Physics 221 Name: ______________________

Practice Quiz — chapter 1, Form: A Date: ______________________

1. If you travel around a loop on a roller coaster, you feel "heavy" at the bottom and you feel "light" at the top. Consider the roller coaster shown below.

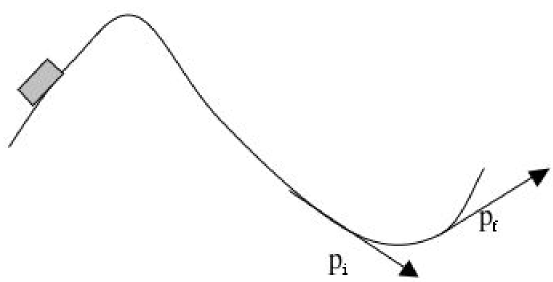


Figure 1:

Your momentum just before the dip and your momentum just after the dip are shown in the picture. Sketch the direction of the change in momentum $\Delta\vec{p}$ for the roller coaster and sketch the direction of $\vec{F}_{net}$ on the roller coaster during this time interval. (Note: you must construct it correctly using the vectors shown. You may not simply guess and draw a vector.)

2. A space probe is moving in the $-y$ direction when a thruster briefly fires and exerts a force on the probe in the +x direction. After a time interval Δt, the thruster stops firing. Which path below is the path of the space probe before, during, and after the thruster fired. (Circle or otherwise mark the correct path.)

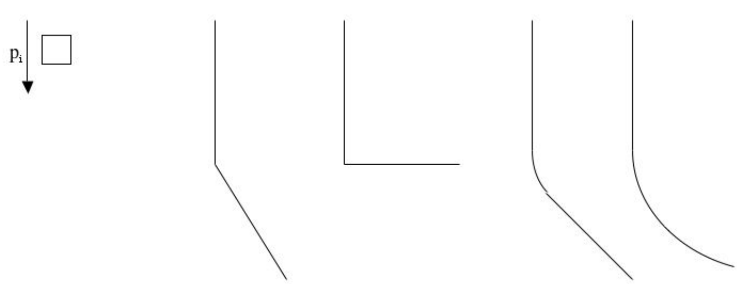


Figure 2:

3. At a certain instant of time t, a star is located at $< 6 \times 10^{10}, 9 \times 10^{10}, 8 \times 10^{10} >$ m and a planet is located at $< -8 \times 10^{10}, -4 \times 10^{10}, 8 \times 10^{10} >$ m. What is the vector pointing from the planet to the star?

4. What is the distance $|\vec{r}|$ from the star to the planet?

Questions 5–8: A hockey puck slides on ice. Consider the origin to be at the center of the rink; the plane of the rink is the xy plane. At time t = 0 s, a hockey puck is observed to be at the location $< -5.0, -4.0, 0 >$ m. At time t = 0.40 seconds the puck is observed at the location $< 5.0, 2.0, 0 >$ m.

5. On a x-y coordinate system, with +y toward the top edge of the page and +x drawn to the right, sketch the initial position vector, the final position vector, and the displacement vector for the puck during this time interval.

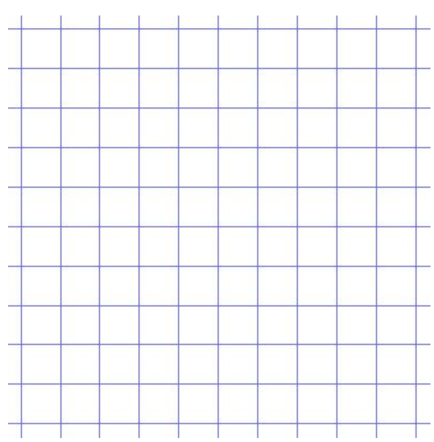


Figure 3:

6. What is the average velocity of the hockey puck during this time interval? Show all work.

7. What is the magnitude of the average velocity? Show all work.

8. What is the direction of the velocity (i.e. the unit vector) and what angle does it make with respect to the +x axis? Show all work.

9. Write an equation for the definition of the momentum of a particle that is valid at all speeds. Also write the approximate momentum for a particle moving at speeds much less than the speed of light. Your answer must be exactly correct to receive credit, including vectors, correct subscripts, etc. There is no partial credit.

10. Write the most general equation for the momentum principle (Newton's second law). Your answer must be exactly correct to receive credit, including arrows for vectors, correct subscripts, etc. There is no partial credit. (Note: the equation can be written in multiple ways.)

Questions 11–12: For the following questions, give your answers with three significant figures.

An object of mass 0.500 kg has a momentum $< 2.00, 8.00, 5.00 >$ kg m/s and is at the location $\vec{r} =< -2.00, 1.00, -1.00 >$ m. At this instant the object is acted on by a force $< 20.0, -50.0, 75.0 >$ N for 3.00×10^{-3} s (3 milliseconds).

11. What is the momentum of the object at the end of this time interval? Show all your work.

12. Assuming that the object has a constant momentum that is equal to its final momentum and assuming that the object starts at its initial position $\vec{r} =< -2.00, 1.00, -1.00 >$ m. What is its position after $\Delta t = 0.003$ s? (Note: your calculation will be correct for a small time interval but incorrect for large time intervals.)

13. At a certain instant of time, the forces on a 1000-kg boat are $\vec{F}_{grav} =< 0, -1 \times 10^{-4}, 0 >$ N and $\vec{F}_{water} =< 3000, 1 \times 10^{-4}, 0 >$ N and $\vec{F}_{air} =< -1000, 1 \times 10^{-4}, 0 >$ N. What is the net force on the boat and what is its acceleration at this instant?

14. You toss a ball vertically upward. The ball leaves your hand at a height of 1.0 m above the ground, rises 3.0 m above your hand, and lands on the ground. Sketch a motion map for the ball, showing it on the way up and on the way down, and calculate the total time of flight of the ball.

15. Sketch a y-position vs. time graph and a x-position vs. time graph for the ball. Properly label and title the graphs.

16. State Newton's first law.

17. State Newton's third law.

Answer Key for Exam A

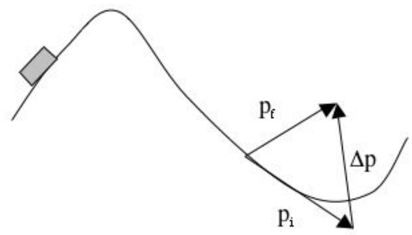


Figure 4:

1.

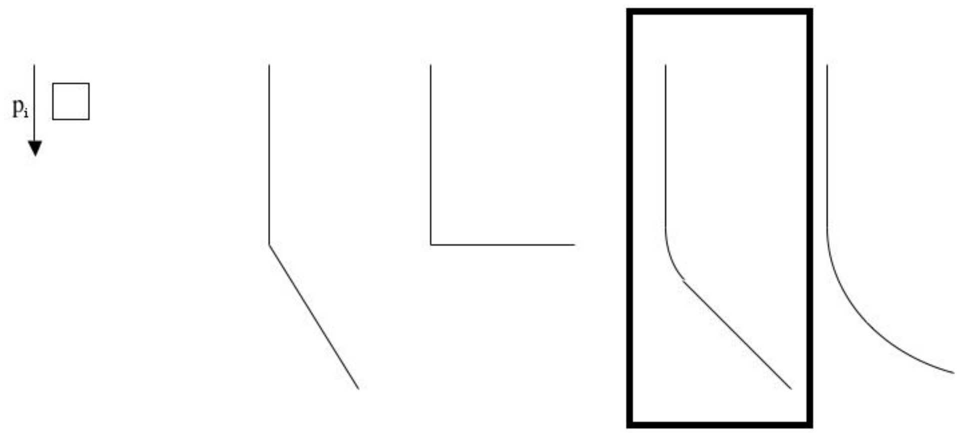


Figure 5:

2.

3.

$$\vec{r} = \vec{r}_s - \vec{r}_p = < 6\times10^{10}, 9\times10^{10}, 8\times10^{10} > - < -8\times10^{10}, -4\times10^{10}, 8\times10^{10} > = < 14\times10^{10}, 13\times10^{10}, 0 > \text{ m}$$

4.

$$|\vec{r}| = |\vec{r}_p - \vec{r}_s = < 6 \times 10^{10}, 9 \times 10^{10}, 8 \times 10^{10} > - < -8 \times 10^{10}, -4 \times 10^{10}, 8 \times 10^{10} > |$$

$$= \sqrt{14e10^2 + 13e10^2} = 1.91 \times 10^{11} \text{ m}$$

5.

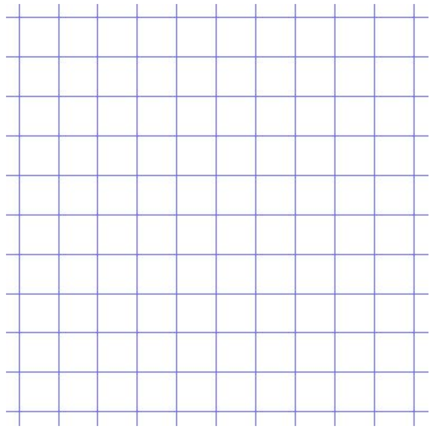


Figure 6:

6.

$$\vec{v} = \frac{\Delta \vec{r}}{\Delta t} = \frac{< 5, 2, 0 > \text{m} - < -5, -4, 0 > \text{m}}{0.4 \text{ s}} = \frac{< 10, 6, 0 > \text{m}}{0.4 \text{ s}} =< 25, 15, 0 > \text{m/s}$$

7.

$$|\vec{v}| = \sqrt{25^2 + 15^2 + 0^2} = 29 \text{ m/s}$$

8.

$$\hat{v} = \frac{\vec{v}}{|\vec{v}|} = \frac{< 25, 15, 0 > \text{m/s}}{29.1\text{m/s}} =< 0.86, 0.52, 0 >$$

$$\theta = \tan^{-1} \frac{|v_y|}{|v_x|} = \tan^{-1} \left(\frac{15}{25} \right) = 31^\circ$$

9.

$$\vec{p} = \frac{m\vec{v}}{\sqrt{1 - \frac{|\vec{v}|^2}{c^2}}}$$

$$\vec{p} \approx m\vec{v} \quad \text{for speeds much less than the speed of light}$$

10.

$$\Delta\vec{p} = \vec{F}_{net}\Delta t \text{ for a small time interval}$$

or

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t \text{ for a small time interval}$$

or

$$\vec{F}_{net} = \frac{\Delta\vec{p}}{\Delta t} \text{ for a small time interval}$$

or

$$\vec{F}_{net} = \frac{d\vec{p}}{dt}$$

11.

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t =< 2, 8, 5 > + < 20, -50, 75 > (3 \times 10^{-3}) =< 2.06, 7.85, 5.23 > \text{ kg m/s}$$

12.

$$\vec{r}_f = \vec{r}_i + \vec{v}\Delta t$$
$$\vec{r}_f = \vec{r}_i + \left(\frac{\vec{p}}{m}\right)\Delta t$$
$$\vec{r}_f =< -2, 1, -1 > \text{ m} + \left(\frac{< 2.06, 7.85, 5.23 > \text{kg m/s}}{0.5 \text{ kg}}\right)(0.003 \text{ s})$$
$$\vec{r}_f =< -1.99, 1.05, -0.969 > \text{m}$$

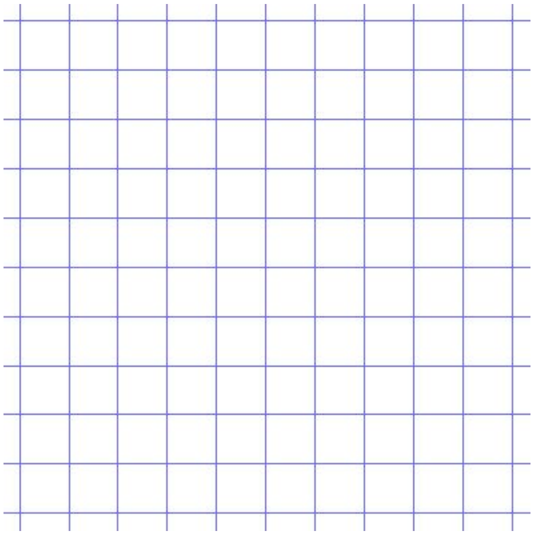
13.

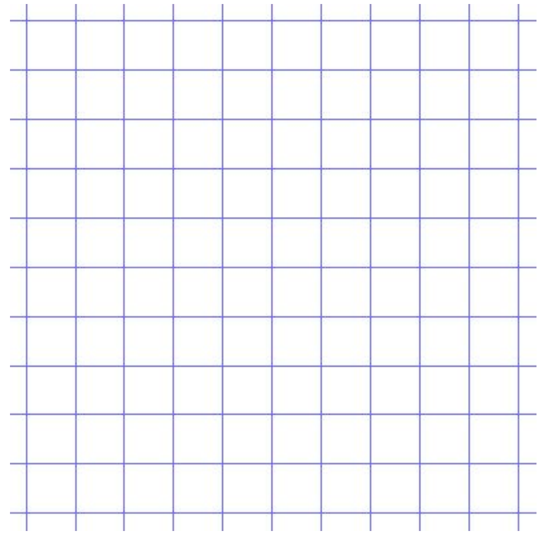
$$\vec{F}_{net} = \vec{F}_{grav} + \vec{F}_{water} + \vec{F}_{air}$$
$$\vec{F}_{net} =< 0, -1\times10^{-4}, 0 > \text{ N} + < 3000, 1\times10^{-4}, 0 > \text{ N} + < -1000, 1\times10^{-4}, 0 > \text{ N} =< 2000, 0, 0 > \text{ N}$$
$$\vec{F}_{net} = \frac{\Delta\vec{p}}{\Delta t} = m\vec{a} \quad \text{for constant mass}$$
$$\vec{a} = \vec{F}_{net}/m = \frac{< 2000, 0, 0 > \text{ N}}{1000\text{kg}} = \vec{2}00\text{m/s}^2$$

14.

$$\text{to rise or fall a distance h} \quad t = \sqrt{\frac{2h}{g}}$$
$$t_{up} = \sqrt{\frac{2(3 \text{ m})}{9.8 \text{ m/s}^2}} = 0.78s$$
$$t_{down} = \sqrt{\frac{2(4 \text{ m})}{9.8 \text{ m/s}^2}} = 0.90 \text{ s}$$
$$t_{total} = 0.78 \text{ s} + 0.90 \text{ s} = 1.68 \text{ s}$$

15.





16. Our textbook's definition is: *An object moves in a straight line and at constant speed except to the extent that it interacts with other objects.*

    However, the main idea is that if the net force on an object is zero, then the object's velocity will be constant. If the object is at rest, it will remain at rest. If it is moving, then it will move in a straight line at constant speed, as long as the net force on the object is zero.

17. Newton's third law governs interactions. If object A exerts a force on object B, then object B exerts an equal magnitude force on object A, but in the opposite direction.