Name Surname: «First_Name» «Last»	Student ID Number: «ID»
Exam Room: «EXAM_ROOM»	Signature:

PHYS 101 General Physics I – Final Exam

January 11, 2016 Monday 11:45 -13:45

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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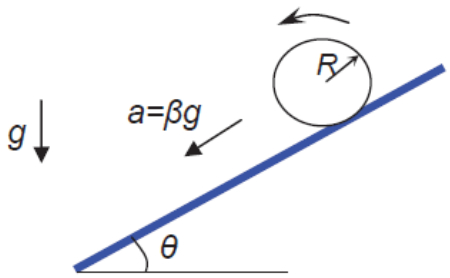
1-(25 points) A cylinder of radius R and mass M (but with an unknown mass distribution) rolls without slipping down an inclined plane of angle θ. It is given that the acceleration of the center of mass of the cylinder along the inclined plane is βg, where $\beta < \sin\theta < 1$.
(Your final expressions should only contain M, β, g, θ, and R)



a) Write equations of motion for the cylinder.

b) Determine the angular acceleration of the cylinder.

$\alpha =$

c) What must be the rotational inertia of cylinder?

$I =$

d) What should be the smallest value of coefficient of static friction for the rolling without slipping condition?

$\mu_s =$

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

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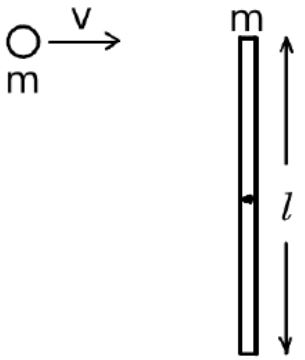
2-(25 points) A ball with mass m is approaching horizontally with speed *v* towards one end of a vertically standing uniform bar which is free to rotate about a fixed pivot at its center. The bar has length *l* and the same mass *m* as the ball. The bar and the ball go through an *elastic collision* and they remain in the same plane afterwards. There is no gravitational acceleration.



(a) Calculate (by integration) the moment of inertia *I* of the bar about its center.

$I =$

(b) Find the final speed v_f of the ball. Does it bounce back or continue its motion in the same direction?

$v_f =$

(c) At what distance *r* from the pivot should the same ball (horizontally approaching again) hit the bar, so that the ball comes to rest immediately after the collision?

$r =$

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

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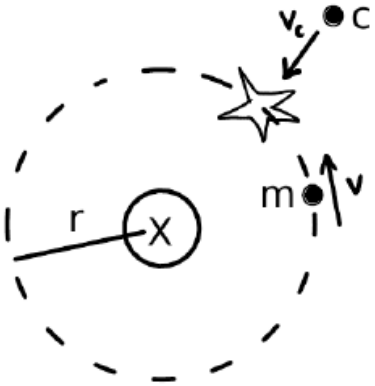
3-(25 points) Planet *X* with mass M_x has a small moon with mass *m* which moves on a circular orbit around the planet at speed *v*. A comet also with mass *m* and speed v_c collides and merges with the moon while moving head-on towards Planet *X*. We will call the merger "Com-moon". Give your answers below in terms of M_x, *m*, *v* and the gravitational constant *G* only. Simplify your answers in order to get full credit.



(a) Find the radius *r* of the moon's circular orbit before the collision.

$r =$

(b) Find the angular momentum (with respect to the planet's center) of
(i) the moon (L_m) before the collision

$L_m =$

(ii) the comet (L_c) before the collision

$L_c =$

(iii) Com-moon (L_{cm}) after the collision

$L_{cm} =$

(c) After the collision Com-moon escapes the gravitational pull of Planet *X*. What is the smallest possible value of v_c?

$v_c =$

(d) Use conservation of angular momentum and energy to find the minimum distance $r_{\min}$ between Com-moon's trajectory and Planet *X* for the value of v_c asked in part (c).
You don't need to know the answer to (c) in order to solve part (d).

$r_{\min} =$

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

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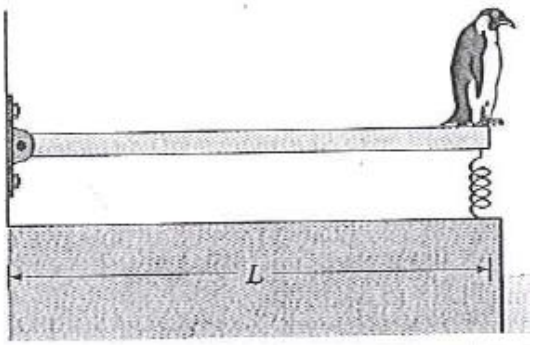
4-(25 points) A penguin (obviously skilled in aquatic sports) dives from a uniform board that is hinged at the left and attached to a spring at the right. The board has length L and mass m and the spring constant is k. When the penguin dives, it leaves the board and spring oscillating with a small amplitude. Assume that the board is stiff enough not to bend , and find the period T of the oscillations.
(For small amplitude of oscillation: $\sin\theta \approx \theta$.)



T =

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