Physics 218 – Exam I

Spring 2018 (all UP sections) February 19$^{\text{th}}$, 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. **Please note there are a number of corrections to this exam listed on the 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 $\boxed{\text{final answer(s)}}$ 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 Ko Kocharovsky Lyuksyutov

Mahapatra Mioduszewski Royston Wu

Short Problems:

A) Two objects are thrown from the top of a tall building and experience no appreciable air resistance. One is thrown directly upwards, and the other is thrown directly downwards, both with the same initial speed. Which ball will be moving faster when it hits the ground? Briefly explain your reasoning.

LO	S	U
13.1		
14.1		
15.1		

B) Alice is walking at a constant velocity $\vec{v}_A = (3\hat{\imath} - \hat{\jmath})$ m/s. Take $\hat{\jmath}$ to be north, and $\hat{\imath}$ to be east.

(a) Draw a coordinate system, and draw Alice's velocity vector on it.

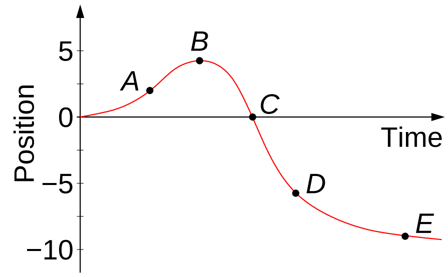
(b) Bob's velocity is $\vec{v}_B = (x\hat{\imath} + \hat{\jmath})$ m/s. What value of x, if any, makes Bob's direction of motion perpendicular to Alice's? If there is no x which satisfies this, briefly explain your reasoning. You do <u>not</u> need to draw Bob's velocity.

(c) Say instead Bob's velocity is $\vec{v}_B = (x^2\hat{\imath} - 3\hat{\jmath})$ m/s. What value of x, if any, makes Bob's direction parallel to Alice's? If there is no x which satisfies this, briefly explain your reasoning.

(d) Lastly, say Bob's velocity is $\vec{v}_B = (-x^2\hat{\imath} - \hat{\jmath})$ m/s. What value of x, if any, makes Bob's direction anti-parallel to Alice's? If there is no x which satisfies this, briefly explain your reasoning.

LO	S	U
9.1		
2.1		
3.1		
6.1		
2.2		
2.3		

C) The graph in the figure shows the position of an object as a function of time. The letters $A - E$ represent particular postions along the particle's trajectory.



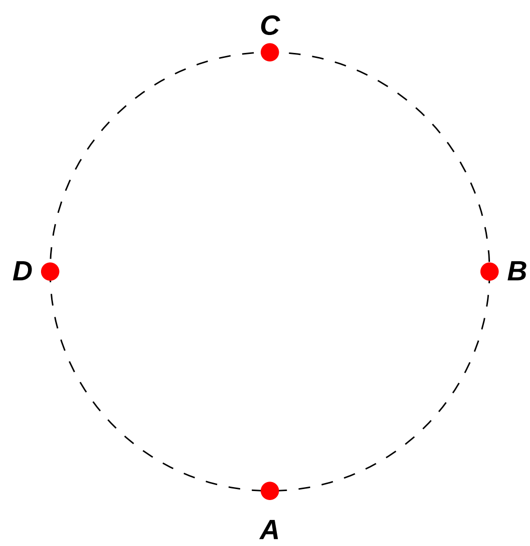
(a) Which of the labelled points (A, B, etc.) corresponds to when the speed of the object is the greatest?

(b) Which of the labelled points (A, B, etc.) corresponds to when the speed of the object is the smallest?

(c) At the point labelled C, is the velocity positive or negative? Briefly explain your reasoning so we know you didn't simply guess.

LO	S	U
12.1		
12.2		
13.2		

D) Consider a centrifuge for the astronauts at the NASA center which allows an astronaut to experience non-uniform circular motion in a horizontal plane. Suppose the astronaut starts at the point A and makes one full revolution speeding up for the first half (the semicircle $A \to B \to C$) and slowing down for the second half (semicircle $C \to D \to A$). Draw the instantaneous acceleration vectors at the points B and D of the astronaut's path, clearly indicating their directions and illustrating their decomposition into radial and tangential components.



LO	S	U
13.3		
13.4		
17.1		
17.2		
18.1		
18.2		

Prob 1 A bicyclist made a full circle on a track of radius $30/\pi$ km in 1 hour and 40 minutes with constant speed. Calculate, in the SI system of units, each of the following:

(a) the average speed.

(b) the average velocity.

(c) the magnitude of his radial acceleration.

(d) the magnitude of his parallel (*i.e.* tangential) acceleration.

(e) the number of revolutions the bicyclist makes in a time of 10 hours.

LO	S	U
10.1		
10.2		
11.1		
16.1		
11.2		
16.2		
10.3		
18.3		
17.3		
10.4		
16.3		

Prob 2 A drone flies between two points on the ground that are 36 km apart. The destination is directly north of where the drone began its flight. The drone flies with an air speed of $10\sqrt{2}$ m/s. A weather station informs you that there is a constant wind blowing at 10 m/s due west during the flight.

(a) What direction must the drone fly, relative to north, to arrive at the destination? Draw a coordinate system labeling your axes and illustrate your velocity vector equation by drawing the relevant velocities.

(b) What is the velocity of the ground relative to the wind?

(c) How long would it take to reach the destination?

LO	S	U
1.1		
3.2		
6.2		
9.2		
20.1		
20.2		
1.2		
10.5		
11.3		

Prob 3 A bird is flying in a horizontal plane where $\hat{\imath}$ is pointed east, and $\hat{\jmath}$ is pointed north. The trajectory of the bird is given by $\vec{r}(t) = \alpha t^3 \hat{\imath} + (\beta t - \gamma t^2)\hat{\jmath}$, where $\alpha = 1$ m/s^3, $\beta = 6$ m/s, and $\gamma = 3$ m/s^2.

(a) What is the position of the bird at $t = 1$ s?

(b) What is the velocity of the bird at $t = 1$ s?

(c) What is the acceleration of the bird at $t = 1$ s? Is this acceleration constant in time?

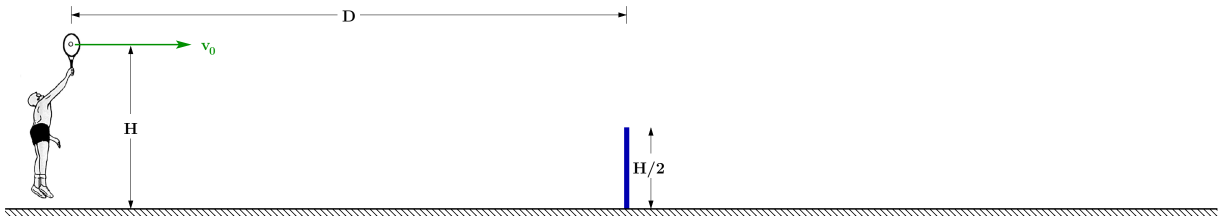
(d) Is the bird speeding up or slowing down at $t = 1$ s? Briefly explain your reasoning.

(e) Is the bird turning to its left, to its right, or heading straight forward at $t = 1$ s? Briefly explain your reasoning.

(f) At $t = 2$ s, the bird changes course and its new velocity is $\vec{v}(t) = \delta t^{-1}\hat{\imath} + \omega t^7 \hat{\jmath}$, where $\delta = 3$ m and $\omega = 5$ m/s^8. What is the acceleration as a function of time after $t = 2$ s?

LO	S	U
12.3		
8.1		
12.4		
8.2		
12.5		
15.2		
13.5		
17.4		
13.6		
18.4		
8.3		

Prob 4 A tennis player stands at a distance D from the net and serves the ball with an initial velocity which has an unknown speed v_0, but the direction is known to be horizontal, as shown in the diagram below. Answer the following in terms of D, the initial height H, and the acceleration due to gravity g.



(a) Introduce a coordinate system and label your axes. What minimum speed is required for the ball to clear the net (height $H/2$) if the ball is launched horizontally from a height of H as shown?

(b) If the ball just clears the net, how long will its entire flight take before it hits the ground?

(c) If the ball just clears the net, how far from the net will it land? Assume that there is no air resistance.

LO	S	U
1.3		
1.4		
3.3		
3.4		
6.3		
6.4		
9.3		
14.2		
14.3		
15.3		
3.5		
6.5		
14.4		
1.5		
14.5		

Extra Space: