COEFFICIENT OF FRICTION

The coefficient of friction between two surfaces is the ratio of the force required to move one over the other to the force pressing the two together. Thus if F is the minimum force needed to move one surface over the other, and W is the force pressing the surfaces together, the coefficient of friction μ is given by $\mu = F/W$. A greater force is generally needed to initiate movement from rest that to continue the motion once sliding has started. Thus the static coefficient of friction μ(static) is usually larger that the sliding or kinetic coefficient μ(sliding).

This table gives characteristic values of both the static and sliding coefficients of friction for a number of material combinations. In each case Material 1 is moving over the surface of Material 2. The type of lubrication or any other special condition is indicated in the third column. All values refer to room temperature unless otherwise indicated. It should be emphasized that the coefficient of friction is very sensitive to the condition of the surface, so that these values represent only a rough guide.

References

1. Minshall, H., in *CRC Handbook of Chemistry and Physics, 73rd Edition*, Lide, D. R., Ed., CRC Press, Boca Raton, FL, 1992.
2. Fuller, D. D., in *American Institute of Physics Handbook, 3rd Edition*, Gray, D. E., Ed., McGraw-Hill, New York, 1972.

Material 1	Material 2	Conditions	μ(static)	μ(sliding)
Metals				
Hard steel	Hard steel	Dry	0.78	0.42
		Castor oil	0.15	0.081
		Steric acid	0.005	0.029
		Lard	0.11	0.084
		Light mineral oil	0.23	
		Graphite		0.058
Hard steel	Graphite	Dry	0.21	
Mild steel	Mild steel	Dry	0.74	0.57
		Oleic acid		0.09
Mild steel	Phosphor bronze	Dry		0.34
Mild steel	Cast iron	Dry		0.23
Mild steel	Lead	Dry	0.95	0.95
		Mineral oil	0.5	0.3
Mild steel	Brass	Dry	0.35	
Cast iron	Cast iron	Dry	1.10	0.15
Aluminum	Aluminum	Dry	1.05	1.4
Aluminum	Mild steel	Dry	0.61	0.47
Brass	Mild steel	Dry	0.51	0.44
		Castor oil	0.11	
Brass	Cast iron	Dry		0.30
Bronze	Cast iron	Dry		0.22
Cadmium	Mild steel	Dry		0.46
Copper	Copper	Dry	1.6	
Copper	Mild steel	Dry	0.53	0.36
		Oleic acid		0.18
Copper	Cast iron	Dry	1.05	0.29
Copper	Glass	Dry	0.68	0.53
Lead	Cast iron	Dry		0.43
Magnesium	Magnesium	Dry	0.6	
Magnesium	Mild steel	Dry		0.42
Magnesium	Cast iron	Dry		0.25
Nickel	Nickel	Dry	1.10	0.53
Nickel	Mild steel	Dry		0.64
Tin	Cast iron	Dry		0.32
Zinc	Cast iron	Dry	0.85	0.21
Nonmetals				
Diamond	Diamond	Dry	0.1	
Diamond	Metals	Dry	0.12	
Garnet	Mild steel	Dry		0.39
Glass	Glass	Dry	0.94	0.4
Glass	Nickel	Dry	0.78	0.56

Material 1	Material 2	Conditions	μ(static)	μ(sliding)
Graphite	Graphite	Dry	0.1	
Mica	Mica	Freshly cleaved	1.0	
Nylon	Nylon	Dry	0.2	
Nylon	Steel	Dry	0.40	
Polyethylene	Polyethylene	Dry	0.2	
Polyethylene	Steel	Dry	0.2	
Polystyrene	Polystyrene	Dry	0.5	
Polystyrene	Steel	Dry	0.3	
Sapphire	Sapphire	Dry	0.2	
Teflon	Teflon	Dry	0.04	0.04
Teflon	Steel	Dry	0.04	0.04
Tungsten carbide	Tungsten carbide	Dry, room temp.	0.17	
		Dry, 1000°C	0.45	
		Dry, 1600°C	1.8	
		Oleic acid	0.12	
Tungsten carbide	Graphite	Dry	0.15	
Tungsten carbide	Steel	Dry	0.5	
		Oleic acid	0.08	
Miscellaneous materials				
Cotton	Cotton	Threads	0.3	
Leather	Cast iron	Dry	0.6	0.56
Leather	Oak	Parallel to grain	0.61	0.52
Oak	Oak	Parallel to grain	0.62	0.48
		Perpendicular to grain	0.54	0.32
Silk	Silk	Clean	0.25	
Wood	Wood	Dry	0.35	
		Wet	0.2	
Wood	Brick	Dry	0.6	
Wood	Leather	Dry	0.35	
Various materials on ice and snow				
Ice	Ice	Clean, 0°C	0.1	0.02
		Clean, -12°C	0.3	0.035
		Clean, -80°C	0.5	0.09
Aluminum	Snow	Wet, 0°C	0.4	
		Dry, 0°C	0.35	
Brass	Ice	Clean, 0°C		0.02
		Clean, -80°C		0.15
Nylon	Snow	Wet, 0°C	0.4	
		Dry, -10°C	0.3	
Teflon	Snow	Wet, 0°C	0.05	
		Dry, 0°C	0.02	
Wax, ski	Snow	Wet, 0°C	0.1	
		Dry, 0°C	0.04	
		Dry, -10°C	0.2	