First Name_____ Last Name_____ NetID_____

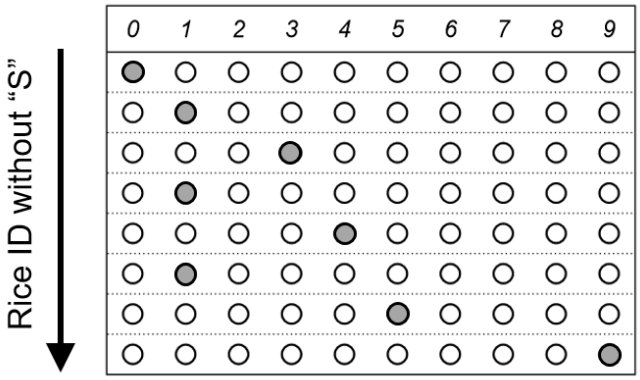
Physics 101 Fall 2022 Exam 1

Time allowed: 90 minutes, closed book

Instructions:
Please print your name and NetID in **two** places: on the top of this cover sheet, and on the multiple-choice answer sheet. If you use any additional paper for your work, please make sure to print your name on the top of each sheet and staple the extra sheets to this exam packet when you hand in your work at the end of the session. **(No name, No credit!)**

- There are 10 multiple choice questions and 3 free response questions in total.
- The maximum possible points are 100 points.
- Mark your answers to the multiple-choice questions on the answer sheet provided. Make sure to fill the appropriate bubble **completely** using a #2 pencil, or a black pen. Any multiple-choice responses written on pages other than the answer sheet will NOT be graded.
- Write all your solutions to the free response questions in the space provided in the exam packet, or on the extra space provided at the end of the exam packet. Make sure that it is very clear which problem your work corresponds to. If needed, extra papers will be provided at the front of the exam room. Remember to print your name on any extra sheets and staple them to the exam packet.
- When you finish, please place the exam packets and the multiple-choice answer sheet in two separate piles at the front of the exam room. If you use additional sheets of paper, make sure to staple them to the exam packet. Hand in all your work at the end of the 90-minute exam period.
- You are not allowed to take anything written away from the exam room.
- You may not use phones, computers, tablets, or any other web-connected device during the exam.
- You may not use the symbolic manipulation or graphing capabilities of your calculator. (You can look up trig functions, *i.e.*, calculating sin(45) is not a symbolic manipulation.)
- You may not store or use pre-stored formulae, saved in your calculator's memory, or anything written down in advance of entering the exam.

On your multiple-choice answer sheet, you will need to fill in your Rice ID. Beginning with the number “01”, enter your Rice ID by bubbling in one number per row. In the example below, the Rice ID entered is "S01314159".



Potentially Useful Constants, Integrals and Derivatives:

$g = 9.8\ \text{m/s}^2$

$$\int x^n\,dx = \frac{x^{n+1}}{n+1} \quad (\text{provided n} \neq \text{-1})$$

$$\int \frac{dx}{x} = \ln x$$

$$\int \sin ax\,dx = -\frac{1}{a}\cos ax$$

$$\int \cos ax\,dx = \frac{1}{a}\sin ax$$

$$\int e^{ax}\,dx = \frac{1}{a}e^{ax}$$

$$\frac{d}{dx}\left(ax^n\right) = nax^{n-1}$$

$$\frac{d}{dx}\left(\sin ax\right) = a\cos ax$$

$$\frac{d}{dx}\left(\cos ax\right) = -a\sin ax$$

$$\frac{d}{dx}\left(e^{ax}\right) = ae^{ax}$$

Rice Honor Code:

On my honor, I have neither given nor received any unauthorized aid on this exam.

Signature: _____

Multiple-Choice Questions: (4 points each)

1) Two cars, car 1 of mass m and car 2 of mass $2m$, are initially at rest and are then subject to identical constant forces. If in some time interval car 1 has traveled a distance d, the distance traveled in the same time interval by car 2 is _____.

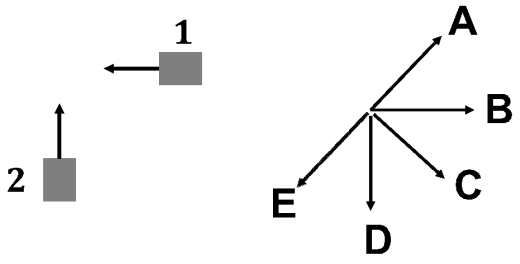
(a) $0.25d$
(b) $0.50d$
(c) $0.61d$
(d) $0.71d$
(e) d

2) Two objects are dropped from a bridge, an interval of 1.0 $second$ apart. Air resistance is negligible. During the time that both objects continue to fall, their separation _____.

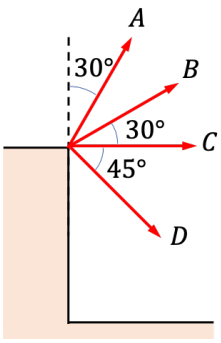
(a) increases.
(b) decreases.
(c) stay constant.
(d) increases at first, but then stays constant.
(e) decreases at first, but then stays constant.

3) At $t = 0$, two cars 1 and 2 are approaching an intersection with the same initial speed, and they are equal distances from the intersection as shown in the figure below. Sensing a possible collision, the timid driver of car 1 begins to slow down with an acceleration of magnitude a, whereas the aggressive driver in car 2 begins to speed up with an acceleration of magnitude a in order to pass in front of car 1. Which of the vectors shown best represents the acceleration of car 1 relative to car 2?

(a) Vector A
(b) Vector B
(c) Vector C
(d) Vector D
(e) Vector E

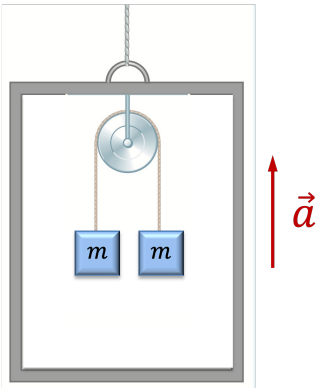


4) Projectiles are launched with equal speeds from the edge of a cliff at the angles indicated in the figure. For which case will the absolute value of the vertical component of the projectile's velocity upon hitting the ground be greatest?



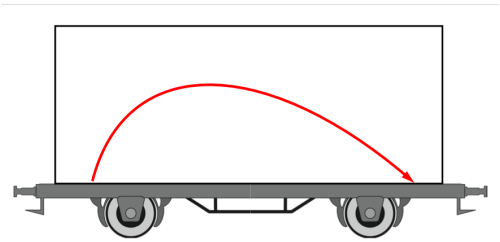
(a) Case *A*
(b) Case *B*
(c) Case *C*
(d) Case *D*
(e) None of these – it will be the same for all launch angles

5) Consider two identical 5-kg masses that are initially at rest suspended by a light string from a pulley anchored to the roof of an elevator that is also initially at rest. If the elevator is now given an upward acceleration of 2 m/s^2, the tension in the string will be ____. (*For simplicity, assume that* $g = 10\ m/s^2$.)



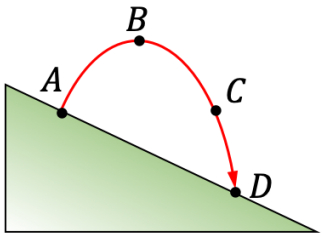
(a) 10 N
(b) 50 N
(c) 60 N
(d) 100 N
(e) 120 N

6) A passenger in a railroad car traveling on a level track tosses a stone from the back to the front of the car. If the trajectory of the stone relative to the car is as shown, we can conclude:



(a) The car is not moving.
(b) The car is moving to the right with constant speed.
(c) The car is moving to the left with constant speed.
(d) The car is accelerating to the right.
(e) The car is accelerating to the left.

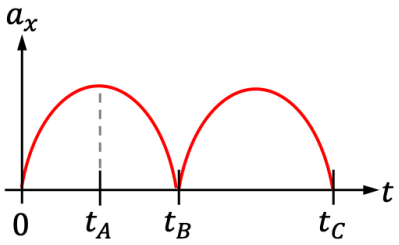
7) An object is launched down an inclined plane. Which of the following statements is/are correct? Points A and C are at the same vertical position.



I. The magnitude of its acceleration at point *B* is zero.
II. It moves with equal speeds at points *A* and *C*.
III. Its horizontal velocity component is greatest at point *D*.

(a) Statement I only
(b) Statement II only
(c) Statement III only
(d) Statements I and II only
(e) Statements II and III only

8) Consider the acceleration-time graph for an object that starts from rest at $t = 0$. Which of the following statements is/are true?

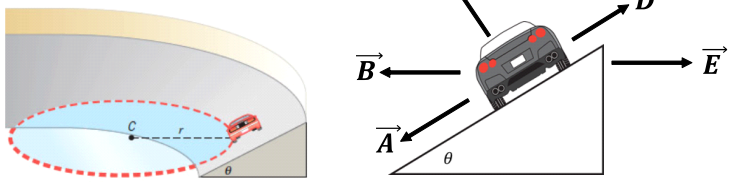


I. At time t_A the velocity is zero.
II. At point t_B the velocity is negative.
III. The net displacement of the object between $t = 0$ and t_C is zero.

(a) Statement I only
(b) Statement II only
(c) Statement III only
(d) Statements I and II only
(e) None of the statements are true.

9) A car is moving around a banked curve of radius r at constant speed without sliding. The car is moving directly into the page. Which of the vectors shown corresponds most nearly to the car's acceleration?

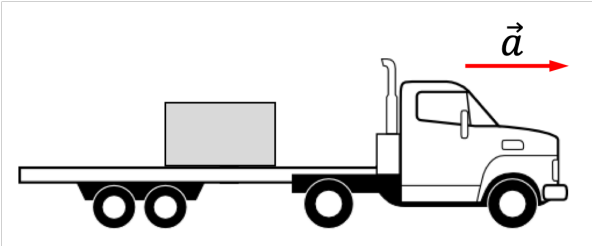
(a) Vector A
(b) Vector *B*
(c) Vector *C*
(d) Vector *D*
(e) Vector *E*



10) A crate is secured to the bed of a truck. If the truck is accelerating to the right (i.e., in the +x direction), which of the following statements is/are true?

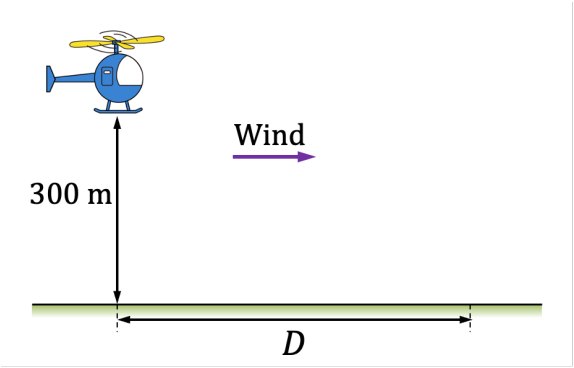
I. The crate exerts a force on the truck in the +x direction.
II. The road experiences a force from the truck in the +x direction.
III. The net force on the truck is zero.

(a) Statement I only
(b) Statement II only
(c) Statement III only
(d) Statements I and II only
(e) None of the statements are true



Free-Response Questions: (20 points each)

1) As part of an overly dramatic kinematics demonstration, your PHYS 101 instructor decides to drop a soccer ball from rest at $t = 0$ from a helicopter that hovers stationary at an altitude of $y = 300$ meters above the horizontal ground. When the soccer ball is released from rest, a strong steady crosswind gives the soccer ball a constant 2.0 m/s^2 horizontal component of acceleration but does not affect its vertical motion. The crosswind continues to be in effect until the ball hits the ground. You can consider the horizontal position of the ball at $t = 0$ to be at $x = 0\ m$. For this problem, the magnitude of the acceleration due to gravity is $g = 9.8$ m/s^2.



(a) What is the magnitude of the acceleration of the soccer ball as it moves through the air?

(b) How long is the soccer ball in the air before it first hits the ground?

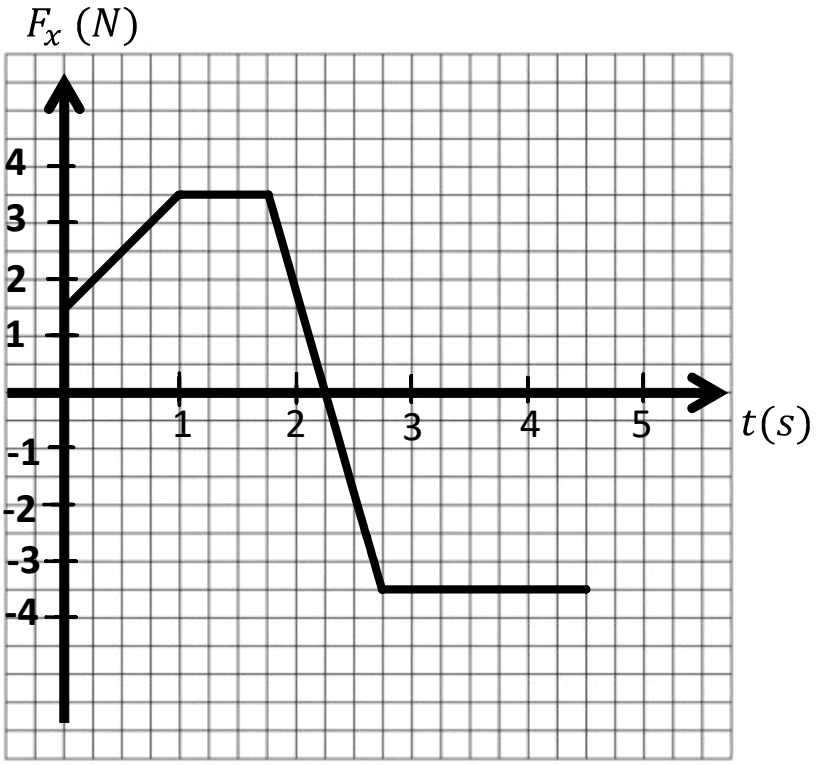
1) (continued):

(c) What horizontal distance D does the soccer ball travel before it first hits the ground?

(d) What is the velocity of the soccer ball when it first hits the ground? *Report your answer using the Cartesian unit vectors $\hat{\imath}$ and $\hat{\jmath}$.*

(e) Plot the horizontal component of the soccer ball's velocity vector from $t = 0$ to when it hits the ground.

2) The graph below shows the x-component of the net force on a 5-kg object as a function of time. At $t = 0$, the object's speed is zero and the object is at $x = 0$.



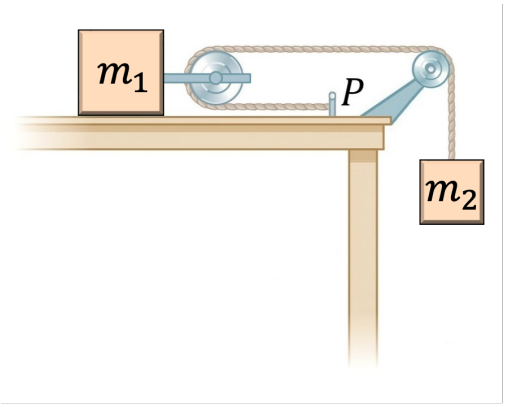
(a) What is the x-component of the object's acceleration at $t = 1\ s$?

2) (continued):

(b) What is the x-component of the object's velocity at $t = 1.75\ s$?

(c) At what time does the object reach its maximum displacement along the x-axis from $x = 0$?

3) A block of mass m_2 hangs on the end of a light cord and is connected to a second block of mass m_1 by the pulley arrangement shown in the figure below. The pulleys have negligible mass and no friction, and the light cord does not stretch. When released from rest, mass m_2 begins to accelerate downwards and mass m_1 moves without friction.



(a) Find a numerical expression for the ratio a_1/a_2 where a_1 is the magnitude of the acceleration of mass m_1 and a_2 is the magnitude of the acceleration of mass m_2.

(b) Draw free body diagrams for mass m_1 and mass m_2, with all forces clearly labeled.

3) (continued):

(c) Find a symbolic expression for a_2, the magnitude of the acceleration of mass m_2, when block m_2 is moving downward. *Express your answer in terms of the symbols m_1, m_2, g, as needed.*

(d) Find a symbolic expression for the magnitude of the tension force T in the light cord while block m_2 is accelerating downwards. *Express your answer in terms of the symbols m_1, m_2, g, as needed.*

Extra Work Space (Clearly indicate which problem your work corresponds to):