3.2 Which branch (e.g. set theory, topology, metric space, Euclidean space, Graph Theory, Fractal Geometry) of mathematics is used to formalize following spatial concepts: Universal Transverse Mercator (UTM), geodesic distance, direction (e.g. North, East), shortest path (for driving on urban roads), boundary, space-filling curves (Fig. 6.8, pp. 234), planar configurations such as polygons, straight-line distance, convex polygon, landslide probability (chapter 9.4, pp. 350) interior, symmetric relationship, complement, exterior.

Universal Transverse Mercator: Euclidean space
Geodesic distance: Metric space
Direction: Euclidean space
Shortest path: Graph theory
Boundary: topology
Space-filling curves: Fractal geometry
Planar configurations: Euclidean space
Straight-line distance: Euclidean space
Convex polygon: Euclidean space
Landslide probability: Set theory
Interior: Topology
Symmetric relationship: Set theory
Complement: Set theory
Exterior: Topology

3.4 Review wikipedia article on map projections and article on upsidedown maps. Classify following map projections in to the most specific transform classes listed in previous question: cylindrical, Azimuthal (projection onto a plane), upside down (South up)

Cylindrical: Topological
Azimuthal: Projective
Upside down: Affine

4.2 Consider a spatial framework defined by latitudes and longitude (1 degree by 1 degree cells) to represent (time-average) annual temperatures for years 1900 to present over the surface of Earth. Consider zones defined by countries and assume that each cell belongs to a unique zone. For simplicity, ignore cell convergence in polar regions. Classify following operations into local, focal, zonal operations:

1. Determine warmest temperature (or year) for each cell. local
2. Determine warmest cell in each country in year 2000. focal
3. Identify country with highest average cell temperature in year 2000. zonal
4. For each cell, compute spatial-neighborhood average temperature in the year 2000. focal
5. For each cell, compute heat-island-factor as the difference between its temperature and its spatial-neighborhood average temperature for the year 2000. Assume the results of previous step were available as an input for this step. focal
6. For each country, list the cell with highest value of heat-island-factor. Assume the results of previous step were available as an input for this step. focal

7. Compute average annual temperature of surface of Earth for each year. zonal

4.4 Consider a Euclidean spatial datasets with three layers: (i) countries represented as polygons. (ii) continents represented as polygons. (iii) Lakes represented as polygons. Consult a world map (e.g. Google Map to classify following pairs of spatial objects into one of 8 topological relationships between cells in the Euclidean place listed in Table 4.3 (pp. 162):

1. Austria, Europe    Austria inside Europe
2. USA, Canada        USA meet Canada
3. Europe, Asia       Europe meet Asia
4. Lake Superior, USA Lake Superior overlaps USA
5. Turkey, Europe     Turkey meet Europe
6. Lesotho, South Africa Lesotho meet South Africa