Name, Surname:	Signature:
Exam Room:	Student ID Number:

PHYS 102 General Physics I – Final

5 June, 2018 Tuesday 18:15 -19:55

Please read!

- Count to make sure that there are 6 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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Short Questions

1	2	3	4	5	6

Problems

1	2	3	4

TOTAL

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1- SHORT QUESTIONS (5 points each)

1) As you are leaving the classroom the door opens inwards. If the hinges of the door are on your left, what is the direction of the angular velocity of the door (as a vector) as you open it?

a) Up b) Down c) To your right d) To your left e) Backwards

2) A 72.0kg person pulls back a small doorknob with a force 5.00N in a direction perpendicular to the surface of the door. Suppose the doorknob is located 0.80m from the axis of the frictionless hinges of the door. The door begins to rotate with an angular acceleration of 0.50rad/s^2. What is the moment of inertia of the door about the hinges?

a) 2kg–m^2 b) 4kg–m^2 c) 8kg–m^2 d) 12kg–m^2 e) None

3) A uniform solid disk, a uniform hoop (cylindrical shell) and a uniform solid spherical ball, all with same mass M and same radius R are released at the same time at the top of an inclined plane. They roll down without slipping. In what order they reach the bottom of the inclined plane?

a) disk, hoop, sphere b) hoop, sphere, disk c) sphere, disk, hoop d) sphere, hoop, disk
e) hoop, disk, sphere

4) (Rotational kinematics of a computer disk drive) A computer disk drive is turned on from rest and has constant angular acceleration. Suppose it takes 0.61s for the drive to make its second revolution. Then how long did it take to make its first complete revolution?

a) 0.253 s b) 0.305 s c) 0.863 s d) 1.220 s e) None

5) (Designing a propeller) An airplane propeller is 1.73m in length (from tip to tip) with mass 109kg and is rotating at 2500rpm (revolutions per minute) about an axis through its center of mass. You can model this propeller as a slender rod. Suppose that due to weight constraints you have to reduce the propeller's mass to 75% of its original mass. In order to keep the same size and the same kinetic energy, what would be its angular speed has to be (in rpm)?

a) 7500 b) 4335 c) 2880 d) 833 e) None

6) (Gravitational collapse of a super-heavy star) A very heavy star under certain conditions may collapse under its own gravity to a very dense object made mostly of neutrons and called a neutron star. The density of a neutron star is about 10^4 times as great as that of ordinary solid matter found on the Earth. Suppose we describe a neutron star as a uniform solid rigid sphere, both before and after the collapse. Star's initial radius was 9.0×10^5km (which is comparable to the size of our Sun) and its final radius is 16km. If the original star rotated once in 32 days, what will be the rotational frequency (in cycles per second) of the neutron star?

a) 560 b) 1120 c) 1680 d) 2240 e) None

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

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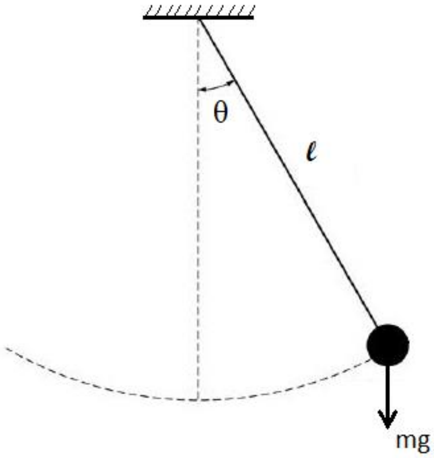
PROBLEMS (20 points each)

Write all the relevant equations and show details of your calculations.

Problem 1 (Rotational Kinematics of a Simple Pendulum) The small oscillations of a simple pendulum are described by the equation

$$\theta(t) = \frac{\pi}{10}\cos\left(\frac{\pi}{2}t + \pi\right).$$



(i) What is the maximum angular displacement?(in degrees)
(ii) What is the period of oscillations?(in seconds)
(iii) Take g = 10m/s^2. Find the length of the pendulum.
(iv) Find the maximum tangential speed of the pendulum.
(v) If m = 0.5kg, determine the total energy of the pendulum (in Joules).

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

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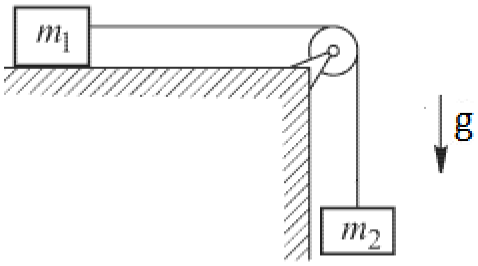

Problem 2 Two blocks of masses m_1 = 3.00kg and m_2 = 2.00kg are connected by a light, flexible but non-strechable string that passes over a pulley that is free to rotate about its axis. The moment of inertia of the pulley

I = 0.0040kg–m^2 and the radius of the pulley

R = 5cm. The block of mass m_1 rests on a horizontal tabletop whose coefficient of kinetic friction is given by μ_k = 0.3. The second block m_2 hangs vertically at the other end of the string. Take the gravitational acceleration g = 10m/s^2 and suppose that the blocks are released from rest.

(i) Find the angular acceleration of the pulley?

(ii) What will be the speed of the block on the tabletop after it moved over a distance of 60cm?

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

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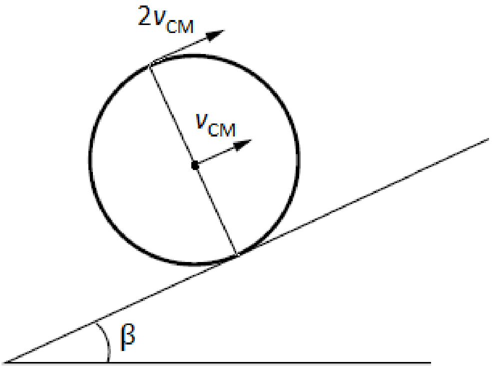
Problem 3 (A ball rolling without slipping up an inclined plane)

A bowling ball rolls without slipping up a ramp that slopes upwards at an angle β to the horizontal. Treat the ball as a uniform solid rigid sphere of mass M and radius R (ignoring the finger holes).



(i) Draw the free-body force diagram for the ball. (Explain why the friction force must be directed upwards?)

(ii) What is the acceleration of the center of mass of the ball?

(iii) What should the minimum value of the static friction coefficient μ_s be to prevent slipping?

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

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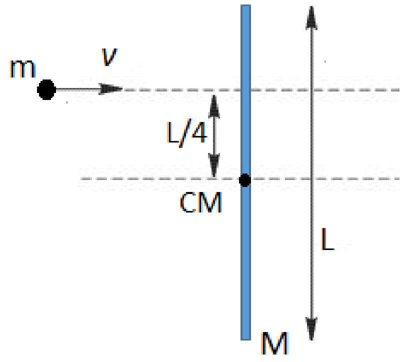
Problem 4 A thin straight rod of mass M and length L rests on an icy (frictionless) horizontal surface. It is struck at a point L/4 away from its center of mass by a hockey puck of mass m moving at a speed v from left to right along a straight line that is orthogonal to the rod. After the collision puck recoils back at half the speed $v/2$ while the rod starts to move to the right, rotating about its center of mass as it moves. (Moment of inertia of the rod about its center of mass $I = \frac{1}{12}ML^2$.)



(i) Determine the velocity of the center of mass of the rod after the collision.

(ii) Determine the angular velocity of the rod about its center of mass after the collision.

(iii) Find the change in the energy of the system during the collision.

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