LAB 2: FRICTION

Introduction: Friction is a tangential reaction force that acts parallel to two contacting surfaces. This force is what causes one surface to resist sliding across the other. For example, a football sled is difficult to push across Astroturf because of the friction that develops from the sled bottom rubbing on the Astroturf. The frictional force is *tangential* because it acts along the line where the two surfaces meet. The frictional force is *reactionary* because it occurs as a result of the force applied to the sled by the football player. If the football player does not push on the sled, there is no frictional force. These frictional forces are very important in many biomechanical contexts.

<u>There are two types of Friction</u>:

1. *Static friction* occurs between two surfaces that are not moving relative to one another. It is equal and opposite to the applied tangential force and will match the applied force in magnitude until the applied force exceeds the *limiting friction force*, at which point the two bodies start moving relative to one another. The limiting frictional force is the maximum value of the static friction force that occurs when motion is impending.

The magnitude of the limiting friction force is dependent of the nature of both surfaces and is directly proportional to the perpendicular or "normal" force exerted between two surfaces in contact (Fig. 1 & Fig. 2). The larger the normal force, the larger the frictional force.

$$F_{Limiting} = \mu_{Limiting} \cdot F_{Normal}$$

For inclined surfaces, the coefficient of limiting friction can be calculated using the following equation:

$$\mu_L = \tan\theta$$

where θ = the angle of surface inclination from the horizontal surface at which sliding begins.

2. *Dynamic (or sliding) friction* occurs between two objects which are moving relative to one another. Generally the dynamic friction between two surfaces is constant, regardless of the relative velocities of the two objects. Dynamic friction, like static friction, is also dependent on the nature of the two surfaces and proportional to the normal force.

$$F_{Sliding} = \mu_{Sliding} \cdot F_{Normal}$$

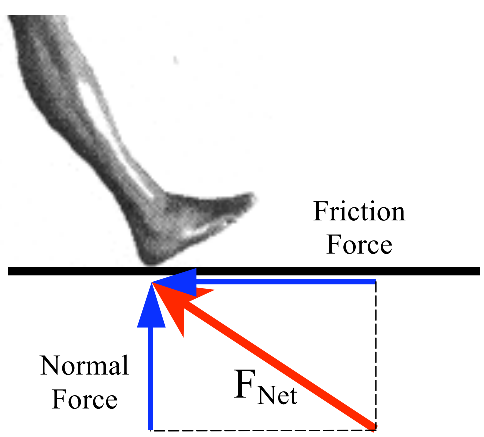

Fig. 1 – Friction is always proportional to the normal force applied perpendicular to two surfaces

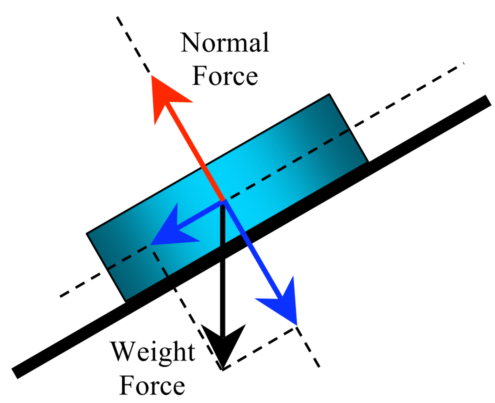

Fig. 2 – When the surface is tilted, the normal force is also tilted.

Other Important Notes:

1. Friction does not depend on the surface area between the two surfaces.
2. The coefficient of limiting friction is almost always greater than the coefficient of sliding friction.

Purpose of Today's Lab: Utilize the incline method to determine the coefficients of friction between different shoe sole materials and floor surfaces.

Questions:

1. Draw a free body diagram of the set-up for the incline method. Be sure to include all forces and all angles.
2. Use the free body diagram and the basic equation $F_{Limiting} = \mu_{Limiting} \cdot F_{Normal}$ to show how you arrive at $\mu_L = \tan\theta$.

Exercise 1: Comparing the Coefficient of Friction for Different Types of Shoes and Floor Surfaces

Equipment: Friction block (with various shoe soles affixed), ramps with different surfaces, weights, scale

Procedure: Work in groups to collect data using the ramps. Collect data to calculate the limiting coefficient of friction for ***four*** different shoe soles, with ***two*** different weights, on ***two*** different surfaces, utilizing the procedures below. Your T. A. will assign you different weights.

1. Weigh your friction block with your first assigned number of plates and record in Table 1.
2. Place the friction block on the ramp with 0 deg of inclination (specify the shoe sole type and the ramp surface in Table 1).
3. **Slowly** increase the ramp angle until the friction block begins to slide down the ramp. Record the angle (theta) of the ramp in Table 1.
4. **Repeat** the above steps with the other 3 shoe surfaces. Then test all four shoe surface again with the same weight for the second surface. Place these results in table 2.
5. Place your next assigned number of plates into the friction block and repeat steps 1 to 4.

Equations: Recall that $\mu_L = \tan\theta$.

Table 1. Calculate the coefficient of friction, μ.

Ramp Surface 1: ____

Shoe Type 1: ____________________		Theta	μ	**Shoe Type 2: __________________**		Theta	μ
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		

Shoe Type 3: ____________________		Theta	μ	**Shoe Type 4: __________________**		Theta	μ
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		

Table 2. Calculate the coefficient of friction, μ.

Ramp Surface 2: ____

Shoe Type 1: ____________________		Theta	μ	**Shoe Type 2: __________________**		Theta	μ
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		

Shoe Type 3: ____________________		Theta	μ	**Shoe Type 4: __________________**		Theta	μ
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		
Block with ___ weights	Trial 1			Block with ___ weights	Trial 1		
Total Weight:	Trial 2			Total Weight:	Trial 2		
______kg	Trial 3			______kg	Trial 3		
	Average				***Average***		

Questions:

3. Which shoe surface / floor surface combination had the *lowest* coefficient of limiting friction? Which combination had the *highest* coefficient of limiting friction? Why?

4. Did the weight of the friction block have an effect on the coefficient of friction (for any given sole/surface combination)? Why or why not?

5. How else do skilled performers attempt to manipulate the coefficient of friction to their advantage (*besides* footwear)? Provide two examples.

What to Turn In:

- **Any data tables, graphs, or spreadsheets, typed answers to all questions.**