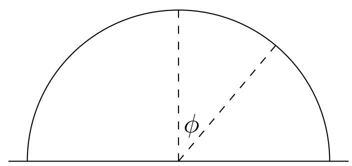
Chapter 5 - Applications of Newton's Laws

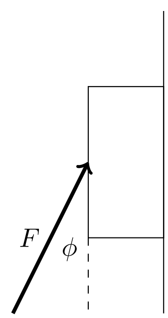
Physics 206

For any problems where you are given a variable/symbol and a value for that variable, make sure to solve the problem symbolically first. Your final answer should then only contain the variables that you are given values for in the problem, constants that appear on the equation sheet and numbers like 2 or π.

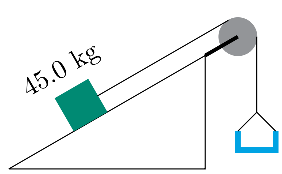
Group 1 Problems:
Problem 1: Ralph is skateboarding down a perfect semi-circle from the top. To test it out he holds himself at rest at an angle ϕ from the vertical. What is the normal force at this angle? What force parallel to the ramp is acting on him so he stays in place?



Problem 2: According to a website where you can purchase our textbook, the hardcover version is 7.05 pounds. A copy of this book is being pushed against a wall by a force F at an angle $\phi = 20.0$ degrees as shown in the figure below. If the wall has a coefficient of static friction $\mu_s = 0.400$, what is the range of magnitude that F can be so that the box doesn't move?



Problem 3: An open-topped box with a mass of $m = 5.00$ kg is hanging from a massless rope that is wound around an ideal pulley and connected to a 45.0 kg block that is at rest on a slope that makes an angle of $\theta = 15.0$ degrees relative to the horizontal. The coefficients of static and kinetic friction are $\mu_s = 0.45$ and $\mu_k = 0.35$. What is the maximum amount of 1.00 kg stones that can be placed in the hanging box before the system begins to move? If you put one too many stones in the box, what will the acceleration of the box be?



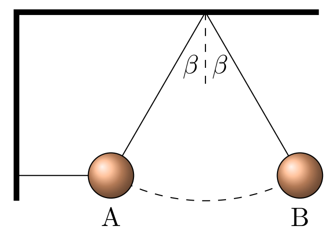
Problem 4: A block is sliding across the ground at $v = 5.00$ m/s. There is a coefficient of kinetic friction of $\mu_k = 0.300$. How far does the box slide before coming to rest?

Problem 5: A camper with a mass of $m = 85.0$ kg is laying in a hammock where the straps are producing a force that suspends them in equilibrium with gravity. The straps of the hammock are each at an angle of $\theta = 20.0$ degrees with respect to the horizontal. What is the tension of each strap of the hammock? What if the straps were 20.0 degrees with respect to the vertical instead?

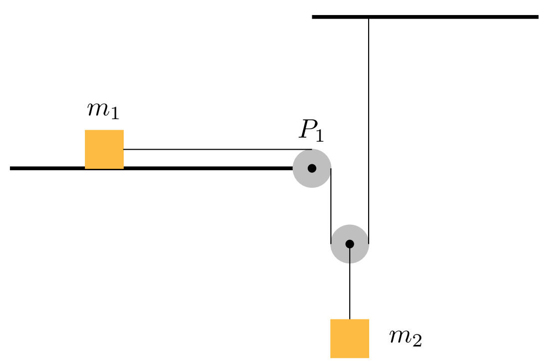
Group 2 Problems:
Problem 6: A box of mass m is sliding up an incline that makes an angle of θ relative to the horizontal and it has a speed v_0 at the bottom of the incline. The coefficient of kinetic friction between the box and the incline is μ_k. At what height above the bottom of the ramp will the box (at least briefly) come to rest? What minimum value of the coefficient of static friction is necessary for the box to stay at rest once it stops?

Problem 7: A heavy box with mass $m = 105$ kg is on the floor and you want to move it. You are taller than the box and so you have two reasonable options. You can either push the box with a force that is directed 30 degrees below the horizontal or you can pull the box with a force that is directed 30 degrees above the horizontal. The coefficient of static friction between the box and the floor is $\mu_s = 0.375$. Let the force needed to get the box to move be F_{push} and F_{pull} in their respective cases. By what factor is F_{push} greater than F_{pull}?

Problem 8: In the figure to the right, a small sphere is held at rest as position A by two light strings, one horizontal and one connected to ceiling.
(a) What is the tension in the horizontal string while the sphere is held at position A?
(b) If the horizontal string is cut, the sphere will swing over to position B and then swing back. What is the ratio of the tension in the string at position B to the tension in that same string before the horizontal string was cut?
(c) What is the magnitude of acceleration of the sphere at point B?



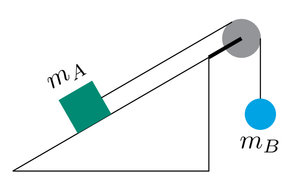
Problem 9: The rope in the figure below is fixed to the ceiling, wound through two pulleys and then connected to m_1 which is sitting on a frictionless surface. Pulley P_1 is fixed in place but the other pulley is free to move up and down, and both pulleys are massless. If the system is released from rest, $m_1 = 15.0$ kg and $m_2 = 6.00$ kg, how much time does it take for m_1 to travel $\Delta x = 0.250$ m? How about m_2 to travel the same distance? Remember to use the fact that if the rope is light and the pulley is massless, the tension is the same at all points along the rope.



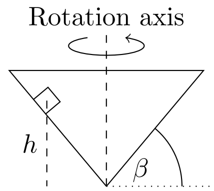
Problem 10: As part of training, astronauts will take a ride on the (unofficially nicknamed) "Vomit Comet". This is where an airplane will make a series of parabolic maneuvers to simulate weightlessness. The top and bottom of these parabolas can be approximated by circular paths with radius R. An example flight speed of this aircraft is 350 knots or 180 m/s. Assume that the radius is the same for the top of the arc and the bottom of the arc.
(a) What does the radius have to be so that the difference in a passenger's apparent weight between the top and bottom of the arc is equal to their weight on the ground?
(b) What does the radius have to be so that their apparent weight at the top of the arc is 10% of their weight on the ground?

Group 3 Problems:
Problem 11: Two cars are racing around a flat, circular track with radius R. Car A has a mass m and the tires have coefficients of friction μ_s and μ_k. Car B has a mass of $3m$ and coefficients of friction $\mu_s/2$ and $\mu_k/2$. Both cars start from rest.
(a) If both cars accelerate with constant a, which one will make it further before sliding?
(b) How far does each car go before they start to slide?
(c) How much time does it take before each starts to slide?

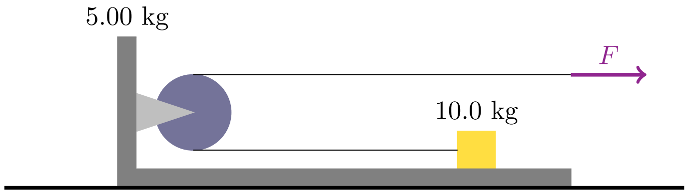
Problem 12: A block of mass $m_A = 15.0$ kg is placed on a ramp that makes a $\theta = 30$ degree angle with the horizontal. The coefficients of friction between the block and the ramp are $\mu_s = 0.300$ and $\mu_k = 0.200$. The block is connected by a light rope over a pulley and attached to a ball of unknown mass, m_B, that hangs vertically.
a) What range of masses of the ball will hold the system at rest?
b) If the ball mass is just past the threshold to cause the block to slide up the ramp, what is the acceleration of the system?
c) What mass of the ball will allow the block to slide up the ramp at constant speed, assuming you manually set it in motion?
d) If the ball mass is just past the threshold to cause the block to slide down the ramp, what is the acceleration of the system?
e) What mass of the ball will allow the block to slide down the ramp at constant speed, assuming you manually set it in motion?



Problem 13: A small block with mass $m = 250$ g is placed inside an inverted cone that is spinning about a vertical axis. The time to do one full rotation of the cone is T. The wall of the cone makes an angle $\beta = 55.0$ degrees with the horizontal. The coefficient of static friction between the block and the cone is $\mu_s = 0.480$. If the block is supposed to stay at a constant height $h = 10.0$ cm above the point of the cone, what are the minimum and maximum values that T can be?



Problem 14: A 10.0 kg block rests on a 5.00 kg bracket as shown in the figure. The bracket sits on a frictionless surface. The coefficient of friction between the block and the bracket are $\mu_s = 0.400$ and $\mu_k = 0.300$. What is the maximum force F that can be applied to the cable if the block is not supposed to slide relative to the bracket? What is the acceleration of the bracket if that force is applied?



Problem 15: In the figure below, Box A and B are both 25.0 N and have a coefficient of kinetic friction of $\mu_k = 0.350$ between them and the surface. Block C is descending at a constant speed, $v_0 = 4.00$ m/s. The plane has an angle of $\theta = 20.0$ above the horizontal.

(a) What is the mass of Block C?

(b) If the string connecting Blocks A and B was cut, what will the acceleration of Block C be?

(c) If instead, the string between Blocks B and C was cut, how far up the ramp does Block B move before it briefly comes to a stop?