

# How much can *you* drink and be able to legally drive?

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## Alcohol and driving

A significant amount of traffic accidents are related to one or more of the people involved having consumed alcohol. As you know, it is illegal to drive with too high *blood alcohol content*. What is the legal limit of blood alcohol content for drivers in your country?

The **blood alcohol content** or BAC is the concentration of alcohol in a person's blood. In most European countries the measure of BAC is milligrams alcohol per milliliter blood. So if you have 50 mg alcohol per ml blood, it would mean that you have a BAC of 0.5 ‰.

After consummation, alcohol is degraded in the body. So after a certain amount of time after consummation you will no longer have alcohol in your blood. It can be a great advantage to know the amount of blood alcohol content at a given time after the consummation of alcohol. But the degradation of alcohol is very individual. In particular the speed of degradation is depended on sex, weight and height. But also factors like being used to drink large quantities of alcohol have an influence. In the following activities you are going to construct a *rule of thumb* about how much alcohol you can drink before driving, and how long you must wait before driving. You can use this rule as a guide in situations in which you are in doubt whether you can legally drive. And maybe you can avoid being involved in accidents.

**Assignment 1:** Discuss and list what happens to you when you drink, and use your experiences and knowledge of e.g. biology to say something about your ability to drive while intoxicated with alcohol.

Now would be a good time to familiarize yourself with the concept of mathematical models by reading the handout "*Mathematical models*".

Swedish chemist Widmark developed a mathematical model for the blood alcohol content (measured in alcohol pro mille blood).

Since alcohol is water soluble, it can only be distributed in the body's water. Therefore, if one wants to calculate the blood alcohol content, one must first ascertain how much of a person's body mass is comprised by water. Widmark developed a so-called

reduction factor  $r$ , with which one can calculate how much water one's body contains. This factor is gender specific:

$$r_{Male} = 0,3161 - 0,0048 \cdot v + 0,0046 \cdot h$$

$$r_{Female} = 0,3122 - 0,0064 \cdot v + 0,0045 \cdot h$$

Here  $v$  denotes the person's weight in kg, and  $h$  denotes the person's height in cm.

**Assignment 2:** Using the above formula, calculate your reduction factor.

Widmark thought that if a person's reduction factor is known it would be possible to calculate that person's blood alcohol content from this formula

$$C_t = \frac{n \cdot D}{r \cdot w} - \beta \cdot t$$

Here

$C_t$ : the blood alcohol content (measured in grams of alcohol per liter blood) at time  $t$ .

$n$ : the amount of standard units of alcohol drunk by the person.

$D$ : the amount of alcohol in a standard unit of alcohol in grams (a standard unit contains 12 grams of alcohol).

$r$ : the person's reduction factor.

$w$ : the person's body weight in kilos.

$\beta$ : metabolic rate in grams per liter per hour (for males: 0.18; for females: 0.15).

$t$ : the time in hours.

**Assignment 3:** Draw a graph which describes the development of your blood alcohol content if you consume 3, 5, and 8 units of alcohol. What is your blood alcohol content in each of the three cases after 4, 6 and 8 hours?

**Assignment 4:** Consider different scenarios in which you would have blood alcohol content just above the legal limit. What do you think about the legal limit with the information about these scenarios in mind? Is the limit fair, too low or too high? Explain and justify your answer.

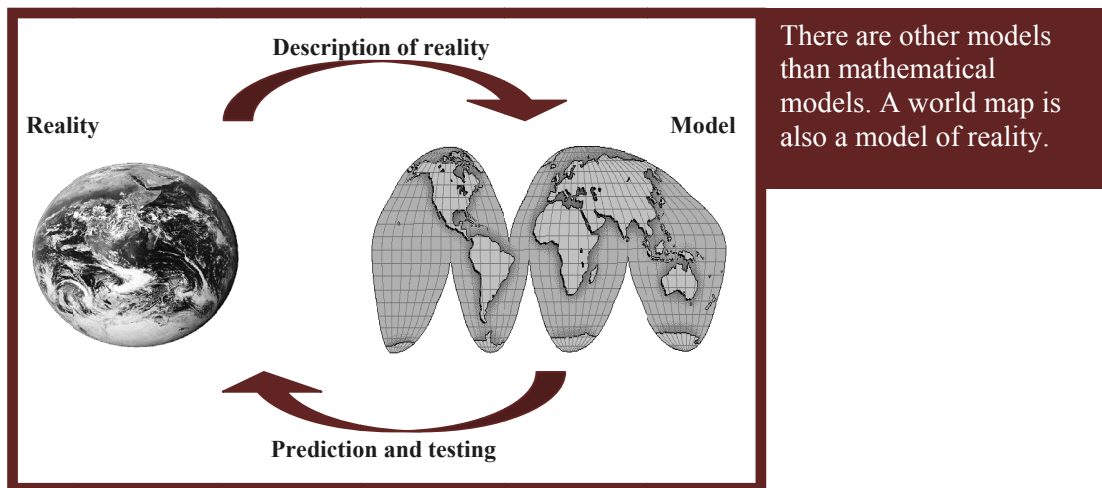
**Assignment 5:** Malthe weighs 80 kilos and he is 178 cm high. Today he was pulled over by the police and asked to breathe into an alcoholmeter. His blood alcohol content

was measured to be 0.93. Malthe explained that he had his last drink 3 hours ago. How many units of alcohol did Malthe drink 3 hours ago if he is telling the truth?

**Assignment 6:** Construct an individual verbal model or a rule of thumb, which you can use whenever you are consuming alcohol. The model should help you to remember a good drinking habit in situations where you know you must drive later on. Think about which factors you will include in the model. Will you focus on how long you have to wait after drinking a specific amount of alcohol, or will you focus on how much you can legally consume if you wait a specific amount of time, or will you focus on something else or even both? Explain your choice of focus, and present the model to the class.

## Mathematical models

An important reason to learn mathematics is that in doing so one acquires methods to solve real-life problems. The problem areas that are described using mathematics are often immensely complex. Therefore it can be necessary to simplify and idealize the situation. This is why mathematical descriptions of real-life situations are called *mathematical models* of reality.



The construction and application of a mathematical model is usually a process in which the individual steps must be repeated. The first version of a model typically yields some predictions on the problem at hand. These predictions can be tested against the course of reality. This test may, in turn, lead to improvements on a second version of the model and thereby to new predictions, which, again, can be tested. Repeating this process often leads to very precise predictions on real-life situations.

The construction of a mathematical model often includes one of the following description methods.

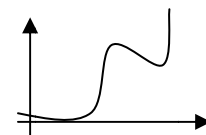
1. One can give a *numerical* description. Here one would usually arrange a series of data in a table which describes a specific development.
2. One can give a *symbolic* description. Here one would use mathematical symbols and expressions to describe a specific development
3. One can give a *graphical* description. Here one would describe a situation by means of a graph in a system of coordinates.

Height	160	171	172
Weight	66	68	75

Numerical method

$$P = \alpha \cdot t + \beta$$

Symbolic method



Graphical method

## Verbal Models

Before the construction of a mathematical model of a situation it is a good idea to describe that situation in words. In that way it can be easier to see how the mathematical model can be constructed. This is why some mathematical models begin as *rules of*

*thumb* – a simple description with words of a situation in real-life. A good example of a rule of thumb – or a verbal model – is:

“Your height at age 2 is half your eventual height as an adult”

Having constructed such a verbal model it is possible to continue to construct a mathematical model on the basis of the verbal model. Try to construct other types of models, such as graphic and symbolic models on the basis of this rule of thumb.