Normal force

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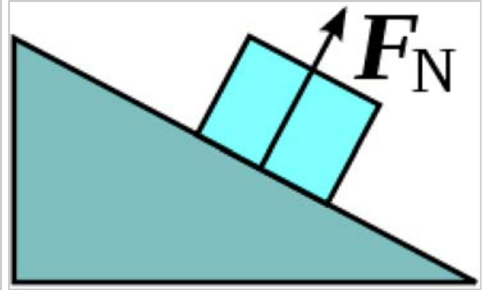

F_N represents the **normal force**

In physics, the **normal force** F_n (occasionally N) is the component, perpendicular to the surface of contact, of the contact force exerted by, for example, the surface of a floor or wall, on an object, preventing the object from entering the floor or wall. In a static situation it is just enough to balance the forces acting on the object, such as the force with which the object pushes against the surface and friction.

In another common situation, if an object hits the surface with some speed, and the surface can withstand it, the normal force provides for a rapid deceleration, with the speed depending on the flexibility of the surface. If the object is soft, the part on the side of the surface will tend to decelerate more rapidly, the part on the other side can do that more gradually, and the layer in between is compressed, deforming the object.

The normal force is one of the basic concepts in mechanics, the branch of physics concerned with the behaviour of physical bodies when subjected to forces or displacements.

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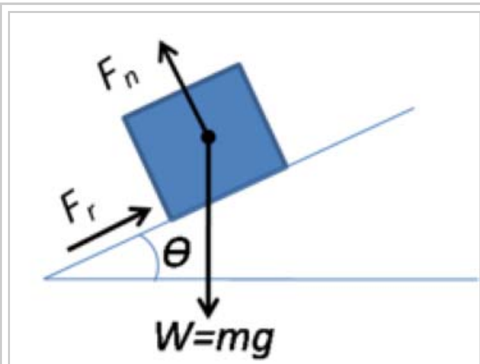
Equations

See also: Inclined plane#Calculation of forces acting on an object on an inclined plane



Weight (W), the frictional force (F_r), and the normal force (F_n) impacting a cube. Weight is mass (m) multiplied

In a simple case such as an object resting upon a table, the normal force on the object is equal but in opposite direction to the gravitational force applied on the object (or the weight of the object), that is, $N = mg$, where m is mass, and g is the gravitational field strength (about 9.81 Newtons/kilogram on Earth). The normal force here represents the force applied by the table against the object that prevents it from sinking through the table, and requires that the table is sturdy enough to deliver this normal force without breaking.

Where an object rests on an incline, the normal force is perpendicular to the plane the object rests on. Still, the normal force will be as large as necessary to prevent sinking through the surface, presuming the surface is sturdy enough. The strength of the force can be calculated as:

by gravity (g).

$$N = mg\cos(\theta)$$

where N is the normal force, m is the mass of the object, g is the gravitational field strength, and θ is the angle of the inclined surface measured from the horizontal.

The normal force is one of several forces which act on the object. In the simple situations so far considered, the most important other forces acting on it are friction and the force of gravity.

Using vectors

In general, the magnitude of the normal force, N, is the projection of the net surface interaction force, T, in the normal direction, **n**, and so the normal force vector can be found by scaling the normal direction by the net surface interaction force. The surface interaction force, in turn, is equal to the dot product of the unit normal with the stress tensor describing the stress state of the surface. That is,

$$\mathbf{N} = \mathbf{n}\,N = \mathbf{n}\,(\mathbf{T}\cdot\mathbf{n}) = \mathbf{n}\,(\mathbf{n}\cdot\tau\cdot\mathbf{n}).$$

Or, in indicial notation,

$$N_i = n_i N = n_i T_j n_j = n_i n_k \tau_{jk} n_j.$$

The parallel shear component of the contact force is known as the frictional force ($F_f r$).

The static coefficient of friction for an object on an inclined plane can be calculated as follows:[1]

$$\mu_s = \tan(\theta)$$

Real-world applications

For a person standing in an elevator either stationary or moving at constant velocity, the normal force on the person's feet balances the person's weight. In an elevator that is accelerating upward, the normal force is greater than the person's ground weight and so the person's perceived weight increases (making the person feel heavier). In an elevator that is accelerating downward, the normal force is less than the person's ground weight and so a passenger's perceived weight decreases. If a passenger were to stand on a "weighing scale", such as a conventional bathroom scale, while riding the elevator, the scale will be reading the normal force it delivers to the passenger's feet, and will be different than the person's ground weight if the elevator cab is *accelerating* up or down. The weighing scale measures normal force (which varies as the elevator cab accelerates), not gravitational force (which does not vary as the cab accelerates). It is impossible to measure true gravitational force without knowledge of the motion of one's immediate environment.

When we define upward to be the positive direction, constructing Newton's second law and solving for the normal force on a passenger yields the following equation:

$$N = m(g + a)$$

Lagrangian Mechanics

In Lagrangian Mechanics, the normal force plays an important part in its formalization. Suppose a smooth surface, Σ, is defined by the explicit equation $f(x,y,z) = 0$. Furthermore, suppose a particle must move along this surface. The equation of motion would be given by

$$m\mathbf{a} = \mathbf{F} + \mathbf{N}$$

Where $\mathbf{a}$ is the acceleration of the particle,

References

1. ^ Nichols, Edward Leamington; Franklin, William Suddards (1898). *The Elements of Physics* (http://books.google.com/books?id=8IlCAAAAIAAJ) . **1**. Macmillan. p. 101. http://books.google.com/books?id=8IlCAAAAIAAJ.