NAME: ________________ AP PHYSICS 1 DATE: ________________

CRASH-ZONE ENGINEERING: IMPULSE AND PADDING

THE PROBLEM

In a car crash or a fall, your momentum **will** change to zero. Physics tells us Δp is fixed.

Engineering Goal: If Δp is fixed, we must increase time (Δt) to decrease Force (F_{avg}).

TEST YOUR DESIGN: CRASH ZONE CHALLENGE

YOUR HOMEWORK DESIGN

Time to test the crash zone you built. We want an inelastic design that spreads the stop over more time. Crumpling or deforming shows energy being dissipated; the measured goal is a lower peak force. (Soft, contained materials only — see the safety note in last night's homework.)

Materials you used:

Sketch:

Condition	Peak Force (N)	Δt (s)
No protection		
Your design		
% improvement		

What absorbed energy?

☐ Deformation ☐ Friction ☐ Sound

STATION A: PARKOUR PHYSICS (THE DROP)

The Scenario: You jump from a wall. Your momentum hitting the ground is determined by gravity (height). You cannot change Δp.

You **can** control how you land.

- **Trial 1:** Stiff knees (The "Lego Man" land)
- **Trial 2:** Bent knees (The "Athlete" land)
- **Trial 3:** Full Crouch/Roll (The "Parkour" land)

Landing Style	Contact Time Δt (s)	Peak Force F_{max} (N)	Impulse J (Area)	Survival Rating
Stiff				
Bent				
Deep Crouch				

ANALYSIS

1. Did the **Impulse** change significantly between landings? Why or why not?

2. How many times greater was the Peak Force for Stiff vs. Deep Crouch? (F_{stiff}/F_{crouch})

STATION B: HELMET PADDING DESIGN

CHALLENGE

We are dropping a 5 kg mass (the "head form") from a fixed height.

Design limit: If $F_{max} > 80$ N, the design exceeds the safe force target. (Note: sensor scaled down.)

Sketch F-t: Bare Floor

Sketch F-t: Your Best Padding

Material	Δt (s)	F_{max} (N)	Peak-Force Status (Within limit / Over limit)
Bare Floor			**Over limit**
Foam / Towel			
Bubble Wrap / Air			

CRITICAL THINKING

Why are football helmets hard on the outside but soft on the inside? Which part handles the Impulse?

STATION C: THE CRUMPLE ZONE PARADOX

Old Cars (1950s): Rigid steel frames. Cars survived crashes; people died.

New Cars: Crumple zones. Cars are destroyed; people survive.

COMPARE THE IMPULSES

Bouncing back at the same speed (elastic) means $\Delta v = 2v$. (Impulse $\approx 2mv$)

Sticking/Crushing means $\Delta v = v$. (Impulse $\approx mv$)

Experiment: Use a cart with a spring (elastic) vs. a cart with a clay/foil cone (plastic).

Collision Type	Observed Motion	Peak Force (N)	Analogy
Elastic (Spring Bumper)	Bounces back		Rigid 1950s Car
Inelastic (Clay/Foil Bumper)	Stops / Crushes		Modern Crumple Zone

Synthesis Questions

1. The "Strong" Car Myth: My grandfather says, "They don't make cars like they used to! A fender bender ruins a modern car." Explain to him, using the word **Impulse**, why he is wrong.

2. Airbags: An airbag extends the stopping time from 0.01s to 0.15s. If the impulse remains constant, by what factor does the average force decrease?

FINAL ANALYSIS: ENGINEERING FOR SURVIVAL

THE BIG IDEA

In all three stations, the **impulse** (change in momentum) was essentially the same.

$$J = F_{avg} \cdot \Delta t = \Delta p \quad \rightarrow \quad F_{avg} = \frac{\Delta p}{\Delta t}$$

The engineering variable is time. Increase Δt, decrease F_{avg}.

3. Station Summary: For each station, what increased Δt?

Station	What extended the stopping time?
A: Parkour	
B: Helmet	
C: Crumple	

4. Real-World Application:

Name one safety device (not mentioned today) that uses this same principle. Explain how it works.

AP-Style Claim-Evidence-Reasoning

Prompt: A student claims: "Airbags are dangerous because they hit you really hard." Use your data and the impulse-momentum theorem to critique this claim.

Claim: (State whether you agree or disagree)

Evidence: (Reference specific data from today's lab)

Reasoning: (Connect to $J = F \cdot \Delta t$)

Tomorrow: 2D Momentum — when objects collide at angles, we track momentum in *both* x and y directions separately.