Newton's First Law

6.5.4.2.1 · Physics · revision notes

Newton's First Law says that an object's velocity only changes if a resultant force acts on it. You need to use it to explain the motion of objects that are stationary, moving at a steady velocity, or changing speed or direction, and (Higher) explain what inertia means.

Key facts

- Resultant force = 0 → velocity stays the same (at rest, or steady speed in a straight line)
- Steady speed in a straight line: driving force = resistive forces
- Driving force < resistive forces → decelerates
- Resultant force ≠ 0 → velocity changes (speed and/or direction)
- Driving force > resistive forces → accelerates
- Grade 7+ only Inertia = the tendency to stay at rest or in uniform motion

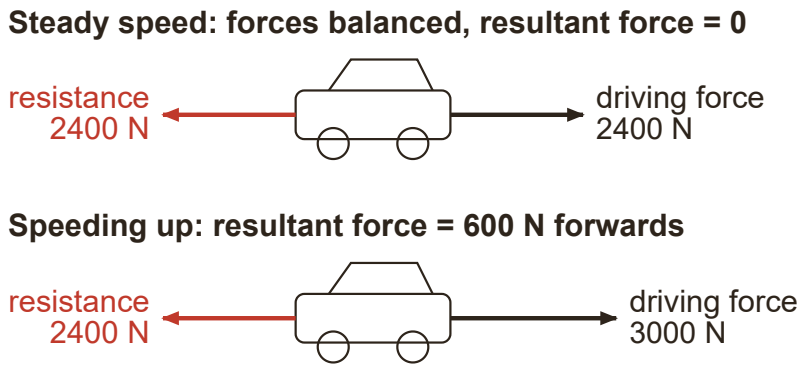
Notes

The law

- If the resultant force acting on an object is zero and the object is stationary, the object remains stationary.
- If the resultant force acting on an object is zero and the object is moving, it continues to move at the same speed and in the same direction: at the same velocity.
- So the velocity (speed and/or direction) of an object will only change if a resultant force acts on it.

Steady speed and changing speed

- When a vehicle travels at a steady speed in a straight line, the resistive forces (friction and air resistance) balance the driving force.
- A moving object does **not** need a resultant force to keep moving. It needs one to speed up, slow down or change direction.
- Driving force greater than the resistive forces: the vehicle speeds up. Driving force smaller than the resistive forces: it slows down.



Balanced forces: constant velocity. Unbalanced forces: the velocity changes.

- A car turning a corner at a steady speed is changing direction, so there must be a resultant force on it (sideways friction from the road).

Inertia Grade 7+ only

- The tendency of objects to continue in their state of rest or of uniform motion is called **inertia**.
- Example: when a bus brakes suddenly, standing passengers lurch forwards, because their bodies tend to keep moving at the original velocity.
- The greater an object's mass, the harder it is to change its velocity (see inertial mass in Newton's Second Law).

How to answer each type of question

Apply the First Law to find a force 2 marks **Grade 4**

1. Spot the words 'constant velocity' or 'steady speed in a straight line'.
2. So the resultant force is zero and the forces are balanced.
3. Set the forces in opposite directions equal.

Example. A car travels at a constant velocity along a straight, level road. The driving force is 2400 N. What is the total resistive force on the car? Give a reason for your answer.

Model answer.

2400 N (1)

The car moves at a constant velocity, so the resultant force is zero (the forces are balanced) (1).

Explain why a moving object does not need a resultant force

2 marks | Grade 5

1. Identify the forces (or say there are none).
2. Use the First Law: zero resultant force means constant velocity.

Example. A student says: 'A spacecraft travelling through deep space with its engines switched off will slow down and stop.'
Explain why the student is wrong.

Model answer.

There is no resultant force on the spacecraft: there is no air resistance or friction in space (1)
so it continues to move at the same speed in the same direction (Newton's First Law) (1).

Explain changes in motion using forces

3 marks | Grade 6

1. Compare the driving force with the resistive forces.
2. Say how the resistive forces change as the speed changes.
3. Say what happens when the forces balance again.

Example. A cyclist is moving at a steady speed. She then pedals harder, so the driving force increases.
Explain how the cyclist's speed changes and why it eventually becomes constant again.

Model answer.

The driving force is greater than the resistive forces, so there is a resultant force forwards and the cyclist accelerates (1).
As her speed increases, the air resistance increases (1).
When the resistive forces equal the driving force again, the resultant force is zero and she moves at a new, higher, constant speed (1).

Explain using inertia

2 marks | Grade 7

1. Say that the object tends to stay at rest (or keep moving): inertia.
2. Explain why the force acting is not enough to change its velocity much.

Example. A magician pulls a smooth tablecloth very quickly from under a plate. The plate stays in almost the same place.
Use the idea of inertia to explain why.

Model answer.

The plate tends to stay at rest because of its inertia (1).
The friction force from the smooth cloth is small and acts for only a very short time, so it cannot change the plate's velocity much (1).

Don’t lose marks

- Saying an object moving at a steady speed must have a forward resultant force on it.
- Writing 'the forces are equal' without saying they act in opposite directions, or that the resultant force is zero.
- Forgetting that a change of direction at a steady speed also needs a resultant force.
- Calling inertia a force. It is a tendency (a property of the object), not a force.

More tips

Memory tricks

- First Law in five words: no resultant force, no change (in velocity).
- Balanced forces do not mean 'not moving'. They mean 'not accelerating'.
- Changing direction counts as changing velocity, so it needs a resultant force too.

Exam technique

- Link forces to motion in one sentence: 'the resultant force is zero, so the velocity is constant'.
- In questions about changing speed, describe how the forces change, then the resultant force, then the motion.
- When a question says 'constant velocity' or 'steady speed in a straight line', think 'the forces are balanced'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Recognise balanced forces on a diagram**
Equal-sized arrows in opposite directions mean the resultant force is zero.

Grade 4 — **State Newton's First Law**
If the resultant force on an object is zero, it stays at rest or keeps moving at the same velocity.

Grade 4 — **Find a force from steady motion**
At a steady speed in a straight line, the driving force equals the total resistive force.

Grade 5 — **Explain steady motion using balanced forces**
A zero resultant force means there is no change in speed or direction.

Grade 6 — **Explain changing motion using resultant force**
Velocity (speed and/or direction) only changes if a resultant force acts.

Grade 7 — **Define and use the idea of inertia**
Inertia is the tendency of objects to continue in their state of rest or of uniform motion.

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