IMPULSE WITH SPRING BUMPERS

Force-time area, momentum change, and collision duration

Name: _____	Period: _____	Date: _____

INVESTIGATION QUESTION **How can two bumpers produce similar impulses but different peak forces and contact times?**

TIME 30 minutes	SIMULATION BuildPhysics > Impulse with spring bumpers	UNIT 4 Linear Momentum

Learning targets

- Relate force-time area to momentum change.
- Compare soft and stiff bumpers during otherwise similar collisions.
- Explain the tradeoff between peak force and collision duration.

Model before you measure

Impulse is the signed area under a force-versus-time graph. For one cart, impulse equals its momentum change.	J_x = Area of F vs t graph = $\Delta p_x = m(v_f - v_i)$

Important: Use the graph Area tool on Spring force x. Record the sign consistently or compare magnitudes throughout.

Pre-lab prediction | 4 minutes

1. Which bumper should have the larger peak force: soft or stiff?

_____

2. Which bumper should have the longer collision time?

_____

3. Predict whether the two impulses will be similar for equal initial and final speeds.

_____

PART A Compare the preset soft and stiff bumpers

Setup | 3 minutes

- ☐ Load Impulse with spring bumpers. Record both cart masses and initial speeds.
- ☐ Select one cart and graph Spring force x and p_x.
- ☐ Run each cart through its bumper collision and use the Area tool over the full contact interval.
- ☐ Record force-time area, peak force, collision duration, and momentum change.

Data table | 10 minutes

Bumper	v_i (m/s)	v_f (m/s)	Δp_x (N·s)	Force-time area J_x (N·s)	Peak $\lvert F_x \rvert$ (N)	Contact time (s)
Soft bumper						
Stiff bumper						

Force-time sketches | 3 minutes

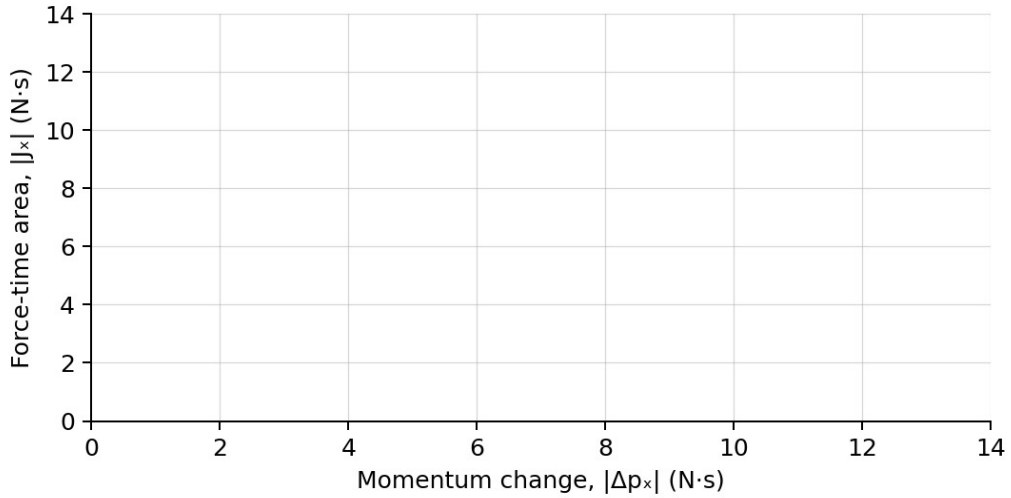
Soft bumper force-time shape	Stiff bumper force-time shape

PART B Change initial speed

Speed test | 8 minutes

Controlled trial: Use the same bumper and cart mass. Change only the incoming speed.

Incoming speed (m/s)	Outgoing speed (m/s)	$\lvert\Delta p_x\rvert$ (N·s)	$\lvert J_x\rvert$ (N·s)	Peak force (N)
1.0				
2.0				
3.0				
4.0				



4. Plot force-time area magnitude versus momentum-change magnitude. Draw a best-fit line.

Analysis | 6 minutes

5. Compare the two preset bumpers' impulses, peak forces, and collision times.

6. What should the slope of the J-versus-Δp graph be?

7. How did incoming speed affect impulse and peak force?

8. Explain how a longer collision time can reduce peak force while producing the same momentum change.

Claim-Evidence-Reasoning conclusion

Evaluate this claim: A softer bumper reduces impulse because it reduces the peak force.

CLAIM	Accept, reject, or revise the statement.
EVIDENCE	Cite at least two measured trials or graph features.
REASONING	Use force-time area and momentum-change evidence, not peak force alone.

Exit ticket

An air bag increases the stopping time of a passenger. Explain what happens to impulse and average force.