

## Definition

The GRS80

A. based on the theory of the geocentric equipotential ellipsoid, defined by the following conventional constants :

- equatorial radius of the Earth :  
 $a = 6\,378\,137$  m,
- geocentric gravitational constant of the Earth (including the atmosphere):  
 $GM = 3\,986\,005 \cdot 10^8$  m<sup>3</sup>/s<sup>2</sup>,
- dynamical form factor of the Earth, excluding the permanent tidal deformation :  
 $J_2 = 108\,263 \cdot 10^{-8}$ ,
- angular velocity of the Earth :  
 $\omega = 7\,292\,115 \cdot 10^{-11}$  rad/s,

B. used the same computational formulas, adopted at the XV General Assembly of IUGG in Moscow 1971 and published by IAG, for the Geodetic Reference System 1967,

C. is orientated in such kind, that the minor axis of the reference ellipsoid, defined above, be parallel to the direction defined by the Conventional International Origin, and that the primary meridian be parallel to the zero meridian of the BIH adopted longitudes.

## Numerical Values

### *Derived Geometrical Constants*

$b = 6\,356\,752.3141$ m	semiminor axis
$e^2 = 0.006\,694\,380\,022\,90$	$e$ = first excentricity
$f = 0.003\,352\,810\,681\,18$	flattening

### *Derived Physical Constants*

$U_0 = 6\,263\,686.0850 \cdot 10$ m <sup>2</sup> s <sup>-2</sup>	normal potential at ellipsoid
$m = 0.003\,449\,786\,003\,08$	$m = \frac{\omega^2 \cdot a^2 \cdot b}{GM}$ $\omega$ = angular velocity of the earth
$\gamma_e = 9.780\,326\,771\,5$ m/s <sup>2</sup>	normal gravity at equator
$\gamma_P = 9.832\,186\,368\,5$ m/s <sup>2</sup>	normal gravity at pole
$f^* = 0.005\,302\,440\,112$	$f^* = \frac{\gamma_P - \gamma_e}{\gamma_e}$
$k = 0.001\,931\,851\,353$	$k = \frac{b \cdot \gamma_P - a \cdot \gamma_e}{a \cdot \gamma_e}$

## Gravity Formular 1980

Somigliana's closed formula for normal gravity is

$$\gamma_0 = \frac{a\gamma_e \cos^2\varphi + b\gamma_p \sin^2\varphi}{\sqrt{a^2 \cos^2\varphi + b^2 \sin^2\varphi}}$$

For numerical computations, the form

$$\gamma_0 = \gamma_e \frac{1 + k \sin^2\varphi}{\sqrt{1 - e^2 \sin^2\varphi}}$$

with the values of  $\gamma_e$ ,  $k$ , and  $e^2$  shown above, is more convenient.  $\varphi$  denotes the geographical latitude.

The series expansion

$$\gamma_0 = \gamma_e \left( 1 + \sum_{n=1}^{\infty} a_{2n} \sin^{2n} \varphi \right)$$

with

$$a_2 = \frac{1}{2}e^2 + k$$

$$a_4 = \frac{3}{8}e^4 + \frac{1}{2}e^2 k$$

$$a_6 = \frac{5}{16}e^6 + \frac{3}{8}e^4 k$$

$$a_8 = \frac{35}{128}e^8 + \frac{5}{16}e^6 k$$

becomes

$$\begin{aligned} \gamma_0 = \gamma_e & (1 + 0.0052790414 \sin^2\varphi \\ & + 0.0000232718 \sin^4\varphi \\ & + 0.0000001262 \sin^6\varphi \\ & + 0.0000000007 \sin^8\varphi) \end{aligned}$$

it has a relative error of  $10^{-10}$ , corresponding to  $10^{-3} \mu\text{ms}^{-2} = 10^{-4} \text{ mgal}$ .

The conventional series

$$\gamma_0 = \gamma_e \left( 1 + f^* \sin^2 \varphi - \frac{1}{4} f_4 \sin^2 2\varphi \right)$$

with

$$f_4 = -\frac{1}{2} f^2 + \frac{5}{2} f m$$

becomes

$$\gamma_0 = 9.780327 \left( 1 + 0.0053024 \sin^2 \varphi - 0.0000058 \sin^2 2\varphi \right) \frac{m}{s^2}$$

## **Origin and Orientation of the Reference System**

IUGG Resolution No. 7, quoted at the beginning of this paper, specifies that the Geodetic Reference System 1980 be geocentric, that is, that its origin be the center of mass of the earth. Thus, the center of the ellipsoid coincides with the geocenter.

The orientation of the system is specified in the following way. The rotation axis of the reference ellipsoid is to have the direction of the Conventional International Origin for Polar Motion (CIO), and the zero meridian as defined by the Bureau International de l'Heure (BIH) is used.

To this definition there corresponds a rectangular coordinate system XYZ whose origin is the geocenter, whose Z-axis is the rotation axis of the reference ellipsoid, defined by the direction of CIO, and whose X-axis passes through the zero meridian according to the BIH.