NEWTON'S 3RD LAW: ACTIONS AND REACTIONS ANSWER KEY

***Instructions**: Use complete sentences and your knowledge of Newton's 3rd Law to answer the following questions completely in your journal. Draw FBDs when necessary.*

1. Clearly **explain**: If the force on the bullet and the force on the gun are truly equal in magnitude, why not just turn the gun around and fire it?
   Even though the forces are equal in magnitude, since the bullet has a smaller mass, it will have a larger acceleration!

2. Why bother lifting weights?! If you push up on the bar with a force, the reaction force of the bar pushing down on you is equal in magnitude! **How** can you ever hope to move the bar?
   Third law pair forces do not act on the same object, so they don't cancel out. The force you exert on the bar will provide a net upward force.

3. Consider the truck and the VW Beetle.
   a. Which experiences the **greater force** of impact?
      They will experience impact forces of equal magnitude.
   b. Why would a non-Physics student insist that the VW experienced a large impact force?
      The VW Beetle has a smaller mass, so it will have a greater acceleration. This causes more damage to the car.

4. Identify the **action-reaction forces** (3rd law pair) for a rocket being propelled through the vacuum (no air!) of space.
   The exhaust exerts a reaction force on the rocket that propels it forward.

5. Identify at least two **3rd law pairs** for the situation to the right. (For a challenge, identify all 3 pairs!) **Important: 3rd law pairs DO NOT cancel out!*
   3rd Law Pair 1 is between the 10 N weight and the spring scale
   3rd Law Pair 2 is between the spring scale and the hook
   3rd Law Pair 3 is between the hook and the ceiling
   (There are additional pairs for the weights of the objects as well)

6. In the situation to the left, list the two **3rd law pairs** present and determine the **net force** on the scale.
   3rd Law Pair 1 is between the 10 N weight and the spring scale
   3rd Law Pair 2 is between the spring scale and the hand
   Since 2 of these forces act on the spring scale in opposite directions and both have magnitudes of 10 N, the net force on the scale is 0 N.

7. Let's say that all 7,058,343,499 people on Earth are shoved into a capsule and dropped toward the Earth. The mass of the capsule is 50kg (7 x 10^9) = 3.5 x 10^{11} kg and the mass of the Earth is 6.0 x 10^{24} kg.
    a. What is the **reaction force** to the force due to gravity pulling down on the capsule? List force written in 3rd law notation, the magnitude, and the direction.
    The reaction force is the force of the capsule on the Earth. The magnitudes of the forces in the third law pair are the equal and opposite, so the magnitude of the force of the weight is:

$$F_{Earth\to capsule} = F_g = m \cdot g = (3.5 \times 10^{11}\ \text{kg}) \cdot \left(9.80\ {}^{\text{m}}/_{s^2}\right)$$
$$= 3.4 \times 10^{12}\ \text{N downwards}$$
$$\boxed{F_{capsule\to Earth} = 3.4 \times 10^{12}\ \text{N upward}}$$

    b. Calculate the **acceleration of the Earth** in this situation.

$$F_{NET} = F_{capsule\to Earth} = 3.4 \times 10^{12}\ \text{N upward}$$
$$F_{NET} = ma \leadsto a = \frac{F_{NET}}{m} = \frac{3.4 \times 10^{12}\ \text{N}}{6.0 \times 10^{24}\ \text{kg}}$$
$$\boxed{a = 5.7 \times 10^{-13}\ {}^{\text{m}}/_{s^2}}$$

8. **Resolve** the horse and cart problem from the cool-down today.
    Looking at the wagon in the diagram above, you can see that there is just one force exerted on the wagon - the force that the horse exerts on it. The wagon accelerates because the horse pulls on it!