**PHYS 1311 Spring 2023 Test 1**
Feb. 2, 2023

**Name** _____ **Student ID** _____ **Score** _____

**Note: This test consists of one set of conceptual questions, five problems, and a bonus problem. For the problems, you *must show all* of your work, calculations, and reasoning clearly to receive credit. Be sure to include units in your solutions where appropriate. An equation sheet is provided on the last page.**

**Problem 1. Conceptual questions**. State whether the following statements are *True* or *False*. (10 points total, no calculations required)

(a) The speedometer in a car measures the car's velocity.

(b) The following is a valid mathematical operation: $\vec{A} + |\vec{B}|$.

(c) The forces in Newton's second law of motion must be external forces.

**Problem 2.** The position of a particle is given by the function $x(t) = (2t^3 - 9t^2 + 12)$ m, where $t$ is in s. Determine (a) At what time or times is the velocity $v_x = 0$ m/s? (b) What are the particle's position and and acceleration at this time(s)? (15 points total)

**Problem 3.** A student standing on the ground throws a ball straight up. The ball leaves the student's hand with a speed of 15 m/s when the ball is initially 2.0 m above the ground. How long is the ball in the air before it hits the ground? (The student moves her hand out of the way). (15 points total)

**Problem 4.** Given vectors $\vec{A} =< 4, -2, 0 >$ m and $\vec{B} =< -3, 4, 0 >$ m, find the vector $\vec{C} = \vec{A} - 4\vec{B}$. (a) Write $\vec{C}$ in component form. (b) Make a sketch on a 2D coordinate system of $\vec{A}$, $\vec{B}$, and $\vec{C}$. (c) Find the magnitude and direction of $\vec{C}$. (15 points total)

**Problem 5.** A proton is accelerated to 0.999c. What is its momentum? (15 points total)

**Problem 6.** A soccer ball is kicked with a speed of 9.00 m/s at an angle of 30.0° above the horizontal. It the ball lands at the same level as from which it was kicked, determine (a) the maximum height the ball reaches, (b) the total time it is in the air, and (c) the total horizontal displacement of the ball. You must show all work. (30 points total)

**Bonus Problem.** You are watching an archery tournament when you start wondering how fast an arrow is shot from the bow. Remembering your PHYS 1311 course, you ask one of the archers to shoot an arrow parallel to the ground. You find the arrow stuck in the ground 60 m away, making a 3.0° angle with the ground. How fast was the arrow shot? (5 points)

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Equation Sheet

$$\Delta\vec{r} = \vec{r}_f - \vec{r}_i \qquad \vec{v}_{\text{avg}} = \frac{\Delta\vec{r}}{\Delta t} \qquad \vec{a}_{\text{avg}} = \frac{\Delta\vec{v}}{\Delta t} \tag{1}$$

$$\Delta t = t_f - t_i \qquad \vec{v} = \frac{d\vec{r}}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt} \qquad \vec{v}_{\text{avg}} = \frac{1}{2}(\vec{v}_i + \vec{v}_f) \tag{2}$$

$$x_f = x_i + \frac{1}{2}(v_{xi} + v_{xf})(t_f - t_i) \qquad y_f = y_i + \frac{1}{2}(v_{yi} + v_{yf})(t_f - t_i) \tag{3}$$

$$x_f = x_i + v_{xi}(t_f - t_i) + \frac{1}{2}a_x(t_f - t_i)^2 \quad y_f = y_i + v_{yi}(t_f - t_i) + \frac{1}{2}a_y(t_f - t_i)^2 \tag{4}$$

$$v_{xf} = v_{xi} + a_x(t_f - t_i) \qquad v_{yf} = v_{yi} + a_y(t_f - t_i) \tag{5}$$

$$v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i) \quad v_{yf}^2 = v_{yi}^2 + 2a_y(y_f - y_i) \quad \vec{a}_y = -g\hat{j} \tag{6}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}_{\text{net}}\Delta t \qquad \vec{p} \approx m\vec{v} \qquad \vec{p} = \gamma m\vec{v} \tag{7}$$

$$\gamma = \frac{1}{\sqrt{1 - (|\vec{v}|/c)^2}} \qquad \sum_j \vec{F}_j = \vec{F}_{\text{net}} = m\vec{a} = \frac{d\vec{p}}{dt} \tag{8}$$

$$\vec{J} = \vec{F}_{\text{net}}\Delta t = \int \vec{F}_{\text{net}}(t)dt \qquad |\vec{F}_{\text{grav}}| = mg \tag{9}$$

## Math relations and constants

$$\cos\theta = x/h \qquad \sin\theta = y/h \qquad \tan\theta = y/x \tag{10}$$

$$\vec{r} = |\vec{r}|\hat{r} \qquad |\vec{r}| = \sqrt{x^2 + y^2 + z^2} \tag{11}$$

$$az^2 + bz + c = 0 \qquad z = \frac{-b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} \tag{12}$$

$$\int t^n dt = t^{n+1}/(n+1) \quad (\text{if } n \neq -1) \qquad \int t^{-1}dt = \ln t \tag{13}$$

$$A = \pi r^2 \quad V = \frac{4}{3}\pi r^3 \quad g = 9.8 \text{ m/s}^2 \quad c = 2.998 \times 10^8 \text{ m/s} \tag{14}$$

$$m_e = 9.109 \times 10^{-31} \text{ kg} \quad m_p = 1.6726 \times 10^{-27} \text{ kg} \tag{15}$$