# Physics 218 – Exam III

**Spring 2018 (all UP sections)  April 16$^{th}$, 2018**

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 4 short ($A$, $B$, $C$ and $D$) and 3 long problems (1–3) on four 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, the last page has been left blank and may be used for extra space. 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**. In the case of questions with numerical values, the math should be simple enough you will not need a calculator. For purely symbolic questions, 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. Unless explicitly stated in the problem, all of the questions require you show your work and reasoning.
9. Have your TAMU ID ready when submitting your exam to the proctor.
10. For **any** numerical questions involving the acceleration due to gravity, instead of 9.8 m/s$^2$ take $\boldsymbol{g = 10}$ **m/s$^2$**.

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)

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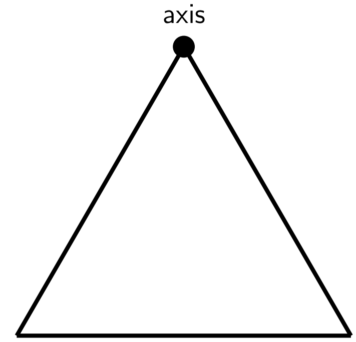
|---|---|---|---|---|
| Akimov | Dierker | Ko | Kocharovsky | Lyuksyutov |
| Mahapatra | Mioduszewski | Ross | Royston | Wu |

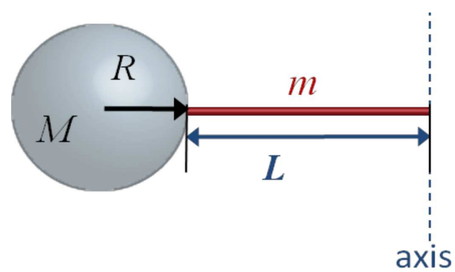
## Short Problems:

A) Calculate the moment of inertia for the following cases.

(a) A piece of thin uniform wire of mass $3m$ and length $3b$ is bent into an equilateral triangle. Find the moment of inertia of the wire triangle about an axis perpendicular to the plane of the triangle and passing through one of its vertices. (You do not need to simplify the expression.)



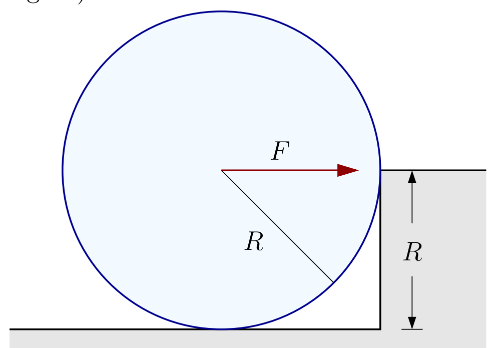

(b) An object consists of a solid ball of mass $M$ and radius $R$ connected to a rod of mass $m$ and length $L$, as shown in the figure. Find the moment of inertia of this object about the axis drawn at the end of the rod.




| LO | S | U |
|---|---|---|
| 51.1 | | |
| 52.1 | | |
| 52.2 | | |
| 53.1 | | |
| 53.2 | | |
| 51.2 | | |
| 51.3 | | |
| 52.3 | | |
| 53.3 | | |

B) You are trying to raise a bicycle wheel of mass $m$ and radius $R$ up over a curb of height $R$. To do this, you apply a horizontal force $F$. Determine whether it is possible to raise the wheel onto the curb in the following two cases below. If it is not possible, explain why not. If it is possible, calculate the magnitude of force $F$ required to raise the wheel. (Hints: Take the axis of rotation to be the corner of the curb in contact with the wheel and realize that if the wheel is successfully raised, there is no more contact with the floor).

(a) The force $F$ is applied at the center of the wheel (as is shown in the figure).

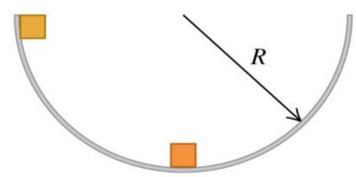



(b) The force $F$ is applied in the same direction but at the top of the wheel.

| LO | S | U |
|---|---|---|
| 54.1 | | |
| 55.1 | | |
| 54.2 | | |
| 55.2 | | |

C) What is conserved in the following cases (linear momentum, angular momentum about an axis, mechanical energy, kinetic energy, none of these)? There may be more than one conserved quantity. For this question, you do not have to show your reasoning.

(a) Two masses are released from rest, from the positions shown in the figure, in a frictionless hemispherical bowl. The masses collide and stick together. (Note that the circular motion is characterized simultaneously by the linear and angular momenta.)



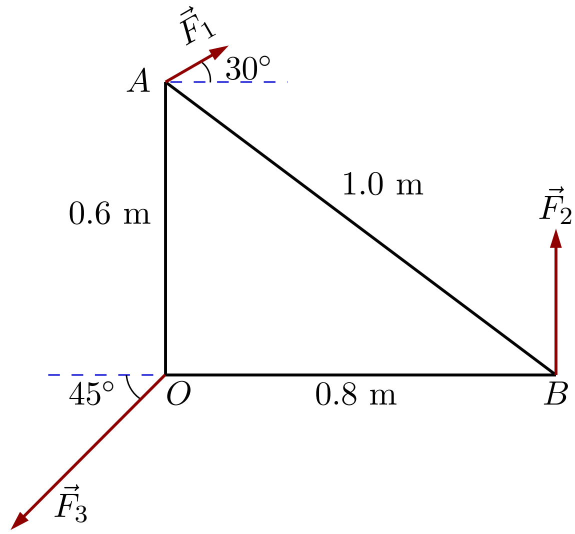

i. What is conserved during the collision?

ii. What is conserved in the motion after the collision?

(b) A uniform rod rests on a frictionless horizontal surface. The rod pivots about a fixed, vertical frictionless axis at one end. The rod is initially at rest. A bullet traveling parallel to the horizontal surface and perpendicular to the rod strikes the rod at its center and becomes embedded in it. What is conserved for the bullet-rod system during the collision?

| LO | S | U |
|---|---|---|
| 39.3 | | |
| 40.1 | | |
| 40.2 | | |
| 48.1 | | |
| 48.2 | | |
| 50.1 | | |
| 59.1 | | |
| 59.2 | | |
| 40.3 | | |
| 48.3 | | |
| 50.2 | | |
| 59.3 | | |

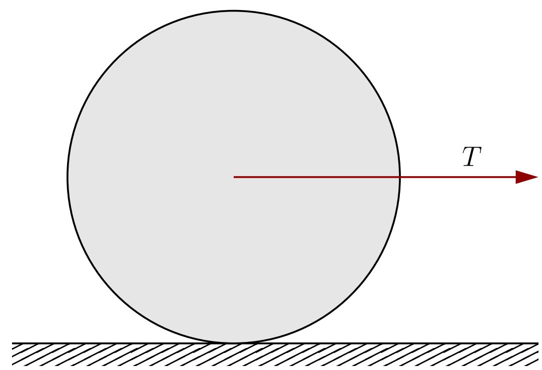
D) A light triangular plate $OAB$ is in a horizontal plane. Three forces, $\vec{F}_1$, $\vec{F}_2$, and $\vec{F}_3$ act on the plate (in the plane of the triangular plate), which is pivoted about a vertical (perpendicular to the plate $OAB$) axis through point $O$. In the figure, $\vec{F}_2$ is perpendicular to $OB$. Consider the counterclockwise sense of rotation as positive. Calculate the sum of the torques about the vertical axis directed out of the plane $OAB$ through the point $O$, acting on the plate due to forces $F_1 = 1$ N, $F_2 = 2$ N, and $F_3 = 3$ N.




| LO | S | U |
|---|---|---|
| 2.1 | | |
| 2.2 | | |
| 2.3 | | |
| 2.4 | | |
| 54.3 | | |
| 54.4 | | |
| 54.5 | | |

**Prob 1** A uniform solid sphere is being pulled horizontally by a string, pulling with force $T$, applied to an axle through the center of the sphere, as shown in the figure. The sphere has radius $r$ and mass $m$, and rolls without slipping.

(a) Plot a free-body diagram for the sphere. Clearly indicate on your diagram the point where each force is applied.

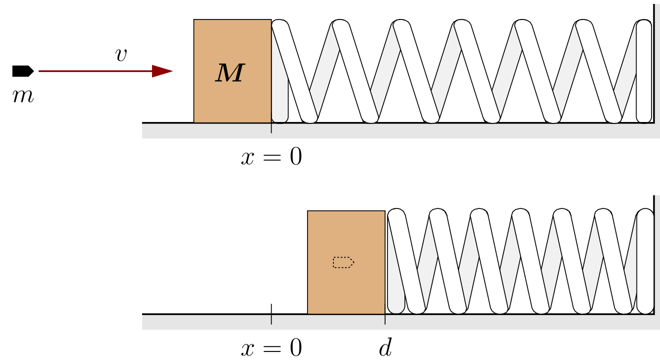



(b) Calculate the magnitude of the friction force on the sphere (in terms of $T$).

| LO | S | U |
|---|---|---|
| 23.1 | | |
| 24.1 | | |
| 26.1 | | |
| 27.1 | | |
| 4.1 | | |
| 6.1 | | |
| 21.1 | | |
| 51.4 | | |
| 55.3 | | |

**Prob 2** A wooden block of mass $M$ is attached to a very light horizontal spring of force constant $k$ and is resting on a horizontal table with a coefficient of kinetic friction $\mu_k$. The other end of the spring is attached to a wall. A bullet of mass $m$ is fired horizontally into the block and gets stuck in it. The maximum distance that the block compressed the spring after the collision is $d$.

(a) Is the collision between the bullet and the block elastic? Is the total momentum in this collision conserved?

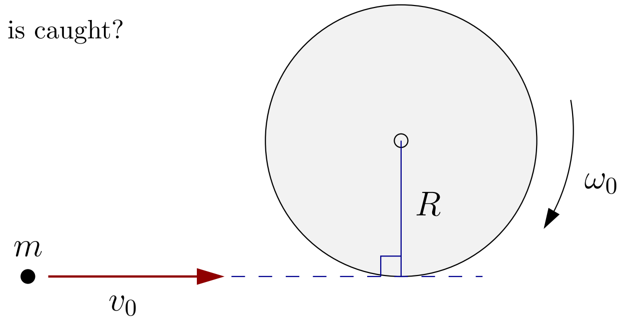



(b) Find the speed of the bullet before its collision with the block. Answer in terms of the given quantities $m$, $M$, $k$, $d$, $\mu_k$, and the acceleration due to gravity $g$.

| LO | S | U |
|---|---|---|
| 48.4 | | |
| 50.3 | | |
| 4.2 | | |
| 26.2 | | |
| 28.1 | | |
| 32.1 | | |
| 34.1 | | |
| 34.2 | | |
| 38.1 | | |
| 39.1 | | |
| 39.2 | | |
| 48.5 | | |

**Prob 3** A turntable has a radius of $R$ and a moment of inertia of $I$. The turntable is rotating with an angular velocity of $\omega_0$ about a vertical axis though its center on frictionless bearings, as shown in the figure. A very small ball (can be considered point-like) of mass $m$ is projected horizontally toward the outer edge of the turntable, with a velocity $v_0$. The rim of the turntable is covered with Velcro, and the ball sticks to it.

(a) What is the angular speed of the turntable just after the ball is caught?




(b) Calculate the kinetic energy of the system (i) before and (ii) after the collision.

i. Before:

ii. After:

| LO | S | U |
|---|---|---|
| 3.1 | | |
| 53.4 | | |
| 57.1 | | |
| 57.2 | | |
| 57.3 | | |
| 59.4 | | |
| 34.3 | | |
| 35.1 | | |
| 35.2 | | |

**Extra space:**