

Inertia, resultant force and reaction pairs

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Full methods are given for every problem: formula first, then substitution, then the result with its unit in bold. Compare your working with the model, not only the final value, and use $g = 9.8$ N/kg unless the problem says otherwise.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS2-1, GCSE P5

Problem 1 Which law is it?

1. **Third law** (action-reaction pair).
2. **Second law**, $F = m \times a$: a larger mass gives a smaller acceleration.
3. **First law**: with no resultant force the ball would keep going; friction and air resistance stop it.
4. $1 \text{ N} = 1 \text{ kg m/s}^2$, so **kg, m and s**.

Problem 2 Motorbike push

1. $F = m \times a$.
2. $F = 180 \times 2.5 = \mathbf{450 \text{ N}}$.

Problem 3 Cricket ball and bat

1. $F = m \times a = 0.16 \times 2000 = \mathbf{320 \text{ N}}$.
2. By the third law the ball pushes the bat with **320 N**, in the opposite direction.

Problem 4 Balanced or not?

1. $80 \text{ N} - 80 \text{ N} = \mathbf{0 \text{ N}}$. The forces are balanced, so sled A keeps moving at constant velocity (or stays at rest).
2. $120 \text{ N} - 70 \text{ N} = \mathbf{50 \text{ N to the right}}$, so sled B accelerates to the right.

Problem 5 Coin on a card

1. The **first law** (inertia).
2. The card is flicked away so fast that almost no horizontal force acts on the coin. With no resultant horizontal force, the coin has no horizontal acceleration, and gravity pulls it down into the glass.

Problem 6 Mass and weight

1. $W = m \times g = 50 \times 9.8 = \mathbf{490\ N}$.
2. $W = 50 \times 1.6 = \mathbf{80\ N}$.
3. Mass does not change: **50 kg**.

Problem 7 Name the partner force

1. The runner's foot pushes **backwards on the ground**.
2. The van pulls **backwards on the rope**.
3. The apple pulls **upwards on the Earth**, with the same size of force.

Problem 8 Pushing a crate

1. $140 - 60 = \mathbf{80\ N}$.
2. $a = F \div m = 80 \div 25 = \mathbf{3.2\ m/s^2}$.

Problem 9 Driving force of a car

1. $F = 900 \times 1.8 = \mathbf{1620\ N}$.
2. Driving force = $1620 + 500 = \mathbf{2120\ N}$.

Problem 10 Reading a force graph

1. At $2.5\ m/s^2$ the line gives **10 N** (between 8 N at 2 and 12 N at 3).
2. Gradient = $16\ N \div 4\ m/s^2 = 4\ kg$. It represents the **mass, 4.0 kg**.
3. $a = 20 \div 4.0 = \mathbf{5.0\ m/s^2}$.

Problem 11 Same force, different masses

1. $a = 60 \div 5.0 = \mathbf{12\ m/s^2}$; $a = 60 \div 15 = \mathbf{4.0\ m/s^2}$.
2. It is **3 times smaller**, because the mass is 3 times larger and a is inversely proportional to m .

Problem 12 Kilonewtons and tonnes

1. $m = 1200\ kg$ and $F = 2400\ N$, so $a = 2400 \div 1200 = \mathbf{2.0\ m/s^2}$.
2. $m = 0.350\ kg$, so $F = 0.350 \times 20 = \mathbf{7.0\ N}$.

Problem 13 Crate under a helicopter

1. $W = 200 \times 9.8 = \mathbf{1960\ N}$.
2. $2260 - 1960 = \mathbf{300\ N}$ upwards.
3. $a = 300 \div 200 = \mathbf{1.5\ m/s^2}$ upwards.

Problem 14 Rowing a boat

1. The oar pushes the water backwards. The water pushes the oar, and so the boat, forwards with an equal and opposite force. This force acts on the boat, so the boat accelerates forwards.
2. Water resistance grows with speed. When it equals the forward force, the resultant force is zero and by the first law the boat keeps a **constant speed**.

Problem 15 Braking car

1. $a = (0 - 20) \div 5.0 = -4.0 \text{ m/s}^2$ (4.0 m/s² backwards).
2. $F = 1100 \times 4.0 = 4400 \text{ N}$ backwards.

Problem 16 Two crates in contact

1. $a = 30 \div (6.0 + 4.0) = 3.0 \text{ m/s}^2$.
2. $F = 4.0 \times 3.0 = 12 \text{ N}$.
3. **12 N** in the opposite direction, by the third law.
4. Resultant on 6.0 kg crate = $30 - 12 = 18 \text{ N}$; $a = 18 \div 6.0 = 3.0 \text{ m/s}^2$. It matches.

Problem 17 Skydiver speed graph

1. $W = 80 \times 9.8 = 784 \text{ N}$.
2. Resultant = $784 - 300 = 484 \text{ N}$; $a = 484 \div 80 = 6.05 \text{ m/s}^2$ downwards.
3. In B the speed is constant, so the resultant is zero: air resistance = **784 N**.
4. Resultant = $2500 - 784 = 1716 \text{ N}$ upwards; $a = 1716 \div 80 = 21 \text{ m/s}^2$ upwards (the skydiver slows down).

Problem 18 Lift cable tension

1. Constant velocity: $T = W = 800 \times 9.8 = 7840 \text{ N}$.
2. $W - T = m a$, so $T = 800 \times (9.8 - 1.5) = 800 \times 8.3 = 6640 \text{ N}$.
3. Slowing while moving down means acceleration upwards: $T - W = m a$, so $T = 800 \times (9.8 + 2.0) = 800 \times 11.8 = 9440 \text{ N}$.

Problem 19 Spot the errors

1. Mistake: the floor force and weight act on the **same object**, so they are not a third-law pair. The partner of your weight is your pull on the Earth.
2. Mistake: at a steady speed the resultant force is **zero**; the engine force only balances resistance.
3. Mistake: the larger weight is shared by a larger mass, so $a = g$ for both: they accelerate at the **same rate**, 9.8 m/s².

Problem 20 Trolley data

1. $0.50 \times 6.1 = 3.05$; $1.0 \times 2.9 = 2.9$; $1.5 \times 2.0 = 3.0$; $2.0 \times 1.5 = 3.0$ (all in N).
2. The product is constant, close to the applied force: mean = $(3.05 + 2.9 + 3.0 + 3.0) \div 4 =$ **about 3.0 N**. So acceleration is inversely proportional to mass.
3. $a = 3.0 \div 3.0 =$ **1.0 m/s²**.
4. A **curve that falls** (a reciprocal curve), not a straight line.