as the contour interval, what contour lines would be on the map?

7. Describe factors that can influence the visual effect of hill shading.
8. Explain how the viewing azimuth, viewing angle, viewing distance, and *z*-scale can change a 3-D perspective view.
9. Describe in your own words (no equation) how a computing algorithm derives the slope of the center cell by using elevations of its four immediate neighbors.
10. Describe in your own words (no equation) how ArcGIS derives the slope of the center cell by using elevations of its eight surrounding neighbors.
11. What factors can influence the accuracy of slope and aspect measures from a DEM?
12. Suppose you need to convert a raster from degree slope to percent slope. How can you complete the task in ArcGIS?
13. Suppose you have a polygon layer with a field showing degree slope. What kind of data processing do you have to perform in ArcGIS so that you can use the polygon layer in percent slope?
14. What are the advantages of using an elevation raster for terrain mapping and analysis?
15. What are the advantages of using a TIN for terrain mapping and analysis?

## APPLICATIONS: TERRAIN MAPPING AND ANALYSIS

This applications section includes three tasks. Task 1 lets you create a contour layer, a vertical profile, a shaded-relief layer, and a 3-D perspective view from a DEM. In Task 2, you will derive a slope layer, an aspect layer, and a surface curvature layer from DEM data. Task 3 lets you build and modify a TIN. You will use Spatial Analyst, 3-D Analyst, and ArcToolbox to perform terrain mapping and analysis in this section.

### Task 1: Use DEM for Terrain Mapping

**What you need:** *plne,* an elevation raster; and *streams.shp,* a stream shapefile.

The elevation raster *plne* is imported from a USGS 7.5-minute DEM. The shapefile *streams.shp* shows major streams in the study area.

#### 1.1 Create a contour layer

1. Start ArcCatalog, and connect to the Chapter 13 database. Launch ArcMap. Add *plne* to Layers, and rename Layers Tasks 1&2. Make sure that both the Spatial Analyst and 3-D Analyst extensions are checked in the Tools menu and their toolbars are checked in the View menu.
2. Click the Spatial Analyst dropdown arrow, point to Surface Analysis, and select Contour. In the Contour dialog, select *plne* for the input surface, enter 100 (meters) for the contour interval and 800 (meters) for the base contour, and save the output features as *ctour.shp.* Click OK to run the analysis.
3. *ctour* appears in the map. Select Properties from the context menu of *ctour.* On the Labels tab, check the box to label features in this layer and select CONTOUR for the label field. Click OK. The contour lines are now labeled. (To remove the contour labels, right-click *ctour* and uncheck Label Features.)

#### 1.2 Create a vertical profile

1. Add *streams.shp* to Tasks 1&2. This step selects a stream for the vertical profile. Open the attribute table of *streams.* Click the Options dropdown arrow and choose Select By Attributes. Enter the following SQL statement in the expression box: "USGH_ID" = 167. Click Apply. Close the *streams* attribute table. Zoom in on the selected stream.

2. Click the Interpolate Line tool on the 3-D Analyst toolbar. Use the mouse pointer to digitize points along the selected stream. Double-click the last point to finish digitizing. A rectangle with handles appears around the digitized stream.
3. Click the Create Profile Graph tool on the 3-D Analyst toolbar. A vertical profile appears with a default title and footer. Right-click the title bar of the graph and select Properties. The Graph Properties dialog allows you to enter a new title and footer and to choose other advanced design options.

**Q1.** What is the elevation range along the vertical profile? Does the range correspond to the readings on *ctour* from Task 1.1?

4. The digitized stream becomes a graphic element on the map. You can delete it by using the Select Elements tool to first select it. To unselect the stream, choose Clear Selected Features from the Selection menu.

### 1.3 Create a hillshade layer

1. Click the Spatial Analyst dropdown arrow, point to Surface Analysis, and select Hillshade. In the Hillshade dialog, select *plne* for the Input surface. Take the default values of 315 for the azimuth, 45 for the altitude, 1 for the Z factor, and 30 for the output cell size. Opt for a temporary output raster. Click OK to run the operation. *Hillshade of plne* is added to the table of contents.
2. Try different values of azimuth and altitude to see how these two parameters affect hill shading.

**Q2.** Does the hillshade layer look darker or lighter with a lower altitude?

### 1.4 Create a perspective view

1. Click the ArcScene tool on the 3-D Analyst toolbar to open the ArcScene application. Add *plne* and *streams.shp* to view. By default, *plne* is displayed in a planimetric view, without the 3-D effect. Select Properties from the context menu of *plne*. On the Base Heights tab, click the radio button to obtain heights for layer from surface, and select *plne* for the surface. Click OK to dismiss the dialog.
2. *plne* is now displayed in a 3-D perspective view. The next step is to drape *streams* on the surface. Select Properties from the context menu of *streams*. On the Base Heights tab, click the radio button to obtain heights for layer from surface, and select *plne* for the surface. Click OK.
3. Using the properties of *plne* and *streams*, you can change the look of the 3-D view. For example, you can change the color scheme for displaying *plne*. Select Properties from the context menu of *plne*. On the Symbology tab, right-click the Color Ramp box and uncheck Graphic View. Click the Color Ramp dropdown arrow and select Elevation #1. Click OK. Elevation #1 uses the conventional color scheme to display the 3-D view of *plne*. Click the symbol for *streams* in the table of contents. Select the River symbol from the Symbol Selector, and click OK.
4. You can tone down the color symbols for *plne* so that *streams* can stand out more. Select Properties from the context menu of *plne*. On the Display tab, enter 40 (%) transparency and click OK. (For ArcGIS 9.3 users, notice that the legend symbols for *plne* are also shown in 40% transparency.)
5. Click the View menu and select Scene Properties. The Scene Properties dialog has four tabs: General, Coordinate System, Extent, and Illumination. The General tab has options for the vertical exaggeration factor (the default is 1 or none), background color, and a check box for enabling animated rotation. The Illumination tab has options for azimuth and altitude.
6. ArcScene has standard tools to navigate, zoom in or out, center on target, zoom to target, and to perform other 3-D manipulations. For example, the Navigate tool allows you to rotate the 3-D surface.

7. Besides the preceding standard tools, ArcScene has additional toolbars for perspective views. Click the View menu, point to Toolbars, and check the boxes for 3-D Effects and Animation. The 3-D Effects toolbar has tools for adjusting transparency, lighting, and shading. The Animation toolbar has tools for making animations. For example, you can save an animation as an .avi file and use it in a PowerPoint presentation.

## Task 2: Derive Slope, Aspect, and Curvature from DEM

**What you need:** *plne,* an elevation raster, same as Task 1.

Task 2 covers slope, aspect, and surface curvature.

### 2.1 Derive a slope layer

1. Click Show/Hide ArcToolbox Window to open the ArcToolbox window in ArcMap. Set the Chapter 13 database as the current workspace. Double-click the Slope tool in the Spatial Analyst Tools/Surface toolset. Select *plne* for the input raster, specify *plne_slope* for the output raster, select PERCENT_RISE for the output measurement, and click OK to execute the command.

**Q3.** What is the range of percent slope values in *plne_slope*?

2. *plne_slope* is a continuous raster. You can divide *plne_slope* into slope classes. Double-click Reclassify in the Spatial Analyst Tools/Reclass toolset. In the Reclassify dialog, select *plne_slope* for the input raster and click on Classify. In the next dialog, change the number of classes to 5, enter 10, 20, 30, and 40 as the first four break values, and click OK.

### 2.2 Derive an aspect layer

1. Double-click the Aspect tool in the Spatial Analyst Tools/Surface toolset. Select *plne* for the input raster, specify *plne_aspect* for the output raster, and click OK.

2. *plne_aspect* shows an aspect layer with the eight principal directions and flat area. But it is actually a continuous raster. You can verify the statement by checking the layer properties. To create an aspect raster with the eight principal directions, you need to reclassify *plne_aspect.*

3. Double-click the Reclassify tool in the Spatial Analyst Tools/Reclass toolset. Select *plne_aspect* for the input raster and click on Classify. In the Classification dialog, make sure that the number of classes is 10. Then click the first cell under Break Values and enter −1. Enter 22.5, 67.5, 112.5, 157.5, 202.5, 247.5, 292.5, 337.5, and 360 in the following nine cells. Click OK to dismiss the Classification dialog.

4. The old values in the Reclassify dialog are now updated with the break values you have entered. Now you have to change the new values. Click the first cell under new values and enter −1. Click and enter 1, 2, 3, 4, 5, 6, 7, 8, and 1 in the following nine cells. The last cell has the value 1 because the cell (337.5° to 360°) and the second cell (−1° to 22.5°) make up the north aspect. Click OK, and the output is an integer aspect raster with the eight principal directions and flat (−1).

**Q4.** The value with the largest number of cells on the reclassed aspect raster is −1. Can you speculate why?

### 2.3 Derive a surface curvature layer

1. Double-click the Curvature tool in the Spatial Analyst Tools/Surface toolset. Select *plne* for the input raster, specify *plne_curv* for the output raster, and click OK.

2. A positive cell value in *plne_curv* indicates that the surface at the cell location is upwardly convex. A negative cell value indicates that the surface at the cell location is upwardly concave. The ArcGIS Desktop Help further suggests that the curvature output value should be within −0.5 to 0.5 in a hilly area and within −4 to 4 in rugged

mountains. The elevation data set *plne* is from the Priest Lake area in North Idaho, a mountainous area with steep terrain. Therefore, it is no surprise that *plne_curv* has cell values ranging from −6.89 to 6.33.

3. Right-click *plne_curv* and select Properties. On the Symbology tab, change the show type to Classified, click yes to compute unique values, and then click on Classify. In the Classification dialog, first select 6 for the number of classes and then enter the following break values: −4, −0.5, 0, 0.5, 4, and 6.34. Return to the Properties dialog, select a diverging color ramp (e.g., red to green diverging, bright), and click OK.
4. Through the color symbols, you can now tell upwardly convex cells in *plne_curv* from upwardly concave cells. Priest Lake on the west side carries the symbol for the −0.5 to 0 class; its cell value is actually 0 (flat surface). Add *streams.shp* to Tasks 1&2, if necessary. Check cells along the stream channels. Many of these cells should have symbols indicating upwardly concave.

## Task 3: Build and Display a TIN

**What you need:** *emidalat,* an elevation raster; and *emidastrm.shp,* a stream shapefile.

Task 3 shows you how to construct a TIN from an elevation raster and to modify the TIN with *emidastrm.shp* as breaklines. You will also display different features of the TIN.

1. Select Data Frame from the Insert menu in ArcMap. Rename the new data frame Task 3, and add *emidalat* and *emidastrm.shp* to Task 3.
2. Double-click the Raster to TIN tool in the 3-D Analyst Tools/Conversion/From Raster toolset. Select *emidalat* for the input raster, specify *emidatin* for the output TIN, and change the *Z* Tolerance value to 10. Click OK to run the command.

**Q5.** The default *Z* tolerance in the Raster to TIN dialog is 48.2. What happens when you change the tolerance to 10?

3. *emidatin* is an initial TIN converted from *emidalat.* This step is to modify *emidatin* with *emidastrm,* which contains streams. Double-click the Edit TIN tool in the 3-D Analyst Tools/TIN Creation toolset. Select *emidatin* for the input TIN, and select *emidastrm* for the input feature class. Notice that the default for SF_type (surface feature type) is hardline. Click OK to edit the TIN.
4. You can view the edited *emidatin* in a variety of ways. Select Properties from the context menu of *emidatin.* Click the Symbology tab. Click the Add button below the Show frame. An Add Renderer scroll list appears with choices related to the display of edges, faces, or nodes that make up *emidatin.* Click "Faces with the same symbol" in the list, click Add, and click Dismiss. Uncheck all the boxes in the Show frame except Faces. Make sure that the box to show hillshade illumination effect in 2-D display is checked. Click OK on the Layer Properties dialog. With its faces in the same symbol, *emidatin* can be used as a background in the same way as a shaded-relief map for displaying map features such as streams, vegetation, and so on.

**Q6.** How many nodes and triangles are in the edited *emidatin*?

## Challenge Task

**What you need:** *lidar, usgs10,* and *usgs30.*

This challenge task lets you work with DEMs at three different resolutions: *lidar* at 1.83 meters, *usgs10* at 10 meters, and *usgs30* at 30 meters.

1. Insert a new data frame in ArcMap and rename the data frame Challenge. Add *lidar, usgs10,* and *usgs30* to Challenge.

**Q1.** How many rows and columns are in each DEM?