Exam questions

Reference Frames, Datum and Geoid

1. Most positions on the surface of the Earth are given as Cartesian coordinates (X,Y,Z) in an Earth Centered Earth Fixed (ECEF) coordinate system. If we further introduce the World Geodetic System 1984 (WGS84) we can transform the Cartesian coordinates to geographical coordinates (phi, lambda, h). WGS84 defines the semi-major axis and the flattening of the Earth. Can you tell the formulas that transform from (X,Y,Z) to (phi, lambda, h)?

2. The geographical coordinates (phi, lambda, h) refer to an ellipsoidof reference. Many applications ask for 2-D Cartesian coordinates like(N,E) as defined in the Universal Transverse Mercator (UTM) system. Can you in words describe how this happens and do you know literature where to find the exact formulas?

3. The ellipsoid of reference is an artificial mathematical surface thatis introduced as a first approximation to the actual surface of the Earth. The Earth masses create a potential field outside the Earth. A certain equipotential surface in the files is named the geoid. How big can the separation between the geoid and ellipsoid be at most?

4. At any point of the topographic surface of the Earth is defined the physical normal to the local equipotential surface. This line or direction is called the plum line. Likewise there is a well defined normal to the ellipsoid at the same point. The angle between these two normals is called the deflection of the vertical. How big can that angle be and does it influence the values of (phi, lambda, h)?

5. At the Equator a minute of arc is the same in the north-south direction as in the east-west direction. How many meters it such a minute of arc.

In north -south direction a second of arc is nearly constant (the flattening of the ellipsoid has some effect). However, a second of arc in east-west direction changes with latitude. How is this law?

6. At any point on the Surface of the Earth we have the following equation h = H + N where h is the distance from the ellipsoid to the point, N is called the geoidal undulation, and H is the orthometric height. In GNSS activities two of these variables are known and one is unknown. Which ones?

7. Before the era of GNSS is was impossible to perform geodetic measurements across oceans. So each (part of) a continent or larger islands defined introduced its own ellipsoid with own values for the semi-major axis and flattening and deflection of the vertical and geoidal undulation N at a so-called datum point. Examples are Pulkova Observatory and the Helmert Tower in Potsdam. A frequent task is to transform coordinates from one datum to another datum. Can you tell where to find information about these transformation parameters which are official public values.

8. What is a ITRF? How accurate are the coordinates of the GNSS tracking stations known in this reference frame?

9. WGS84 comes with a global geoid model. How accurate is that model? Is it necessary to supply this one with a local geoid model to obtain cm-level accuracy in the computation of N?