Accelerating Fluids

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I read with interest the item "Relative Horizontality" on p. 503 of the 28 April issue of Science.[1]

In this it is reported that people who frequently MOVE liquids RAPIDLY in open containers seem not to appreciate that the STATIC surface of a liquid is "horizontal".

However, these people are paid not to spill the liquids, whose surfaces are often very near the rims of the containers. When one ACCELERATES a liquid, its surface tends to be perpendicular to the effective gravity vector obtained by subtracting the acceleration vector from the ordinary downward gravity vector.

For example, a fast-food waitperson might accelerate a coffee cup over its first meter of travel in 0.5 sec, corresponding to $a = 2s/t^2 = 8$ m/sec^2, which is nearly 1 g!. During this acceleration the surface of the liquid would approach an angle given by $\tan(\theta) = a/g = 8/9.8$, or $\theta = 39^\circ$.

To save his/her job, the waitperson would be well advised to tilt the cup during the initial acceleration, restoring it to the horizontal only during the steady walk to the table, and then giving it a reverse tilt as the cup is decelerated onto the table.

Thus, these workers may well respond to the psychologists' question by noting that in situations in which the surface of a liquid is not horizontal, the container has usually been tipped to keep the surface parallel to the rim.

The "correct" answer to the psychologists' question is "relative" to details of the situation. Technically, we are talking about Galilean relativity here.

I would change the psychologists' quote: "the more likely you are to evaluate the situation relative to the container, the more likely there would be error", to "the more likely you are to evaluate the situation relative to the container, the more likely you will get the correct, practical answer".

A related example: What is the direction to the center of the earth?

A plumb bob does not point to the center of the earth. Nor is the surface of a lake, or water in an apparently static cup, perpendicular to the direction to the center of the earth. Because the Earth is rotating, the apparent "downward" direction is along the the gravity vector minus the local acceleration vector associated with the rotation of the earth.

[1] http://kirkmcd.princeton.edu/examples/mechanics/mcdonald_science_268_1261_95.pdf