Skill 23: Coefficient of Friction

134. A 5kg block is on a frictionless slope inclined at 30°. Determine the acceleration of block.

$F_{net} = F_{g\parallel} = mg\sin\theta$

$F_{net} = ma$

so $ma = mg\sin\theta$

$a = g\sin\theta = (9.81 m/s^2)(\sin 30°) = 4.9 m/s^2$

axis inclined plane ||

135. A 10kg block slides at a constant velocity down a ramp with an incline of 25 degrees. What is the frictional force acting on the block?

$\theta = 25°$

$F_{Net} = 0$

$m = 10kg$

$F_f = ?$

axis inclined plane

$F_{net} = F_f + F_{g\parallel}$

$0 = F_f + mg\sin\theta$

$0 = F_f + (10kg)(9.81 m/s^2)\sin 25°$

$0 = F_f + 41.5N$

F_f = up ramp

$F_f = 41.5N$

136. A 3kg block is pulled at constant velocity up a ramp inclined at 30° with a force of 20N. What is the force of friction acting between the block and the ramp?

axis inclined plane

$m = 3kg$

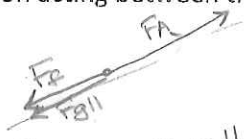
$F_{Net} = 0$

$a = 0$

$F_A = 20N$

$F_f = ?$

$\theta = 30°$



Forces on parallel axis

$\Sigma F_{\parallel} = F_f + F_{g\parallel} + F_A$ (down, down, up)

$\Sigma F_{\parallel} = F_f + mg\sin\theta + 20N$

$0 = F_f + (3kg)(9.81 m/s^2)\sin 30° + 20N$

$0 = F_f + -14.75N + 20N$

$F_f = -5.3N$

137. What is the frictional force on a 5 kg wooden block at rest on a horizontal wooden surface?

axis "x" ||

$m = 5kg$

$a = 0$

$F_f = ?$

$\mu = .42$ (static coefficient)

$F_f = \mu F_N$

$F_f = .42\,mg$

$= .42(5kg)(9.81 m/s^2) = 20.6N$

horizontal surface

$F_N = F_g\cos\theta$ $\theta = 0°$

so $F_N = F_g = mg$

138. What is the frictional force on a 2kg copper block sliding on a horizontal steel surface?

kinetic

axis "x" ||

$\mu_K = .36$

$m = 2kg$

$F_N = F_g\cos\theta$ ($\theta = 0$)

$F_N = mg\cos 0° = (2kg)(-9.81 m/s^2) = -19.6N$

$F_f = \mu F_N$

$= (.36)(-19.6N) = -7N$

139. What is the frictional force acting on a 2 kg steel block sliding down a steel ramp inclined at 20 degrees?

axis ||&⊥

$\mu_K = .57$

$F_N = F_{g\perp}$

$m = 2kg$

$\theta = 20°$

$F_f = ?$

$F_N = mg\cos\theta$

$= (2kg)(9.81 m/s^2)\cos 20°$

$= (-19.6N)\cos 20°$

$= 18.4N$

$F_f = \mu F_N$

$F_f = (.57)(18.4N)$

$F_f = 10.5N$

140. What is the frictional force acting on a 40kg skier on waxed ski's at rest on a snow covered hill with an incline of 40 degrees?

axis ||&⊥

$\theta = 40°$

$\mu_S = .14$

$F_f = ?$

$m = 40kg$

$F_f = \mu F_N$

$= .14(mg\cos\theta)$

$= .14(40kg)(9.81 m/s^2)\cos 40°$

$= 42N$

141. For each of the following state whether the relationship between the force of friction on object 1 vs. 2 as 1 >2 ; 1=2 ; 1< 2 briefly state your reason.

a. Object 1: A 2kg steel block at rest on a level steel surface
Object 2: A 2kg steel block in motion on a level steel surface 1?2

b. Object 1: A 3 kg rubber brick at rest on a dry asphalt surface
Object 2: A 3kg rubber brick at rest on a wet asphalt surface 1?2

c. Object 1: A 3kg copper block in motion on a steel surface
Object 2: A 2kg copper block in motion on a steel surface 1?2

d. Object 1: A 5kg wooden block moving on a horizontal wooden surface with a speed of 4 m/s
Object 2: A 5kg wooden block moving on a horizontal wooden surface with a speed of 1 m/s

1=2

e. Object 1: A waxed ski at rest on a snow covered inclined surface
Object 2: A waxed ski at rest on a snow covered horizontal surface

2?1 $F_f = \mu F_N$
$F_N = F_g \cos\theta$
as $\theta \uparrow F_N \downarrow$

To find the coefficient of **static** friction between two surfaces, determine the minimum angle at which an object starts to slide on a ramp. The tangent of that angle is equal to the coefficient of static friction.

$$\mu_s = \frac{F_f}{F_N} = \frac{F_g \sin\theta}{F_g \cos\theta} = \tan\theta$$

142. A rubber duck is a rest on a ramp of unknown material. The ramp is then lifted so that the duck begins to slide when the angle is 34 degrees. What is the coefficient of static friction?

$\mu_s = \tan 34^\circ$
$\mu_s = .67$

143. Coefficient of friction is very important to the design of shoes. A shoe designed for basketball must have a coefficient with the court that is high enough to stop sliding but not so high as to impede movement. In order to determine the coefficient of static friction between a basketball shoe and the gymnasium floor a student placed a shoe on a ramp made of a material matching the floor. The shoe began to slide at an angle of 50 degree. What is the coefficient of friction?

$\mu_s = \tan 50^\circ = 1.2$

Skill 23-Coefficient of Friction

144. An 8.0-newton wooden block slides across a horizontal wooden floor at constant velocity. What is the magnitude of the force of kinetic friction between the block and the floor?

horizontal

A) 2.4 N
B) 3.4 N
C) 8.0 N
D) 27 N

$F_N = F_g = 8N$
$F_f = ?$
$\mu_K = .3$
$F_f = \mu F_N$
$= .3(8N) = 2.4N$

145. The force required to start an object sliding across a uniform horizontal surface is larger than the force required to keep the object sliding at a constant velocity. The magnitudes of the required forces are different in these situations because the force of kinetic friction

A) is greater than the force of static friction
B) is less than the force of static friction
C) increases as ~~the speed of the object~~ relative to the surface increases
D) decreases as ~~the speed of the object~~ relative to the surface increases

$\mu_S > \mu_K$

146. When a 12-newton horizontal force is applied to a box on a horizontal tabletop, the box remains at rest. The force of static friction acting on the box is

A) 0 N
B) between 0 N and 12 N
C) 12 N
D) greater than 12 N

F_f can't be greater than F_A or object would suddenly start moving
$0 = F_A + F_f$
$0 = 12N + F_f$
$F_f = 12N$

147. A wooden block is at rest on a horizontal steel surface. If a 10.-Newton force applied parallel to the surface is required to set the block in motion, how much force is required to keep the block moving at constant velocity?

A) less than 10. N
B) greater than 10. N
C) 10. N

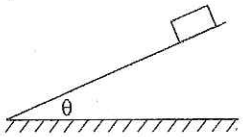
$F_{f_{static}} > F_{f_{kinetic}}$

axis is x & y

148. Sand is often placed on an icy road because the sand

A) decreases the coefficient of friction between the tires of a car and the road
B) increases the coefficient of friction between the tires of a car and the road
C) decreases the gravitational force on a car
D) increases the normal force of a car on the road

149. The diagram below shows a block sliding down a plane inclined at angle θ with the horizontal.



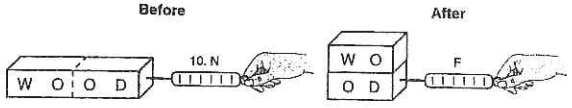
As angle θ *is increased, the coefficient of kinetic friction between the bottom surface of the block and the surface of the incline will*

A) decrease
B) increase
C) remain the same

θ alters the F_N and as a result F_f not μ

Skill 23-Coefficient of Friction

150. The diagram below shows a student applying a 10.-newton force to slide a piece of wood at constant speed across a horizontal surface. After the wood is cut in half, one piece is placed on top of the other, as shown.

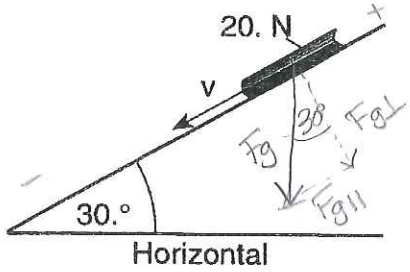


What is the magnitude of the force, F, required to slide the stacked wood at constant speed across the surface?

A) 40 N
B) 20 N
C) 10 N
D) 5.0 N

surface area doesn't change
F_N so it doesn't change
μ or F_f

151. A book weighing 20. Newtons slides at constant velocity down a ramp inclined 30.° to the horizontal as shown in the diagram below.



What is the force of friction between the book and the ramp?

A) 10. N up the ramp
B) 17 N up the ramp
C) 10. N down the ramp
D) 17 N down the ramp

$F_{Net\parallel} = F_{g\parallel} + F_f$
$0 = F_g \sin\theta + F_f$
$0 = -20N \sin 30^\circ + F_f$
$0 = -10N + F_f$
$F_f = 10N$

152. The table below lists the coefficients of kinetic friction for four materials sliding over steel.

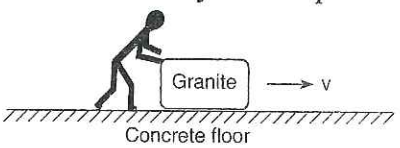
Material	Coefficient of Kinetic Friction
Aluminum	0.47
Brass	0.44
Copper	0.36
Steel	0.57

A 10.-kilogram block of each of these materials is pulled horizontally across a steel floor at constant velocity. Which block requires the *smallest* applied force to keep it moving at constant velocity?

A) aluminum
B) brass
C) copper
D) steel

lowest μ_K

153. The diagram below shows a granite block being slid at constant speed across a horizontal concrete floor by a force parallel to the floor.



Which pair of quantities could be used to determine the coefficient of friction for the granite on the concrete?

A) mass and ~~speed of the block~~
B) mass and normal force on the block
C) frictional force and ~~speed of the block~~
D) frictional force and normal force on the block

$\mu = \frac{F_f}{F_N}$

Skill 23-Coefficient of Friction

154. A 0.50-kilogram puck sliding on a horizontal shuffleboard court is slowed to rest by a frictional force of 1.2 newtons. What is the coefficient of kinetic friction between the puck and the surface of the shuffleboard court?

A) 0.24 B) 0.42 C) 0.60 D) 4.1

$F_f = 1.2N$ $m = .5kg$ $\mu_K = ?$

$\mu = \frac{F_f}{F_N} = \frac{1.2N}{mg\cos\theta} = \frac{1.2N}{(.5g)(9.81N/kg)}$

$= \frac{1.2N}{4.9N} = .24$

155. A car's performance is tested on various horizontal road surfaces. The brakes are applied, causing the rubber tires of the car to slide along the road without rolling. The tires encounter the greatest force of friction to stop the car on highest μ_K with rubber

A) dry concrete .68 B) dry asphalt .67
C) wet concrete .58 D) wet asphalt .53

156. What is the magnitude of the force needed to keep a 60.-newton rubber block moving across level, dry asphalt in a straight line at a constant speed of 2.0 meters per second?

A) 40. N B) 51 N
C) 60. N D) 120 N

$F_g = F_N = 60N$ $\mu_K = .67$ $F_f = ?$

$F_f = \mu F_N$
$= (.67)(60N)$
$= 40N$

157. What is the minimum horizontal force needed to start a 300. kilogram steel block on a steel table in motion?

A) 5.70 N B) 7.40 N
C) 1710 N D) 2220 N

$\mu_S = .74$ $m = 300kg$ $F_N = mg$

$F_f = \mu F_N$
$= \mu mg$
$= (.74)(300kg)(9.81m/s^2)$
$= 2220N$

158. The table below lists the coefficients of kinetic friction for four materials sliding over steel.

Material	Coefficient of Kinetic Friction
aluminum	0.47
brass	0.44
copper	0.36 smallest
steel	0.57

A 10.-kilogram block of each of these materials is pulled horizontally across a steel floor at constant velocity. Which block requires the *smallest* applied force to keep it moving at constant velocity?

A) aluminum B) brass
C) copper D) steel

159. According to your reference table, *Approximate Coefficents of Friction,* what is the minimum horizontal force needed to start a 300. N steel block on a steel table in motion?

A) 0.57 N B) 074 N
C) 171 N D) 222 N

$F_f = ?$ $F_N = F_g = 300N$ $\mu_S = .74$

$F_f = \mu F_N$
$= .74(300N)$
$= 222N$

160. As more force is applied to a steel box sliding on a steel surface, the coefficent of kinetic friction will

A) decrease B) increase
C) remain the same

μ is determined by

Skill 23-Coefficient of Friction

161. Jim wishes to push a 100. N wood crate across a wood floor. What is the minimum horizontal force that would be required to start the crate moving?

A) 30. N
B) 42 N
C) 72 N
D) 100 N

$F_N = F_g = 100\,N$

$F_{Ax} = F_f = ?$ (static)

$F_f = \mu F_N$

$F_f = .42(100N) = 42N$