Newton's 3rd Law Worksheet

N3: All forces come in pairs due to interactions between two objects.

Such pairs of forces:

1. Act on different objects
2. Act at the same time
3. Are the same type of force
4. Are of equal magnitude
5. Are in opposite directions to each other (by 180°)
6. Act along the same straight line joining the centres of the objects

Questions

1. A heavy book sits completely still on a flat wooden desk. A student claims that the downward weight of the book and the upward normal contact force from the desk form a Newton's third law pair because they are equal and opposite.

    a. Identify the two specific objects interacting to cause the book's weight.

    b. State the actual Newton's third law pair force to the book's weight, specifying its direction and the object it acts upon.

2. A skydiver is falling through the air at a constant terminal velocity. The downward gravitational pull of the Earth on the skydiver is exactly balanced by the upward air resistance pushing against the skydiver.

    Explain why the downward gravitational force and the upward air resistance force do not form a Newton's third law pair, even though they are equal in size and opposite in direction.

3. Two ice skaters, Skater A (mass 80 kg) and Skater B (mass 50 kg), are standing still on frictionless ice facing each other. Skater A suddenly reaches out and gives Skater B a sharp push forward.

    a. Compare the size (magnitude) of the force experienced by Skater A to the force experienced by Skater B during the push.

    b. Explain why Skater B accelerates much faster than Skater A, despite the interaction rules of Newton's third law.

4. A strong permanent magnet is placed near an ordinary iron nail on a smooth table. The magnet pulls the nail toward itself using a magnetic force, causing the nail to slide across the table. The nail does not move the heavy magnet.

    a. State the direction and type of force that the nail exerts on the magnet during this interaction.

    b. State whether these two forces act at the exact same time, or if there is a time delay before the second force occurs.

5. A horse is hitched to a heavy cart. The horse tries to pull the cart forward. A student argues:

   'If the horse pulls forward on the cart, the cart pulls backward on the horse with an equal force. Because these forces cancel each other out, the system can never accelerate forward.'

   Resolve this paradox. Explain how the horse and cart are able to accelerate forward, making specific reference to the surfaces involved and why these two interaction forces do not cancel each other out.

Newton’s 3rd Law Worksheet - Answers

Q1a. The Earth and the book.

Q1b. Newton’s third law pair force: An upward gravitational force, acting on the Earth.

Q2. Explanation:

- Newton’s third law pairs must act on two different objects.
- Both forces in this scenario act on the same single object (the skydiver).
- Newton's third law pairs must be of the same type of force.
- These are two different types of forces (one is gravitational, the other is a contact/frictional force).

Q3a. The forces are exactly equal in size (magnitude).

Q3b. Explanation:

- Newton's second law states that acceleration equals force divided by mass a = F/m
- Both skaters experience the exact same size force.
- Skater B has a smaller mass (50 kg) than Skater A (80 kg), resulting in a larger acceleration for Skater B.

Q4a. A magnetic force acting in the direction toward the nail.

Q4b. The forces act simultaneously. There is no time delay between them.

Q5. Explanation:

- The two interaction forces act on different objects (the forward force acts on the cart, the backward force acts on the horse), so they cannot cancel each other out.
- To accelerate forward, the horse pushes backward on the ground with its hooves.
- The ground pushes forward on the horse with an equal and opposite frictional force.
- This forward force from the ground is greater than the backward pull of the cart, creating a net forward force that accelerates the system.