PHYS 115 Midterm Exam #1 – Regular Version – Solutions

Description
This set of 1 statement of commitment to academic integrity and 8 questions is the first midterm exam for PHYS 115 Fall 2020 at the University of Saskatchewan.

30% of the exam mark is based on the answers for all 8 questions submitted through WebAssign. All 8 questions are weighted equally.

70% of the exam mark is based on the solutions for the 4 problems (questions 6 through 9) that are submitted through Canvas. All 4 solutions are weighted equally.

Instructions
Answers for all questions need to be submitted in WebAssign. For each of questions 6 through 9, in addition to submitting your answers in WebAssign, write the complete solution, **including a diagram**, using the problem-solving method discussed in class. **Keep extra decimal places throughout your calculations, and then round-off your final answer to <u>three significant figures</u>.** Submit your answer to each question in WebAssign.

When you have finished the entire exam, scan your written work for questions 6 through 9 and submit a single multi-page PDF file using the link in the Canvas site for your section.

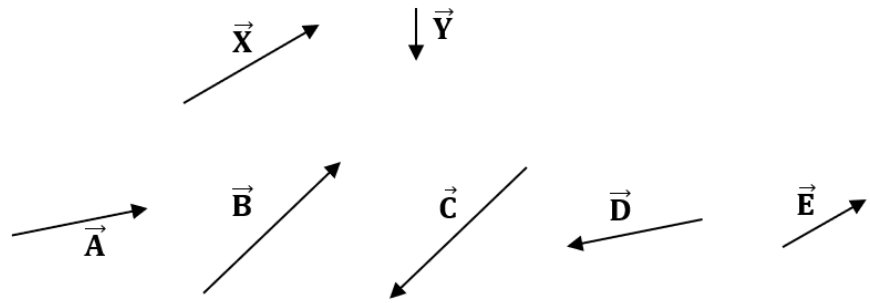
The exam begins at 10:00 AM, Saturday, October 3rd. Your WebAssign submission is due no later than 11:30 AM and your Canvas submission is due no later than 12:00 PM (Noon). All times are **Saskatchewan Time**. **LATE SUBMISSIONS WILL NOT BE ACCEPTED.**

1. - UofS-P115-P117-Honour [4820285]
On my honour, I pledge that I will not give or receive aid during this assessment. I understand that I am expected to complete this assessment with no communication with other persons and no resource material other than the PHYS 115/117 Formulae sheet. I recognize that it is my responsibility to uphold academic integrity and I agree to follow the rules of this assessment and the guidelines laid forth in the policies of the University of Saskatchewan. Furthermore, I fully understand that disciplinary action may be taken against me if I am discovered to have communicated with another person or to have used an internet resource.

○ Yes, I understand and agree.

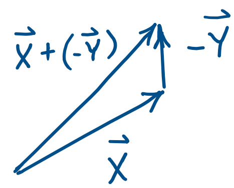
2. - MT1-A-6 [4820249]

Given the two vectors labeled $\vec{\mathbf{X}}$ and $\vec{\mathbf{Y}}$, which one of the vectors labeled $\vec{\mathbf{A}}$, $\vec{\mathbf{B}}$, $\vec{\mathbf{C}}$, $\vec{\mathbf{D}}$, and $\vec{\mathbf{E}}$ <u>best</u> represents the vector $\vec{\mathbf{X}} - \vec{\mathbf{Y}}$**?**



- Vector $\vec{\mathbf{B}}$
- Vector $\vec{\mathbf{E}}$
- Vector $\vec{\mathbf{A}}$
- Vector $\vec{\mathbf{D}}$
- Vector $\vec{\mathbf{C}}$

$\vec{X} - \vec{Y} = \vec{X} + (-\vec{Y})$



3. - MT1-A-2 [4816551]
Assuming that the average person takes about 10 breaths per minute, which one of the following is the best estimate of the order of magnitude of the number of breaths taken in 60 years?

- 10^6 breaths
- 10^8 breaths
- 10^{10} breaths
- 10^{12} breaths
- 10^{14} breaths

$$n = \# \text{ of breaths} = \text{breath rate} \times \text{time}$$

$$= \frac{10 \text{ breaths}}{\cancel{min}} \times 60 \cancel{y} \times \frac{365 \cancel{d}}{\cancel{y}} \times \frac{24 \cancel{h}}{\cancel{d}} \times \frac{60 \cancel{min}}{\cancel{h}}$$

$$= 10 \text{ breaths} \times (60 \times 60) \times (365 \times 24)$$

$$= 10 \text{ breaths} \times 3.6 \times 10^3 \times (\sim 4 \times 10^2 \times \sim 2 \times 10^1)$$

$$= 10 \text{ breaths} \times 3.6 \times 10^3 \times 8 \times 10^3$$

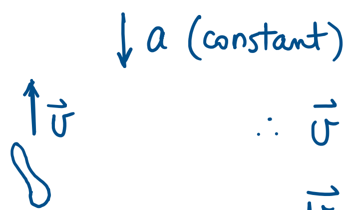
$$= 10 \text{ breaths} \times \sim 30 \times 10^6 = 30 \times 10^7 \text{ breaths} \simeq 10^8 \text{ breaths}$$

4. - MT1-A-3 [4816554]

A juggler throws a bowling pin straight up in the air. After the pin leaves his hand and while it is in the air, which one of the following statements is true?

- The velocity of the pin is always in the same direction as its acceleration.
- The velocity of the pin is never in the same direction as its acceleration.
- The velocity of the pin is in the same direction as its acceleration on the way up.
- The acceleration of the pin is zero.
- The velocity of the pin is opposite to its acceleration on the way up.

The acceleration is constant, magnitude g, directed downward.



$\therefore$ $\vec{v}$ and $\vec{a}$ are oppositely directed on the way up.

$\vec{v}$ and $\vec{a}$ are in the same direction on the way down.

5. - MT1-A-5 [4816606]

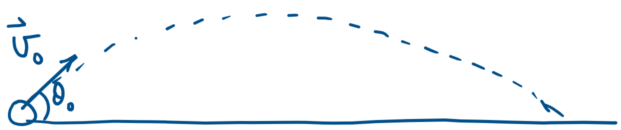
A machine launches a tennis ball at an angle of 25.0° above the horizontal at a speed of 14.0 m/s. The ball returns to level ground. Which one of the following changes is guaranteed to (i.e. must) produce an increase in the time of flight of the ball? Ignore any effects due to air resistance.

- Decrease the launch angle and increase the ball's initial speed.
- Increase the launch angle and increase the ball's initial speed.
- Decrease the launch angle and do not change the ball's initial speed.
- Decrease the launch angle and decrease the ball's initial speed.
- Increase the launch angle and decrease the ball's initial speed.

$$\Delta y = v_{0y} t + \frac{1}{2} a_y t^2 = 0$$

$$v_{0y} = -\frac{1}{2} a_y t$$

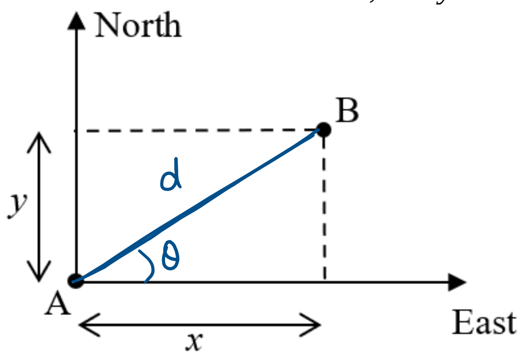
$$t = \frac{-2 v_{0y}}{a_y} = \frac{-2 v_0 \sin\theta_0}{a_y}$$



$\sin\theta_0$ increases when θ_0 increases

$\therefore$ t must increase if both v_0 and θ_0 are increased.

6. - MT1-B-6 [4820256]
City B is located x = 167 km East, and y = 161 km North of city A, as shown in the diagram.



Since North and East are perpendicular directions, $d = \sqrt{x^2+y^2}$

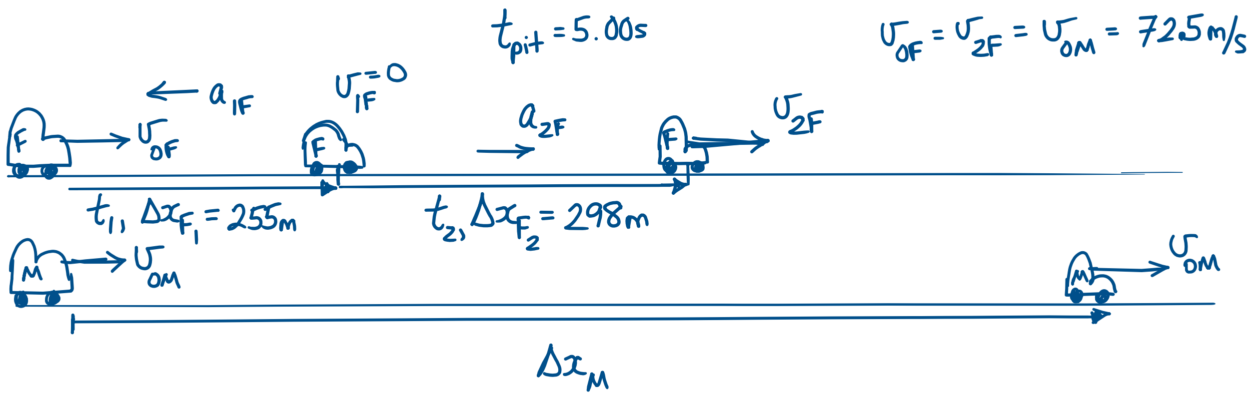
$$d = \sqrt{(167\text{ km})^2 + (161\text{ km})^2} = 232\text{ km}$$

(a) What is the distance between city A and city B? 232 km

(b) In what direction would a plane fly to get from city A to city B? (Give your answer in degrees as the counter-clockwise angle from the East direction.) 44°

$$\theta = \text{invtan}\left(\frac{y}{x}\right) = \text{invtan}\left(\frac{161\text{ km}}{167\text{ km}}\right) = 44.0^\circ$$

7. - MT1-B-2 [4816576]
During a sports car race, a Ferrari and a McLaren are beside each other and moving with the same speed of 72.5 m/s. The Ferrari driver decides to make a pit stop and she comes to a stop after experiencing a constant acceleration over a distance of 255 m. She spends 5.00 s in the pit and then accelerates out, reaching her previous speed of 72.5 m/s after a distance of 298 m. At this point how far is the Ferrari behind the McLaren, which has continued at a constant speed?
916 m



Calculate the time, t_{tot}, between when the started to slow down and when it again reached a speed of 72.5 m/s.

$t_{tot} = t_1 + t_{pit} + t_2$ Constant acceleration $\Rightarrow$ $\Delta x = \left(\frac{v_0 + v}{2}\right) t$

$$\Delta x_{F_1} = \left(\frac{v_{0F} + v_{1F}}{2}\right) t_1 \quad ; \quad \Delta x_{F_2} = \left(\frac{v_{1F} + v_{2F}}{2}\right) t_2$$

$$t_{tot} = \frac{\Delta x_{F_1}}{v_{0F}/2} + t_{pit} + \frac{\Delta x_{F_2}}{v_{2F}/2} = \frac{255m}{(72.5 m/s)/2} + 5.00s + \frac{298m}{(72.5 m/s)/2}$$

$$t_{tot} = 20.26s$$

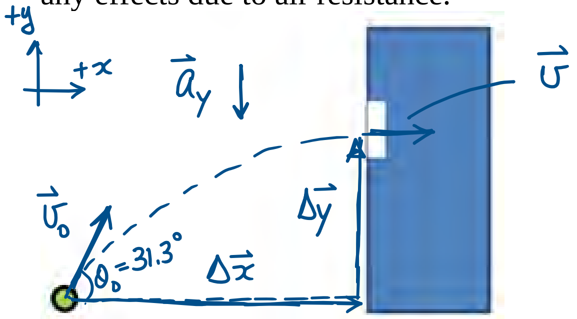
During t_{tot}, the Ferrari has travelled $255m + 298m = 553m$

and the McLaren has travelled $20.26\,s \times 72.5\,m/s = 1.469 \times 10^3 m$

The McLaren is ahead by $1.469 \times 10^3 m - 553m = 916m$

8. - MT1-B-8 [4820283]

You wish to kick a soccer ball, initially sitting on the ground, so that it passes through the centre of an open window in a nearby building. At the instant that the ball reaches the centre of the window, you want it to be moving horizontally only. The ball is initially a distance of 22.9 m from the building and the centre of the window is 6.96 m above the level ground. The initial velocity of the ball when it leaves your foot is at an angle of 31.3° above the horizontal. Ignore any effects due to air resistance.



x	y
$\Delta x = +22.9\,m$	$\Delta y = +6.96\,m$
$v_{0x} = v_0 \cos\theta_0$	$v_{0y} = v_0 \sin\theta_0$
$a_x = 0$	$a_y = -9.80\,m/s^2$
$v_x = v_{0x}$	$v_y = 0$
t	t

(a) Calculate the initial speed at which the ball must be kicked. That is, calculate the magnitude of the initial velocity of the ball when it leaves your foot. 22.5 m/s

(b) Calculate the time interval between when the ball leaves your foot and when it passes through the centre of the window. 1.19 s

(a) We know v_y, Δy, and a_y. $v_y^2 = v_{0y}^2 + 2a_y\Delta y \Rightarrow 0 = v_{0y}^2 + 2a_y\Delta y$

$v_{0y} = v_0 \sin\theta_0$ $\qquad$ $v_{0y} = \pm\sqrt{-2a_y\Delta y} = \pm\sqrt{-2(-9.80\,m/s^2)(+6.96\,m)}$

$v_0 = \dfrac{v_{0y}}{\sin\theta_0}$ $\qquad$ $v_{0y} = +11.68\ m/s$

$$v_0 = \frac{+11.68\ m/s}{\sin(31.3°)} = 22.5\ m/s$$

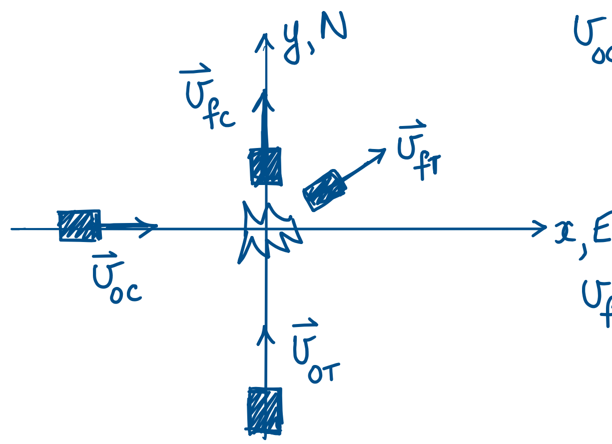
(b) $$\Delta x = v_{0x}t \Rightarrow t = \frac{\Delta x}{v_{0x}} = \frac{\Delta x}{v_0\cos\theta_0} = \frac{+22.9\ m}{(22.5\,m/s)(\cos 31.3°)} = 1.19\,s$$

CHECK: $$v_y = v_{0y} + a_y t \Rightarrow t = \frac{v_y - v_{0y}}{a_y} = \frac{0 - 11.68\ m/s}{-9.80\,m/s^2}$$

$$t = 1.19\,s$$

9. - MT1-B-5 [4816619]
A car travelling east with a speed of 55.1 km/h collides with a truck travelling north. During the collision, the car is in contact with the truck for 1.42 s. After the collision, when the car is no longer in contact with the truck, and its velocity is no longer changing, the car is moving north with a speed of 44.9 km/h.
(a) Calculate the magnitude of the average acceleration of the car due to the collision. Express your answer in m/s^2. 13.9 m/s^2

(b) Calculate the direction of the average acceleration of the car due to the collision. Express your answer as an angle North of West. 39.2°



$$v_{oc} = 55.1\,\frac{\text{km}}{\text{h}} \times \frac{1\,\text{h}}{3600\,\text{s}} \times \frac{1000\,\text{m}}{\text{km}}$$

$$v_{oc} = 15.31\,\text{m/s}$$

$$v_{fc} = 44.9\,\frac{\text{km}}{\text{h}} \times \frac{1\,\text{h}}{3600\,\text{s}} \times \frac{1000\,\text{m}}{\text{km}}$$

$$v_{fc} = 12.47\,\text{m/s}$$

The car experiences an acceleration while it is in contact with the truck.

$$\vec{a}_c = \frac{\Delta \vec{v}_c}{\Delta t} = \frac{\vec{v}_{fc} - \vec{v}_{oc}}{\Delta t}$$

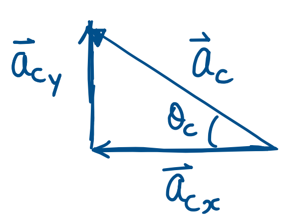
$$a_{cx} = \frac{v_{fcx} - v_{ocx}}{\Delta t} = \frac{0 - 15.31\,\text{m/s}}{1.42\,\text{s}} = -10.78\,\text{m/s}^2$$

$$a_{cy} = \frac{v_{fcy} - v_{ocy}}{\Delta t} = \frac{+12.47\,\text{m/s} - 0}{1.42\,\text{s}} = +8.78\,\text{m/s}^2$$

$$a_c = \sqrt{a_{cx}^2 + a_{cy}^2} = 13.9\,\text{m/s}^2$$

(b) $\theta_c = \text{invtan}\left(\left|\frac{a_{cy}}{a_{cx}}\right|\right) = 39.2°$

since a_{cx} is -ve and a_{cy} is +ve, $\vec{a}$ is in the 2nd quadrant.



∴ 39.2° North of West