Lesson 2: More about grids

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Goals

In this lesson, you will learn:

- how grids represent discrete and continuous surfaces
- how grid themes are located
- how to display grids
- how grid theme attributes are stored
- how to query grid themes
- how grid themes are classified
- how to create a histogram

TOPIC1: Grid theme basics

Grid themes can represent either discrete or continuous data. In a grid theme, discrete features (points, lines, polygons) and continuous surfaces are represented by assigning numeric values to each cell corresponding to a feature location. Cells are displayed based upon these numeric values. Cell values can be either integer or floating point

Concept

Discrete and continuous data

Grid themes can represent discrete features with integer values or continuous phenomena with floating point values.

Discrete grids represent geographic features that have definable boundaries, sometimes referred to as categorical or discontinuous data. In the graphic below, there is a distinct boundary between the residential and commercial areas. Discrete geographic features include points, lines, and polygons. They could be representing discrete objects like buildings, roads, and parcels.



Land use is an example of discrete data. Here you see distinct boundaries between the four land use types. Each land use type is stored as an integer value. [Click to enlarge]

Continuous surfaces represent geographic phenomena that can vary spatially. Each cell value on the surface is a measure of the concentration or level at that location. Continuous geographic phenomena do not have distinct boundaries like discrete geographic features. A geographic feature, such as a lake, has a real and definable boundary. A geographic phenomenon, like lake depth, continuously changes. The depth varies spatially.

Potentially, each cell in a continuous grid can have a different value. Examples of continuous data include contamination levels, heat from a fire, elevation, or a concentration diminishing from a source.



Elevation is an example of continuous data. Elevation

values continuously change over space. Continuous data is stored as floating point values. [Click to enlarge]

Some features are not clearly into either discrete or continuous. There is a spectrum between pure discrete and pure continuous. Examples are soil types, forest edges, wetland boundaries, or geographic markets influenced by a television ad campaign.

When evaluating the values resulting from modeling, it is important to understand the data. The validity and accuracy of the boundaries in the input data must be understood. Would you select a building site given only a soils map? Use the data carefully when making decisions.

For example, temperature and rainfall may be slightly different at different monitoring stations. The variance can be slight or extreme from one monitoring station to another. One station may report 1.12 inches of rain while another station, less than a mile away, may report 0 inches of rain

Concept

Grid theme location

Every grid theme has a Cartesian coordinate system. Two things are stored about the coordinate system: the coordinates of the grid's Cartesian coordinate origin (bottom left of grid) and the cell size. Because every cell is the same size, you can determine the location of a given cell by knowing its row and column number; that is, its location relative to the origin.



Knowing the grid origin coordinates, a cell's row and column location, and the grid cell size allows you to find a cell's real-world location.

Because a grid exists in a Cartesian coordinate system, you can determine the real-world location of a cell. For example, the grid origin above is stored as x,y coordinates (530, 684). Given a row and column location and the cell size, you can determine a real-world x,y location.

A grid theme has a Cartesian coordinate origin (bottom left of the grid) and a row and column index position origin (top left of the grid). The Cartesian coordinate origin references a cell's position to a real-world location on the Earth's surface. The row and column index position references a cell location within the grid matrix

Concept

Displaying grids

Grid themes have cells that are assigned a solid fill color based on cell value or zone. The values are assigned a color and are presented in a legend. Grid themes are symbolized in a Legend Editor just as feature themes are.

Grid themes can be classified so that each group or category of cells has the same color. Integer grid themes can have either a unique value or a graduated color legend type. Floating point grids can have only a graduated color legend.

The default color assigned to No Data cells depends on the percentage of No Data cells in a grid. If fewer than 20 percent of the cells in a grid are No Data cells, the default color is black. Otherwise, No Data cells are automatically transparent. You can change the color of No Data cells yourself using the Legend Editor.

A cell's color brightness can be varied with values from another grid theme. This allows you to see a variable's spatial distribution and how the other theme's variable changes within it. A good example is examining the relationship between land use and topography. Topography would be set as the brightness theme, allowing you to see the land use change with elevation.



This elevation grid of Keller Peak in Southern California is displayed with a hillshade theme set as a brightness theme.

Example

Displaying grids

William is a meteorologist modeling the effects of above normal winter rainfall on anticipated brush growth for use in the upcoming fire season. Heavy winter rains typically cause brush to grow abnormally high, providing an abundance of fuel for late summer brush fires. Of particular concern are areas at high elevation which may be difficult to reach in the event of fire.

Before starting his research, William wants to visualize the distribution of rainfall in relation to topography. He has grid themes of precipitation and elevation for his fire district.



Top: Grid theme of precipitation. Bottom: Grid theme of elevation. [Click to enlarge]

The first thing William wants to do is create a hillshade theme to better view the elevation theme. With the elevation theme active, he chooses Compute Hillshade from the Surface menu, and uses the default azimuth and altitude values.



This hillshade grid of elevation was created by choosing Compute Hillshade from the Surface menu. [Click to enlarge]

Now that William can see differences in elevation more clearly in the study area, he wants to see how precipitation varies in relationship to topography. He double-clicks on the Precipitation theme to display the Legend Editor. In the Legend Editor, he creates a color ramp to better represent the precipitation values. He assigns the color light green to represent the lowest precipitation total

and dark blue to represent the highest. He then clicks the Color Ramp button

RELATED CONCEPT

🍭 Legend B	ditor		_ 🗆 ×
Theme: Precipitation			Load
Legend Type: Graduated Color		-	Save
			Default
Classification	Field: Value	•	Classify
Normalize by:	<none></none>	•	
Symbol	Value	La	bel
	1 - 12	1 - 12	▲
	13-23	13 - 23	
	24 - 34	24 - 34	
	35 - 45	35 - 45	
	46 - 56	46 - 56	
	57 - 67	57 - 67	
	68 - 78	68 - 78	
	79 - 89	79 - 89	
	90 - 100	90 - 100	
		No Data	.
+ ×		5 ∎↓	
Color Ramps:	Precipitation		•
Advanced.	Statistics	Undo	Apply

The Legend Editor for the Precipitation grid theme. A color ramp from light green to dark blue was applied to symbolize precipitation totals.

Next, he clicks the Advanced button in the Legend Editor to specify a brightness theme. Hillshade of Elevation is selected as the brightness theme.

Advanced Options 🛛 🛛 🔀				
Brightness Theme	Hillshade of E	levation 🔽		
Minimum Cell Bright (0 - 100)	ness	20		
Maximum Cell Brigh (0 - 100)	ntness	80		
	ОК	Cancel		

The Advanced Options dialog of the Legend Editor is used to select a brightness theme.

He then applies the new legend and turns on the Precipitation theme. He notices the areas in the mountains with high precipitation. These may be areas with a high fire risk later in the summer.

William will proceed with his research using themes of vegetation, soil, and slope and make maps showing fire risk.



Precipitation theme with a hillshade theme set as a brightness theme.

Exercise

Display grids

In this exercise, you will see how to display two grid themes at the same time by setting a brightness theme. You will work with the "Mt. St. Helens before" grid theme.

If you have not downloaded the exercise data for this module, you should download the data now.

Step 1 Start ArcView

Start ArcView and load the Spatial Analyst extension.

Note: If you are running ArcView GIS 3.1, you see a Welcome to ArcView GIS dialog. Click Cancel to close this dialog.

If ArcView is already running, close any open projects.

Step 2 Open a project

From the File menu, choose Open Project. Navigate to the **gridsa\lesson2** folder and open the project **l2_ex01.apr**.

Note: If you are running ArcView GIS 3.1, you see an Update I2_ex01.apr message box. Click No to dismiss this box.

When the project opens, you see an empty view called Mt. St. Helens.

Step 3 Add a theme to the view

Click the Add Theme button to display the Add Theme dialog.

In the Data Source Types dropdown list, choose Grid Data Source.

Then, in the gridsa\lesson2 folder, click the Hbefore grid and click OK.

Turn on the Hbefore theme, a theme of elevation.

Step 4 Create a hillshade theme

From the Surface menu, choose Compute Hillshade and click OK to accept the default settings. Turn on the Hillshade theme to see what a hillshaded grid looks like.

You will learn more about hillshading in the module, *Introduction to Surface Analysis* with ArcView Spatial Analyst.

Step 5 Use the Legend Editor to specify a brightness theme

You will set the brightness theme in the Legend Editor.

Turn off the Hillshade theme. In the Table of Contents, double-click the Hbefore theme to open the Legend Editor.

Click the Advanced button to set the brightness theme.

In the Brightness Theme dropdown list, choose Hillshade of Hbefore and click OK.

Apply the changes and close the Legend Editor.

By using a brightness theme, you gave the Hbefore theme a three-dimensional look. Besides giving your display more depth, you can use this technique to show how one grid varies spatially within another, such as how land use varies with elevation.

REVIEW CONCEPT

Step 6 Close the project

Close the project without saving any changes.

You have completed this exercise

TOPIC 2: Representing features in a grid

The same cell-based structure is used to represent all feature types within a grid; therefore, all feature types are treated the same. When all the data types are in the same structure, one semantical language can be used. This uniform structure is important when combining or comparing data types.

Because of this uniform structure, grid processing is very fast. Cells are square and readily stack on top of one another for overlay operations. Computing or deriving a value for an output cell from two or more input cells is a matter of direct value computation

Concept

Grid theme attributes

Recall that only integer grids have a theme table. Grid theme tables differ slightly from feature theme tables. Grid theme tables store one record per category, not one record per cell. They are also referred to as value attribute tables (VATs). These tables are similar to any other theme attribute table. They can store character or integer values and can be joined or linked with other tables.



This diagram represents an integer grid theme and its theme table. Only integer grid themes have a theme table. One record is stored for each unique value in the grid theme. Grid theme tables store one record per zone.

Grid theme tables are always INFO format files (the same INFO format as other feature theme tables created from ArcInfo coverages). Grid theme tables contain at least two fields: Value and Count, although other fields can be added. You should not edit either the Value or Count fields.

The Value field stores the value assigned to each zone in a grid theme. The Count field stores the total number of cells in a zone.

Integer grid themes will not have a table when there are more than 500 unique values and when the range of the values exceeds 100,000.

Concept

Querying grid themes

You can query a grid theme table just like a feature theme table. There are two ways to query grid themes: Query Builder and Map Query.

Using the Query Builder on grid themes is similar to using it for feature themes. The main difference is that cells, not vector features, are selected and highlighted as a result of the query.

Each value in the attribute table is linked to all the cells with that value. When you make selections on grid themes, the selected records are highlighted in the table and the cells linked to these records are highlighted in the view. Selecting a value automatically selects the cells with that value.



Using the Query Builder results in selected cells in the view. [Click to enlarge]

You use the Map Query dialog to enter a Boolean expression to find cells meeting certain criteria. Map Query outputs a new grid theme. The output grid theme will contain values of 1 (true) for areas that met the query requirements and 0 (false) for areas that didn't meet the query requirements.

Queries are structured with [grid.field] syntax; for example, [Landuse.Type] = "Residential". Landuse is the name of the grid and Type is the name of a field in the Landuse grid theme's table.

Map Query can be used on a single theme. The graphic below shows a query being evaluated based on the values of a single precipitation theme.



Map Query is being used to query a single grid theme. In the query, Precipitation greater than 65 centimeters is being selected. [Click to enlarge]

Map Query can also be used to create a new theme by entering an expression based on the values of multiple themes. Below you see a query involving land use and elevation themes.



Map Query is being used to query two themes, Landuse and Elevation. Areas in red meet the conditions of the query.

Concept

Classifying grid themes

You can classify grid themes so that each group or category of cells has the same color.

The legend type for a floating point grid can only be graduated color. Floating point grid themes are divided by default into nine classes according to their cell values. The default classification method is <u>Equal Interval</u>, but you can change it to <u>Standard Deviation</u>. Classes can be added or deleted and their value ranges changed manually. You can also turn on and off the display of the No Data class (which contains all the cells that have No Data values).

🍭 Legend E	ditor		_ 🗆 ×
Theme: Eleva	2grd	•	Load
Legend Type: Graduated Color		•	Save
			Default
Classification F	ield: Value	•	Classify
Normalize by:	<none></none>	-	
Symbol	Value	La	ibel
	1010.208 - 1186.007	1010.208 - 1	1186.007 🔺
	1186.007 - 1361.807	1186.007 - 1	1361.807
	1361.807 - 1537.607	1361.807 - 1	1537.607
	1537.607 - 1713.407	1537.607 - 1	1713.407
	1713.407 - 1889.206	1713.407 - 1	1889.206
	1889.206 - 2065.006	1889.206 - 2	2065.006
	2065.006 - 2240.806	2065.006 - 2	2240.806 📃 💌
+ 🗶	<u> </u>	5 ∎↓	
Color Ramps:	Red monochromatic		•
Advanced	. Statistics	Undo	Apply

The Legend Editor for a floating point grid. The legend type can only be graduated color.

Integer grid themes can have a legend type of either graduated color or unque value. When their legend type is to graduated color, integer grid themes can be classified by any of the five methods available in ArcView: <u>Equal Area</u>, Equal Interval, <u>Natural Breaks</u>, <u>Quantile</u>, or Standard Deviation.

Legend E Theme: Loov Legend Type:	ditor grid Graduated Color	Classif Type: Numbe Round	ication Natural Breaks of classes: 5 values at: d.d. OK.	id Canc	cel	
Classification f	Field: Value			Classity		
Normalize by:	<none></none>		*			
Symbol	Value		Lat	bel		
	17 - 20		17 - 20		-	
	21 - 27		21 · 27			
	28 - 31		28 · 31			
	32 - 99		32 · 99			
	100 - 998		100 - 998			
					•	
+ 😹		1 4	5 81			
Color Ramps:	Land Cover #2				-	
Advanced	. Statistics		Undo	Apply		

The Legend Editor for an integer grid theme. When the Legend Type is set to Graduated Color, integer themes may be classified using any of the five classification methods available in ArcView.

Concept

Creating histograms

A histogram is a chart of the distribution of cell values in a grid theme. One chart marker is created for each unique cell value or category. If you change the legend classification, the cell value groups also change.

Histograms are useful when you're working with continuous variables because you can check to see if the values are skewed to one side of the mean or if you have a normal distribution.

You can use graphic shapes drawn with the Draw tools or selected theme features to create histograms. For example, you could draw a trade area with the Draw Circle tool and use that shape to make a histogram of the grid theme.



A histogram of the land use types (cell values) within the circle. [Click to enlarge]

In the example above, the height of each marker represents the number of cells in that category. There are a little less than 2000 cells in the Ceanothus Chapparal category (1899, if you were to look at the theme table). It appears that some of the markers are missing. The markers may have very small values compared to the other markers, or the land use types may not exist inside the area defined by the selected graphic.

To calculate the area of Ceanothus Chapparal, multiply 1899 by the width and height of each cell ((width * height) * 1899). You can examine the cell dimensions for each theme by looking at the Theme Properties dialog.

Example

Querying and classifying grids

Hillary is a real estate developer looking for the ideal location for a new upscale housing tract called Citrus Vista. It is desired that the new subdivision be located at an elevation greater than 1500 feet and within orchards. It must not be located within any Alquist-Priolo fault zones, established by the state government to prevent the construction of homes near the surface traces of active faults.

Hillary has grid themes of Elevation, Landuse, Alquist-Priolo zones, and a streets theme for reference.



Hillary's three grid themes: Elevation, Landuse, and Alquist-Priolo fault zones. [Click to enlarge]

The first thing Hillary wants to do is classify the Landuse theme as the current cell values are not very descriptive. To do this, she opens the Legend Editor for the Landuse theme, sets the Values field to Landuse_desc and applies the changes. Now the cell values in the legend are labeled with land use descriptions. Note that this is an integer grid so it has a VAT.

RELATED CONCEPT

RELATED CONCEPT

🍭 Legend	Editor		_ 🗆 ×
Theme: La	induse	•	Load
Legend Typ	e: Unique Value	•	Save
			Default
Values Field	: Landuse_desc		
Symbol	Value	Label	Count
	AGR: Dairy and livest	AGR: Dairy and lives	23 🔺
	AGR: Horse ranches	AGR: Horse ranches	68
	AGR: Irrigated crop/p	AGR: Irrigated crop/p	422
	AGR: Non-irrigated cr	AGR: Non-irrigated cr	476
	AGR: Nurseries	AGR: Nurseries	139
	AGR: Orchards and v	AGR: Orchards and v	3216
	AGR: Other agricultur	AGR: Other agricultur	180 💌
+ 🗙		個5 ×色 ×②	
Color Schen	nes: Bountiful Harvest		•
Advance	d Statistics	Undo	Apply

Legend Editor for the Landuse theme. A land use description field is used to classify the theme.

The next thing she wants to do is see the distribution of existing orchards. To do this, she opens the theme table for the Landuse theme and selects the record with the "AGR: Orchards and vineyards" land use description. Notice there appear to be a quite a few possibilities.



The record in the theme table with a land use type of "AGR: Orchards and vineyards" was selected. All the

cells with that value are highlighted in the view. [Click to enlarge]

Next, Hillary wants to see the orchards that are higher than 1500 feet in elevation. To do this, she opens the Map Query dialog and enters the following expression:

([Landuse . Landuse_desc] = "AGR: Orchards and vineyards") and ([Elevation] > 1500)



The Map Query dialog is used to select orchards that are higher than 1500 feet in elevation. [Click to enlarge]

This creates a new theme of areas that met the criteria, which she saves as High Orchards.

RELATED CONCEPT



The areas that met the criteria are in red. Some of the areas fall within the Alquist-Priolo fault zone. Hillary will take care of this in her next step. [Click to enlarge]

Next, she needs to exclude any areas that fall within an Alquist-Priolo fault zone. These zones are meant to prevent the construction of buildings used for human occupancy on the surface trace of active faults. Surface fault ruptures that occur during an earthquake have been shown to cause extensive damage to homes built upon surface traces.

Hillary again uses Map Query, this time building the following expression:

([High Orchards] = 1.AsGrid) and (not ([Ap-Zones] = 1.AsGrid))

🔍 Map Query 1			_ 🗆 X
Lapers [High Oschards] [High Oschards] [Ap2Cones] [Ap2Cones] [Ap2Cones] [Landuce] [Landuce] [Landuce]	= <> =0 > >= 0 < <= not ()	Unique Values 1 2 3 Image: Update Values	•
([High Orchards] = 1.AcGrid) /	and not [[Ap-Zonec] =	1 AoGrid)]	< *
	Evaluate		

Map Query being used to exclude sites that are within the Alquist Priolo fault zone. [Click to enlarge]

She saves this new theme as Prospects.



Results of Map Query showing candidate sites not within the Alquist-Priolo Fault Zone. Candidate sites are symbolized in red. [Click to enlarge]

Hillary now has several potential sites for the new development. Later, she'll complete a full cost and site analysis to narrow her selection down further.

Exercise

Display, classify and query grid themes

The objective of this exercise is to display and examine the data associated with a grid theme. You will learn how to query a grid theme and create a histogram.

If you have not downloaded the exercise data for this module, you should download the data now.

Step 1 Start ArcView

Start ArcView and load the Spatial Analyst extension.

Note: If you are running ArcView GIS 3.1, you see a Welcome to ArcView GIS dialog. Click Cancel to close this dialog.

If ArcView is already running, close any open projects.

Step 2 Open the project

From the File menu, choose Open Project. Navigate to the **gridsa\lesson2** folder and open the project **l2_ex2.apr**.

Note: If you are running ArcView GIS 3.1, you see an Update I2_ex2.apr message box. Click No to dismiss this box.

When the project opens, you see an empty Tahoe view.

Step 3 Add and display a grid theme

First, you will add the vegetation grid theme, Tahoeveg, to the empty view and examine it.

Click the Add Theme button to open the Add Theme dialog.

In the Data Source Types dropdown list, choose Grid Data Source.

In the gridsa\lesson2 folder, click the Tahoeveg grid and click OK.

Turn on the Tahoeveg grid theme.

Notice that it is classified/symbolized according to cell values. The cell values (1–6) are not very meaningful, so in the next step you will open the theme table and look for a field that describes the vegetation codes. The Tahoeveg grid theme has a theme table because it is an integer grid. It stores only integer values.

REVIEW CONCEPT VIEW RESULT

Step 4 Classify a theme

With the Tahoeveg grid theme active, click the Open Theme Table button

The S_value field contains character strings of vegetation types (e.g., Brushland, Grassland, etc.). This field can be used to classify the grid theme.

After examining the table, make the view active and open the Legend Editor for the Tahoeveg grid theme.

Set the Values Field to S_value. Click Apply.

The legend no longer displays the cell values; it now displays the land use descriptions from the S_value field in the grid theme table.

Close the Legend Editor.

REVIEW CONCEPT VIEW RESULT

Step 5 Select records in the grid theme table

Next, you will make some selections in the table to see the relationship that exists between records in the grid theme table and cells in the grid.

With the Attributes of Tahoeveg table active, click the Select Record tool **b** and click on the record that has the Grassland vegetation type.

Notice the selected record is highlighted in the table and the corresponding cells in the view are also highlighted. You can increase or decrease the size of the selection set by selecting or unselecting more records. Next, you will add to the selection set.

Hold down the Shift key and click on the record with the Mixed Brushland vegetation type.

Selected records in the grid theme table are highlighted along with corresponding cells in the view. Close the Attributes of Tahoeveg table.

REVIEW CONCEPT VIEW RESULT

Step 6 Make a histogram for an entire grid theme

You can create histograms with the Histogram button by choosing Histogram By Zone from the Analysis menu. Histograms are useful if you need to know the number of cells per unique category. You can create histograms for an entire grid theme or for grid theme cells that are intersected by selected graphics.

Make the Tahoeveg grid theme active and click the Histogram button.

Examine the Histogram of Tahoeveg chart to see which unique values or categories have the most cells and the least cells in the Tahoeveg grid.

VIEW RESULT

Most cells in the Tahoeveg grid theme are Urban / Built Up. Notice that the Grassland and Disturbed area markers are very small and may not appear in the chart.

Close the histogram.

REVIEW CONCEPT

Step 7 Make a histogram based on a graphic shape

Now you will create another histogram by drawing a graphic shape over the Tahoeveg grid theme.

In the Tahoeveg view, click the Draw Polygon tool

pulldown and draw a polygon that intersects part of the Tahoeveg grid.

With the graphic selected, click the Histogram button

The chart called Histogram of Tahoeveg Within Selected Graphics is created. Notice that the chart markers represent cells inside the graphic you drew.

Step 8 Close the project

Close the project without saving any changes.

You have completed this exercise

Summary

In this lesson, you learned how grid themes can represent continuous and discrete data. Discrete features have distinct boundaries and are stored as integer values, whereas continuous data have continuously changing values and are stored as floating point values.

Grid themes are stored with a Cartesian coordinate system and each cell references a real-world location. Grids are displayed based on cell value or zone and they are classified using the Legend Editor. A cell's color brightness can be varied with values from another grid theme.

Only integer grid themes have a theme table and only one record is stored in the table for each unique value in the grid theme. Grid themes can be queried just like feature themes. Using the Query Builder results in selected cells, while using Map Query results in a new output theme.

You can create a histogram to view the distribution of cells either in the entire theme or within a graphic shape

This is the Understanding the ArcView Spatial Analyst Grid Model - Lesson 2 Self test. Please watch your time—you have 2 hours to complete this test.

Use the knowledge you have gained in *Understanding the ArcView Spatial Analyst Grid Model* to answer the following questions. You will need to correctly answer 7 of the following questions to pass.

Netscape Users: Do not resize this browser window. This can cause the page to reload and generate new questions.

GOOD LUCK!

- 1. A histogram is a chart of the distribution of cell values in a grid theme.
 - C True
 - C False
- 2. You can use the Query Builder to create a new grid theme.
 - C True
 - C False
- 3. Integer grids can have only a unique value legend type.
 - C True

C False

- 4. Only integer grids have a theme table.
 - C True
 - C False
- 5. Map Query creates a new grid theme containing values of 1 (true) and 2 (false).
 - C True
 - C False
- 6. Floating point grids can have either a unique value or a graduated color legend type.
 - C True
 - C False
- 7. Where is a grid theme's Cartesian coordinate origin located?
 - C Top left of the grid
 - C Top right of the grid
 - C Bottom left of the grid
 - C Bottom right of the grid
- 8. An integer grid theme will not have a value attribute table when the range of values exceeds:
 - C 10,000
 - C 50,000
 - ° 75,000
 - C 100,000
- 9. What is the default method of classification for floating point grid themes?
 - C Standard Deviation
 - C Quantile
 - C Equal Interval
 - C Natural Breaks
- **10.** Integer grid themes, when their legend type is set to Unique Value, can be classified using which of the following methods?
 - ^C They cannot be classified when the legend type is Unique Value.
 - C Natural Breaks

C Standard Deviation C Quantile

Calculate My Grade