

Optional sessions (Sequence 2)

Verticality and horizontality

1) Study of the verticality

Duration : a 45 minute session for all the activities described in this slip.

Location : the classroom, the hall or another room and in the schoolyard for a moment, if it is possible.



Equipment

For the class

To build plumb lines:
yarns and various strings (fishing thread),
various small objects that can be hanging,
washers (in two or three different sizes) and
plumbs for fishing.

Preliminary investigation

The pupils share what they know about what is called verticality and especially the objects they think vertical : the tests can be read at that time, and commented.

How can you check the verticality of an object ?

The pupils tell what they know about what we call verticality and give examples of objects that they believe to be vertical: this is an opportunity to consult the test questionnaire and comment it.

How to verify the verticality of an object?

Game-experiment

Perhaps some children will propose to make a simple visual check, not on one isolated object but rather on two different objects supposed to be vertical.

For instance, one can go next to the vertical edge of an open door and one takes a sight on the vertical part of a window on the wall facing at the door by closing an eye. If by slightly nodding one's head one can see the edge and the window coming closer and one can observe that they seem to be little by little parallel until being adjusted all through their length, it is probably because they are both really vertical (or because, by chance, they all bend in the same way either really either by a perspective effect!). It is very interesting to apply this method when one deals with two very high buildings (towers of our modern cities): the accuracy of their verticality is really breathtaking!

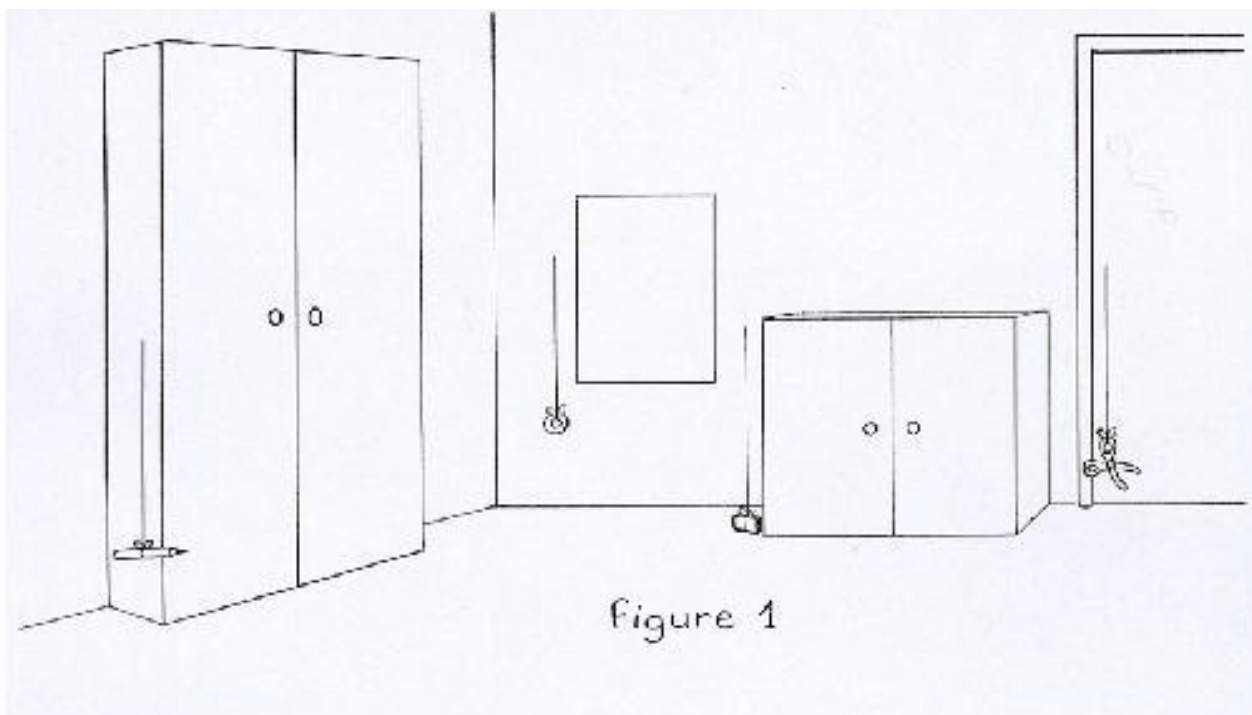
Hence the children can enjoy trying to apply this method. When they note that something does not work properly, they must detect which one of the two objects is not vertical (or maybe both!) taking a new sight for each object with respect to a third reference already calibrated (that is to say an object whose verticality has been positively verified).

Building and using plumb lines

After understanding that one absolutely needs to refer to an object which is also vertical, the children may ask: how to check the verticality of an isolated object?

Some children will have seen sophisticated spirit levels whose one of the three bubble tubes allows to check the verticality of an object (the two others indicating of course the horizontality for one and the 45 degree angle for the other). Other pupils will probably have heard about the plumb line. So it will be interesting to build one plumb line from different types of strings and plumbs: one will observe that fine string or fishing thread suits relatively light plumbs better than thick string which becomes taut with difficulty. The metal washers will be especially useful because they can be attached easily and their flatness permits to approach the line to the object to be tested as close as possible.

Once the plumb lines are finished, the pupils will use them to check the verticality of various objects inside the classroom and outside (figure 1).



2) Experiment slip on

horizontality

Duration : 3 sessions

Location : classroom.



Equipment :

For the class

For the main session (experiment with the containers of water):

8 to 10 large ordinary white paper sheets (50 x 65 cm),

about a dozen plastic containers (see further down which ones) with some water slightly colored (foresee a sponge!),

black pencils,

a few long flat rules or pieces of electric

beadings perfectly straight,

a spirit level bought in the shops.

For each group of 2 pupils :

building the spirit levels

one phial of physiological serum (item sold in chemist's shops for babies hygiene),

20 cm of a 40 mm moulding,

adhesive tape..

Preliminary investigation

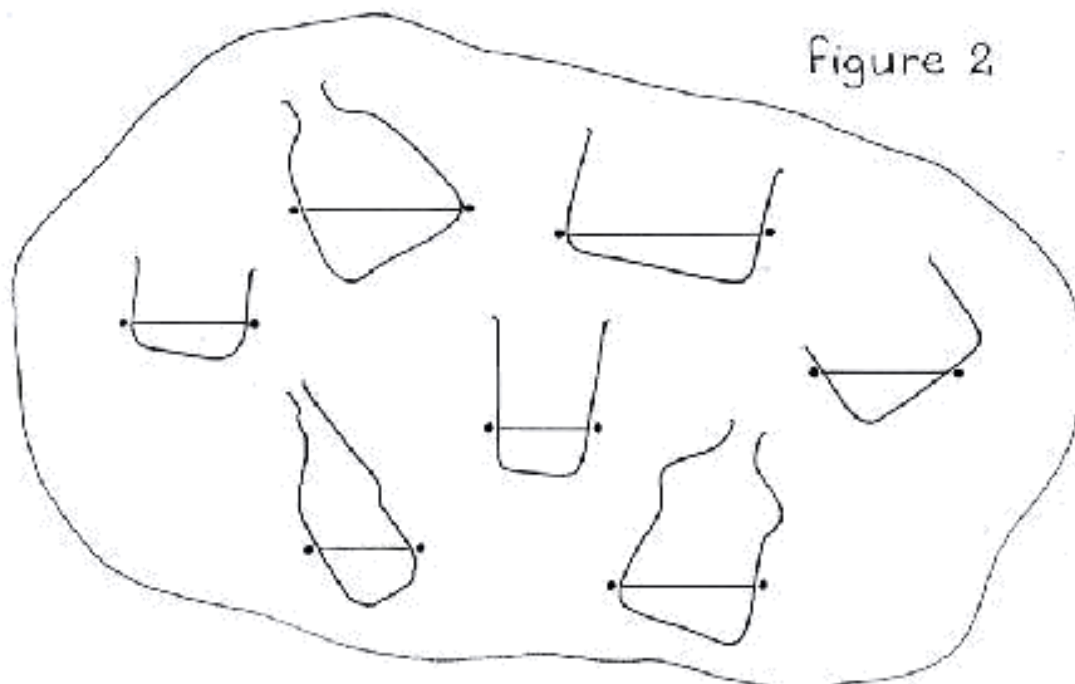
In general, the children define horizontality by quoting various objects of the daily life like the ground of rooms for instance: "it is always perfectly flat and if it climbs a bit sometimes, one feels it immediately", or the top of a table: "it is flat too and if it is slightly leaning a ball will roll and fall down on the ground". Hence, horizontality is a synonym of stability for them. This is perhaps the reason why they do not think of quoting water at rest, unstable by nature. Ask the pupils to draw a liquid in a container: many will trace a waving line as a surface. And if one asks them to draw a bottle about to pour a liquid in a glass, the liquid level will be definitely leaning.

Experiment

There is a little experiment to discover the horizontality of the free surface of a liquid, the pupils divided into groups of 3 to 5 but using a shared equipment.

Several large paper sheets, re-cut to get an ordinary irregular shape, are posted up on the walls and on the black board, one per group.

About a dozen different transparent (or translucent) plastic containers are put on a central table. They are containers for deep freezing, small containers for carry-out food, various bottles. Their section is preferentially square, rectangular, or oblong; each of them contains slightly colored water until about a quarter of their height.



One child per group takes one of the containers, brings it near to the wall and "applies" it carefully against one of the sheets, without trying to put it "straight" but rather by slightly leaning it, and keeps it motionless. A fellow draws its contour and, once the water is at rest, he leaves a small mark near the container here and there to locate the liquid level. The operation is done several times with various containers differently leaning.

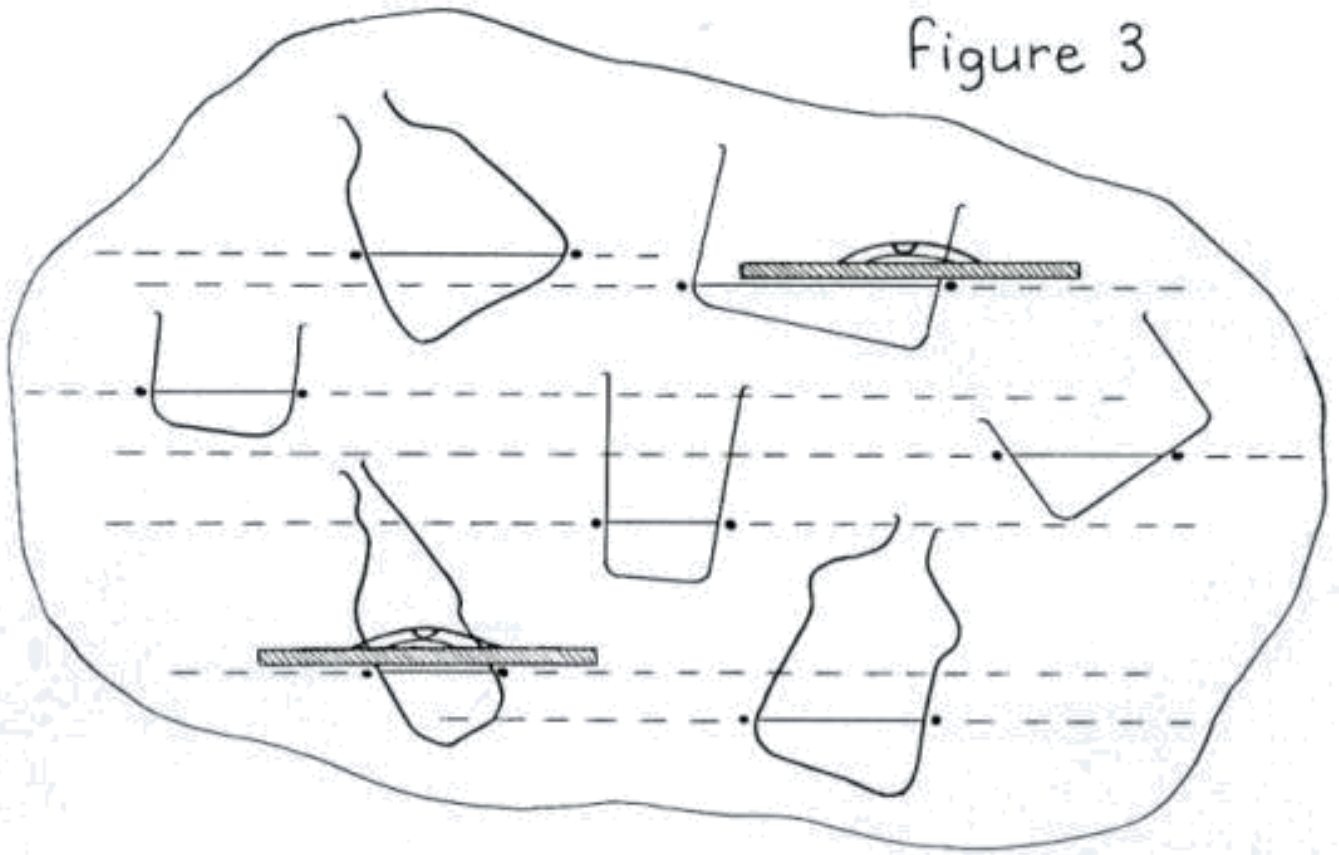
The children realize that "all the marks appear absolutely flat". How to verify it? "One can enlarge them on both sides with a long rule to better see". This brings the note: "The lines are parallel. How to verify this parallelism?" Some will propose to measure the separation of the lines continued at each of their ends.

Thus, to verify that two lines are perfectly parallel, they will continue (carefully and with a long rule) the lines of the water levels until the edge of the sheet posted on the black board. Then they will measure the separation between both ends of those lines. A half a centimeter error being accepted, they will be able to conclude that the lines have the same separation and hence are parallel! (see figure3).

The children whose parents are do-it-yourself enthusiasts will certainly quote the water level and will propose to bring one in class. Once the object will have been observed and tested, it will permit to check on the sheets still posted the horizontality of the lines corresponding to the water levels in the different drawings of containers (figure 3).

The pupils will certainly use spontaneously the spirit level on tables, shelves, benches, and so on, to check their horizontality.

Figure 3



However they will often place it in only one position, usually parallel to one edge: then dare them to obtain the centering of the bubble on a table that you will have leaned before (raising up one foot on a book for instance). They will do it after a few attempts and they will understand that it is necessary to place their spirit levels in at least two very different positions on a given object to be sure of its horizontality.

Building and using spirit levels

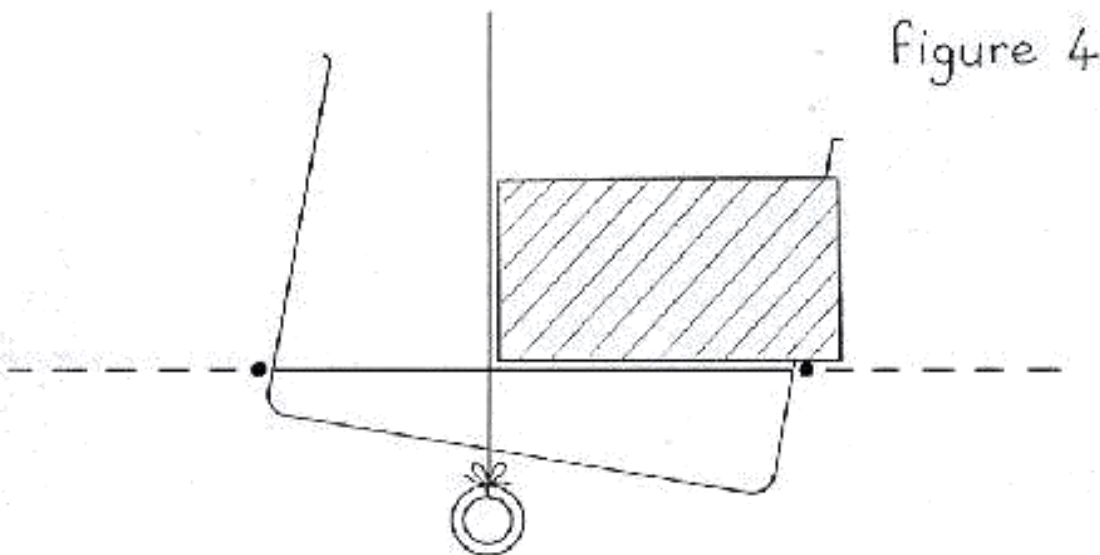
Here is an easy and quick manner so that the pupils build some spirit levels very smart: from physiological serum phial attached on pieces of 40 mm mouldings, with 20 cm per level. The phial, put flat in the hollow of the moulding, is maintained by adhesive tape. Now one needs to test the whole tool on a surface whose horizontality will have been verified with a "true" level, this in order to possibly modify the phial position on its support with paper chocks. The pupils will adjust the phial so that the bubble stabilizes exactly in the middle. They will see that it is not necessary to put a mark on each side (like in the levels found in the shops whose the tube has slightly the shape of a bridge) because at the smallest leaning the bubble goes back to one of the phial ends.

Hence the children will be able to use the level (or their own level) to settle the support of their solar stick.

Discover experimentally the right angle

The great sheets with the drawings of the vessels containing water being still there, suggest, if your pupils haven't already had the idea, to take the plumb lines and use them next to the drawings to see if there isn't something interesting to discover... *"The plumb line crosses the surface line just like the + of an addition."* . .

Give a small sheet of coloured paper to each group and ask if it couldn't be inserted in the "crossing". The pupils readily see that the sheet can not only coincide with each of the four sectors of their "crossings", but that also, if they turn it, each of its "corners" would fit (fig. 4). *"We could also put in a crossing four set squares just like my big brother's ! With it, he can draw right angles exactly like those we were asked to point in the test."*



Of course, the pupils will look for objects around them, numerous, that show right angles. They will also try to draw right angles with a set square, and see that they may not need one with graph paper or small square paper (but only when one of the sides of the right angle coincides, or is parallel to a ruling).

So, having discovered what is "upright" is vertical and what is "level" is horizontal, and that the "crossing" of both gives the right angle of the set square, the pupils understand that the gnomons on their support must have these characteristics to be really reliable.