

## Newton's Laws – Coefficient of Friction

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*For each problem, include a correctly labeled free-body diagram.*

1. A 40 kg box is being pushed by a constant force  $F$  across the floor. The coefficient of friction between the floor and the box is  $\mu = 0.3$ . Find the acceleration for each of the following cases:
  - a.  $F = 200$  N, horizontally.
  
  
  
  
  
  
  
  
  
  
  - b.  $F = 300$  N at an angle of  $35^\circ$  above the horizontal.
  
  
  
  
  
  
  
  
  
  
  - c.  $F = 300$  N at an angle of  $20^\circ$  below the horizontal.
  
  
  
  
  
  
  
  
  
  
  - d.  $F = 100$  N, horizontally. (*Be careful!*)
  
  
  
  
  
  
  
  
  
  
2. A 15 kg box is being pulled by a force  $F$  at an angle of  $30^\circ$  above the horizontal. If the coefficient of friction between the box and the floor is  $\mu = 0.4$ , what is the maximum  $F$  can be and not accelerate the box?
  
  
  
  
  
  
  
  
  
  
3. A mass  $M$  is resting on horizontal table and is attached by a string to a mass  $m$  that is hanging from a pulley. If the coefficient of friction between  $M$  and the table is  $\mu$ , what is the maximum that  $m$  can be and not accelerate  $M$ ?
  
  
  
  
  
  
  
  
  
  
4. A 250 gram mass is sliding with constant speed down an inclined plane with a base angle of  $20^\circ$ . What is the coefficient of friction between the mass and the inclined plane?

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5. A 0.5 kg mass is on an inclined plane with base angle of  $30^\circ$ . The coefficient of friction between the mass and the plane is 0.35. The 0.5 kg mass is attached by a string to a little mass  $m$  that is hanging from a pulley from the top of the ramp. If the system is to remain at rest, what are the minimum and maximum that  $m$  can be?
6. A 3 kg box is resting on top of a 5 kg box, which is on a horizontal table. The coefficient of friction between the box and the table is 0.3. If the bottom box is pushed by a horizontal force of 40 N, what is the acceleration of the boxes, assuming the little box stays on top of the big box.
7. In the previous problem, what must be the minimum coefficient of friction between the two boxes so that the little box stays on top of the big box?
8. A box slides from rest down an inclined plane with base angle  $40^\circ$  and then onto a flat horizontal table. The coefficient of friction between the box and both surfaces is 0.2. If the ramp is 1.5 meters long, how far on the table does the box slide before coming to rest?

Answers: 1 a)  $2 \text{ m/s}^2$     b)  $4.4 \text{ m/s}^2$     c)  $3.3 \text{ m/s}^2$     d)  $0 \text{ m/s}^2$  2)  $56.3 \text{ N}$     3)  $\mu M$   
 4) 0.36    5) 0.098 & 0.4 kg    6)  $2 \text{ m/s}^2$  7) 0.2    8) 3.65 m