

# Does coffee stay hotter in a white or black mug?

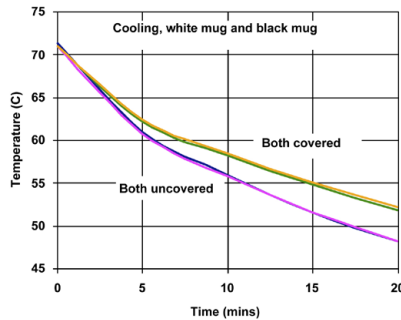
Christmas is traditionally a holiday that places a lot of importance on food and drink. We have therefore chosen to include an article on this subject in our December issue of Pentronic News. Professor Dan Loyd answers the following question:

**QUESTION:** Does coffee cool faster in a black mug than in a white one? *Mai-Gret F.*

**ANSWER:** The colour of the mug only affects that portion of the heat flow which radiates from the outer surface of the mug to its surroundings. Inside the mug, the heat is transferred via natural convection from the hot coffee to the mug's inner surface, and then via heat conduction through the wall of the mug to its outer surface. On the outer surface, in addition to the heat flow that radiates outwards, there is also a convective heat transfer to the mug's surroundings. The heat flow from the bottom of the mug to the table is primarily via conduction. The heat transfer from the surface of the coffee to the surroundings occurs largely via natural convection and radiation. The coffee surface also gives off steam. This phase change of water to steam requires heat, which results in additional cooling of the coffee.

## VERY LITTLE DIFFERENCE

The radiation from the mug's outer surface is influenced by factors like the surface's temperature and emissions coefficient. The latter depends on the materials used to make the mug, the surface structure, et cetera. A black mug has a slightly higher emissions coefficient than a white one in the wave range relevant to thermal radiation, but the difference is not large. A black mug therefore cools slightly faster than




Questions should be of general interest and be about temperature measurement techniques and/or heat transfer.

## QUESTIONS? ANSWERS!

a white one, but in most cases the difference in the cooling speed is tiny. The diagram shows an experiment involving a black mug and a white one. We can see that in this experiment, the difference between the cooling time for coffee in a white mug compared to a black mug is basically nonexistent. If the mug is covered, for instance with a saucer, this will reduce the effect of the surface vaporisation (see diagram). In this case, too, the difference in cooling time between the black mug and the white one is basically nonexistent.

## LIKE A TEMPERATURE SENSOR

In thermal terms, a sensor closely resembles a coffee mug. When installing a sensor, it is therefore essential always to check what effect the radiation process can have on the heat flow and therefore on the temperature measurement process. The temperature of a wet sensor will be affected by the vapourisation process, which requires heat. In both cases, the temperature readings will therefore be affected. 

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