create two child CandlestickItem nodes. One is for the up days and one is for the down days. A day is an up day if the closing price is greater than the opening price. The `getUp` and `getDown` accessor methods can be used to retrieve these nodes.

The line ("whisker") part of a candlestick shows the stock's high and low prices. The whiskers can be formatted using the line attributes (see "Line Attributes" on page 78).

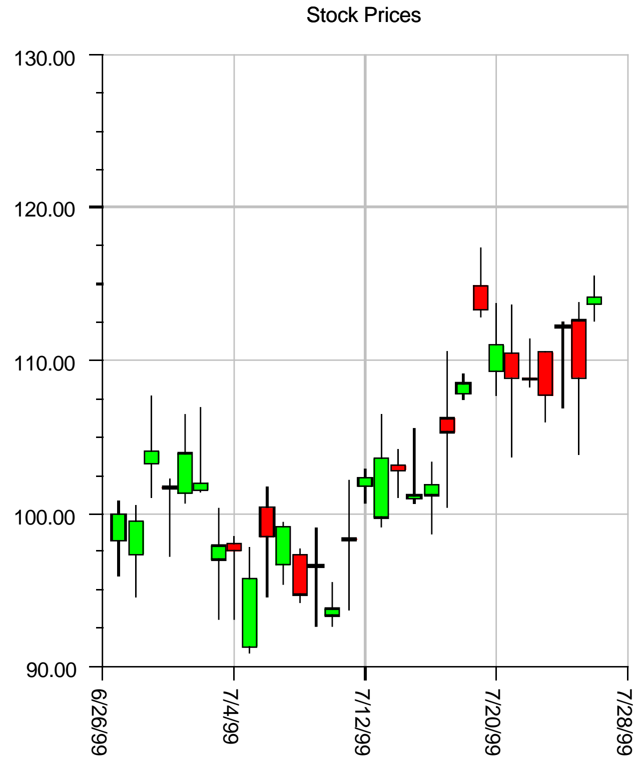
The body of a candlestick shows the stock's opening and closing prices. The body color is used to flag if the top of the body is the closing price (up day) or the opening price (down day). The fill area attributes determine how the body is drawn (see "Fill Area Attributes" on page 81). By default, up days are white and down days are black.

The width of a candlestick is controlled by the MarkerSize attribute (see "Attribute MarkerSize" on page 80).

Example

In this example, random security prices are computed in the `createData` method. The time axis is prepared by calling `setDateAxis`.

The up days are colored green and the down days are colored red.




```
import com.imsl.chart.*;
import java.text.DateFormat;
import java.util.*;

public class SampleCandlestick extends JFrameChart {
    private double high[], low[], open[], close[];

    public SampleCandlestick() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        // Date is June 27, 1999
       Date date = new GregorianCalendar(1999, GregorianCal-
```

```
endar.JUNE, 27).getTime();

     int n = 30;
     createData(n);

     //Create an instance of a HighLowClose Chart
    Candlestick stick = new Candlestick(axis, date, high,
low, close, open);

     // show up days in green and down days in red
     stick.getUp().setFillColor("green");
     stick.getDown().setFillColor("red");

     //Set the HighLowClose Chart Title
     chart.getChartTitle().setTitle("Stock Prices");

     // Setup the x axis
     Axis1D axisX = axis.getAxisX();

     // Setup the time axis
     stick.setDateAxis("Date(SHORT)");

     // Turn on grid and make it light gray
     axisX.getGrid().setPaint(true);
     axisX.getGrid().setLineColor("lightgray");
     axis.getAxisY().getGrid().setPaint(true);
     axis.getAxisY().getGrid().setLineColor("lightgray");
 }


 private void createData(int n) {
     high = new double[n];
     low = new double[n];
     close = new double[n];
     open = new double[n];
     Random r = new Random(123457);
     for (int k = 0;  k < n;  k++) {
         double f = r.nextDouble();
         if (k == 0) {
             close[0] = 100;
         } else {
             close[k] = (0.95+0.10*f)*close[k-1];
         }
         high[k] = close[k]*(1.+0.05*r.nextDouble());
         low[k] = close[k]*(1.-0.05*r.nextDouble());
```

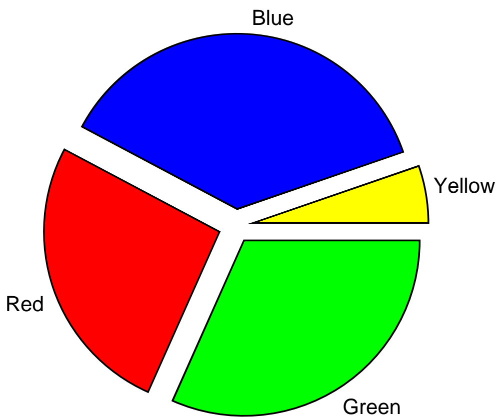
```
            open[k] = low[k] + r.nextDouble()*(high[k]-low[k]);
        }
    }

    public static void main(String argv[]) {
        new SampleCandlestick().setVisible(true);
    }
}
```

Pie Chart

A pie chart is a graphical way to organize data. This section describes the construction of a pie chart.

Example

The JFrameChart class is used to create a frame containing a Chart node. A Pie node is then created as a child of the Chart node. The Pie node constructor creates PieSlice nodes as its children. The number of PieSlice nodes created is `y.length`, here equal to 4. After the PieSlice nodes are created they are retrieved from the object pie and customized by setting attributes.



The LabelType attribute is set in the pie node. The pie node itself does not use this attribute, but from there it is inherited by all of the PieSlice nodes.

The Title attribute is set in each PieSlice node. This is the slice label. It is used to label the slice only if the slice's LabelType attribute is LABEL_TYPE_TITLE.

The FillColor attribute is also set in each slice. This determines the color of the slice. Since the default value of FillColor is black, it is generally recommended that FillColor be set in each slice.

The FillOutlineColor attribute sets the border color of each slice. In this example it is set in the pie node to be blue and set in the `slice[1]` node to be yellow. All except `slice[1]` are outlined in blue, and `slice[1]` is outlined in yellow.

The Explode attribute moves a pie slice out from the center. Its default value is 0, which puts the slice vertex in the center. A value of 1.0 would put the slice vertex on the circumference.

```
import com.imsl.chart.*;
import java.awt.Color;

public class SamplePieChart extends JFrameChart {

    public SamplePieChart() {
        Chart chart = getChart();

        double y[] = {35., 20., 30., 5.};
        Pie pie = new Pie(chart, y);
        pie.setLabelType(Pie.LABEL_TYPE_TITLE);
        pie.setFillOutlineColor(Color.blue);

        PieSlice[] slice = pie.getPieSlice();

        slice[0].setFillColor(Color.green);
        slice[0].setTitle("Green");
slice[0].setExplode(0.1);

        slice[1].setFillColor(Color.red);
        slice[1].setTitle("Red");
        slice[1].setFillOutlineColor(Color.yellow);
slice[1].setExplode(0.1);

        slice[2].setFillColor(Color.blue);
        slice[2].setTitle("Blue");
slice[2].setExplode(0.1);

        slice[3].setFillColor(Color.yellow);
        slice[3].setTitle("Yellow");
        slice[3].setExplode(0.15);
    }

    public static void main(String argv[]) {
        new SamplePieChart().setVisible(true);
    }
}
```

Box Plot

Box plots are used to show statistics about multiple groups of observations.

For each group of observations, the box limits represent the lower quartile (25-*th* percentile) and upper quartile (75-*th* percentile). The median is displayed as a line across the box. Whiskers are drawn from the upper quartile to the upper adjacent value, and from the lower quartile to the lower adjacent value.

Optional notches may be displayed to show a 95 percent confidence interval about the median, at

$$\pm 1.58\ IRQ / \sqrt{n}$$

where IRQ is the interquartile range and n is the number of observations. Outside and far outside values may be displayed as symbols. Outside values are outside the inner fence. Far out values are outside the outer fence.

The BoxPlot has several child nodes. Any of these nodes can be disabled by setting their "Paint" attribute to false.

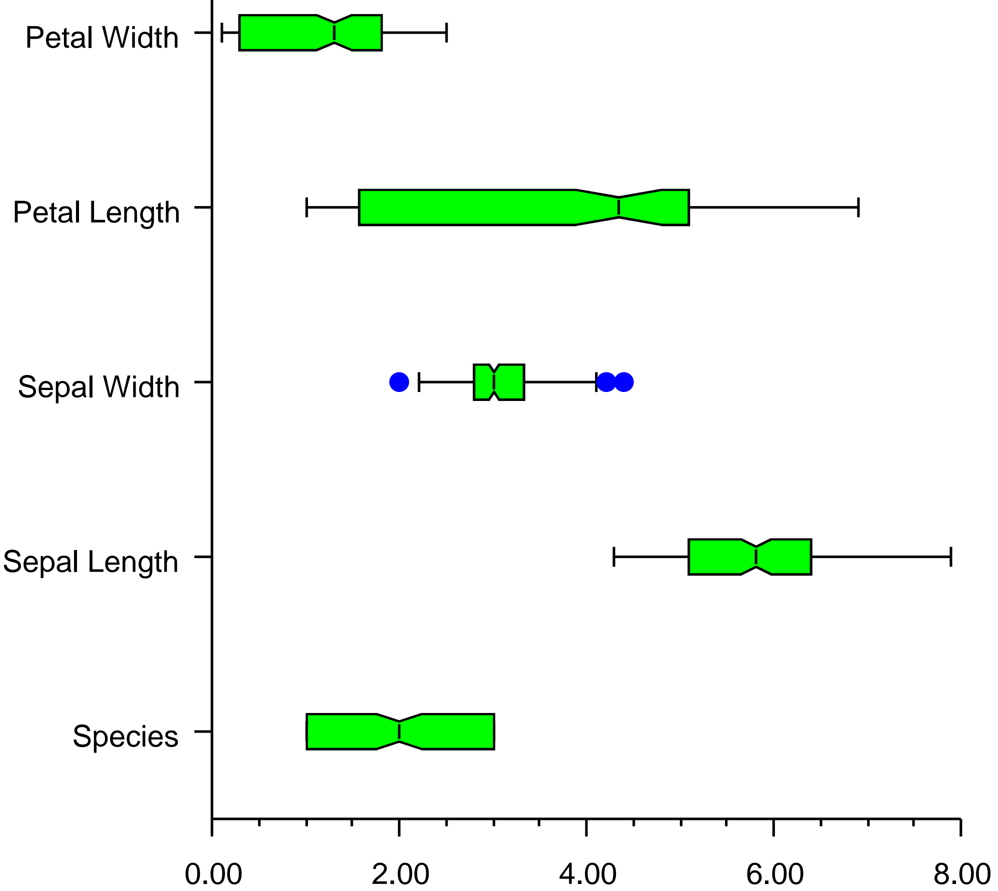
- The "Bodies" node has the main body of the box plot elements. Its fill attributes determine the drawing of (notched) rectangle (see “Fill Area Attributes” on page 81). Its line attributes determine the drawing of the median line. The width of the box is controlled by the "MarkerSize" attribute (see “Attribute MarkerSize” on page 80) .
- The "Whiskers" node draws the lines to the upper and lower quartile. Its drawing is affected by the marker attributes.
- The "FarMarkers" node hold the far markers. Its drawing is affected by the marker attributes.
- The "OutsideMarkers" node hold the outside markers. Its drawing is affected by the marker attributes.

Example

In this example, the Fisher iris data set is read from a file and a Box plot is created from data. The data is in a file called "FisherIris.csv" (see “Attribute MarkerSize” on page 80) in the same directory as this class.

The *y*-axis labels are taken from the column names.

The boxes are colored green, the markers are all filled circles. The outside markers are blue and the far outside markers would be red, if there were any.



```
import com.imsl.chart.*;
import com.imsl.io.FlatFile;
import java.io.*;
import java.sql.SQLException;
import java.util.StringTokenizer;


public class SampleBoxPlot extends JFrameChart {

    public SampleBoxPlot() throws IOException, java.sql.SQLException {
        // Read the data
        InputStream is =
SampleBoxPlot.class.getResourceAsStream("FisherIris.csv");
        DataReader reader = new DataReader(is);
        int nColumns = 5;
        int nObs = 150;
        String labels[]  = new String[nColumns];
        for (int i = 0;  i < nColumns;  i++) {
            labels[i] = reader.getMetaData().getColumnName(i+1);
        }
        double irisData[][] = new double[nColumns][nObs];
        for (int j = 0;  reader.next();  j++) {
            for (int i = 0;  i < nColumns;  i++) {
                irisData[i][j] = reader.getDouble(i+1);
            }
        }

        // Setup the chart
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        BoxPlot boxPlot = new BoxPlot(axis, irisData);
        boxPlot.setBoxPlotType(BoxPlot.BOXPLOT_TYPE_HORIZONTAL);
        boxPlot.setLabels(labels);
        boxPlot.getBodies().setFillColor("green");
        boxPlot.setMarkerType(BoxPlot.MARKER_TYPE_FILLED_CIRCLE);
        boxPlot.getOutsideMarkers().setMarkerColor("blue");
        boxPlot.getFarMarkers().setMarkerColor("red");
        boxPlot.setNotch(true);
    }


    public static void main(String argv[]) throws IOException, java.sql.SQLEx-
ception {
        new SampleBoxPlot().setVisible(true);
    }


    /**
     *  Read the Fisher Iris data
```

```
     */
    static private class DataReader extends FlatFile {
        public DataReader(InputStream is) throws IOException {
            super(new BufferedReader(new InputStreamReader(is)));
            String line = readLine();
            StringTokenizer st = new StringTokenizer(line, ",");
            for (int j = 0;  st.hasMoreTokens();  j++) {
                setColumnName(j+1, st.nextToken().trim());
                setColumnClass(j, Double.class);
            }
        }
    }
}
```

```
Species,Sepal Length,Sepal Width,Petal Length,Petal Width
 1.0, 5.1, 3.5, 1.4, .2
 1.0, 4.9, 3.0, 1.4, .2
 1.0, 4.7, 3.2, 1.3, .2
 1.0, 4.6, 3.1, 1.5, .2
 1.0, 5.0, 3.6, 1.4, .2
 1.0, 5.4, 3.9, 1.7, .4
 1.0, 4.6, 3.4, 1.4, .3
 1.0, 5.0, 3.4, 1.5, .2
 1.0, 4.4, 2.9, 1.4, .2
 1.0, 4.9, 3.1, 1.5, .1
 1.0, 5.4, 3.7, 1.5, .2
 1.0, 4.8, 3.4, 1.6, .2
 1.0, 4.8, 3.0, 1.4, .1
 1.0, 4.3, 3.0, 1.1, .1
 1.0, 5.8, 4.0, 1.2, .2
 1.0, 5.7, 4.4, 1.5, .4
 1.0, 5.4, 3.9, 1.3, .4
 1.0, 5.1, 3.5, 1.4, .3
 1.0, 5.7, 3.8, 1.7, .3
 1.0, 5.1, 3.8, 1.5, .3
 1.0, 5.4, 3.4, 1.7, .2
 1.0, 5.1, 3.7, 1.5, .4
 1.0, 4.6, 3.6, 1.0, .2
 1.0, 5.1, 3.3, 1.7, .5
 1.0, 4.8, 3.4, 1.9, .2
 1.0, 5.0, 3.0, 1.6, .2
 1.0, 5.0, 3.4, 1.6, .4
 1.0, 5.2, 3.5, 1.5, .2
 1.0, 5.2, 3.4, 1.4, .2
 1.0, 4.7, 3.2, 1.6, .2
 1.0, 4.8, 3.1, 1.6, .2
```

```
1.0, 5.4, 3.4, 1.5, .4
1.0, 5.2, 4.1, 1.5, .1
1.0, 5.5, 4.2, 1.4, .2
1.0, 4.9, 3.1, 1.5, .2
1.0, 5.0, 3.2, 1.2, .2
1.0, 5.5, 3.5, 1.3, .2
1.0, 4.9, 3.6, 1.4, .1
1.0, 4.4, 3.0, 1.3, .2
1.0, 5.1, 3.4, 1.5, .2
1.0, 5.0, 3.5, 1.3, .3
1.0, 4.5, 2.3, 1.3, .3
1.0, 4.4, 3.2, 1.3, .2
1.0, 5.0, 3.5, 1.6, .6
1.0, 5.1, 3.8, 1.9, .4
1.0, 4.8, 3.0, 1.4, .3
1.0, 5.1, 3.8, 1.6, .2
1.0, 4.6, 3.2, 1.4, .2
1.0, 5.3, 3.7, 1.5, .2
1.0, 5.0, 3.3, 1.4, .2
2.0, 7.0, 3.2, 4.7, 1.4
2.0, 6.4, 3.2, 4.5, 1.5
2.0, 6.9, 3.1, 4.9, 1.5
2.0, 5.5, 2.3, 4.0, 1.3
2.0, 6.5, 2.8, 4.6, 1.5
2.0, 5.7, 2.8, 4.5, 1.3
2.0, 6.3, 3.3, 4.7, 1.6
2.0, 4.9, 2.4, 3.3, 1.0
2.0, 6.6, 2.9, 4.6, 1.3
2.0, 5.2, 2.7, 3.9, 1.4
2.0, 5.0, 2.0, 3.5, 1.0
2.0, 5.9, 3.0, 4.2, 1.5
2.0, 6.0, 2.2, 4.0, 1.0
2.0, 6.1, 2.9, 4.7, 1.4
2.0, 5.6, 2.9, 3.6, 1.3
2.0, 6.7, 3.1, 4.4, 1.4
2.0, 5.6, 3.0, 4.5, 1.5
2.0, 5.8, 2.7, 4.1, 1.0
2.0, 6.2, 2.2, 4.5, 1.5
2.0, 5.6, 2.5, 3.9, 1.1
2.0, 5.9, 3.2, 4.8, 1.8
2.0, 6.1, 2.8, 4.0, 1.3
2.0, 6.3, 2.5, 4.9, 1.5
2.0, 6.1, 2.8, 4.7, 1.2
2.0, 6.4, 2.9, 4.3, 1.3
2.0, 6.6, 3.0, 4.4, 1.4
```

```
2.0, 6.8, 2.8, 4.8, 1.4
2.0, 6.7, 3.0, 5.0, 1.7
2.0, 6.0, 2.9, 4.5, 1.5
2.0, 5.7, 2.6, 3.5, 1.0
2.0, 5.5, 2.4, 3.8, 1.1
2.0, 5.5, 2.4, 3.7, 1.0
2.0, 5.8, 2.7, 3.9, 1.2
2.0, 6.0, 2.7, 5.1, 1.6
2.0, 5.4, 3.0, 4.5, 1.5
2.0, 6.0, 3.4, 4.5, 1.6
2.0, 6.7, 3.1, 4.7, 1.5
2.0, 6.3, 2.3, 4.4, 1.3
2.0, 5.6, 3.0, 4.1, 1.3
2.0, 5.5, 2.5, 4.0, 1.3
2.0, 5.5, 2.6, 4.4, 1.2
2.0, 6.1, 3.0, 4.6, 1.4
2.0, 5.8, 2.6, 4.0, 1.2
2.0, 5.0, 2.3, 3.3, 1.0
2.0, 5.6, 2.7, 4.2, 1.3
2.0, 5.7, 3.0, 4.2, 1.2
2.0, 5.7, 2.9, 4.2, 1.3
2.0, 6.2, 2.9, 4.3, 1.3
2.0, 5.1, 2.5, 3.0, 1.1
2.0, 5.7, 2.8, 4.1, 1.3
3.0, 6.3, 3.3, 6.0, 2.5
3.0, 5.8, 2.7, 5.1, 1.9
3.0, 7.1, 3.0, 5.9, 2.1
3.0, 6.3, 2.9, 5.6, 1.8
3.0, 6.5, 3.0, 5.8, 2.2
3.0, 7.6, 3.0, 6.6, 2.1
3.0, 4.9, 2.5, 4.5, 1.7
3.0, 7.3, 2.9, 6.3, 1.8
3.0, 6.7, 2.5, 5.8, 1.8
3.0, 7.2, 3.6, 6.1, 2.5
3.0, 6.5, 3.2, 5.1, 2.0
3.0, 6.4, 2.7, 5.3, 1.9
3.0, 6.8, 3.0, 5.5, 2.1
3.0, 5.7, 2.5, 5.0, 2.0
3.0, 5.8, 2.8, 5.1, 2.4
3.0, 6.4, 3.2, 5.3, 2.3
3.0, 6.5, 3.0, 5.5, 1.8
3.0, 7.7, 3.8, 6.7, 2.2
3.0, 7.7, 2.6, 6.9, 2.3
3.0, 6.0, 2.2, 5.0, 1.5
3.0, 6.9, 3.2, 5.7, 2.3
```

```
3.0, 5.6, 2.8, 4.9, 2.0
3.0, 7.7, 2.8, 6.7, 2.0
3.0, 6.3, 2.7, 4.9, 1.8
3.0, 6.7, 3.3, 5.7, 2.1
3.0, 7.2, 3.2, 6.0, 1.8
3.0, 6.2, 2.8, 4.8, 1.8
3.0, 6.1, 3.0, 4.9, 1.8
3.0, 6.4, 2.8, 5.6, 2.1
3.0, 7.2, 3.0, 5.8, 1.6
3.0, 7.4, 2.8, 6.1, 1.9
3.0, 7.9, 3.8, 6.4, 2.0
3.0, 6.4, 2.8, 5.6, 2.2
3.0, 6.3, 2.8, 5.1, 1.5
3.0, 6.1, 2.6, 5.6, 1.4
3.0, 7.7, 3.0, 6.1, 2.3
3.0, 6.3, 3.4, 5.6, 2.4
3.0, 6.4, 3.1, 5.5, 1.8
3.0, 6.0, 3.0, 4.8, 1.8
3.0, 6.9, 3.1, 5.4, 2.1
3.0, 6.7, 3.1, 5.6, 2.4
3.0, 6.9, 3.1, 5.1, 2.3
3.0, 5.8, 2.7, 5.1, 1.9
3.0, 6.8, 3.2, 5.9, 2.3
3.0, 6.7, 3.3, 5.7, 2.5
3.0, 6.7, 3.0, 5.2, 2.3
3.0, 6.3, 2.5, 5.0, 1.9
3.0, 6.5, 3.0, 5.2, 2.0
3.0, 6.2, 3.4, 5.4, 2.3
3.0, 5.9, 3.0, 5.1, 1.8
```

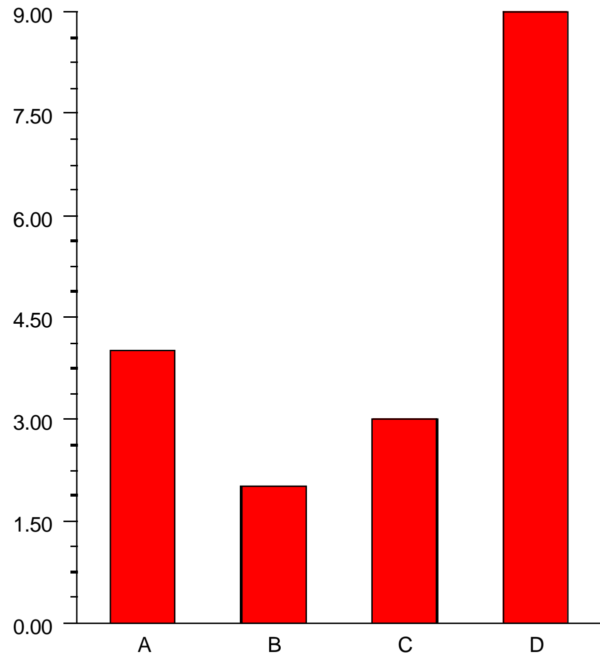
Bar Chart

The class Bar is used to create bar charts and histograms. This section describes the construction of labeled bar charts. For a discussion of histograms, see "Histogram" on page 66.

Simple Bar Chart

The following code creates this labeled bar chart. The BarType attribute can be either BAR_TYPE_VERTICAL or BAR_TYPE_HORIZONTAL. The method `setLabels` sets the bar labels and adjusts the attributes of the axis to be appropriate for bar labels. The `setLabels` method *must be called after* the `setBarType` method, so that the correct axis has its attributes adjusted.

The drawing of the bars is controlled by the "FillType" on page 81 and "FillOutlineType" on page 81 attributes. By default FillType has the value FILL_TYPE_SOLID, so setting the associated attribute "FillColor" on page 81 to red causes solid red bars to be drawn.




```
import com.imsl.chart.*;
import java.awt.Color;
```

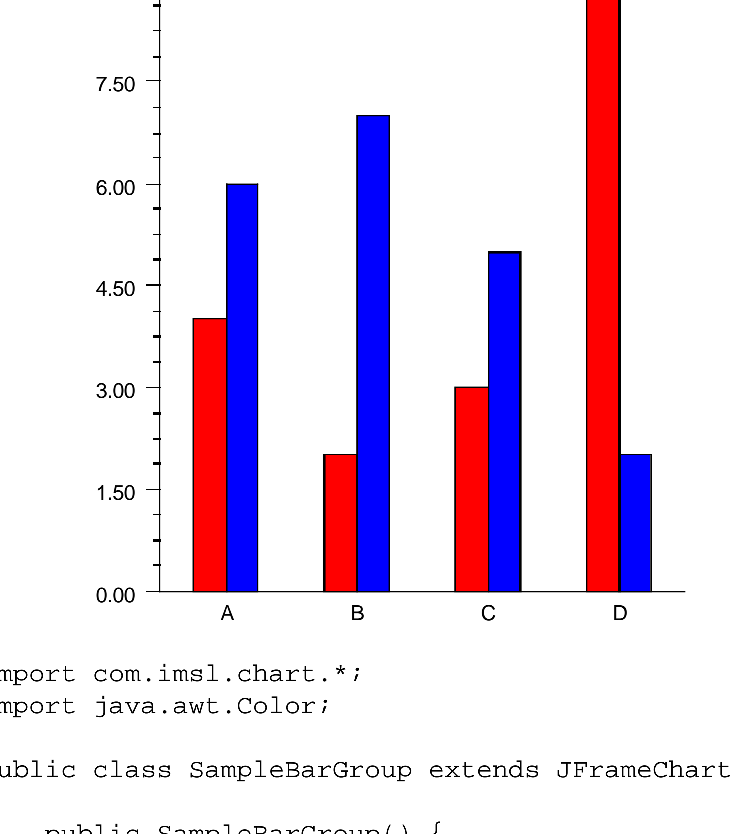
```
public class SampleBar extends JFrameChart {

    public SampleBar() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        Bar bar = new Bar(axis, y);
        bar.setBarType(Bar.BAR_TYPE_VERTICAL);
        bar.setLabels(new String[]{“A”,”B”,”C”,”D”});
        bar.setFillColor(Color.red);
    }

    public static void main(String argv[]) {
        new SampleBar().setVisible(true);
    }
}
```

Grouped Bar Chart

In a grouped bar chart multiple sets of data are displayed as side-by-side bars.

The data argument to the constructor for a grouped bar chart is an `nGroups` by `nItems` array of doubles. In this example there are two groups, each containing four items. All of the groups must contain the same number of items.

The `getBarSet(int)` method returns a BarSet object that is a collection of the BarItems that make up a given group. Here the bars in group 0 are set to red and those in group 1 are set to blue.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleBarGroup extends JFrameChart {

    public SampleBarGroup() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double y[][] = {{4,2,3,9},{6,7,5,2}};
        Bar bar = new Bar(axis, y);
        bar.setBarType(Bar.BAR_TYPE_VERTICAL);
        bar.setLabels(new String[]{"A","B","C","D"});
```

```
        bar.getBarSet(0).setFillColor(Color.red);
        bar.getBarSet(1).setFillColor(Color.blue);
    }

    public static void main(String argv[]) {
        new SampleBarGroup().setVisible(true);
    }
}
```

In the above SampleBarGroup example, the Bar constructor creates a collection of chart nodes. For each group, it creates a BarSet node as its direct child. Each BarSet node has BarItem nodes as children, one for each bar in the set.

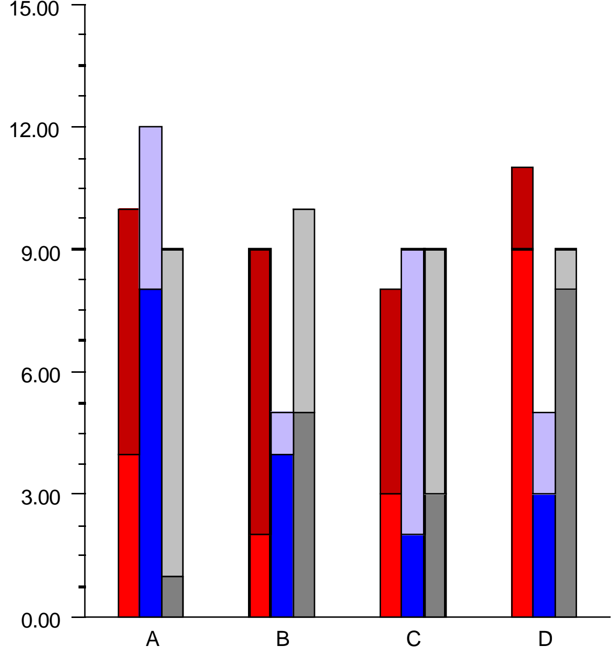
Stacked Grouped Bar Chart

The most general form of the bar chart is a stacked, grouped bar chart.

The data argument to the constructor for a stacked, grouped bar chart is an `nStacks` by `nGroups` by `nItems` array of doubles. In this example there are two stacks in three groups each containing four items. All of the stacks must contain the same number of groups and all of the groups must contain the same number of items.

The `getBarSet(int,int)` method returns a BarSet object that is a collection of the BarItems that make up a given stack/group. Here within each group the stacks are set to shades of the same color.

A stacked bar chart, without groups, can be constructed as a stacked-grouped bar chart with one group.

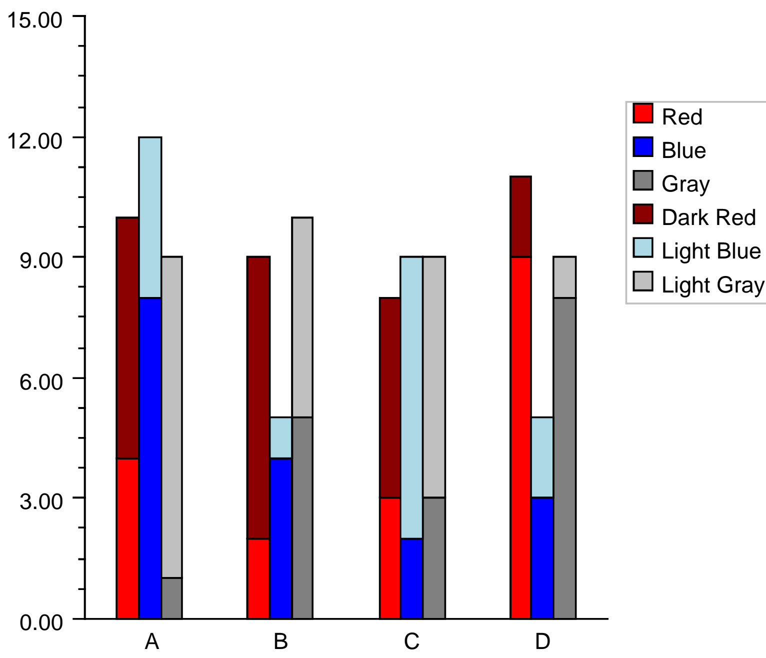



```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleBarGroupStack extends JFrameChart {
    static final Color darkRed = new Color(196,0,0);
    static final Color lightBlue = new Color(196,185,253);
```

```
    public SampleBarGroupStack() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        // y is a 2 by 3 by 4 array
        double y[][][] = {
            {{4,2,3,9},{8,4,2,3},{1,5,3,8}},
            {{6,7,5,2},{4,1,7,2},{8,5,6,1}}
        };
        Bar bar = new Bar(axis, y);
        bar.setBarType(Bar.BAR_TYPE_VERTICAL);
        bar.setLabels(new String[]{"A","B","C","D"});
        // group 0 - shades of red
        bar.getBarSet(0,0).setFillColor(Color.red);
        bar.getBarSet(1,0).setFillColor(darkRed);
        // group 1 - shades of blue
        bar.getBarSet(0,1).setFillColor(Color.blue);
        bar.getBarSet(1,1).setFillColor(lightBlue);
        // group 2 - shades of gray
        bar.getBarSet(0,2).setFillColor(Color.gray);
        bar.getBarSet(1,2).setFillColor(Color.lightGray);
    }

    public static void main(String argv[]) {
        new SampleBarGroupStack().setVisible(true);
    }
}
```

Legend

The Legend for a bar chart is turned on by setting the Legend's Paint attribute to `true` and defining the Title attributes for the legend entries. The legend entries are the BarSet objects. The following example is the stacked, grouped bar example with the legend enabled.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleBarLegend extends JFrameChart {
    public SampleBarLegend() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        chart.getLegend().setPaint(true);
        // y is a 2 by 3 by 4 array
        double y[][][] = {
            {{4,2,3,9},{8,4,2,3},{1,5,3,8}},
            {{6,7,5,2},{4,1,7,2},{8,5,6,1}}
        };
        Bar bar = new Bar(axis, y);
        bar.setBarType(Bar.BAR_TYPE_VERTICAL);
        bar.setLabels(new String[]{"A","B","C","D"});
        // group 0 - shades of red
        bar.getBarSet(0,0).setTitle("Red");
```

```
        bar.getBarSet(0,0).setFillColor("Red");
        bar.getBarSet(1,0).setTitle("Dark Red");
        bar.getBarSet(1,0).setFillColor("DarkRed");
        // group 1 - shades of blue
        bar.getBarSet(0,1).setTitle("Blue");
        bar.getBarSet(0,1).setFillColor("Blue");
        bar.getBarSet(1,1).setTitle("Light Blue");
        bar.getBarSet(1,1).setFillColor("LightBlue");
        // group 2 - shades of gray
        bar.getBarSet(0,2).setTitle("Gray");
        bar.getBarSet(0,2).setFillColor("Gray");
        bar.getBarSet(1,2).setTitle("Light Gray");
        bar.getBarSet(1,2).setFillColor("LightGray");
    }

    public static void main(String argv[]) {
        new SampleBarLegend().setVisible(true);
    }
}
```

Attribute BarGap

The BarGap attribute sets the gap between bars in a group. A gap of 1.0 means that space between bars is the same as the width of an individual bar in the group. Its default value is 0.0, meaning there is no space between groups.

Attribute BarWidth

The BarWidth attribute sets the width of the groups of bars at each index. Its default value is 0.5. If the number of groups is increased, the width of each individual bar is reduced proportionately.

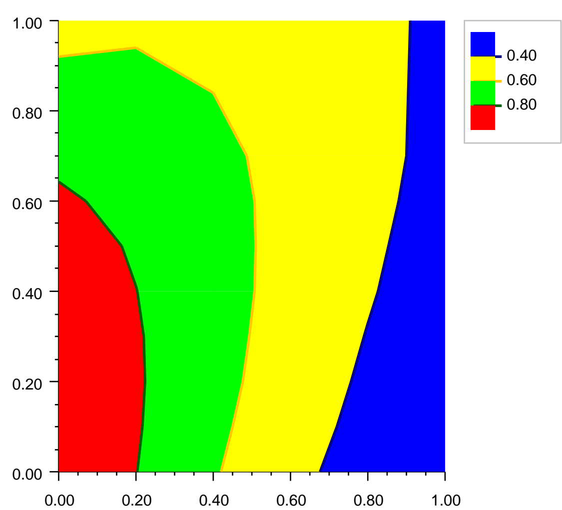
See "Histogram" on page 66 for an example of the use of the BarWidth attribute.

Contour Chart

A Contour chart shows level curves of a two-dimensional function.

Example

The JFrameChart class is used to create a frame containing a Chart node. A Contour node is then created as a child of the Chart node. The Contour node constructor creates ContourLevel nodes as its children. The number of ContourLevel nodes created is equal to the number of contour levels plue one, here equal to 4. After the ContourLevel nodes are created they are retrieved from the object pie and customized by setting attributes.



The FillColor and LineColor attributes are set in each level. This determines the color of the fill area for the level and the color of the level curves. Since the default value of FillColor is black, it is generally recommended that FillColor be set in each level.

Each level corresponds to the area less than or equal to the contour level value and greater than the previous level, if any. So in this example, since the 0-th level value

is 0.4, the area where the function is less than 0.4 is filled with blue (the level-0 fill color) and the level curve equal to 0.4 is draw with dark blue, the level-0 line color.

Heatmap

A heatmap divides a rectangle into subrectangles. The color of each subrectangle is determined by the value of a data array and a colormap.

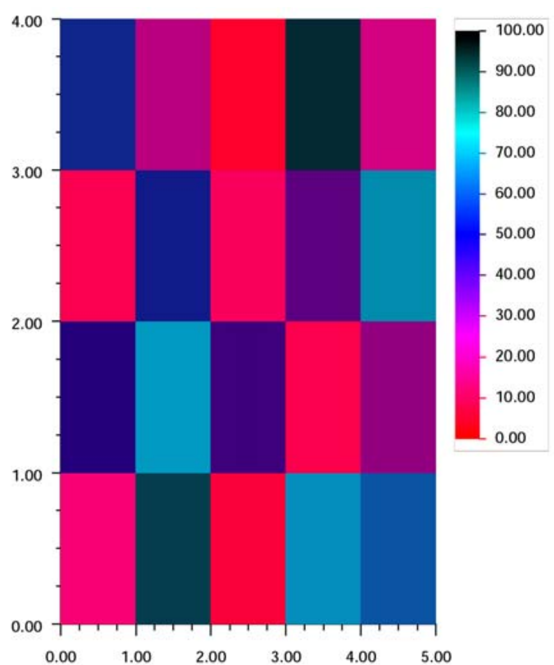
If the data array is *m* by *n* then there are *m* divisions along the *x*-axis and *n* divisions along the *y*-axis.

A colormap is a mapping from [0,1] to color values. The blue-red colormap, used in the example below, maps 0 to red and 1 to dark blue and interpolates between these endpoints values. The heatmap maps the minimum data value to the color corresponding to 0 and the highest data value to the color corresponding to 1.

The Heatmap class has a special legend for colormaps. It displays the color values as a gradient labeled with corresponding data values.

Example

In this example a two-dimensional array of data is plotted as a heatmap. The "red-blue" colormap is used. The heatmap legend is enabled by settings its "Paint" attribute to true.



```
import com.imsl.chart.*;

public class SampleHeatmap extends JFrameChart {

    public SampleHeatmap() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double xmin = 0.0;
        double xmax = 5.0;
        double ymin = 0.0;
        double ymax = 4.0;
        double zmin = 0.0;
        double zmax = 100.0;
        double data[][] = {
            {23, 48, 16, 56},
            {89, 74, 54, 32},
            {12, 45, 18,  9},
            {72, 15, 42, 92},
            {63, 36, 78, 29}
        };
        Heatmap heatmap = new Heatmap(axis, xmin, xmax, ymin, ymax,
            zmin, zmax, data, Colormap.BLUE_RED);
        heatmap.getHeatmapLegend().setPaint(true);
    }

    public static void main(String argv[]) {
        new SampleHeatmap().setVisible(true);
    }
}
```

Histogram

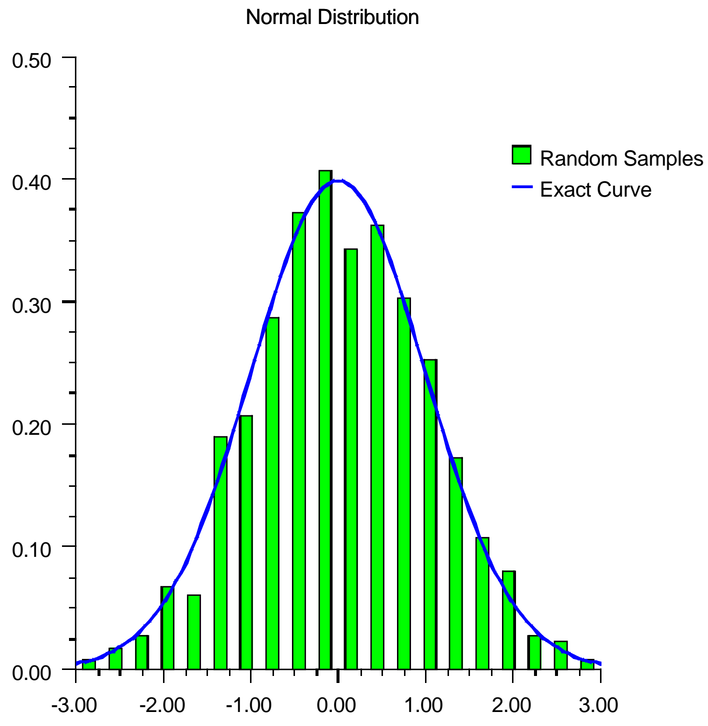
A histogram is a bar chart in which the height of the bars is proportional to the frequencies. A histogram generally uses the same axis style as a scatter plot (i.e. the bars are numbered not labeled.)

In JMSL, histograms are drawn using the Bar class, but its `setLabels` method is not used.

Example

In this example normally distributed random numbers are generated and placed into 20 uniformly sized bins in the interval [-3,3]. Points outside of this interval are ignored. The bins counts are scaled by the number of samples and the bin width. The scaled bin counts are charted using `Bar` chart. The exact normal distribution is implemented as a ChartFunction and plotted.

The legend is displayed by setting the legend node's Paint attribute to `true` and defining the bar chart's Title attribute. The legend is positioned on the chart by setting its Viewport attribute.



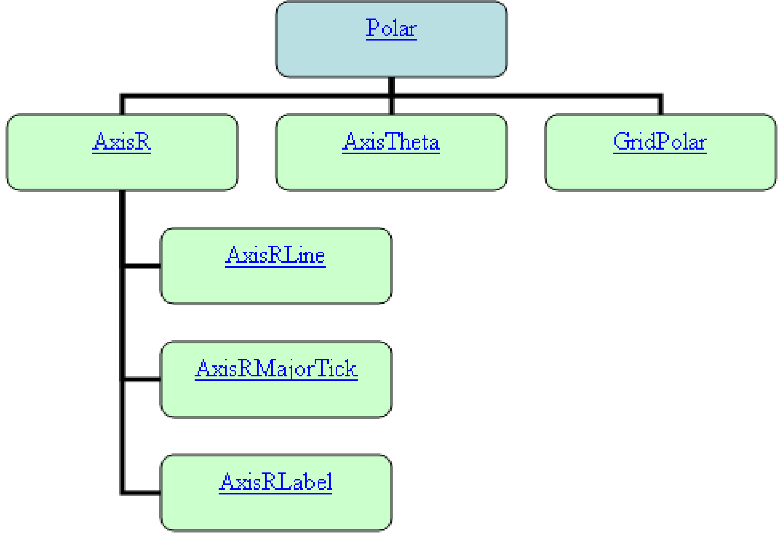
```
import com.imsl.math.Sfun;
import com.imsl.stat.Random;
import com.imsl.chart.*;
import java.awt.*;
import javax.swing.*;

public class SampleHistogram extends JFrameChart {

    public SampleHistogram() {
        int nSamples = 1000;
        int nBins = 20;

        // Setup the bins
        double bins[] = new double[nBins];
        double dx = 6.0/nBins;
        double x[] = new double[nBins];
        for (int k = 0;  k < nBins;  k++) {
            x[k] = -3.0 + (k+0.5)*dx;
        }

        Random r = new Random(123457);
        for (int k = 0;  k < nSamples;  k++) {
            double t = r.nextNormal();
            int j = (int)Math.round((t+3.0-0.5*dx)/dx);
            if (j >= 0  &&  j < nBins)  bins[j]++;
        }

        // Scale the bins
        for (int k = 0;  k < nBins;  k++) {
            bins[k] /= nSamples*dx;
        }

        // create the chart
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        chart.getChartTitle().setTitle("Normal Distribution");
        chart.getLegend().setPaint(true);
        chart.getLegend().setViewport(0.7, 1.0, 0.2, 0.3);
        chart.getLegend().setFillOutlineType(chart.FILL_TYPE_NONE);

        Bar bar = new Bar(axis, x, bins);
        bar.setBarType(bar.BAR_TYPE_VERTICAL);
        bar.setFillColor(Color.green);
        bar.setBarWidth(0.5*dx);
        bar.setTitle("Random Samples");

        // plot the expected curve
        ChartFunction f = new ChartFunction() {
```

```
            public double f(double x) {
                return Math.exp(-0.5*x*x)/Math.sqrt(2.0*Math.PI);
            }
        };
        Data data = new Data(axis, f, -3, 3.0);
        data.setLineColor(Color.blue);
        data.setTitle("Exact Curve");
        data.setLineWidth(2.0);
    }

    public static void main(String argv[]) {
        new SampleHistogram().setVisible(true);
    }
}
```

Polar Plot

The class Polar is used to plot (r,theta) data, where *r* is the distance from the origin and theta is the angle from the positive *x*-axis. Data node (*x*,*y*) values are treated as if they were (r,theta) values.

When a Polar node is created, a subtree of other nodes is created. These automatically created nodes are shown in the following diagram.



AxisR is the *r*-axis node. This is drawn along the positive *x*-axis. This node has three subnodes: AxisRLine for the actual line, AxisRMajorTick for the tick marks along the line and AxisRLabel for the tick mark labels.

The drawing of the AxisRLine and the AxisRMajorTick is controlled by the Line Attributes (see page 78). The drawing of the AxisRLabel is controlled by the Text Attributes (see page 85).

The Window attribute in AxisR specifies the length of the *r*-axis. Since the *r*-axis range is [0,*rmax*], the Window attribute for this node is the *rmax* value. Autoscaling is used to automatically determine *rmax* from the data. Autoscaling can be turned off. See "Autoscale" on page 96 for more details.

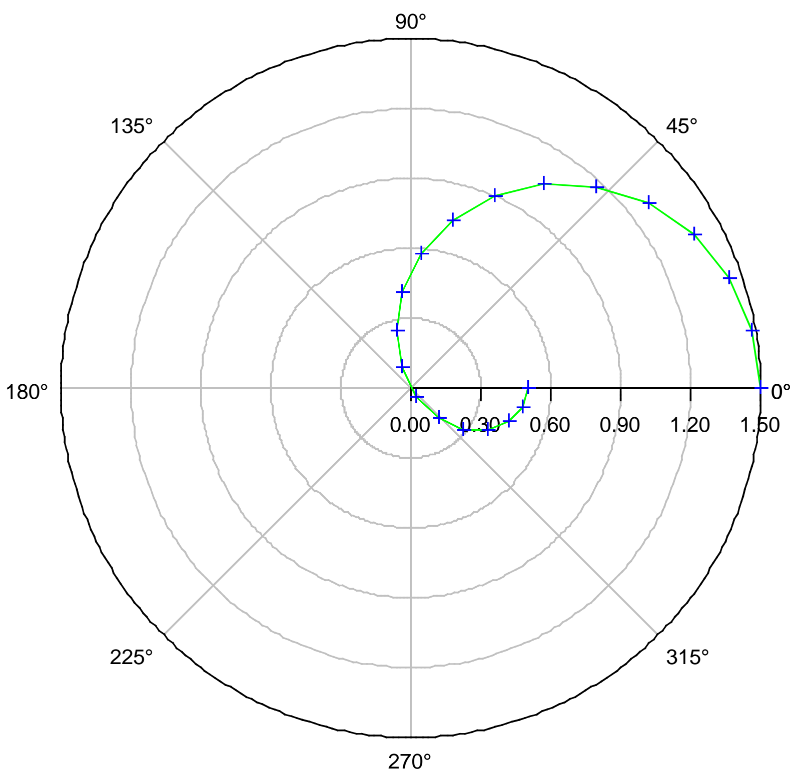
AxisTheta is the theta-axis node. It is drawn as a circle around the plot. The drawing of the circle itself is controlled by the line attributes. The drawing of the axis labels is controlled by the text attributes.

The Window attribute in the `AxisTheta` node contains the angular range, in radians. Its default value is [0,2π]. The Window attribute can be explicitly set to change the range, but autoscaling is *not* available to determine the angular range.

GridPolar is the plot grid. It consists of both radial and circular lines. The drawing of these lines is controlled by the line attributes. By default, these lines are drawn and are light gray.

Example

The function $r = 0.5 + \cos(\theta)$, for $0 <= \theta <= \pi$ is plotted.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SamplePolar extends JFrameChart {

    public SamplePolar() {
        Chart chart = getChart();
```

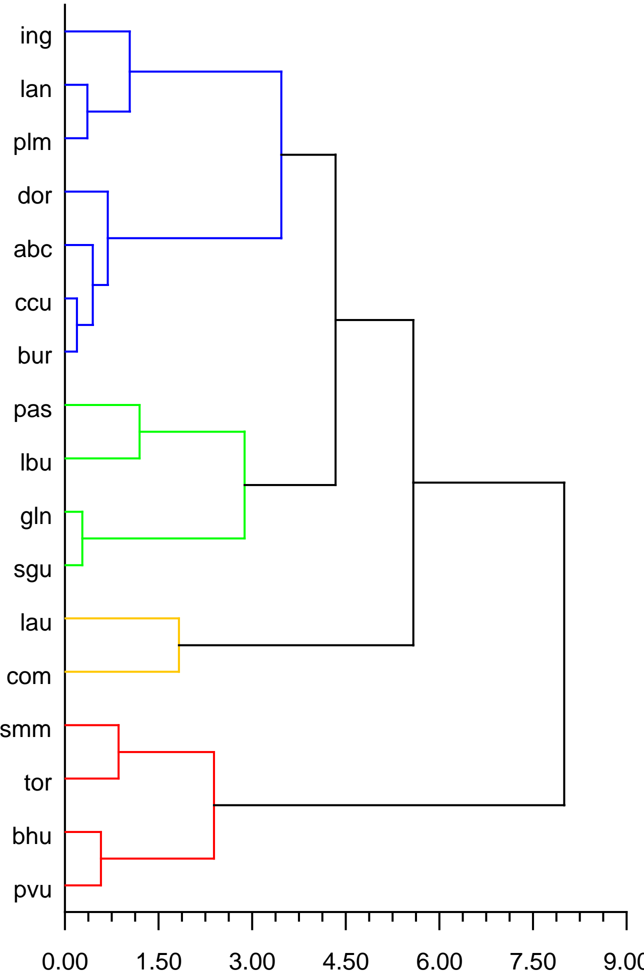
```
        Polar axis = new Polar(chart);

        double r[] = new double[20];
        double theta[] = new double[r.length];
        for (int k = 0;  k < r.length;  k++) {
            theta[k] = Math.PI*k/(r.length-1);
            r[k] = 0.5 + Math.cos(theta[k]);
        }
        Data data = new Data(axis, r, theta);
        data.setDataType(Data.DATA_TYPE_MARKER | Data.DATA_TYPE_LINE);
        data.setLineColor(Color.green);
        data.setMarkerColor(Color.blue);
    }

    public static void main(String argv[]) {
        new SamplePolar().setVisible(true);
    }
}
```

Dendrogram Chart

A dendrogram chart is a graphical way to display results from hierarchical cluster analysis. This section describes the construction of a dendrogram chart.

Example

The data for this example is grouped into clusters using the Dissimilarities and ClusterHierarchical classes. A Dendrogram node is then created as a child of an Axis node. The Dendrogram constructor requires input values from the ClusterHierarchical object



The setLables and setLineColor methods are used to customize the look of the chart. Labels are provided in a String array in the order of the input data and sorted by the Dendrogram object to match the output order. Clusters are grouped by color based on the number of elements in the array passed to the setLineColor method.

```
import com.imsl.stat.*;
import com.imsl.chart.*;

public class SampleDendrogram extends javax.swing.JApplet {
    private JPanelChart panel;

    public void init() {
        Chart chart = new Chart(this);
        panel = new JPanelChart(chart);
        getContentPane().add(panel, java.awt.BorderLayout.CENTER);
        setup(chart);
    }

    static private void setup(Chart chart) {

        /*
        1998 test data from 17 school districts in Los Angeles County.

        The variables were:
        lep - Proportion of LEP students to total tested
        read - The Reading Scaled Score for 5th Grade
        math - The Math Scaled Score for 5th Grade
        lang - The Language Scaled Score for 5th Grade

        The districts were:
        lau - Los Angeles
        ccu - Culver City
        bhu - Beverly Hills
        ing - Inglewood
        com - Compton
        smm - Santa Monica Malibu
        bur - Burbank
        gln - Glendale
        pvu - Palos Verdes
        sgu - San Gabriel
        abc - Artesia, Bloomfield, and Carmenita
        pas - Pasadena
        lan - Lancaster
        plm - Palmdale
        tor - Torrance
        dow - Downey
        lbu - Long Beach
```

```
input lep read math lang str3 district
.38 626.5 601.3 605.3 lau
.18 654.0 647.1 641.8 ccu
.07 677.2 676.5 670.5 bhu
.09 639.9 640.3 636.0 ing
.19 614.7 617.3 606.2 com
.12 670.2 666.0 659.3 smm
.20 651.1 645.2 643.4 bur
.41 645.4 645.8 644.8 gln
.07 683.5 682.9 674.3 pvu
.39 648.6 647.8 643.1 sgu
.21 650.4 650.8 643.9 abc
.24 637.0 636.9 626.5 pas
.09 641.1 628.8 629.4 lan
.12 638.0 627.7 628.6 plm
.11 661.4 659.0 651.8 tor
.22 646.4 646.2 647.0 dow
.33 634.1 632.0 627.8 lbu
*/

double[][] data = {
    {.38, 626.5, 601.3, 605.3},
    {.18, 654.0, 647.1, 641.8},
    {.07, 677.2, 676.5, 670.5},
    {.09, 639.9, 640.3, 636.0},
    {.19, 614.7, 617.3, 606.2},
    {.12, 670.2, 666.0, 659.3},
    {.20, 651.1, 645.2, 643.4},
    {.41, 645.4, 645.8, 644.8},
    {.07, 683.5, 682.9, 674.3},
    {.39, 648.6, 647.8, 643.1},
    {.21, 650.4, 650.8, 643.9},
    {.24, 637.0, 636.9, 626.5},
    {.09, 641.1, 628.8, 629.4},
    {.12, 638.0, 627.7, 628.6},
    {.11, 661.4, 659.0, 651.8},
    {.22, 646.4, 646.2, 647.0},
    {.33, 634.1, 632.0, 627.8}};

String[] lab = {"lau", "ccu", "bhu", "ing", "com", "smm",
                "bur", "gln", "pvu", "sgu", "abc", "pas",
                "lan", "plm", "tor", "dor", "lbu"};


// 3rd arg in Dissimilarities gives different results for 0,1,2
try {
    Dissimilarities dist = new Dissimilarities(data, 0, 1, 1);
    double[][] distanceMatrix = dist.getDistanceMatrix();
    ClusterHierarchical clink = new ClusterHierarchical(
```

```
                dist.getDistanceMatrix(),4,0);

            int nClusters = 4;
            int[] iclus = clink.getClusterMembership(nClusters);
            int[] nclus = clink.getObsPerCluster(nClusters);

            AxisXY axis = new AxisXY(chart);

            // use either method below to create the chart
            Dendrogram dc = new Dendrogram(axis, clink,
Data.DENDROGRAM_TYPE_HORIZONTAL);
            //Dendrogram dc = new Dendrogram(axis, clink.getClusterLevel(),
clink.getClusterLeftSons(), clink.getClusterRightSons(),
Data.DENDROGRAM_TYPE_HORIZONTAL);

            dc.setLabels(lab);
            dc.setLineColor(new String[] {"Blue","Green", "Red", "Orange"});
        } catch (com.imsl.IMSLException e) {
            System.out.println(e.getStackTrace());
        }
    }

    public static void main(String argv[]) {
        JFrameChart frame = new JFrameChart();
        SampleDendrogram.setup(frame.getChart());
        frame.setVisible(true);
    }
}
```

Chapter 3: 2D Drawing Elements

This chapter discusses these JMSL Chart2D drawing elements:

- “Line Attributes” on page 78
- “Marker Attributes” on page 79
- “Fill Area Attributes” on page 81
- “Text Attributes” on page 85
- “Labels” on page 88
- “AxisXY” on page 93
- “Background” on page 119
- “Legend” on page 125
- “Colormaps” on page 129
- “Tool Tips” on page 130

Line Attributes

All lines, except for those used to draw markers or outline filled regions, are affected by the attributes described in this section. These include axis lines and lines drawn when a Data node is rendered with its DataType attribute having its DATA_TYPE_LINE bit set.

Attribute LineColor

LineColor is a Color-valued attribute that determines the color of the line. Its default value is `Color.black`.

Attribute LineWidth

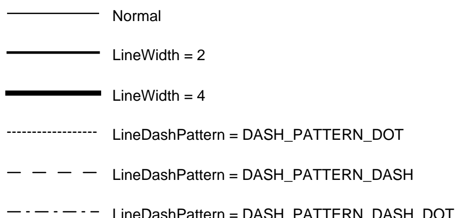
LineWidth is a double-valued attribute that determines the thickness of the lines. Its default value is 1.0.

Attribute LineDashPattern

LineDashPattern is a double-array-valued attribute that determines the line pattern used to draw the line. It defaults to a solid line. Alternate entries in the array represent the lengths of the opaque and transparent segments of the dashes.

Some dash patterns are defined. They are DASH_PATTERN_DOT, DASH_PATTERN_DASH and DASH_PATTERN_DASH_DOT.

Samples



Marker Attributes

Markers are drawn when a Data node is rendered with its DataType attribute having its DATA_TYPE_MARKER bit set. Drawing of markers is affected by the attributes described in this section. Note that even though some markers are drawn using lines, the line attributes do not apply to markers.

An alternative to markers are images, which can be used to draw arbitrary symbols instead of markers.

Attribute MarkerType

MarkerType is an integer-valued attribute that determines which marker will be drawn. There are constants defined in ChartNode for the marker types. The default value is MARKER_TYPE_PLUS. The following are all of the defined marker types. For clarity, these are drawn larger than normal.

MARKER_TYPE_ASTERISK
MARKER_TYPE_X
MARKER_TYPE_HOLLOW_SQUARE
MARKER_TYPE_FILLED_SQUARE
MARKER_TYPE_HOLLOW_TRIANGLE
MARKER_TYPE_FILLED_TRIANGLE
MARKER_TYPE_HOLLOW_DIAMOND
MARKER_TYPE_FILLED_DIAMOND
MARKER_TYPE_DIAMOND_PLUS
MARKER_TYPE_SQUARE_X
MARKER_TYPE_SQUARE_PLUS
MARKER_TYPE_OCTAGON_X
MARKER_TYPE_OCTAGON_PLUS
MARKER_TYPE_HOLLOW_CIRCLE
MARKER_TYPE_FILLED_CIRCLE
MARKER_TYPE_CIRCLE_X
MARKER_TYPE_CIRCLE_PLUS
MARKER_TYPE_CIRCLE_CIRCLE

Attribute MarkerColor

MarkerColor is a Color-valued attribute that determines the color of the marker. Its default value is `Color.black`.

Attribute MarkerSize

MarkerSize is a double-valued attribute that determines the size of the marker. Its default value is 1.0. The actual size of the drawn marker, in pixels, is 0.007**MarkerSize*width*, where *width* is the width of the Component containing the chart.

Attribute MarkerThickness

MarkerThickness is a double-valued attribute that determines the thickness of the lines used to draw the marker. Its default value is 1.0.

Attribute MarkerDashPattern

MarkerDashPattern is a double-array-valued attribute that determines the line pattern used to draw the marker. It defaults to a solid line. Alternate entries in the array represent the lengths of the opaque and transparent segments of the dashes.

Some dash patterns are defined. They are DASH_PATTERN_DOT, DASH_PATTERN_DASH and DASH_PATTERN_DASH_DOT.

Samples

Normal

MarkerThickness = 2

MarkerThickness = 4

MarkerDashPattern = DASH_PATTERN_DOT

MarkerDashPattern = DASH_PATTERN_DASH

MarkerDashPattern = DASH_PATTERN_DASH_DOT

Fill Area Attributes

FillOutlineType

FillOutlineType is an integer-value attribute that turns on or off the drawing of an outline around filled areas. Its value should be FILL_TYPE_NONE (for outline off) or FILL_TYPE_SOLID (for outline on). The default is to draw solid lines.

FillOutlineColor

FillOutlineColor is a Color-valued attribute that determines the color used to outline the filled regions. The outline is drawn only if the attribute FillOutlineType has the value FILL_TYPE_SOLID. Its default value is `Color.black`.

FillType

FillType is an integer-value attribute that turns on or off the drawing of the interior of filled areas. Its value should be

- FILL_TYPE_NONE for fill off.
- FILL_TYPE_SOLID for fill by a single, solid color. This is the default.
- FILL_TYPE_GRADIENT for fill by a color gradient.
- FILL_TYPE_PAINT for fill by a Paint object. This is usually a texture.

FillColor

FillColor is a Color-valued attribute that determines the color used to fill a region with a solid color. Its default value is `Color.black`.

Gradient

Gradient is a Color array-valued attribute that fills a region with a gradient color. It does not have a default value.

The value of Gradient should be an array of four colors. These are the colors at the four corners of a square. In order they are: lower-left, lower-right, upper-right and upper-left.

- If the lower-side colors are equal (color[0] equals color[1]) and the upper-side colors are equal (color[2] equals color[3]), then a vertical gradient is drawn.
- If the left-side colors are equal (color[0] equals color[3]) and the right-side colors are equal (color[1] equals color[2]), then a horizontal gradient is drawn.
- If the lower-right and upper-left colors (color[1] and color[3]) are null, then a diagonal gradient is drawn using the lower-left (color[0]) and upper-right (color[2]) colors.
- If the lower-left and upper-right colors (color[0] and color[2]) are null, then a diagonal gradient is drawn using the lower-right (color[1]) and upper-left (color[3]) colors.

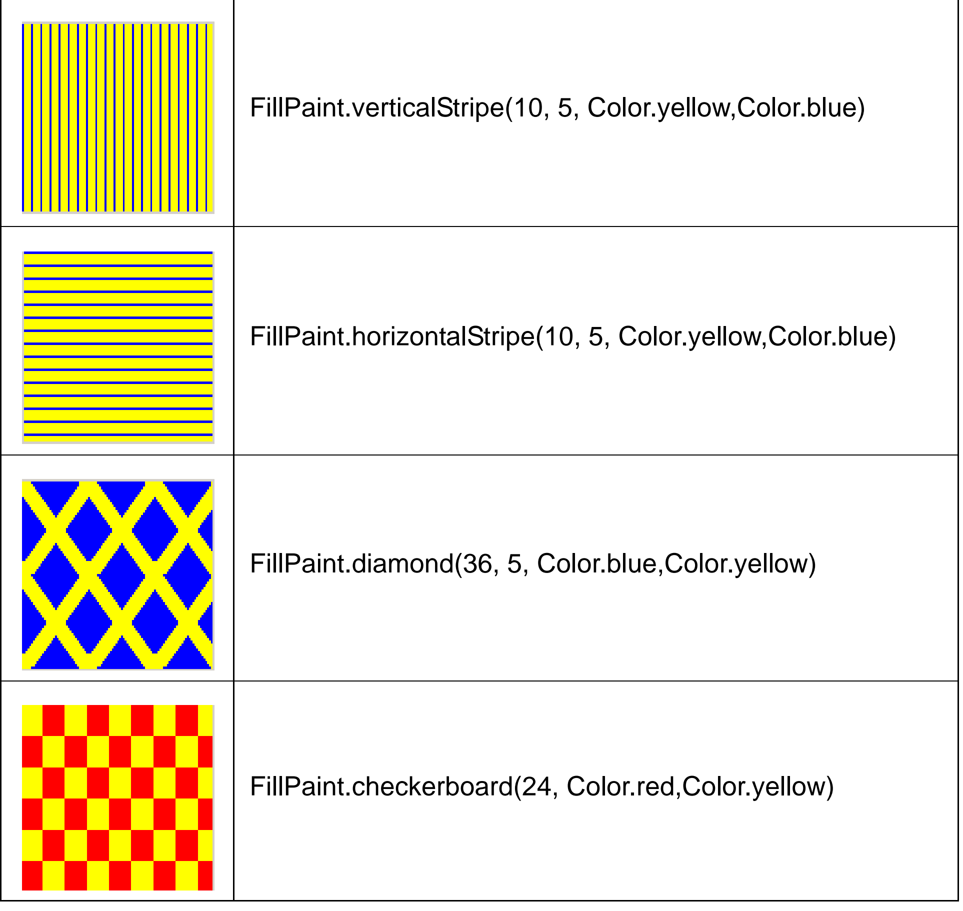
If none of the above patterns exist, then no gradient is drawn.

Vertical		setGradient(Color.yellow, Color.yellow, Color.red, Color.red)
Horizontal		setGradient(Color.yellow, Color.red, Color.red, Color.yellow)
Diagonal		setGradient(Color.yellow, null, Color.red, null)
Diagonal		setGradient(null, Color.yellow, null, Color.red)

FillPaint

FillPaint is a Paint-valued attribute that fills a region with a tiled pattern. It does not have a default value. The class FillPaint contains utilities to define some useful paint patterns.

Some Examples of FillPaint



	FillPaint.verticalStripe(10, 5, Color.yellow,Color.blue)
	FillPaint.horizontalStripe(10, 5, Color.yellow,Color.blue)
	FillPaint.diamond(36, 5, Color.blue,Color.yellow)
	FillPaint.checkerboard(24, Color.red,Color.yellow)

The FillPaint attribute can also be set using an Image, which is used to tile filled regions

Text Attributes

Attribute Font

Text is drawn using Font objects constructed using the FontName, FontSize and FontStyle attributes. The `ChartNode.setFont(Font)` method does not save the Font object, but sets these three attributes.

This arrangement allows one to specify font size and style at lower nodes and change the font face at the root node.

Multiline text strings are allowed. They are created by newline characters in the string that creates the text item.

Attribute FontName

FontName is a string-valued attribute that specifies the logical font name or a font face name. Its default value is "SansSerif". Java always defines the font names "Dialog", "DialogInput", "Monospaced", "Serif", "SansSerif", and "Symbol". Depending on the system, additional font names may be defined.

Attribute FontSize

FontSize is an integer-valued attribute that specifies the point size of the font. Its default value is 12.

Attribute FontStyle

FontStyle is an integer-valued attribute that specifies the font style. This can be a bitwise combination of `Font.PLAIN`, `Font.BOLD` and/or `Font.ITALIC`. Its default value is `Font.PLAIN`.

Samples

Following are sample fonts in styles plain, italic and bold. These may look different on different platforms.

Dialog	*Dialog*	**Dialog**
DialogInput	*DialogInput*	**DialogInput**
Monospaced	*Monospaced*	**Monospaced**
Serif	*Serif*	**Serif**
SansSerif	*SansSerif*	**SansSerif**

Attribute TextAngle

TextAngle is an integer-valued attribute that specifies the angle, in degrees, at which text is drawn. The angle is measured counterclockwise. Its default value is 0.

Attribute TextColor

TextColor is a Color-valued attribute that specifies the color in which the text is drawn. Its default value is `Color.black`.

Attribute TextFormat

TextFormat is a `java.text.Format`-valued or a String-valued attribute that specifies how to format string objects.

TextFormat can also be set using a String, which is used to generate a Format object when the attribute is accessed. The Format object is created using the value of locale in the chart node.

Some strings have special meanings (case is ignored in these strings):

- `"Date(SHORT)"` means use: `DateFormat.getDateInstance(SHORT, locale)`
- `"Date(MEDIUM)"` means use `DateFormat.getDateInstance(MEDIUM, locale)`
- `"Date(LONG)"` means use: `DateFormat.getDateInstance(LONG, locale)`
- `"Currency"` means use `NumberFormat.getCurrencyInstance(locale)`
- `"Percent"` means use: `NumberFormat.getPercentInstance(locale)`

If TextFormat has a string value that is not one of the above, then

`new DecimalFormat(`*value*`, new DecimalFormatSymbols(locale))`

is used. For example, if its value is `"0.00"`, then numbers will be formatted with exactly two digits after the decimal place. See DecimalFormat for a detailed description of these format patterns.

The default value of TextFormat is the value returned by the factory method `NumberFormat.getInstance(locale).`

Attribute Title

Title is a Text-valued attribute that contains the title for a node. The class Text holds a string and its alignment and offset information.

The alignment of a Text object is the bitwise combination of one of

- TEXT_X_LEFT, TEXT_X_CENTER, TEXT_X_RIGHT, and one of
- TEXT_Y_BOTTOM, TEXT_Y_CENTER, TEXT_Y_TOP.

The offset moves the start of the text away from the reference point in the direction of the alignment. So if the alignment bit TEXT_X_LEFT is set and the offset is greater than zero then the text starts a distance further to the left than if the offset were zero. The distance moved is the value of offset times the default marker size. The offset is usually zero, but the Data node sets it to 2.0 for labeling data points.

A Text object is drawn relative to a reference point. The alignment specifies the position of the reference point on the box that contains the text. There are nine such possible positions. In the following samples, the reference point is marked with a square

If the text is drawn at an angle, then the alignment is relative to the horizontally/ vertically aligned bounding box of the text.

Labels

Labels annotate data points or pie slices. As a degenerate case they can be used to place text on a chart without drawing a point. Labels are controlled by the value of the attribute LabelType in a Data node.

Multiline labels are allowed. They are created by newline characters in the string that creates the label.

Attribute LabelType

The attribute LabelType takes on one of the following values.

- LABEL_TYPE_NONE for no label. This is the default.
- LABEL_TYPE_X label with the value of the *x*-coordinate.
- LABEL_TYPE_Y label with the value of the y-coordinate.
- LABEL_TYPE_TITLE label with the value of the Title attribute.
- LABEL_TYPE_PERCENT label with the percentage value. This applies only to PieSlice objects.

Data Point Labeling Example

This example shows three data sets, each labeled in a different fashion.

The first data set is blue and the points are labeled by the value of their *x*-coordinates.

The second data set is pink and the points are labeled by the value of their *y*-coordinates. The data set is drawn with both markers and lines.

The third data set is red and the points are labeled with the Data node’s Title attribute.

```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleLabels extends JFrameChart {

    public SampleLabels() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
      chart.getLegend().setPaint(true);

        // Data set 1 - labeled with X
        double y1[] = {4, 6, 2, 1, 8};
        Data data1 = new Data(axis, y1);
        data1.setDataType(Data.DATA_TYPE_MARKER);
        data1.setMarkerColor(Color.blue);
        data1.setTextColor(Color.blue);
        data1.setLabelType(Data.LABEL_TYPE_X);

        // Data set 2 - labeled with Y
        double y2[] = {2, 5, 3, 4, 6};
        Data data2 = new Data(axis, y2);
```

```
        data2.setDataType(Data.DATA_TYPE_MARKER | Data.DATA_TYPE_LINE);
         data2.setMarkerColor(Color.pink);
         data2.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);
         data2.setLineColor(Color.pink);
         data2.setTextColor(Color.pink);
         data2.setLabelType(Data.LABEL_TYPE_Y);

         // Data set 3 - labeled with Title
         double y3[] = {6, 2, 5, 7, 3};
         Data data3 = new Data(axis, y3);
         data3.setDataType(Data.DATA_TYPE_MARKER);
         data3.setMarkerColor(Color.red);
         data3.setMarkerType(Data.MARKER_TYPE_HOLLOW_SQUARE);
         data3.setLineColor(Color.red);
         data3.setTextColor(Color.red);
         data3.setLabelType(Data.LABEL_TYPE_TITLE);
         data3.setTitle("Red");
         data3.getTitle().setAlignment(Data.TEXT_X_LEFT |
Data.TEXT_Y_CENTER);
     }

     public static void main(String argv[]) {
         new SampleLabels().setVisible(true);
     }
}
```

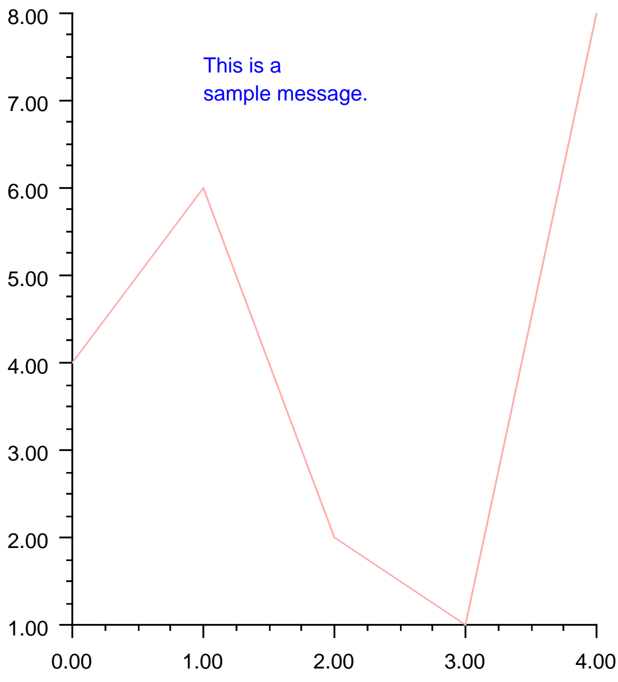
Annotation

Labels can be used to place text on a chart, without an associated point being drawn. In this example a text message is drawn at (1,7) as its bottom left corner.

Note that it is a two line message. Newlines in the string are reflected in the chart.

The label offset is set to zero, so that the message will be placed exactly at (1,7). This overrides the default offset of 2.0 applied to data labels. The text alignment is set to TEXT_X_LEFT | TEXT_Y_BOTTOM, so (1,7) is the lower left corner of the text's bounding box (see "Attribute Title" on page 87).

No marker or line is drawn because the DataType attribute has its default value of zero.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleLabelMessage extends JFrameChart {

    public SampleLabelMessage() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
```

```
        double y[] = {4, 6, 2, 1, 8};
        Data data = new Data(axis, y);
        data.setDataType(Data.DATA_TYPE_LINE);
        data.setLineColor(Color.pink);

        double xLabel[] = {1.0};
        double yLabel[] = {7.0};
        Data dataMessage = new Data(axis, xLabel, yLabel);
        dataMessage.setTextColor(Color.blue);
        dataMessage.setLabelType(Data.LABEL_TYPE_TITLE);
        dataMessage.setTitle("This is a\nsample message.");
        dataMessage.getTitle().setAlignment(Data.TEXT_X_LEFT |
Data.TEXT_Y_BOTTOM);
        dataMessage.getTitle().setOffset(0.0);
    }

    public static void main(String argv[]) {
        new SampleLabelMessage().setVisible(true);
    }
}
```

AxisXY

The AxisXY node is the basis of many chart types, including scatter, line, area and error bar. Its parent node must be the root Chart node.

When an AxisXY node is created, it creates two Axis1D nodes. They can be obtained by using the methods `AxisXY.getAxisX()` and `AxisXY.getAxisY()`. Each of the Axis1D nodes in turn creates additional child nodes, as seen in the diagram below.

Accessor methods can be chained together, so the x-axis line can be retrieved using

```
axis.getAxisX().getAxisLine()
```

The code to set the x-axis line to blue is

```
axis.getAxisX().getAxisLine().setLineColor(Color.blue)
```

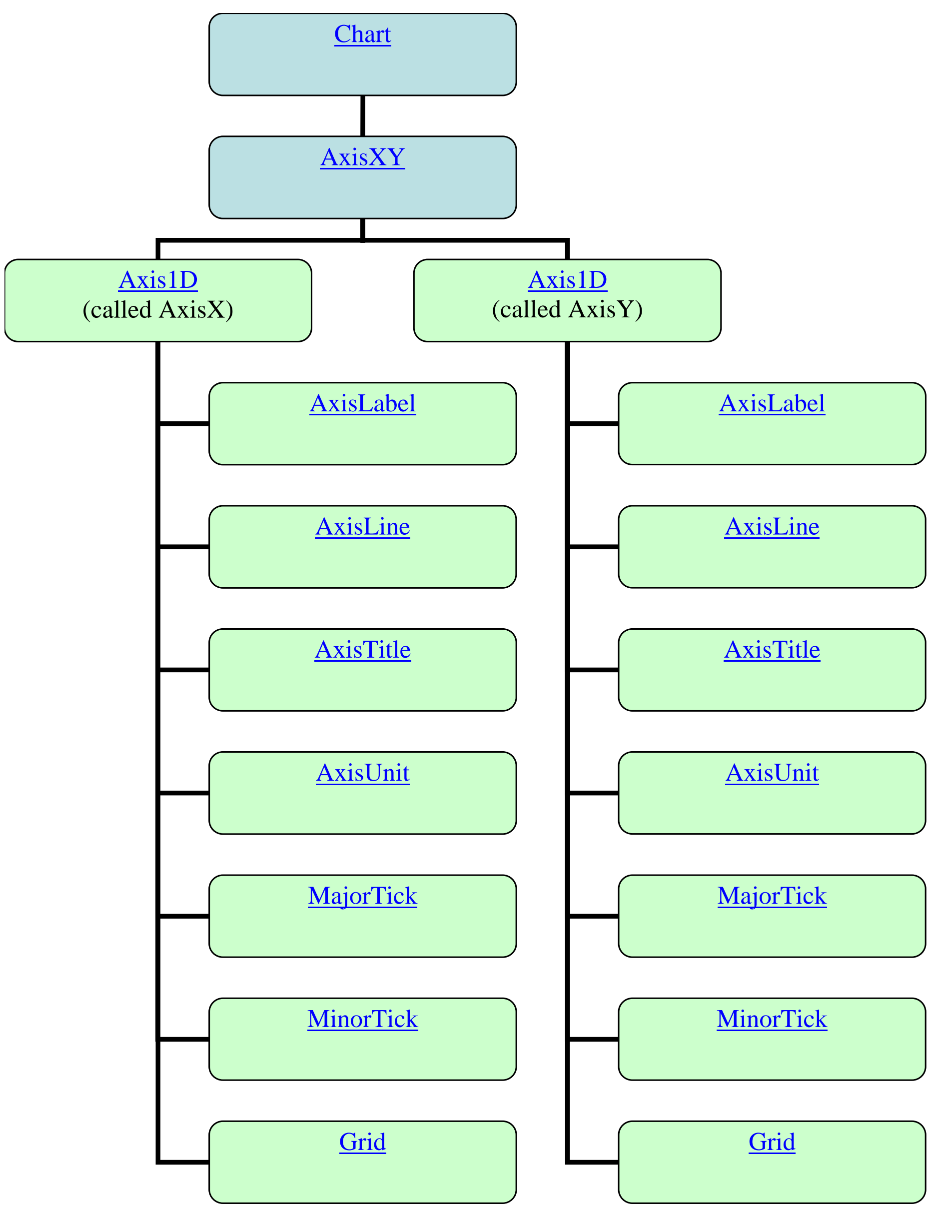
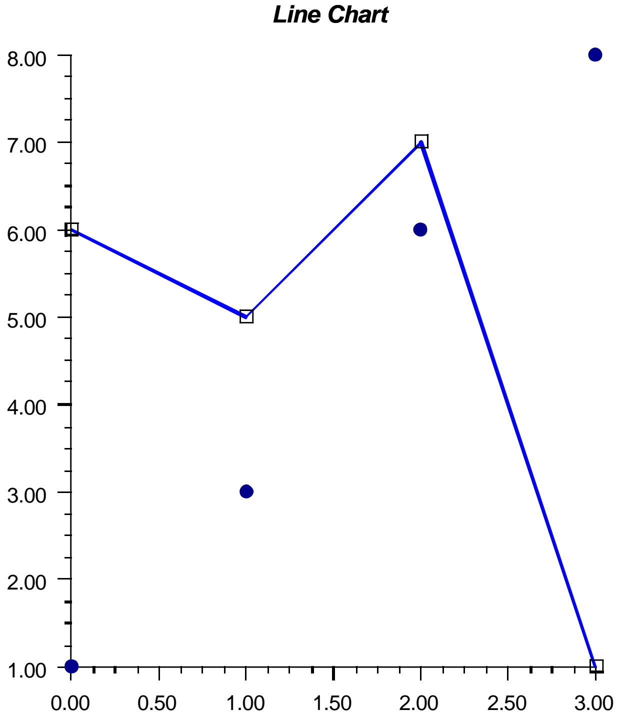


Chart
AxisXY
Axis1D
(called AxisX)
Axis1D
(called AxisY)
AxisLabel
AxisLine
AxisTitle
AxisUnit
MajorTick
MinorTick
Grid
AxisLabel
AxisLine
AxisTitle
AxisUnit
MajorTick
MinorTick
Grid

Axis Layout

The layout of an AxisXY chart, such as the one below, is controlled by the attributes Window, Density, and Number.



Window

Window is a double-array-valued attribute that contains the axis limits. Its value is {*min, max*}. For the above chart, the value of the Window attribute for the *x*-axis is [0, 3] and for the *y*-axis it is [1, 8].

Number

Number is an integer-valued attribute that contains the number of major tick marks along an axis. In an Axis1D node its default value is 5, which is also the value in the above example.

Density

Density is the number of minor tick marks per major tick mark. Its default value is 4, which is also the value in the example.

Transform

The *x*- and *y*-axes may be linear, logarithmic, or customized, as specified by the Transform attribute. This attribute can have the values:

- TRANSFORM_LINEAR indicating a linear axis. This is the default.
- TRANSFORM_LOG indicating a logarithmic axis
- TRANSFORM_CUSTOM indicating a custom transformation. The transformation specified by the CustomTransform attribute is used.

CustomTransform

A customized transformation is used when the Transform attribute has the value TRANSFORM_CUSTOM. A custom transform is an object implementing the Transform interface. It defines a mapping from the interval specified by the Window attribute to and from the interval `[0,1]`. See "Custom Transform" on page 110 for more information.

The class TransformDate implements the Transform interface. It maps from a regular calendar to one without weekends, which is useful for charting stock prices that are defined only on weekdays.

Autoscale

Autoscaling is used to automatically determine the attribute Window (the range of numbers along an axis) and the attribute Number (the number of major tick marks). The goal is to adjust the attributes so that the data fits on the axes and the axes have "nice" numbers as labels.

Autoscaling is done in two phases. In the first ("input") phase the actual range is determined. In the second ("output") phase chart attributes are updated.

Attribute AutoscaleInput

The action of the input phase is controlled by the value of attribute AUTOSCALE_INPUT in the axis node. It can have one of three values.

- AUTOSCALE_OFF turns off autoscaling.
- AUTOSCALE_DATA scans the values in the Data nodes that are attached to the axis to determine the data range. This is the default value.
- AUTOSCALE_WINDOW uses the value of the Window attribute to determine the data range.

Attribute AutoscaleOutput

The value of the AUTOSCALE_OUTPUT attribute can be the bitwise combination of the following values.

- AUTOSCALE_OFF no attributes updated.
- AUTOSCALE_NUMBER updates the value of the Number attribute. This is the number of major tick marks along the axis.
- AUTOSCALE_WINDOW updates the value of the Window attribute. This is the range of numbers displayed along the axis.

The default is AUTOSCALE_NUMBER | AUTOSCALE_WINDOW; both the attributes Number and Window are adjusted.

Axis Label

The AxisLabel node controls the labeling of an axis. The drawing of this node is controlled by the Text Attributes (see page 85).

Scientific Notation

If the values along an axis are large, scientific notation is more readable than a decimal format with many zeros. In this example the *y*-axis is labeled with scientific notation where each number has exactly two fractional digits displayed. This format pattern is `"0.00E0"`. See `java.text.DecimalFormat` for details on number formatting patterns.

Date Labels

If the TextFormat attribute for an axis is an instance of `DateFormat`, then the axis is scaled and labeled as a date/time axis, instead of as a real axis.

Date information passed to the Date constructor must be a double number representing the number of milliseconds since the standard base time known as “the epoch”, namely January 1, 1970, 00:00:00 GMT. This is used by the constructor for Date.

Skipping Weekends

An additional feature of Date axes is the ability to skip weekends. This feature is often needed for charting stock price data.

To skip weekends it is necessary to adjust the autoscaling for weekdays-only. This is done by setting the attribute `SkipWeekends` to true. It is also necessary to set a

custom transformation, `TransformDate`, on the axis. This is shown in the following example, which is a modification of the example in the previous section.

Skipping weekends is intended only for data sets where no weekend data exists. It will not give the expected results if the data set contains weekend data.

String Labels

Any array of strings can be used to label the tick marks using the `setLabels(String[])` method. The `setLabels(String[])` method sets the Number attribute to the number of strings.

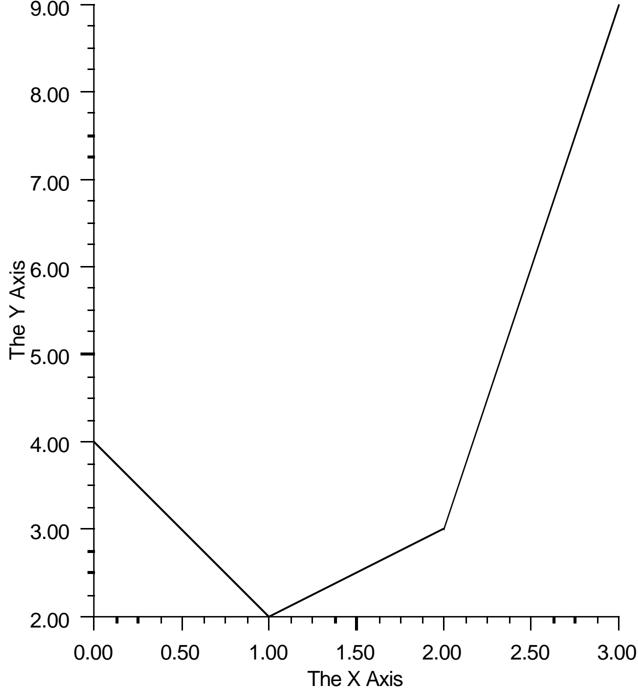
Axis Title

The AxisTitle node controls the titling of an axis. The drawing of this node is controlled by the Text Attributes (see page 85).

Axes are titled with the value of the Title attribute in the AxisTitle node. By default, the title is empty.

Setting the Title

To set an axis title, set the Title attribute in the AxisTitle node. In this example both the *x*-axis and *y*-axis titles are set.




```
import com.imsl.chart.*;

public class SampleAxisTitle extends JFrameChart {

    public SampleAxisTitle() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);
```

```
        axis.getAxisX().getAxisTitle().setTitle("The X Axis");
        axis.getAxisY().getAxisTitle().setTitle("The Y Axis");
    }

    public static void main(String argv[]) {
        new SampleAxisTitle().setVisible(true);
    }
}
```

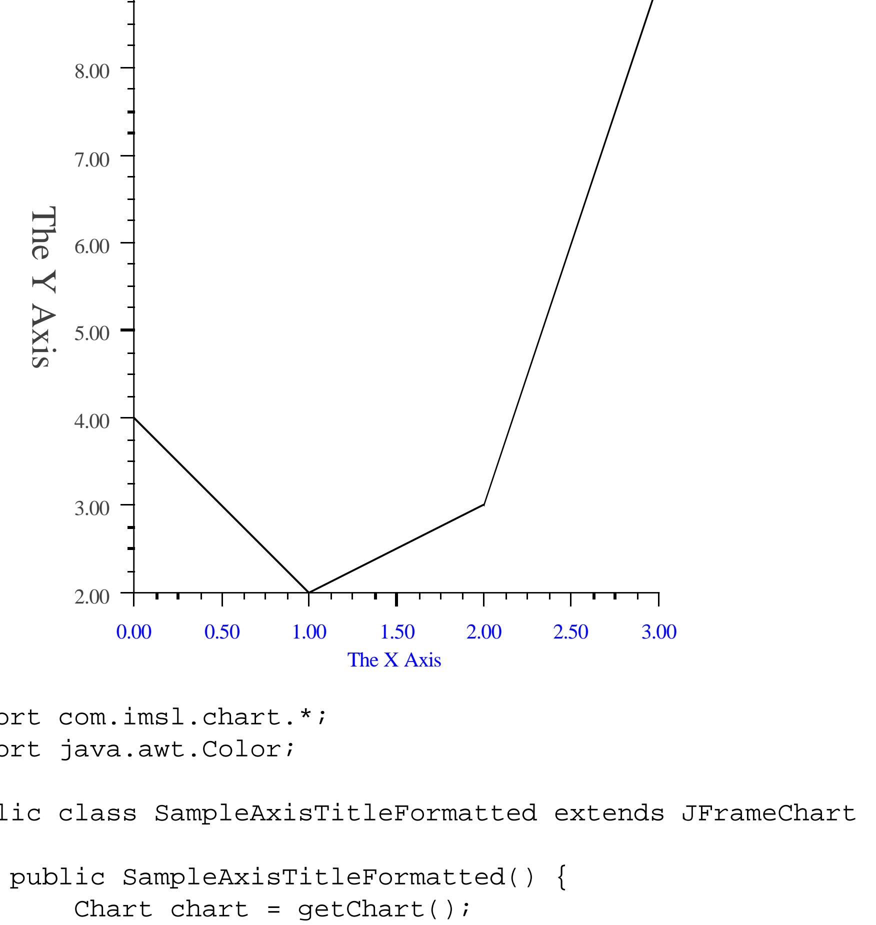
More Formatting

An axis title, like any other text string, can have further formatting applied.

The FontName attribute is set to "`Serif`" in the axis node. This value is then inherited by all of it ancestor nodes.

The TextColor attribute is set differently in the *x*-axis and *y*-axis nodes. Note that this setting is inherited by both the AxisTitle and nodes within the same axis.

The y-axis title node has its FontSize attribute set to 20, so it is larger. Also, its TextAngle attribute is set to -90. By default, the *y*-axis title is drawn at a 90 degree angle, so the -90 degree setting flips the title from its usual position.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleAxisTitleFormatted extends JFrameChart {

    public SampleAxisTitleFormatted() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
```

```
            new Data(axis, y);

            axis.setFontName("Serif");

            axis.getAxisX().setTextColor(Color.blue);
          axis.getAxisX().getAxisTitle().setTitle("The X Axis");

            axis.getAxisY().setTextColor(Color.darkGray);
          axis.getAxisY().getAxisTitle().setTitle("The Y Axis");
            axis.getAxisY().getAxisTitle().setTextAngle(-90);
            axis.getAxisY().getAxisTitle().setFontSize(20);
        }

        public static void main(String argv[]) {
            new SampleAxisTitleFormatted().setVisible(true);
        }
    }
```

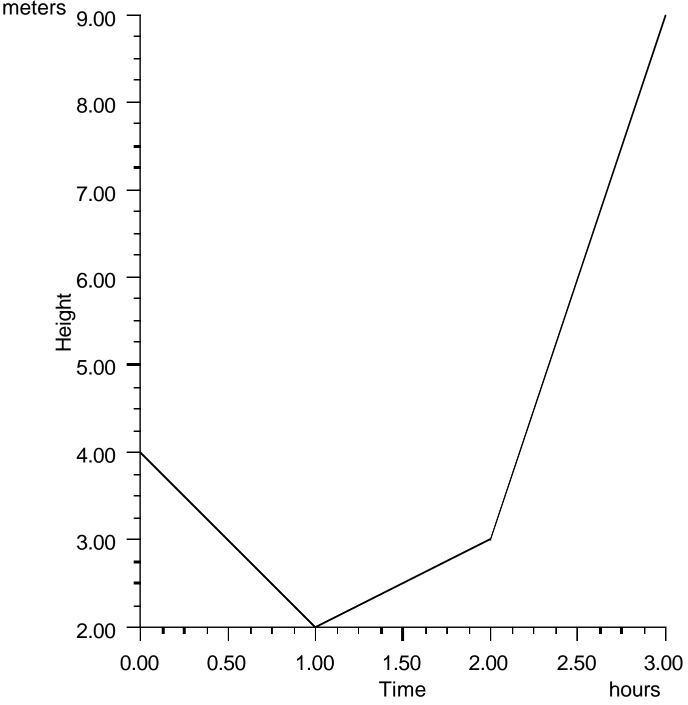
Axis Unit

The AxisUnit node controls placing of a unit tag on an axis. The tag is the value of the Title attribute in the node. By default, it is empty.

The axis unit is used for labeling only; it has no other effect on the chart.

Setting the Axis Unit

In this example, the axis unit for the *x*-axis is set to "hours" and the axis unit for the *y*-axis is set to "meters". While not required, the axis titles are also set.




```
import com.imsl.chart.*;

public class SampleAxisUnit extends JFrameChart {

    public SampleAxisUnit() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);

        axis.getAxisX().getAxisTitle().setTitle("Time");
        axis.getAxisY().getAxisTitle().setTitle("Height");
```

```
        axis.getAxisX().getAxisUnit().setTitle("hours");
        axis.getAxisY().getAxisUnit().setTitle("meters");
    }

    public static void main(String argv[]) {
        new SampleAxisUnit().setVisible(true);
    }
}
```

Major and Minor Tick Marks

The nodes MajorTick and MinorTick control the drawing of tick marks on an AxisXY.

The location of the major tick marks can be set explicitly, using the `Axis1D.setTicks(double[])` method. However, it is usually easier to allow autoscaling to automatically set the tick locations (see "Autoscale" on page 96).

Attribute TickLength

The length of the tick marks is proportional to the screen size. They can be made relatively longer or shorter by setting the attribute TickLength. Its default value is 1.0. If its value is negative, the tick marks are drawn in the opposite direction: i.e., into the center of the plot region rather than away from it.

Attribute Number

Number is the number of major tick marks along an axis.

Attribute Density

Density is the number of minor tick marks in each interval between major tick marks. The minor ticks are equally spaced in user coordinates. If the Transform attribute in not TRANSFORM_LINEAR, then they will not be equally spaced on the screen.

Attribute FirstTick

The FirstTick attribute, in an Axis1D node, is the position of the first major tick mark. The default value is the 0-th element of the Windows attribute.

Attribute TickInterval

The TickInterval attribute, in an Axis1D node, is the interval between tick marks in the user coordinates. If this attribute is not explicitly set, its value is computed from the attributes Number, Window and Transform.

Attribute Ticks

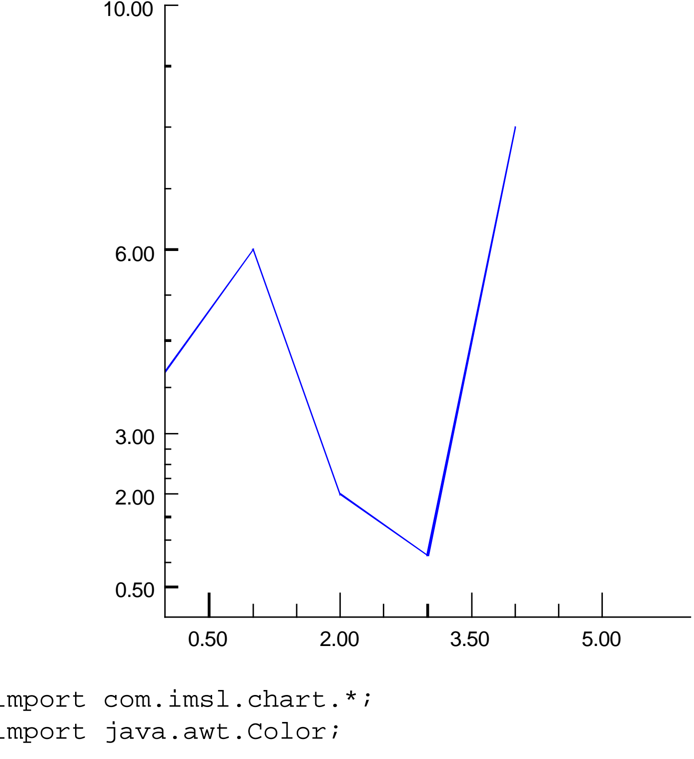
The Ticks attribute, in an Axis1D node, contains the position of the major tick marks. If this attribute is not explicitly set, its value is computed from the attributes FirstTick, TickInterval, Number, Window and Transform.

Example

This example shows the effects of the tick mark attributes. Note that autoscaling is turned off so that the attribute values are not overridden (see "Autoscale" on page 96).

On the x-axis, there are four major tick marks (Number), starting with 0.5 (FirstTick) at an interval of 1.5 (TickInterval). There are three minor tick intervals (Density) between each major tick mark. The tick marks are twice as long and are drawn in the opposite direction as normal (TickLength).

On the y-axis, the tick mark locations are set explicitly by the attribute Ticks. This automatically sets the attribute Number. The TickLength is set to -1, so the tick marks are drawn inward (to the right) instead of outward (to the left).




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleTicks extends JFrameChart {

    public SampleTicks() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
```

```
            axis.setAutoscaleOutput(axis.AUTOSCALE_OFF);

            axis.getAxisX().setWindow(0.0, 6.0);
            axis.getAxisX().setDensity(3);
            axis.getAxisX().setNumber(4);
            axis.getAxisX().setFirstTick(0.5);
            axis.getAxisX().setTickInterval(1.5);
            axis.getAxisX().setTickLength(-2);

            axis.getAxisY().setWindow(0.0, 10.0);
            double ticksY[] = {0.5, 2.0, 3.0, 6.0, 10.0};
            axis.getAxisY().setTicks(ticksY);
            axis.getAxisY().setTickLength(-1);

            double y[] = {4, 6, 2, 1, 8};
            Data data = new Data(axis, y);
            data.setDataType(Data.DATA_TYPE_LINE);
            data.setLineColor(Color.blue);
        }

        public static void main(String argv[]) {
            new SampleTicks().setVisible(true);
        }
    }
```

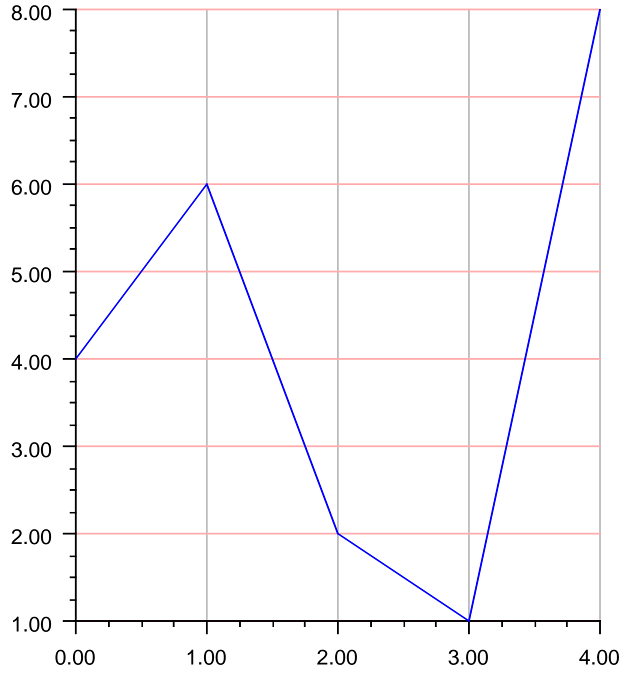
Grid

The Grid node controls the drawing of grid lines on a chart. The Grid is created by Axis1D as its child. It can be retrieved using the method `Axis1D.getGrid()`.

By default, Grid nodes are not drawn. To enable them, set their "Paint" attribute to `true`. Grid nodes control the drawing of the grid lines perpendicular to their parent axis. So the *x*-axis Grid node controls the drawing of the vertical grid lines.

Example

In this example, the *x*-axis grid lines are painted light gray and the *y*-axis grid lines are pink.




```
import com.imsl.chart.*;

public class SampleGrid extends JFrameChart {

    public SampleGrid() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        axis.getAxisX().getGrid().setPaint(true);
```

```
        axis.getAxisY().getGrid().setPaint(true);
        axis.getAxisX().getGrid().setLineColor("lightgray");
        axis.getAxisY().getGrid().setLineColor("pink");

        double y[] = {4, 6, 2, 1, 8};
        Data data = new Data(axis, y);
        data.setDataType(Data.DATA_TYPE_LINE);
        data.setLineColor("blue");
    }

    public static void main(String argv[]) {
        new SampleGrid().setVisible(true);
    }
}
```

Custom Transform

A custom transformation allows a user-defined mapping of data to an axis. A custom transform is used when the Transform attribute has the value TRANSFORM_CUSTOM. The custom transform is the value of the CustomTransform attribute.

A custom transform implements the Transform interface. This interface has three methods. One, `setupMapping`, is called first to allow the transformation to initialize itself. The other two, `mapUserToUnit` and `mapUnitToUser`, specify a mapping from the window interval onto `[0,1]`. These methods must each be the inverse of the other.

Example: Normal Probability Plot

A normal probability plot maps normally distributed data into a straight line, just as a semilog plot maps exponential data into a straight line.

In this example, 400 normally distributed random numbers are grouped into 20 bins. The bin counts are normalized by dividing by the number of samples (400). Cumulative probabilities are computed by summing the probabilities in all of the bins to the left of the current bin.

The custom transformation is the normal cumulative distribution function, `Cdf.normal`, and its inverse, `Cdf.inverseNormal`, scaled to map the probability range `[0.001,0.999]` onto `[0,1]`.

Autoscaling is turned off on the probability (y) axis and a fixed set of probability tick marks are specified.

The plot is of the bin center on the x-axis versus the cumulative probabilities on the y-axis. The points are not in an exactly straight line because with only a finite number of samples, the distribution does not exactly match the normal distribution.

```
import com.imsl.chart.*;
import com.imsl.stat.Cdf;
import com.imsl.stat.Random;
import java.awt.Color;

public class SampleProbability extends JFrameChart {

    public SampleProbability() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

      double ticks[] = {0.001, 0.005, 0.01, 0.02, 0.05, 0.10,
   0.20, 0.30,
            0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95, 0.98,
   0.99, 0.995, 0.999};
        double a = ticks[0];
        double b = ticks[ticks.length-1];

        axis.getAxisX().getAxisTitle().setTitle("x");

   axis.getAxisY().getAxisTitle().setTitle("Probability");
```

```
        axis.getAxisY().setTransform(axis.TRANSFORM_CUSTOM);
        axis.getAxisY().setCustomTransform(new
NormalTransform());
     axis.getAxisY().setAutoscaleInput(axis.AUTOSCALE_OFF);
        axis.getAxisY().setWindow(a, b);
        axis.getAxisY().setTextFormat(new
java.text.DecimalFormat("0.000"));
        axis.getAxisY().setTicks(ticks);
        axis.getAxisY().getMinorTick().setPaint(false);

        int nSamples = 400;
        int nBins = 20;

        // Setup the bins
        double bins[] = new double[nBins];
        double dx = 6.0/nBins;
        double x[] = new double[nBins];
        for (int k = 0;  k < nBins;  k++) {
            x[k] = -3.0 + (k+0.5)*dx;
        }

        // Generate random normal deviates and sort into bins
        Random r = new Random(123457);
        for (int k = 0;  k < nSamples;  k++) {
            double t = r.nextNormal();
            int j = (int)Math.round((t+3.0-0.5*dx)/dx);
            if (j <= 0) {
                bins[0]++;
            } else if (j >= nBins-1) {
                bins[nBins-1]++;
            } else {
                bins[j]++;
            }
        }

        // Compute the cumulative distribution
        // y[k] is the sum of bins[j] for j=0,...,k divided
by the nSamples.
        double y[] = new double[nBins];
        y[0] = bins[0]/nSamples;
        for (int k = 1;  k < nBins;  k++) {
            y[k] = y[k-1] + bins[k]/nSamples;
        }
```

```
        // Plot the data using markers
        Data data = new Data(axis, x, y);
        data.setDataType(Data.DATA_TYPE_MARKER);
        data.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);
        data.setMarkerColor(Color.blue);
    }


    public static void main(String argv[]) {
        new SampleProbability().setVisible(true);
    }


    static class NormalTransform implements Transform {
        private double scaleA, scaleB;

        /**
         *Initializes the mappings between user and coordi-
   nate space.
         */
        public void setupMapping(Axis1D axis1d) {
            double w[] = axis1d.getWindow();
            double t = Cdf.inverseNormal(w[0]);
            scaleB = 1.0/(Cdf.inverseNormal(w[1])-t);
            scaleA = -scaleB*t;
        }

        /**
         * Maps a point in [0,1] to a probability.
         */
        public double mapUnitToUser(double unit) {
            return Cdf.normal((unit-scaleA)/scaleB);
        }

        /**
         * Maps a probablity to the interval [0,1].
         */
        public double mapUserToUnit(double p) {
            return scaleA + scaleB*Cdf.inverseNormal(p);
        }
    }
}
```

Multiple Axes

A JMSL chart can contain any number of axes. Each axis has its own mapping from the user coordinates to the device (screen) coordinates.

Normally, the *x*-axis is at the bottom of the chart and the *y*-axis is to the left. The attribute Type can be changed to move the *x*-axis to the top of the chart and/or the *y*-axis to the right of the chart.

Axis can be moved from the chart edge, either away from the chart or into the middle of the chart data area, by setting the attribute Cross.

Attribute Type

The attribute Type specifies the position of an *x* or *y*-axis. Applied to the x-axis it can have the values AXIS_X (the default) or AXIS_X_TOP. Applied to the y-axis, it can have the value AXIS_Y (the default) or AXIS_Y_RIGHT.

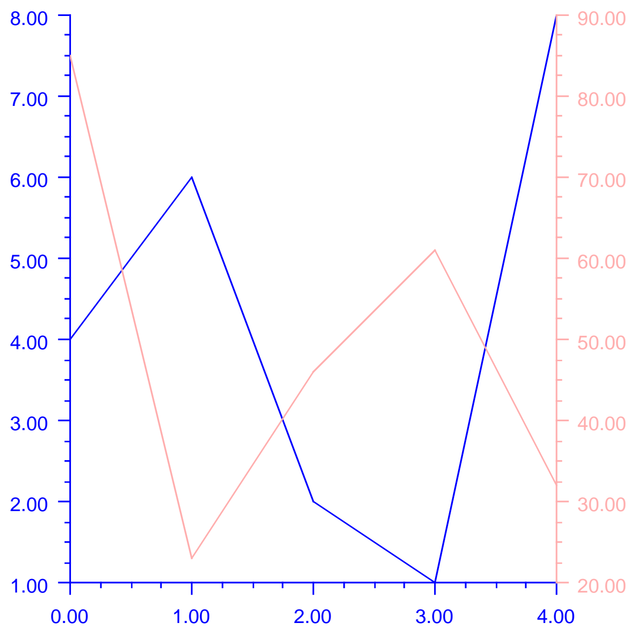
Attribute Cross

The Cross attribute specifies the coordinates of intersection of the *x*-axis and *y*-axis. This can be inside or outside of the chart body. Cross can be used to place multiple *y*-axes to the left of the chart or multiple *x*-axes below the chart.

Example

Two data sets are plotted, each on its own axis. The first (blue) axis is left in the default position with the *y*-axis on the left. The second (pink) axis has its *y*-axis moved to the left.

In this example the *x*-axis is shared between the two axes, so it is not painted as part of the second (pink) axis. This is done by setting its Paint attribute to false.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleAxesLeftRight extends JFrameChart {

    public SampleAxesLeftRight() {
        Chart chart = getChart();

        AxisXY axisLeft = new AxisXY(chart);
        double yLeft[] = {4, 6, 2, 1, 8};
        Data dataLeft = new Data(axisLeft, yLeft);
        dataLeft.setDataType(Data.DATA_TYPE_LINE);
        axisLeft.setLineColor(Color.blue);
        axisLeft.setTextColor(Color.blue);
```

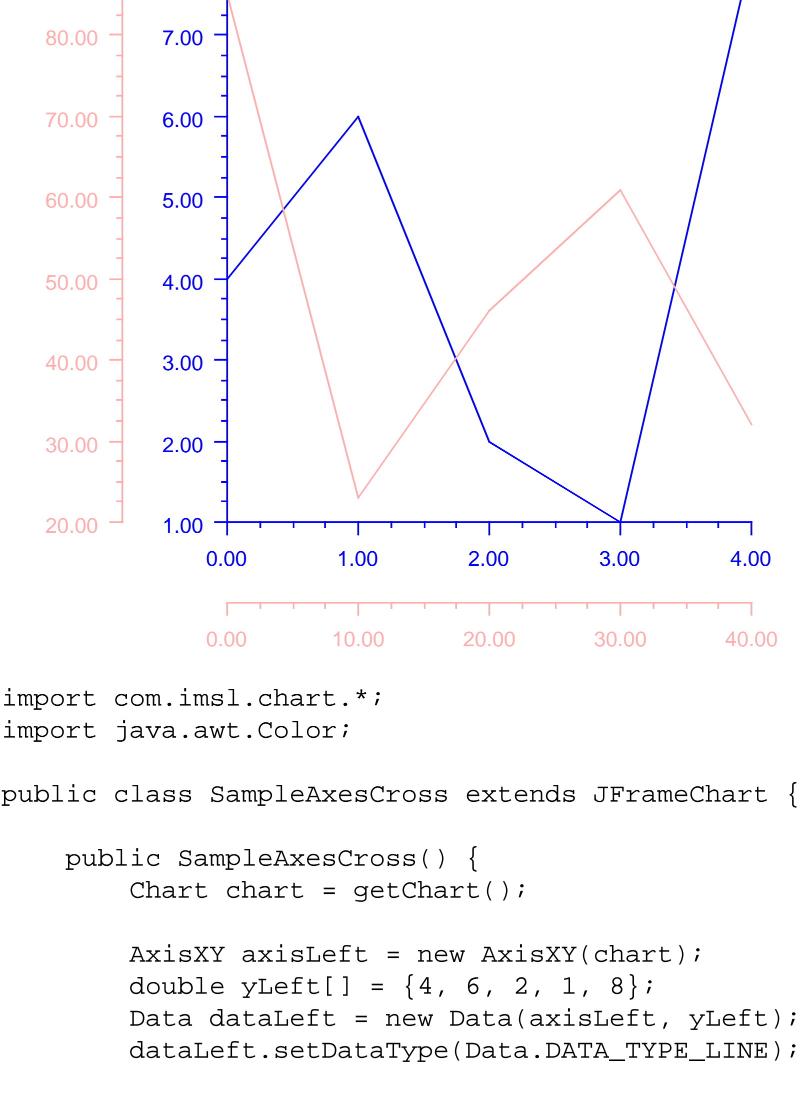
```
        AxisXY axisRight = new AxisXY(chart);
        axisRight.getAxisX().setPaint(false);
        axisRight.getAxisY().setType(Axis1D.AXIS_Y_RIGHT);
        double yRight[] = {85, 23, 46, 61, 32};
        Data dataRight = new Data(axisRight, yRight);
        dataRight.setDataType(Data.DATA_TYPE_LINE);
        axisRight.setLineColor(Color.pink);
        axisRight.setTextColor(Color.pink);
    }

    public static void main(String argv[]) {
        new SampleAxesLeftRight().setVisible(true);
    }
}
```

Cross Example

Multiple *x* and *y*-axes are shown.

The Cross attribute is used to specify that the second (pink) axes intersect at (-8,10), in the pink-axis coordinate system.

The Viewport attribute is changed in both sets of axes to shrink the size of the chart body and leave more room to the left and below the chart for the pink axes.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleAxesCross extends JFrameChart {

    public SampleAxesCross() {
        Chart chart = getChart();

        AxisXY axisLeft = new AxisXY(chart);
        double yLeft[] = {4, 6, 2, 1, 8};
        Data dataLeft = new Data(axisLeft, yLeft);
        dataLeft.setDataType(Data.DATA_TYPE_LINE);
```

```
        axisLeft.setLineColor(Color.blue);
        axisLeft.setTextColor(Color.blue);

        AxisXY axisRight = new AxisXY(chart);
        axisRight.setCross(-8,10);
        double xRight[] = {0, 10, 20, 30, 40};
        double yRight[] = {85, 23, 46, 61, 32};
        Data dataRight = new Data(axisRight, xRight, yRight);
        dataRight.setDataType(Data.DATA_TYPE_LINE);
        axisRight.setLineColor(Color.pink);
        axisRight.setTextColor(Color.pink);

        double viewport[] = {0.3, 0.9, 0.05, 0.7};
        axisLeft.setViewport(viewport);
        axisRight.setViewport(viewport);
    }

    public static void main(String argv[]) {
        new SampleAxesCross().setVisible(true);
    }
}
```

Background

Background controls the drawing of the chart's background. It is created by Chart as its child. It can be retrieved from a Chart object using the `Chart.getBack-ground()` method.

The fill area attributes in the Background node determine how the background is drawn (see "Fill Area Attributes" on page 81).

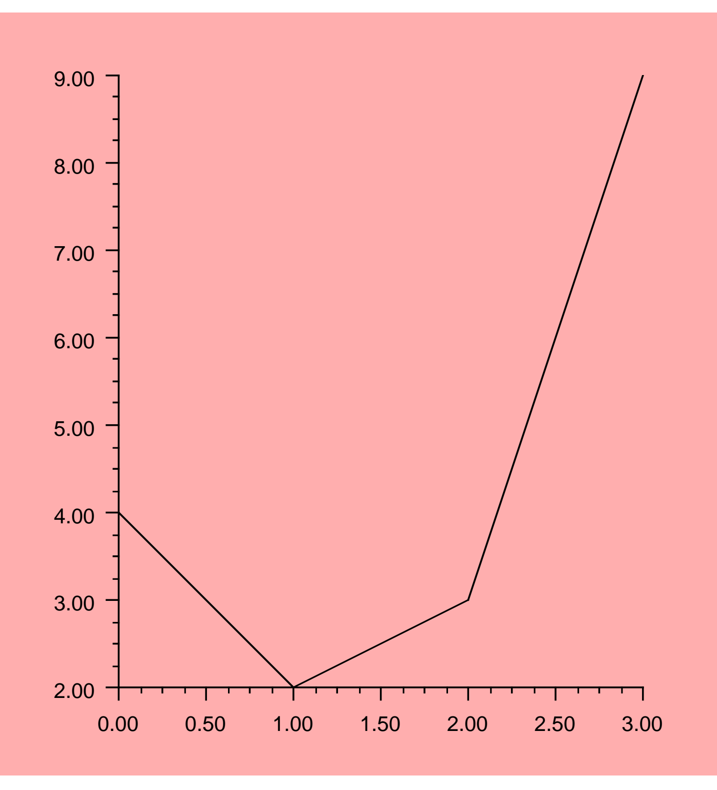
The attribute FillType has the global default value of FILL_TYPE_SOLID. The attribute FillColor attribute is set to `Color.white` in this node.

Solid Color Background

To set the background to a solid color:

- set the attribute FillType to FILL_TYPE_SOLID, and
- set the attribute FillColor to the desired color.

For example the following code sets the background to pink. To view chart in color please see the online documentation.



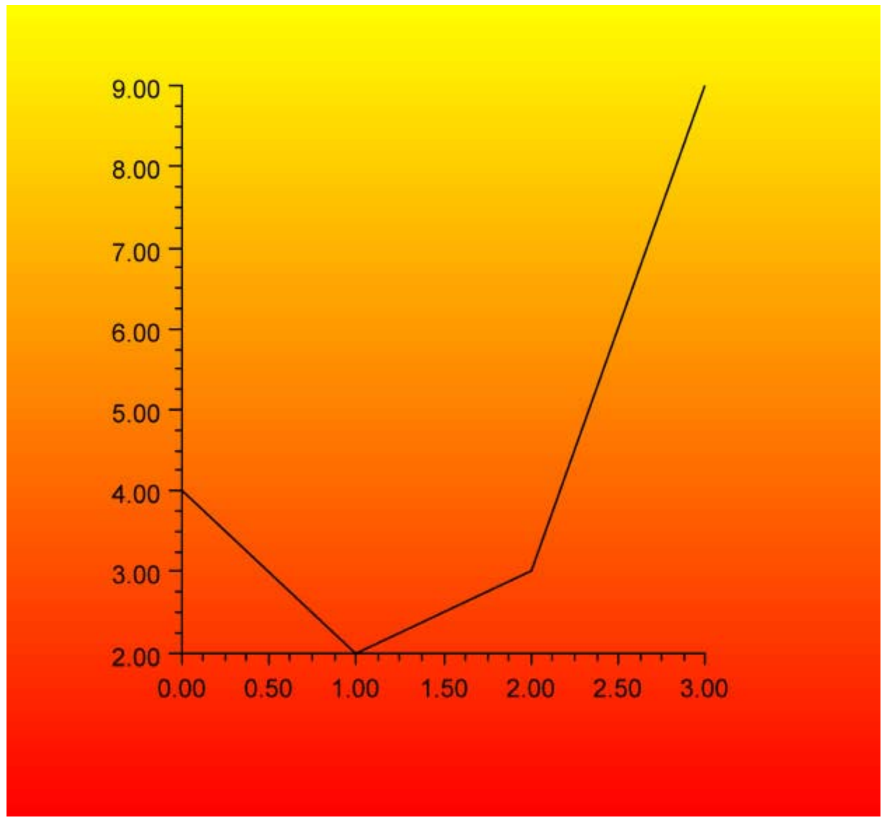

```
import com.imsl.chart.*;

public class SampleBackgroundSolid extends JFrameChart {

    public SampleBackgroundSolid() {
        Chart chart = getChart();
        chart.getBackground().setFillType(ChartNode.FILL_TYPE_SOLID);
        chart.getBackground().setFillColor(java.awt.Color.pink);
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);
    }

    public static void main(String argv[]) {
        new SampleBackgroundSolid().setVisible(true);
    }
}
```

Gradient Color Background

To set the background to a color gradient:

- set the attribute FillType to FILL_TYPE_GRADIENT, and
- set the attribute Gradient to the desired color gradient specification.

For example the following code uses a yellow-to-red vertical gradient for the background setting. See "Fill Area Attributes" on page 81 for more information on gradients.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleBackgroundGradient extends JFrameChart {

    public SampleBackgroundGradient() {
        Chart chart = getChart();
        chart.getBackground().setFillType(ChartNode.FILL_TYPE_GRADIENT);
```

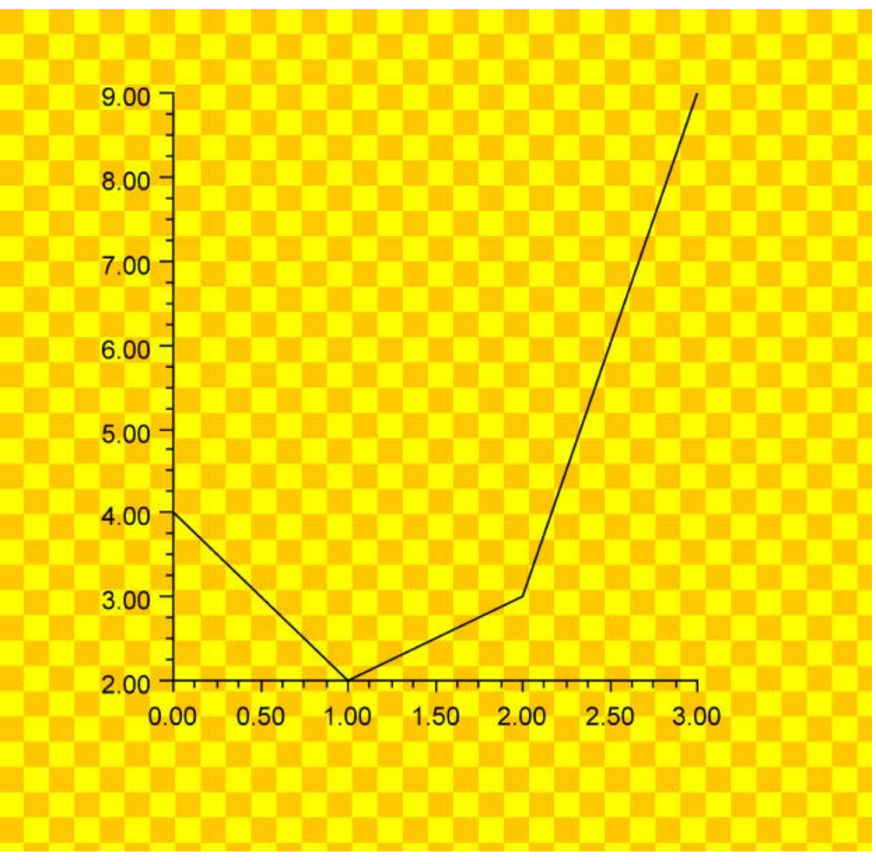
```
        chart.getBackground().setGradient(Color.yellow, Color.yellow,
Color.red, Color.red);
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);
    }

    public static void main(String argv[]) {
        new SampleBackgroundGradient().setVisible(true);
    }
}
```

Pattern Background

To set the background to a color pattern:

- set the attribute FillType to FILL_TYPE_PAINT, and
- set the attribute FillPaint to the desired pattern.

For example the following code sets the background to yellow/orange checkerboard pattern. See "Fill Area Attributes" on page 81 for more information on patterns.




```
import com.imsl.chart.*;
import java.awt.Color;
import java.awt.Paint;

public class SampleBackgroundPaint extends JFrameChart {

    public SampleBackgroundPaint() {
```

```
        Chart chart = getChart();
        chart.getBackground().setFillType(ChartNode.FILL_TYPE_PAINT);
        Paint paint = FillPaint.checkerboard(24, Color.yellow,Color.orange);
        chart.getBackground().setFillPaint(paint);
        AxisXY axis = new AxisXY(chart);
        double y[] = {4, 2, 3, 9};
        new Data(axis, y);
    }

    public static void main(String argv[]) {
        new SampleBackgroundPaint().setVisible(true);
    }
}
```

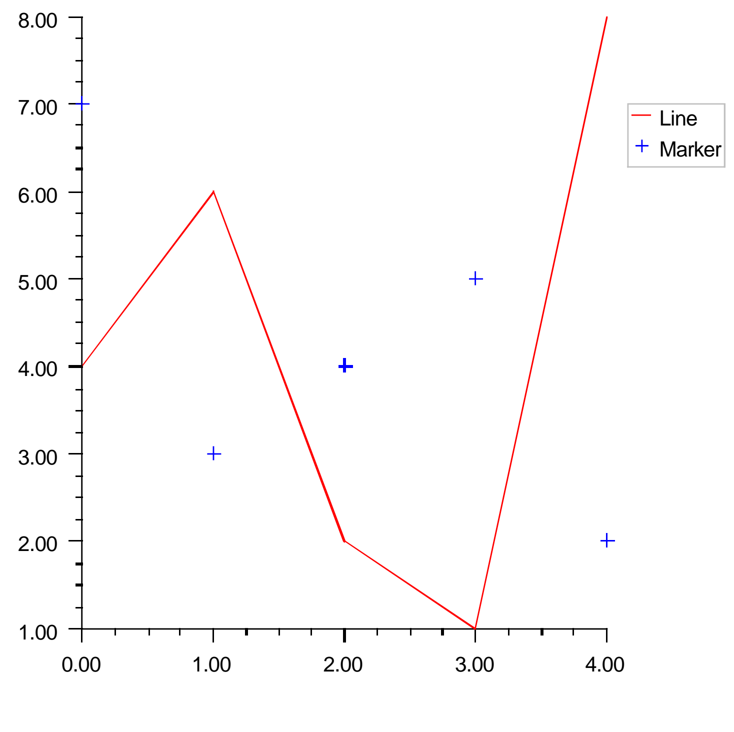
Legend

The legend is used to identify data sets. Data nodes that have their Title attribute defined are automatically included in the legend box.

The Legend node is automatically created by the Chart node as its child. By default, the legend is not drawn because its Paint attribute is set to false.

Simple Legend Example

At a minimum, adding a legend to a chart requires setting the legend's Paint attribute to true and setting the Title attribute in the Data nodes that are to appear in the legend box. This example shows such a minimal legend.




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleLegend extends JFrameChart {

    public SampleLegend() {
```

```
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        Legend legend = chart.getLegend();
        legend.setPaint(true);
        legend.setTitle("Legend");
        legend.setTextColor(Color.white);
        legend.setFillType(legend.FILL_TYPE_SOLID);
        legend.setViewport(0.3, 0.4, 0.1, 0.4);

        double y1[] = {4, 6, 2, 1, 8};
        Data data1 = new Data(axis, y1);
        data1.setDataType(Data.DATA_TYPE_LINE);
        data1.setLineColor(Color.red);
        data1.setTitle("Line");

        double y2[] = {7, 3, 4, 5, 2};
        Data data2 = new Data(axis, y2);
        data2.setDataType(Data.DATA_TYPE_MARKER);
        data2.setMarkerColor(Color.blue);
        data2.setTitle("Marker");
    }

    public static void main(String argv[]) {
        new SampleLegend().setVisible(true);
    }
}
```

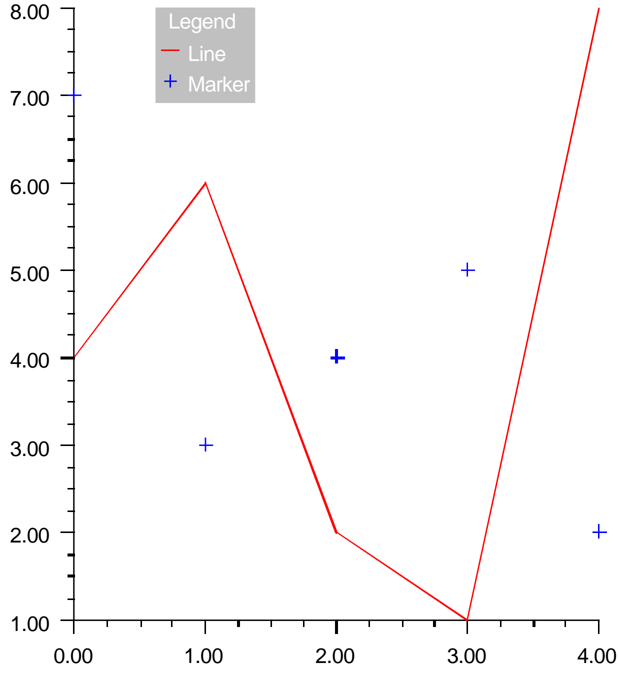
Legend Example

This example shows more of the attributes that affect a legend. If the legend's Title attribute is set, then it is used as a header in the legend box.

The text properties for all of the text strings in the legend box are obtained from the Legend node, not from the associated Data nodes (see "Text Attributes" on page 85). Here the TextColor is set to white.

The background of the legend box can be set by changing the fill attributes (see "Fill Area Attributes" on page 81). By default in the Legend node, FillType is set to FILL_TYPE_NONE and FillColor is set to `Color.lightGray`.

The position of the legend box is controlled by its Viewport attribute. The viewport is the region of the `Component`, in which the chart is being drawn, that the legend box occupies. The upper left corner is (0,0) and the lower right corner is (1,1). The default value of the legend viewport is [0.83, 0.0] by [0.2, 0.2].




```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleSimpleLegend extends JFrameChart {

    public SampleSimpleLegend() {
```

```
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        chart.getLegend().setPaint(true);

        double y1[] = {4, 6, 2, 1, 8};
        Data data1 = new Data(axis, y1);
        data1.setDataType(Data.DATA_TYPE_LINE);
        data1.setLineColor(Color.red);
        data1.setTitle("Line");

        double y2[] = {7, 3, 4, 5, 2};
        Data data2 = new Data(axis, y2);
        data2.setDataType(Data.DATA_TYPE_MARKER);
        data2.setMarkerColor(Color.blue);
        data2.setTitle("Marker");
    }

    public static void main(String argv[]) {
        new SampleSimpleLegend().setVisible(true);
    }
          }
```

Colormaps

Colormaps are mappings from [0,1] to colors. They are a one-dimensional parameterized path through the color cube. For an example of their use, see "Heatmap" on page 64.

A number of colormaps are predefined in the Colormap class. It is also possible to create new custom colormaps.

The predefined colormaps are listed in the table below.

RED	Light red to dark red
GREEN	Light green to dark green
BLUE	Light blue to dark blue
BW_LINEAR	Black and white linear
BLUE_WHITE	Blue/White
GREEN_RED_BLUE_WHITE	Green/Red/Blue/White
RED_TEMPERATURE	Red Temperature
BLUE_GREEN_RED_YELLOW	Blue/Green/Red/Yellow
STANDARD_GAMMA	Standard Gamma
PRISM	Prism
RED_PURPLE	Red/Purple
GREEN_WHITE_LINEAR	Green/White Linear
GREEN_WHITE_EXPONENTIAL	Green/White Exponential
GREEN_PINK	Green/Pink
BLUE_RED	Blue/Red
LEVEL_16	16 Levels
SPECTRAL	Spectral
WHITE_BLUE_LINEAR	White/Blue Linear

Tool Tips

Swing supports tool tips, small help boxes that pop up when the mouse hovers over some element. The ToolTip node allows tool tips to be associated with chart elements. The text displayed in the tool tip is the Title attribute of the ToolTip's parent node.

Example

In this example two Data nodes are created. Each Data node has a Title defined and a ToolTip node added as a child. Note that the ToolTip node just has to be created, no methods using it are normally required.

```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleToolTip extends JFrameChart {

    public SampleToolTip() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);

        double y1[] = {4, 6, 2, 1, 8};
        Data data1 = new Data(axis, y1);
        data1.setDataType(Data.DATA_TYPE_MARKER);
        data1.setMarkerColor(Color.red);
        data1.setMarkerType(Data.MARKER_TYPE_FILLED_CIRCLE);
        data1.setTitle("Set A");
        new ToolTip(data1);

        double y2[] = {7, 3, 4, 5, 2};
        Data data2 = new Data(axis, y2);
        data2.setDataType(Data.DATA_TYPE_MARKER);
        data2.setMarkerColor(Color.blue);
        data2.setMarkerType(Data.MARKER_TYPE_FILLED_SQUARE);
        data2.setTitle("Set B");
        new ToolTip(data2);
    }

    public static void main(String argv[]) {
        new SampleToolTip().setVisible(true);
    }
}
```

Chapter 4: XML

A JMSL chart tree can be created from an XML file. XML (Extensible Markup Language) is a universal format for structured data. XML looks similar to HTML but has application-dependent tag names instead of HTML tags (`<p>`, `<h1>`, etc.). JMSL defines a set of tags for describing charts.

The JMSL distribution includes the "Crimson 1.1.3" XML parser from Apache at `lib/crimson.jar`. *The XML features of JMSL require that either JDK 1.4 or later, crimson.jar, or another XML parser that supports the JAXP API be used.*

Chart XML Syntax

The Chart XML syntax is defined by a document type definition (DTD) file at `http://www.vni.com/products/jmsl/Chart.dtd.`

Valid XML files begin with a prolog that contains the XML declaration and the document type declaration. For example,

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//
EN" "http://www.vni.com/products/jmsl/Chart.dtd">
```

Following the prolog is the body of the chart XML file. This is a tree of tags, with the `<Chart>` tag at the root. These tags mirror a JMSL chart tree. The following outline shows the hierarchy of tags.

```
<Chart >
   <Array> | <Array id=name>
   <Background>
   <ChartTitle>
   <Legend>
   <AxisXY>
      <AxisX> | <AxisY>
         <AxisTitle>
         <AxisLabel>
         <AxisLine>
         <AxisUnit>
         <Grid>
         <MajorTick>
         <MinorTick>
   <Data x=array y=array> | <Data y=array> | <Data>
   <Bar x=array y=array> | <Bar y=array>
    <BarSet> | <BarSet index=int>
     <BarItem> | <BarItem index=int>
      <ErrorBar x=array y=array low=array high=array>
      <HighLowClose start=array high=array low=array
   close=array>
      <HighLowClose high=array low=array close=array>
   <Polar>
   <Pie y=array>
   <PieSlice> | <PieSlice index=int>
< Contour xGrid=array yGrid=array zData=array>
< Heatmap xmin=double xmax=double ymin=double y
          max=double zmin=double  zmax=double
          data=array colormap=name>
```

Some of the tags have array-valued arguments. These are either a list of doubles of the form "{1.2,3.4,5}" or "#*id*", where *id* is an <Array> tag id.

Each of the chart tags can also have any number of <Attribute> tags as children. They can have either of two forms:

```
<Attribute name="attribute-name" value="attribute-value"/>
```

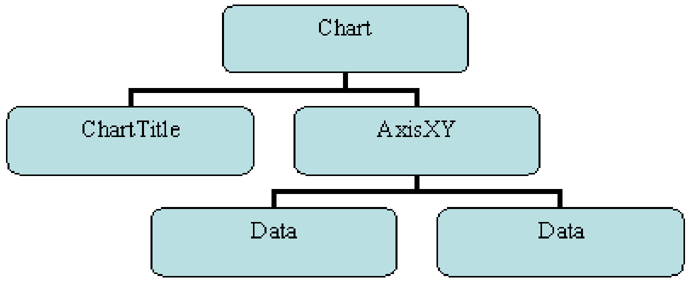
or

```
<Attribute name="attribute-name">attribute-value</Attribute>
```

Also, while not shown in the above list, each chart node can have a <ToolTip> node as a child.

Syntax Example

The chart tree is created from the following XML file.




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <ChartTitle>
        <Attribute name="Title">Line Chart</Attribute>
        <Attribute name="FontSize" value="14"/>
        <Attribute name="FontStyle" value="3"/>
    </ChartTitle>
    <AxisXY>
        <Data y="{6,5,7,1}">
            <Attribute name="LineColor" value="blue"/>
            <Attribute name="LineWidth" value="2.0"/>
         <Attribute name="DataType" value="DATA_TYPE_LINE|DATA_TYPE_MARKER"/>
            <Attribute name="MarkerType" value="MARKER_TYPE_HOLLOW_SQUARE"/>
            <Attribute name="Title" value="Blue Line"/>
        </Data>
        <Data y="{1,3,6,8}">
            <Attribute name="MarkerColor" value="darkblue"/>
            <Attribute name="DataType" value="DATA_TYPE_MARKER"/>
            <Attribute name="MarkerType" value="MARKER_TYPE_FILLED_CIRCLE"/>
            <Attribute name="Title" value="Markers"/>
        </Data>
    </AxisXY>
</Chart>
```

In the ChartTitle node there are three attributes defined: Title, FontSize and Font-Style. The argument "y={6,5,7,1}" in the Data node is used to create an array passed to the Data constructor.

Note that the attribute name must be specified using `"name="`, but that the attribute's value can be either the value of a `"value="` or the body of the attribute tag.

Attribute Tags

Attribute tags can have either of two forms:

```
<Attribute name="attribute-name" value="attribute-value"/>
```

or

```
<Attribute name="attribute-name">attribute-value</Attribute>
```

The type of an attribute's value is determined by the return type of its getter method. For example, if the attribute type is `Foo`, its type is the return type of the 0-argument method `getFoo()` defined in the node being defined or in one of its ancestor nodes.

Symbolic names can be used for enumerated types. See "Enumerated Types in Chart XML Files" on page 138 for details.

Attribute values of the following types can be handled: String, Color, int or Integer, double or Double, Double[], boolean or Boolean, Image, Paint, or Locale.

Colors are either red, green, blue triples in the range [0,255] or color names. For example `"255,215,0"` or `"gold"`.

A locale can be either the name of one of the static, public fields in Locale, such as ENGLISH or of the form `language_country` or `language_country_variant`. For example, `"nl_BE"` or `"nl_BE_EURO"`.

Attribute values of type Image and Paint are specified by giving the URL of an image file, for example

```
"http://www.google.com/images/logo.gif"
```

As a special case, the URL protocol can be a classpath, for example

```
"classpath:/com/imsl/example/chart/marker.gif"
```

The image is then loaded as a resource by the classloader using `getResource(String)`. The classloader used is the one used to load the ChartXML class. This feature is used to load images from JAR files.

Array Tags

The array tag is used to define data. The `id` argument is used to name the array. Array tags can be nested to form multidimensional arrays. At the inner most level the following tags are allowed.

- <String value=*string*/>
- <Color value=*color*/>

The value of color can be either a red, green, blue triple in the range [0,255] or color names. For example `"255,215,0"` or `"gold"`.

- <Date value=*date* style=*style* locale=*locale*/>

If the argument locale is specified, it is parsed the same as the locale argument in the tag Attribute as described above. If the locale is not specified, then the default locale is used.

If the argument style is `SHORT`, `MEDIUM`, `LONG` or `FULL`, then the date is parsed using the object `DateFormat.getDateInstance (style,locale)`. If style is not specified, then `SHORT` is assumed.

Style can also be a pattern used to construct a `SimpleDateObject (style,locale)`.

- <Number value=*number*/>

Numbers are parsed using `Double.valueOf(number)`.

- <NumberList>*number,...,number*</NumberList> | <NumberList value=*list*/>

The body of this tag is a comma separated list of numbers. Each number is parsed using `Double.valueOf(number)`.

The value arguments are optional. If omitted, the tag's body is used instead.

Array Tag Examples

The first example is of a three-dimensional array called `foo`.

```
<Array id="foo">
   <Array>
      <Array><NumberList value="1,2,3"/></Array>
      <Array><NumberList value="4,5,6"/></Array>
   </Array>
   <Array>
      <Array><NumberList value="11,12,13"/></Array>
      <Array><NumberList value="14,15,16"/></Array>
   </Array>
</Array>
```

This corresponds to the Java declaration

```
double foo[][][] = {{{1,2,3},{4,5,6}},{{11,12,13},{14,15,16}}}
```

The second example is an array of three strings called `states`.

```
<Array id="states">
   <String value="NJ"/>
   <String value="TX"/>
   <String value="CO"/>
</Array>
```

The final example is an array of four colors, called `bg`.

```
<Array id="bg">
   <Color value="yellow"/>
   <Color value="0,128,64"/>
   <Color value="lightblue"/>
   <Color value="yellow"/>
</Array>
```

Creating a Chart from XML

The class ChartXML creates a chart tree from an XML file. It can be used directly as an application to view an XML file. The following command displays the chart described by the XML file *filename*. (This assumes that the CLASSPATH is correctly set up.)

```
java com.imsl.chart.xml.ChartXML filename
```

Interacting with an XML Created Chart

The class ChartXML can also be used to create a chart tree within a larger Java program. The object's `getChart()` method is used to retreive the created chart object. The `get(String)` method is used to obtain objects created by array tags.

Enumerated Types in Chart XML Files

In a chart XML file, the following symbolic names can be used for enumerated values. Their numerical equivalents can also be used.

These enumerated types can be "or-ed" together. For example,

```
<Attribute name="DataType"
   value=DATA_TYPE_LINE|DATA_TYPE_MARKER"/>
```

is allowed.

Marker Types

MARKER_TYPE_PLUS

MARKER_TYPE_ASTERISK

MARKER_TYPE_X

MARKER_TYPE_HOLLOW_SQUARE

MARKER_TYPE_FILLED_SQUARE

MARKER_TYPE_HOLLOW_TRIANGLE

MARKER_TYPE_FILLED_TRIANGLE

MARKER_TYPE_HOLLOW_DIAMOND

MARKER_TYPE_FILLED_DIAMOND

MARKER_TYPE_DIAMOND_PLUS

MARKER_TYPE_SQUARE_X

MARKER_TYPE_SQUARE_PLUS

MARKER_TYPE_OCTAGON_X

MARKER_TYPE_OCTAGON_PLUS

MARKER_TYPE_HOLLOW_CIRCLE

MARKER_TYPE_FILLED_CIRCLE

MARKER_TYPE_CIRCLE_X

MARKER_TYPE_CIRCLE_PLUS
MARKER_TYPE_CIRCLE_CIRCLE

Fill Types

FILL_TYPE_NONE
FILL_TYPE_SOLID
FILL_TYPE_GRADIENT
FILL_TYPE_PAINT

Text Alignments

TEXT_X_LEFT
TEXT_X_CENTER
TEXT_X_RIGHT
TEXT_Y_BOTTOM
TEXT_Y_CENTER
TEXT_Y_TOP

Font Styles

PLAIN
BOLD
ITALIC

Axis Parameters

AXIS_X
AXIS_X_TOP
AXIS_Y
AXIS_Y_RIGHT

Autoscale Parameters

AUTOSCALE_OFF

AUTOSCALE_DATA

AUTOSCALE_WINDOW

AUTOSCALE_NUMBER

Axis Transforms

TRANSFORM_LINEAR

TRANSFORM_LOG

Data Node Types

DATA_TYPE_LINE

DATA_TYPE_MARKER

DATA_TYPE_FILL

DATA_TYPE_PICTURE

Label Types

LABEL_TYPE_NONE

LABEL_TYPE_TITLE

LABEL_TYPE_Y

LABEL_TYPE_X

LABEL_TYPE_PERCENT

Bar Types

BAR_TYPE_VERTICAL

BAR_TYPE_HORIZONTAL

Creating Charts from General XML Files Using XSLT

JMSL can create charts from XML files that are written using a particular set of tags, but you can also generate charts from more general XML files. This is done by using XSL Transformations (XSLT) to transform other types of XML files into the type of XML file required by JMSL.

Example

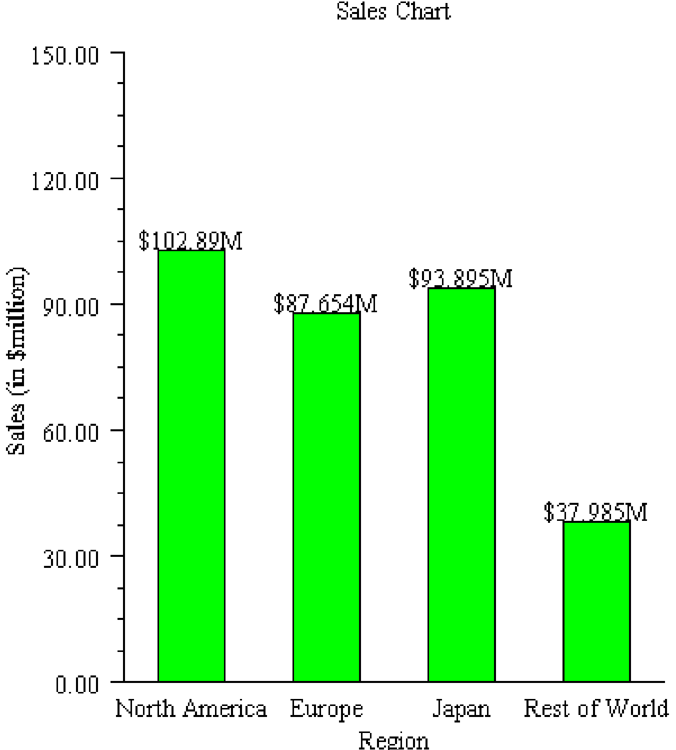
Consider the following sales report in XML that does not use the tag names and structure that JMSL requires.

```
<?xml version="1.0" encoding="UTF-8" ?>
<sales>
    <region>
        <name>North America</name>
        <amount>102.890</amount>
    </region>
    <region>
        <name>Europe</name>
        <amount>87.654</amount>
    </region>
    <region>
        <name>Japan</name>
        <amount>93.895</amount>
    </region>
    <region>
        <name>Rest of World</name>
        <amount>37.985</amount>
    </region>
</sales>
```

To create a bar chart from this XML, it must be transformed into an XML file similar to the following

```
<?xml version="1.0" encoding="UTF-8" ?>
<Chart>
    <Array id="amount">
        <Number>102.890</Number>
        <Number>87.654</Number>
        <Number>93.895</Number>
        <Number>37.985</Number>
    </Array>
```

```
    <Array id="region">
        <String value="North America"/>
        <String value="Europe"/>
        <String value="Japan"/>
        <String value="Rest of World"/>
    </Array>
    <Attribute name="FontName" value="Serif"/>
    <Attribute name="FontSize" value="14"/>
    <ChartTitle><Attribute name="Title" value="Sales Chart"/></ChartTitle>
    <AxisXY>
        <AxisY>
            <AxisTitle><Attribute name="Title" value="Sales (in $million)"/>
            </AxisTitle>
        </AxisY>
        <AxisX>
            <AxisTitle><Attribute name="Title" value="Region"/></AxisTitle>
        </AxisX>
        <Bar y="#amount">
           <Attribute name="BarType" value="BAR_TYPE_VERTICAL"/>
           <Attribute name="Labels" value="#region"/>
           <Attribute name="LabelType"  value="LABEL_TYPE_Y"/>
           <Attribute name="FillColor" value="green"/>
           <Attribute name="TextFormat">$###.###M</Attribute>
        </Bar>
    </AxisXY>
</Chart>
```



The following XSLT file can be used to perform this transformation.

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
version="1.0">
<xsl:output method="xml" indent="yes"/>

<xsl:template match="/">
<Chart>
    <Array id="region">
        <xsl:for-each select="sales/region/name">
            <String><xsl:apply-templates/></String>
        </xsl:for-each>
    </Array>
    <Array id="amount">
        <xsl:for-each select="sales/region/amount">
            <Number><xsl:apply-templates/></Number>
        </xsl:for-each>
```

```
    </Array>
    <Attribute name="FontName" value="Serif"/>
    <Attribute name="FontSize" value="14"/>
    <ChartTitle><Attribute name="Title" value="Sales Chart"/></ChartTitle>
    <AxisXY>
        <AxisY>
            <AxisTitle>
                <Attribute name="Title" value="Sales (in $million)"/>
            </AxisTitle>
        </AxisY>
        <AxisX>
            <AxisTitle><Attribute name="Title" value="Region"/></AxisTitle>
        </AxisX>
        <Bar y="#amount">
           <Attribute name="BarType" value="BAR_TYPE_VERTICAL"/>
           <Attribute name="Labels" value="#region"/>
           <Attribute name="LabelType"  value="LABEL_TYPE_Y"/>
           <Attribute name="FillColor" value="green"/>
           <Attribute name="TextFormat">$###.###M</Attribute>
        </Bar>
    </AxisXY>
</Chart>
</xsl:template>

</xsl:stylesheet>
```

While a complete discussion of XSLT is beyond the scope of this manual, note that most of the file is the same as the target. The XSL tags are in the "xsl" namespace. In this example, the key XSL tags are the two `for` loops that reformat the data. For instance, the region names are formatted by the fragment

```
<xsl:for-each select="sales/region/name">
   <String><xsl:apply-templates/></String>
</xsl:for-each>
```

where the path "sales/region/name" selects tags in the original XML file and the body of the tag

```
<String><xsl:apply-templates/></String>
```

is copied into the new file.

The given XSL document will work for similar documents with different data, but other XML document formats may require different XSL files.

The Java code required to implement this transformation is:

```
import com.imsl.chart.JFrameChart;
import com.imsl.chart.xml.ChartXML;
import javax.xml.parsers.DocumentBuilderFactory;
import javax.xml.parsers.DocumentBuilder;
import javax.xml.transform.TransformerFactory;
import javax.xml.transform.Transformer;
import javax.xml.transform.dom.DOMSource;
import javax.xml.transform.dom.DOMResult;
import org.w3c.dom.Document;

public class SampleSalesTransform {
    public static void main(String argv[]) throws Exception {
        String filenameXSL = argv[0];
        String filenameXML = argv[1];

        // Create an XML parser factory
        DocumentBuilderFactory factory = DocumentBuilderFactory.newInstance();
        factory.setNamespaceAware(true);
        DocumentBuilder builder = factory.newDocumentBuilder();

        // Parse the XSL file as an XML file
        Document docXSL = builder.parse(filenameXSL);
        DOMSource sourceXSL = new DOMSource(docXSL);
        sourceXSL.setSystemId(filenameXSL);

        // Create a transformation based on the XSL file
        TransformerFactory tFactory = TransformerFactory.newInstance();
        Transformer transformer = tFactory.newTransformer(sourceXSL);

        // Parse the input XML file
        Document docXML = builder.parse(filenameXML);
        DOMSource sourceXML = new DOMSource(docXML);
        sourceXML.setSystemId(filenameXML);

        // Transform the input XML file using the XSL transformer
        DOMResult result = new DOMResult();
        transformer.transform(sourceXML, result);

        // Create a chart from the transformed XML
        ChartXML chartXML = new ChartXML((Document)result.getNode());
        new JFrameChart(chartXML.getChart()).show();
    }
}
```

This program takes two arguments, the names of the XSL and XML files, and creates a JMSL chart. The transformed XML exists only in memory and is not written

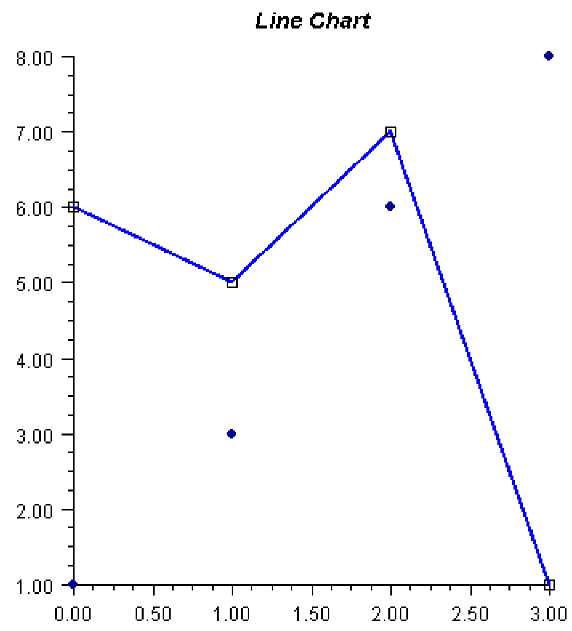
to disk. This class will work with any (correct) XSL and XML files; it is not dependent on the details of this example. In the interests of simplicity, error handling and validation is not implemented, as they should be for a production implementation.

Also, for simplicity, this example is a desktop application. XML and XSLT are generally more useful as part of a server-side Web application. The above code can be used with `com.imsl.chart.JspBean` to create a server-side XML/XSLT solution.

XML Examples

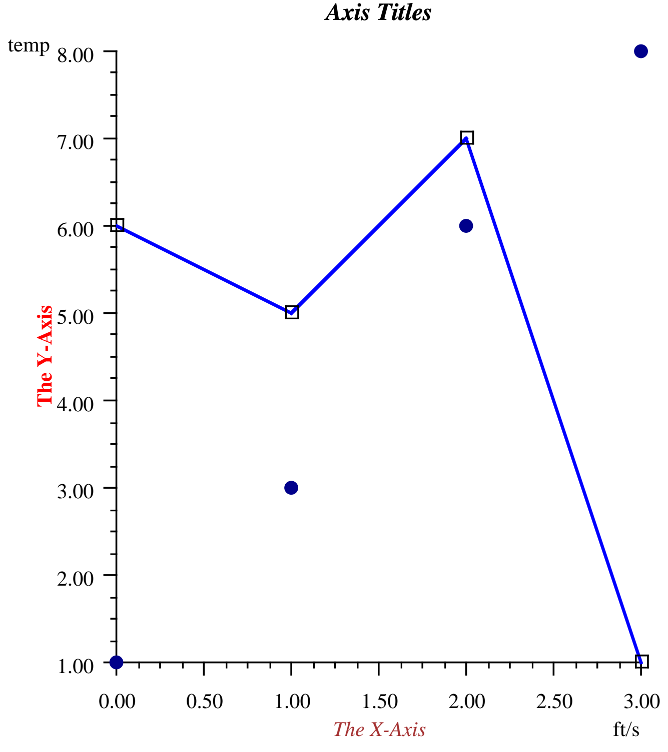
- Line Chart (see page 147)
- Axis Titles (see page 149)
- Multiple Axes (see page 150)
- Axis Offset (see page 152)
- Rotated Labels (see page 154)
- Pie Chart (see page 159)
- Box Plot (see page 156)
- Contour Chart (see page 161)
- Heatmap Chart (see page 163)
- Large Bar Chart (see page 165)
- Grouped and Stacked Bar Chart (see page 168)
- Polar Plot (see page 170)

XML Example: Line Chart



```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <ChartTitle>
        <Attribute name="Title">Line Chart</Attribute>
        <Attribute name="FontSize" value="14"/>
        <Attribute name="FontStyle" value="3"/>
    </ChartTitle>
    <AxisXY>
        <Data y="{6,5,7,1}">
            <Attribute name="LineColor" value="blue"/>
            <Attribute name="LineWidth" value="2.0"/>
          <Attribute name="DataType" value="DATA_TYPE_LINE|DATA_TYPE_MARKER"/>
            <Attribute name="MarkerType" value="MARKER_TYPE_HOLLOW_SQUARE"/>
            <Attribute name="Title" value="Blue Line"/>
            <ToolTip/>
        </Data>
        <Data y="{1,3,6,8}">
            <Attribute name="MarkerColor" value="darkblue"/>
            <Attribute name="DataType" value="DATA_TYPE_MARKER"/>
            <Attribute name="MarkerType" value="MARKER_TYPE_FILLED_CIRCLE"/>
            <Attribute name="Title" value="Markers"/>
            <ToolTip/>
        </Data>
    </AxisXY>
</Chart>
```

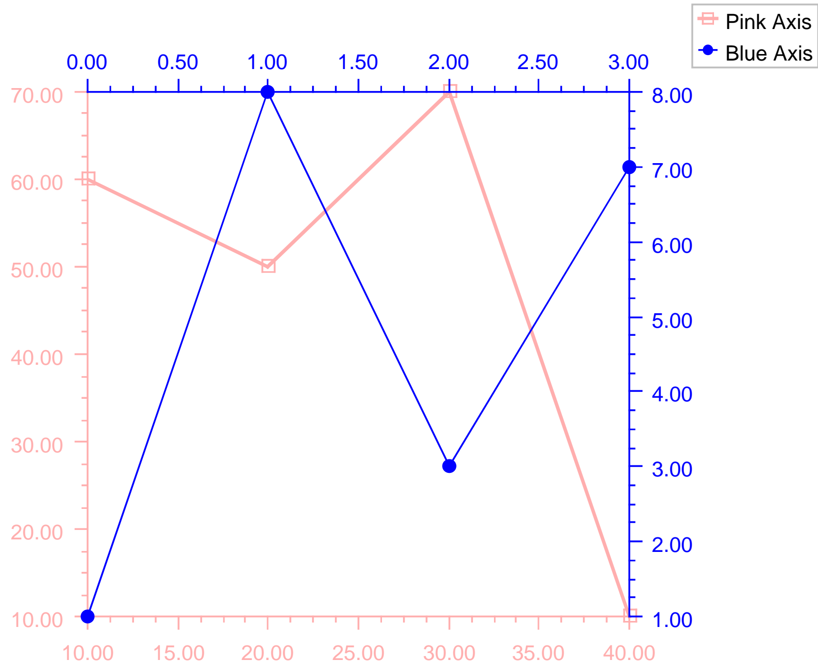
XML Example: Axis Titles




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <Attribute name="FontName" value="Serif"/>
    <ChartTitle>
        <Attribute name="Title">Axis Titles</Attribute>
        <Attribute name="FontSize" value="14"/>
        <Attribute name="FontStyle" value="3"/>
    </ChartTitle>
    <AxisXY>
        <AxisX>
            <AxisTitle>
                <Attribute name="Title" value="The X-Axis"/>
                <Attribute name="TextColor" value="brown"/>
                <Attribute name="FontStyle" value="ITALIC"/>
            </AxisTitle>
            <AxisUnit><Attribute name="Title" value="ft/s"/></AxisUnit>
        </AxisX>
        <AxisY>
```

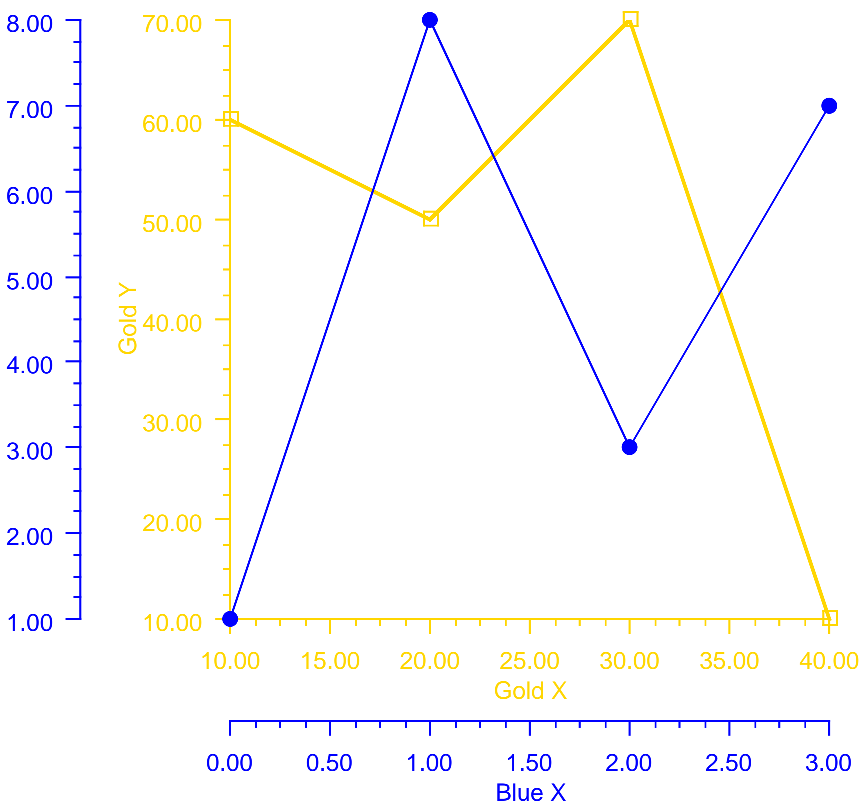
```
        <AxisTitle>
            <Attribute name="Title" value="The Y-Axis"/>
            <Attribute name="TextColor" value="red"/>
            <Attribute name="FontStyle" value="BOLD"/>
        </AxisTitle>
        <AxisUnit><Attribute name="Title" value="temp"/></AxisUnit>
    </AxisY>
    <Data y="{6,5,7,1}">
        <Attribute name="LineColor" value="blue"/>
        <Attribute name="LineWidth" value="2.0"/>
     <Attribute name="DataType" value="DATA_TYPE_LINE|DATA_TYPE_MARKER"/>
        <Attribute name="MarkerType" value="MARKER_TYPE_HOLLOW_SQUARE"/>
    </Data>
    <Data y="{1,3,6,8}">
        <Attribute name="MarkerColor" value="darkblue"/>
        <Attribute name="DataType" value="DATA_TYPE_MARKER"/>
        <Attribute name="MarkerType" value="MARKER_TYPE_FILLED_CIRCLE"/>
    </Data>
  </AxisXY>
</Chart>
```

XML Example: Multiple Axes



```
<?xml version=”1.0” encoding=”UTF-8” standalone=”no” ?>
<!DOCTYPE Chart PUBLIC “-//Visual Numerics//DTD JMSL Chart//EN” “http://
www.vni.com/products/jmsl/Chart.dtd”>
<Chart>
    <Legend>
        <Attribute name=”Paint” value=”true”/>
        <Attribute name=”Viewport” value=”0.83,1.0,0.1,0.3”/>
    </Legend>
    <AxisXY>
        <Attribute name=”Viewport” value=”0.13,0.75,0.2,0.8”/>
        <Attribute name=”LineColor” value=”red”/>
        <Attribute name=”MarkerColor” value=”red”/>
       <Attribute name=”TextColor” value=”red”/>
        <Data x=”10,20,30,40” y=”60,50,70,10”>
            <Attribute name=”LineWidth” value=”2.0”/>
         <Attribute name=”DataType” value=”DATA_TYPE_LINE|DATA_TYPE_MARKER”/>
            <Attribute name=”MarkerType” value=”MARKER_TYPE_HOLLOW_SQUARE”/>
            <Attribute name=”Title” value=”Red Axis”/>
            <ToolTip/>
        </Data>
    </AxisXY>
    <AxisXY>
        <Attribute name=”Viewport” value=”0.13,0.75,0.2,0.8”/>
        <Attribute name=”LineColor” value=”blue”/>
        <Attribute name=”MarkerColor” value=”blue”/>
       <Attribute name=”TextColor” value=”blue”/>
        <AxisX>
            <Attribute name=”Type” value=”AXIS_X_TOP”/>
        </AxisX>
        <AxisY>
            <Attribute name=”Type” value=”AXIS_Y_RIGHT”/>
        </AxisY>
        <Data y=”1,8,3,7”>
         <Attribute name=”DataType” value=”DATA_TYPE_LINE|DATA_TYPE_MARKER”/>
            <Attribute name=”MarkerType” value=”MARKER_TYPE_FILLED_CIRCLE”/>
            <Attribute name=”Title” value=”Blue Axis”/>
            <ToolTip/>
        </Data>
    </AxisXY>
</Chart>
```

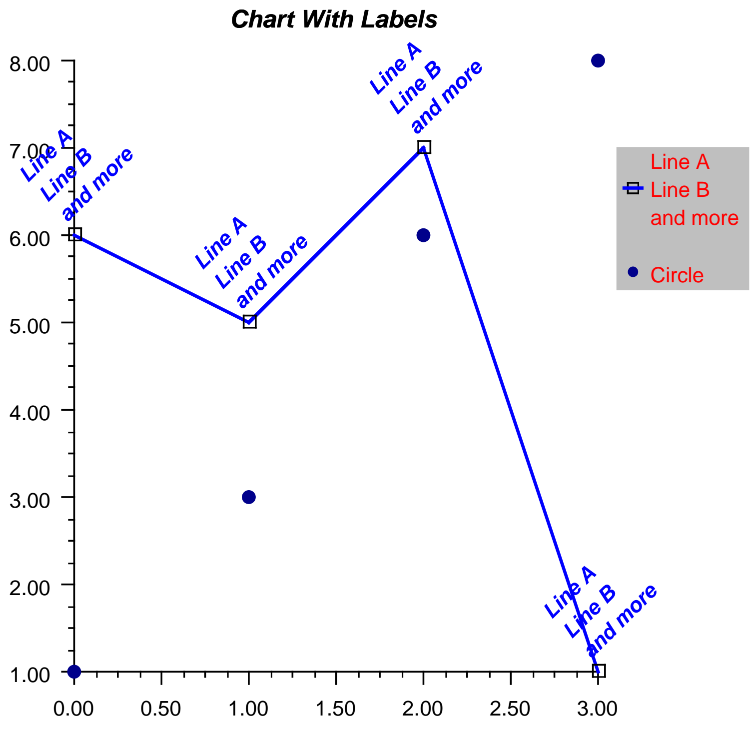
XML Example: Axis Offset




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <AxisXY>
        <Attribute name="Viewport" value="0.3,0.9,0.1,0.7"/>
        <Attribute name="LineColor" value="gold"/>
        <Attribute name="MarkerColor" value="gold"/>
        <Attribute name="TextColor" value="gold"/>
        <AxisX><AxisTitle><Attribute name="Title" value="Gold X"/></AxisTi-
tle></AxisX>
        <AxisY><AxisTitle><Attribute name="Title" value="Gold Y"/></AxisTi-
```

```
tle></AxisY>
        <Data x=”10,20,30,40” y=”60,50,70,10”>
            <Attribute name=”LineWidth” value=”2.0”/>
         <Attribute name=”DataType” value=”DATA_TYPE_LINE|DATA_TYPE_MARKER”/>
            <Attribute name=”MarkerType” value=”MARKER_TYPE_HOLLOW_SQUARE”/>
            <Attribute name=”Title” value=”Gold Axis”/>
        </Data>
    </AxisXY>
    <AxisXY>
        <Attribute name=”Cross” value=”-0.75,-0.2”/>
        <Attribute name=”Viewport” value=”0.3,0.9,0.1,0.7”/>
        <AxisX><AxisTitle><Attribute name=”Title” value=”Blue X”/></AxisTi-
tle></AxisX>
        <AxisY><AxisTitle><Attribute name=”Title” value=”Blue Y”/></AxisTi-
tle></AxisY>
        <Attribute name=”LineColor” value=”blue”/>
        <Attribute name=”MarkerColor” value=”blue”/>
        <Attribute name=”TextColor” value=”blue”/>
        <Data y=”1,8,3,7”>
         <Attribute name=”DataType” value=”DATA_TYPE_LINE|DATA_TYPE_MARKER”/>
            <Attribute name=”MarkerType” value=”MARKER_TYPE_FILLED_CIRCLE”/>
            <Attribute name=”Title” value=”Blue Axis”/>
        </Data>
    </AxisXY>
</Chart>
```

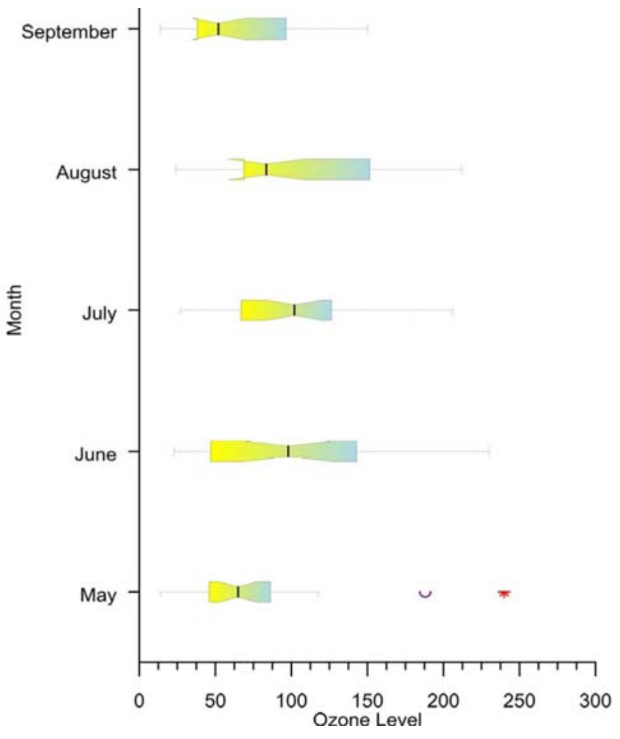
XML Example: Rotated Labels




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <ChartTitle>
        <Attribute name="Title">Chart With Labels</Attribute>
        <Attribute name="FontSize" value="14"/>
        <Attribute name="FontStyle" value="3"/>
    </ChartTitle>
    <Legend>
        <Attribute name="Paint" value="true"/>
        <Attribute name="TextColor" value="red"/>
        <Attribute name="FillType" value="FILL_TYPE_SOLID"/>
    </Legend>
    <AxisXY>
        <Attribute name="ClipData" value="false"/>
        <Data y="{6,5,7,1}">
            <Attribute name="LabelType" value="LABEL_TYPE_TITLE"/>
```

```
            <Attribute name="TextAngle" value="45"/>
            <Attribute name="LineColor" value="blue"/>
            <Attribute name="LineWidth" value="2.0"/>
           <Attribute name="DataType" value="DATA_TYPE_LINE|DATA_TYPE_MARKER"/>
            <Attribute name="MarkerType" value="MARKER_TYPE_HOLLOW_SQUARE"/>
            <Attribute name="TextColor" value="blue"/>
            <Attribute name="FontStyle" value="3"/>
            <Attribute name="Title"><![CDATA[Line A
Line B
and more]]></Attribute>
        </Data>
        <Data y="{1,3,6,8}">
            <Attribute name="MarkerColor" value="darkblue"/>
            <Attribute name="DataType" value="DATA_TYPE_MARKER"/>
            <Attribute name="MarkerType" value="MARKER_TYPE_FILLED_CIRCLE"/>
            <Attribute name="Title" value="Circle"/>
        </Data>
    </AxisXY>
</Chart>
```

XML Example: Box Plot

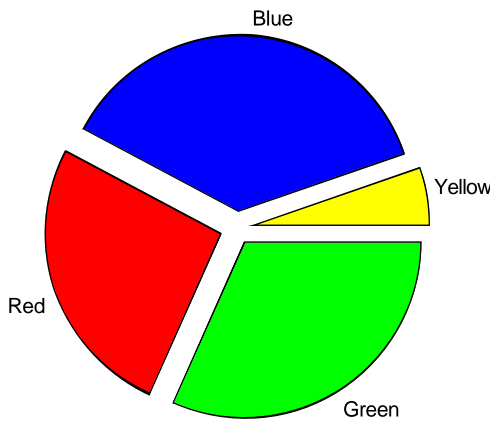



```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <Array id="ozone">
        <Array>
            <NumberList>
                66.0, 52.0, 49.0, 64.0, 68.0, 26.0, 86.0, 52.0,
                43.0, 75.0, 87.0, 188.0, 118.0, 103.0, 82.0,
                71.0, 103.0, 240.0, 31.0, 40.0, 47.0, 51.0, 31.0,
                47.0, 14.0, 71.0
            </NumberList>
         </Array>
         <Array>
            <NumberList>
                61.0, 47.0, 196.0, 131.0, 173.0, 37.0, 47.0,
                215.0, 230.0, 69.0, 98.0, 125.0, 94.0, 72.0,
                72.0, 125.0, 143.0, 192.0, 122.0, 32.0, 114.0,
                32.0, 23.0, 71.0, 38.0, 136.0, 169.0
```

```
            </NumberList>
        </Array>
        <Array>
            <NumberList>
                   152.0, 201.0, 134.0, 206.0, 92.0, 101.0, 119.0,
                   124.0, 133.0, 83.0, 60.0, 124.0, 142.0, 124.0, 64.0,
                   75.0, 103.0, 46.0, 68.0, 87.0, 27.0,
                   73.0, 59.0, 119.0, 64.0, 111.0
            </NumberList>
        </Array>
        <Array>
            <NumberList>
                   80.0, 68.0, 24.0, 24.0, 82.0, 100.0, 55.0, 91.0,
                   87.0, 64.0, 170.0, 86.0, 202.0, 71.0, 85.0, 122.0,
                   155.0, 80.0, 71.0, 28.0, 212.0, 80.0, 24.0,
                   80.0, 169.0, 174.0, 141.0, 202.0
           </NumberList>
        </Array>
        <Array>
           <NumberList>
                   113.0, 38.0, 38.0, 28.0, 52.0, 14.0, 38.0, 94.0,
                   89.0, 99.0, 150.0, 146.0, 113.0, 38.0, 66.0, 38.0,
                   80.0, 80.0, 99.0, 71.0, 42.0, 52.0, 33.0, 38.0,
                   24.0, 61.0, 108.0, 38.0, 28.0
           </NumberList>
        </Array>
    </Array>
    <Array id="months"><String value="May"/><String value="June"/><String 
value="July"/><String value="August"/><String value="September"/></Array>
    <Array id="grad"><Color value="yellow"/><Color value="lightblue"/><Color 
value="lightblue"/><Color value="yellow"/></Array>

    <ChartTitle><Attribute name="Title" value="Ozone Levels in Stanford by 
Month"/></ChartTitle>
    <AxisXY>
        <BoxPlot obs="#ozone">
            <Attribute name="BoxPlotType" value="BOXPLOT_TYPE_HORIZONTAL"/>
            <Attribute name="Labels" value="#months"/>
            <Attribute name="Notch" value="true"/>
            <Attribute name="ProportionalWidth" value="true"/>
            <Bodies>
                <Attribute name="FillType" value="FILL_TYPE_GRADIENT"/>
                <Attribute name="Gradient" value="#grad"/>
            </Bodies>
            <OutsideMarkers>
             <Attribute name="MarkerType" value="MARKER_TYPE_HOLLOW_CIRCLE"/>
                <Attribute name="MarkerColor" value="purple"/>
            </OutsideMarkers>
            <FarMarkers>
```

```
                <Attribute name=”MarkerType” value=”MARKER_TYPE_ASTERISK”/>
                <Attribute name=”MarkerColor” value=”red”/>
            </FarMarkers>
            <Whiskers>
                <Attribute name=”MarkerColor” value=”darkgreen”/>
            </Whiskers>
        </BoxPlot>
        <AxisY>
            <AxisTitle><Attribute name=”Title” value=”Month”/></AxisTitle>
        </AxisY>
        <AxisX>
          <AxisTitle><Attribute name=”Title” value=”Ozone Level”/></AxisTitle>
            <Attribute name=”TextFormat” value=”#”/>
        </AxisX>
    </AxisXY>
</Chart>
```

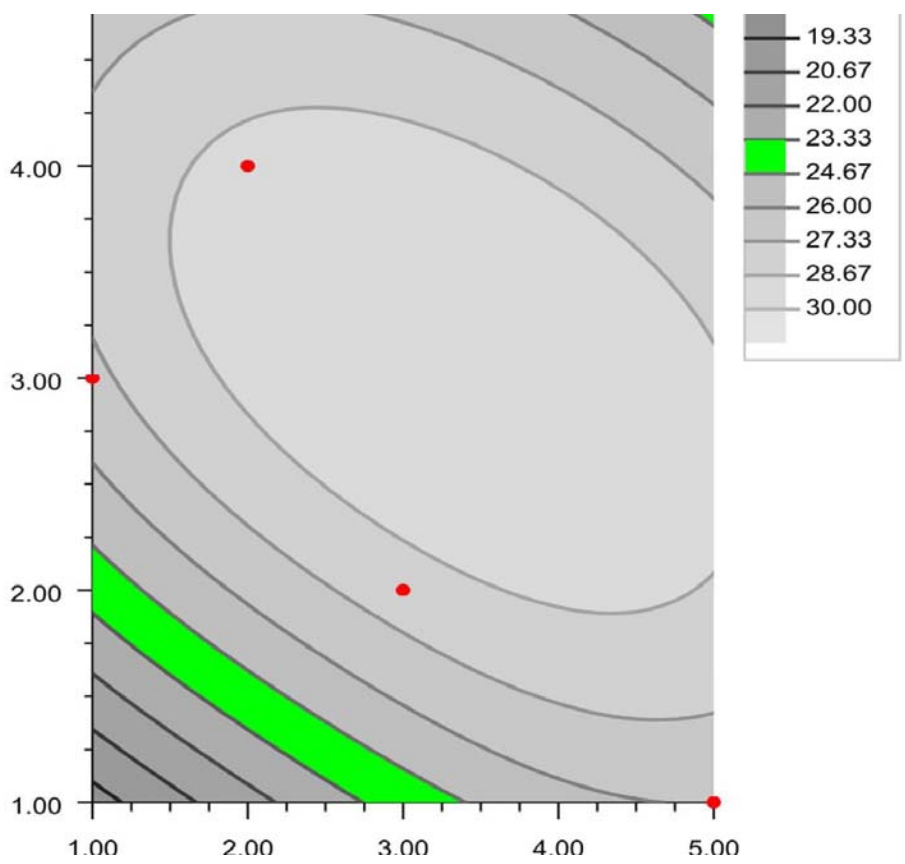
XML Example: Pie Chart




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <ChartTitle>
        <Attribute name="Title">Pie Chart</Attribute>
        <Attribute name="FontSize" value="14"/>
        <Attribute name="FontStyle" value="3"/>
    </ChartTitle>
    <Pie y="{6,5,7,1}">
        <Attribute name="LabelType" value="LABEL_TYPE_TITLE"/>
        <Attribute name="Explode" value="0.1"/>
        <PieSlice index="0">
            <Attribute name="FillColor" value="green"/>
            <Attribute name="Title"  value="Green"/>
            <ToolTip/>
        </PieSlice>
        <PieSlice index="1">
            <Attribute name="FillColor" value="red"/>
            <Attribute name="Title" value="Red"/>
            <ToolTip/>
        </PieSlice>
        <PieSlice index="2">
```

```
            <Attribute name="FillColor" value="blue"/>
            <Attribute name="Title" value="Blue"/>
            <ToolTip/>
        </PieSlice>
        <PieSlice index="3">
            <Attribute name="FillColor" value="yellow"/>
            <Attribute name="Title" value="Yellow"/>
            <ToolTip/>
        </PieSlice>
    </Pie>
</Chart>
```

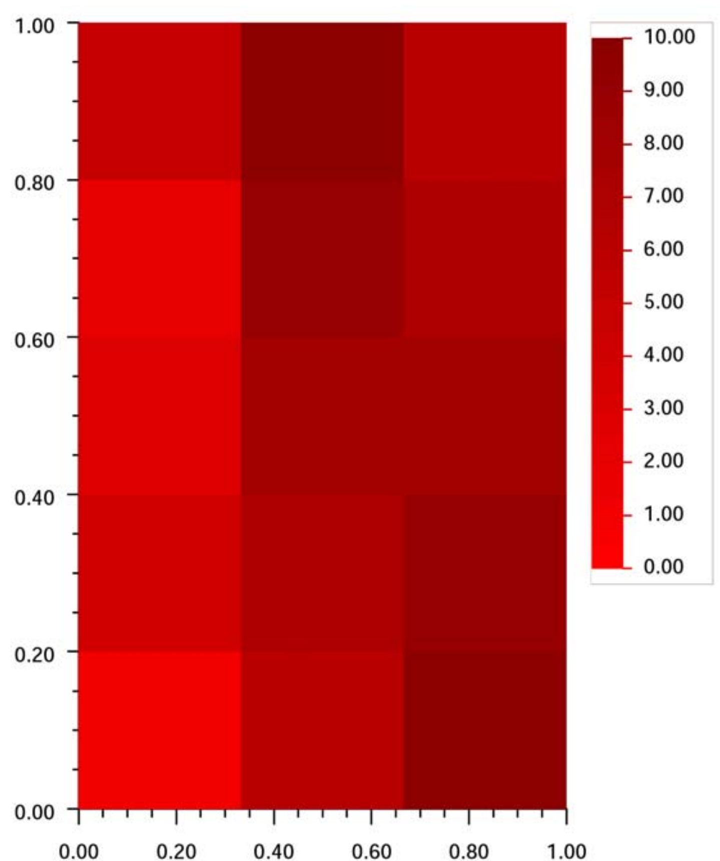
XML Example: Contour Chart




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <Array id="x"><NumberList>5,3,1,2,4</NumberList></Array>
    <Array id="y"><NumberList>1,2,3,4,5</NumberList></Array>
    <Array id="z"><NumberList>26,28,27,29,25</NumberList></Array>

    <ChartTitle><Attribute name="Title" value="Scattered Data Contour Plot"/
></ChartTitle>
    <AxisXY>
        <Contour xGrid="#x"  yGrid="#y"  zData="#z">
```

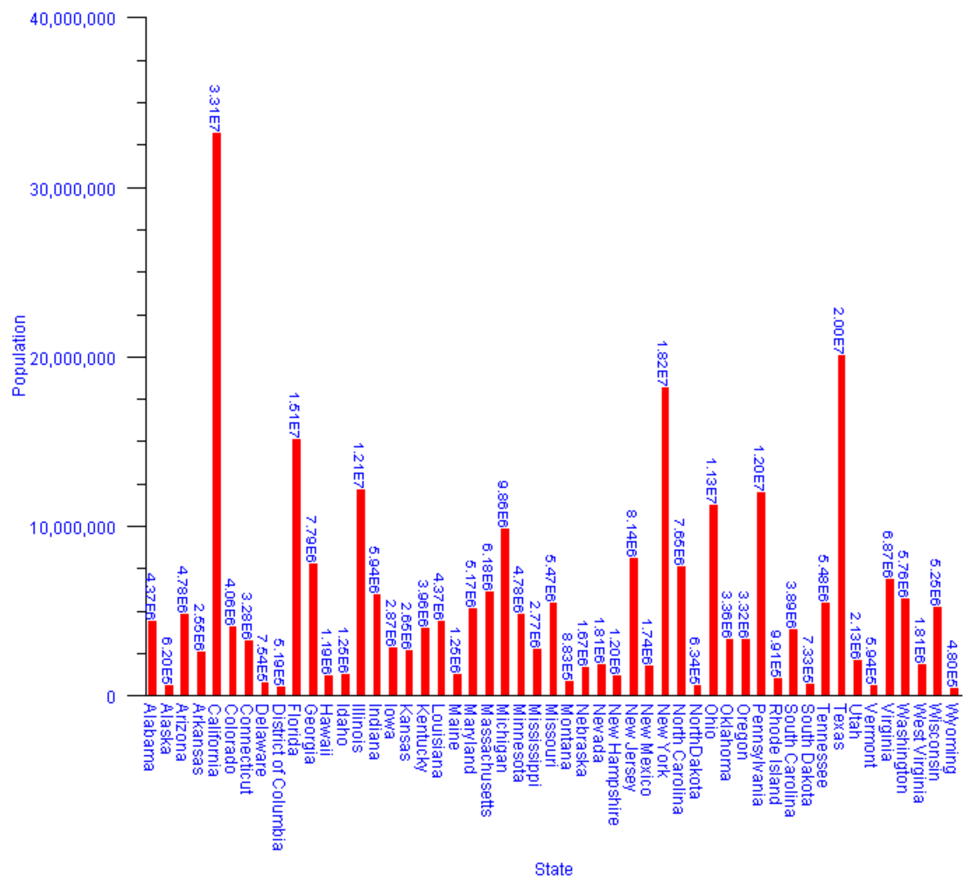
```
            <ContourLegend>
                <Attribute name="Paint" value="true"/>
            </ContourLegend>
            <ContourLevel index="5">
                <Attribute name="FillColor" value="green"/>
            </ContourLevel>
        </Contour>
        <Data x="#x" y="#y">
             <Attribute name="DataType" value="DATA_TYPE_MARKER"/>
             <Attribute name="MarkerType" value="MARKER_TYPE_FILLED_CIRCLE"/>
             <Attribute name="MarkerColor" value="red"/>
        </Data>
    </AxisXY>
</Chart>
```

XML Example: Heatmap



```
import com.imsl.chart.*;

public class SampleHeatmap extends JFrameChart {

    public SampleHeatmap() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        double xmin = 0.0;
        double xmax = 5.0;
        double ymin = 0.0;
        double ymax = 4.0;
        double zmin = 0.0;
        double zmax = 100.0;
        double data[][] = {
            {23, 48, 16, 56},
            {89, 74, 54, 32},
            {12, 45, 18,  9},
            {72, 15, 42, 92},
            {63, 36, 78, 29}
        };
        Heatmap heatmap = new Heatmap(axis, xmin, xmax, ymin, ymax,
            zmin, zmax, data, Colormap.BLUE_RED);
        heatmap.getHeatmapLegend().setPaint(true);
    }

    public static void main(String argv[]) {
        new SampleHeatmap().setVisible(true);
    }
}
```

XML Example: Bar Chart of States

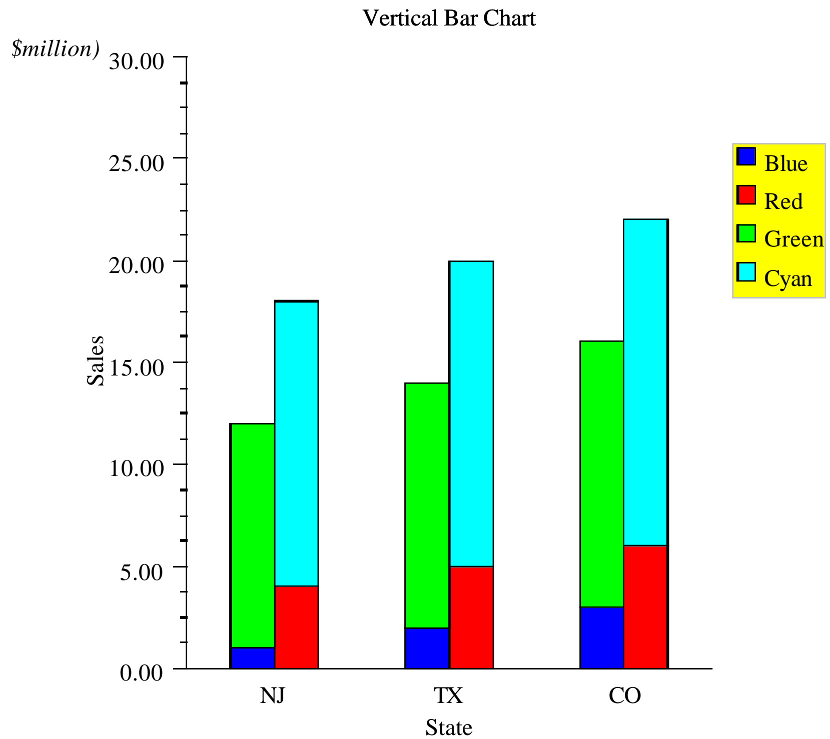



```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <!-- Data from http://www.census.gov/population/estimates/state/st-99-
3.txt -->
    <Array id="population">
        <NumberList>
            4369862,619500,4778332,2551373,33145121,4056133,3282031,753538,
            519000,15111244,7788240,1185497,1251700,12128370,5942901,2869413,
            2654052,3960825,4372035,1253040,5171634,6175169,9863775,4775508,
            2768619,5468338,882779,1666028,1809253,1201134,8143412,1739844,
```

```
        18196601,7650789,633666,11256654,3358044,3316154,11994016,
        990819,3885736,733133,5483535,20044141,2129836,593740,6872912,
        5756361,1806928,5250446,479602
    </NumberList>
</Array>
<Array id="states">
    <String value="Alabama"/>
    <String value="Alaska"/>
    <String value="Arizona"/>
    <String value="Arkansas"/>
    <String value="California"/>
    <String value="Colorado"/>
    <String value="Connecticut"/>
    <String value="Delaware"/>
    <String value="District of Columbia"/>
    <String value="Florida"/>
    <String value="Georgia"/>
    <String value="Hawaii"/>
    <String value="Idaho"/>
    <String value="Illinois"/>
    <String value="Indiana"/>
    <String value="Iowa"/>
    <String value="Kansas"/>
    <String value="Kentucky"/>
    <String value="Louisiana"/>
    <String value="Maine"/>
    <String value="Maryland"/>
    <String value="Massachusetts"/>
    <String value="Michigan"/>
    <String value="Minnesota"/>
    <String value="Mississippi"/>
    <String value="Missouri"/>
    <String value="Montana"/>
    <String value="Nebraska"/>
    <String value="Nevada"/>
    <String value="New Hampshire"/>
    <String value="New Jersey"/>
    <String value="New Mexico"/>
    <String value="New York"/>
    <String value="North Carolina"/>
    <String value="NorthDakota"/>
    <String value="Ohio"/>
    <String value="Oklahoma"/>
    <String value="Oregon"/>
    <String value="Pennsylvania"/>
    <String value="Rhode Island"/>
    <String value="South Carolina"/>
    <String value="South Dakota"/>
    <String value="Tennessee"/>
```

```
        <String value=”Texas”/>
        <String value=”Utah”/>
        <String value=”Vermont”/>
        <String value=”Virginia”/>
        <String value=”Washington”/>
        <String value=”West Virginia”/>
        <String value=”Wisconsin”/>
        <String value=”Wyoming”/>
    </Array>

    <Attribute name=”TextColor” value=”blue”/>
    <Background>
        <Attribute name=”FillColor” value=”white”/>
        <Attribute name=”FontSize” value=”24”/>
    </Background>
    <ChartTitle>
        <Attribute name=”Title”>Population of the United States</Attribute>
        <Attribute name=”FontSize” value=”24”/>
        <Attribute name=”FontStyle” value=”3”/>
    </ChartTitle>
    <AxisXY>
        <AxisY>
          <AxisTitle><Attribute name=”Title” value=”Population”/></AxisTitle>
            <Attribute name=”TextFormat”>###,###</Attribute>
        </AxisY>
        <AxisX>
            <AxisTitle><Attribute name=”Title” value=”State”/></AxisTitle>
            <AxisLabel><Attribute name=”TextAngle” value=”270”/></AxisLabel>
        </AxisX>
        <Bar y=”#population”>
            <Attribute name=”BarType” value=”BAR_TYPE_VERTICAL”/>
            <Attribute name=”Labels” value=”#states”/>
            <Attribute name=”FillColor” value=”red”/>
            <Attribute name=”FillOutlineType” value=”FILL_TYPE_NONE”/>
            <Attribute name=”LabelType”  value=”LABEL_TYPE_Y”/>
            <Attribute name=”TextAngle” value=”270”/>
            <Attribute name=”TextFormat” value=”0.00E0”/>
            <Attribute name=”FontSize” value=”10”/>
        </Bar>
    </AxisXY>
</Chart>
```

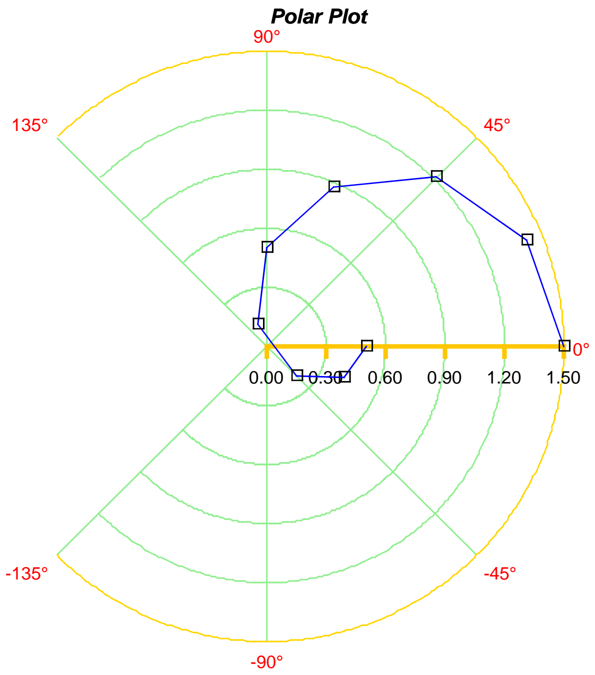
XML Example: Bar Chart




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <Array id="foo">
        <Array>
            <Array><NumberList value="1,2,3"/></Array>
            <Array><NumberList value="4,5,6"/></Array>
        </Array>
        <Array>
            <Array><NumberList value="11,12,13"/></Array>
            <Array><NumberList value="14,15,16"/></Array>
        </Array>
    </Array>
    <Array id="states"><String value="NJ"/><String value="TX"/><String
value="CO"/></Array>
   <Array id="bg"><Color value="lightblue"/><Color value="lightblue"/><Color
value="yellow"/><Color value="yellow"/></Array>

    <Attribute name="FontName" value="Serif"/>
```

```
    <Attribute name="FontSize" value="14"/>
    <ChartTitle><Attribute name="Title" value="Vertical Bar Chart"/></
ChartTitle>
    <Background>
        <Attribute name="Gradient" value="#bg"/>
    </Background>
    <Legend>
        <Attribute name="Paint" value="true"/>
        <Attribute name="FillColor" value="yellow"/>
        <Attribute name="FillType" value="FILL_TYPE_SOLID"/>
    </Legend>
    <AxisXY>
        <AxisY>
            <AxisTitle><Attribute name="Title" value="Sales"/></AxisTitle>
            <AxisUnit>
                <Attribute name="Title" value="(in $million)"/>
                <Attribute name="FontStyle" value="ITALIC"/>
            </AxisUnit>
        </AxisY>
        <AxisX>
            <AxisTitle><Attribute name="Title" value="State"/></AxisTitle>
        </AxisX>
        <Bar x="{0,1,2}"  y="#foo">
           <Attribute name="BarType" value="BAR_TYPE_VERTICAL"/>
            <Attribute name="Labels" value="#states"/>
            <BarSet index="{0,0}">
                <Attribute name="FillColor" value="blue"/>
                <Attribute name="Title" value="Blue"/>
            </BarSet>
            <BarSet index="{0,1}">
                <Attribute name="FillColor" value="red"/>
                <Attribute name="Title" value="Red"/>
            </BarSet>
            <BarSet index="{1,0}">
                <Attribute name="FillColor" value="green"/>
                <Attribute name="Title" value="Green"/>
            </BarSet>
            <BarSet index="{1,1}">
                <Attribute name="FillColor" value="cyan"/>
                <Attribute name="Title" value="Cyan"/>
            </BarSet>
        </Bar>
    </AxisXY>
</Chart>
```

XML Example: Polar Plot




```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE Chart PUBLIC "-//Visual Numerics//DTD JMSL Chart//EN" "http://
www.vni.com/products/jmsl/Chart.dtd">
<Chart>
    <ChartTitle>
        <Attribute name="Title">Polar Plot</Attribute>
        <Attribute name="FontSize" value="14"/>
        <Attribute name="FontStyle" value="3"/>
    </ChartTitle>
    <Polar>
        <Attribute name="LineColor" value="gold"/>
        <AxisR>
            <Attribute name="LineColor" value="orange"/>
            <AxisRLine>
                <Attribute name="LineWidth" value="3"/>
            </AxisRLine>
            <AxisRMajorTick>
                <Attribute name="LineWidth" value="3"/>
```

```
            </AxisRMajorTick>
        </AxisR>
        <AxisTheta>
            <Attribute name="Window" value="{-2.35619449019,2.35619449019}"/>
            <Attribute name="Number" value="7"/>
            <Attribute name="TextColor" value="red"/>
        </AxisTheta>
        <GridPolar>
            <Attribute name="LineColor" value="lightgreen"/>
        </GridPolar>
        <Data  x="{1.50,1.42,1.21,0.88,0.50,0.12,-0.21,-0.42,-0.50}"
               y="{0.00,0.39,0.79,1.18,1.57,1.96,2.36,2.75,3.14}">
            <Attribute name="LineColor" value="blue"/>
          <Attribute name="DataType" value="DATA_TYPE_LINE|DATA_TYPE_MARKER"/>
            <Attribute name="MarkerType" value="MARKER_TYPE_HOLLOW_SQUARE"/>
            <Attribute name="Title" value="Blue Line"/>
            <ToolTip/>
        </Data>
    </Polar>
</Chart>
```

Chapter 5: Actions

JMSL supports the following actions:

- “Picking” on page 173
- “Zoom” on page 176
- “Printing” on page 182
- “Serialization” on page 184

Picking

The pick mechanism allows MouseEvents to be associated with chart nodes. The pick mechanism follows the Java listener pattern.

The class that is to handle the pick events implements the `com.imsl.chart.PickListener` interface. This requires the implementation of the method `pickPerformed(PickEvent)`.

The PickListener is then added to a chart node, using the node’s `addPickListener` method.

A pick is fired by calling the method `pick(MouseEvent)` in the top-level Chart node. Normally this is done in response to a mouse click. Mouse clicks can be detected by implementing the MouseListener interface and adding it to the chart’s container.

Example

In this example, when a bar is clicked it toggles its color between blue and red.

A MouseListener is implemented as an inner class. Its `mouseClicked` method calls `chart.pick(MouseEvent)`.

The class SamplePick implements the PickListener interface. It is not an inner class only because of the size of the `pickPerformed` method. The pick listener is added to the chart node bar. This means that it is active for that node and its children but is not active for the axes and other nodes.

```
import com.imsl.chart.*;
import java.awt.Color;

public class SamplePick extends JFrameChart implements PickListener {
    static private final double x[] = {0, 1, 2, 3};
    static private final double y[] = {4, 1, 2, 5};

    public SamplePick() {
        // Create a bar chart
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        Bar bar = new Bar(axis, x, y);
        bar.setBarType(Bar.BAR_TYPE_VERTICAL);
        bar.setLabels(new String[]{"A","B","C"});
        bar.setFillColor(Color.blue);

        // Add the pick listener to the bar
        bar.addPickListener(this);

        // Add the mouse listener
        addMouseListener(new java.awt.event.MouseAdapter() {
            public void mouseClicked(java.awt.event.MouseEvent event) {
                getChart().pick(event);
            }
        });
    }

    public void pickPerformed(PickEvent event) {
        // Track the number of hits on this bar
        ChartNode node = event.getNode();
        int count = node.getIntegerAttribute("pick.count", 0);
        count++;
        node.setAttribute("pick.count", new Integer(count));

        // Change the bar's color depending on the number of times
        // it has been picked.
        Color color = ((count%2==0) ? Color.blue : Color.red);
```

```
        node.setFillColor(color);
        node.setLineColor(color);
        repaint();
    }

    public static void main(String argv[]) {
        new SamplePick().setVisible(true);
    }
}
```

Zoom

JMSL provides the functionality to implement a variety of zoom policies instead of implementing a single specific zoom policy. The following example shows how to build a zoom policy that draws a rubber-band box in a scatter plot and zooms both the *x*-axis and *y*-axis to correspond to the region selected. Zoom out is also implemented.

This code can be used as the basis of an implementation of other zoom policies. For example, with a function plot one might want to only change the x-axis in response to a zoom and leave the y-axis alone. In other situations it may be desirable to zoom in or out a fixed amount around the location of a mouse click.

Example

In the constructor:

- A scatter plot is created,
- Zoom items are added to the main menu,
- A MouseListener is added to the panel. A JFrameChart contains a number of components, including a JPanel in which the chart is drawn. *It is important that the MouseListener be added to the component in which the chart is drawn*, so that the MouseEvent coordinates are the same as the device coordinates of the chart.

A mouse press event starts the zoom. In response to the event a MouseMotionListener is added to the panel to listen for mouse drag events. The location of this initial event is also recorded.

A mouse drag event resizes the area of the zoom. In response, the old rubber-band box is erased and a new box is drawn. The new box has the initial mouse press location as one corner and this drag event location as the opposite corner. The location of this event is stored in (`xLast`,`yLast`).

api/com/imsl/chart/Axis.html#mapDeviceToUser(int, int, double[])

A mouse release event completes the zoom. In response,

- The MouseMotionListener is removed from the panel,
- The existing Window attributes for the *x*-axis and *y*-axis are saved on a stack. They may be used later to zoom out.
- The new Window is computed. The Window is the range, in user coordinates, along an axis. The method `Axis.mapDeviceToUser` is used to map the device (pixel) coordinates to the user coordinate space. The new windows are constrained to be inside of the existing window.
- Autoscaling is turned off, so that the new Window values will be used without further modification.
- The chart is redrawn with the new windows.

The menu items, added by the constructor to the main menu, can be used to zoom out. The added menu items added `"this"` as an ActionListener, so the `actionPerformed` method is called when these menu items are selected. The `actionPerformed` method implements `"Out"` by popping previous Window attribute values off a stack. It implements `"Restore"` by re-enabling autoscaling.

```
import com.imsl.chart.*;
import java.awt.*;
import java.awt.event.*;
import java.util.Stack;
import javax.swing.JMenu;
import javax.swing.JMenuItem;

public class SampleZoom extends JFrameChart
              implements MouseListener, MouseMotionListener, ActionListener {
    private javax.swing.JPanel panel;
    private AxisXY  axis;
    private int     xFirst, yFirst;
    private int     xLast, yLast;
    private Stack   stack;

    public SampleZoom() {
        // create a scatter plot with some random points
        Chart chart = getChart();
        axis = new AxisXY(chart);
        int n = 1000;
        double x[] = new double[n];
        double y[] = new double[n];
        for (int k = 0;  k < n;  k++) {
            x[k] = 10.*Math.random();
            y[k] = 10.*Math.random();
        }
```

```
        Data data = new Data(axis, x, y);
        data.setDataType(Data.DATA_TYPE_MARKER);

        // add menu "Zoom" menu
        JMenu jMenuZoom = new JMenu("Zoom");
        jMenuZoom.setMnemonic('Z');
        addMenuItem(jMenuZoom, "Out");
        addMenuItem(jMenuZoom, "Restore");
        getJMenuBar().add(jMenuZoom);

        // save x-axis and y-axis Window attributes on this stack.
        // they are used to zoom out one level.
        stack = new Stack();

        // listen for mouse press events
        panel = getPanel();
        panel.addMouseListener(this);
    }

    /**
     *  Add a menu item
     */
    private void addMenuItem(JMenu jMenuZoom, String title) {
        JMenuItem jMenuItem = new JMenuItem(title);
        jMenuItem.setActionCommand(title);
        jMenuItem.setMnemonic(title.charAt(0));
        jMenuZoom.add(jMenuItem);
        jMenuItem.addActionListener(this);
    }

    /**
     *  A mouse press starts the zoom
     *  Record location of this point and listen for drag (motion) events.
     */
    public void mousePressed(MouseEvent event) {
        xFirst = xLast = event.getX();
        yFirst = yLast = event.getY();
        panel.addMouseMotionListener(this);
    }

    /**
     *  A mouse release ends the zoom.
     *  Stop listening for drag events and update the
     *  Window attribute in the x and y axes.
     */
    public void mouseReleased(MouseEvent event) {
        panel.removeMouseMotionListener(this);

        // ignore degenerate zooms
```

```
        if (xFirst==xLast || yFirst==yLast) {
            repaint();
            return;
        }

        // get window and convert to user coordinates
        double windowX[] = (double[])axis.getAxisX().getWindow();
        double windowY[] = (double[])axis.getAxisY().getWindow();

        // save the windows on the stack (for zoom out option)
        stack.add(windowX);
        stack.add(windowY);

        // get user coordinate of left-upper corner of the box
        // limit it to stay inside current window
        double boxLU[] = new double[2];
        int x = Math.min(xFirst, xLast);
        int y = Math.min(yFirst, yLast);
        axis.mapDeviceToUser(x, y, boxLU);

        // get user coordinate of right-lower corner of the box
        // limit it to stay inside current window
        double boxRL[] = new double[2];
        x = Math.max(xFirst, xLast);
        y = Math.max(yFirst, yLast);
        axis.mapDeviceToUser(x, y, boxRL);

        // set axis window to range of rubber-band box
        // and disable autoscale to force use of window settings
        axis.setAutoscaleInput(ChartNode.AUTOSCALE_OFF);
        double xa = Math.max(windowX[0], boxLU[0]);
        double xb = Math.min(windowX[1], boxRL[0]);
        double ya = Math.max(windowY[0], boxRL[1]);
        double yb = Math.min(windowY[1], boxLU[1]);
        axis.getAxisX().setWindow(xa, xb);
        axis.getAxisY().setWindow(ya, yb);

        // force redraw of the chart
        repaint();
    }

    /**
     *  A drag event continues the zoom.
     *  Erase the old rubber-band box and draw a new one.
     *  Also keep track of the location of this event.
     */
    public void mouseDragged(MouseEvent event) {
        // erase previous rectangle
        Graphics g = panel.getGraphics();
```

```
        g.setXORMode(Color.cyan);  // complement of drawing color red
        drawBox(g);

        // draw new rectangle
        xLast = event.getX();
        yLast = event.getY();
        g.setPaintMode();
        g.setColor(Color.red);
        drawBox(g);
    }

    public void mouseMoved(MouseEvent event) {}
    public void mouseEntered(MouseEvent event) {}
    public void mouseClicked(MouseEvent event) {}
    public void mouseExited(MouseEvent event) {}

    /**
     *  Draw a box with (xFirst,yFirst) and (xLast,yLast) as its corners.
     */
    private void drawBox(Graphics g) {
        int x = Math.min(xFirst, xLast);
        int y = Math.min(yFirst, yLast);
        int w = Math.abs(xLast - xFirst);
        int h = Math.abs(yLast - yFirst);
        g.drawRect(x, y, w, h);
    }

    /**
     *  Handle menu item events.
     *  Command "Out" zooms out one level.
     *  Command "Restore" undoes all zooms.
     */
    public void actionPerformed(ActionEvent actionEvent) {
        String command = actionEvent.getActionCommand();
        if (command.equals("Out")) {
            try {
                // zoom out by restoring window settings from the stack
                axis.getAxisY().setWindow((double[])stack.pop());
                axis.getAxisX().setWindow((double[])stack.pop());
            } catch (java.util.EmptyStackException e) {
                // no more levels to zoom out
                // restore original setting by turning on autoscale
                axis.setAutoscaleInput(ChartNode.AUTOSCALE_DATA);
            }
        } else if (command.equals("Restore")) {
           // restore original setting by turning on autoscale an empty stack
            axis.setAutoscaleInput(ChartNode.AUTOSCALE_DATA);
            stack.empty();
        }
```

```
        // force redraw of the chart
        repaint();
    }

    public static void main(String argv[]) {
        new SampleZoom().setVisible(true);
    }
}
```

Printing

Printing from JFrameChart

The JFrameChart class, used to build most of the examples in this manual, includes a print option under the file menu. This option prints the chart as large as possible, without distortion, and centered on the page.

Printable Interface

The Java Printable interface is used to print a single page from Java. It is implemented by the class Chart. The following code fragment shows how to print a chart using its Printable interface and PrinterJob.

```
public void print() {
        PrinterJob printJob = PrinterJob.getPrinterJob();
        printJob.setPrintable(chart);
        if (printJob.printDialog()) {
            try {
                printJob.print();
            } catch (Exception ex) {
                ex.printStackTrace();
            }
        }
    }
```

The `PrinterJob.printDialog()` method displays a dialog box that may contain a "Property Sheet." This property sheet is supplied by the hardware printer driver, not by Java. User changes to property sheet values are not reflected back to Java. Specifically, while a property sheet may allow the user to select landscape or portrait mode, these settings are not reflected back to the PrinterJob object. The correct way to set the orientation is by using the `PrinterJob.pageDialog(PageFormat)` method. For more details see bug report 4311283 on Sun's Java site.

Pageable

The Java Pageable interface is used to print a complex document from Java. The method `Chart.paintChart(Graphics)` can be used to implement a Pageable interface. The following method is the implementation of the Printable interface in Chart. It uses the method `Chart.paintChart(Graphics)`.

Note that the chart is drawn to fit the Component associated with the chart. The `getScreenSize` method returns the size of this component. The following method scales the drawing to compensate for the difference in size between the screen and the paper.

```
    public int print(Graphics graphics, PageFormat pageFormat,
                     int param)
         throws PrinterException {
    if (param >= 1)  return Printable.NO_SUCH_PAGE;

    // translate, so we do not clip on the left
    // scale to fill the page

    graphics.translate((int)pageFormat.getImageableX(),
         (int)pageFormat.getImageableY());

    // scale to fill the page
    double dw = pageFormat.getImageableWidth();
    double dh = pageFormat.getImageableHeight();
    Dimension screenSize = getScreenSize();
    double xScale = dw / screenSize.width;
    double yScale = dh / screenSize.height;
    double scale = Math.min(xScale,yScale);

    // center the chart on the page
    double tx = 0.0;
    double ty = 0.0;
    if (xScale > scale) {
        tx = 0.5*(xScale-scale)*screenSize.width;
    } else {
        ty = 0.5*(yScale-scale)*screenSize.height;
    }
    ((Graphics2D)graphics).translate(tx, ty);
    ((Graphics2D)graphics).scale(scale, scale);

    Dimension bounds = new Dimension((int)dw,(int)dh);
    paint(new Draw(graphics,bounds));
    return Printable.PAGE_EXISTS;
}
```

Serialization

The chart tree can be serialized into a stream of bytes and recreated from that stream.

Serialization is used for lightweight persistence and for communication via sockets or Remote Method Invocation (RMI). See Sun's Java Web site (http://java.sun.com/j2se/1.3/docs/guide/serialization/) for more details about serialization in general.

Serialization of JMSL classes may not be compatible with future JMSL releases. The current serialization support is appropriate for short term storage or RMI between applications running the same version of JMSL.

To serialize a chart tree, create an ObjectOutputStream and then use its `writeObject` method to write out the Chart object. The chart tree can be reconstructed from the stream by creating a ObjectInputStream and using its `readObject` method to read the Chart object.

The chart tree cannot be serialized if it contains any non-serializable objects, such as attribute values. All of the JMSL chart nodes are serializable. Image objects are not serializable, but ImageIcon objects are serializable. Standard Java Paint objects, such as TexturePaint objects, are not serializable. But the Paint objects generated by the JMSL class FillPaint are serializable.

Example

When the following code is executed without any arguments, it creates a chart and serializes it to the file `sample.dat`. When it is executed with the single argument `-read`, it reads the file `sample.dat` and recreates the tree.

```
import com.imsl.chart.*;
import java.io.*;
import java.awt.*;
import javax.swing.ImageIcon;

public class SampleSerialization extends JFrameChart {

    private void createChart() {
        Chart chart = getChart();
        AxisXY axis = new AxisXY(chart);
        chart.getBackground().setFillType(ChartNode.FILL_TYPE_PAINT);
        Paint paint = FillPaint.checkerboard(24, Color.yellow, Color.orange);
        chart.getBackground().setFillPaint(paint);
        double y[] = {4, 6, 2, 1, 8};
```

```
        Data data = new Data(axis, y);
        data.setDataType(Data.DATA_TYPE_LINE);
        data.setLineColor("blue");
     }

    static private java.awt.Image loadImage(String name) {
        return new ImageIcon(Data.class.getResource(name)).getImage();
    }

    private void writeChart() throws IOException {
        FileOutputStream fos = new FileOutputStream("sample.dat");
        ObjectOutputStream oos = new ObjectOutputStream(fos);
        oos.writeObject(getChart());
        oos.flush();
        fos.close();
    }


    private Chart readChart() throws IOException, ClassNotFoundException {
        FileInputStream fis = new FileInputStream("sample.dat");
        ObjectInputStream ois = new ObjectInputStream(fis);
        Chart chart = (Chart)ois.readObject();
        fis.close();
        return chart;
    }

    public static void main(String argv[]) throws Exception {
        if (argv.length == 0) {
            SampleSerialization sample = new SampleSerialization();
            sample.createChart();
            sample.writeChart();
            System.exit(0);
        } else if (argv[0].equals("-read")) {
            SampleSerialization sample = new SampleSerialization();
            Chart chart = sample.readChart();
            sample.setChart(chart);
            sample.setVisible(true);
        } else {
            System.out.println("usage: java SampleSerialization [-read]");
        }
    }
}
```

Appendix A: Web Server Application

A JMSL chart can be returned as an image from a Web server using a servlet. The mechanism depends on the version of the Java runtime library being used.

With JDK 1.4 or later, images are rendered using the standard Java class javax.imageio.ImageIO. This class can be used on a headless server—that is, a server running without graphical interfaces. While most desktop Unix systems run the X Windows System, Unix servers are often run without it. Java runs in a headless mode if the system property `java.awt.headless` is set to `true`.

With JDK 1.3 or earlier, the ImageIO class cannot be used because it does not exist in older versions of Java. Instead the Java Advanced Imaging (JAI) Toolkit is used. *JAI is not included with JMSL.* It is a standard Java extension that can be downloaded, for free, from Sun's JAI download site. Also, it requires that *a windowing system must be running*. With Microsoft Windows this is not usually a problem. A headless server cannot be used; on Unix, X Windows, or its equivalent, must be running.

Overview—Web Servlets

Java Server Pages (JSP) and servlets are the standard mechanism for adding Java functionality to Web servers.

Adding charts to a Web page is complicated by the fact that in response to a request a Web server can return *either* a text HTML page *or* a bitmap image. The response to the initial request is an HTML page that contains an image tag. When the browser parses the HTML page and finds the image tag, it makes a second request to the Web server. The Web server then returns the bitmap image in response to this second request.

The JMSL classes JspBean and ChartServlet are used to coordinate this process. During the first request, one or more JMSL chart trees are constructed and stored in the HttpSession object, obtained from the HttpServletRequest object, using the

method `JspBean.registerChart`. The method `Jsp.getImageTag` is used to construct an HTML image tag with an identifier for the chart in the session object. This image tag refers to the servlet ChartServlet. The second browser request is therefore directed to the ChartServlet, which uses the identifier to retrieve the chart from the session object. The Java Advanced Imaging library is used by the servlet to render the chart as a PNG image, which is returned to the browser.

The use of the session object to hold the chart requires that the user's browser allow cookies, used to track sessions across requests.

Generating a Chart with a JSP

This example consists of a JSP working with a bean (`pieChart`) that contains a JspBean. The HTML image tag is the value of the `imageTag` property from `pieChart`. The following is the JSP.

```
 1  <%@page contentType="text/html"%>
 2  <jsp:useBean id="pieChart" scope="page" class="SampleChartBean"/>
 3  <html>
 4  <head><title>Pie Chart</title></head>
 5  <body>
 6  <h1>Pie Chart</h1>
 7  <jsp:setProperty name="pieChart"  property="*"/>
 8  <% pieChart.createChart(request); %>
 9  <jsp:getProperty name="pieChart"  property="imageTag"/>
10  </body>
11  </html>
```

In the above JSP, line 1 flags that an HTML page is being generated. Line 2 creates the object `pieChart`, which is an instance of SampleChartBean. This object has page scope, so it is discarded after the page has been generated. Line 7 sets attributes in `pieChart` using parameters in the request. Attributes are set in pieChart using its setter methods, following the usual pattern for Java beans. Line 8 calls the `createChart` method to create the chart tree and store it in the session. This is Java code enclosed in the special delimiters. Line 9 inserts the HTML image tag obtained by calling `pieChart.getImageTag()`.

The class SampleChartBean uses a JspBean. It creates a pie chart and registers it with the session obtained from the request. The `getImageTag()` method returns an HTML tag which refers to the ChartServlet servlet that returns the chart image to the browser.

```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleChartBean {
    private JspBean bean;

    public SampleChartBean() {
        bean = new JspBean();
        bean.setSize(300, 300);
    }

    public void createChart(javax.servlet.http.HttpServletRequest request) {
        Chart chart = new Chart();
        bean.registerChart(chart, request);

        double y[] = {35., 20., 30., 40.};
        Pie pie = new Pie(chart, y);
        pie.setLabelType(pie.LABEL_TYPE_TITLE);
        pie.setFillOutlineColor(Color.blue);

        PieSlice[] slice = pie.getPieSlice();

        slice[0].setFillColor(Color.red);
        slice[0].setTitle("Red");

        slice[1].setFillColor(Color.blue);
        slice[1].setTitle("Blue");
        slice[1].setFillOutlineColor(Color.yellow);

        slice[2].setFillColor(Color.black);
        slice[2].setTitle("Black");
        slice[2].setExplode(0.3);

        slice[3].setFillColor(Color.yellow);
        slice[3].setTitle("Yellow");
    }

    public String getImageTag() {
        return bean.getImageTag();
    }
}
```

Generating Charts with Client-side Imagemaps

Client-side image maps allow regions of an image to be linked to a URL. Clicking on such a region behaves the same as clicking on a hypertext link. This can be used to create a degree of interactivity. Target regions are created for chart nodes that have the HREF attribute defined.

In this example the sample pie chart as above is generated, but now when the user clicks on a slice the selected slice is exploded out. Now `pieChart` is an instance of `SampleImageBean`. The JSP gets the `pieChart`'s imageMap property to create a map tag in the HTML code.

```
<%@page contentType="text/html"%>
<jsp:useBean id="pieChart" scope="page" class="SampleImagemapBean" />
<html>
<head><title>Pie Chart Imagemap</title></head>
<body>
<h1>Pie Chart Imagemap</h1>
<jsp:setProperty name="pieChart"  property="*"/>
<% pieChart.createChart(request); %>
<jsp:getProperty name="pieChart"  property="imageMap"/>
<jsp:getProperty name="pieChart"  property="imageTag"/>
</body>
</html>
```

The code for `SampleImagemapBean` is similar to the code for the previous `SampleChartBean`, but with the HREF attribute defined in each slice. The reference is back to `SampleImagemapJSP`, but with the explode parameter defined. The second change is the addition of a setter method for explode. The line

```
<jsp:setProperty name="pieChart" property="*"/>
```

in the JSP file sets properties in the pieChart from parameters in the request. If explode is defined in the HTTP request, then the JSP calls this setter method.

```
import com.imsl.chart.*;
import java.awt.Color;

public class SampleImagemapBean extends JspBean {
    private JspBean bean;
    private int     explode;

    public SampleImagemapBean() {
        bean = new JspBean();
        bean.setSize(300,300);
        bean.setCreateImageMap(true);
```

```
 }

public void createChart(javax.servlet.http.HttpServletRe-
quest request) {
     Chart chart = new Chart();

     double y[] = {35., 20., 30., 40.};
     Pie pie = new Pie(chart, y);
     pie.setLabelType(pie.LABEL_TYPE_TITLE);
     pie.setFillOutlineColor(Color.blue);

     PieSlice slice[] = pie.getPieSlice();

     slice[0].setFillColor(Color.red);
     slice[0].setTitle("Red");

     slice[1].setFillColor(Color.blue);
     slice[1].setTitle("Blue");
     slice[1].setFillOutlineColor(Color.yellow);

     slice[2].setFillColor(Color.black);
     slice[2].setTitle("Black");

     slice[3].setFillColor(Color.yellow);
     slice[3].setTitle("Yellow");

     for (int k = 0;  k < slice.length;  k++) {

slice[k].setHREF("SampleImagemapJSP.jsp?explode="+k);
     }

     try {
         slice[explode].setExplode(0.3);
     } catch (Exception e) {
         // ignore out of range values for explode
     }

     bean.registerChart(chart, request);
 }



 public void setExplode(int explode) {
     this.explode = explode;
```

```
    }

    public String getImageTag() {
        return bean.getImageTag();
    }

    public String getImageMap() {
        return bean.getImageMap();
    }
}
```

Servlet Deployment

A Web server that supports Java servlets will generally have a directory of Web applications, one per directory. In each Web application subdirectory there can be a WEB-INF directory containing the Java classes. This directory contains the subdirectory classes, containing individual class files, and the subdirectory lib, containing JAR files. For the above example, the file structure would be as follows:

```
webapps/
    application_name/
        SampleChartJSP.jsp
        SampleImagemapJSP.jsp
        WEB-INF/
            web.xml
            classes/
                SampleChartBean.class
                SampleImagemapBean.class
            lib/
                jmsl.jar
                jai_core.jar
                jai_codec.jar
```

The file `jmsl.jar` contains the JMSL classes. The files `jai_core.jar` and `jai_codec.jar` contain the JAI classes.

Appendix B: Writing a Chart as a Bitmap Image File

A JMSL chart can be saved as an image file in two ways: either using the Java `ImageIO` class or the Java Advanced Imaging (JAI) API.

Using the ImageIO Class

The `ImageIO` class was added to Java in JDK1.4. The JAI, descibed in the next section, can be used with older versions of Java.

The chart tree is constructed in the usual manner. Here a method called `createChart` is used to create a simple chart, with the null-argument Chart constructor.

The bitmap is generated by creating a BufferedImage object and painting the chart into the buffered image using the graphics object from the buffered image. The buffered image is written to a file using the `ImageIO.write` method.

This method of creating bitmaps does not require that a windowing system be running. The argument -`Djava.awt.headlesss=true` can be used with the java command from JDK1.4, or later, to run Java in a "headless" mode.

```
import com.imsl.chart.*;
import java.awt.image.BufferedImage;
import java.io.File;

public class SampleImageIO {
    public static void main(String argv[]) throws java.io.IOException {
        Chart chart = createChart();
        chart.setScreenSize(new java.awt.Dimension(500,500));

        BufferedImage bi = new BufferedImage(500, 500,
BufferedImage.TYPE_4BYTE_ABGR_PRE);
        chart.paintChart(bi.createGraphics());
```

```
        File file = new File("SampleImageIO.png");
        javax.imageio.ImageIO.write(bi, "PNG", file);
    }


    static Chart createChart() {
        Chart chart = new Chart();
        AxisXY axis = new AxisXY(chart);

        int  npoints = 20;
        double dx = .5 * Math.PI/(npoints-1);
        double x[] = new double[npoints];
        double y[] = new double[npoints];

        //  Generate some data
        for (int i = 0; i < npoints; i++){
            x[i] = i * dx;
            y[i] = Math.sin(x[i]);
        }
        new Data(axis, x, y);
        return chart;
    }
}
```

Using the Java Advanced Imaging API

A JMSL chart can be saved as an image file by generating a java.awt.Image object and then rendering the image using the Java Advanced Imaging (JAI) API. The example below shows the steps needed.

JAI is not included with JMSL Numerical Library. It is a standard Java extension that can be downloaded, for free, from Sun's JAI download site.

The first step is to create a java.awt.Frame object. A Frame object is required because the implementation of the drawing code is based on the code used to write to the screen. Because a Frame object is required, *a windowing system must be running* on the system. The size of the frame, here 500 by 500, determines the size of the bitmap image.

The chart tree is then constructed in the usual manner. Here a method called `createChart` is used to create a simple chart, with the Frame object passed to the Chart constructor.

An Image object is created using the `paintImage` method in Chart.

The `create` method in `javax.media.jai.JAI` can now be used to generate the file. The first call (with `AWTImage`) is used to generate a JAI object from the AWT Image object. The second call (with `filestore`) actually writes the file. In this case we write a PNG format file called `SampleJai.png`. `JAI` can be used to generate image files in other formats, but PNG is usually the best for charts.

The last step is to exit explicitly. The program does not automatically exit because of the existence of a user thread, implicitly created to handle the frame.

```
import com.imsl.chart.*;
import java.awt.*;
import javax.media.jai.*;

public class SampleJai {
    public static void main(String argv[]) {
        Frame frame = new Frame();
        frame.show();
        frame.setSize(500, 500);
        frame.setVisible(false);
        Chart chart = createChart(frame);

        Image image = frame.createImage(500, 500);
        chart.paintChart(image.getGraphics());
        RenderedOp im = JAI.create("AWTImage", image);
        JAI.create("filestore", im,  "SampleJai.png", "PNG");
        System.exit(0);
    }


    static Chart createChart(Component component) {
        Chart chart = new Chart(component);
        AxisXY axis = new AxisXY(chart);

        int  npoints = 20;
        double dx = .5 * Math.PI/(npoints-1);
        double x[] = new double[npoints];
        double y[] = new double[npoints];

        //  Generate some data
        for (int i = 0; i < npoints; i++){
            x[i] = i * dx;
            y[i] = Math.sin(x[i]);
        }
        new Data(axis, x, y);
        return chart;
    }
}
```

Using the Scalable Vector Graphics (SVG) API

Scalable Vector Graphics (SVG) is an XML vocabulary for vector graphics.

JMSL's SVG support is based on the Apache Batik toolkit. *Batik is not included with JMSL Numerical Library.* It can be downloaded, for free, from the Apache Batik site. The `batik.jar` file needs to be added to the CLASSPATH.

Once `batik.jar` is installed, a JMSL chart can be saved as an SVG file by using the `Chart.writeSVG` method.

SVG can also be create from a `JFrameChart` window. Its File | SaveAs menu allows the chart to be saved as either a PNG image or as an SVG file. The PNG option is active only if J2SE 1.4 or later is being used, or if the JAI classes are in the CLASSPATH. The SVG option is active only if `batik.jar` is in the CLASSPATH.

The following example generates SVG output:

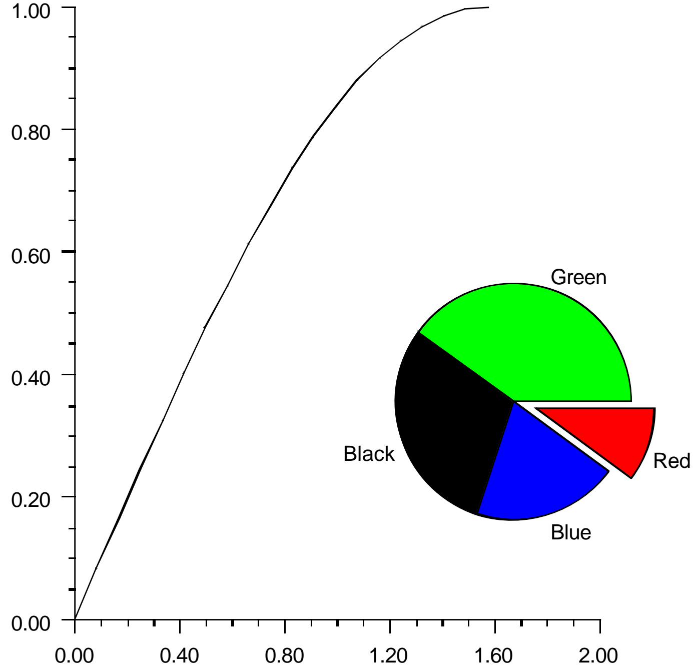
NOTE: The output encoding format is set to UTF-8. This is done because SVG renders do not support all encodings. The UTF-8 is the most general encoding.

```
import com.imsl.chart.*;
import java.io.*;
import java.awt.*;

public class SampleSVG {
    public static void main(String argv[]) throws java.io.IOException {
        Frame frame = new Frame();
        frame.show();
        frame.setSize(500, 500);
        frame.setVisible(false);
        Chart chart = createChart(frame);

        OutputStream os = new FileOutputStream("SampleSVG.svg");
        Writer writer = new OutputStreamWriter(os, "UTF-8");
        chart.writeSVG(writer, true);

        System.exit(0);
    }


    static Chart createChart(Component component) {
        Chart chart = new Chart(component);
        AxisXY axis = new AxisXY(chart);
```

```
        int  npoints = 20;
        double dx = .5 * Math.PI/(npoints-1);
        double x[] = new double[npoints];
        double y[] = new double[npoints];

        //  Generate some data
        for (int i = 0; i < npoints; i++){
            x[i] = i * dx;
            y[i] = Math.sin(x[i]);
        }
        new Data(axis, x, y);
        return chart;
    }
}
```

Appendix C: Picture-in-Picture

The picture-in-picture effect can be obtained by using the Viewport attribute. This sets the fraction of the screen into which the chart is to be drawn. The Viewport attribute's value is a `double[4]` containing {*xmin, xmax, ymin, ymax*}, on a [0,1] by [0,1] grid with (0,0) at the top-left.



This chart tree for the above picture consists of a chart with an AxisXY child and a Pie child. (The Pie class is a subclass of Axis.) The viewport attribute of the Pie node is set to a non-default value.

```
import com.imsl.chart.*;
import java.awt.Color;

public class SamplePnP extends JFrameChart {

    public SamplePnP() {
        Chart chart = getChart();
        createLineChart(chart);
        createPieChart(chart);
    }

    private void createLineChart(Chart chart) {
        AxisXY axis = new AxisXY(chart);

        intnpoints = 20;
        double dx = 0.5 * Math.PI/(npoints-1);
        double x[] = new double[npoints];
        double y[] = new double[npoints];
        for (int i = 0;  i < npoints;  i++){
            x[i] = i * dx;
            y[i] = Math.sin(x[i]);
        }
        new Data(axis, x, y);
    }

    private void createPieChart(Chart chart) {
        double y[] = {10., 20., 30., 40.};
        Pie pie = new Pie(chart, y);
        pie.setLabelType(pie.LABEL_TYPE_TITLE);
        pie.setViewport(0.5, 0.9, 0.3, 0.8);

        PieSlice[] slice = pie.getPieSlice();

        slice[0].setTitle("Red");
        slice[0].setFillColor(Color.red);
        slice[0].setExplode(.2);

        slice[1].setTitle("Blue");
        slice[1].setFillColor(Color.blue);
```

```
        slice[2].setTitle("Black");
        slice[2].setFillColor(Color.black);

        slice[3].setTitle("Green");
        slice[3].setFillColor(Color.green);
    }

    public static void main(String argv[]) {
        new SamplePnP().setVisible(true);
    }
}
```

JMSL CHART 3D

Programmer’s Guide

Part 2

Chapter 6: Introduction - Chart 3D

Java3D

The JMSL 3D chart package is built on top of Java 3D, an open source Java package which renders accelerated 3D graphics using OpenGL or Direct3D.

Java 3D Parent project is at https://java3d.dev.java.net/.

Knowledge of Java3D is not required to use the 3D chart package, but Java 3D must be installed to run a chart 3D application.

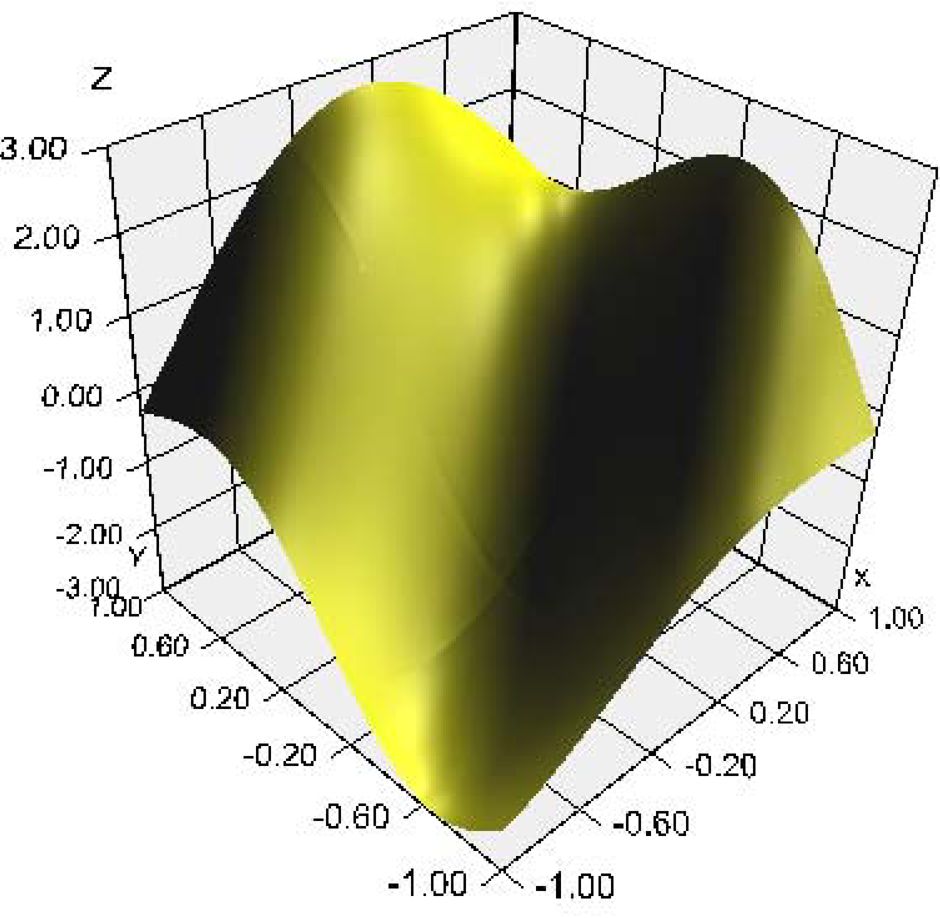
Overview

The JMSL 3D chart package can be used to create customizable 3D using Java and Java3D. Knowledge of Java3D is not required.

The JMSL 3D chart package is similar to the JMSL 2D chart package. In both, a chart is created by assembling chart nodes into a tree. This chart tree is then rendered to the screen.

The following class is a simple example of the use of the 3D chart package. It plots the function $z=2\sin(x+y)-\cos(2x-3y)$ over the square [-1,1] by [-1,1]. The chart is displayed in a Swing frame.

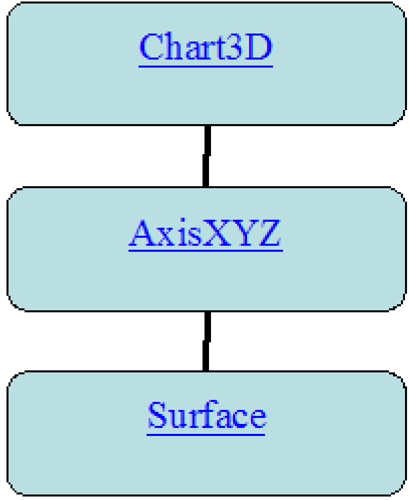
The class for this example extends the `JFrameChart3d` class which creates the root `Chart3D` node. A tree of chart nodes is then created starting from the `Chart3D` root node. After the tree is created, the render method is used to generate a Java 3D scene graph from the chart node tree. The scene graph is used to generate the image on the screen.




```
import com.imsl.chart3d.*;

public class SimpleSurface extends JFrameChart3D
        implements Surface.ZFunction {

    public SimpleSurface() {
        Chart3D chart = getChart3D();
        AxisXYZ axis = new AxisXYZ(chart);
        Surface surface =
            new Surface(axis, this, -1.0, 1.0, -1.0, 1.0);
        surface.setFillColor("yellow");
        surface.setSurfaceType(Surface.SURFACE_TYPE_NICEST);
        render();
```

```
    }

    public double f(double x, double y) {
        return 2*Math.sin(x+y) - Math.cos(2*x-3*y);
    }

    public static void main(String args[]) {
        new SimpleSurface().setVisible(true);
    }
}
```

The above example created and assembled three nodes into the following tree:



The general pattern of the `AbstractChartNode` class and derived classes have constructors whose first argument is the parent `AbstractChartNode` of the `AbstractChartNode` being created. The root node of the tree is always a `Chart3D` object.

Chart nodes can contain attributes, such as `FillColor` and `LineWidth`. Attributes are inherited via the chart tree. For example, when a `Surface` node is being painted, its `FillColor` attribute determines the color of the surface. If this attribute is set in the node being drawn, that is the value used. If it is not set, then its parent node (an AxisXYZ node in the above example) is queried. If the attribute is not set in the parent node, then its parent is queried. This continues until the root node is reached, after which a default value is used. Note that this inheritance is not the same as Java class inheritance.

Attributes are set using setter methods, such as `setFillColor(Color)` and retrieved using getter methods, such as `getFillColor()`.

Chart Movements

The mouse can be used to rotate, translate, or zoom a 3D chart.

Rotate

The chart is rotated when the mouse is moved with the main mouse button pressed. The rotation is in the direction of the mouse movement, with a rotation of 0.01 radians for each pixel of mouse movement.

Translate

The chart is translated when the mouse is moved with the right mouse button pressed (Shift-main mouse button on systems without a right mouse button). The translation is in the direction of the mouse movement, with a translation of 1% for each pixel of mouse movement.

The chart can also be translated using arrows keys (up, down, left, right). If the control key is also pressed, the motions are accelerated.

Zoom In or Zoom Out

The chart is zoomed when the mouse is moved with the middle mouse button pressed (or Alt-main mouse button on systems without a middle mouse button). The chart is zoomed by 1% for each pixel of mouse movement. Moving the mouse up moves the chart closer, moving the mouse down moves the chart further away.

The chart can also be zoomed using the plus ('+') or minus ('-') keys. The plus key zooms in and the minus key zooms out. If the control key is also pressed, the motions are accelerated.

Reset

Typing the Home key or the Equals ('=') key undoes any chart movements.

Chapter 7: Charting 3D Types

This chapter describes these JMSL 3D charting types:

- "Scatter Plot" on page 212
- "Tube Plot" on page 216
- "Surface Plot" on page 218

Scatter Plot

This section describes the construction of scatter charts. The markers can be formatted using the Marker Attributes (see page 79).

It is also possible to mix lines, tubes, markers and surfaces on a single chart (see "Marker Attributes" on page 224).

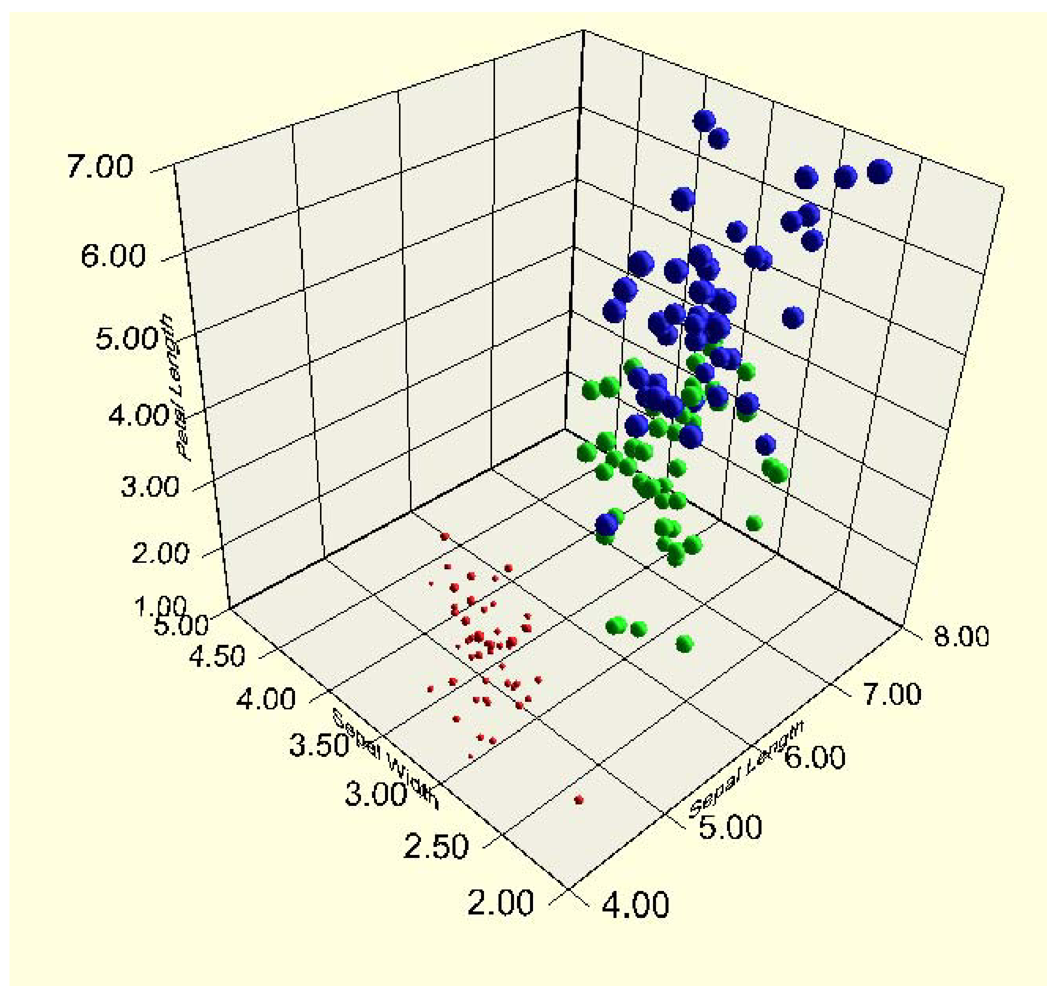
Fisher Iris Data Set

Fisher's Iris data set is read from a flat file and is charted. Each observation in this data set has five values: species, sepal length, sepal width, petal length, and petal width. The sepal length is mapped into the *x*-coordinate, the sepal width is mapped to the *y*-coordinate, and the petal length is mapped into the *z*-coordinate. The pedal width is mapped into the marker size. The species is mapped into the marker color.

```
import com.imsl.chart3d.*;
import com.imsl.io.FlatFile;
import java.awt.Color;
import java.io.*;
import java.sql.SQLException;
import java.util.StringTokenizer;

public class SampleFisherIris extends JFrameChart3D {
    private int species[];
    private double sepalLength[];
    private double sepalWidth[];
    private double petalLength[];
    private double petalWidth[];

   public SampleFisherIris() throws IOException, SQLException
   {
        read();

        Chart3D chart = getChart3D();
        chart.getBackground().setFillColor("lightyellow");
        AxisXYZ axis = new AxisXYZ(chart);
        axis.setAxisTitlePosition(axis.AXIS_TITLE_PARALLEL);

        axis.getAxisX().getAxisTitle().setTitle("Sepal 
   Length");
        axis.getAxisY().getAxisTitle().setTitle("Sepal 
   Width");
```

```
     axis.getAxisZ().getAxisTitle().setTitle("Petal
Length");

     axis.setDataType(Data.DATA_TYPE_MARKER);
     axis.setMarkerType(Data.MARKER_TYPE_SPHERE);
     String color[] = {"red", "green", "blue"};

     for (int k = 0;  k < species.length;  k++) {
         // marker type = Species
         // x = Sepal Length
         // y = Sepal Width
         // z = Petal Length
         // marker size = Petal Width
         double xp[] = {sepalLength[k]};
         double yp[] = {sepalWidth[k]};
         double zp[] = {petalLength[k]};
         Data data = new Data(axis, xp, yp, zp);
         data.setMarkerSize(Math.sqrt(petalWidth[k]));
         data.setMarkerColor(color[species[k]-1]);
     }
     setSize(800, 800);
     render();
 }

 void read() throws IOException, SQLException {
     InputStream is =
        getClass().getResourceAsStream("FisherIris.csv");
     FisherIrisReader fisherIrisReader =
         new FisherIrisReader(is);
     int nObs = 150;
     species = new int[nObs];
     sepalLength = new double[nObs];
     sepalWidth = new double[nObs];
     petalLength = new double[nObs];
     petalWidth = new double[nObs];
     for (int k = 0;  fisherIrisReader.next();  k++) {
         species[k] = fisherIrisReader.getInt("Species");
         sepalLength[k] =
             fisherIrisReader.getDouble("Sepal Length");
         sepalWidth[k] =
             fisherIrisReader.getDouble("Sepal Width");
         petalLength[k] =
             fisherIrisReader.getDouble("Petal Length");
         petalWidth[k] =
             fisherIrisReader.getDouble("Petal Width");
```

```
        }
    }

    static private class FisherIrisReader extends FlatFile {
        public FisherIrisReader(InputStream is)
            throws IOException {
            super(new BufferedReader(new
   InputStreamReader(is)));
            String line = readLine();
         StringTokenizer st = new StringTokenizer(line, ",");
            for (int j = 0;  st.hasMoreTokens();  j++) {
                setColumnName(j+1, st.nextToken().trim());
                setColumnClass(j, Double.class);
            }
        }
    }

    public static void main(String args[])
            throws IOException, SQLException {
        new SampleFisherIris().setVisible(true);
    }
}
```


7.00
6.00
5.00
4.00
3.00
2.00
1.00
Petal Length
5.00
4.50
4.00
3.50
3.00
2.50
2.00
Sepal Width
4.00
5.00
6.00
7.00
8.00
Sepal Length

Tube Plot

Lines are drawn as flat, non 3D elements. Tubes are drawn 3D versions of lines.

Spiral Example

A spiral is defined by the equations parameterized by:

$$t, 0 \le t \le 1$$

$$x(t) = (t + 0.6)\cos(8\pi t)$$

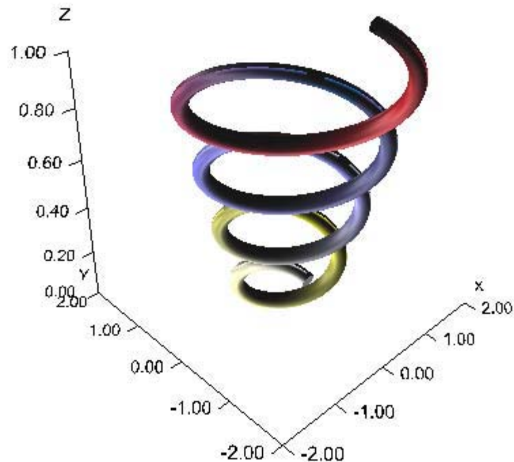
$$y(t) = (t + 0.6)\sin(8\pi t)$$

$$z(t) = t$$

The tube is shaded using the spectral color map from the 2D charting package.

```
import com.imsl.chart3d.*;
import java.awt.Color;

public class SampleSpiral extends JFrameChart3D implements
   ColorFunction {

    public SampleSpiral() {
        Chart3D chart = getChart3D();
        AxisXYZ axis = new AxisXYZ(chart);

        axis.getAxisBox().setPaint(false);

        int nSpiral = 400;
        double xSpiral[] = new double[nSpiral];
        double ySpiral[] = new double[nSpiral];
        double zSpiral[] = new double[nSpiral];
        for (int i = 0;  i < nSpiral;  i++) {
          double t = 8.0 * Math.PI * i / (double)(nSpiral-1);
           double r = 0.6 + (double)i / (double)(nSpiral-1);
            xSpiral[i] = r * Math.cos(t);
            ySpiral[i] = r * Math.sin(t);
            zSpiral[i] = (double)i / (double)(nSpiral-1);
        }
```

```
        Data spiral = new Data(axis, xSpiral, ySpiral, 
   zSpiral);
        spiral.setDataType(spiral.DATA_TYPE_TUBE);
        spiral.setLineWidth(2);
        spiral.setColorFunction(this);
        render();
    }

    public Color color(double x, double y, double z) {
        return com.imsl.chart.Colormap.SPECTRAL.color(z);
    }

    public static void main(String args[]) throws Exception {
        new SampleSpiral().setVisible(true);
    }
}
```



If the function is defined by a set of points, the points in the *xy*-plane are triangulated. The resulting 3D triangles are plotted.

Surface Plot

The surface class is used to draw a surface. Surfaces can be specified either by an interface defining a function over a rectangle or by a set of points in three dimensions.

If a function defined over a rectangle is used, the function is evaluated on a rectangular grid of points. The resulting quadrilaterals are plotted.

Shaded Surface

This example shades a surface with a user-specified function, instead of using shading. The same function is used as in the previous example:

$$z = 2\sin(x + y) - \cos(2x - 3y)$$

over the square [-1,1] by [-1,1].

The shade color function uses a `Colormap` object from the `com.imsl.chart` package. This maps a parameter to a color. In this example the surface is colored using the function

$$t = x^2 + y^2 + z^2.$$

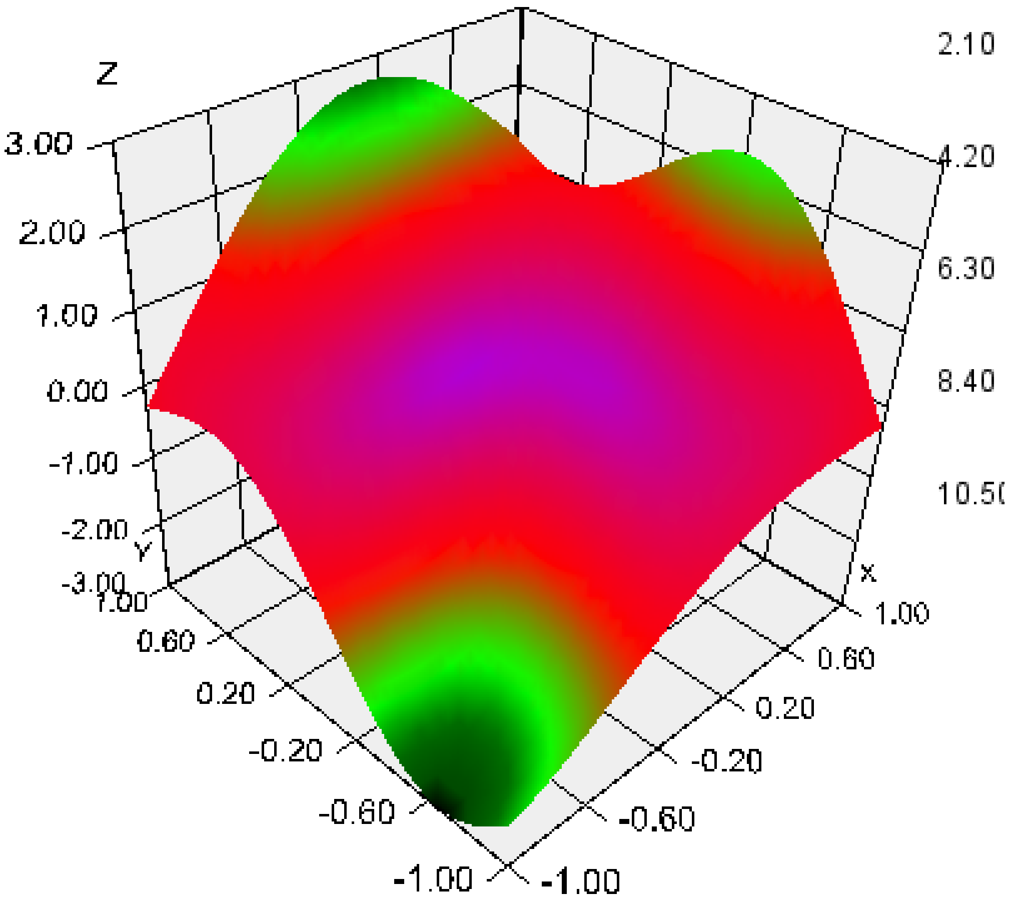
The function value is scaled to a colormap parameter using

$$s = t^{1/4} / 1.8.$$

The chart also includes a colormap legend, which is drawn on the background. It is positioned 5 pixels from the right edge and 5 pixels from the top edge of the canvas.

```
import com.imsl.chart3d.*;
import com.imsl.chart.Colormap;

public class SampleShadedSurface extends JFrameChart3D
        implements Surface.ZFunction, ColorFunction {

   private Colormap colormap = Colormap.GREEN_RED_BLUE_WHITE;

    public SampleShadedSurface() {
        Chart3D chart = getChart3D();
        AxisXYZ axis = new AxisXYZ(chart);
        Surface surface =
            new Surface(axis, this, -1.0, 1.0, -1.0, 1.0);
```

```
            surface.setColorFunction(this);
            surface.setSurfaceType(Surface.SURFACE_TYPE_NICEST);

            double maxColor = Math.pow(1.8,4);
            ColormapLegend colormapLegend =
                    new ColormapLegend(chart, colormap, 0.,
       maxColor);
            colormapLegend.setTitle("Color");
            colormapLegend.setPosition(-5, 5);
            render();
        }

        public double f(double x, double y) {
            return 2*Math.sin(x+y) - Math.cos(2*x-3*y);
        }

       public java.awt.Color color(double x, double y, double z) {
            double t = x*x + y*y + z*z ;
            double s = Math.pow(t, 0.25) / 1.8;
            return colormap.color(s);
        }

        public static void main(String args[]) {
            new SampleShadedSurface().setVisible(true);
        }
}
```


Z
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Y
1.00
0.60
0.20
-0.20
-0.60
-1.00
2.10
4.20
6.30
8.40
X
1.00
0.60
0.20
-0.20
-0.60
-1.00

Chapter 8: 3D Drawing Elements

This chapter discusses these JMSL Chart3D drawing elements:

- “Line Attributes” on page 222
- “Tube Attributes” on page 223
- “Marker Attributes” on page 224
- “Fill Attributes” on page 227
- “Text Attributes” on page 228
- “Labels” on page 230
- “AxisXYZ” on page 231

Line Attributes

All lines, except for those used to draw markers or outline filled regions are affected by the attributes described in this section. These include axis lines and lines drawn when a Data node is rendered with its DataType attribute having its DATA_TYPE_LINE bit set.

Attribute LineColor

LineColor is a Color-valued attribute that determines the color of the line. Its default value is `Color.black`.

Attribute ColorFunction

ColorFunction is a Color-valued method which maps spatial points to colors. If ColorFunction is not defined then the line is drawn with a solid color set by attribute LineColor.

Attribute LineWidth

LineWidth is a double-valued attribute that determines the thickness of the lines. Its default value is 1.0.

Tube Attributes

Tubes are three dimensional shaded lines. A data node is rendered as a tube if its DataType has its DATA_TYPE_TUBE bit set.

Attribute LineColor

LineColor is a Color-valued attribute that determines the color of the tube. Its default value is `Color.black`.

Attribute ColorFunction

ColorFunction is a Color-valued method which maps spatial points to colors. If ColorFunction is not defined then the tube is drawn with a solid color set by attribute LineColor.

Marker Attributes

Markers are drawn when a Data node is rendered with its DataType attribute having its DATA_TYPE_MARKER bit set. Drawing of markers is affected by the attributes described in this section. Note that when markers are drawn using lines, the line attributes do not apply to markers.

An alternative to markers are images, which can be used to draw arbitrary symbols instead of markers.

Attribute MarkerType

MarkerType is an integer-valued attribute that determines which marker will be drawn. There are constants defined in ChartNode3d for the marker types. The default value is MARKER_TYPE_CUBE. The following table defines marker types. For clarity, these are drawn larger than normal.

Marker Type	Description
`MARKER_TYPE_CUBE`	Cube with its edges outlined in a contrasting color.
`MARKER_TYPE_SIMPLE_CUBE`	Solid colored cube without edge outlining.
`MARKER_TYPE_SPHERE`	Shaded sphere
`MARKER_TYPE_TETRAHEDRON`	Tetrahedron with its edges outlined in a contrasting color.
`MARKER_TYPE_SIMPLE_TETRAHEDRON`	Solid colored tetrahedron without edge outlining.
`MARKER_TYPE_PLUS`	3D plus sign with its edges outlined in a contrasting color.
`MARKER_TYPE_SIMPLE_PLUS`	Solid 3D plus sign without edge outlining
`MARKER_TYPE_CUSTOM`	Marker defined by the user set using the attribute CustomMarkerFactory.

Attribute MarkerColor

MarkerColor is a Color-valued attribute that determines the color of the marker. Its default value is `Color.black`.

Attribute MarkerSize

MarkerSize is a double-valued attribute that determines the size of the marker. The default value is 1.0.

Attribute MarkerPulsingCycle

Cycle time, in seconds, for pulsing the marker. If this time is less than or equal to zero the marker is not pulsed. The default value is zero.

Attribute MarkerPulsingCycleOffset

Offset time, in seconds, from the time rendering begins to when the marker begins pulsing. This attribute allows different markers to pulse with different phases.

Attribute MarkerPulsingMinimumScale

The minimum marker size during a pulse cycle is the value of the MarkerPulsing-MinimumScale attribute times the value of the MarkerSize attribute.

Attribute MarkerPulsingMaximumScale

The maximum marker size during a pulse cycle is the value of the MarkerPulsing-MaximumScale attribute times the value of the MarkerSize attribute.

Attribute MarkerRotatingCycle

Cycle time, in seconds, for rotating the marker. If this time is less than or equal to zero the marker is not rotated. The default value is zero.

Attribute MarkerRotatingCycleOffset

Offset time, in seconds, from the time rendering begins to when the marker begins rotating. This attribute allows different markers to rotate with different phases.

Attribute MarkerRotatingAxis

A double[3] array containing the axis of rotation. The default is (0,0,1), the z-axis.

Fill Attributes

Attribute FillColor

FillColor is a Color-valued attribute that determines the color of a surface. The default value is `Color.black`.

Attribute ColorFunction

Colorfunction is a Color-valued function of position. The default is null. If both FillColor and ColorFunction are set, ColorFunction is used to color the surface.

Attribute Material

Material defines the appearance of an object under illumination. Its value is a `javax.media.j3d.Material`. Its default value is the Material object created with default parameters.

Text Attributes

Attribute FontName

FontName is a string-valued attribute that specifies the logical font name or a font face name. The default value is "SansSerif". Java always defines the font names “Dialog”, “DialogInput”, “Monospaced”, “Serif”, “SansSerif”, and “Symbol”. Depending on the system, additional font names may be defined.

Attribute FontSize

FontSize is an integer-valued attribute that specifies the point size of the font. The default value is 12.

Attribute FontStyle

FontStyle is an integer-valued attribute that specifies the font style. This can be a bitwise combination of `Font.PLAIN`, `Font.BOLD` and/or `Font.ITALIC`. The default value is `Font.PLAIN`.

Attribute TextColor

TextColor is a Color-valued attribute that specifies the color in which the text is drawn. The default value is `Color.black`.

Attribute TextFormat

TextFormat is a `java.text.Format`-valued or a String-valued attribute that specifies how to format string objects.

TextFormat can also be set using a String, which is used to generate a Format object when the attribute is accessed. The Format object is created using the value of locale in the chart node.

Some strings have special meanings (case is ignored in these strings):

- `"Date(SHORT)"` means use:
  `DateFormat.getDateInstance(SHORT, locale)`
- `"Date(MEDIUM)"` means use
  `DateFormat.getDateInstance(MEDIUM, locale)`

- `"Date(LONG)"` means use: `DateFormat.getDateInstance(LONG, locale)`
- `"Currency"` means use `NumberFormat.getCurrencyInstance(locale)`
- `"Percent"` means use: `NumberFormat.getPercentInstance(locale)`

If TextFormat has a string value that is not one of the above, then

`new DecimalFormat(`*value*`, new DecimalFormatSymbols(locale))`

is used. For example, if its value is `"0.00"`, then numbers will be formatted with exactly two digits after the decimal place. See DecimalFormat for a detailed description of these format patterns.

The default value of TextFormat is the value returned by the factory method `NumberFormat.getInstance(locale)`.

Labels

Labels annotate data points. As a degenerate case they can be used to place text on a chart without drawing a point. Labels are controlled by the value of the attribute LabelType in a Data node.

Multiline labels are allowed.

Attribute LabelType

The attribute LabelType takes on one of the following values:

- LABEL_TYPE_NONE for no label. This is the default.
- LABEL_TYPE_X label with the value of the *x*-coordinate.
- LABEL_TYPE_Y label with the value of the y-coordinate.
- LABEL_TYPE_Z label with the value of the z-coordinate.
- LABEL_TYPE_TITLE label with the value of the Title attribute.

AxisXYZ

The AxisXYZ node is the basis of both the scatter chart types and surface chart. Its parent node must be the root Chart3D node.

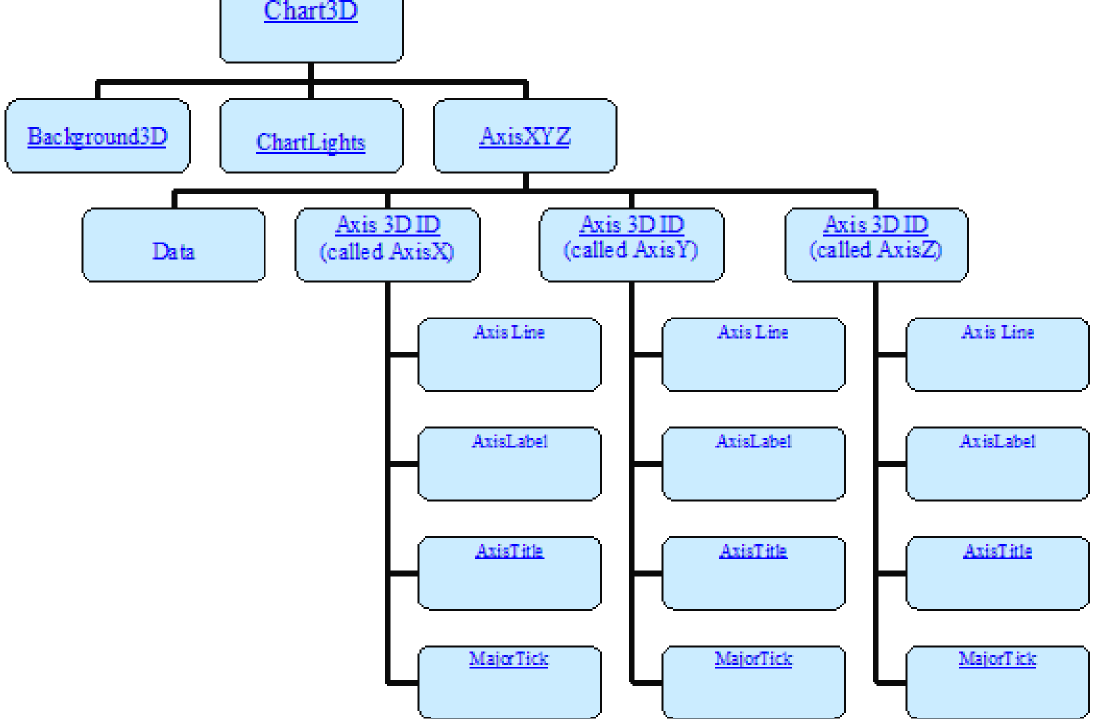
When an AxisXYZ node is created, it creates three Axis3D nodes. They can be obtained by using the methods `AxisXYZ.getAxisX()` and `AxisXYZ.getAxisY()` and `AxisXYZ.getAxisZ()`. Each of the Axis3D nodes in turn creates additional child nodes, as seen in the diagram below.

Accessor methods can be chained together, so the x-axis line can be retrieved using

```
axis.getAxisX().getAxisLine()
```

The code to set the *x*-axis line to blue is

```
axis.getAxisX().getAxisLine().setLineColor(Color.blue)
```



Axis Layout

The layout of an AxisXYZ chart is controlled by the attributes Window and Number.

Attribute Window

Window is a double array-valued attribute that contains the axis limits. Its value is (*min, max*).

Attribute Number

Number is an integer-valued attribute that contains the number of major tick marks along an axis.

Transform

The *x*-, *y*- and *z*-axes may be linear or logarithmic, as specified by the Transform attribute. This attribute can have the values:

- TRANSFORM_LINEAR indicating a linear axis. This is the default.
- TRANSFORM_LOG indicating a logarithmic axis.

Autoscale

Autoscaling is used to automatically determine the attribute Window (the range of numbers along an axis) and the attribute Number (the number of major tick marks). The goal is to adjust the attributes so that the data fits on the axes and the axes have "nice" numbers as labels.

Autoscaling is done in two phases. In the first ("input") phase the actual range is determined. In the second ("output") phase chart attributes are updated.

Attribute AutoscaleInput

The action of the input phase is controlled by the value of attribute AUTOSCALE_INPUT in the axis node. It can have one of three values.

- AUTOSCALE_OFF turns off autoscaling.
- AUTOSCALE_DATA scans the values in the Data nodes that are attached to the axis to determine the data range. This is the default value.
- AUTOSCALE_WINDOW uses the value of the Window attribute to determine the data range.

Attribute AutoscaleOutput

The value of the AUTOSCALE_OUTPUT attribute can be the bitwise combination of the following values.

- AUTOSCALE_OFF no attributes updated.
- AUTOSCALE_NUMBER updates the value of the Number attribute. This is the number of major tick marks along the axis.
- AUTOSCALE_WINDOW updates the value of the Window attribute. This is the range of numbers displayed along the axis.

The default is AUTOSCALE_NUMBER | AUTOSCALE_WINDOW; both the attributes Number and Window are adjusted.

Axis Label

The AxisLabel node controls the labeling of an axis. The drawing of this node is controlled by the Text Attributes (see page 228).

Scientific Notation

If the values along an axis are large, scientific notation is more readable than a decimal format with many zeros. See `java.text.DecimalFormat` for details on number formatting patterns.

Date Labels

If the TextFormat attribute for an axis is an instance of `DateFormat`, then the axis is scaled and labeled as a date/time axis, instead of as a real axis.

Date information passed to the Date constructor must be a double number representing the number of milliseconds since the standard base time known as "the epoch", namely January 1, 1970, 00:00:00 GMT. This is used by the constructor for Date.

String Labels

Any array of strings can be used to label the tick marks using the `setLabels(String[])` method. The `setLabels(String[])` method sets the Number attribute to the number of strings

Axis Title

The AxisTitle node controls the titling of an axis. The drawing of this node is controlled by the Text Attributes (see page 228).

Axes are titled with the value of the Title attribute in the AxisTitle node. By default, the titles are “X”, “Y” or “Z”.

Attribute AxisTitlePosition

This AxisTitlePosition controls the location of the axis tile. Its value is one of the following:

- AXIS_TITLE_AT_END positions the axis title at the end of the axis. When the chart is rotated the axis title text always faces the viewer.
- AXIS_TITLE_PARALLEL positions the axis title parallel to the axis. When the chart is rotated the axis title stays parallel to the axis.

Major Tick Marks

The node MajorTick controls the drawing of tick marks on an AxisXYZ.

The location of the major tick marks can be set explicitly, using the `Axis3D.setTicks(double[])` method. However, it is usually easier to allow autoscaling to automatically set the tick locations (see “Autoscale” on page 232).

Attribute TickLength

Tick marks can be made relatively longer or shorter by setting the attribute TickLength. Its default value is 1.0. If its value is negative, the tick marks are drawn in the opposite direction.

Attribute Number

Number is the number of major tick marks along an axis.

Attribute Ticks

The Ticks attribute, in an Axis3D node, contains the position of the major tick marks. If this attribute is not explicitly set, its value is computed from the attributes Number, Window and Transform.

Background

Background controls the drawing of the chart's background. It is created by Chart3D as its child. It can be retrieved from a Chart3D object using the `Chart3D.getBackground()` method.

The attribute FillColor is the only attribute which affects the background. The default value is FILL_TYPE_SOLID.

Lights

Lights are used in conjunction with the surface fill color to shade surfaces where no color is defined.

The ChartLights node is automatically created by the Chart3D node. It provides a default set of lights. As with any node, it can be disabled by setting its “Paint” attribute to false.

More control over lighting is possible by using lighting chart nodes. There are three types of light nodes:

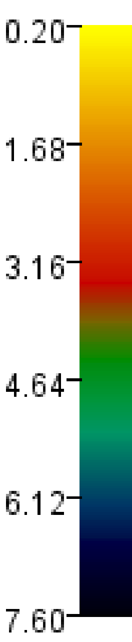
- AmbientLight is a light that seems to come from all directions.
- Directional Light is an oriented light with an origin at infinity. The “Direction” attribute defines the light’s direction.
- PointLight is a light at a fixed point in space that radiates light equally in all directions away from the light source. The “Position” attribute defines the fixed point. The light's position is in a coordinate system in which the default viewport is the cube [-1,1] by [-1,1] by [-1,1].

Each of these nodes has a “Color” attribute to define the color of the light.

Color Map Legend

The color map legend is a color map gradient and scale for drawing on the background of the canvas.

The color map is an object that implements the `com.imsl.chart.Colormap` interface in the JMSL Chart 2D package. The interface includes a number of predefined color maps.



Appendix D: 3D: Drawing to the Canvas

It is possible to draw to the canvas using Java 2D methods using a class which implements `Canvas3DChart.Paint`. This interface defines a single method `public void paint(java.awt.Graphics g)`.

The object passed to the paint method is actually a `java.awt.Graphics2D` object. `Graphics` is used for consistency with standard Java usage. This method is called each time the 3D chart is redrawn.

An object which implements `Canvas3DChart.Paint` can be registered with `Canvas3DChart` using either `addPreRenderPaint` or `addPostRenderPaint`. The former method causes the 2D drawing to appear beneath the 3D drawing, the later method the 2D drawing to appears on top of the 3D drawing.

Since the 3D chart is redrawn many times a minute, redrawing the 2D chart each time can add quite a bit of overhead. If the 2D drawing is not dynamic, the class `BufferedPaint` can be used to capture the 2D drawing into an image that can be quickly redrawn for each 3D redrawing. For example, the `ColormapLegend` class is implemented using `BufferedPaint`.

Appendix E: Java 3D

The JMSL Chart 3D package is built on top of Java 3D. For most purposes, using the Chart 3D package does not require knowledge of Java 3D.

A JMSL chart can be saved as an image file in two ways: either using the Java `ImageIO` class or the Java Advanced Imaging (JAI) API.

Using the Chart 3D with Swing

Swing components are lightweight, but the canvas used to render Java 3D is a heavyweight component. Generally, lightweight components cannot be drawn on top of heavyweight components

To allow Swing menu items to appear on top of the canvas, use

```
JPopupMenu.setDefaultLightWeightPopupEnabled(false);
```

To allow Swing Tooltips, use

```
JPopupMenu.setDefaultLightWeightPopupEnabled(false);
ToolTipManager.sharedInstance().setLightWeightPopupEn-
abled(false);
```

Video Card Drivers

Java 3D is implemented on top of OpenGL. In Windows, there is also an option to use Direct3D. Both of these APIs use the video card hardware to accelerate performance. The interface between OpenGL/Direct3D and the video card hardware is the video card driver.

Problems with the video card drivers can cause problems with Java 3D and therefore with the Chart 3D package. If there is a problem, check with the hardware manufacturer for a driver update. It may also be possible to work around problems by setting certain system properties.

System Properties

Java system properties can be set on the command line using the syntax

```
-Dname=value
```

They can also be set using methods in the System class.

There are many system properties which can be set to control Java 3D. The following table lists some of the most important settings.

For more details, see http://java3d.j3d.org/implementation/properties.html.

Property	Values	Definition
j3d.rend	ogl | d3d	Windows-only. Specifies which underlying rendering API should be used (thus allowing both Direct3D and OpenGL native DLLs to be installed on a singe machine. Default: ogl
j3d.deviceSampleTime	An integer	The sample time in milliseconds for non-blocking input devices. Default: 5
j3d.threadLimit	An integer	Controls how many threads may run in parallel regardless of how many cpu's the system has. Setting it to "1" will make the system act like a traditional OpenGL render loop. Default: number of CPUs plus one.
j3d.disableXinerama	true | false	Solaris only. Allows major performance boost when using dual screen environments with the X11 Xinerama extension enabled. To disable this feature you need JDK1.4. Detailed information in the release notes. Default: false.
j3d.displaylist	true | false	OpenGL only. Enable use of display lists, an OpenGL performance enhancing feature. False to disable for debugging. Default: true

j3d.g2ddrawpixel	true | false	If true, use glDrawPixel to flush the graphics2D to the screen. If false, use texture mapping to flush the graphics2D to the screen. glDrawPixel is not accelerated on some older Windows video cards. Default: true
j3d.sharedctx	true | false	Shared contexts are used in OpenGL for DisplayLists and Texture Objects to improve performance. However some drivers have bugs causing weird rendering artifacts. This can be used to disable their use to see if this is the problem. Default: true for Solaris and false for Windows
j3d.debug	true | false	Prints out startup and running information. Useful for finding out information about the underlying hardware setup. Default: false
j3d.vertexbuffer	true | false	Use of vertex buffers, a D3D performance enhancing feature equivalent to OpenGL display lists. Some drivers have implementation problems so it might be worth turning this off if there are crashes. Default: true
sun.java2d.d3d	true | false	Windows only. Disable use of Direct3D by Java. Default: true
sun.java2d.ddoffscreen	true | false	Windows only. Disable use of DirectDraw and Direct3D by Java for off screen images, such as the Swing back buffer. Default: true
sun.java2d.noddraw	true | false	Windows only. Completely disable use of DirectDraw and Direct3D by Java. This avoids any problems associated with use of these APIs and their respective drivers. Default: false

Index

A

- annotation 91
- Apache 131
- applications, adding charts to 8
- area plots 18
- array XML tags 136
- automatic scaling 96, 232
- axis
  - crossed 117
  - custom tranformation of 110
  - layout 95
  - limits 95
  - setting 93
  - tick marks 95, 104, 235
  - titles 99, 235
  - units 103
  - xyz 231
- axis3d
  - labels 97, 234
  - layout 232
  - limits 232
  - setting 231
  - tick marks 232
  - titles 235

B

- background 119
  - color 119
  - gradient 121
  - pattern 123
- background3d 236
- bar charts 53
  - grouped 55
  - legends for 59
  - simple 53
  - spacing bars 61
  - stacked and grouped 57
  - width of bars in 61
- bitmaps 195, 241
- box plots 46

C

- candlestick charts 40
- canvas
  - drawing 239
- card
  - drivers 241
- chaining method calls 6
- charts
  - bar 53
    - simple 53
    - spacing 61
    - stacked and grouped 57
    - width 61
  - contour 62
  - grouped bar 55
  - heatmap 64
  - histogram 66
  - labels for 88, 230
  - legends for 59
  - pie 44
  - titles for 87
  - *see also* plots
- color
  - background 119, 236
  - gradient 121
  - lights 237
  - text 86, 228

color lines 223
color map legend 238
color3d 238
colormaps 129
contour 62
custom axis transformation 110

D

dashed lines 78
data point labels 88
date/time
    weekends 97
dates in labels 97, 234
dates, transforming 96
dendrogram charts 72
density, of tick marks 95
dotted lines 78

E

enumerators, in XML 138
error bar plots 30
Extensible Markup Language
    see XML

F

fills 81
    colored 81
    gradient 81
    images for 84
    outline colors for 81
    outlines for 81
    patterned 84
    tiled 84
    types of 81
fills3d 227
    colored 227
    colored function 227
    material 227
fisher iris 212
fonts 85
formatting text 86, 228
function plot 22

G

gradient background color 121
gradient fills 81
graphs
    function 22
    spline 24
grid lines 108
grouped bar charts 55

H

heatmap 64
help popups 130
high-low-close plots 36
histograms 66
horizontal error bar plots 32

I

image files 195
ImageIO
    bitmap 195
implicit nodes 4

J

JAI
    see Java Advanced Imaging
JAI API
    bitmap 196
JAR files 193
Java 3d
    drawing to a canvas 239
java 3D 241
Java Advanced Imaging
    using for image files 195, 241
    using for servlets 187
Javadoc 1

L

labels 88
    for axes 97, 234
    string 98, 234
labels3d 230
    dates in 97, 234
legends 59, 125
lights3d 237

line
- color 78, 223
- colored 223
- dashed 78
- dotted 78
- plots 14
- width 78

line and marker plots 16
line3d
- color 222
- color function 222
- width 222

linecolor 223
lines 78
- grid 108
- *see also* line 78, 222

lines3d 222
log plot 26
loglog plot 28

M

marker
- color 80
- patterns 80
- plots 16
- size 80
- thickness 80
- type 79

marker3d
- color 225
- pulsing cycle 225
- pulsing cycle offset 225
- pulsing maximum scale 225
- pulsing minimun scale 225
- rotating axis 226
- rotating cycle 225
- rotating cycle offset 225
- size 225
- type 224

markers 79, 224
method calls, chaining 6
mixed error bar plots 34
mouse selection 173
multiple axes 114

N

normal distribution histograms 66

P

pattern
- background 123
- fills 84

picking 173
picture-in-picture 201
pie charts 44
plots
- area 18
- box 46
- candlestick 40
- dendrogram 72
- error bar 30
- function 22
- high-low-close 36
- horizontal error bar 32
- labels for 88, 230
- line 14
- line and marker 16
- log 26
- loglog 28
- mixer error bar 34
- polar 69
- scatter 10, 212
- semilog 26
- titles for 87
- vertical error bar 30
- *see also* charts

plots3d
- line 218
- tube 216

PNG files 197
polar plots 69
popups 130
printing 182

R

random values 12
reference lines 21
reference manual 1

S

Scalable Vector Graphics (SVG)
    bitmap 198
scaling
    automatic 96
    input values 96
    output values 97, 233
scaling3d
    automatic 232
    input values 232
scatter plots 10
scatter3d plots3d 212
scientific notation 97, 234
semilog plot 26
serialization 184
server
    applications 187
    directories 193
servlets 187
size 228
solid background 119
spline graph 24
stacked bar charts 57
stock-price charts
    candlestick 40
    high-low-close 36
surface
    plots 218
swing
    menu
        chart 3D 241

T

ter 10
text 85, 228
    angle 86
    color 86
    fonts 85
    formatting 86
    size 85
    style 85
    typeface 85
text3d
    color 228
    fontname 228
    fonts 228
    formatting 228
    style 228
tick mark density 95
tick marks 104
tick marks3d 235
titles
    axis 99
    plot 87
titles3d
    axis 235
tool tips 130
transformation
    axes 110
transformations
    dates 96
    XML 141
tube
    plots 216
    see also line 223
tube3d
    colored function 223
    colored line 223
tubes3d 223

U

units, in axes 103

V

vertical error bar plots 30
video 241
viewport attribute 201

W

web servers 187
weekends
    skipping 97

X

XML 131
    array tags 136
    attribute tags 135
    enumerated types 138

parser 131
requirements 131
syntax 131
transformations 141
XSLT 141
XSLT 141

Z

zooming 176