PHYS 115 Midterm Examination #1 – Regular Version

Description

This set of 1 statement of commitment to academic integrity and 9 questions is the first midterm exam for PHYS 115 Fall 2021 at the University of Saskatchewan.

1/3 of the exam mark is based on the answers for the 6 multiple-choice questions submitted through WebAssign. All 6 multiple-choice questions are weighted equally.

2/3 of the exam mark is based on the answers (submitted through WebAssign) and solutions (submitted through Canvas) for the 3 word problems. All 3 word problems are weighted equally.

Instructions

Answers for **all** questions need to be submitted in WebAssign.

For each of questions 8, 9, and 10, in addition to submitting your answers in WebAssign, write the complete solution, **including a diagram**, using the problem-solving method discussed in class.

Your solutions must use the same symbols as are used on the formulae sheet.

Formulas not on the Formulae Sheet must be derived.

Keep extra decimal places throughout your calculations, and then round-off your final answer to three significant figures.

Submit your answer to each question in WebAssign.

When you have finished the entire exam, scan your written work for questions 8, 9, and 10 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.

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. P115-2021-MT1-Reg-A1 [5120814]

The energy stored in a spring which is stretched by a distance x is given by $U = \frac{1}{2}kx^2$. The energy U has dimensions ML^2T^{-2} and the distance x has dimensions L. What must be the dimensions of the constant k?

○ [✓ MT^{-2}]
○ $ML^{-1}T^2$
○ MLT^{-2}
○ $ML^{-1}T^{-2}$
○ $2MT^{-2}$

$$U = \frac{1}{2}kx^2 \Rightarrow [U] = [k][x]^2$$

where [ ] denotes dimensions

$$\therefore [k] = \frac{[U]}{[x]^2} = \frac{ML^2T^{-2}}{L^2} = \boxed{MT^{-2}}$$

3. P115-2021-MT1-Reg-A2 [5120826]

An atom has an approximate width of 10^{-10} m. Make an order of magnitude estimate of the number of atoms in a solid which has a volume of 10^{-3} m^3.

○ [✓ 10^{27}] ○ 10^{13} ○ 10^{30} ○ 10^{7} ○ 10^{33}

Approximating an atom as a cube of side length x, the volume of an atom is x^3

$$\therefore \#\text{of atoms} = \frac{\text{total volume}}{\text{volume per atom}} = \frac{10^{-3}m^3}{(10^{-10}m)^3}$$

$$= \frac{10^{-3}m^3}{10^{-30}m^3} = \boxed{10^{27}}$$

4. P115-2021-MT1-Reg-A3 [5120580]

A tennis player tosses the ball straight up. While the ball is in free fall, which one of the following statements is correct regarding the ball's acceleration?

○ The acceleration of the ball remains constant.
○ The acceleration of the ball steadily increases.
○ The acceleration of the ball steadily decreases.
○ The acceleration of the ball decreases and then increases.
○ The acceleration of the ball increases and then decreases.

By definition, the acceleration of an object in free fall is constant. (Constant magnitude, directed downward.)

5. P115-2021-MT1-Reg-A4 [5120816]

Two objects A and B start from rest and move along a straight line with the same magnitude acceleration. Compare the speed v_A that object A has after it has gone a distance d, to the speed v_B that object B has after it has gone a distance $2d$.

(A) $v_A = 2v_B$

(B) $v_A = \frac{1}{2}v_B$

[✓ (C) $v_A = \frac{1}{\sqrt{2}}v_B$]

(D) $v_A = \frac{1}{4}v_B$

(E) $v_A = \sqrt{2}v_B$

From $v^2 = v_0^2 + 2a\Delta x$ and letting $a_A = a_B = a$

$$v_A = \sqrt{0 + 2ad} = \sqrt{2ad}$$

$$v_B = \sqrt{0 + 2a(2d)} = \sqrt{4ad}$$

$$\frac{v_A}{v_B} = \frac{\sqrt{2ad}}{\sqrt{4ad}} = \frac{1}{\sqrt{2}} \Rightarrow \boxed{v_A = \frac{1}{\sqrt{2}} \cdot v_B}$$

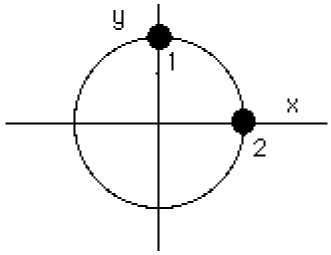
6. P115-2021-MT1-Reg-A5 [5120799]

A projectile is launched with speed v_o at an angle θ above the horizontal. Its motion is described in terms of position, velocity, and acceleration by x, y, v_x, v_y, a_x, and a_y, respectively, where the x direction is horizontal and the y direction is vertical. Which of these quantities are constant <u>and</u> non-zero during the motion if we neglect air resistance? (Select all that apply.)

☑ v_x ☐ y ☐ a_x ☑ a_y ☐ x ☐ v_y

The projectile is moving, so its position components, *x* and *y* are not constant. The horizontal component of the acceleration is constant, but it is zero. Therefore, the horizontal component of the velocity, v_x, is constant and non-zero. The vertical component of the acceleration, a_y, is constant and non-zero (*g* downward). Therefore, the vertical component of the velocity is not constant.

7. P115-2021-MT1-Reg-A6 [5120570]



$\vec{v}$ $\vec{v}$

○ $\vec{v}_1$in the +x direction and $\vec{v}_2$ in the −y direction.

○ $\vec{v}_1$ in the −x direction and $\vec{v}_2$ in the +y direction.

○ $\vec{v}_1$ in the −x direction and $\vec{v}_2$ in the −y direction.

○ Both velocities are at 45 degrees to the axes.

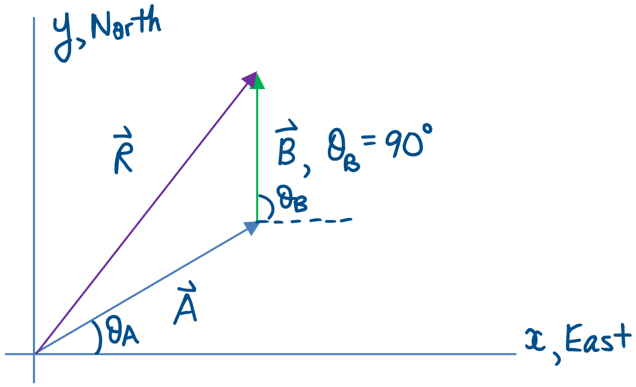
○ $\vec{v}_1$ in the +x direction and $\vec{v}_2$ in the +y direction.

Instantaneous velocity is directed tangent to the trajectory, along the direction of motion at that instant.

$\therefore$ $\vec{v}_1$ in $+x$, $\vec{v}_2$ in $-y$.

8. P115-2021-MT1-Reg-B1 [5120824]
A ship starts from an island and sails 21.9 km in a direction 40.1° North of East. It then sails directly North for a further 15.0 km. The resultant displacement of the ship from the island has magnitude (33.6 km)

and is at an angle of (60.1° North of East). To receive full marks, you must include a diagram showing the physical situation and your choice of coordinate system.



$$\vec{R} = \vec{A} + \vec{B}$$

$$\therefore \; R_x = A_x + B_x \;\; \& \;\; R_y = A_y + B_y$$

$$R_x = A\cos\theta_A + 0 = 21.9\,\text{km}\,\cos(40.1°) = 16.75\text{ km}$$

$$R_y = A\sin\theta_A + B = 21.9\text{ km}\,\sin(40.1°) + 15.0\text{ km} = 29.11\text{ km}$$

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(16.75\text{ km})^2 + (29.11\text{ km})^2} = \boxed{33.6\text{ km}}$$

The angle θ_R that $\vec{R}$ makes with the x-axis (East direction) is

$$\theta_R = \text{invtan}\left(\frac{R_y}{R_x}\right) = \text{invtan}\left(\frac{29.11\text{ km}}{16.75\text{ km}}\right) = \boxed{60.1°\text{ North of East}}$$

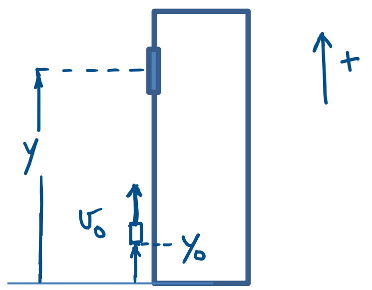
agrees with diagram

9. P115-2021-MT1-Reg-B2 [5120563]

Juliet is standing in front of a wall and Romeo is at a window above her at a height of 3.68 m from the ground. Juliet tosses a box of candy straight up with speed 7.60 m/s from a height of 1.60 m above the ground. Ignore any effects due to air resistance. To receive full marks, you must include a diagram showing the physical situation and your choice of coordinate system.

(a) Will the box reach Romeo? ○ Yes ○ No

(b) If so, what is the box's speed when it reaches Romeo? If not, what initial speed must the box have to reach Romeo? 4.12 m/s



Given that $y = 3.68\,m$, $y_0 = 1.60\,m$, $v_0 = +7.60\,m/s$

Know that $a = -9.80\,m/s^2$

(a) Calculate y_{max} (when $v = 0$) and check whether $y_{max} > y$.

From $v^2 = v_0^2 + 2a\Delta y$, $\Delta y = \frac{v^2 - v_0^2}{2a} = -\frac{v_0^2}{2a}$

$\therefore \Delta y = y_{max} - y_0 = -\frac{v_0^2}{2a} \Rightarrow y_{max} = y_0 - \frac{v_0^2}{2a} = 1.60m - \frac{(7.60m/s)^2}{2(-9.80m/s^2)}$

$y_{max} = 4.55\,m$, which is greater than $3.68\,m$

$\therefore$ box reaches Romeo.

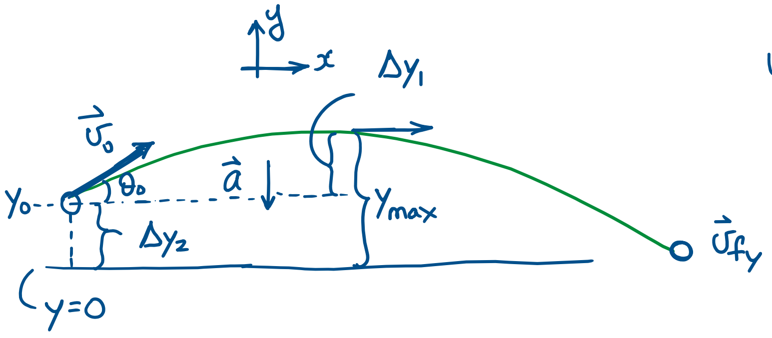
(b) Now use $v^2 = v_0^2 + 2a\Delta y$ to calculate v as the box passes Romeo.

$v = \left[(7.60m/s)^2 + 2(-9.80m/s^2)(3.68m - 1.60m)\right]^{1/2} = \boxed{4.12m/s}$

10. P115-2021-MT1-Reg-B3 [5118817]

On September 13th, 2021, Vladimir Guerrero Jr. hit a baseball such that it was launched with a speed of 175 km/h at an angle of 16.1° above the horizontal. The ball was at a height of 1.30 m above the level ground when it was launched. Ignore any effects due to air resistance. To receive full marks, you must include a diagram of the trajectory of the ball and the coordinate system that you will use.

Calculate the horizontal distance of the ball from its launch point when it hits the level ground. 133 m



$v_0 = 175\ \text{km/h} \times \frac{1000\text{m}}{\text{km}} \times \frac{1\text{h}}{3600\text{s}} \rightarrow v_0 = 48.6\ \text{m/s}$

$\theta_0 = 16.1°$

$y_0 = 1.30\text{m}$

horizontal distance $= R = v_{0x}t$ where t is the time that the ball is in the air.

$v_{0x} = v_0\cos\theta_0$. t can be determined from $\Delta y_2 = v_{0y}t + \frac{1}{2}a_y t^2$

$$-\frac{1}{2}a_y t^2 - v_{0y}t + \Delta y_2 = 0 \Rightarrow -\frac{1}{2}(-9.80\text{m/s}^2)t^2 - (48.6\text{m/s})\sin(16.1°)t - 1.30\text{m} = 0$$

$$(4.90\text{m/s}^2)t^2 - 13.48\ \text{m/s}\,t - 1.30\text{m} = 0$$

$$t = \frac{-(-13.48\text{m/s}) \pm \sqrt{(-13.48\text{m/s})^2 - 4(4.90\text{m/s}^2)(-1.30\text{m})}}{2(4.90\text{m/s}^2)} = \underline{2.844\ \text{s}}\ ; -0.0933\text{s}$$

$$R = (48.6\text{m/s})(\cos 16.1°)(2.844\text{s}) = \boxed{133\ \text{m}}$$

Alternatively, from $v_{fy}^2 = v_{0y}^2 + 2a_y\Delta y_2$, $v_{fy} = -\sqrt{(48.6\text{m/s})^2(\sin^2(16.1°)) + 2(-9.80\text{m/s}^2)(-1.30\text{m})}$

$v_{fy} = -14.39\ \text{m/s}$

and $t = \frac{v_{fy} - v_{0y}}{a} = \frac{-14.39\ \text{m/s} - (48.6\ \text{m/s})(\sin(16.1°))}{-9.80\text{m/s}^2} = \underline{2.844\ \text{s}}$