Chapter 6

Synopsis

If we slide or attempt to slide a body over a surface, the motion is resisted by a bonding between the body and surface. The resistance is considered to be a single force f, called friction. If you attempt to move an object by exerting a force on it and it doesn't move this resistance is known as the static frictional force, f_s. This force arises, pointing in the equal but opposite direction of the applied force. Once the object begins to move and accelerates, the frictional force that opposes the motion is called the kinetic frictional force, f_k. Normally f_k is less than the maximum value of f_s. *Note: f_s acts when there is no motion and f_k acts when there is motion.

Properties of Friction:

Property 1. If the body does not move, then the static frictional force f_s and the component of F that is parallel to the surface are equal in magnitude, and f_s is directed opposite that component. If that parallel component increases, f_s also increases.

Property 2. The magnitude of f_s has a maximum value $f_{s,max}$ that is given by $f_{s,max} = \mu_s N$, where μ_s is the coefficient of static friction and N is the magnitude of the normal force. If the component of F that is parallel to the surface exceeds $f_{s,max}$, then the body slides on the surface.

Property 3. If the body begins to slide along the surface, the magnitude of the frictional force rapidly decreases to a constant value f_k given by $f_k = \mu_k N$, where μ_k is the coefficient of kinetic friction.

*Note: The properties 1 and 2 also hold for the resultant of several applied forces acting on a body, not just one.

*Note: The coefficients μ_s and μ_k are dimensionless.

Drag Force and Terminal Speed:

When there is a relative velocity between a fluid and a body the body experiences a drag force. The drag force, D, opposes relative motion and points in the direction in which the fluid flows relative to the body. *Note: A fluid is anything that can flow.

The magnitude of D is related to the relative speed *v* by an experimentally determined drag coefficient, C. We find C by the equation $D = 1/2C\ \rho\ Av^2$, where ρ is the air density of the fluid and A is the effective cross-sectional area of the body.

When an object falls from rest through the air, D gradually increases from zero as the speed of the object increases. If the body falls far enough, D will eventually equal the object's weight. When this happens the net vertical force is then zero. Newton's second law then states that if the net vertical force is zero then the acceleration must be zero as well. The speed of the object no longer increases and it is known to fall at a constant terminal speed v_t. We find this by substituting D into the equation W=mg to get D=mg. From this equation we get, $1/2C\ \rho\ Av_1^2 = mg$. Finally this gives us the equation

$$V_t = \sqrt{\frac{2mg}{C\rho A}}\ .$$

Uniform Circular Motion:

When a body moves in a circle at constant speed v, it has uniform circular motion and centripetal acceleration. We find this acceleration, of constant magnitude, by $A = v^2/r^2$. The centripetal acceleration is caused by a centripetal force that directs to the center of the object. Newton's second law states that $F=ma=m\ v^2/r$.

The Forces of Nature:

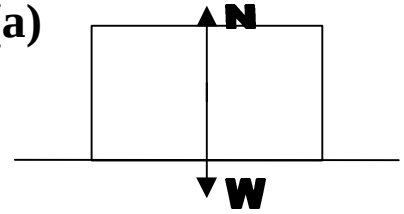
A gravitational force is weight. An electromagnetic force includes forces such as tension, and drag force, or frictional force as well as many others. The electromagnet weak and strong forces can not be experienced through our senses. The weak force is involved in certain types of radioactive decay. The strong force binds together the quarks that make up protons and neutrons.

Chapter 6 Major Concepts/Equations

A. Friction

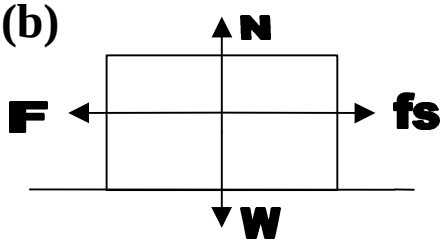
1. **Static friction (f_s)- Frictional force that prevents an object from moving when a force is applied. It is exactly equal in magnitude and opposite in direction to that applied force.**
2. **Kinetic friction (f_k)- Frictional force that opposes motion while object is in motion. It is less than the value of static force. It is opposite in direction to the force of motion. At a constant velocity, it is equal in magnitude to the force that brings about motion.**

(a)



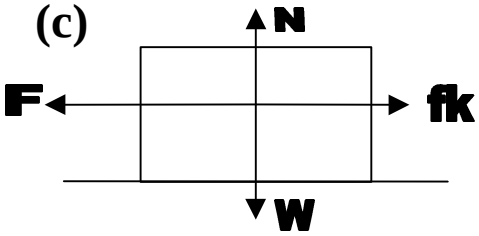
Object at rest. ÓF=0

(b)



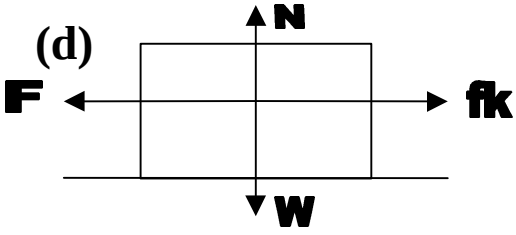
Force applied to box. Static friction equal and opposite motion. f_s ì$_s$N. Object still at rest, so ÓF=0.

(c)

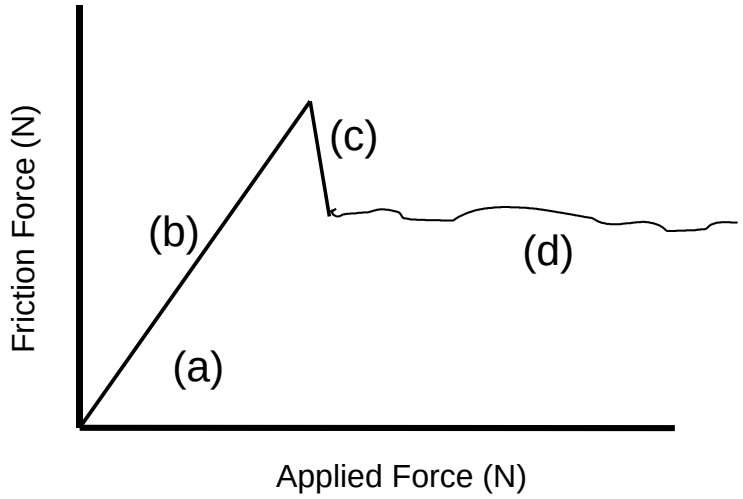


Force applied to box that is greater than static friction. Friction is converted into kinetic form. f_k<ì$_k$N.

(d)



Force applied to box is equal to kinetic friction. Velocity is constant. f_k=ì$_k$N.



B. Drag Force- A force directed in the opposite direction of motion. This is the result of turbulence created by an object moving through fluid or air. Magnitude of drag determined by equation: $D=1/2C\tilde{n}Av^2$. Terminal speed, or speed at which body falls at constant rate, is reached when the drag force equals the weight force. When this occurs, there is a net vertical force equal to zero and the object no longer accelerates.

C. Uniform Circular Motion- When a body moves in a circle at a constant velocity, the centripetal acceleration (directed towards the center of the circle) is given by $a=v^2/r$. This is caused by a centripetal force that acts on the body also directed towards the center of the circle. The magnitude of this force is $F=ma=mv^2/r$.

Major equations

Static friction = $F_{s(max)} = \mu_s N$
μ_s = coefficient of static friction (dimensionless)

Kinetic friction = $F_k = \mu_k N$
μ_k = coefficient of kinetic friction (dimensionless)

Drag force = $D = 1/2 C \rho A v^2$
C = drag coefficient
ρ = fluid density
A = effective cross-sectional area

Terminal Speed = v = (2mg/CñA)^(1/2)

Uniform Circular Motion = $a = v^2/r$

Centripetal Force = $F = mv^2/r$

CHAPTER 6 TIPS AND ADVICE:

- ∃ Always read the chapter for *understanding*, don=t just read it (ex. know when to use static friction and kinetic, also be able to tell the difference between the two)

- ∃ Before attempting to do any of the questions at the end of the chapter, do all sample problems given to you throughout chapter 6.

- ∃ Draw a diagram

- ∃ Write down everything given to you from the problem

- ∃ Draw a free-body diagram, make sure you find a suitable axis for your problem and remember to label it with the forces that act on the mass

- ∃ Watch out for *negative signs*

- ∃ Remember that frictional force is parallel to the surface but opposes the motion of the body
- ∃ Do as many problems, besides that of homework, as possible. (You will be better equipped for the test)

- ∃ Always read ahead

- ∃ Lastly, know that you can do all the problems given in the book, because they aren=t hard. Its all mental!!!!