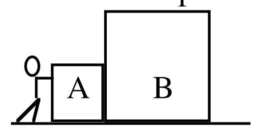
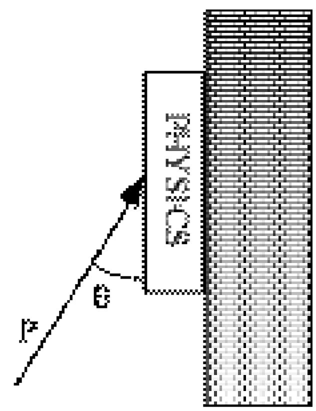
Newton's Second Law Problems: We will be working on these problems during the next several classes. Please bring them to each class.

In all problems start with a complete free body diagram. Indicate and Newton's Third Law pairs on your diagrams.

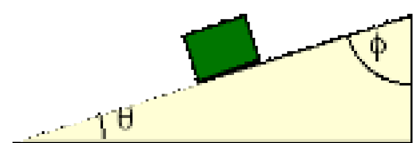
1. Boxes A and B, with masses m_A and m_B can move on a horizontal frictionless surface. You push horizontally with a push P on block A. (a) Find the acceleration of the boxes. (b) Find the force between the boxes. Answers may contain symbols already given plus any constants like g.(c) Suppose m_A = 10 kg and m_B = 40 kg, and P = 100 N. What are the numerical answers? (d) Suppose m_A = 40 kg and m_B = 10 kg, and P = 100 N. What are the numerical answers?



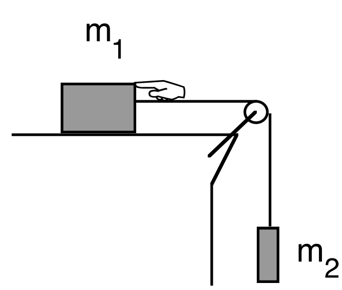
2. A book of mass m is pushed against a smooth frictionless wall by a force P that makes an angle θ with the vertical. Find (a) the normal force on the book and (b) its acceleration in terms of P, m, θ, and constants. (c) Look at limiting cases (large and small angles) to see if it makes sense.



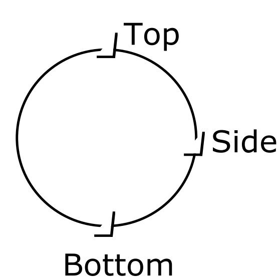
3. You are skiing on a hill inclined at θ to the horizontal where there is a constant frictional force f. Find the normal force and your acceleration in terms of your mass, m, f, θ, and constants. Look at limiting cases to see if the answer makes sense.



4. Two blocks, masses m_1 and m_2, are connected by an ideal string passing over an ideal pulley. One block is on a horizontal frictionless surface and the other can move vertically and only touches the string. Find the acceleration of each block and the tension in the string in terms of the masses and constants.



5. A Ferris Wheel has a radius R = 11.0 m and rotates once every 11.0 s. What is the force of the chair seat on you at each of the three positions, top, side, and bottom? Answer as a multiple of your weight (e.g. 1.4 mg).

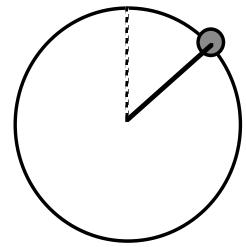


6. You whirl a ball of mass $m = 0.40$ kg on a string of length $L = 0.90$ m. At the point shown the angle of the string from the vertical is $\theta = 30°$ and the ball has a speed of $v = 3.50$ m/s.

(a) Find the tension in the string.

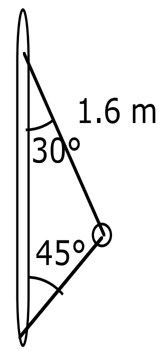
(b) What is the acceleration of the ball, tangential and radial components?

(c) Now consider the ball at the top of the circle. What is the smallest speed of the ball so that the ball continues in a circle?

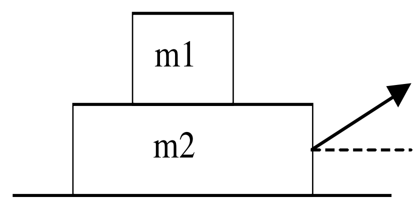


7. A ball of mass m = 1.34 kg is attached to a vertical rod by two strings. The top string is 1.60 m long and makes a 30° angle with the rod, while the bottom string makes a 45° angle with the rod. The rod is rotated at 1 revolution every 1.20 s.

Find the tension in each string.

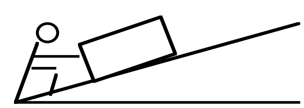


8. I have a horizontal table that is **very** low friction. On it I place a pair of blocks, with m_1 on top of m_2. Between the blocks there is friction, with static coefficient μ_s and kinetic coefficient μ_k I attach a rope to the lower block and pull with a pull P acting at an angle θ above the horizontal.



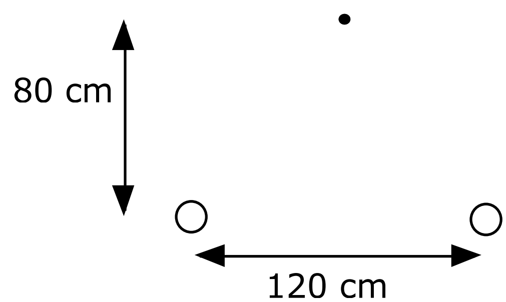
Try using $m_1 = 0.600$ kg, $m_2 = 2.400$ kg, $\theta = 30.0°$, $\mu_s = 0.450$, $\mu_k = 0.350$ and for a small pull, $P = 5.000$ N, large pull $P = 20.000$ N. What answers do you get? Do they make sense?

9. You are pushing a box uphill the hill has a pitch of $\theta = 15°$ above the horizontal, and friction coefficients between the box and the hill are $\mu_s = 0.45$, $\mu_k = 0.35$. The box has a mass of $m = 40$ kg. You push horizontally with a push of $P = 180$ N, and the box is initially moving uphill. Find the acceleration of the box.



10. If you move along a line joining the earth to the moon, at what point is the net gravitational force from the two objects equal to zero? Astronomical data is available in the appendix of the text or in the flyleafs.

11. Identical masses of 1200 kg are separated by 120 cm. A third, unknown mass is located as shown. Find the acceleration of the unknown mass assuming that the three objects are located far from the earth with no nearby planets.



12. **Gravitational:** You have been hired as a consultant for the new Star Trek TV series to make sure that the science in the show is correct. In this episode, the crew of the Enterprise goes into standard orbit around a newly discovered planet. The plot requires that the planet is hollow and contains the underground cities of a lost civilization. From orbit the science officer determines that the radius of the planet is 1/3 (one-third) that of Earth. The first officer beams down to the surface of the planet and measures that his weight is only 1/2 (one-half) of his weight on Earth. How does the mass of this planet compare with the mass of the Earth? Assuming that the planet is composed of the same type of material as the earth, with the same density, are the measurements consistent with a hollow planet?

13. **Weight, Normal, Friction:** While visiting a friend in San Francisco you decide to drive around the city. You turn a corner and are driving up a steep hill. Suddenly, a small boy runs out on the street chasing a ball. You slam on the brakes and skid to a stop leaving a 50 foot long skid mark on the street. The boy calmly walks away but a policeman watching from the sidewalk walks over and gives you a ticket for speeding. You are still shaking from the experience when he points out that the speed limit on this street is 25 mph. After you recover your wits, you examine the situation more closely. You determine that the street makes an angle of 20^{o} with the horizontal and that the coefficient of static friction between your tires and the street is 0.80. You also find that the coefficient of kinetic friction between your tires and the street is 0.60. Your car's information book tells you that the mass of your car is 1570 kg. You weigh 130 lbs. Witnesses say that the boy had a weight of about 60 lbs. and took 3.0 seconds to cross the 15 foot wide street. Will you fight the ticket in court?