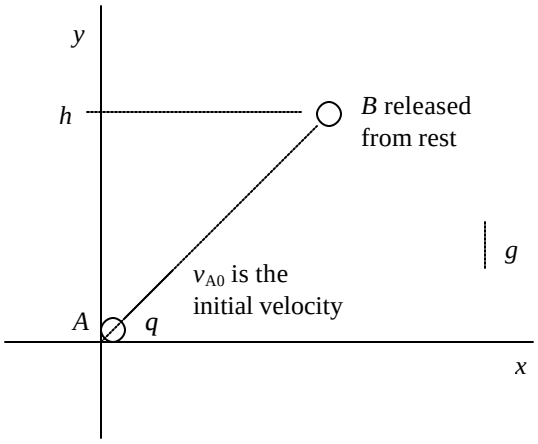
Prof. M. Tuts **Physics 1201 - Test 1** October 8, 2001

You must answer all three questions, and show all your work in order to receive full credit. Partial credit will be given. The test is closed book, but a formula sheet is provided on the last page. Start each question on a new page, and remember that your answers must indicate the units and directions of vectors where appropriate. You have 75min to complete the test. Good Luck!

1 A bullet, *A*, is fired at an angle q from the horizontal with initial velocity $\boldsymbol{v}_{A0}$ at time $t=0$ directly at a second particle, *B*, as shown. At the instant *A* is fired, *B* is released from rest from a height *h*, and then proceeds to drop freely. Gravity acts down (as shown) and you should neglect air resistance. Some time *t* later the two particles are observed to collide. Express your answers in terms of v_{A0}, h, g and q.



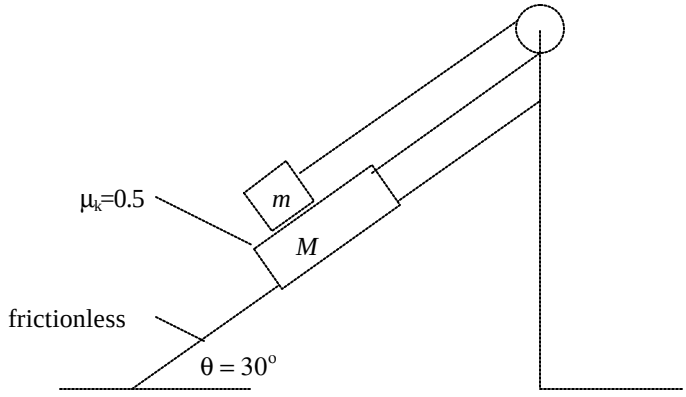
A. (10pts) When do they collide? In other words, what is the value of *t* at the time they collide.

B. (10pts) Where do they collide? Answer by providing the *x* and *y* coordinates of the collision point.

C. (10pts) What is the velocity of *A* just before they collide? [Remember $\boldsymbol{v}$ is a vector].

D. (10pts) Prove that if the bullet, *A*, is not fired directly at *B*, then *A* will miss *B*. [Hint: Assume it is fired and <u>not</u> pointing at B at (assume it makes an angle f), then find the time when $x_A = x_B$ and the time when $y_A = y_B$ and show that $\phi = \theta$ if they are to collide]

2. Consider a system of two masses as shown. The mass M = 30kg is attached to a mass m=10kg via a rope. The rope attaching them is massless and it passes around a massless and frictionless pulley. The coefficient of kinetic friction betweem *m* and *M* is $\mu_k = 0.5$. The surface between *M* and the inclined plane is frictionless. The inclined plane makes an angle $\theta = 30^o$ with the horizontal. Assume that when you answer the following questions both masses are in motion.

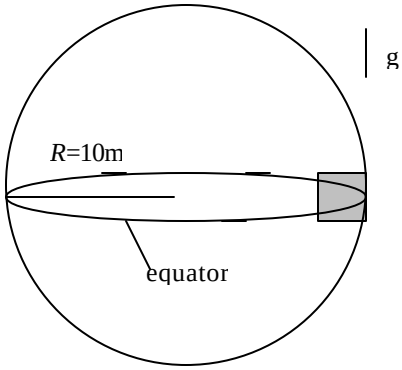


A. (10pts) Draw a free body diagram for each mass separately. Be sure to indicate what each force is due to.

B. (10pts) What is the acceleration of *M*? (direction and magnitude).

C. (10pts) What is the tension in the rope?

3. A circus act consists of a hollow sphere of radius R = 10(m) inside of which a rider drives a motorcycle (represented by the grey square in the picture). The coefficient of static friction between the motorcycle tires and the sphere is μ_s=0.5. The motorcycle is observed to traveling in uniform circular motion around the "equator" (the "equator" is in the horizontal plane that contains the center of the sphere, as shown).



A. (10pts) Draw the free body diagram for the motorcycle when it is traveling around the equator. There is no need to show the forces in the direction of motion (which would be in a direction out of the plane of the paper for this specific drawing), but you must show all the other forces on your diagram (which would be in the plane of the paper).

B. (10pts) What is the minimum speed of the motorcycle required to keep it moving around the "equator" in uniform circular motion?

C. (10pts) Now, suppose that the surface suddenly becomes icy and all surfaces became frictionless. Is there a new speed that would allow the motorcycle to keep going around the equator? (neglect the fact it would be difficult for him to speed up or slow down if there is no friction! He could use a jet pack… just imagine it is possible somehow to slow down or speed up as necessary). Justify your answer by finding the new speed or proving it is not possible.