Remember to produce a clear homework document!
Explain your reasoning when going from one step to the next towards the final solution.

3. (a) A current loop and a long straight current wire lie in the plane of the paper as in the picture. The force acting **on the straight wire** has the following direction:

A left along the wire

B right along the wire

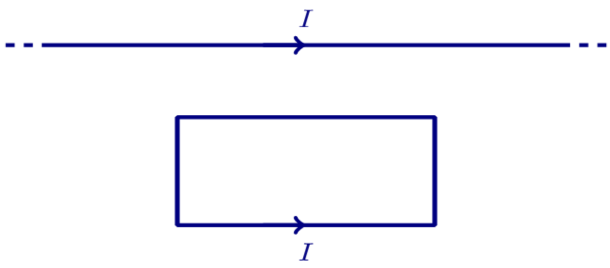
C down toward the loop

D up away from the loop

E out of the paper

F into the paper

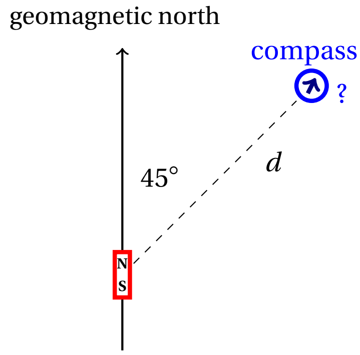
G there is no force acting on the wire



Choose one of the seven suggestions, and justify your answer.

(b) The needle of a compass points to the magnetic North (often quite close to the geographical North). In Helsinki, the horizontal component of the Earth's magnetic flux density is $17\,\mu$T. If there is a permanent magnet in the vicinity, the needle will be deflected.

Let there be a bar magnet such that it is aligned with the geomagnetic field line as in the picture. Treat the bar magnet as a magnetic dipole with moment $m = 5\,\text{Am}^2$.



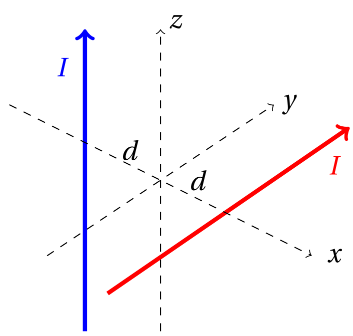
i. Calculate the magnitude of the magnetic flux density created by the bar magnet at a distance $d = 30\,$cm slightly sideways (the angle being 45° with the dipole moment vector).

ii. What is the direction of the magnetic flux density vector created by the bar magnet at this point?

iii. How many degrees will the compass needle be turned from the north at this point? To east or west?

(c) Two straight (infinitely) long wires both carry steady current I. The first current flows parallel to the z axis and it crosses the xy plane at $x = -d, y = 0$. The second one is parallel to the y axis and it crosses the zx plane at $x = +d, z = 0$.

The two wires create together a static magnetic field in the space. Study the magnetic field on the y-axis, in other words $\mathbf{H}(0, y, 0)$.



i. Where on y axis is the field largest? What is the direction of the field at that point?

ii. Illustrate the magnitude of the field as function of y. In other words, plot the function

$$\frac{|\mathbf{H}(0, y, 0)|}{|\mathbf{H}_{\max}|}$$

(With this normalization your plot is such that at the largest point it is unity.)