Name: «First_Name»	Signature:
Surname: «Last_Name»	KUSIS ID Number: «KUSIS_ID»

PHYS 101 General Physics I – Midterm 1

October 31, 2014 Friday 17:30 -19:00

Please read!

- Count to make sure that there are 5 pages in the question booklet
- Check your name and surname on front page, and student ID number on each page, and sign each page.
- This examination is conducted with closed books and notes.
- Put all your personal belongings underneath your seat and make sure that pages of books or notebooks are not open.
- Absolutely no talking or exchanging anything (like rulers, erasers) during the exam.
- You must show all your work to get credit; you will not be given any points unless you show the details of your work (this applies even if your final answer is correct!).
- Write neatly and clearly; unreadable answers will not be given any credit.
- If you need more writing space, use the backs of the question pages and put down the appropriate pointer marks.
- Make sure that you include units in your results.
- Make sure that you label the axis and have units in your plots.
- You are not allowed to use calculators during this exam.

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1	2	3	4	Total

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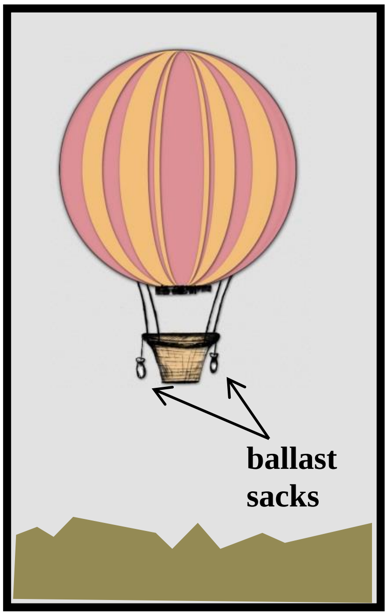
1-(25 Points) A hot air balloon descending vertically towards the ground with constant speed $v_0 = 5$ m/s drops a ballast sack when it is $h_0 = 100$ m above the ground. 10 seconds after the drop, a second ballast sack is dropped. After each drop, the balloon gains an upward acceleration of 1 m/s^2. Gravitational acceleration is $g = 10$ m/s^2. The numerical values are exact.



a) Draw the velocity of the sacks and the balloon as a function of time on the same figure below. In the graph, show clearly the initial velocities, the hit velocities and the hit times of the sacks, and the velocity of the balloon when the second sack hits the ground.

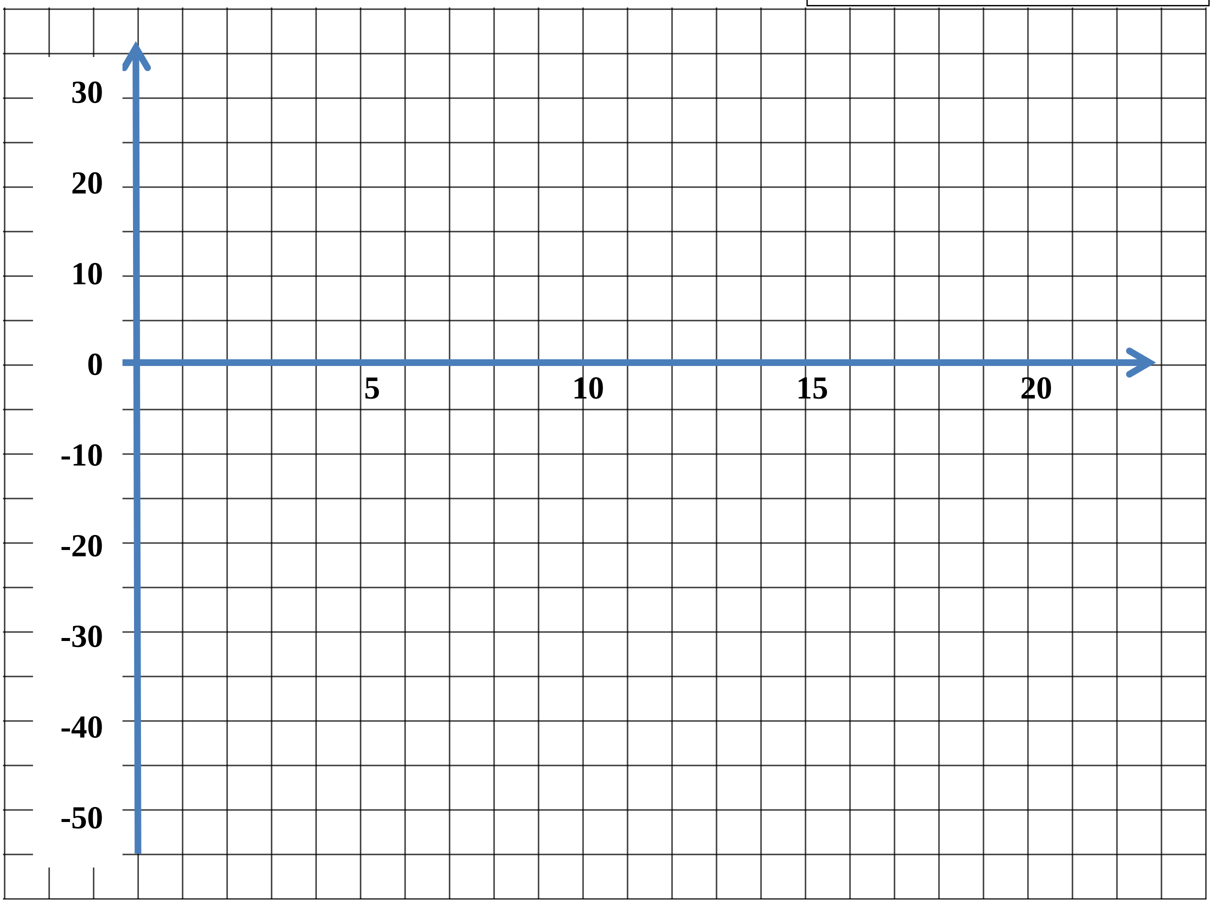
b) Determine the maximum vertical distance from the ground that the second sack can reach.

ANSWER:

c) Determine the vertical distance of the balloon from the ground when the second sack hit the ground.

ANSWER:

Perform your solution at the backside of this sheet!



Solution continues on the back side of the page **Yes** □ **No** □

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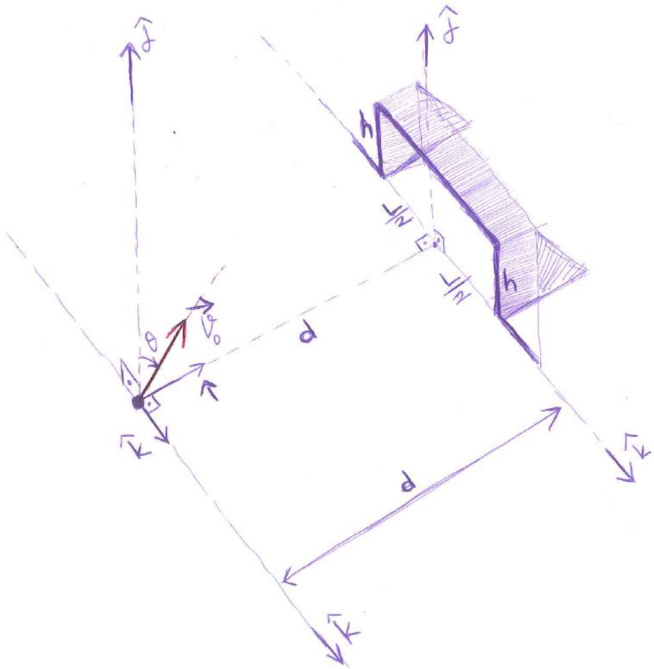
2-(25 Points) In soccer, a penalty kick is a free kick on the goal defended only by the goalkeeper. The penalty kick is scored when the ball crosses the goal line between the goalposts and the crossbar. Consider the penalty kick shown in the figure, where the striker hits the ball with an initial speed v_0 at a **small*** angle θ measured from the vertical (y) axis. The ball is kicked at a distance d from the middle of the goal line which has length L, while the crossbar is at a height h. The magnitude of the gravitational acceleration is g. We would like to model this problem as an ideal projectile motion where the ball is taken as a point particle and both the air resistance and the goalkeeper are ignored.



(a) Since θ is small, it is impossible to score the penalty kick for $v_0 > v_{max}$, no matter which direction is aimed. Find v_{max} in terms of θ, L, d, h and g.

ANSWER:

(b) For $v_0 = v_{max}$, write down the initial velocity of the ball in terms of v_{max}, θ, L, d, h and the given unit vectors (i, j, k).

ANSWER:

* We assume the angle with the vertical axis is small, e.g. θ < arctan(d/h).

Solution continues on the back side of the page **Yes** □ **No** □

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3-(25 Points) A car of mass m is going around a circular turn of radius R over a wet concrete road, that is banked at an angle $\theta = 45^o$ with respect to the ground. The coefficient of static friction between the rubber tires and the road can be taken as $\mu = 0.5$. You may neglect the kinetic friction. A traffic sign indicates that maximum speed to take the turn is 60 km/h.

Let g = $10 m/s^2$ be the magnitude of the gravitational acceleration.

(i) Sketch the free body diagram of the car if it just starts to slip down.

(ii) Sketch the free body diagram of the car if it just starts to slip up.

(iii) Show your coordinate systems; and write the equations of motion.

(iv) State the just slipping condition for the car.

ANSWER:

(v) Calculate the minimum speed to take the turn to avoid sliding down.

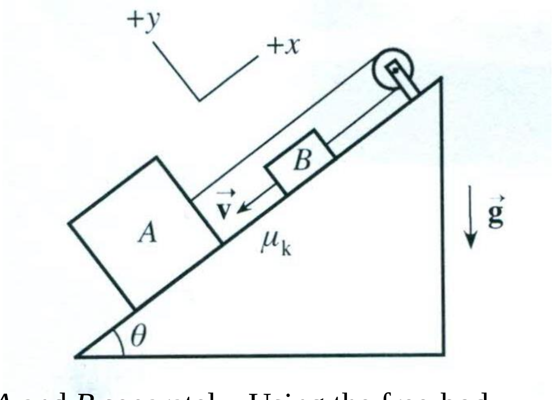
ANSWER:

(vi) Find the radius of the turn.

ANSWER:

Solution continues on the back side of the page **Yes** □ **No** □

4-(25 Points) Two blocks *A* and *B* with masses m_A and m_B are moving on an inclined plane that makes an angle θ with the horizontal. The coefficient of kinetic friction between each block and the inclined plane is μ_k. The two blocks are tied together by a non-strechable, massless cord which slides over a frictionless, massless pulley as shown in the figure. At time t= 0, block *B* is sliding down the plane ($m_B > m_A$) with a constant velocity **v.**



a.) Draw the free-body force diagrams for each block *A* and *B* separately. Using the free-body diagrams and the *x*- and *y*-axes as given in the figure, write down Newton's second law of motion for the blocks *A* and *B*.

b.) Derive an expression for the coefficient of kinetic friction μ_k in terms of m_A, m_B and θ.

ANSWER :

c.) Assume that the cord connecting the blocks *A* and *B* breaks down suddenly at time *t*=0. Find the acceleration a_B of block *B* just after the cord breaks. Express your answer in terms of *g*, m_A, m_B , and θ only.

ANSWER :

Solution continues on the back side of the page **Yes** □ **No** □