Impact time and average force

Student activity • observation and reasoning

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The question

Why can a longer stopping time reduce the average force for the same momentum change?

Analyse low-speed cart data and an original calculation. The model does not certify protective equipment for people.

Equipment

- Staff sensor cart, track, padded safety stop and two soft buffers
- Compatible high-enough-rate recording device and balance
- Booklet and calculator

Staff perform low-speed runs only. Secure the buffers and add a separate end stop so the cart cannot leave the track. Keep fingers out of impact zones. Never test impacts on people, helmets being worn or fragile objects.

Course coverage: Physics only: 1.26P, 1.28P. Momentum change and safety features.

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. Observe staff sending one sensor cart slowly into a securely mounted soft stop. Record the cart mass, velocity just before impact and final velocity.

2. Staff compare two suitable soft stopping materials at closely matched initial speeds. The cart must remain on the track and stop without a hard collision or rebound.

3. Use a recording rate that resolves the stopping interval. Identify its start and end on the velocity trace; do not infer a precise duration from too few samples.

4. Calculate momentum change and average force magnitude using $|\Delta p|/\Delta t$. Compare only runs with similar momentum changes and repeat each material three times.

5. Calculate an invented example: a 0.50 kg cart stops from 0.40 m s^{-1} in 0.05 s, then in 0.20 s. Compare the two average forces.

6. Explain cushioning, crumple zones and follow-through using longer stopping times. Distinguish average force from peak force and note that rebound changes momentum change.

Cleanup

- Stop recording, remove buffers and switch off the cart before storage.

Record your evidence

Blank spaces are for your own work

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Reference and task data

The same momentum change spread over longer time gives a smaller average force. Practice data are not class measurements. Average force does not specify the peak or distribution of force. Use recorded suitable data if the apparatus cannot resolve the collision; do not perform person-impact tests.

Buffer / trial	Δp magnitude / kg m s^{-1}	Stopping time / s	Average force / N
A / 1			
A / 2			
A / 3			
B / 1			
B / 2			
B / 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. Find the practice cart's momentum-change magnitude.

2. Find average force over 0.05 s.

3. Find average force over 0.20 s.

4. Why match initial speeds?

5. Why account for rebound?

6. Does a smaller average force prove a helmet is safe?