Name: «Name_»	**Signature:**
Surname: «Surname_»	**Student ID Number: «Student_ID»**

PHYS 101 General Physics I – Final

June 3, 2015 Saturday 15:00 -16:10

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	5	Total

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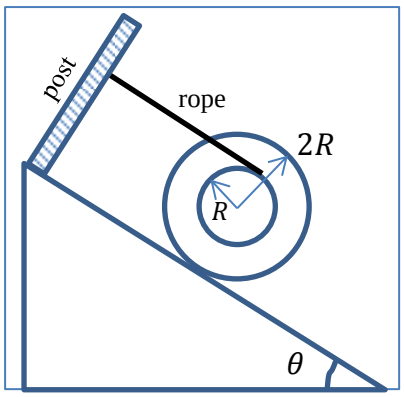
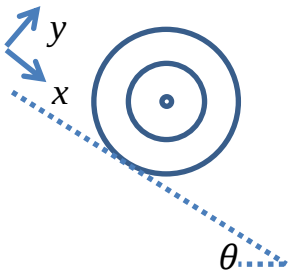
1-(25 points) A yo-yo consists of two coaxial disks each of mass *m* and radius *R* and radius *2R*, respectively (total mass of the yoyo is $2m$). The yoyo is placed on an inclined plane with the static and kinetic friction coefficients $\mu_s = \mu_k = \mu$.A rope is wrapped around the smaller disk and the end of the rope is attached to a fixed post. The rope is always parallel to the inclined plane. When the yo-yo is released from rest, it accelerates. During this motion, the rope unwinds without slipping or loosening. (For a disk: $I_{cm} = \frac{mR^2}{2}$)



a) Indicate the forces acting on the yo-yo on the free-body diagram below and write the dynamics equations for translational and rotational motion of the yo-yo:

Answer here:



$\sum F_x =$

$\sum F_y =$

$\sum \tau_z =$

b) What is the relation between the center of mass linear acceleration and the angular acceleration of the yo-yo?

Answer here:

c) Solve the equations in part a and b to determine the tension on the rope.

d) Find the value of μ for which the yoyo would move with constant speed on the inclined plane.

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

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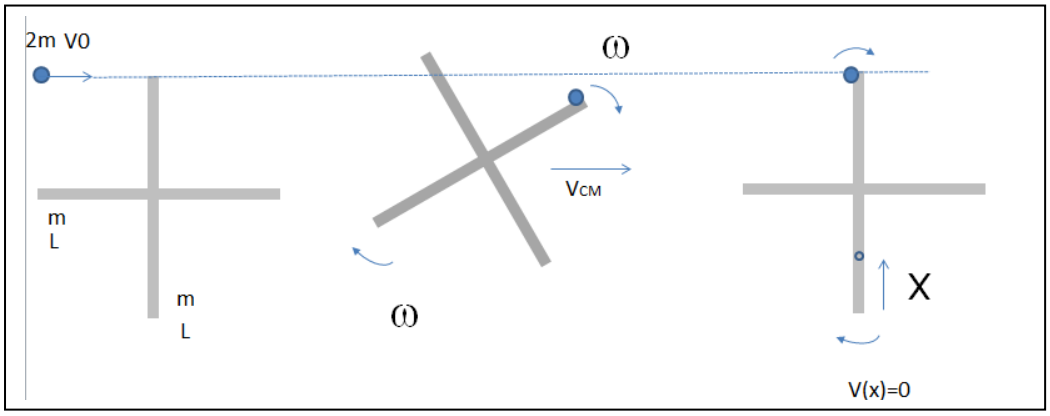
2-(25 points)

A sticky gum of mass 2**m** moves to the right with a speed of **V0**. The gum strikes and sticks to one edge of a stationary rigid shape which consists of two identical rods that are attached perpendicular to one another as shown in Figure. The length and the mass of each rod are **L** and **m** respectively (the total mass of the rods is **2m**). The moment of inertia of a single rod about its center of mass is ($\mathbf{mL^2/12}$)

a) Calculate the center of mass velocity (**Vcm**) of the system (rods and gum together) after the collision.
b) Calculate the total moment of inertia of the system about the new center of mass of the combined rod-gum rigid body.
c) Calculate the angular speed (**w**) of the system after the collision
d) After one turn, there is a specific point on the rod which is instantaneously at rest (total velocity is zero V(x) = 0) See the last Figure. Calculate the position of this point (X) from the edge of that rod.



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

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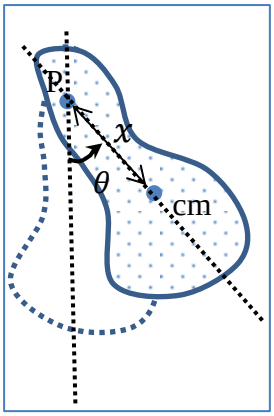
3- (25 points) A physical pendulum of total mass m is suspended from a point P, which is at a distance x from the center of mass. The moment of inertia of the pendulum about its center of mass is I_{cm}. Take gravitational acceleration as g.



a) Derive and formulate the frequency of small oscillations of the physical pendulum about point P in terms of given parameters. (Hint: Suppose that the pendulum is swung by a small angle θ from its vertical equilibrium position as shown in the figure. Then, apply rotational dynamics and use small angle approximations: $\sin\theta \approx \theta, \cos\theta \approx 1$)

b) Determine x for oscillation frequency to be maximum, and find this maximum value of the frequency.

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

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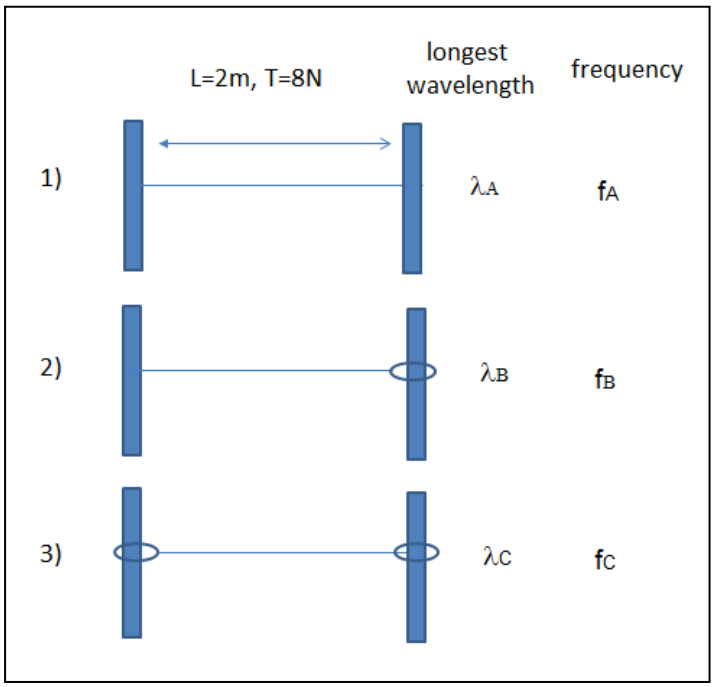
4-(25 points)

A vibrating string **2 m** long is under a tension of **8 N**. The total mass of the string is **4** kg. As shown in figure both ends of the string are attached to the posts in three different configurations; 1) both ends are fixed, 2) only one end is fixed and the other end is free to move in vertical direction, 3) both ends are free to move.

a) Calculate the speed of the waves on the string.
b) Calculate the wavelength of the fundamental mode of the standing wave (n=1, longest wavelength) for each string.
c) Calculate the fundamental frequency of the standing wave (n=1) for each string.



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