Physics 221
Quiz 2, Form: A

Name: _____

Date: _____

1. Which of these equations should you use to calculate the momentum of an electron moving at nearly the speed of light?
   (a) $\vec{p} = (m/\sqrt{1 - |\vec{v}|^2/c^2})\vec{v}$
   (b) $\vec{p} = m\vec{v}$
2. Which of these equations is an approximation that can only be used for objects moving slowly compared to the speed of light? It's especially useful for macroscopic objects like toys, people, cars, roller coasters, satellites, planets, etc.
   (a) $\vec{p} = (m/\sqrt{1 - |\vec{v}|^2/c^2})\vec{v}$
   (b) $\vec{p} = m\vec{v}$
3. As a particle's speed gets closer to the speed of light–the universal speed limit–its relativistic mass
   (a) remains the same because it is independent of speed.
   (b) decreases.
   (c) increases.
4. Suppose that in a Star Trek episode, an enemy space ship is approaching the *USS Enterprise* at a speed of $0.95c$ and turns on a laser. The speed of the laser light in the reference frame of the enemy spaceship is c (3×10^8 m/s). Captain Picard on the *Enterprise* measures the speed of the laser light as
   (a) $0.05c$
   (b) $0.95c$
   (c) less than c, but not $0.05c$ or $0.95c$
   (d) greater than c
   (e) c
5. According to Newton's first law, if an object does not interact with anything or if the effects of its interactions cancel each other out, then its velocity (and therefore momentum) must be
   (a) zero.
   (b) constant.
   (c) positive.
   (d) negative.
   (e) equal to the speed of light.
6. The Moon travels at a constant speed in a circular path around the Earth. Newton understood that this implied that
   (a) there is no interaction between the Moon and Earth.
   (b) the net interaction due to the Sun and Earth pulling on the Moon must be zero.
   (c) there is an interaction between the Moon and Earth.

7. When two objects touch, like your hand pushing against your physics book, they fundamentally interact according to

   (a) a gravitational interaction.

   (b) a strong nuclear interaction.

   (c) a weak nuclear interaction.

   (d) an electromagnetic interaction.

Questions 8– 10: A billiard ball on a billiards table has a momentum $< 3, 0, 4 >$ kg m/s.

8. What is its direction, expressed as a unit vector?

   (a) $< 1/3, 0, 1/4 >$

   (b) $< -3, 0, -4 >$

   (c) $< 1, 0, 1 >$

   (d) $< 0.6, 0, 0.8 >$

   (e) $< 0.9, 0, 0.16 >$

9. When a stick strikes the ball, a net force of $< 10, 4, -3 >$ N acts on the billiard ball for 0.1 s. What is the final momentum of the ball after it is struck?

   (a) $< 4, 0.4, 3.7 >$ kg m/s

   (b) $< 0.1, 0.4, -0.3 >$ kg m/s

   (c) $< 0.3, 0, 0.4 >$ kg m/s

   (d) $< 7, 0, -7 >$ kg m/s

   (e) $< 13, 4, 1 >$ kg m/s

10. According to the momentum principle, the change in momentum of the billiard ball and the net force on the billiard ball

    (a) are in opposite directions.

    (b) are in the same direction.

    (c) are not necessarily in the same or opposite directions, but can be.

11. Suppose you write a VPython program simulating the motion of two GPS satellites around the Earth. Which of these equations will give you a vector that points from Satellite A to Satellite B (i.e. the position of Satellite B with respect to Satellite A)?

    (a) $\vec{r}_B$

    (b) $\vec{r}_A$

    (c) $\vec{r}_A + \vec{r}_B$

    (d) $\vec{r}_A - \vec{r}_B$

    (e) $\vec{r}_B - \vec{r}_A$

12. You are writing VPython code that will create an arrow object that is the position vector of Satellite B with respect to Satellite A (see previous question). Fill in the blanks of the code below. Your answer should NOT use numbers but should instead refer to the position of satelliteA and/or the position of satelliteB.

    satelliteA=sphere(pos=vector(7e6,0,0), radius=1e6, color=color.red)

    satelliteB=sphere(pos=vector(6.5e6,-5.5e6,8e6), radius=1e6, color=color.blue)

    arrow(pos= _____ **axis=**_____**)**

Questions 13– 14: You are working as a consultant to a theme park. You job is to ensure the safety of the children's rides. Fortunately, you have knowledge and experience in physics, human anatomy and physiology, and computers so that you can calculate the net force on a child, write a simulation, and understand whether the strain on a child's body will be too much to be healthy.

For this particular project, you are studying a children's roller coaster.

13. A child of mass 20 kg who is riding the roller coaster has a speed of 5 m/s in the direction $< 1, 0, 0 >$. What is the momentum of the child? (Remember that momentum is a vector and should be expressed in component form.)

14. Two seconds later, the child's velocity is 3 m/s in the direction $< 0.333, 0.667, 0.667 >$. What was the net force on the child during this time interval? (You already know the child's initial momentum, but you will need to first calculate the final momentum of the child. Remember that net force is a vector and should be expressed in component form.)

Answer Key for Exam A

1. (a)
2. (b)
3. (c)
4. (e)
5. (b)
6. (c)
7. (d)
8. (d)
9. (a)
10. (b)
11. (e)
12. satelliteA.pos
    satelliteB.pos – satelliteA.pos
13. $\vec{p} = m\vec{v} = (20)(5) < 1, 0, 0 >=< 100, 0, 0 >$ kg m/s
14. $\vec{F_net} = \Delta\vec{p}/\Delta t = (< 20, 40, 40 > - < 100, 0, 0 >)/2 =< -40, 20, 20 >$ N