Zip It!

Grades: 2nd - 5th
Team Size: 1-3 competitors
Duration: 30 minutes
Supervisors: Shwetha Rajaram, Terence Groening

Summary Description

Given a few household materials, each team will construct a cable car capable of safely carrying a ping-pong ball down a zip line. The objective will be to achieve a target run time which will be revealed on the day of the event. There will be a short written portion, for students in 4th and 5th grade, testing the physics concepts of the zip line, including an average velocity calculation.

Concepts Covered

- Physics concepts for zip line (friction, air resistance, gravity, average velocity)
- Creativity and flexibility in building a cable car with materials unknown in advance
- Teamwork

Rules/Competition Format

This event will take place in one large room. Each team will have a table for building and modifying their cable car, and may use one of two frames for testing the cable car.

Phase 1: Written Test (Grades 4 & 5 only)

Duration: 5 minutes

- The team will take a written test that consists of 2-3 multiple choice questions and 1 free response question. The multiple choice questions will test the physics concepts of the zip line (friction, air resistance, gravity). The free response question will be an average velocity calculation using sample data.
- The average velocity should be calculated along the distance of the zip line (hypotenuse of the triangle). For the velocity calculation on the test, we will provide the distance and run time, and the students will be expected to calculate the average velocity. The kids are not expected to know trigonometry (e.g., they will not have to calculate the hypotenuse given the width / height of the triangle). The formula for average velocity is $v_{avg} = \Delta x / \Delta t$, where Δx is change in position and Δt is change in time. This formula will **not** be provided on the test.
- The sample data will be in SI units, and the final answer should be provided in SI units as well.

Phase 2: Building the Cable Car
Duration: 8 minutes

The following materials will be provided to each school on the day of the competition:

- scissors
- tape
- glue
- calculator
- zip line harness

A **subset** of the following materials will also be provided:

- 3oz Dixie Bath Cups
- straws
- construction paper
- washers
- cardboard tubes
- paper clips
- yarn
- zip ties
- rubber bands
- pipe cleaners

Using the materials listed, each team will build a cable car. The cable car will have to carry a ping-pong ball safely down the zip line.
Target time and zip line dimensions will be disclosed to teams in this area - the kids will not be expected to do any calculations in the building phase.
There will be one test zip line in the build area of the room. This test line will not have the same dimensions as the competition zip lines, but can be used, if teams wish, to ensure their cable car slides as they wish it to do.
Each team is free to use any of the materials provided for the cable car, but should keep in mind that:

- <u>The ping pong ball is not allowed to be modified in any way.</u> The ping pong ball "passenger" can not be glued, taped or encased in the cable car in such a way that it can not be removed and reseated in the cable car. The goal should be to build a cable car that a ping pong ball can be placed into, not to build around the ping pong ball.
- <u>The harness is not allowed to be modified in any way.</u> This includes twisting the hooks or adding any additional material to the harness.

- Only the top hooks of the harness can touch the zipline; no portion of the cable car should touch the zip line (to avoid damaging the fishing wire between runs).
- Each team will have no longer than 30 seconds to attach the cable car to the harness.
    - Since there will be multiple runs, the cable car must be able to be returned to a "ready position" quickly.

When the teams are satisfied with their cable car, they may queue for the Olympiad Zip line.

Phase 3: Testing and Modifying the Cable Car

Duration: 15 minutes

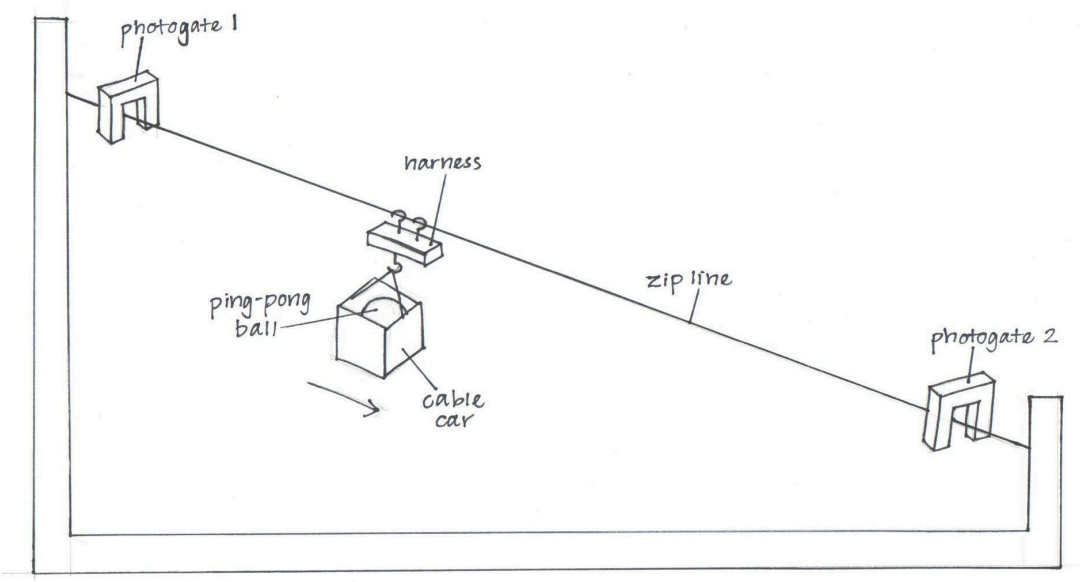
- One area of the room will contain two competition zip line setups. These setups will be fixed and cannot be altered by the teams. Each team will perform 3 cable car runs. They may use any of the zip lines they wish, but may find more consistency if they do all of their runs on the same line.
- Each team will have no longer than 30 seconds to place the ping-pong ball in the cable car and attach their cable car to the harness on the zip line. Teams will release their own cable car. A step ladder will be positioned by the start for teams that need it. Only one student can load the harness and cargo on the zipline at one time. Teams can switch students for each of the 3 trials.
- Volunteers will write the run time on an index card and return it to the team. Each team will then be responsible for detaching their cable car from the zip line. Note that the ping pong ball must remain in the cable car between the timing gates for the run time to be valid, but it is okay if the ball falls out at the end of the zip line (which can happen as the harness and cable car come to a sudden stop).
    - The photogates we use to time cable car runs measure down to ten thousandths of a second (0.0001 seconds). We will give the target times with four decimal places. Students often have trouble with decimals when the number of significant digits doesn't match (e.g. Which is larger, 3.30 or 3.2587?). In keeping the number of significant digits consistent, this has not been an issue in Zip It in the past, even with the younger students that have not worked with long decimals in the classroom.
- After the first and second runs, each team will have no longer than 2 minutes to modify their cable car as needed. No extra materials will be provided; each team is responsible for rationing their original materials.

Zip Line Setup

The runtime of the cable cars will be measured using a system of two photogates (http://www.arborsci.com/timer-and-photogates.html?ff=4&fp=636). The photogates measure to ten thousandths of a second (0.0001 seconds). We will give the target times with four decimal places. The zip line frame is constructed from Unistrut beams to provide rigidity and

allow for flexibility in length and drop. The zip line itself is Hillman Fasteners invisible cord (15 lb rating).

The vertical drop of the zip line will be about 1.2-1.5 meters (4-5 feet) and the horizontal distance covered between the photogates will be 3.0-4.6 meters (10-15 feet). The height of the cable car should not exceed 0.3 meters (1 foot), as that will be the approximate distance from the second photogate to the base of the setup. The line will be tensioned to approximately 5 lbs.



Scoring

Each team score will have two components:

> Cable car score: Only the best run time (closest to the target time) of the three trials for each team will be considered. The team(s) with the least deviation from the target time will be given a cable car score of 1. The team(s) with the second lowest deviation will have a score of 2, and so on.
>
> Written test rank (grades 4&5): Teams will be ranked based on their written test score, with the highest scoring team(s) receiving a rank of 1.

The final score for each team in grades 4&5 will be computed as follows:

*Final score = cable car score + 0.2*written test rank*

The team with the lowest final score will be the winner.

The following penalties will apply:

Runs where the cable car does not successfully traverse the entire distance of the zip line or where the ping-pong ball falls out of the cable car will **not** be considered in determining that team's best time. Teams will **not** be permitted to rerun their cable cars in these cases.

Tie Break Criteria

In the case that teams have the same final scores, the range of the three run times will be used as a tiebreaker. The team with the lowest range will win the tie. If any of the participating teams have one or more penalties, the following rules will apply:

- The team with the most penalties automatically loses the tie.
- If there are multiple teams with the same number of penalties, the team with the lowest run time range over the non-penalized trials will win the tie.
- The written score will be used to break the tie as a last resort for grades 4 and .

Materials Distributed by WESO

- Invisible Cord for Zip Line (Hillman Fasteners Invisible Cord, 25 foot long, 15lb rated). Available at many local hardware stores (Stadium Hardware, True Value, etc.)
- Cable Car Harness (1.5" x 3" Komatex block with 2 cup hooks for Zip line and one cup hook to hang the cable car).

Additional Materials useful for practices

- See list of potential materials
- Scissors
- Ping Pong Ball
- Photogate system or other timer. We are using http://www.arborsci.com/timer-and-photogates.html?ff=4&fp=636. The students will not be interacting with the Photogate system.

Materials to be brought to competition

n/a

****No cell phones or smart watches are allowed in event rooms. Participants who bring those items will be asked to leave them with the event supervisor for the duration of the event. Participants observed using them during the event will be disqualified.**

Additional Resources/References

Open practice times on the competition equipment will be announced. Please go to https://wesoscience.org/events/ for more details.

Reference video from Zip-it Workshop: https://www.youtube.com/watch?v=FbI54LYZ3bU&t=2s

Example scores from a previous year can be found at https://wesoscience.org/wp-content/uploads/2024/04/WESO-2024-Summary-Score-statistics.pdf

Event Questions

Please go to https://wesoscience.org/events/ for information on how to submit questions about this event to the supervisors.

Example Question

What force causes the cable car to accelerate down the zip line?

a). Friction
b). Gravity
c). Air resistance (drag)
d). Spring force