University of Alabama
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PH 105 LeClair | Summer 2012

Quiz 4: momentum and such

1. A rubber ball strikes a brick wall with a velocity (just before the collision) of $\vec{\mathbf{v}}_i = 3.0\hat{\imath}+4.0\hat{\jmath}$ m/s. It rebounds with a velocity of $\vec{\mathbf{v}}_f = -3.0\hat{\imath}+4.0\hat{\jmath}$ m/s, *i.e.*, the collision was perfectly elastic. What can be said about the change in momentum of the rubber ball?

- □ The momentum $\vec{\mathbf{p}}$ did not change, since the collision was elastic.
- ■ The momentum $\vec{\mathbf{p}}$ changed direction, its magnitude is the same.
- □ The momentum $\vec{\mathbf{p}}$ decreased.
- □ The momentum $\vec{\mathbf{p}}$ increased.
- □ The question cannot be answered, we do not know the mass of the ball.

Solution: The magnitude of the momentum $|\vec{\mathbf{p}}|=m|\vec{\mathbf{v}}|$ is the same in either case, but its direction has changed. Both before and after the collision, $|\vec{\mathbf{v}}|=3^2+4^2=5^2$, so independent of the mass, $|\vec{\mathbf{p}}|$ is constant.

2. Which of the following is in error?

- □ $\vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$
- □ $K = \frac{p^2}{2m}$
- □ $\vec{\mathbf{p}} = m\frac{d\vec{\mathbf{x}}}{dt}$
- ■ $\Delta\vec{\mathbf{p}} = \int \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}}$

Solution: With $p = mv$ and constant mass m, all are true but the last option, it should be $\Delta\vec{\mathbf{p}}=\int \vec{\mathbf{F}}\,dt$.

3. A 60 kg person standing on a frictionless surface fires a 0.5 kg arrow horizontally at 50 m/s. With what velocity does the archer move backwards across the ice after firing the arrow?

- □ $v_{\text{archer}} = +0.42$ m/s
- ■ $v_{\text{archer}} = -0.42$ m/s
- □ $v_{\text{archer}} = -0.84$ m/s
- □ $v_{\text{archer}} = +0.84$ m/s

Solution: Conservation of momentum: initially there is zero momentum, so afterwards we must have $m_{\text{archer}}v_{\text{archer}}+m_{\text{arrow}}v_{\text{arrow}} = 0$. The archer's velocity must be negative, ruling out two answers right off the bat. Solving for v_{archer} and plugging in the numbers, $v_{\text{archer}} = +0.42\,\text{m/s}$.

4. A ball of mass m is dropped from rest at a height h. What is the magnitude of the ball's momentum just before impact?

- ☐ $2mgh$
- ☐ $m\sqrt{gh}$
- ■ $m\sqrt{2gh}$
- ☐ $\sqrt{2mgh}$

Solution: The ball starts at height h above the ground, with potential energy $U_i = mgh$. It reaches the ground with zero potential energy, and thus kinetic energy $K_f = \frac{1}{2}mv^2 = U_i = mgh$. This gives the velocity as the ball strikes the ground as $v = \sqrt{2gh}$, so the momentum is $p = mv = m\sqrt{2gh}$.