Tangensbousole

Aims
To find the horizontal component of the magnetic field of the Earth in Copenhagen.
To examine dependence of the magnetic field B in the centre of a loops of circular current carrying wires of the current I, of the radius R and of the number of current-loops N.

Apparatus
Tangensbousole (loops of circular wires with compass in the centre), ammeter, direct current supply, ruler, wires.

Theory
Assume the loops of circular wires being positioned such that the horizontal component of the local Earth-magnetic field-vector $\mathbf{B_E}$ is parallel to the plane of the loop. The direction of the magnetic field-vector $\mathbf{B_L}$ created by the current in the loops will then be perpendicular to the direction of $\mathbf{B_E}$. The resultant magnetic field-vector $\mathbf{B_R}$ is the vector-sum of the earth- and loop-magnetic fields:

$$\mathbf{B_R} = \mathbf{B_E} + \mathbf{B_L}$$

Knowing that $\mathbf{B_L} \perp \mathbf{B_E}$ and the angle between $\mathbf{B_R}$ and $\mathbf{B_E}$ being ϕ we have:

$$B_L = B_E \tan(\phi)$$

B_L *and* B_E being lengths of the vectors.

According to the laws of electromagnetism (Biot and Savart's Law or the Maxwell equations) the magnitude of the magnetic field in the centre of a circular loop current I of radius R, number of loops N, is:

$$B_L = \mu_0 \frac{N I}{2R}$$

(Do not mix this with the magnetic field near a long straight wire or inside a long solenoid).

The experiment
Position the tangensbousole correctly and start measurement series investigating

1. tan(ϕ) as a function of I for constant R and N
2. tan(ϕ) as a function of 1/R for constant I and N
3. tan(ϕ) as a function of N for constant I and R

Advices:
Be sure to read the angle ϕ correctly using the compass.
Keep away from artificial (electro)magnetic fields.

The measurement series together with the theory should make it possible to fulfil the two aims of this experiment.
Discuss random and systematic errors attempting to give some numerical judgements.
Make sketches to illustrate vector-relations and experimental set-up.

The present value of the horizontal component of the Earth magnetic field in Copenhagen can hopefully be found on the Internet.