# Momentum: two carts separating

Student activity • observation and reasoning

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## The question

**How does the total momentum compare before and after two carts push apart?**

Observe a staff-run low-speed cart demonstration and use signed velocities to calculate the momentum of the whole system.

## Equipment

- Staff setup: two sensor carts, level track and padded stops
- Compatible recording device, balance and secure additional mass
- Student booklet and calculator

Staff operate the release. Use low speeds, secure added masses and padded end stops. Keep hands and faces out of the track line. Do not let carts fall from the bench or use the plunger to launch loose objects.

Course coverage: Physics only: 1.25P, 1.27P. Momentum and conservation.

## Plan, model or apparatus sketch

**Draw a labelled setup or force diagram; include the measured quantities.**

# Method and reasoning

Read the whole sequence before starting

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**1.** Staff level a track with padded end stops, place two sensor carts together and measure each cart’s complete mass. Choose one common positive direction along the track.

**2.** Use the lowest suitable spring-plunger setting to separate the initially stationary carts. Keep everyone clear of the track and stops.

**3.** Read both wheel-derived velocities just after separation and before appreciable slowing or any stop collision. Convert each sensor’s sign to the common track direction.

**4.** Calculate $m_1v_1$ and $m_2v_2$ and add them algebraically. Compare with the initially zero total momentum and estimate the effect of measurement uncertainty.

**5.** Repeat three trials, then add a secure small mass to one cart and repeat after measuring its new total mass. Compare speeds without expecting them to be equal.

**6.** Explain why internal forces cannot change total system momentum, while external friction can. Keep kinetic energy separate from momentum; the spring supplies energy during separation.

## Cleanup

- Disarm the plunger, remove added masses and switch off the carts before storage.

# Record your evidence

Blank spaces are for your own work

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## Reference and task data

Momentum p = mv is a vector with unit kg m $s^{-1}$. For an isolated system, total momentum is conserved. Practice example: 0.50 kg at +0.20 m $s^{-1}$ and 1.00 kg at −0.10 m $s^{-1}$ have equal and opposite momenta. This is a model example, not a promised experimental result.

| Setup / trial | $v_1$ / m $s^{-1}$ | $v_2$ / m $s^{-1}$ | Total p / kg m $s^{-1}$ |
|---|---|---|---|
| Original / 1 | | | |
| Original / 2 | | | |
| Original / 3 | | | |
| Added mass / 1 | | | |
| Added mass / 2 | | | |
| Added mass / 3 | | | |

**Show your calculations, labelled model or correction here.**

# Explain and evaluate

Use evidence and show calculation steps where relevant

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**1.** What is the initial total momentum?

**2.** Calculate 0.50 kg × 0.20 m $s^{-1}$.

**3.** Why assign signs to velocities?

**4.** Must the carts have equal speeds?

**5.** What external effect can spoil the comparison?

**6.** Where does the carts' kinetic energy come from?