

Name: \_\_\_\_\_ Partner's Name: \_\_\_\_\_

## The Physics of Car Crashes: Paper Car Design - AP1

**Vocab words:** Impulse, momentum, force, collision, time

### EQ:

How can we design our craft so that it protects our egg from cracking, utilizing the principles we have learned about momentum, impulse, and the force of impact?

### Purpose

The objective of the Paper Car Crash Design is to apply your physics knowledge and skills to design and build the most crashworthy car. Crashworthiness will be based on whether the car in which the occupant (egg) is neither injured (cracked shell) nor killed (broken shell) as a result of the collision.

### Materials (per group)

- |                                                                                       |                                                                                                                                                     |
|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| - Copy paper, 2 sheets (8½ in. x 11 in.)                                              | - Ruler                                                                                                                                             |
| - Scissors                                                                            | - Metric balance                                                                                                                                    |
| - Wheels and axles (2 sets)                                                           | - 0.5 m of tape                                                                                                                                     |
| - Glue (glue sticks and white glue only)                                              | - One raw, Grade A, large chicken egg (NOTE: Wash hands thoroughly with soap and water after handling raw eggs, especially if they crack or break!) |
| - Colored pencils, crayons, and markers for vehicle decoration (no stickers or paint) |                                                                                                                                                     |

### Design Considerations

So far in this unit, we have discussed the importance of minimizing the impulse experienced by an object so that it feels a lesser force of impact. We have looked at the impulse-momentum theorem conceptually, mathematically, and applied it to a simulation in efforts of understanding its real-world connections. As you design your craft, consider the following:

1. How will you utilize the concepts of impulse, force, and momentum to create a safety cage to protect your egg?
2. How will you restrain your egg in the car?
3. How can your vehicle be designed to easily remove and inspect the egg after a crash?

### Design Product/Presentation

Your challenge is to design and build the fastest and safest car using only two sheets of copy paper, unlimited amounts of glue, and 0.5 m of tape for the car's frame and body. Your paper car must be able to carry a raw egg down an inclined racetrack ramp and protect it during a crash with a brick wall. Mr. Carrillo will provide the wheels, axles, and axle housing for construction of your car. Read the rules listed below before beginning your design process and remember that in order to be successful, you must have BOTH a car with the greatest velocity possible (so no frictional forces) AND an egg occupant that survives the crash **unharm**ed. On the day of the car crash contest, you must introduce your design to the class and identify **at least 3 safety design features you incorporated into your car's design**.

### Rules and Specifications

1. Maximum car width: < 7 centimeters (including axles and wheels)
2. Maximum car length: < 16.5 centimeters Minimum car mass without the egg: > 15 grams
3. Glue, paper, tape, wheels, axles, and the straw-axle housing are the only construction materials allowed.
4. The body of your vehicle is made out of the paper provided only. Other materials cannot contribute to the structural integrity of your car. Your vehicle will be disqualified if it exceeds length and width dimensions, does not meet minimum mass requirements, or contains stickers, paint, tape, cardboard or any other non-licensed materials that contribute to the structural integrity of the vehicle.
5. Vehicle designs must allow for easy access to and removal of the egg (occupant) for inspection after the crash. I should not have to strap, close, or attach anything on your vehicle before or after testing.
6. Vehicle designs should be able to withstand 1 practice trial without parts replacement or repairs.
7. Vehicle wheels must spin, allowing it to roll down the ramp. Car performs as intended
8. There can be no physical contact between the vehicle and the designer once the vehicle has been released onto the track.
9. All vehicles must visibly display the following information on their frames:
  - a. vehicle name
  - b. builder's name
  - c. vehicle length in centimeters
  - d. vehicle mass in grams





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**Grading Rubric for Car**

| Category                          | Description                                                                                                                                                                                                    | Points Possible | Points Earned |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------|
| Pre-design Questions              | Pre-design questions are completed                                                                                                                                                                             | 10              |               |
| Physics Theory                    | There are at least 3 safety features with the impulse-momentum theorem in mind.                                                                                                                                | 10              |               |
| Creativity & Construction Quality | Overall design or particular feature of design is unique. Construction shows evidence of time and effort in the process. Design is neat and well made.                                                         | 10              |               |
| Measurements                      | Meets requirements of length, width, and mass.                                                                                                                                                                 | 5               |               |
| Teamwork                          | Both members of the group contributed to the building and design of the project equally.                                                                                                                       | 5               |               |
| Performance                       | Carries the egg the entire length of the track during test runs. Wheels spin. Vehicle performs <b>as intended</b> . Nothing interferes with the acceleration of the vehicle down the ramp (no dragging parts). | 5               |               |
| Survival                          | Egg survives car crash                                                                                                                                                                                         | 5               |               |
| Extra Credit                      | Vehicle and egg can survive an extra crash.                                                                                                                                                                    | 1               |               |
| <b>Car Total</b>                  |                                                                                                                                                                                                                | <b>/50</b>      |               |