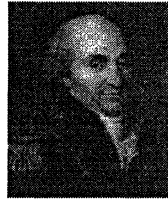


### 1.6 Charles Augustin Coulomb (1736-1806)

Coulomb learned about Amontons' work and got so interested in this daily life physics that he started making measurements himself. His was not only interested in friction coefficients, but also in the time dependence of the static friction force on the time of rest. He found an increase of the friction force with the time of rest and tried to find a mathematical description. Phenomenologically he found the following relation between the static friction  $F_{L,stat}$  and time of rest  $t$ :



C. A. Coulomb

$$F_{L,stat} = \frac{A + mt^s}{C + t^s} \quad (1.2)$$

where  $A$ ,  $B$  and  $m$  are material dependent constants. For the exponent  $s$  he found about  $s = 0.2$ . The friction force for  $t = 0$  is  $F_{L,stat} = A/C = 502$  and for  $t \rightarrow \infty$  it increases to  $F_{L,stat} = m = 2700$  measured for two pieces of well-worn oak lubricated with tallow<sup>a</sup>

He published his major results in an "Essai sur la théorie du frottement", namely the friction laws, often referred to as "Coulomb's laws of friction":

1. For wood sliding on wood under dry conditions, the friction rises initially but soon reaches a maximum. Thereafter, the force of friction is essentially proportional to load.
2. For wood sliding on wood the force of friction is essentially proportional to load at any speed, but kinetic friction is much lower than the static friction to long periods of repose.
3. For metals sliding on metals without lubricant the force of friction is essentially proportional to load and there is no difference between static and kinetic friction.
4. For metals on wood under dry conditions the static friction rises very slowly with time of repose and might take four, five or even more days to reach its limit. With metal-on-metal the limit is reached almost immediately and with wood-on-wood it takes only one or two minutes. For wood-on-wood or metal-on-metal under dry conditions speed has very little effect on kinetic friction, but in the case of wood-on-metal the kinetic friction increases with speed.

The second part of the fourth law, which describes the velocity independence of kinetic friction is nowadays well known as Coulomb's Law (See beginning of this chapter)

<sup>a</sup>The units are not SI-standard, but have to be viewed in the historical context.