Physics 218 – Exam III

Fall 2017 (all sections) **November 15$^{\text{th}}$, 2017**

Please fill out the information and read the instructions below, but **do not open the exam** until told to do so.

Rules of the exam:

1. You have 90 minutes (1.5 hrs) to complete the exam.
2. Formulae are provided to you with the exam on a separate sheet. Make sure you have one before the exam starts. You may *not* use any other formula sheet.
3. Check to see that there are 6 numbered (three double-sided) pages in addition to the scantron-like cover page. **Do not remove any pages**.
4. If you run out of space for a given problem, ask the proctor for an extra sheet of paper. Be sure to indicate *at the problem under consideration* that the extra space is being utilized so the graders know to look at it!
5. Calculators of any type are **not allowed**. Ensure that all your answers are in terms of the known variables given in the question.
6. Cell phone use during the exam is strictly prohibited. Please turn off all ringers as calls during an exam can be quite distracting.
7. Be sure to put a box around your $\boxed{\text{final answer(s)}}$ and clearly indicate your work. Credit can be given **only** if your work is legible, clearly explained, and labelled.
8. All of the questions require you show your work and reasoning.
9. Have your TAMU ID ready when submitting your exam to the proctor.

Fill out the information below and sign to indicate your understanding of the above rules

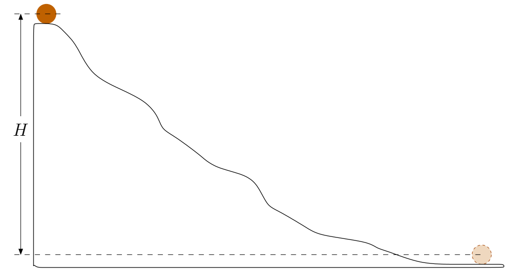
Name: ______________________________ UIN: ______________________________
(printed *legibly*)

Signature: ______________________________ Section Number: ____________________

Instructor (circle one): Akimov Dierker Melconian

Short Problems:

A) A basketball, which one can approximate as a thin-walled hollow sphere of unknown mass and radius, starts from rest before rolling down a hill of height H. No mechanical energy is lost due to friction, and the ball rolls without slipping throughout the motion. What is the centre-of-mass velocity of the ball when it reaches the bottom of the hill?



LO	S	U
3.1		
34.1		
35.1		
38.1		
40.1		
51.1		

B) Consider the thin-walled hollow cylinder shown below which has a moment of inertia about its centre of mass $I_{\text{CM}} = \frac{1}{2}M(R_1^2 + R_2^2)$. On the right side of the figure, three different axes of rotation are shown, all parallel to the axis through the centre-of-mass shown on the left: A is on the inner radius, B is to the left of centre by R_1 and below the centre by R_2, and C is on the outer surface of the cylinder. Determine which of the following moments of inertia correspond to each of the axes of rotation by writing $\boxed{A}$, $\boxed{B}$ and $\boxed{C}$ next to the correct expression.

$\frac{3}{2}M(R_1^2 + R_2^2)$

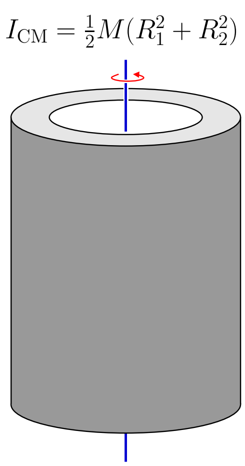
$M(\frac{3}{2}R_1^2 + \frac{1}{2}R_2^2)$

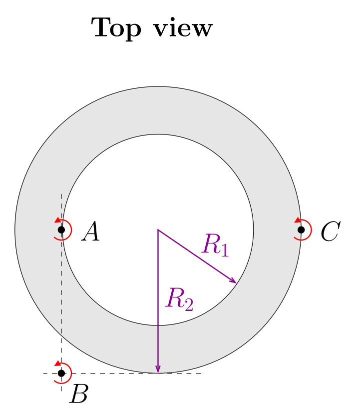
$M(\frac{1}{2}R_1^2 + \frac{3}{2}R_2^2)$

$\frac{5}{2}M(R_1^2 + R_2^2)$

$M(\frac{5}{2}R_1^2 + \frac{3}{2}R_2^2)$

$M(\frac{3}{2}R_1^2 + \frac{5}{2}R_2^2)$





LO	S	U
52.1		
52.2		
52.3		

C) Alice of mass $M_A = 60$ kg and Bob of mass $M_B = 80$ kg are standing on the frictionless ice surface at Spirit Ice Arena. They pushed off each other and observed that Bob was moving at $+2\hat{\imath}$ m/s after the push. Treat Alice and Bob as point-like particles (*i.e.* there is no rotation). For this problem, we expect numerical answers.

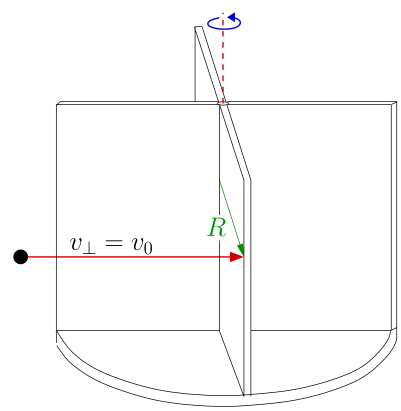
(a) Remembering what she learned in `PHYS 218`, what speed did Alice calculate she was moving at?

(b) What impulse was imparted to Alice, and what impulse was imparted to Bob? (Make sure the relative sign of these two vectors is correct).

LO	S	U
3.2		
46.1		
46.2		
48.1		
49.1		
49.2		

D) A windmill of sorts is made up of a solid uniform disk of mass M and radius R, upon which four flaps of mass m and width R are mounted as shown. The system is free to rotate around a frictionless axis through the centre.

(a) What is the moment of inertia of this object?



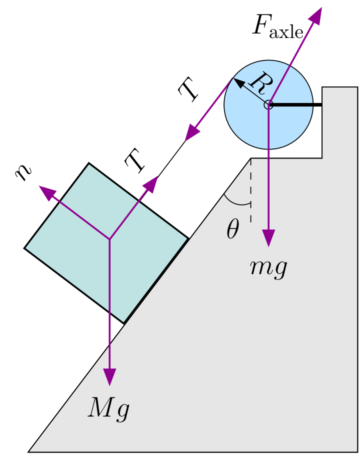
(b) A ball of mass m is thrown horizontally and hits the very edge of one of the flaps with a speed v_0 and bounces in exactly the opposite direction with a speed v_f. What is the angular speed of the windmill after the collision?

LO	S	U
51.2		
51.3		
53.1		
3.3		
57.1		
57.2		
59.1		

Prob 1 A block of mass $M = 5$ kg is at rest on a smooth frictionless surface which makes an angle $\theta = 53.1°$ as shown. The block is attached to a solid uniform cylinder of mass $m = 2$ kg and radius $R = 100$ cm via a massless cord which is wound around the spool many times. There is no friction between the spool and its axle. For this problem, take $g = 10$ m/s^2 and note that $\sin 53.1° = 4/5$ and $\cos 53.1° = 3/5$. For part (b) of this problem, we expect a numerical result.

(a) The figure shows all of the forces acting on the spool and block.

- For the **spool**: draw your positive sense of rotation about the spool's axle in the figure.
- For the **block**: define your coordinate system by drawing it on the figure, and break up any forces acting on the block into components along those axes (sketching it on the figure and labelling its magnitude in terms of known variables).



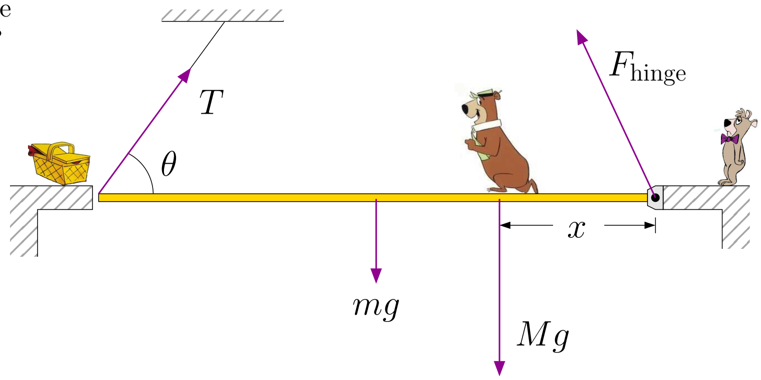
(b) The block is released from rest. Find the angular acceleration of spool.

LO	S	U
1.1		
9.1		
9.2		
4.1		
10.1		
21.1		
51.4		
54.1		
55.1		

Prob 2 A hungry Yogi Bear (mass M) found a picnic basket across a deep ravine. He crosses a uniform beam of length L and mass m to reach his treats. One side of the beam is supported by strong hinge providing an unknown force $\vec{F}_{\text{hinge}}$ and the other by a cable as shown.

(a) The figure shows all of the forces acting on the beam. Draw your positive sense of rotation about the axle of the hinge in the figure, define your $\hat{\imath}$ and $\hat{\jmath}$ coordinate system and, for any forces not already along those axes (except $\vec{F}_{\text{hinge}}$), draw and label with known variables (m, M, g, L and θ) the components along those axes on the figure.

(b) What is the magnitude of the tension in the cable when Yogi is a distance $x = \frac{1}{4}L$ from the hinge?



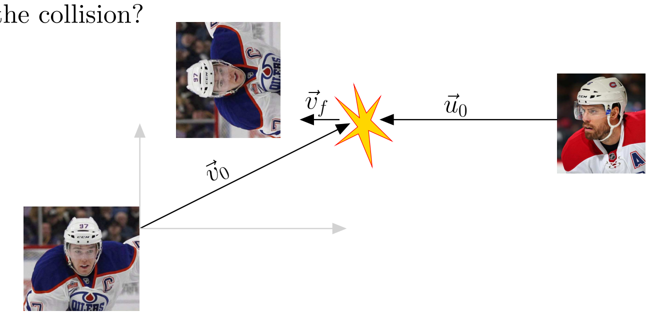
(c) What is the moment of inertia of the beam+Yogi about the axis of rotation defined by the hinge on the right side of the beam when Yogi is at the end ($x = L$)?

(d) Just as Yogi reached the other end of the beam at $x = L$, the cable broke. What was the magnitude of the initial angular acceleration of the beam?

LO	S	U
1.2		
9.3		
9.4		
3.4		
54.2		
54.3		
54.4		
55.2		
53.2		
3.5		
54.5		
55.3		

Prob 3 Speedy Connor McDavid of mass M was skating up the ice to try and get past big Shea Weber (who has mass $\frac{4}{3}M$) for a breakaway. As McDavid skated with a velocity $\vec{v}_0 = v_{0,x}\hat{\imath} + v_{0,y}\hat{\jmath}$, Weber suddenly moved toward him with a velocity $\vec{u}_0 = -u_{0,x}\hat{\imath}$. The two collided and the instant replay showed poor McDavid getting crushed in this inelastic collision, resulting in his sliding backwards on the frictionless ice with a velocity $\vec{v}_f = -\frac{1}{10}v_{0,x}\hat{\imath}$ as Weber went off in an different direction.

(a) What were the initial momenta of the two skaters prior to the collision?



(b) What impulse did Weber impart to McDavid during the collision?

(c) What were the $\hat{\imath}$ and $\hat{\jmath}$ components of Weber's final velocity, $\vec{u}_f$, after the collision?

LO	S	U
46.3		
46.4		
46.5		
49.3		
3.6		
3.7		
48.2		
48.3		