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Friction Sled

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INTRODUCTION

Falls were the number two cause of unintentional deaths in the United States in 1993, second only to motor vehicle accidents. This has been true every year since 1921 except 1943, when falls ranked first. Prior to 1921, falls were always the number one killer.

About 1495, Leonardo da Vinci [1] formulated the fundamental rules of friction. For hard surfaces in contact with one another, he proved that for static friction:

- Frictional resistance depends on the nature of the materials in contact. (Not only one surface)
- Frictional resistance is independent of the area of the surfaces in contact.
- Frictional resistance increases proportionally with the force pressing one body against another. The proportionality constant is called the coefficient of friction.

When applied to the device shown in Fig. 1, these three concepts may be summarized by the simple formula,

$$\text{Drag} = (\text{Weight}) \times (\text{Coefficient of Friction}) \qquad \text{Eq.1}$$

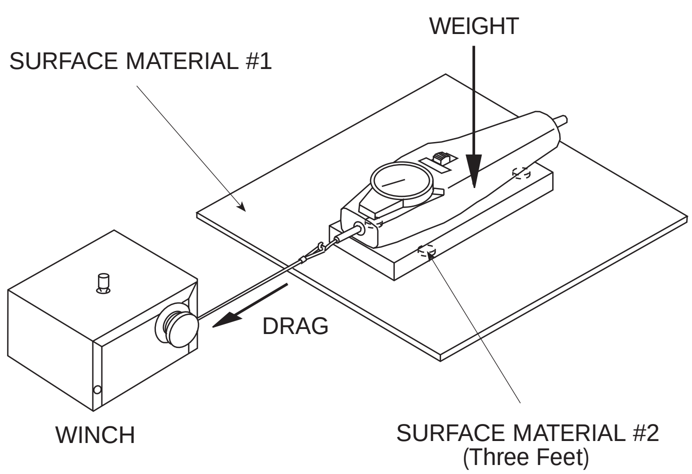

Fig. 1 ASTM Horizontal Pull Slipmeter

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When the drag force and weight are known, this equation may be used to determine the coefficient of friction between surfaces 1 and 2. The ASTM Horizontal Pull Slipmeter, illustrated in Fig. 1 [2], is one of the more notable tests for determining friction coefficients.

The device consists of a chatillon force gage attached to a heavy steel plate. Three samples of material #2 are attached to the bottom of the plate in a triangular formation. The total weight of this unit is used in Eq. 1. A horizontal pull, provided by the winch, causes the unit to slide; its maximum value is recorded by the force gage and represents the Drag in Eq. 1.

Unfortunately, the rules of Leonardo fail decisively when they are applied to compliant surfaces such as grass, soil or carpeting. Suddenly, the contact area between surfaces becomes important; frictional resistance is no longer proportional to the compressive force between the surfaces which now cause changes in the contact geometry by burying one material in another. For compliant surfaces, drag cannot be determined using a formula such as Eq. 1; it must be measured with a simulation device.

Figure 2 illustrates a simulation device for footwear used on either hard or compliant surfaces. It retains many of the features associated with the ASTM Horizontal Pull Slipmeter including a similar scaled up triangular pattern for locating shoe stretchers and a winch for pulling the simulation sled. Various devices are shown in Fig. 2 for holding shoes at a fixed or adjustable orientation or for substituting a low friction roller where no shoe is available. Wherever a shoe is located, barbell weights are mounted on the associated vertical rod to equal the total weight of the individual under study. Measuring the total maximum drag force in repeated tests in various directions across a test surface gives rise to the "Average Static Drag Per Shoe" for a given weight individual. Test protocol should follow ASTM F-609. It must be pointed out that a coefficient of friction exists only for cases involving hard surfaces.

Table I gives the bill-of-materials for the test sled system. It is characterized by the following features:

- May be used with one, two or three nominally identical shoes.
- May be used to test only soles or only heels.
- May be used on either hard or compliant surfaces.
- Gives the conventional coefficient of friction on hard surfaces
- Minimizes subjectiveness.
- Preserves many features of the ASTM Horizontal Pull Slipmeter.
- Is portable.

REFERENCES:

1. Leonardo da Vinci, (Memorial Edition). New York, Reynal and Company, 1975, p. 499.

2. "Standard Test Method for Static Slip Resistance of Footwear Sole, Heel, or Related Materials by Horizontal Pull Slipmeter (HPS)," ASTM F609-79 (Reapproved 1989). Philadelphia, PA, American Society For Testing and Materials, current edition approved February 23,1979.

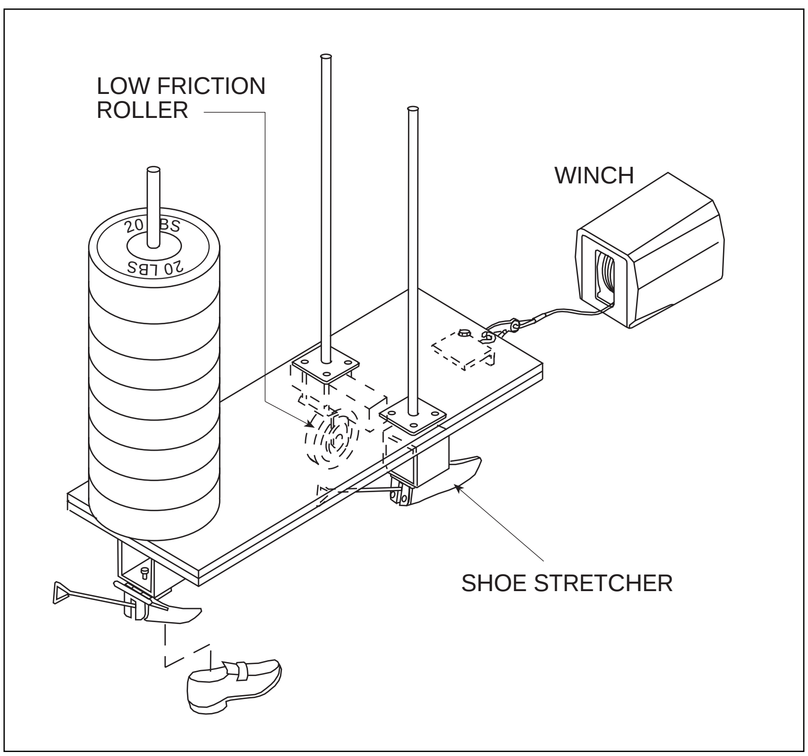

Fig. 2 Test Sled System

Table I - Bill of Materials for Triodyne Friction Tester

1.	1/4" x 1" Hex Head Bolt (6)
2.	10/24" x 3/4" Slotted Head Machine Screw (6)
3.	1/4" x 2 1/2" Hex Head Bolt (12)
4.	1/4" Nuts (12)
5.	1/4" Washers (12)
6.	3/16" x 2" Hex Head Bolt (1)
7.	3/16" Nut (1)
8.	3/16" Washer (1)
9.	4" x 4" x 1/8" Steel Plate (3)
10.	7/8" dia. x 30" Steel Pipe (3)
11.	Front Pull Bracket (1)
12.	3" log 4" Steel Square Tubing (3)
13.	1" x 2" x 1/4" Steel Tabs (Welded to square tubing) (6)
14.	1/2" x 1" x 1/4" Steel Spacers (Welded to square tubing) (3)
15.	40 3/4" x 15" Plywood (2)
16.	Shoe Stretchers (3)
17.	6" dia. Casters (3)
18.	Winch
19.	2" Steel Square Tubing (Caster Spacers) (3)
20.	1/4" x 4 1/2" Hex Head Bolt (use with caster spacers) (12)
21.	1/4" Nuts (use with caster spacers) (12)
22.	1/4" Washers (use with caster spacers) (12)
23.	Barbell Weights