Midterm Exam 1

Physics 7A, Spring 2012

Lecture 1: Herdman

Februrary 22, 2012

Please do all your work in a bluebook. You will be graded on your *solutions* not just your *answers*. Show all work and thoroughly justify your solutions with figures, diagrams, equations, and words, as appropriate. Partial credit will be given to partially correct and/or partially complete solutions. No credit will be given to unjustified answers. Cross out any parts of solutions that you do not want to be graded.

There are 6 problems and 100 possible points on the exam. Please read all 6 problems carefully at the beginning of the exam and attempt all problems to maximize your partial credit. Make sure that your answers to questions that ask for a vector quantity are given in the form of vectors (i.e. have vector components, or a magnitude and direction). Where appropriate, clearly label the choice of axes you are using. You have two hours to complete the exam. This is a closed-book exam–you may use one double-sided $3'' \times 5''$ index card of notes. Calculators are not allowed.

On the front or your bluebook, write your:

- full name
- SID
- D/L section number
- GSI name
- signature

Do not open the exam until you are told to do so.

Good luck!!

1 Ball in a tube [10 pts]

In figure 1 a ball slides through a frictionless tube; it's initial speed entering tube, v_0, is large enough that the ball makes it over the top. Treat the ball's motion as one-dimensional such that the position is measured along the length of the tube. Draw 1D position, velocity, and acceleration vs. time plots for the ball's motion from the begining to the end of the tube. Label the times t_a, t_b and t_c where the ball crosses the points a, b, and c as shown in figure 1. Your plots need only be qualitatively correct.

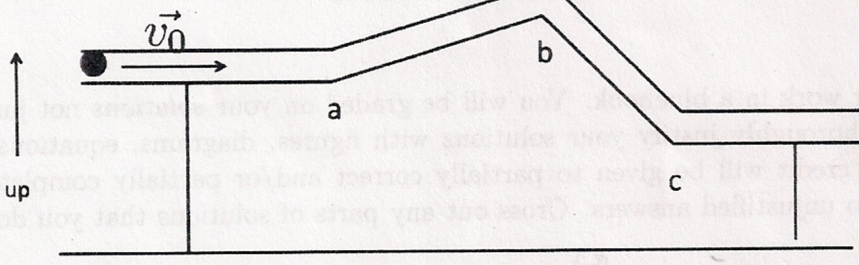

Figure 1: Problem 1

2 Toy rocket [15 pts]

A toy rocket of mass m is fired from the ground, starting at rest. The engine provides and vertical force of magnitude F_R for a time t_R. Ignore air resistance. What is the maximum height the rocket reaches? All answers should be given in terms of F_R, t_R, m and any relevant physical constants.

3 Truck and crate [20 pts]

Starting from rest, a flatbed truck of mass m_T is accelerating up a hill with an incline of angle θ to the horizontal with an acceleration of magnitude a_T. As the truck accelerates up the hill, a crate of mass m_C in the back of the truck starts to slide down the truck bed which has a coefficient of kinetic friction, μ_k with respect to the crate.

(a) Draw free body diagrams of the crate and truck.

(b) Find the *total* force vector on the road from the truck in terms of m_T, m_C, a_T, θ, and μ_k and any relevant physical constants.

4 Block a on table [15 pts]

Block A (mass m_A) is sliding on a frictionless table and is attached to a massless string that runs through a frictionless hole in the table; block B (mass m_B) is hanging from the other end of the string (see figure 2) and remains at rest. Block A is moving in a counter-clockwise circle (as viewed from above) at constant speed and there is a length ℓ of string between the hole that is centered at the origin and block A. At time t_0 the string is along x-axis, as shown in figure 2. For all questions use the axes given in figure 2 and put your answers in terms of m_A, m_B, ℓ, t_0, t_1, t_2 and any relevant physical constants.

(a) Draw free body diagrams for block A and block B at time t_0.

(b) Find the position, velocity, and acceleration vectors of block A at time t_0, given that block B remains at rest for times $t < t_1$.

(c) At a time after t_0, a blade is then placed at $\vec{r} = -\ell/2\hat{i}$ such that when the string hits the blade at time t_1 ($t_1 > t_0$), the string instantly breaks. Find the position, velocity, and acceleration vectors of block A at a later time t_2, where $t_2 > t_1$. Assume the table is large enough that block A does not slide off the table before time t_2.

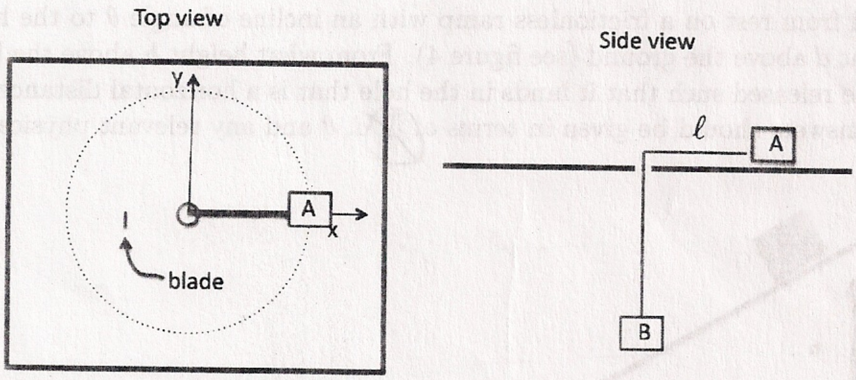

Figure 2: Problem 4. For $t < t_1$, block A moves in a counter-clockwise circle at constant speed. The position of block A at time t_0 is shown in the figure.

5 Blocks & Pulley [20 pts]

In figure 3, block B is connected to a cord which is wrapped around a pulley that is attached to block A: the other end of the cord is attached to an anchor which is fixed to the table. Block A has mass $3m_0$ and block B has mass m_0. The coefficients of static friction and kinetic friction between block A and the table are μ_s and μ_k, respectively. The cord and pulley are massless, and the pulley is frictionless.

(a) Draw free body diagrams for blocks A and B

For parts (b) & (c), both blocks remain at rest:

(b) Find the friction force vector acting on block A

(c) What is the minimum μ_s that allows the blocks to remain at rest?

Now block A is given a slight kick such that it starts sliding. After the blocks start sliding:

(d) Find the acceleration vectors for blocks A and B.

(e) Find the tension in the cord.

All answers should be given in terms of μ_s, μ_k, m_0 and relevant physical constants.

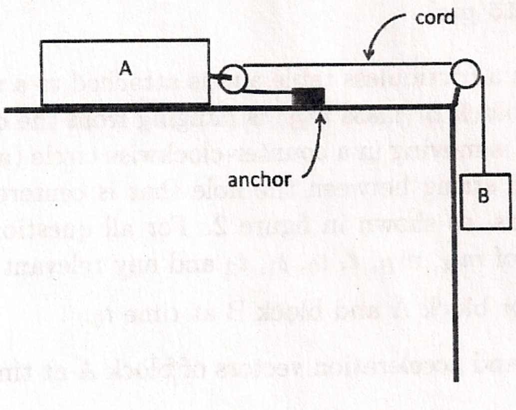

Figure 3: Problem 5

6 Sliding block [20 pts]

A block is released from rest on a frictionless ramp with an incline of angle θ to the horizontal ($\theta < 45^o$) which ends a height d above the ground (see figure 4). From what height h above the bottom of the ramp should the block be released such that it lands in the hole that is a horizontal distance d from the bottom of the ramp. All answers should be given in terms of h, d, θ and any relevant physical constants.

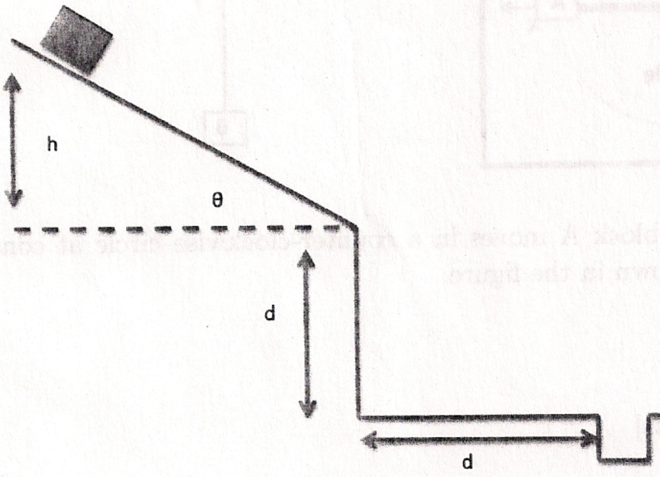

Figure 4: Problem 6