PHYS 115 Midterm Exam #1 – Alternative 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.

Your WebAssign submission is due no later than 90 minutes after the questions become available and your Canvas submission is due no later than 120 minutes after the questions become available. 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-1 [4816538]
You decide that you want to walk a distance equal to the circumference of the Earth. Which one of the following is the best estimate of the order of magnitude of the number of steps required? (The length of a step for an average person is about 0.6 m and the radius of the Earth is 6.38 × 10^6 m.)

- 10^5 steps
- 10^8 steps
- 10^{11} steps
- 10^{15} steps
- 10^{20} steps

C_E = circumference = $2\pi R_E$ where R_E = radius of Earth

Let n = # of steps required and let ℓ = length of one step.

$$\therefore \quad C_E = n\ell \Rightarrow n = \frac{C_E}{\ell} = \frac{2\pi R_E}{\ell} = \frac{2\pi\,(6.38\times 10^6\,\cancel{m})}{0.6\,\cancel{m}}$$

$$2\pi \simeq 6 \Rightarrow n \simeq 10 \times 6.38\times 10^6 = 6.38\times 10^7 \simeq 1\times 10^8$$

3. - MT1-A-7 [4820251]
In a particularly odd situation, the acceleration of an object that is moving in one-dimension along the x-axis has an acceleration that depends on its position x and is given by the equation $a = Cx^2$. What must be the dimensions of the quantity C?

- $L\,T^2$
- $L^{-2}\,T^{-2}$
- $L^{-1}\,T^{-2}$
- $L^{-1}\,T^2$
- $L\,T^{-2}$

$$a = Cx^2 \Rightarrow [a] = [C][x^2] = [C][x]^2$$

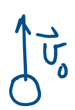
$$[a] = L/T^2 = LT^{-2} \quad \text{(acceleration)}$$

$$[x] = L \quad \text{(position)}$$

$$[C] = \frac{[a]}{[x]^2} = \frac{\cancel{L}T^{-2}}{L^{\cancel{2}}} = \frac{T^{-2}}{L} = T^{-2}L^{-1}$$

4. - MT1-A-4 [4816599]
A ball is kicked straight up in the air. Air resistance effects can be neglected. Which one of the following statements is correct regarding the ball's speed after it is no longer in contact with the kicker's foot?

- The ball's speed increases linearly as the ball approaches maximum height.
- The ball's speed increases rapidly at first, and then more and more slowly as the ball approaches maximum height.
- The ball's speed decreases linearly to zero as the ball approaches maximum height.
- The ball's speed increases slowly at first, and then more and more rapidly as the ball approaches maximum height.
- The ball's speed is constant throughout its motion.

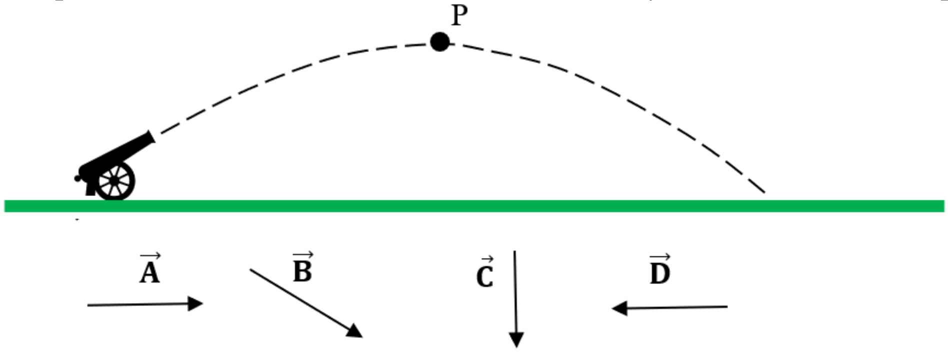


$\downarrow \vec{a} = g$ downward (constant)

Since the ball is in free fall, it has constant downward acceleration of magnitude g.

$\therefore$ The ball's velocity is changing at a constant rate, i.e. linearly or uniformly with time. While it is moving upward, the ball's speed is decreasing linearly with time.

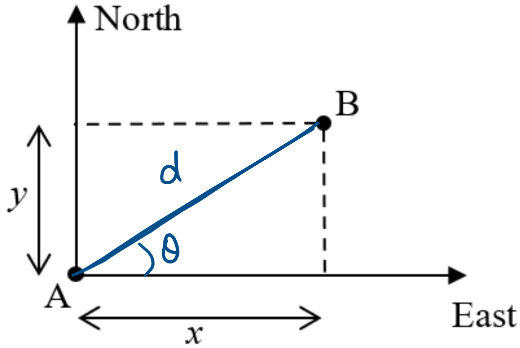
5. - MT1-A-8 [4820254]
A cannonball is flying through the air in the parabolic path shown in the diagram. Air resistance can be neglected. The point P is the highest point in the path. Which one of the vectors below best represents the direction of the acceleration, if any, of the cannonball at point P?



- ○ There is no acceleration of the cannonball at point P.
- ◉ Vector **D**
- ○ Vector **A**
- ○ Vector **B**
- ○ Vector **C**

The cannonball is in freefall.
The acceleration of the ball is constant magnitude g, directed downward. $\therefore \vec{C}$.

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°

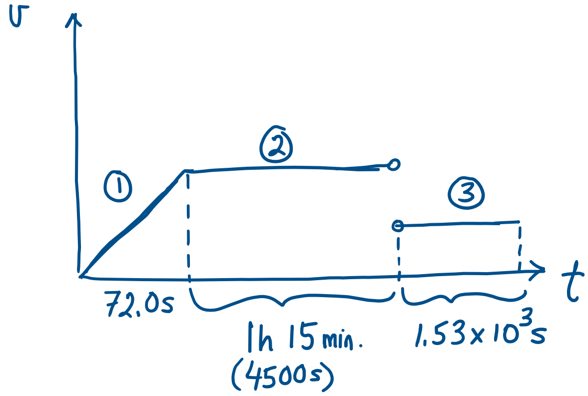
$$\theta = \text{invtan}\left(\frac{y}{x}\right) = \text{invtan}\left(\frac{161\text{ km}}{167\text{ km}}\right) = 44.0^\circ$$

7. - MT1-B-4 [4816610]
In a particular cycling road race along a perfectly straight road, there is a flat portion followed by a hill climb to the finish line. A cyclist starts from rest at the beginning of the flat portion and accelerates at 0.168 m/s^2 for 72.0 s. The cyclist then maintains constant velocity for an additional 1 hour and 15 minutes (4.50×10^3 s), which brings the cyclist to the start of the hill climb. The cyclist's velocity immediately drops to 7.15 m/s and the cyclist maintains this velocity for 1.53×10^3 seconds, reaching the top of the hill and the finish line.

(a) As part of your written submission, sketch the graph of the cyclist's velocity versus time for the entire race.

(b) Calculate the length of the entire race from start to finish. Express your answer in km.
68.4 km

(a)



$v_0 = 0$; $a_1 = +0.168\ \text{m/s}^2$

Let v_1 = velocity at $t_1 = 72.0\text{s}$

Let $t_2 = 4500\text{s}$

Let $t_3 = 1.53 \times 10^3\text{s}$

Let $v_3 = 7.15\text{m/s}$

(b) $\Delta x_{tot} = \Delta x_1 + \Delta x_2 + \Delta x_3$

$$\Delta x_{tot} = v_0 t_1 + \frac{1}{2} a_1 t_1^2 + v_1 t_2 + v_3 t_3$$

$$v_1 = v_0 + a_1 t_1$$

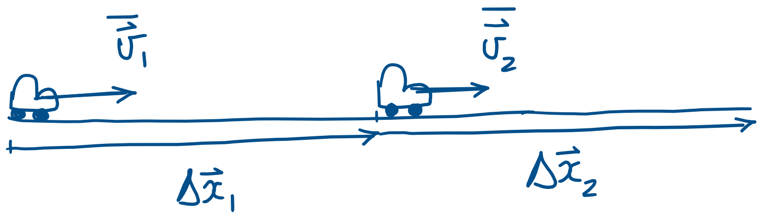
$$v_1 = (0.168\ \text{m/s}^2)(72.0\ \text{s})$$

$$v_1 = +12.1\ \text{m/s}$$

$$\Delta x_{tot} = 0 + \frac{1}{2}(0.168\ \text{m/s}^2)(72.0\ \text{s})^2 + (+12.1\ \text{m/s})(4500\text{s}) + (+7.15\ \text{m/s})(1.53 \times 10^3\text{s})$$

$$\Delta x_{tot} = 6.58 \times 10^4\ \text{m} = \boxed{65.8\ \text{km}}$$

8. - MT1-B-3 [4816587]
A race car must achieve an average speed of 255 km/h while travelling a total distance of 2,480 m to qualify for a race. If a particular car travels the first half of the distance at an average speed of 221 km/h, what minimum average speed must it have while travelling the second half of the distance to qualify? 301 km/h



$$\Delta x_1 = \Delta x_2 = \frac{2.48\times10^3\,\text{m}}{2} = 1.24\times10^3\,\text{m} = 1.24\,\text{km}$$

Recall that $\bar{v} = \dfrac{\Delta x}{t} \Rightarrow t_1 = \dfrac{\Delta x_1}{\bar{v}_1} = \dfrac{1.24\,\text{km}}{221\,\text{km/h}} = 5.611\times10^{-3}\,\text{h}$

At the qualifying average speed of 255 km/h, the maximum allowed time for 2.48 km is $t_{tot} = \dfrac{\Delta x_{tot}}{\bar{v}} = \dfrac{2.48\,\text{km}}{255\,\text{km/h}} = 9.725\times10^{-3}\,\text{h}$

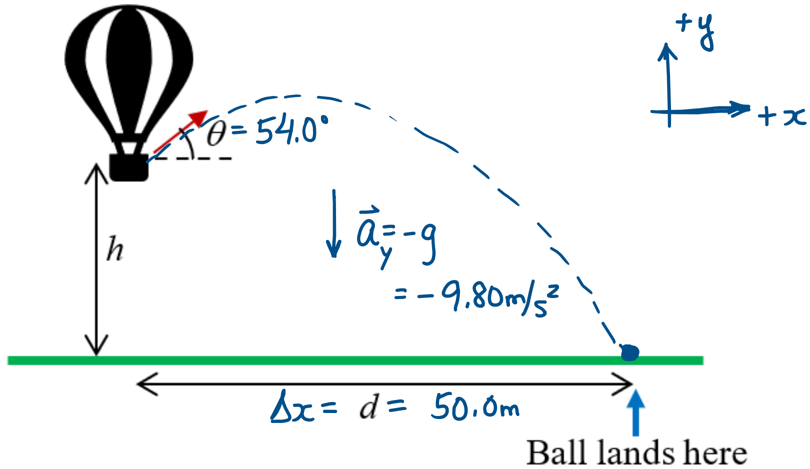
$$t_2 = t_{tot} - t_1 = 4.114\times10^{-3}\,\text{h}$$

$\therefore$ In the second half, the car must have an average speed of

$$\bar{v}_2 = \frac{\Delta x_2}{t_2} = \frac{1.24\,\text{km}}{4.114\times10^{-3}\,\text{h}} = 301\,\text{km/h}$$

9. - MT1-B-7 [4820257]

A person in a balloon gondola is a vertical distance h above the horizontal ground. She throws a ball with an initial speed v_0 at an angle $\theta = 54.0°$ to the horizontal as shown in the diagram. The ball lands a horizontal distance $d = 50.0$ m from the balloon's position. The time of flight of the ball is $t = 5.48$ s. Air resistance can be neglected in the flight of the ball.



x	y
$\Delta x = d$	$\Delta y = -h$
$v_{0x} = v_0 \cos\theta$	$v_{0y} = v_0 \sin\theta$
$a_x = 0$	$a_y = -g$
$v_x = v_{0x}$	v_y

$t = 5.48s$

(a) Calculate the initial speed v_0 with which the ball was thrown. 15.5 m/s

(b) Calculate the height h from where the ball was thrown. 78.3 m

(a) $\Delta x = v_{0x} t = v_0 \cos\theta t \Rightarrow v_0 = \dfrac{\Delta x}{(\cos\theta)t} = \dfrac{50.0m}{\cos(54.0°)\cdot 5.48s} = 15.5 m/s$

(b) $\Delta y = v_{0y} t + \frac{1}{2} a_y t^2 = (v_0 \sin\theta)t + \frac{1}{2} a_y t^2 = (15.52 m/s)(\sin 54.0°)(5.48s)$

$+ \frac{1}{2}(-9.80 m/s^2)(5.48s)^2 = -78.3m$

$\boxed{h = -\Delta y = 78.3m}$