Name: _____

Midterm 1: Physics 215 --- February 13, 2018

Do not turn this page until instructed to do so. You must sign and acknowledge the academic integrity policy below and write your name and SUID. You must also write your name **on the top of each page of the exam**, so please do this immediately when you are instructed to begin the exam.

Academic Integrity Policy: This exam is closed book and closed notes. No cell phone or smart watch use is permitted. Calculators are allowed, but the memory must be cleared, and the exam proctors may ask to check your calculator during the exam. Therefore, the following activities are automatically considered cheating are a violation of academic integrity: having any extra papers or notes on your desk, looking at another student's exam, allowing another student to look at your exam, using your cell phone during the exam, and/or having information in your calculator memory. There are different versions of this exam, so it will not help to copy numbers from your neighbor.

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Exam instructions:

- You will have 1 hour and 20 minutes to complete this exam. Plan accordingly.
- Neatly write out your full answer (with all of your work) to each problem so that you can receive partial credit. You can use the back of the exam pages or an empty blue book if you need extra space.
- The formula sheet is at the back of this exam. It is a good idea to detach this formula sheet so you can easily refer to it during the exam
- There are 4 questions. Some are easier than others, so work on the problems you know how to do before concentrating on the more difficult ones.

do not write below this line

Problem	Score
1	
2	
3	
4	
Total	

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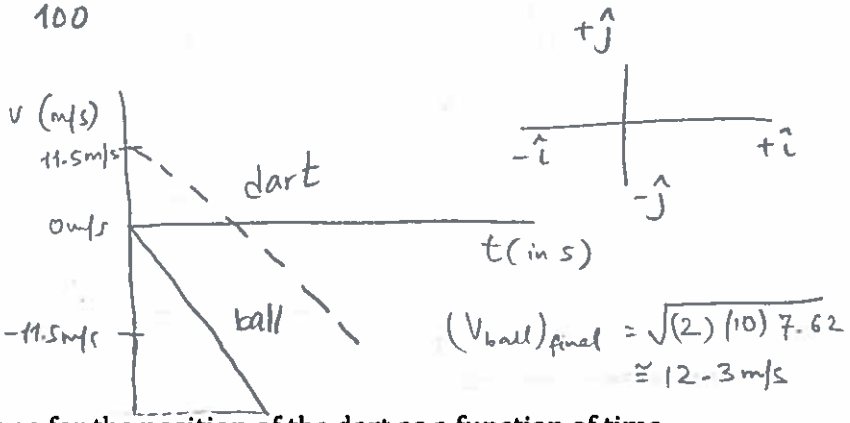
1. [25 pts] Two circus performers practice one segment of their act. Horatio stands on a platform h = 25 feet above the ground and drops a ball straight down. At the same moment, Amelia uses a spring-loaded device on the ground to launch a dart straight up toward the ball. The dart is launched at 11.5 m/s. Let g= 10 m/s^2. Let t=0 be the moment that the ball drops and the dart launches, let the +y direction point upward, and let the origin of the y-axis be the ground. *You must show all work to receive credit.*

a) [2 pts] What is the height of the platform in meters? (1 inch = 2.54 cm).

$$25 \text{ feet} = \frac{25 \times 12 \times 2.54}{100} = 7.62 \text{ m}$$

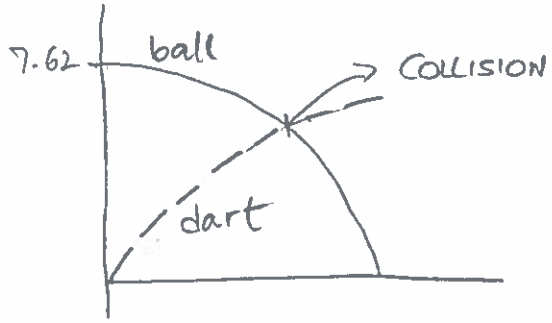
b) [4 pts] Draw a plot of the velocity vs. time for the ball. On the same set of axes, use a dashed line to draw the velocity vs. time graph for the dart. Axes and important features should be labeled with numbers.



c) [5 pts] Write two equations – one for the position of the dart as a function of time and one for the position of the ball as a function of time:

$$y_{dart} = (11.5)t - 5t^2 \quad \text{metres}$$
$$y_{ball} = (7.62) - 5t^2 \quad \text{metres}$$

d) [4pts] Draw a plot of the position vs. time for the ball. On the same set of axes, use a dashed line to draw the position vs. time for the dart.



e) [5 pts] At what time will the two objects collide?

$$11.5t - 5t^2 = 7.62 - 5t^2$$
$$\Rightarrow t = 0.6626 \text{ s}$$

f) [5 pts] At what height does the collision occur?

$$y_{dart}\big|_{t=0.6626} = (11.5)t - 5t^2$$
$$= 7.62 - 2.1951 = 5.4248 \text{ m}$$

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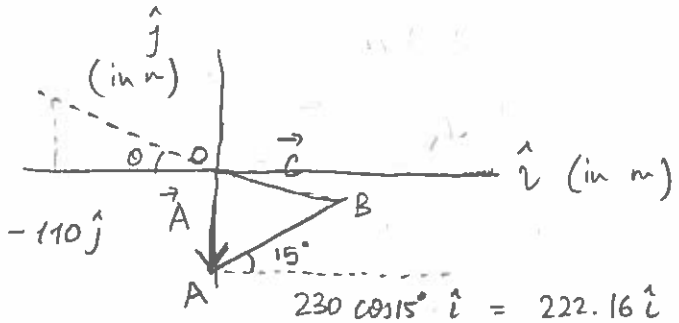
2. [25 pts] A supertanker is moving through the ocean. It first sails directly South for 110 miles. Denote this vector as . It then sails for 230 miles in a direction that is θ = 15 degrees north of east. Denote this vector as . *You must show all work to receive credit.*

a) [3 pts] Sketch the tanker's path in two dimensions. Axes and important features should be labeled with numbers.



b) [5 pts] Assume the tanker then returns in a straight line to where it began. What is the vector that describes the tanker's displacement for this third part of the trip? Give your answer using and notation.

$\vec{OA} + \vec{AB} = \vec{OB} = 222.16\,\hat{i} - 50.48\,\hat{j}$ (this also implies that B should be below x-axis)

But $\vec{C} = -\vec{OB} = -222.16\,\hat{i} + 50.48\,\hat{j}$ miles

$|\vec{C}| = 227.82$ mile

c) [2 pts] What angle does this vector make relative to West?

$\theta = \tan^{-1}\left(\frac{50.48}{222.16}\right) = 12.8^\circ$ North of west.

d) [5 pts] Assume that the tanker moves at constant speed. If the tanker completes the three-step trip in 36 hours, what is value of this constant speed?

$\text{speed} = \frac{567.82 \text{ miles}}{36 \text{ hours}}$

≈ 15.8 mph

e) [2 pts] What is the average velocity of the tanker over the whole three-step trip?

zero !!

f) [8 pts] While the tanker is returning along vector , another small ship is cruising along at a speed of 10 mph in a direction that directly West. What is the velocity of the tanker in the rest frame of the smaller ship? Give your answer using and notation.

$\vec{V}_{CG} = -15.4\,\hat{i} + 3.5\,\hat{j}$ mph

$\vec{V}_{SG} = -10\,\hat{i} + 0\,\hat{j}$ mph

$\vec{V}_{\text{tanker in rest frame of ship}} = -5.4\,\hat{i} + 3.5\,\hat{j}$ mph.

$\left(t_C = \frac{227.82}{15.8} \approx 14.42 \text{ h}\right)$

$\vec{V}_{CG} = \vec{C}/t$

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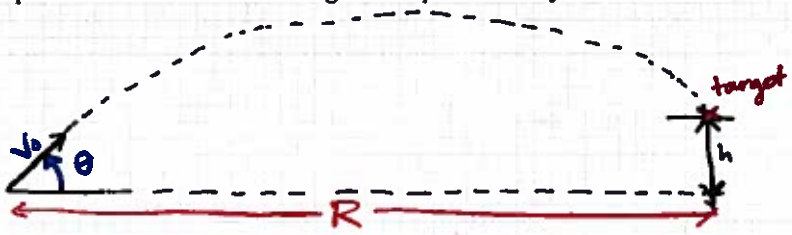
3. [25 pts] A student is firing a potato cannon towards a target on top of a nearby hill. The initial speed of the potato as it leaves the cannon is **36 m/s**, and she has adjusted her initial launch angle ($\theta = 30°$) so that the potato perfectly hits the target after achieving its maximum height. The hill is h meters above the initial position of the potato cannon. Neglect air resistance. Let g = 10. m/s^2. *You must show all work to receive credit.*



2

a) [3 pts] Write expressions for the **initial** x-velocity and y-velocity of the potato.

$V_x = V_0 \cos 30° = 31.177$ m/s

$V_y = V_0 \sin 30° = 18$ m/s

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b) [5 pts] Write down equations for the x- and y- components of the potato **position** as a function of time. Be sure to substitute in what you know for the velocities and accelerations.

$a_x = 0\ m/s^2$; $a_y = -g\ m/s^2 = -10\ m/s^2$ $\quad x_0 = y_0 = 0$ m

$x(t) = (V_{ix})t = (31.177t)$ m

$y(t) = 18t - 5t^2$

c) [4 pts] Write down equations for the x- and y-components of the potato **velocity** as a function of time.

$V_x(t) = V_{ix} = 31.177$ m/s

$V_y(t) = 18 - 10t$ m/s

d) [10 pts] Let h = **7.0** m. What is this horizontal distance R between the student and the target where the potato hits?

$x(t) = (31.177)t = R \Rightarrow t = \frac{R}{31.177}$

$y(t) = 18t - 5t^2 = 7 \Rightarrow t = 3.156$ s

(think why we ignore second solution?)

$R \cong 98.4$m

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e) [4 pts] What is the speed of the potato just before it hits the target?

$V_x = 31.177$ m/s

$V_y = 18 - 31.56 = -13.56$ m/s

speed $\cong$ 34 m/s

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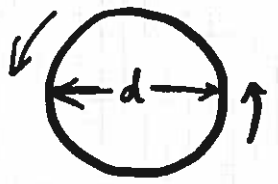
4. [25 pts] Swimsuit dryer. At the local indoor pool, a swimsuit dryer consists of a cylindrical tube with holes in it that spins around rapidly to remove water from a swimsuit. You are looking down at the cylindrical tube, which rotates counterclockwise as shown. The diameter of the tube is d=20 cm. The dryer is initially at rest. *You must show all work to receive credit.*



a) [5 pts] Beginning at t=0s, it takes 5 seconds for the dryer to speed up until it is spinning fast enough to complete 1 revolution in **0.1** seconds. At t=5 s, what is the **angular** velocity of the dryer in units of radians/sec?

2π rad $\rightarrow$ 1/10 s

$\omega \rightarrow 20\pi$ rad/s OR 62.8 rad/s

b) Assuming constant angular acceleration as the dryer speeds up, what is the value of the angular acceleration during this process?

$\omega_f - \omega_i = \alpha \Delta t$

$\frac{20\pi}{5} = 4\pi \text{ rad/s}^2 = \alpha$

c) [5 pts] At t=5 s, what is the **linear** velocity of the edge of the dryer in units of m/s?

$v = \omega r$

$= \frac{(20\pi)1}{10}$ m/s

$= 2\pi$ m/s

d) [6 pts] How many revolutions does the dryer complete from t=0 to t=5s?

$\theta = \omega_i t + \frac{1}{2}\alpha(\Delta t)^2$

$= \frac{1}{2}(4\pi)\,25$

$= 50\pi$ radians $= 25$ revolutions

e) [4 pts] In future classes, we will learn to describe this problem in terms of angular momentum. The equation for angular momentum is L = I ω, where ω is the same angular velocity as in part b), and L has units of length squared times mass divided by time. Using dimensional analysis, what are the units of I?

$\omega \rightarrow$ rad/s

$L \rightarrow M^1 L^2 T^{-1}$

$I \rightarrow \frac{M^1 L^2 T^{-1}}{T^{-1}} \rightarrow M^1 L^2$

kg m^2