Lab 6: Distance and Density

Exercise 1: Air Ambulance study

The dispatch managers of local hospitals providing air ambulance service are working together with local schools and colleges to conduct a preliminary study of air rescue and air ambulance service in the San Diego area in an attempt to improve the initial response times of the services. As one of the lead GIS analysts on the team, you need to determine the distance from the schools to the hospitals, which hospitals providing air ambulance are nearest to the schools, and the direction from the hospitals to the schools. First, you will create a straight line distance surface that will be used to find the distance from the schools (locations on the surface) to the nearest hospitals (source). You will then create a direction surface and an allocation surface, which are optional outputs generated from the Straight Line Distance function. You will use Map Algebra and the CON function to create a reverse direction surface of the Direction to Hospital layer. This way, dispatchers can also help the pilots navigate back to the hospital. Since helicopters can fly "as the crow flies" through the area, you can provide directions in degrees azimuth.

Step 1: Start ArcMap and open a map

Start ArcMap and open the Distance.mxd map document from your ...\Lab6Data\ folder. The locations of 14 hospitals in the San Diego, California area are identified on the map. Notice that several hospitals are located near each other.

Step 2: Set the analysis environment

Set the Environment Settings as follows:
- Set the Current Workspace and Scratch Workspace directories to your ...\Lab6Data\MyData\ folder
- Processing Extent: Same as Layer "Study Area"
- Raster Analysis cell size: 100
- Raster Analysis mask: San Diego Area

Step 3: Run the Euclidean Distance function

Use the Euclidean Distance function to create three new surfaces. Surfaces created using the Euclidean Distance function use Euclidean (straight line) distance measurements. The source features in this exercise are hospitals with air ambulance service.

From the Spatial Analyst Tools menu in ArcToolbox, expand Distance and double-click Euclidean Distance. For input raster, select Hospital. Click OK.
When the processing is complete, ArcGIS Spatial Analyst adds the new distance raster to the Table of Contents. Rename the new distance raster, Distance to Hospital.

In the Distance menu, there are two other tools, Euclidean Allocation and Euclidean Direction. Both of these additional rasters need to be created. Double-click Euclidean Allocation to open the dialog. For input raster, select Hospital. Click OK.

Rename the new allocation raster, Allocation to Hospital. Double-click Euclidean Direction to open the dialog. For input raster, select Hospital. Click OK.

Rename the new direction raster, Direction to Hospital. You have should now have three temporary rasters; allocation, direction, and distance. Turn off the San Diego Area layer to view these surfaces.

**Step 4: Investigate the Distance to hospital surface**
Every cell value in the Distance to Hospital surface represents the straight line distance back to the nearest hospital. Click the Identify button on the Tools toolbar, then click somewhere on the map. In the Identify Results dialog, click the Layers dropdown menu, and click Distance to Hospital. Hold the Shift key down and click several places on the map. You may have to move the Identify Results dialog aside so you can see the map.

**Step 5: Use the raster calculator to create a new surface**
It would be helpful to have the distance reported in some other unit of measure, by mile for example, but the Distance to Hospital layer is a continuous surface and you can’t edit the attribute table. In this exercise you will create a new surface that uses a different unit of measure by using the Raster Calculator. Dividing the grid by 5280 will create a new surface with cell values expressed in miles. Open the Raster Calculator and enter the following expression:

"Distance to Hospital" / 5280

For the Output Raster change the name to DistInMiles. Click OK. A new layer named DistInMiles
is added to the Table of Contents. Rename the new layer **Distance in miles to Hospital.** Use the Identify tool to query cell values for the new surface. The new layer is a continuous surface, but the cell values are now expressed in miles.

**Step 6: Classify the distance in miles to hospital layer**
Classifying the Distance in miles to Hospital layer will allow dispatchers to visually assess the approximate distances to schools in easier-to-read zones. For example, the dispatcher could look at the map and quickly determine that a particular school is about 4 miles from the nearest hospital. The exact distance values are still contained in the Distance in miles to Hospital surface.
Open the Layer Properties dialog for the Distance in miles to Hospital layer, then click the Symbology tab and select Classified. Click the Classify button. Change the number of Classes to 7. In the Break Values box, change the first six break values to their respective whole numbers: 1, 2, 3, 4, 5, and 6. Don't change the last break value. Click OK. Change the Label text for the symbols as follows:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Range</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - 1</td>
<td>Less than 1 mile</td>
</tr>
<tr>
<td></td>
<td>1 - 2</td>
<td>1 - 2 miles</td>
</tr>
<tr>
<td></td>
<td>2 - 3</td>
<td>2 - 3 miles</td>
</tr>
<tr>
<td></td>
<td>3 - 4</td>
<td>3 - 4 miles</td>
</tr>
<tr>
<td></td>
<td>4 - 5</td>
<td>4 - 5 miles</td>
</tr>
<tr>
<td></td>
<td>5 - 6</td>
<td>5 - 6 miles</td>
</tr>
<tr>
<td></td>
<td>6 - 7.008522511</td>
<td>More than 6 miles</td>
</tr>
</tbody>
</table>

Click OK to close the Layer Properties dialog.

Now a dispatcher can quickly estimate the distance to any school by simply selecting a school and looking at the map. Clicking on the Distance in miles to Hospital layer at a school location with the Identify tool will provide a more accurate distance to nearest hospital report. Look at the map and try to estimate the distance from a school to the nearest hospital, then use the Identify tool to see how close your estimate was.
Click on the school with the Distance in miles to Hospital layer entered in the Identify Results dialog. Close the Identify Results dialog when you are finished.

**Step 7: Explore the allocation to hospital layer**
One output of the Straight Line Distance function is an allocation layer. Allocation simply means certain cells are assigned to certain sources. In this case, cells are assigned to the nearest hospital. Because the allocation is based on straight line distance, the allocated cells form zones around the hospital locations. Turn off the Distance in miles to Hospital, Distance to Hospital, and Direction to Hospital layers. The allocation zones are composed of cells with like values. If you were to use the Identify tool to query the surface, you would find that the cell values range from 1 to 9, so there is a number for each hospital. For now, turn off the Allocation to Hospital layer.

**Step 8: Explore the direction to hospital layer**
Turn on the Direction to Hospital layer. When this layer was created, it was based on the hospital locations, giving each cell a value that indicates the direction to the nearest hospital along a straight line. The direction value is expressed in degrees. Cells in the direction surface that correspond to source locations (i.e., hospitals) have a value of zero, or no direction. Another way to think about the direction surface values is to imagine a compass circle around any cell location on the map.
At the top of the circle is north. If you centered the compass circle on a school location, the Direction to Hospital cell value that corresponds with that location would be the direction to the nearest hospital. Explore the Direction to Hospital surface using the Identify tool. First, zoom in to one of the hospitals so that you can see several of the school locations surrounding it. Center the hospital in your display. Select the Identify tool and click somewhere on the map. Move the Identify Results dialog so you can see the map. In the Identify Results dialog, click the Layers dropdown arrow and choose Direction to Hospital. Now click a school location on the map. The direction back to the nearest hospital is reported. Try clicking more places on the map. Notice distance from the hospital does not affect direction, and if you click on the exact location of the hospital, the direction value is zero. Close the map.

**Key points**

- Straight Line Distance functions create continuous surfaces where a distance value is assigned to each cell in the surface.
- Straight Line Distance functions use Euclidean measurements: the distance is measured along a straight line, from the cell center to the nearest source.
- Distance units are measured in map units. If the map units are in feet, then the distance value assigned to each cell is also in feet.
- Cell values in a straight line direction surface provide compass directions to the nearest location of a source or sources. Cell values range from 0 to 360 with north being 360.
- Zero values indicate no direction. Source cells or cells that correspond to source locations have zero values in a straight line direction surface.
- You can create a straight line direction surface when you create a straight line distance surface.

**Exercise 2: Find the Least-Cost Path**

The primary goal of this exercise is to find the least-cost path for a proposed power transmission line between a power plant site (Otay Valley Power Plant) and substation (Jamul Substation) in Southern California. You must balance two important considerations: keeping construction costs down and minimizing risks to public safety.

Consider the following objectives:

- The least-cost path should be primarily composed of land with shallow slope, because steep terrain will increase the cost of operating construction equipment.
- On the other hand, the longer the path, the higher the construction costs; therefore, the distance between the two sites will also be considered.
- You will consider the cost of construction through various land use types. In order to minimize costly delays, you will try to avoid construction in possibly contentious areas, such as residential locations,
commercial zones, and open space preserves.
- For safety reasons, power lines should not be located near certain areas, like airports and lakes.

The process of preparing the total cost surface involves deriving surfaces from existing surfaces. The diagram below illustrates the entire process of finding the least-cost path.

**Step 1: Open a map document**
Open the **FindPath.mxd** map document located in your ...\Lab6Data\ folder. The dashed red line in the lower-left corner represents an existing power line.

**Step 2: Determine source and destination**
In order to determine an optimum path, you will need to identify two points: where the path will begin and where the path will end. Turn on the Otay Valley Power Plant layer. The Otay Valley Power Plant is where the path will begin—the source. Turn on the Jamul Substation layer. The Jamul Substation is where the path will end—the destination.

**Step 3: Determine cost surface criteria**
For this analysis, you will consider two factors that will impact the cost of constructing a power line between the Otay Valley Power Plant and the Jamul Substation: steepness of slope and type of land use. Turn off the Hillshade layer. You will use the Power line DEM layer to create a slope layer. Turn on the Land use layer.

The slope and land use data must be in raster format. These rasters are referred to as cost surfaces and are the ones you will add to create a total cost surface. Cost surfaces are used to gage the expense of travel across a surface. Time, money, effort, and speed are examples of travel expense. In this case, a wildlife preserve composed of steep slopes would be a more costly place to construct a power line than vacant land with shallow slope.

**Step 4: Set the analysis environment**
Set the Environment Settings as follows:
- Set the Current Workspace and Scratch Workspace directories to your ...\Lab6Data\MyData folder
- Processing Extent: Same as Layer "Study Area"
- Raster Analysis cell size: Same as Layer "Power line DEM"

**Step 5: Create a slope map**
First, you need to derive a slope map from the digital elevation model (DEM). From the Spatial Analyst Tools menu in ArcToolbox, expand the Surface menu, then double-click **Slope**. For the Input surface, click Power line DEM. For Output measurement, select PERCENT_RISE. Accept the default value for Z factor. Click OK. Rename the new raster, Powerslope.

**Step 6: Reclassify slope**
You assume that steeper slopes add to construction costs, and you will reclassify the slope layer accordingly. From the Spatial Analyst Tools menu in ArcToolbox, expand the Reclass menu, then double-click **Reclassify**. Click the Input raster dropdown arrow and choose Powerslope. Click
Classify. Click the Method dropdown arrow and choose Equal Interval. Click the Classes dropdown arrow and choose 10. Click OK. Click OK in the Reclassify dialog. Rename the new raster layer, Reclass of Powerslope. Right-click Reclass of Powerslope in the Table of Contents, then click Properties. Click the Symbology tab, click the Color Scheme dropdown arrow, and select a dark to light shade ramp (for example, black to white). **Hint:** If you use Stretched values, on the Symbology tab, you can check Invert to reverse the direction of a color ramp. Click OK. Click OK.

The darker shades represent areas of shallow slope—areas where construction costs will be less expensive. Right-click the Powerslope layer in the Table of Contents and choose Remove. Click the minus sign next to the Reclass of Powerslope layer in the Table of Contents to hide the legend. Turn the Reclass of Powerslope layer off.

**Step 7: Reclassify the land use layer**

In the Table of Contents, expand the Land use layer. From the Spatial Analyst Tools menu in ArcToolbox, expand the Reclass menu, then double-click Reclassify. Click the Input raster dropdown arrow and choose Land use. Make sure that the Reclass field is LUTYPE. The data for the land use layer are not continuous; they are discrete. A classification scheme where 1 corresponds to airstrips, 2 corresponds to communications, and so on, does not correspond at all to the relative suitability of land use and the construction of powerlines; so, you have to add your own suitability reclass table, which has already been created for you.

In the Reclassify dialog you have open, click Load. Navigate to your `\Lab6Data\` folder, select reclassoflu, and click Load. Scroll through the list to see how different land use types have been ranked. Locations such as Single family residential and Open space preserves have been ranked as most cost-prohibitive. Vacant land and agricultural areas have been given a lower cost ranking. Notice that the land use values for Lakes/Reservoirs and Airstrips are missing from the list. Remember, the power line path should not go across water or airstrips under any circumstances. While giving these features a high reclass value, such as 10, would likely prevent the path from doing this, you don't want to take any chances.

Instead, you will change the values representing water and airstrips to NoData because Spatial Analyst will not allow the path to go through NoData cells. Check the Change missing values to NoData box. Locations of NoData will not be considered in the analysis. Click OK. Rename the new raster layer, Reclass of Land use.

Right-click the Land use layer in the Table of Contents, and click Remove. Click the minus sign next to the Reclass of Land use layer in the Table of Contents to hide the legend. Turn the Reclass of Land use layer off.

**Step 8: Create a total cost layer**

In this step, you will create a total cost layer by combining the common scale values for the Reclass of Powerslope and Reclass of Land use layers. Areas of NoData in either of the input layers will be NoData in the total cost layer. Open the Raster Calculator and build this expression:

"Reclass of Land use" + "Reclass of Powerslope"

Click OK. The resulting output layer is another surface with a value range of 3 to 19. Open the Layer Properties dialog for the new output layer. Click the Symbology tab. Click the Color scheme dropdown arrow and choose the dark green to light green color ramp.

**Hint:** Use Stretched values.

Click the Display NoData as dropdown arrow and choose a bright yellow color. Click OK. Turn off the Lakes layer.
The darker shades indicate areas through which it will be less costly to construct a power line. The areas of NoData will not be considered in the analysis. Rename the total cost surface to Cost. Collapse the Cost layer in the Table of Contents.

It is important to remember that a total cost layer, like the one you just created, may represent only one version of total costs. Typically, you might consider different combinations of contributing factors, thereby creating several total cost surface alternatives.

**Step 9: Perform cost distance analysis**

Before you find the least-cost path for a power line between the Otay Valley Power Plant and the Jamul substation, you must derive two surfaces from the total cost surface. One surface model is increasing costs as you travel farther away from the source. The other surface model is increasing costs depending on the direction you are traveling. Both of these surfaces are used as inputs to calculate the least-cost path.

From the Spatial Analyst Tools menu in ArcToolbox, expand the Distance menu, then double-click Cost Distance. For Input raster, choose Otay Valley Power Plant. For Input Cost raster, choose Cost. For Output distance raster, type Distance. For Output backlink raster, type Direction. Click OK. Two new layers are added to your map.

The Distance to Otay Valley Power Plant layer represents how costs accumulate as you move further away from the source (i.e., the Otay Valley Power Plant). The cost distance layer takes into account distance measurements from the source and the values of the total cost layer for each location on the map. Turn off the CostDistance to Otay Valley Power Plant layer.

The Cost Backlink or Direction to Otay Valley Power Plant layer also takes into account the total cost layer and determines the bearing to the easiest (least costly) path back to the Otay Valley Power Plant. Turn off the Direction to Otay Valley Power Plant layer. Neither of these new layers is easily understood, and they probably wouldn’t be used as a final analysis, but when combined in the next step they form the obstacle course used in the final least-cost path analysis. Collapse both layers in the Table of Contents.

**Step 11: Find the least-cost path**

Now you are prepared to use the least-cost path function and find the least-cost path between the source point, Otay Valley Power Plant, and the destination point, Jamul Substation. Remember the two cost factors, slope and landuse, are not weighted, but assume equal influence.

From the Spatial Analyst Tools menu in ArcToolbox, expand the Distance menu, then double-click Cost Path. For Input raster or feature source data, choose Jamul Substation. For Input cost distance raster, choose Distance. For Input cost backlink raster, choose Direction. For Path type, choose BEST_SINGLE. Name the output NewPath, then click OK. Turn off the Distance and Direction layers.

The resulting layer represents the least-cost path (avoiding steep slopes and costly land use types) between the Otay Valley Power Plant and the Jamul Substation. Notice the path follows an existing power line corridor and skirts the edges of a lake and open space preserve. Rename the NewPath layer Least Cost Path.

**Key points**

- In a shortest or least-cost path analysis you must identify at least two points or locations: the source and the destination.
- Before adding the cost surfaces together to create the total cost surface, you must reclassify each of them into a common scale.
- NoData cells will be excluded from the shortest or least-cost path analysis.
- Before you can run a shortest or least-cost path analysis, you must create a total cost
surface. This is usually the most time-consuming portion of the process because you must determine the variables, put the layers together, and rank the values.

- Before you can run a shortest or least-cost path analysis, you must run a cost weighted distance analysis on the total cost surface to create two surfaces: a cost distance surface and a cost backlink or direction surface.

**Exercise 3: Estimate Density**

Mapping density enables you to measure the number of features in a study area based on some standard unit of area. For example, you can measure the number of burglaries per square kilometer in a city. You will see patterns emerge that indicate higher concentrations of the crime in some areas than in others. In this exercise, you will use the Density function to find patterns based on the location of six murders in a downtown study area. The density surface reveals underlying patterns that might not otherwise be evident. You will use both the kernel and simple options of the density function.

**Step 1: Open the map document**

Open the CrimeStudy.mxd map document from your ...\Lab6Data\ folder. The map contains a series of point layers, which indicate the occurrence of various crimes within a study area.

Turn on the layers for Murder, Grand theft, Burglary, and Assault. By simply observing the point features, you can see that there are concentrations of crime. A density analysis of the different crime types will help to reveal additional patterns of concentrations that are not apparent when looking at the features alone.

**Step 2: Examine the location of the murder sites**

Before you create a density surface, examine the data you will use to create it. Turn off the Grand theft, Burglary, and Assault layers.

Six unsolved murders have occurred in the downtown area in the last year. The police detectives know that if they can find some sort of pattern in the data, these cases stand a better chance of being solved. They also need to know where to concentrate their efforts.

The murder site locations are a place to start, but a density analysis could reveal areas where they might concentrate their efforts.

**Step 3: Set the analysis environment**

Set the Environment Settings as follows:

- Set the Current Workspace and Scratch Workspace directories to your ...\Lab6Data\MyData folder
- Processing Extent: Same as Layer "Crime study area"
- Raster Analysis cell size: 20

**Step 4: Create a density surface using a small search radius**

To begin the investigation, detectives must re-interview witnesses, but they must also seek new witnesses and information. They want to keep their canvassing area as small as possible and concentrate on locations with the best chance that someone may have seen or heard something having to do with the crime.

In the first density surface that you create, you will use a modest search radius based on the proximity of several of the murder sites. In this way, you will be concentrating the differences in density values to areas near each murder. In other words, the density values will quickly decrease as you move farther from the site. You might use this type of analysis when looking for witnesses or searching for evidence related to the crime.

From the Spatial Analyst Tools menu in ArcToolbox, expand the Density menu, then double-click Kernel Density. Fill out the dialog as follows:
Input point of polyline features—Murder
Output cell size—20
Search Radius—700
Area Units—Square Kilometers

Click OK. This density surface reveals areas of concentration around the murder sites. In particular, the highest density of murder appears to be between two pairs of sites.

**Step 5: Use a larger search radius**
Using the same procedure as above, create another density surface of the murders, only this time double the search radius. Click OK. In this new density surface, the relationships between the murder sites become more apparent, at least in a spatial sense. Perhaps the investigation is delegated to two teams of detectives who will focus their efforts on the areas of highest density.

**Step 6: Use the simple method to create a density surface**
Now, suppose that the two detective teams have gone into the field, collected information, compared notes, and the evidence suggests that these murders are related. It could be possible that the murderer lives or works or knows somebody in the area. Patterns in the data along with more evidence could lead to a suspect.

This time, create a density surface using the Point Density method. Simple density calculations include both point and line density functions. You will use the Point Density method since your input data consists of point features.

Fill out the Density dialog as follows:
- Input point features—Murder
- Output cell size—20
- Neighborhood—Circle
- Units—Map
- Search Radius—1400
- Area Units—Square Kilometers

Click OK. This density surface reveals a concentration in the center of the map. If the same person were committing the murders and they were living or working in the downtown area, they might be trying to optimize their distance to potential victims. If this were true, the high-density area could indicate where the investigation might concentrate.

**Key points**
- Density surfaces reveal patterns in the data that might not otherwise be evident.
- Even though a larger search radius tends to generalize the data, you may need to increase the size of the search neighborhood in order to find meaningful patterns.
- The kernel method of density analysis creates a smoother looking density surface than the simple method.

**Exercise 4: Estimate density using attributes**
In this exercise, you will use the kernel option of the density function to find patterns based on the locations of burglary and grand theft in a downtown study area. In the case of grand theft, certain locations have been attributed with more than one occurrence. This means that the number of occurrences, not the number of features, will be used to calculate density. On the other hand, the burglary layer contains an attribute that divides the data into daytime and nighttime events. This means that you can create a density surface of burglaries based on the time of day the crime occurred.

**Step 1: Turn on the layers for Grand theft and Burglary.**
You can see from the features that there are concentrations of burglary and grand theft. What is not evident is that there have been multiple incidences of grand theft at some of the locations and that some of the burglaries occurred at night, while others occurred during the daylight hours.
For now, turn off the Burglary layer so that the only crime showing is Grand Theft.

**Step 2: Create a density surface of the Grand Theft layer**
If each location in the Grand Theft layer represents one occurrence of the crime, a density surface will present a different pattern than if certain locations represented multiple occurrences. First, create a density surface of the Grand Theft layer as if each location represented only one incident. Fill out the Kernel Density dialog as follows:

- Input point or polyline features—Grand Theft
- Output cell size—20
- Search Radius—500
- Area Units—Square Kilometers

Click OK. According to this density surface, the highest density of grand theft is in the north-central part of downtown.

**Step 3: Create a density surface using a population field**
Suppose incidents of grand theft have occurred repeatedly at certain addresses and you want to factor that information into your analysis. This means a location that has had four incidents of grand theft will influence the density surface more than a location that has had fewer incidents. In other words, some locations are weighted heavier than others.

Open the attribute table for the Grand theft layer and examine the Occur field. This field indicates the number of times each site has had a crime. Some sites have been hit four or five times. Close the attribute table.

Create a density surface from the Grand theft layer using the Occur field as the population field. Fill out the Kernel Density dialog as follows:

- Input point or polyline features—Grand Theft
- Population Field—Occur
- Output cell size—20
- Search Radius—500
- Area Units—Square Kilometers

Click OK. Turn off the Grand theft layer and compare the two density surfaces for Grand theft by toggling the new density surface of Grand theft off and on.

While the Density of Grand theft layer treats each location of Grand theft equally, the new surface of Grand theft layer depicts more areas of higher concentration because certain locations have been hit more than once. Turn both of the layers off.

**Step 5: Create a density surface using selected features**
In this step, you will create two density surfaces based on feature attributes, but in this case the attribute is a code, not a quantity value. The code allows you to create a selected set.

Suppose the police department would like to compare density surfaces for burglaries based on whether they occurred during the day or night. You can create density surfaces based on a selected set.

Turn on the Burglary layer. Open the attribute table for the Burglary layer. Click the Table Options button at the top of the table window, click Select By Attributes, and fill out the Select By Attributes dialog as follows: “AMPM”=’1’
The value 1 in the AMPM field is a code that indicates that the crime occurred during the daytime, between 6 a.m. and 6 p.m. Click Apply. Close the attribute table.

Now create a density surface of all the daytime burglaries using Kernel as the Density type and 500 as the search radius. Fill out the Density dialog to match the View Result graphic below.

- Input point or polyline features—Burglary
- Output cell size—20
- Search Radius—500
- Area Units—Square Kilometers

Click OK. Rename the new layer to **Density of Daytime Burglary**.
Open the attribute table for the Burglary layer again. Click the Options button and click Switch Selection to select all the burglaries that occurred at night. Close the attribute table. Now create another density surface just like the previous one, only this time the nighttime burglaries will be analyzed. Rename the new layer to **Density of Nighttime Burglary**.

**Key points**
- Density surfaces are good for showing where point features are concentrated, but you can also use the attributes of the point features to create density surfaces.
- If the attribute field is a count, such as the number of occurrences, you can use that field as the population field. This has the effect of weighting the point features.
- If the attribute field is a code, you must create a selected set and then create the density surface. In this case, you don’t have to use a population field, although it is perfectly acceptable if you do.

**Lab 6 Assignment**

Please produce “hardcopy” pdf with **four figures** that contain maps in proper **layout** form with **legends, cartographic components**, etc. for the following lab exercises. Each figure should have an associated **caption** that explains the data and the analysis. The caption should be stand alone and not require a reference to understand the figure. Look at captions of figures in primary literature for examples. Upload the pdf to the lab 6 assignment on ecampus.

Map 1: Distance in miles from hospitals to schools in San Diego (Exercise 1).  
Map 2: Least cost path for a power transmission line between Otay Valley Power Plant and Jamul substation with appropriate base layer (Exercise 2).  
Map 3: Kernel density of downtown murder sites with a search radius of 1400m (Exercise 3).  
Map 4: Kernel density of nighttime burglaries with a search radius of 500m (Exercise 4).