## Exam: Introduction to Geodesy 22.10.2005

## (Also qualifies as Fundamental Geodesy I) <br> (Function calculator)

## 1. Fundamentals

(a) What is a clothoid, and why is it being used for building railroads and motorways?
(b) If in Peru the length of a degree of latitude is 110 km and in Lapland it is 112 km , calculate the radius of curvature of the Earth in both locations. Based on these numbers, is the Earth flattened or elongated?

## 2. Statistics, units

(a) Explain random, gross and systematic errors.
(b) Convert the angle $36^{\circ} 45^{\prime} 30^{\prime \prime}$ to gon and radians.

## 3. Measurement instruments and methods

(a) Explain how an automatic level works. Explanatory sketch.
(b) Describe the axes and circles in an optical theodolite and the angles that are measured with a theodolite.

## 4. First and second geodetic problems

(a) Given a point $A: x_{A}=6700000 \mathrm{~m}, y_{A}=500000 \mathrm{~m}$. The distance to point $B$ is $s=2000 \mathrm{~m}$ and the azimuth (direction angle) $t=66.6666$ gon. Solve the first (forward) geodetic problem for points $A, B$.
(b) Given is also point $C$ with coordinates $x_{C}=6698267.9492 \mathrm{~m}, y_{C}=499000 \mathrm{~m}$. Solve the second (inverse) geodetic problem for the points $A, C$

## 5. Helmert transformation

(a) Given the Helmert (similarity) transformation:

$$
\left[\begin{array}{l}
x^{(2)} \\
y^{(2)}
\end{array}\right]=(1+m)\left[\begin{array}{cc}
\cos \theta & -\sin \theta \\
\sin \theta & \cos \theta
\end{array}\right]\left[\begin{array}{l}
x^{(1)} \\
y^{(1)}
\end{array}\right]+\left[\begin{array}{c}
\Delta x \\
\Delta y
\end{array}\right]
$$

Explain (in words only) what all transformation parameters $m, \theta, \Delta x, \Delta y$ mean.
(b) Given are points' $A, B$ coordinates in the coordinate system (1):

$$
x_{A}^{(1)}=0 \mathrm{~m}, y_{A}^{(1)}=0 \mathrm{~m}, x_{B}^{(1)}=1000 \mathrm{~m}, y_{B}^{(1)}=1000 \mathrm{~m} ;
$$

and in the coordinate system (2):

$$
x_{A}^{(2)}=3500 \mathrm{~m} ; y_{A}^{(2)}=1500 \mathrm{~m} ; x_{B}^{(2)}=4502 \mathrm{~m} ; y_{B}^{(2)}=2502 \mathrm{~m}
$$

Assuming that the transformation between systems (1) and (2) is a Helmert transformation:

$$
\left[\begin{array}{l}
x^{(2)} \\
y^{(2)}
\end{array}\right]=(1+m)\left[\begin{array}{cc}
\cos \theta & -\sin \theta \\
\sin \theta & \cos \theta
\end{array}\right]\left[\begin{array}{l}
x^{(1)} \\
y^{(1)}
\end{array}\right]+\left[\begin{array}{c}
\Delta x \\
\Delta y
\end{array}\right]
$$

calculate its parameters $m, \theta, \Delta x$ and $\Delta y$.

## Points:

| Question | 1 <br> ab b | 2 <br> ab b | 3 <br> ab b | 4 <br> ab | 5 <br> ab | Total. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Points | 5 | 5 | 5 | 5 | 5 | 25 |
|  | 23 | 32 | 23 | 23 | 23 |  |


| Points | 10 | 13 | 16 | 19 | 23 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Grade | 1 | 2 | 3 | 4 | 5 |

