

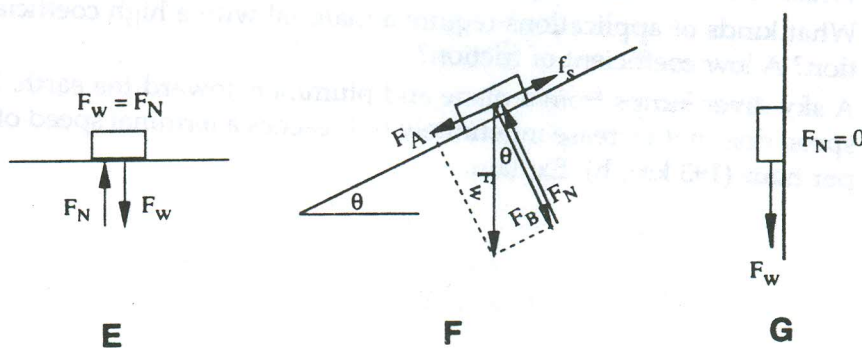
## 3.3.2 Ranking Frictional Forces

**Concepts to Investigate:** Coefficient of static friction, surface interactions, angle of slip, ranking frictional forces.

**Materials:** Block of wood, fine and rough sandpaper, plastic bag, cotton cloth, aluminum foil, piece of smooth plate glass with no sharp edges, wood inclined plane, tape, protractor.

**Principles and Procedures:** In this activity you will use an inclined plane to rank the coefficients of static friction  $\mu_s$  for various materials. Rather than pulling on the object, you will use gravity to provide the force to move the object down an incline. Place a block of wood on a board and slowly raise one end of the board. As the board is raised, the block remains stationary until a certain angle  $\theta$  is reached, at which point it slides down the board.

When the weight of the block  $F_w$  is resolved, it can be seen that part acts to move the block down the board  $F_A$ , and part acts to hold the block against the board  $F_B$ . The normal force  $F_N$  is of equal magnitude to the force holding the block against the board  $F_B$ . When the board is horizontal, there is no force pulling the block down the board and the normal force is equal to the weight of the block (Figure E). As the end of the board is raised, the component of the weight pulling the block down the board increases while the normal force decreases (Figure F). When the board is vertical, the force pulling the block down the board is equal to the weight of the block and there is no normal force (Figure G).



Examine the surfaces of the materials listed in the table and predict the rank of each in terms of their coefficients of friction. A rank of 7 would indicate the greatest friction (greatest  $\mu_s$ ) while a rank of 1 would indicate the lowest friction (lowest  $\mu_s$ ).

Test your predictions. Place the block on a smooth wooden board and slowly raise one end until the block begins to slide. This angle is known as the angle of slip or the angle of repose. Use a protractor to measure this angle. The angle of slip is proportional to the frictional interaction and the coefficient of friction. Secure other materials to the bottom of the block and repeat this procedure. Determine the rank order of the coefficients of friction for each of the seven materials using a scale of 1 to 7, 7 being greatest. How accurate were your predictions?

Material	Angle of slip ( $^{\circ}$ )	Your Prediction (1-7)	Coefficient $\mu_s$ ranking (1-7)
Wood on wood			
<del>Aluminum</del> on wood			
Plastic on wood			
<del>Cotton</del> on wood			
<del>Glass</del> on wood			
Fine sandpaper on wood			
Coarse sandpaper on wood			

### Questions

- (1) Which material had the greatest coefficient of friction? The smallest?
- (2) What kinds of applications require a material with a high coefficient of friction? A low coefficient of friction?
- (3) A sky diver jumps from a plane and plummets toward the earth. His or her speed does not increase indefinitely but reaches a terminal speed of 120 miles per hour (193 km/h). Explain.