

P2: Forces and motion

Lesson sequence

1. Resultant forces
2. Newton's first law
3. Mass and weight
4. Newton's second law
5. Core practical – investigating acceleration (CP12)
6. Newton's third law
7. Momentum (HT)
8. Stopping distances
9. Car safety

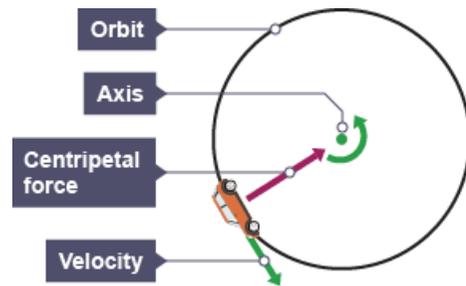
1. Resultant forces

*Scalar quantity	A quantity with magnitude (but no direction).
*Vector quantity	A quantity with magnitude and direction.
*Force arrows	Arrows can be used to represent forces: - Direction = direction of force - Length = size of force
**Resultant force	The force left over when forces acting in opposite directions are cancelled out.
**Calculating resultant force	Subtract the total force in one direction from the total force in the other direction.
*Balanced forces	When the resultant force is zero (because forces acting in opposite directions are the same size).
*Unbalanced forces	When the resultant force is non-zero (because there is more force in one direction than another).

2. Newton's first law

*Newton's first law of motion	An object will move at the same speed and direction unless it experiences a resultant force.
**The effect of resultant forces	Resultant forces cause acceleration: speeding up, slowing down or changing direction

**Effect of forces on motion	Forces make you start moving, stop moving or change direction, they are not needed to keep you moving!
***Circular motion	Moving in a circle is a type of acceleration because you are changing velocity (your direction changes even if your speed does not).
***Centripetal force	A force acting towards the centre of a circle that enables objects to move in a circle.
***Sources of centripetal force	Gravity – keeps the Earth orbiting the sun Tension – lets a bucket swing in circles on a rope Friction – keeps cars turn round a roundabout



3. Mass and weight

*Mass	The quantity of matter in an object is made of. Units = kilograms, kg.
*Weight	A force caused by gravity pulling downward on an object. Units = newtons, N.
*Force meter	An instrument for measuring forces. They usually involve a spring that stretched more the more the force.
**Gravitational field strength	The strength of gravity, which is different on different planets. Units = newtons per g=kilogram, N/kg.
**Gravitational field strength on Earth	10 N/kg

**Calculating weight	Weight = mass x gravitational field strength $W = m \times g$ Weight = N Mass = kg Gravitational field strength = N/kg
**Air resistance	A force greater by the air pushing against you as you move. Faster movement → greater air resistance.
***Motion whilst falling	Accelerate until the air resistance is equal to the weight; now there is no resultant force so speed stays constant.

4. Newton's second law

*Newton's second law of motion	Force = mass x acceleration
**Acceleration is greater when...	- The force is greater - The mass is smaller
*Calculating forces	Force = mass x acceleration $F = m \times a$ Force = N Mass = kg Acceleration = m/s^2
*Calculating acceleration	Acceleration = mass / force $a = F / m$ Force = N Mass = kg Acceleration = m/s^2
***Inertial mass	The mass calculated by measuring the acceleration produced by force, using the equation ' $m = F / a$ '
***The point of inertial mass	Inertial mass is the same as mass measured with a mass balance, but it gives us a way to measure mass where there is no gravity, such as in space.

5. Core practical – investigating acceleration (CP12)

*CP12 - Aim	To investigate how changing force changes acceleration.
*CP12 - Setup	A trolley on a ramp with 90 g masses. 10 g mass hanger attached to trolley via a string over a pulley.
*CP12 – Data collection	Release the trolley, use light gates to measure the acceleration.
*CP12 – Variations	Move 10 g of mass from the trolley to the mass hanger each time.
*CP12 – Independent variable	The force: each 10 g mass = 0.1 N force
*CP12 - Results	Ore mass → more force → greater acceleration.

6. Newton's third law

*Newton's third law	For every action force there is an equal but opposite reaction force.
*Action force	The force you push or pull with.
*Reaction force	A force of the same size but opposite direction to an action force.
*Action-reaction forces	If, A applies an action force to B, B applies a reaction force of same size and opposite direction to A.
**Action-reaction forces vs balanced forces	Similarities: same sizes, opposite directions Differences: balanced forces act on same object, action-reaction act on different objects
***Action-reaction forces - collisions	E.g. kicking a ball: the foot pushes the ball, the ball pushes back on the foot.

7. Momentum (HT)

*Momentum	The tendency of an object to keep moving.
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*Calculating momentum	Momentum = mass x velocity $p = m \times v$ Momentum = kg m/s Mass = kg velocity = N/kg
Momentum and force calculations	Force = change in momentum / time $F = (mv - mu)/t$ Force = N Mass = kg Velocity = m/s Time = s
***Conservation of momentum	Total momentum before and after a collision is the same.

**Three car safety features	Crumple zones, (stretchy) seat belts, air bags
***Collision forces	Greater momentum change → greater force
**Calculating collision forces	Force = change in momentum / time $F = (mv - mu)/t$ Force = N Mass = kg Velocity = m/s Time = s

8. Stopping distances	
*Stopping distance	The distance travelled from when a hazard is seen to when you fully stop.
*Thinking distance	The distance travelled from when a hazard is seen to when you brake.
*Braking distance	The distance travelled from when you brake to when you fully stop.
**Calculating stopping distance	Stopping distance = thinking distance + braking distance
**Thinking distance and reaction time	Slower reactions = greater thinking distance
**Thinking distance increased by...	Higher speed, tiredness, illness, drugs, distractions, old age
**Braking distance increased by	Higher speed, poor brakes, poor tyres, wet/icy/gravelly road, downhill, heavier load

9. Crash hazards	
**Crash danger	Crashes involve large decelerations, creating large forces which can injure you.
**Car safety features	Increase the time a collision takes, reducing deceleration and forces.