# Forces and their effects

OxfordAQA International GCSE Physics 9203, topic 3.1: forces, motion, momentum (P), moments (P)

# Every push, pull and hold

> Every push, pull and hold in the world is a force.

- OxfordAQA International GCSE Physics 9203, topic 3.1.
- Statements marked (P) are Paper 2 only.

# Contact and non-contact forces

| Non-contact (field) |
| --- |
| gravity |
| electrostatic |
| magnetic |

| Contact |
| --- |
| **friction**, air resistance |
| tension |
| normal contact force |

# Scalars and vectors

A **vector** is drawn as an arrow: length for size, direction for direction.

- Scalars: distance, speed, time, mass.
- Vectors: displacement, velocity, acceleration, force, **momentum**.

# Weight

1. **Equation** $W = m \times g$
2. **Data** $m = 5.0$ kg, $g = 9.8$ N/kg
3. **Weight** $W = 5.0 \times 9.8 = 49$ N

## Decision

Mass stays 5.0 kg everywhere; weight changes with g.

# Stretching a spring

Below the limit of proportionality: $F = k \times e$.

- Required practical: hang masses, measure extension, plot the line.
- Elastic distortion recovers; inelastic does not.

# Worked example: spring constant

1. **Extension** $e = 15.0 - 12.0 = 3.0$ cm $= 0.030$ m
2. **Constant** $k = F/e = 3.0 \div 0.030 = 100$ N/m
3. **5.0 N load** $e = 5.0 \div 100 = 0.050$ m, length 17.0 cm

**Decision**

k = 100 N/m; with 5.0 N the spring is 17.0 cm long.

# Reading a velocity-time graph

800 m in 60 s: an average speed of 13 m/s.

- Gradient of a distance-time graph = speed.
- Gradient of a velocity-time graph = acceleration; area = distance.

# Newton's three laws

| Law | In one sentence |
|---|---|
| First | zero resultant force: velocity does not change |
| Second | $F = m \times a$, in the direction of the resultant |
| Third | interacting objects exert equal, opposite forces |

# Resultant force and F = ma

Resultant 2400 N forwards, so a $= 2400 \div 1200 = 2.0$ m/s$^2$.

- Draw the arrows on the object first.
- At a steady speed the resultant is zero.

# Third-law pairs never cancel

> Equal and opposite, on different objects.

- The two forces act on different objects.
- Forces cancel only when they act on the same object.

# Adding forces by scale drawing

400 N east + 300 N north = 500 N at 37° north of east.

- Scale: 1 cm = 100 N. Draw head to tail.
- Never add perpendicular forces as numbers: not 700 N.

# (P) Momentum in an explosion

1. **Before** both still: total **momentum** $= 0$
2. **40 kg skater** $p = 40 \times 3.0 = 120$ kg m/s
3. **60 kg skater** $v = 120 \div 60 = 2.0$ m/s, the other way

## Decision

Total after $= 120 - 120 = 0$, as before.

# (P) Longer impacts, smaller forces

F = Δp / t: for the same Δp, a longer time means a smaller force.

- Airbags, seat belts, crumple zones, helmets, crash mats.
- All lengthen the time of the impact.

# (P) Stopping distance

> Stopping distance = thinking distance + braking distance.

- Braking turns kinetic energy into heat in the brakes.
- Faster cars need larger braking forces.

# (P) Terminal velocity

Drag grows with speed until it equals weight.

- Parachutes raise drag; streamlining lowers it.
- At **terminal velocity** the resultant force is zero.

# (P) Centre of mass and toppling

If the weight line falls outside the base, the object topples.

- A symmetrical object: on its axis of symmetry.
- Irregular lamina: hang from two points, draw two plumb lines.

# (P) Moments: balancing a seesaw

$300 \times 2.0 = 400 \times \text{d}$, so $\text{d} = 1.5$ m.

- **Moment** $\text{M} = \text{F} \times \text{d}$, distance from the pivot.
- Balanced: clockwise moments = anticlockwise moments.

# Common mistakes

| Mistake | Fix |
|---|---|
| length in $F = ke$ | use the extension, in metres |
| one force in $F = ma$ | find the resultant first |
| 400 N + 300 N = 700 N | perpendicular: scale drawing, 500 N |
| third-law pair cancels | different objects: never |

# Check yourself

| **Question** | **Answer** |
|---|---|
| 900 kg car, 2 m/s$^2$: resultant force? | 1800 N |
| Vectors: speed, displacement, time, force? | displacement, force |
| (P) Parachute opens: why a lower **terminal velocity**? | more drag: balance at lower speed |
| (P) 250 N at 0.4 m: **moment**? | 100 N m |