# Physics 218 – Exam III

## Fall 2018 (all UP sections)     November 14$^{\text{th}}$, 2018

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

<u>Rules of the exam</u>:

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 8 numbered (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 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 otherwise in the question, all of the free-response problems in this exam require you show your work and reasoning. You do **not** need to show your work for the multiple-choice problems.

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:        Kocharovsky          Melconian
(circle one)

## Short Problems:

A) Jacques and George meet in the middle of a lake while paddling in their canoes. They come to a complete stop and talk for a while. When they are ready to leave, Jacques pushes George's canoe with a force $\vec{F}$ to separate the two canoes. Which of the following is/are correct statements about the final momentum and kinetic energy of the system of the two canoes with Jacques and George in them if we can neglect any resistance due to the water? There may be more than one that is true.

   ($i$) The final momentum is zero, and the final kinetic energy is positive.

   ($ii$) The final momentum is in the direction of $\vec{F}$, and the final kinetic energy is positive.

   ($iii$) The final momentum is in the direction of $\vec{F}$, and the final kinetic energy is zero.

   ($iv$) The final momentum is in the direction opposite of $\vec{F}$, and the final kinetic energy is zero.

   ($v$) The final momentum is zero, and the final kinetic energy is zero.

| LO | S | U |
|------|---|---|
| 34.1 |   |   |
| 45.1 |   |   |
| 48.1 |   |   |

B) In each of the cases depicted by the following figures, the body can be in rotational equilibrium, translational equilibrium, both translational and rotational equilibrium, or not in equilibrium in either case. If the body is in rotational equilibrium, circle the R below it, and if it isn't cross it out. If the body is in translational equilibrium, circle the T and if it isn't in equilibrium cross it out. In each of the figures, the point $A$ marks the position of the body's centre-of-mass.
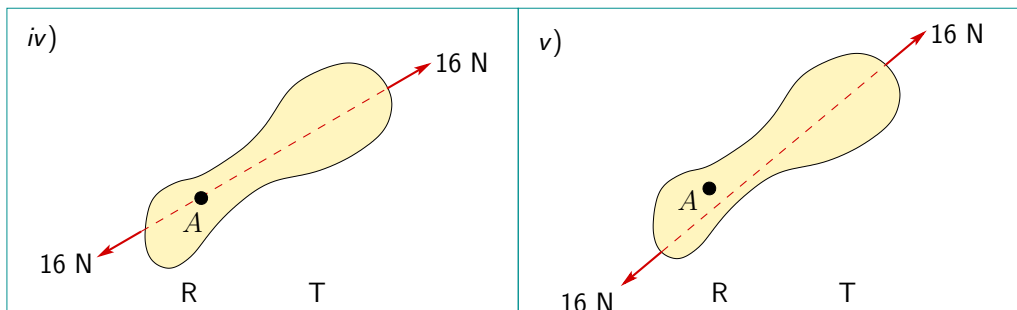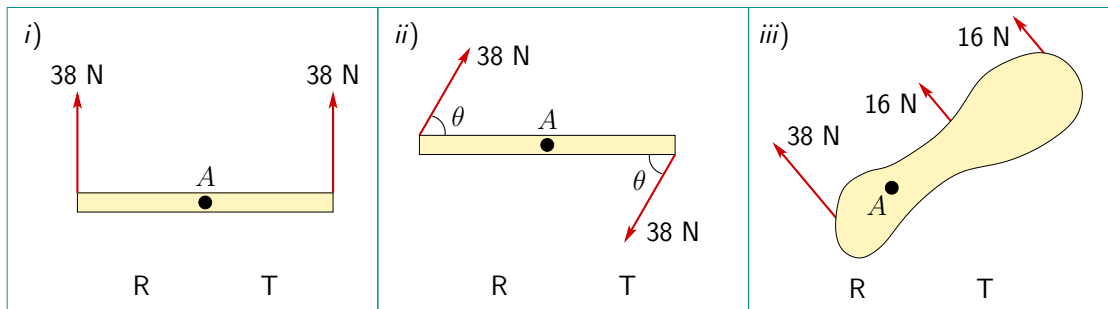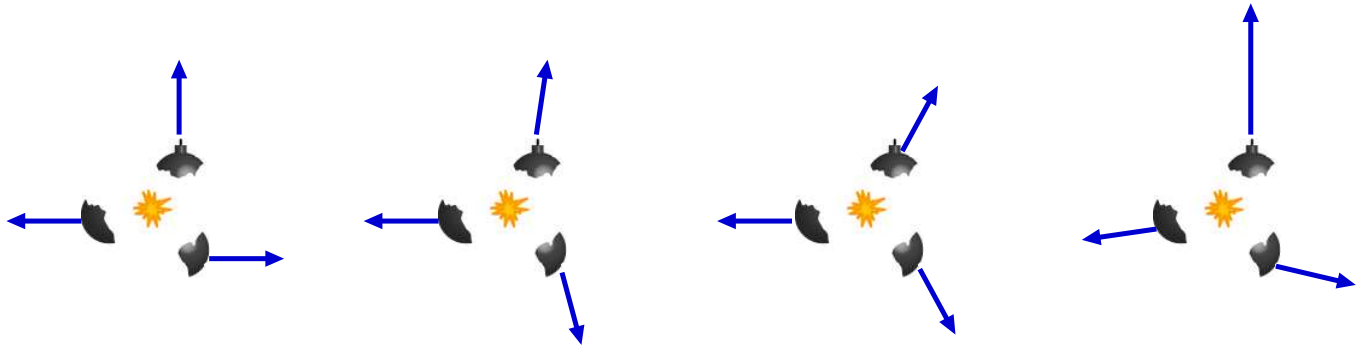


| LO | S | U |
|------|---|---|
| 31.1 |   |   |
| 31.2 |   |   |
| 31.3 |   |   |
| 31.4 |   |   |
| 31.5 |   |   |

C) A block and a ball have the same mass and are moving with the same initial centre-of-mass velocity across a floor before encountering identical ramps. The block slides without friction and the ball rolls without slipping. Mark all of the following statements that are true (there are more than one).

(i) The block has more kinetic energy than the ball before encountering the ramp.

(ii) The ball has more kinetic energy than the block before encountering the ramp.

(iii) The block and ball both have the same kinetic energy before encountering the ramp.

(iv) The block will make it farther up the ramp than the ball.

(v) The ball will make it farther up the ramp than the block.

(vi) The block and ball will both reach the same vertical height.

(vii) The ball will make it farther up the ramp if the ramp is completely frictionless and the ball slips once it encounters the ramp.

(viii) The ball will make it to the same vertical height whether or not it slips after encountering the ramp.

(ix) The ball will not make it as far up the ramp if the ramp is completely frictionless and the ball slips once it encounters the ramp.

| LO | S | U |
|---|---|---|
| 34.2 | | |
| 35.1 | | |
| 35.2 | | |
| 40.1 | | |
| 35.3 | | |
| 40.2 | | |

D) A bomb which is initially at rest in outer space explodes into 3 pieces of identical mass. Which of the following configurations of the final velocities is/are possible (there may be more than one)? Circle the possible ones and cross out the impossible ones.



| LO | S | U |
|---|---|---|
| 2.1 | | |
| 2.2 | | |
| 45.2 | | |
| 46.1 | | |
| 48.2 | | |

**Prob 1** A uniform ladder of length $L$ and mass $M$ leans in equilibrium against a frictionless, vertical wall. The bottom of the ladder rests on the rough (*not* frictionless) ground at a distance $D$ from the wall as shown. Let the horizontal axis through this point be the axis of rotation in what follows.

(a) Choose a coordinate system, define your positive senses of direction and rotation, turn the drawing into a free-body diagram for the ladder, and name/label all the forces acting on the ladder.

(b) Write down the conditions (equations) for the translational (both vertical and horizontal) and rotation equilibrium of the ladder.

(c) Use the rotational equilibrium condition to determine the force that the wall exerts on the ladder in terms of $M$, $L$, $D$ and the acceleration due to gravity, $g$.
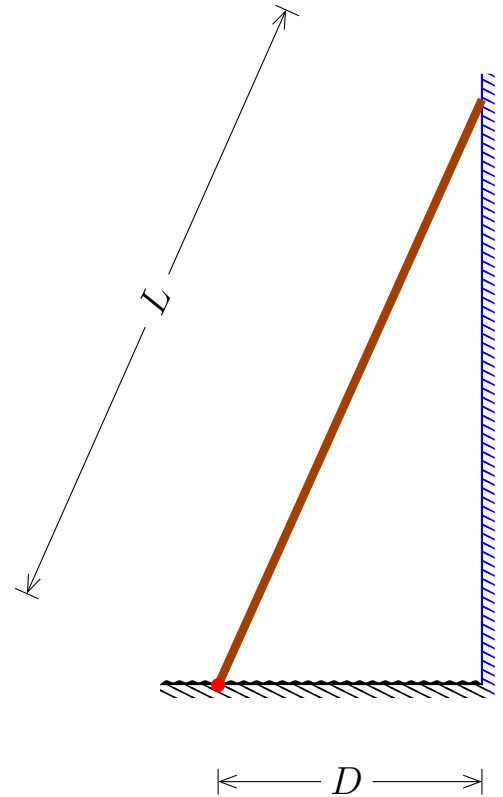


Ans: _____

(d) Use the translational equilibrium conditions to determine the force of friction and the normal force of the floor on the ladder, again in terms of $M$, $L$, $D$ and the acceleration due to gravity, $g$. If you didn't get part (c), take the force from the wall to be $n_{\text{wall}}$.

Ans: _____

_____

| LO | S | U |
|------|---|---|
| 9.1 | | |
| 23.1 | | |
| 26.1 | | |
| 26.2 | | |
| 29.1 | | |
| 45.3 | | |
| 21.1 | | |
| 21.2 | | |
| 55.1 | | |
| 1.1 | | |
| 1.2 | | |
| 3.1 | | |
| 54.1 | | |
| 54.2 | | |
| 3.2 | | |
| 3.3 | | |

**Prob 2** A 9.0-kg block is attached to a very light horizontal spring of force constant 5 N/cm and is resting on a frictionless horizontal table. (See the figure below.) Suddenly it is struck by a 3.0 kg steel ball-bearing traveling horizontally at 6.0 m/s to the right, whereupon the ball-bearing rebounds at 3.0 m/s horizontally to the left.

(a) What is the speed of the block just after the collision? Assume it has not moved at all during the short collision.

3 kg  →  6 m/s   9 kg
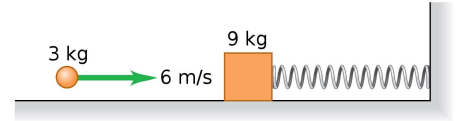
Ans: _____

(b) Describe in a few words what makes a collision "elastic" versus "inelastic." Determine quantitatively which type of collision this was

Ans: _____

(c) What is the spring constant in N/m?

Ans: _____

(d) Find the maximum distance that the block will compress the spring after the collision. Your answer should be left as the square-root of a simple fraction; you are *not* expected to evaluate it beyond this.

| LO | S | U |
|------|---|---|
| 46.2 | | |
| 46.3 | | |
| 46.4 | | |
| 48.3 | | |
| 34.3 | | |
| 34.4 | | |
| 50.1 | | |
| 50.2 | | |
| 50.3 | | |
| 10.1 | | |
| 3.4 | | |
| 34.5 | | |
| 38.1 | | |
| 40.3 | | |

Ans: _____

**Prob 3** A certain rock is very close to being a solid, uniform sphere with a radius of $R$. It is sitting at a height $H$ at the top of a hill overlooking a valley as shown to the right.

(a) The terrain is rough enough to cause the rock to roll down most of the mountainside without slipping (but not enough that any energy is lost). What is the translational speed of the rock when it reaches the valley at the bottom of the hill?
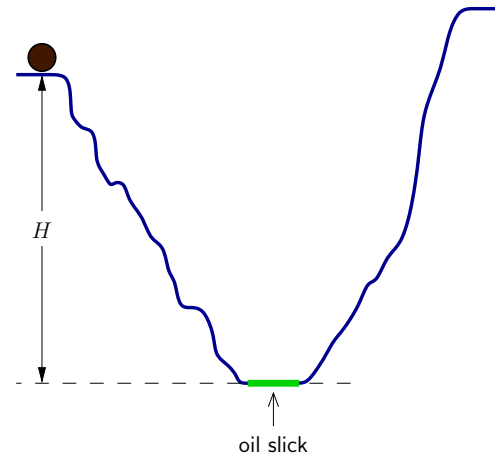


oil slick

Ans: _____

(b) At the bottom of the hill the rock hits an oil slick which removes all friction for the rest of its entire motion. How high up the other side of the valley will the rock go before stopping and sliding back down?

| LO | S | U |
|------|---|---|
| 4.1 | | |
| 16.1 | | |
| 34.6 | | |
| 35.4 | | |
| 38.2 | | |
| 40.4 | | |
| 51.1 | | |
| 3.5 | | |
| 34.7 | | |
| 35.5 | | |
| 38.3 | | |
| 40.5 | | |

Ans: _____

**Prob 4** You are tasked with designing a unique fire escape from a building. Above the escape window, you mount a flywheel (a uniform solid cylinder of undetermined mass and radius) with a rope which has a handle on the end of it wrapped around the flywheel many times. With this system, you want a person of mass $m$ that grabs on to be guided to the ground with a reduced acceleration, $a$. Assume that air resistance and any friction between the flywheel and its axle are negligible.

flywheel

(a) To the right of the figure, draw one free-body diagram for the flywheel and another for the person as they are descending to the ground. Don't forget to define your axes and positive senses of direction and rotation.

(b) Find an expression relating the tension in the rope with the acceleration of the person.

Ans: _____

(c) Find an expression relating the tension in the rope with the angular acceleration of the flywheel, assuming the flywheel will have a mass $M$ and radius $R$.

Ans: _____

(d) Since the rope is wound many times, it can't slip. Using your results above, determine what the mass, $M$, of the flywheel should be (in terms of the person's mass, $m$) so that the person does not descend too quickly, *i.e.* so that $a = \frac{1}{4}g$ or less.

| LO | S | U |
|------|---|---|
| 9.2 | | |
| 22.1 | | |
| 23.2 | | |
| 23.3 | | |
| 24.1 | | |
| 30.1 | | |
| 3.6 | | |
| 21.3 | | |
| 3.7 | | |
| 51.2 | | |
| 54.3 | | |
| 55.2 | | |
| 4.2 | | |
| 16.2 | | |
| 17.1 | | |

Ans: _____

**Extra space:**