STUDY ON FRICTION

Friction is the force that opposes the relative motion or tendency of such motion of two surfaces in contact. It is not, however, a fundamental force, as it originates from the electromagnetic forces between atoms. Friction between solid objects and gases or liquids is called fluid friction.

Equations

The classical approximation of the force of friction known as Coulomb friction (named after Charles-Augustin de Coulomb) [[1]] is expressed as $F_f = \mu N$, where μ is the coefficient of friction, N is the force normal to the contact surface, and F_f is the force exerted by friction. This force is exerted in the direction opposite the object's motion.

This simple (although incomplete) representation of friction is adequate for the analysis of many physical systems.

Coefficient of friction

The coefficient of friction (also known as the frictional coefficient) is a dimensionless scalar value which describes the ratio of the force of friction between two bodies and the force pressing them together. The coefficient of friction depends on the materials used -- for example, ice on metal has a low coefficient of friction (they slide past each other easily), while rubber on pavement has a high coefficient of friction (they do not slide past each other easily). Coefficients of friction need not be less than 1 - under good conditions, a tire on concrete may have a coefficient of friction of 1.7.

Sliding (dynamic) friction and static friction are distinct concepts. For sliding friction, the force of friction does not vary with the area of contact between the two objects. This means that sliding friction does not depend on the size of the contact area.

When the surfaces are adhesive, Coulomb friction becomes a very poor approximation (for example, Scotch tape resists sliding even when there is no normal force, or a negative normal force). In this case, the frictional force may depend on the area of contact. Some drag racing tires are adhesive in this way (see, for example,[2]).

The force of friction is always exerted in a direction that opposes movement (for kinetic friction) or potential movement (for static friction) between the two surfaces. For example, a curling stone sliding along the ice experiences a static force slowing it down. For an example of potential movement, the drive wheels of an accelerating car experience a frictional force pointing forward; if they did not, the wheels would spin, and the rubber would slide backwards along the pavement. Note that it is not the direction of movement of the vehicle they oppose, it is the direction of (potential) sliding between tire and road.

The coefficient of friction is an empirical measurement -- it has to be measured experimentally, and cannot be found through calculations. Rougher surfaces tend to have higher values. Most dry materials in combination give friction coefficient values from 0.3 to 0.6. It is difficult to maintain values outside this range. A value of 0.0 would mean there is no friction at all. Rubber in contact with other surfaces can yield friction coefficients from 1.0 to 2.0. A system with "interlocking teeth" between surfaces may be indistinguishable from friction, if the "teeth" are small, such as the grains on two sheets of sandpaper or even molecule-sized "teeth".

Types of friction

Static friction

Static friction (informally known as stiction) occurs when the two objects are not moving relative to each other (like a desk on the ground). The coefficient of static friction is typically denoted as μs. The initial force to get an object moving is often dominated ion.

Rolling friction occurs moving relative to each other and one "rolls" on the other (like a car's wheels on the ground). This is classified under static friction because the patch of the tire in contact with the ground, at any point while the tire spins, is stationary relative to the ground. The coefficient of rolling friction is typically denoted as μr.

Kinetic friction

Kinetic (or dynamic) friction occurs when two objects are moving relative to each other and rub together (like a sled on the ground). The coefficient of kinetic friction is typically denoted as μk, and is usually less than the coefficient of static friction. From the mathematical point of view, however, the difference between static and kinematic friction is of minor importance: Let us have a coefficient of friction which depends on the displacement velocity and is such that its value at 0 (the static friction μs) is the limit of the kinetic friction μk for the velocity tending to zero. Then a solution of the contact problem with such Coulomb friction solves also the problem with the original μk and any static friction greater than that limit.

Examples of kinetic friction:

Sliding friction is when two objects are rubbing against each other. Putting a book flat on a desk and moving it around is an example of sliding friction

Fluid friction is the friction between a solid object as it moves through a liquid or a gas. The drag of air on an airplane or of water on a swimmer are two examples of fluid friction.

When an object is pushed along a surface with coefficient of friction μk and a perpendicular (normal) force acting on that object directed towards the surface of magnitude N, then the energy loss of the object is given by:

$$U = N\mu_k d$$

where d is the distance travelled by the object whilst in contact with the surface. This equation is identical toEnergy Loss = Force x Distance as the frictional force is a non-conservative force. Note, this equation only applies to kinetic friction, not rolling friction.

Physical deformation is associated with friction. While this can be beneficial, as in polishing, it is often a problem, as the materials are worn away, and may no longer hold the specified tolerances.

The work done by friction can translate into deformation and heat that in the long run may affect the surface's specification and the coefficient of friction itself. Friction can in some cases cause solid materials to melt.

Friction may occur between solids, gases and fluids or any combination thereof.
See aerodynamics andhydrodynamics.

Limiting friction is the maximum value of static friction, or the force of friction that acts when a body is just on the verge of motion on a surface.

Reducing friction

Devices

Devices, such as ball bearings can change sliding friction into the less significant rolling friction.

Techniques

One technique used by railroad engineers is to back up the train to create slack in the linkages between cars. This allows the train to pull forward and only take on the static friction of one car at a time, instead of all cars at once, thus spreading the static frictional force out over time.

Generally, when moving an object over a distance: To minimize work against static friction, the movement is performed in a single interval, if possible. To minimize work against kinetic friction, the movement is performed at the lowest velocity that's practical. This also minimizes frictional stress.

Lubricants

A common way to reduce friction is by using a lubricant, such as oil, that is placed between the two surfaces, often dramatically lessening the coefficient of friction. The science of friction and lubrication is called tribology. Lubricant technology is when lubricants are mixed with the application of science, especially to industrial or commercial objectives.

Superlubricity, a recently-discovered effect, has been observed in graphite: it is the substantial decrease of friction between two sliding objects, approaching zero levels - a very small amount of frictional energy would be dissipated due to electronic and atomic vibrations [[3]].

Lubricants to overcome friction need not always be thin, turbulent fluids or powdery solids such as graphite and talc; acoustic lubrication actually uses sound as a lubricant.

Energy of friction

According to the law of conservation of energy, no energy should be lost due to friction. The kinetic energy lost is transformed primarily into heat or motion of other objects. In some cases, the "other object" to be accelerated may be the Earth. A sliding hockey puck comes to rest due to friction both by changing its energy into heat and accelerating the Earth in its direction of travel (by an immeasurably tiny amount). Since heat quickly dissipates, and the change in velocity of the Earth cannot be seen, many early philosophers, including Aristotle [[4]], wrongly concluded that moving objects lose energy without a driving force.

Source : http://engineering.wikia.com/wiki/Friction