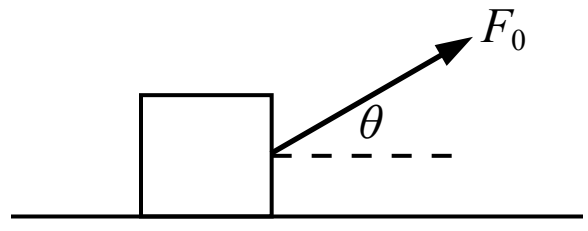
FRICTION



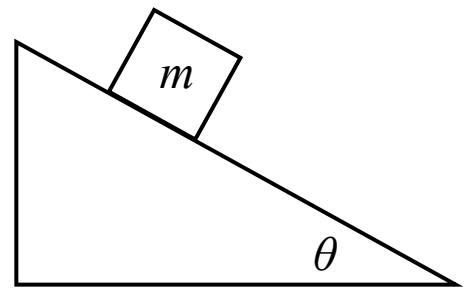
1. A block is sitting on the floor and the friction between the block and the floor is not negligible. A force is then applied to the box at an angle θ above the horizontal as shown in the figure above and the box slides across the floor. If the angle θ is increased but the magnitude of the force remains the same and block continues sliding then

   (A) the magnitude of the friction force on the block will increase

   (B) the magnitude of the friction force on the block will decrease, but not to zero

   (C) the magnitude of the friction force on the block will not change

   (D) the magnitude of the friction force on the block will be zero



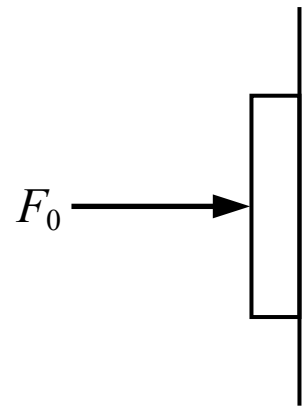
2. A block with a mass of m is sitting at rest on an incline as shown in the figure above. The coefficient of static friction between the block and the incline surface is μ_s. Which of the following must be equal to the magnitude of the friction force acting on the block?

   (A) $\mu_s mg\cos(\theta)$

   (B) $\mu_s mg\sin(\theta)$

   (C) $mg\sin(\theta)$

   (D) $\mu_s mg$



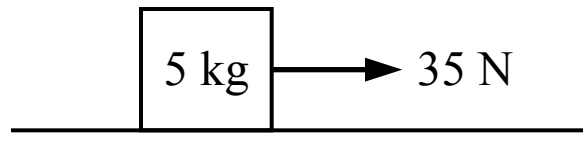
3. A person pushes horizontally on a book which is against a wall so that the book remains at rest. Which of the following shows the direction of the friction force acting on the book from the wall?

(A) ←

(B) ↓

(C) →

(D) ↑



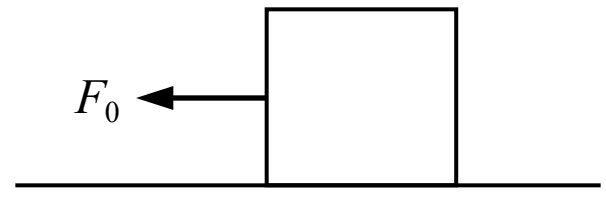
4. A block with a mass of 5 kg is sitting at rest. The coefficient of static friction between the block and the floor is 0.5 and the coefficient of kinetic friction is 0.4. A force with a magnitude of 35 N is then applied to the block. After the force is applied, the acceleration of the block is most nearly

(A) 0 m/s²

(B) 3 m/s²

(C) 7 m/s²

(D) 2 m/s²



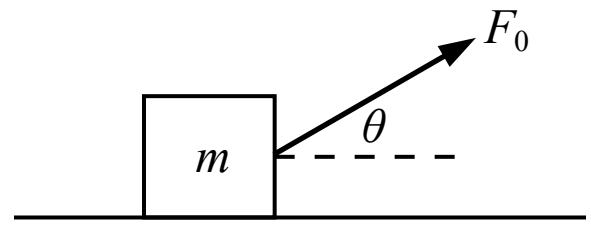
5. A block is sitting on a floor and the friction force between the block and the floor is not negligible. A force is applied to the block as shown in the figure above and the block remains at rest. Which of the following is true about the friction force acting on the block from the floor while the force is applied?

   (A) The magnitude of the friction force is less than the magnitude of F_0

   (B) The magnitude of the friction force is greater than the magnitude of F_0

   (C) The magnitude of the friction force is equal to the magnitude of F_0

   (D) The relationship between the magnitude of the friction force and the magnitude of F_0 cannot be determined



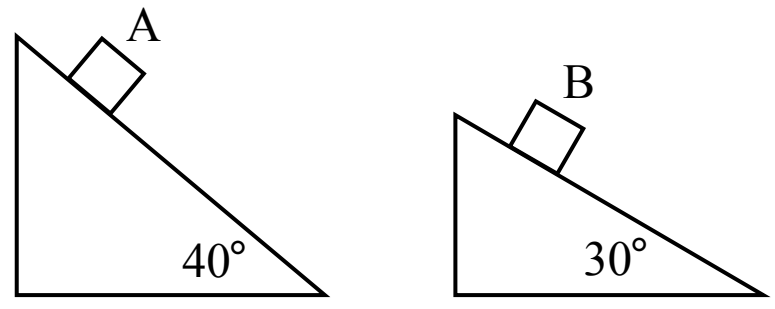
6. A force is exerted on a block as shown in the figure above. The block accelerates horizontally along the floor and the coefficient of kinetic friction between the block and the floor is μ_k. Which of the following is a correct expression for the acceleration of the block?

   (A) $\dfrac{F_0\cos(\theta) - \mu_k(mg - F_0\sin(\theta))}{m}$

   (B) $\dfrac{F_0\cos(\theta) - \mu_k mg}{m}$

   (C) $\dfrac{F_0\sin(\theta) - \mu_k(F_0\sin(\theta) - mg)}{m}$

   (D) $\dfrac{F_0\sin(\theta) - \mu_k mg}{m}$



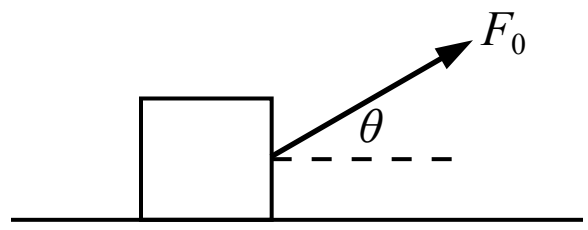
7. Two identical blocks are sliding down two inclines as shown in the figure above. The coefficient of kinetic friction is the same for both inclines. Which block experiences a friction force with a greater magnitude?

   (A) Block A

   (B) Block B

   (C) The blocks experience friction forces with equal magnitudes

   (D) Cannot be determined



1. A block is sitting on the floor and the friction between the block and the floor is not negligible. A force is then applied to the box at an angle θ above the horizontal as shown in the figure above and the box slides across the floor. If the angle θ is increased but the magnitude of the force remains the same and block continues sliding then

   (A) the magnitude of the friction force on the block will increase

   (B) the magnitude of the friction force on the block will decrease, but not to zero

   (C) the magnitude of the friction force on the block will not change

   (D) the magnitude of the friction force on the block will be zero

A Incorrect

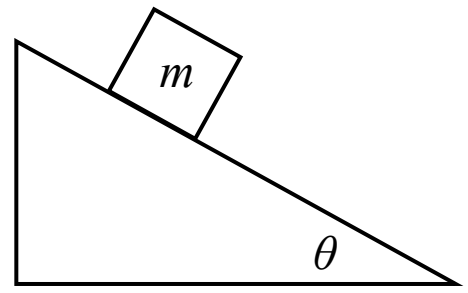
B Correct

The block is sliding across the floor so the friction force acting on the block is kinetic friction. The magnitude of the kinetic friction depends on the coefficient of kinetic friction and the normal force exerted on the block by the floor. The net force in the vertical direction is zero because the block does not accelerate in the vertical direction so the normal force (and therefore the kinetic friction force) decreases if θ increases.

$\Sigma F_y = F_0 \sin(\theta) + F_n - F_g = m(0\ \text{m/s}^2) \qquad F_n = F_g - F_0 \sin(\theta) \qquad f_k = \mu_k F_n$

C Incorrect

D Incorrect



2. A block with a mass of m is sitting at rest on an incline as shown in the figure above. The coefficient of static friction between the block and the incline surface is μ_s. Which of the following must be equal to the magnitude of the friction force acting on the block?

(A) $\mu_s mg\cos(\theta)$

(B) $\mu_s mg\sin(\theta)$

(C) $mg\sin(\theta)$

(D) $\mu_s mg$

A Incorrect

This answer is the maximum possible static friction force that could be acting on the block using the equation $f_{s\,max} = \mu_s F_n$. However, the actual magnitude of the static friction force may be less than that.

B Incorrect

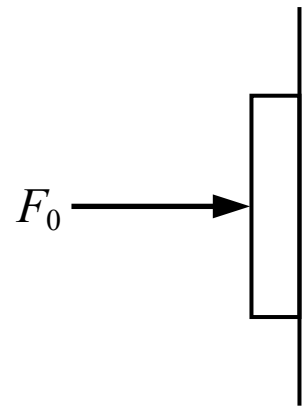
This answer incorrectly uses the equation for the maximum possible static friction force, and incorrectly uses $mg\sin(\theta)$ for the normal force instead of $mg\cos(\theta)$.

C Correct

The block is at rest and not accelerating so the net force parallel to the incline surface is zero. The magnitude of the static friction force (acting up the incline) must be equal to the magnitude of the component of the weight force parallel to the incline (acting down the incline) which is $mg\sin(\theta)$. Remember that the maximum possible static friction force depends on the normal force, $f_{s\,max} = \mu_s F_n$, but the actual static friction force may be less than that and depends on the other forces acting along the same axis.

D Incorrect

This answer incorrectly uses the equation for the maximum possible static friction force, and incorrectly uses mg for the normal force instead of $mg\cos(\theta)$.



3. A person pushes horizontally on a book which is against a wall so that the book remains at rest. Which of the following shows the direction of the friction force acting on the book from the wall?

(A) 

(B) 

(C) 

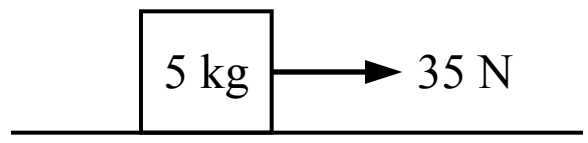
(D) 

A **Incorrect**
This is the direction of the normal force acting on the book from the wall.

B **Incorrect**
This is the direction of the weight force acting on the book.

C **Incorrect**
This is the direction of the force acting on the book from the person.

D **Correct**
The book is at rest and not accelerating so the net force on the book is zero. There is a downwards weight force acting on the book, so the friction force acting on the book is upwards and the weight force and friction force are equal in magnitude.



4. A block with a mass of 5 kg is sitting at rest. The coefficient of static friction between the block and the floor is 0.5 and the coefficient of kinetic friction is 0.4. A force with a magnitude of 35 N is then applied to the block. After the force is applied, the acceleration of the block is most nearly

(A) 0 m/s²

(B) 3 m/s²

(C) 7 m/s²

(D) 2 m/s²

A Incorrect

This answer incorrectly assumes that 35 N is less than the maximum static friction force, so the friction force is static and equal to 35 N, which would mean the net horizontal force is 0 N and the acceleration is 0.

B Correct

There is a 35 N force acting on the block to the right and a friction force acting on the block to the left which opposes the direction of motion. The magnitude of the friction force needs to be found first. If 35 N is less than the maximum static friction force then the friction force is static friction and is equal to 35 N, so the net horizontal force would be 0 N and the block would remain at rest (Newton's 1st law). If 35 N is greater than the maximum static friction force then the friction force transitions to kinetic friction and the block will slide. The friction force depends on the normal force between the block and the floor, which is equal in magnitude to the weight of the block because the vertical acceleration of the block is 0 (Newton's 1st law).

$\Sigma F_y = F_n - F_g = m a_y \qquad F_n - mg = m(0) \qquad F_n = mg$

Maximum static friction force: $f_{s\,max} = \mu_s F_n = \mu_s mg = (0.5)(5\text{ kg})g = 25\text{ N}$

Kinetic friction force: $f_k = \mu_k F_n = \mu_k mg = (0.4)(5\text{ kg})g = 20\text{ N}$

The 35 N force is greater than the maximum static friction force (25 N) so the friction force is kinetic (20 N):

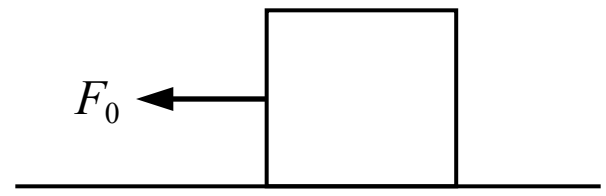
$\Sigma F_x = (35\text{ N}) - f_k = m a_x \qquad (35\text{ N}) - (20\text{ N}) = (5\text{ kg})a_x \qquad a_x = 3\text{ m/s}^2$

C Incorrect

This answer incorrectly assumes there is no friction force acting on the block so the net horizontal force is 35 N.

D Incorrect

This answer incorrectly assumes the friction force on the block is the maximum static friction force (25 N).



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(A) The magnitude of the friction force is less than the magnitude of F_0

(B) The magnitude of the friction force is greater than the magnitude of F_0

(C) The magnitude of the friction force is equal to the magnitude of F_0

(D) The relationship between the magnitude of the friction force and the magnitude of F_0 cannot be determined

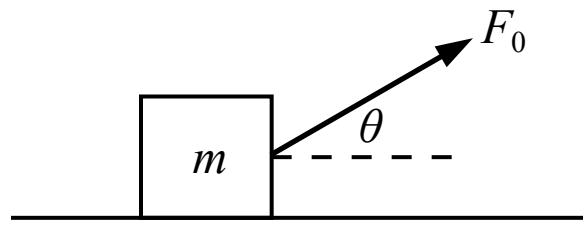
A Incorrect

B Incorrect

C Correct

The block remains at rest so the net horizontal force on the block is zero and the static friction force must be equal in magnitude and opposite in direction to the applied force F_0.

D Incorrect



6. A force is exerted on a block as shown in the figure above. The block accelerates horizontally along the floor and the coefficient of kinetic friction between the block and the floor is μ_k. Which of the following is a correct expression for the acceleration of the block?

(A) $\dfrac{F_0\cos(\theta) - \mu_k(mg - F_0\sin(\theta))}{m}$

(B) $\dfrac{F_0\cos(\theta) - \mu_k mg}{m}$

(C) $\dfrac{F_0\sin(\theta) - \mu_k(F_0\sin(\theta) - mg)}{m}$

(D) $\dfrac{F_0\sin(\theta) - \mu_k mg}{m}$

A **Correct**

The block accelerates in the horizontal direction so the acceleration and the net force in the vertical direction is zero (Newton's 1st law). The friction force on the block acts to the left and depends on the magnitude of the normal force acting on the block from the floor. The normal force can be found by applying Newton's 2nd law in the vertical direction, then the acceleration can be found by applying Newton's 2nd law to the horizontal direction.

$\Sigma F_y = ma_y \qquad F_0\sin(\theta) + F_n - F_g = m(0) \qquad F_n = F_g - F_0\sin(\theta) = mg - F_0\sin(\theta)$

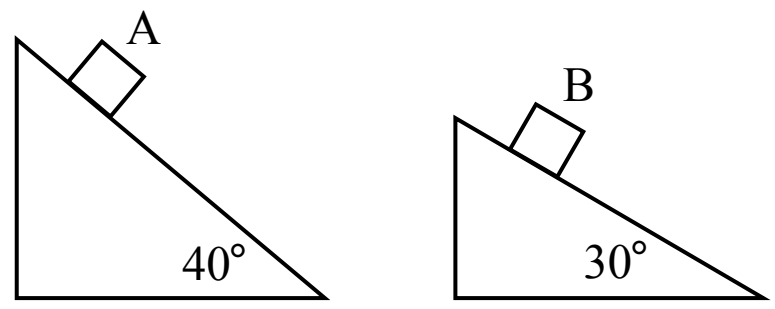
$f_k = \mu_k F_n = \mu_k(mg - F_0\sin(\theta))$

$\Sigma F_x = ma_x \qquad F_0\cos(\theta) - f_k = ma_x \qquad a_x = \dfrac{F_0\cos(\theta) - \mu_k(mg - F_0\sin(\theta))}{m}$

B Incorrect

C Incorrect

D Incorrect



7. Two identical blocks are sliding down two inclines as shown in the figure above. The coefficient of kinetic friction is the same for both inclines. Which block experiences a friction force with a greater magnitude?

(A) Block A

(B) Block B

(C) The blocks experience friction forces with equal magnitudes

(D) Cannot be determined

A Incorrect

B Correct

The friction force on an object is proportional to the normal force between the object and the surface. For each block, the normal force is equal to the component of the weight force that is perpendicular to the incline surface because the block does not accelerate in the direction perpendicular to the incline (Newton's 1st law). The normal force is greater for block B so the friction force is greater for block B.

$\Sigma F_{\perp} = m a_{\perp} \qquad F_{\mathrm{n}} - F_{\mathrm{g}} \cos(\theta) = m(0) \qquad F_{\mathrm{n}} = F_{\mathrm{g}} \cos(\theta) = m g \cos(\theta)$

$f_{\mathrm{k}} = \mu_{\mathrm{k}} F_{\mathrm{n}} = \mu_{\mathrm{k}} m g \cos(\theta)$

C Incorrect

D Incorrect