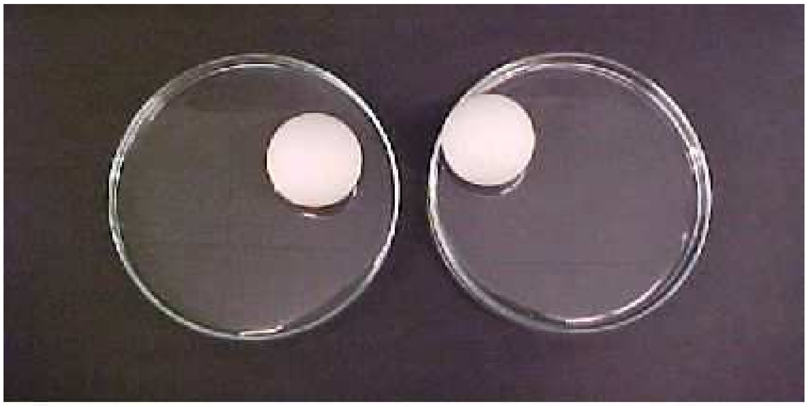
# Equilibrium and potential energy

Aim: To show a counter-intuitive example of stable equilibrium that can be explained by means of minimum potential energy

Subjects: 1J20 (Stable, Unstable and Neut. Equilibrium)

Diagram:



Equipment:

- Two petri dishes.
- Two table tennis balls

# Equilibrium and potential energy

Presentation: One petri dish is half filled with water and the table tennis ball is floating in it. It moves a bit and at a certain moment it will hit the rim and stick to it. When carefully observing it can be seen that when the ball approaches the rim it will even accelerate to it! There is clearly an attracting force acting.

The other petri dish is filled with water to the rim and even a little bit more; the waterlevel is higher than the rim. The table tennis ball is floating around but never touches the rim. When observing carefully it can be seen that on approaching the rim the ball slows down and is repelled. There is clearly a repelling force working.

Explanation: The difference between the two petri dishes is the shape of the meniscus of the watersurface: The dish that is half-filled with water has a hollow meniscus, the one filled to the rim a spherical meniscus. The ball that floats in the halffilled dish floats upwards when approaching the rim. This is the counter-intuitive part of the demonstration. The same holds for the ball floating in the to-the-rim filled dish; this ball "refuses" to float downwards when approaching the downward incline.

The key to understanding is the condition for equilibrium in a conservative force field that says: $dE_p=0$ and that this equilibrium is stable when $E_p$ (potential energy) is a minimum. Applying this to our demonstration we have to consider not only the table tennis ball but also the water it displaces. To have equilibrium the common center of mass of these two should be positioned as low as possible and so the table tennis ball as high as possible. In the situation with the hollow meniscus this is in the water at the rim and in the situation of the spherical meniscus this is in the water away from the rim (see also Figure1).

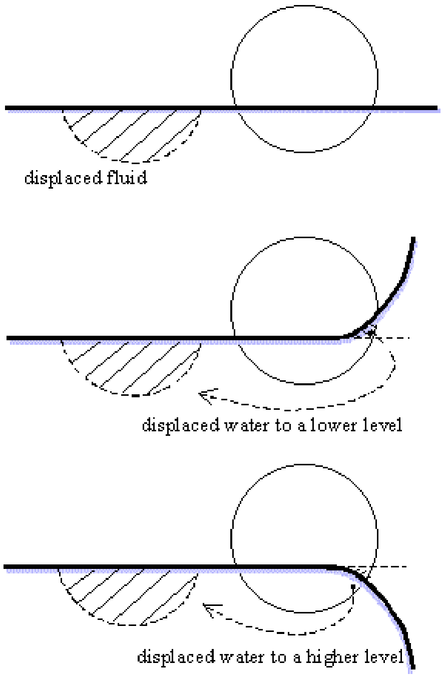



Figure 1

# Equilibrium and potential energy

Remarks:

- This demonstration can be shown on an overhead projector.
- You can also show this demonstration with one ball and petri dish. Just put the ball in the petri dish and slowly fill it with water. When floating the ball will first stick to the rim, but when filling continues, at a certain moment the ball will float away from the rim.
- You can also just place the dishes with water and balls in your lecture-room. Draft in your room will make the balls float around. The performance of the balls will make your students puzzle.

Sources:

- Roest, R., Inleiding Mechanica, pag. 76-78;188-193

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