PHYS 115 Midterm Examination #1 – Alternative 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 through 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-Alt-A1 [5120576]
A ball of radius r moving in a fluid experiences a resistive force whose magnitude F varies with the ball's radius r and speed v according to the equation $F = Cr^2v^2$, where C is a constant. Given that the dimensions of F are MLT^{-2}, what are the dimensions required of C? (The dimensions of mass, length, and time are represented by the symbols M, L, and T respectively.)
(A) MLT^{-4} (B) ML^{-3} (C) $ML^{-2}T^{-1}$ (D) L^3M^{-1} (E) C is dimensionless

$$F = Cr^2v^2 \Rightarrow [C] = \frac{[F]}{[r]^2[v]^2} = \frac{ML/T^2}{L^2L^2/T^2} = \frac{M}{L^3} = ML^{-3}$$

3. P115-2021-MT1-Alt-A2 [5120571]
A building 60 m tall is 30 m by 90 m in cross section. If all four sides of the building are to be covered with a single layer of bricks, estimate, to within an order of magnitude, how many bricks would be required. Assume that each brick is 10 cm high by 20 cm wide. You may ignore the depth of the bricks and any windows or other openings.
○ 10^5 bricks ○ 10^8 bricks ○ 10^7 bricks ○ 10^4 bricks ○ 10^6 bricks

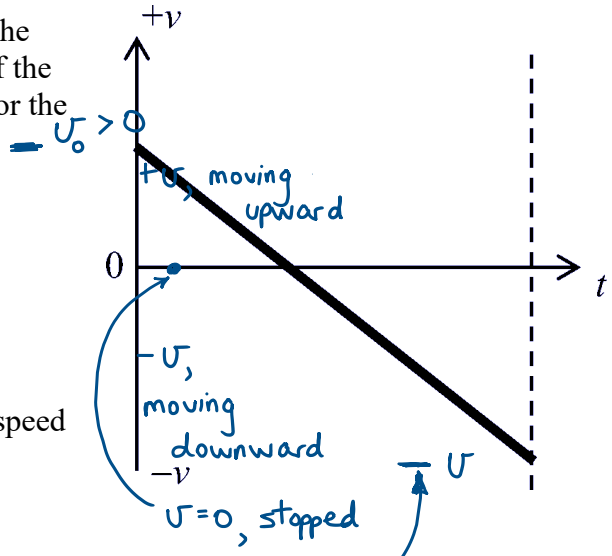
Total area of walls $= 2 \times 60\text{m} \times 30\text{m} + 2 \times 60\text{m} \times 90\text{m}$

$$\#\text{ of bricks} = \frac{\text{total area}}{\text{area of 1 brick}} = \frac{120\text{m} \times (30\text{m} + 90\text{m})}{0.10\text{m} \times 0.20\text{m/brick}}$$

$$\#\text{ of bricks} = \frac{120\text{m} \times 120\text{m}}{0.020\,\text{m}^2/\text{brick}} = \frac{12 \times 10^1\,\text{m} \times 120\text{m}}{2 \times 10^{-2}\,\text{m}^2/\text{brick}}$$

$$\#\text{ of bricks} = 6 \times 10^3 \times 1.2 \times 10^2 \text{ bricks} = 10^6 \text{ bricks}$$

4. P115-2021-MT1-Alt-A3 [5120815]
An elevator moves in a vertical elevator shaft. We choose the positive direction to be up. The graph shows the velocity of the elevator as a function of time. Which statement is correct for the time period shown?



- The elevator was at rest at time $t = 0$. ✗
- The elevator did not change direction. ✗
- The elevator was always going up. ✗
- The elevator did not stop. ✗
- At the end of the time period the elevator had a higher speed than at time $t = 0$. ✓

$|v| > v_0$.

5. P115-2021-MT1-Alt-A4 [5120581]
A sprinter warms up before a race by running along a straight line. It is not known if he runs back and forth or only in one direction. Which one of the following statements is true in either case?

- His average speed must be smaller than the magnitude of his average velocity. ✗
- His average speed must be larger than the magnitude of his average velocity. ✗
- His average speed may be zero. ✗
- His average speed must be equal to the magnitude of his average velocity. ✗
- → His average speed is larger than or equal to the magnitude of his average velocity. ✓

If the runner runs in only one direction, then his average speed equals the magnitude of his average velocity. If the runner runs back and forth, then his total distance covered (path length) is greater than his displacement, and therefore his average speed is greater than the magnitude of his average velocity.

6. P115-2021-MT1-Alt-A5 [5120579]
A ball is thrown horizontally off the roof of a building with an initial speed of v_o. The ball reaches the horizontal, level ground in a time of t_1. A second, identical ball is thrown horizontally off the roof with an initial speed of $2v_o$. In terms of t_1, how long does it take the second ball to reach the ground?

○ $t_1/4$ ○ $2t_1$ ○ $4t_1$ ○ $t_1/2$ ○ t_1

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

Since Δy, v_{oy}, and a_y are the same in both cases, $t_2 = t_1$

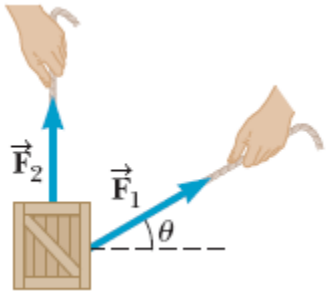
7. P115-2021-MT1-Alt-A6 [5120804]
Suppose you are carrying a ball and running at a constant velocity. You wish to throw the ball and catch it as it comes back down. Neglecting air resistance, which one of the following actions should you do?

○ Throw the ball straight up in the air and slow down to catch it.
○ Throw the ball straight up in the air and stop to catch it.
○ Throw the ball at an angle of about 60° with the horizontal and maintain the same velocity. ○ Throw the ball at an angle of about 45° with the horizontal and maintain the same velocity. ○ Throw the ball straight up in the air and maintain the same velocity. ←

If you throw the ball straight up it will be in projectile motion relative to the ground with a horizontal component of velocity equal to your velocity when you threw the ball. Therefore, if you maintain the same velocity, you will always be directly under the ball and will be able to catch it when it comes back down. If you throw the ball at an angle, then it will be moving horizontally relative to you and will hit the ground ahead of you if you maintain the same velocity.

8. P115-2021-MT1-Alt-B1 [5120549]

Forces are vector quantities. In the figure below, a force $\vec{F}_1$ of magnitude 5.50 units acts on an object at the origin in a direction $\theta = 26.0°$ above the positive x-axis. A second force $\vec{F}_2$ of magnitude 5.00 units acts on the object in the direction of the positive y-axis. To receive full marks, you must include a diagram showing the physical situation and the coordinate system.



(a) Calculate the magnitude of $\vec{F}_1 + \vec{F}_2$. (8.91 units)

$F_{res,x} = F_{1x} + F_{2x}$ $\qquad$ $F_{res,y} = F_{1y} + F_{2y}$

$F_{res,x} = +F_1 \cos\theta + 0$ $\qquad$ $F_{res,y} = +F_1 \sin\theta + F_2$

$F_{res,x} = (+5.50 \text{ units}) \cos(26.0°)$ $\qquad$ $F_{res,y} = (+5.50 \text{ units})(\sin(26.0) + 5.00 \text{ units}$

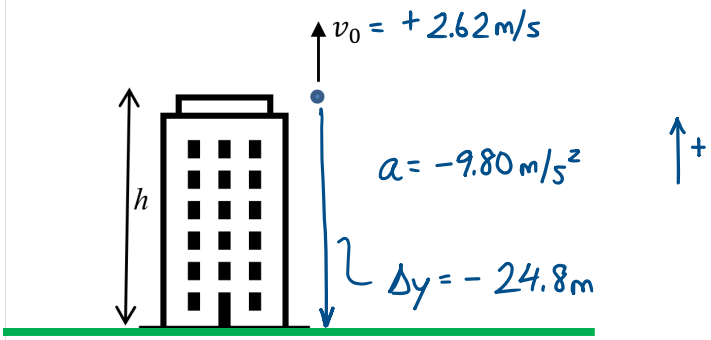
$F_{res,x} = 4.943 \text{ units}$ $\qquad$ $F_{res,y} = 7.411 \text{ units}$

$F_{res} = \sqrt{F_{res,x}^2 + F_{res,y}^2} = 8.91 \text{ units}$

(b) Calculate the direction (in degrees from the +x-axis) of $\vec{F}_1 + \vec{F}_2$. (56.3°)

$\tan\theta_{res} = \dfrac{F_{res,y}}{F_{res,x}} \Rightarrow \theta_{res} = \text{invtan}\left(\dfrac{7.411 \text{ units}}{4.943 \text{ units}}\right) = 56.3°$

9. P115-2021-MT1-Alt-B2 [5120825]
A person reaches out from the top of a building of height h = 24.8 m and throws a ball directly up with a speed v_0 of 2.62 m/s. You may ignore air resistance. To receive full marks, you must include a diagram showing the physical situation and your choice of coordinate system.



(a) What is the speed of the ball when it reaches the ground below? (22.2 m/s)

$$v^2 = v_0^2 + 2a\Delta y \Rightarrow v = \left[(+2.62\,m/s)^2 + 2(-9.80\,m/s^2)(-24.8\,m)\right]^{1/2}$$

$v = \pm 22.2\,m/s$. Take -ve root, because moving downward

$\therefore v = -22.2\,m/s$; speed $= |v| =$ **22.2 m/s**

(b) How much time elapses from when the ball was released to when it reaches the ground? (2.53 s)

$$v = v_0 + at \Rightarrow t = \frac{v - v_0}{a} = \frac{(-22.2\,m/s) - (+2.62\,m/s)}{-9.80\,m/s^2} = 2.53\,s$$

Alternate Solutions:

$$\Delta y = \tfrac{1}{2}(v + v_0)t \Rightarrow t = \frac{2\Delta y}{v + v_0} = \frac{2(-24.8\,m)}{(-22.2\,m/s) + (+2.62\,m/s)} = 2.53\,s$$

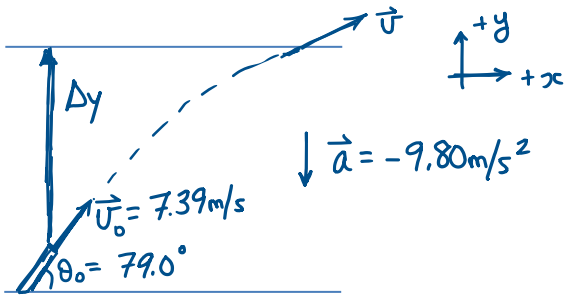
$$\Delta y = v_{0y}t + \tfrac{1}{2}at^2 \Rightarrow 0 = \tfrac{1}{2}at^2 + v_{0y}t - \Delta y$$

$$0 = \tfrac{1}{2}(-9.80\,m/s^2)t^2 + (+2.62\,m/s)t - (-24.8\,m)$$

$$0 = -4.90\,m/s^2\,t^2 + (2.62\,m/s)t + 24.8\,m$$

Solving the quadratic, $t =$ **+2.53 s**, −2.00 s

10. P115-2021-MT1-Alt-B3 [5120569]
A child is playing with a toy cannon. The child fires the cannon and a projectile is launched at 7.39 m/s at an angle of 79.0° above the horizontal. Calculate the speed (in m/s) with which the projectile strikes the ceiling, a height of 2.20 m above the end of the launcher. To receive full marks, you must include a diagram showing the trajectory of the projectile and your choice of coordinate system. (3.39 m/s)



x	y
$\Delta x = ?$	$\Delta y = +2.20 m$
$v_{0x} = v_0 \cos\theta_0$	$v_{0y} = v_0 \sin\theta_0$
$a_x = 0$	$a_y = -9.80 m/s^2$
$v_x = v_{0x}$	$v_y = ?$

$v_{0x} = v_0 \cos\theta_0 = (7.39 m/s)\cos(79.0°) = 1.410 m/s = v_x$ since $a_x = 0$

$v_{0y} = v_0 \sin\theta_0 = (7.39 m/s)\sin(79.0°) = 7.254 m/s$

$v_y^2 = v_{0y}^2 + 2a_y\Delta y \Rightarrow v_y = \left[(7.254 m/s)^2 + 2(-9.80 m/s^2)(+2.20 m)\right]^{1/2}$

$v_y = +3.083 m/s$

$v = \sqrt{v_x^2 + v_y^2} = \left[(1.410 m/s)^2 + (3.083 m/s)^2\right]^{1/2} = \boxed{3.39 m/s}$