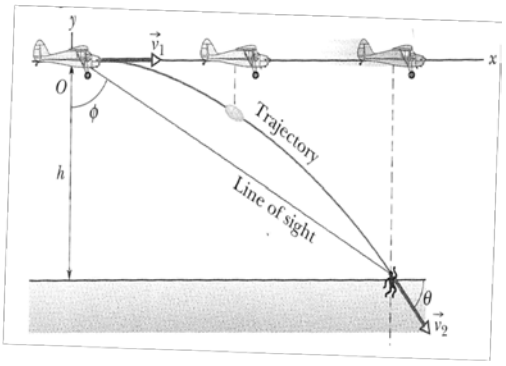
1. (20 pts) A plane is flying horizontally with a speed v_1 = 55.0 m/s (*198 km/h*) at a constant elevation h = 500 m toward a point directly over a target. The pilot wants to release a package so that it lands directly on that target.

   a. What should the angle ϕ (*in degrees*) of the pilot's line of sight to the target be when she releases the package?

   b. With what velocity $\vec{v}_2$ (*in terms of speed and angle θ in degrees with respect to horizontal*) will the package strike the target?

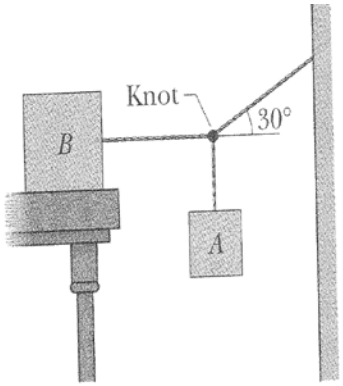


2. (20) Block B in the figure to the right has a mass M_B = 71 kg. The coefficient of static friction between this block and the table is μ_s = 0.25. The cord connecting block B and the knot is horizontal.

   a. Draw free-body-diagrams for block B and for the knot that show all the forces acting on each.

   b. Calculate the maximum tension T_B in the horizontal string (*the string between block B and the knot*) for which the system will remain stationary.

   c. Calculate the maximum mass, M_A of block A for which the system will remain stationary.



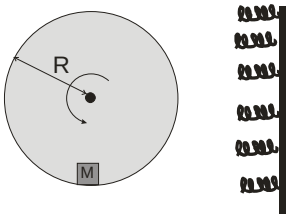
3. (20) A block of mass M is resting at the edge of a turntable of radius R when the turntable starts spinning. A top-down view is drawn to the right. The coefficient of static friction between the mass and turntable is μ_s and the coefficient of kinetic friction is μ_k.

   a. As the turntable accelerates the block will eventually fly off. What will the angular speed ω of the turntable be when this happens?

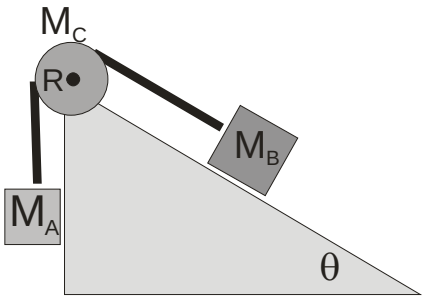
   b. With what speed and at what direction with respect to the turntable (*perpendicular, tangent, in between*) will the block leave?

   c. You expected the block to fly off and arranged to catch it using springs of spring constant k arranged around the turntable. How far will the (*single*) spring be depressed when the block (temporarily) comes to a halt.

   d. The block sticks to the spring that stops it and the block-spring system starts vibrating. What is the frequency of this vibration?



4. (25) Two blocks of mass M_A and M_B respectively are positioned as shown below. The rope joining them is ideal and runs over a pulley or radius R which has no friction but does have mass M_C which is distributed uniformly over its disk-like shape. Block B is accelerating down the incline, which makes an angle θ with horizontal, and the coefficient of kinetic friction between this block and the incline is μ_k.



   a. Without doing any calculations, answer this question: Is the tension T_L on the left side of the pulley greater than, less than, or equal to the tension T_R on the right side of the pulley? Explain how you know this.

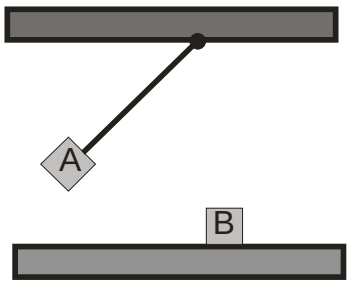
   b. Draw free-body diagrams that show all the external forces acting on masses M_A, M_B and M_C.

   c. Write the equations of motion, similar to F = ma, that are associated with each of the three masses.

   d. Solve for the acceleration of M_A in terms of the masses and other constants you are given. (*NOTE: Since this test concentrates on our knowledge of physics rather than your skills at algebra, this part will not be heavily weighted when this problem is graded.*)

   e. Test that your answer for part d gives reasonable results in the situations where M_A is much greater than the other two masses and where M_C is much greater than the other two masses

5. (15) In the figure below, block A of mass M = 1 kg (*which is mounted on a massless strut of length l = 6 m suspended from the ceiling via a frictionless pivot*) swings down from a height h = 3 m and hits an identical second block B of mass M = 1 kg. Each of the following calculations should be worked out in terms of symbols before you substitute in numbers to obtain a numerical result.



   a. The first time you attempt this experiment the collision between the blocks is completely elastic. How fast will each mass be traveling immediately after the collision, and in what direction will M_A be moving? (*Be certain to DERIVE your answer from fundamental principles; no credit will be given for an answer without proof.*)

   b. You decide to repeat the experiment but your lab partner accidentally leaves some super glue on the face of block B so that the two blocks now stick together when they collide (*the collision is completely inelastic*). What is the speed of the combined mass just after they collide and how far up do the combined masses rise before temporarily coming to a stop?

6. (10) Treasure hunters are trying to pull a wooden box of internal volume 1 m^3 and mass 20 kg up off the bottom of a lake. The box is air-tight, and it contains 1500 kg of gold bars. The density of the wood used to make the box is roughly equal to the density of water.

   a. What force should the treasure hunters exert if the box is to move up at a constant speed?

   b. The box springs a leak, water rushes in and the box starts falling back toward the bottom of the lake with an acceleration of 5.78 m/s^2 even though the hunters are still trying to pull it up using the same force. What volume does the gold occupy in the box?