SPH3U UNIVERSITY PHYSICS

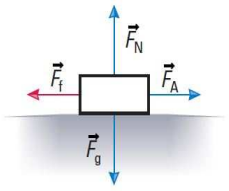
FORCES

☞ Analyzing Motion With Friction (P.169-178)

Analyzing Motion With Friction

Most frictional forces are complex because they are affected by a number of factors, such as the nature of the materials involved and the size, shape, and speed of the moving object. And solving problems involving friction brings together many concepts including:

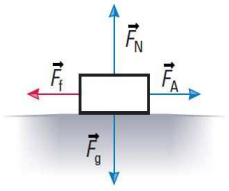
- *velocity*
- *acceleration*
- *forces*
- *free-body diagrams*
- *Newton's laws of motion*
- *weight (F_g)*



Analyzing Motion With Friction

However, the most common mistakes that students make in solving these types of problems are:

① *no FBD*
② *accounting for too many forces (i.e. including an applied force when there is none)*
③ *not including directions in their solutions*

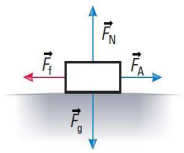


Friction

The force of friction can be calculated using the following:

FORCE OF FRICTION (F_f)

$$F_f = \mu F_N$$



where F_f is the force of friction (N)
μ is the coefficient of friction
F_N is the normal force (N)

NOTE!
μ has no units since it is a ratio of forces.

Coefficient of Friction

*The **coefficient of friction (μ)** is a number that indicates the ratio of the magnitude of the force of friction, F_f , between two surfaces to the magnitude of the normal force, F_N .*

COEFFICIENT OF FRICTION (μ)

- ratio of the friction force to the normal force ($\mu = F_f / F_N$)
- constant – only depends on nature of two surfaces in contact

NOTE!
The only way that the coefficient of friction will change is if the two materials in contact change.

Coefficient of Friction – Kinetic & Static

*In almost all situations, the force needed to start the motion of an object initially at rest is greater than the force needed to keep it going at a constant velocity. This means that the maximum static friction (F_S) is slightly greater than the kinetic friction (F_K), and the coefficients of friction for these situations are different. To account for the difference, two coefficients of friction can be determined – the **coefficient of kinetic friction** and the **coefficient of static friction**.*

$$\mu_K = \frac{F_K}{F_N} \quad \text{and} \quad \mu_S = \frac{F_S}{F_N}$$

NOTE!
Determining the coefficients of friction for various surfaces can only be done experimentally. Even with careful control of other variables, results obtained are often inconsistent.

Coefficient of Friction – Kinetic & Static

COEFFICIENT OF KINETIC FRICTION (μ_K)

- ratio of kinetic friction to normal force (F_K/F_N)

COEFFICIENT OF STATIC FRICTION (μ_S)

- ratio of static friction to normal force (F_S/F_N)

NOTE!

Since it is harder to get an object moving then it is to keep it moving then:

$$F_{f\,STATIC} \geq F_{f\,KINETIC} \quad \text{because} \quad \mu_{STATIC} \geq \mu_{KINETIC}$$

Analyzing Motion With Friction

PRACTICE

1. Which type of road, asphalt or concrete, provides better traction (friction of a tire on a road) for rubber tires under:
   (a) dry conditions? ☞ $\mu_{K\,asphalt} = 1.07$ and $\mu_{K\,concrete} = 1.02$
   (b) wet conditions? ☞ $\mu_{K\,asphalt} = 0.95$ and $\mu_{K\,concrete} = 0.97$

   (a) asphalt
   (b) concrete

Analyzing Motion With Friction

PRACTICE

2. Determine the appropriate coefficient of friction in each case.
   (a) It takes 59 N of horizontal force to get a 22 kg leather suitcase just starting to move across a floor.

   (a) $\mu_S = 0.27$

Analyzing Motion With Friction

PRACTICE

2. Determine the appropriate coefficient of friction in each case.
   (b) A horizontal force of 54 N keeps the suitcase in (a) moving at a constant velocity.

   (b) $\mu_K = 0.25$

Analyzing Motion With Friction

PRACTICE

3. A 73 kg hockey player glides across the ice on skates with steel blades ($\mu_K = 0.010$). What is the force of friction acting on the skater?

   $F_f = 7.2$ N

Analyzing Motion With Friction

PRACTICE

4. A worker of a moving company places a 252 kg trunk on a piece of carpeting and slides it across the floor at a constant velocity by exerting a horizontal force of 425 N on the trunk.
   (a) What is the coefficient of kinetic friction?

   (a) $\mu_K = 0.17$

Analyzing Motion With Friction

PRACTICE

4. A worker of a moving company places a 252 kg trunk on a piece of carpeting and slides it across the floor at a constant velocity by exerting a horizontal force of 425 N on the trunk.
   (b) What happens to the coefficient of kinetic friction if another 56 kg trunk is placed on top of the 252 kg trunk?

   (b) nothing – the two objects in contact have not changed

Analyzing Motion With Friction

PRACTICE

5. A 0.17 kg hockey puck slides along the ice at 19 m/s[E] when it hits a rough patch of ice that is 5.1 m across. Assume the coefficient of kinetic friction between the puck and the rough ice is 0.47.
   (a) Draw a FBD of the puck moving on the rough ice.

Analyzing Motion With Friction

PRACTICE

5. A 0.17 kg hockey puck slides along the ice at 19 m/s[E] when it hits a rough patch of ice that is 5.1 m across. Assume the coefficient of kinetic friction between the puck and the rough ice is 0.47.
   (b) Calculate the kinetic friction acting on the puck.

   (b) $F_k = 0.78$ N[W]

Analyzing Motion With Friction

PRACTICE

5. A 0.17 kg hockey puck slides along the ice at 19 m/s[E] when it hits a rough patch of ice that is 5.1 m across. Assume the coefficient of kinetic friction between the puck and the rough ice is 0.47.
   (c) Determine the puck's average acceleration while on the rough ice.

(c) $a = 4.6\ m/s^2[W]$

Analyzing Motion With Friction

PRACTICE

5. A 0.17 kg hockey puck slides along the ice at 19 m/s[E] when it hits a rough patch of ice that is 5.1 m across. Assume the coefficient of kinetic friction between the puck and the rough ice is 0.47.
   (d) Calculate the puck's velocity as it leaves the rough ice and returns to the smooth ice.

(d) $v_2 = 18\ m/s[E]$

✔ Check Your Learning

TEXTBOOK

P.178 Q.9,10

WIKI (FORCES)

✎.... 3U2 - ASG#1 (Friction)