Friction

Learning Goal: By the end of today, I will be able to recognize and calculate both static and kinetic friction.

Two types of Friction - Kinetic and Static

If you have ever tried to push or pull a heavy object across any significant distance, it always seem to be the most difficult at the start, but once the object is moving, it gets easier to move the object.

Why is that?

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Static friction (F_S) is the force exerted on a stationary object by a surface that prevents the object from starting to move.

Kinetic friction (F_k) is the force exerted on a moving object by a surface, and acts opposite to the direction of motion of the object.

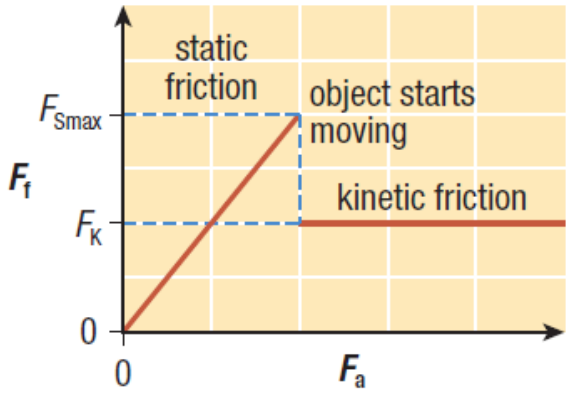

Figure 3 A graph of the magnitude of friction versus the magnitude of the applied force. Once the object starts to move, the friction drops suddenly.

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Coefficients of Friction

Many factors affect the force of friction acting on an object. The magnitude of friction acting on an object may depend on the mass of the object, the type of material the object is made of, and the type of surface the object is in contact with. When dealing with air resistance, the speed of the object and the shape of the object also have an effect. In this section, we will deal only with friction acting on an object in contact with horizontal surfaces. The only applied forces acting on the object will be horizontal.

The Coefficient of Friction is a ratio used to express the degree or level of friction created between an object and the surface it is in contact with.

F_f is the force of friction (kinetic or static), F_N is the Normal Force (contact force) and μ (muu) is the coefficient value (it is unit less).

$$\mu = \frac{F_f}{F_N}$$

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Coefficient of Static Friction

$$\mu_s = \frac{F_{s_{\max}}}{F_N}$$

Coefficient of Kinetic Friction

$$\mu_k = \frac{F_K}{F_N}$$

The coefficient of Static Friction is usually greater than the coefficient of Kinetic Friction.

Static Friction can be thought of the force required to make an object "slip".

Different materials generate different coefficients of friction; some typical values are included in the table that follows.

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Table 1 Approximate Coefficients of Kinetic and Static Friction

Material	μ_S	μ_K
rubber on concrete (dry)		0.6–0.85
rubber on concrete (wet)		0.45–0.75
rubber on asphalt (dry)		0.5–0.80
rubber on asphalt (wet)		0.25–0.75
steel on steel (dry)	0.78	0.42
steel on steel (greasy)	0.05–0.11	0.029–0.12
leather on oak	0.61	0.52
ice on ice	0.1	0.03
steel on ice	0.1	0.01
rubber on ice		0.005
wood on dry snow	0.22	0.18
wood on wet snow	0.14	0.10
Teflon on Teflon	0.04	0.04
near-frictionless carbon		0.001
synovial joints in humans	0.01	0.003

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Sample Problem 1

Two sleds are tied together with a rope (**Figure 3**). The coefficient of static friction between each sled and the snow is 0.22. A small child is sitting on sled 1 (total mass of 27 kg) and a larger child sits on sled 2 (total mass of 38 kg). An adult pulls on the sleds.

Figure 3

(a) What is the greatest horizontal force that the adult can exert on sled 1 without moving either sled?

(b) Calculate the magnitude of the tension in the rope between sleds 1 and 2 when the adult exerts this greatest horizontal force. (but does not get the sleds to move)

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What force is required to drag a 12kg box across a floor with a kinetic friction coefficient of 0.3 at a constant velocity of 2m/s?

What force is required for the same system if the force is applied at 40^{o} to the horizontal?

IF the force is removed, how long does it take the box to come to a complete stop?

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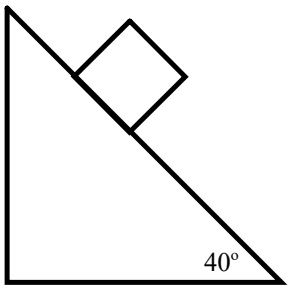
What coefficient of static friction is required to hold the 5kg box stationary on the ramp?



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Homework

Read pg 97 - 101

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