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ROLLER COASTER PHYSICS

1. Uwagi ogólne

Materiał został przygotowany dla studentów fizyki na II stopniu studiów, ale może zostać wykorzystany we fragmentach również na innych kierunkach (szczególnie ścisłych, ze względu na wykorzystane słownictwo), ponieważ dotyczy parków rozrywki, popularnych w tej grupie wiekowej.

2. Poziom zaawansowania: B2+, C1, C1+

3. Czas trwania opisanych ćwiczeń: 90 minut

4. Cele dydaktyczne

Zasadniczym celem tych zajęć jest rozwijanie u studentów sprawności rozumienia ze słuchu oraz rozumienia autentycznego tekstu pisanego (jedynie skróconego). Aby studenci mogli osiągnąć te cele, teksty oraz materiały wideo zostały wzbogacone o zadania wymagające dyskusji oraz wyciągania wniosków na podstawie przeczytanego/usłyszanego fragmentu, pomimo braku możliwości zrozumienia każdego słowa.

Dodatkowym celem jest wprowadzenie specjalistycznego słownictwa służącego do opisu zjawisk fizycznych. Zadania polegające na dyskusjach w parach lub małych grupach pozwolą przećwiczyć słownictwo i przenieść wiedzę ze swoich studiów na grunt języka angielskiego.

5. Schemat lekcji

Lekcja skupia się na zasadach działania kolejki górskiej, która jest idealną ilustracją podstawowych praw fizyki. Użyte teksty i nagrania są raczej nieskomplikowane, ale wprowadzają całe kluczowe w słownictwo w zakresie dynamiki i częściowo elektromagnetyki. Można rozpocząć temat od fragmentu nagrania z testowej jazdy kolejki Hyperion z Energylandii, które powinno poruszyć wyobraźnię studentów i skłonić ich do wymiany doświadczeń.

Pierwsza część lekcji (ćwiczenia 1–5) przedstawia zasadę działania kolejki górskiej i wprowadza podstawowe słownictwo z dziedziny dynamiki. Studenci najpierw pracują w parach podczas dyskusji oraz czytania, wymagającego wymiany informacji. Następnie oglądają nagranie z YouTube'a, podsumowujące i częściowo rozszerzające to, co przeczytali, i uzupełniają tekst brakującymi słowami. Ćwiczenie 5 zawierające kolejny fragment artykułu wymaga odpowiedzi na dość ogólne pytania, co pomoże studentom przełamać niepewność spowodowaną niezrozumieniem każdego słowa z tekstu i przekona ich, że potrafią wyciągnąć właściwe wnioski nawet pomimo tego.

Druga część lekcji (ćwiczenia 6–7) służy ponownemu przećwiczeniu nowego słownictwa i podsumowaniu całości. Studenci oglądają nagranie z Discovery Channel ukazujące ekstremalną kolejkę górską Fahrenheit z Pensylwanii. Mają za zadanie zanotować zawarte w nim liczby i opisać ich znaczenie. Lekcja zakończona jest dyskusją.

ROLLER COASTER PHYSICS

I. Watch the video and discuss.

1. Have you ever been to an amusement park with roller coasters? Did you take a ride?
2. If so – how was it? Would you do it again?
3. If not – why do you think other people seem to enjoy it?

Find the video at: https://www.youtube.com/watch?v=j6T-HY1GnNM [accessed: 10 July 2020].

II. Read the beginning of the article and define the underlined phrases.

By Tom Harris & Cherise Threewitt

Roller coasters are driven almost entirely by basic inertial, gravitational and centripetal forces, all manipulated in the service of a great ride. Amusement parks keep upping the ante, building faster and more complex roller coasters, but the fundamental principles at work remain basically the same.

Adapted from: https://science.howstuffworks.com/engineering/structural/roller-coaster.htm [accessed: 10 July 2020].

inertial force –. . . . .
gravitational force – . . . .
centripetal force –. . . . .
up the ante – . . . .

III. What are the basic roller coaster components? Read your part of the text and tell your partner about it by answering the questions that follow.

A.

At first glance, a roller coaster is something like a passenger train. It consists of a series of connected cars that move on tracks. But unlike a passenger train, a roller coaster has no engine or power source of its own. For most of the ride, the train is moved by gravity and momentum. To build up this momentum, the train has to get to the top of the first hill (the lift hill) or get a powerful launch.

The most traditional way most trains get to that first hill is via a long chain (or chains) running up the hill under the track that simply pulls trains to the top. The chain is fastened in a loop that is wound around a gear at the top of the hill and another gear at the bottom of the hill. The gear at the bottom of the hill is turned by a simple motor. The motor turns the chain loop so that the chain continually moves up the hill like a long conveyer belt. The coaster cars grip onto the chain with several chain dogs, which are mounted to the underside of the rollercoaster cars. Anti-rollback dogs prevent the train cars from rolling back if the chain breaks. They're also responsible for that "clack-clack-clack" sound you hear as a coaster train ascends the lift hill. Once the train cars reach the summit, the chain dogs release and the train starts its descent down the hill.

In some newer coaster designs, a catapult launch sets the train in motion. There are several sorts of catapult launches, but they all basically do the same thing. Instead of dragging the train up a hill to build up potential energy, these systems start the train off by building up a good amount of kinetic energy in a short amount of time. One popular catapult system is the linear-induction motor. A linear-induction motor uses electromagnets to build two magnetic fields – one on the track and one on the bottom of the train – that are attracted to each other. The motor moves the magnetic field on the track, pulling the train along behind it at a high rate of speed. The main advantages of this system are its speed, efficiency, durability, precision and controllability.

Another popular system uses dozens of rotating wheels to launch the train up the lift hill. The wheels are arranged in two adjacent rows along the track. The wheels grip the bottom (or top) of the train between them, pushing the train forward.

Adapted from: https://science.howstuffworks.com/engineering/structural/roller-coaster.htm [accessed: 10 July 2020].

1. How is the coaster train moved, in general?
2. What is the traditional way of getting the train up the first hill?
3. Why doesn't the train roll back accidentally?
4. What's the new way of setting the train in motion?
5. What are the benefits of using electromagnets?

B.

Like any train, a roller coaster needs a <u>brake</u> system so it can stop precisely at the end of the ride or in an emergency. In many roller coasters, there are also spots along the track where the train is slowed or stopped deliberately. This can be for safety reasons, such as where the train approaches the unloading zone at the end of the ride to prevent it from colliding with another train that hasn't yet departed, or through a steep curve. Track designers may also choose to slow down the train through a certain part of the ride to help build suspense for the riders. In roller coasters, the brakes usually aren't built into the train itself; they're built into the track.

Roller coaster designers refer to brakes that slow down the train as "trim brakes," and brakes that stop the train are known as "block brakes." In addition to these two main categories of brakes, there are also several different types.

The most common system is called a "fin brake," even though the fin is on the train car and the brake is on the track. A series of clamps is positioned at the end of the track and at a few other braking points. A central computer operates a hydraulic system that closes these clamps when the train needs to stop. The clamps close in on vertical metal fins running under the train, and this friction gradually slows the train down.

"Skid brakes" are most commonly found on old roller coasters and consist of long, ceramic-coated planks that rise out of the track and exert pressure on the bottom of the train to slow or stop it. There are also "magnetic brakes," which create a magnetic field between the track and the train that forces the train to slow down. Magnetic brakes are often used to complement other brake systems.

Adapted from: https://science.howstuffworks.com/engineering/structural/roller-coaster.htm [accessed: 10 July 2020].

1. What are the two reasons why the train is slowed or stopped?
2. What are the kinds of brakes for these two actions called?
3. Where are the brakes?
4. What are fin brakes?
5. How do magnetic brakes work?

IV. What's the physics behind the roller coaster? Fill in the gaps with the words/phrases from the box, then watch the video to check.

catch-car // conductor // dissipated // Eddy Current // free fall // friction // gravity // heat energy // incompressible // kinetic energy // lift hill // magnetic field // motor // nitrogen // permanent magnets // piston // pressure // propelled forward // sinking feeling // valve // weightless // winch

START: Most roller coasters start with a (1) .... but some are (2)..................................... thanks to hydraulics. The hydraulic launch system uses a cable attached to a (3)...................................... on the train and a giant (4)............................... under the track. The hydraulic fluid and the (5) .... gas are separated by a (6) .... inside the accumulator. Since liquids are (7)......................... the hydraulic fluid compresses the gas and increases its (8) .... Then a (9) .... is opened and the fluid goes through the pipe to power the (10) .... that starts the system.

GOING DOWN: Once you get to the top of the hill and you start plunging down, you get a (11)........................ and you might feel (12)........................ That's because you're in (13)........................ and the (14)........................ is the only force acting on your body.
STOP: Traditionally, roller coasters use brakes that rely on (15)........................ which turns the (16)........................ of the movement into (17)........................ Newer ones use magnetic brakes that move a (18)........................ (a metal fin) through a (19)........................ produced by electric currents. There are rows of (20)........................ on the tracks. The fin passing through them causes an (21)........................ The train stops because the energy of the moving train is (22)........................ as heat by the current.

Find the video at: https://www.youtube.com/watch?v=J8pJiV44hVM [accessed: 10 July 2020].

V. How do roller coasters work on your body? Read the text and answer the questions in pairs.

Your body feels acceleration in a funny way. When a coaster car is speeding up, the actual force acting on you is the seat pushing your body forward. But, because of your body's inertia, you feel a force in front of you, pushing you into the seat. You always feel the push of acceleration coming from the opposite direction of the actual force accelerating you.

This force (for simplicity's sake, we'll call it the acceleration force) feels exactly the same as the force of gravity that pulls you toward Earth. In fact, acceleration forces are measured in g-forces, where 1 g is equal to the force of acceleration due to gravity near Earth's surface (9.8 m/s2).

A roller coaster takes advantage of this similarity. It constantly changes its acceleration and its position to the ground, making the forces of gravity and acceleration interact in many interesting ways. When you plummet down a steep hill, gravity pulls you down while the acceleration force seems to pull you up. At a certain rate of acceleration, these opposite forces balance each other out, making you feel a sensation of weightlessness – the same sensation a skydiver feels in free fall.

If the coaster accelerates down fast enough, the upward acceleration force exceeds the downward force of gravity, making you feel like you're being pulled upward. If you're accelerating up a steep hill, the acceleration force and gravity are pulling in roughly the same direction, making you feel much heavier than normal. If you were to sit on a scale during a roller coaster ride, you would see your "weight" change from point to point on the track.

At the top of a hill on a conventional coaster, inertia may carry you up, while the coaster car has already started to follow the track down. Let go of the safety bar, and you'll actually lift up out of your seat for an instant. Coaster enthusiasts refer to this moment of free fall as "air time." "Air time" has a strange effect on your body because your body is not completely solid – it is composed of many parts. When your body is accelerated, each part of your body accelerates individually. The seat pushes on your back, the muscles in your back push on some of your organs and those organs push on other organs. That's why you feel the ride with your entire body. Everything inside is being pushed around.

The only reason you know that you are moving quickly on a coaster is that the support structure is whipping past you at top speed, and the air is rushing in your face. Your body can't feel velocity at all; it can only feel change in velocity (acceleration).

Adapted from: https://science.howstuffworks.com/engineering/structural/roller-coaster.htm [accessed: 10 July 2020].

1. How do you feel acceleration?

. . . .

2. When do you feel weightless? Why?

. . . .

Why does your body weight seem to change during the ride? . . . .

3. What is 'air time'? Why does it happen?

. . . .

4. How do you know the coaster is moving?

. . . .

VI. Watch a video about Fahrenheit, a terrifying roller coaster from Pennsylvania. What do these numbers stand for?

97 degrees – . . . .
90 degrees – . . . .
2700 feet – . . . .
28.4 degrees – . . . .
12 – . . . .
24 tons – . . . .
400 pounds – . . . .
50 pounds –. . . . .
a few milliseconds – . . . .
1500 miles – . . . .

Find the video at: https://www.youtube.com/watch?v=dBdj7Lcz2Xc (0–6:28) [accessed: 10 July 2020].

VII. Discuss.

1. Would you dare to get on that roller coaster?
2. Do the sensations in your body caused by the ride seem exciting or rather unpleasant?
3. Would you ever do something more extreme, giving you similar sensations, e.g., bungee-jumping, parachuting or skydiving?

ROLLER COASTER PHYSICS – klucz i instrukcje dla nauczyciela

I. Watch the video and discuss.

https://www.youtube.com/watch?v=j6T-HY1GnNM [accessed: 10 July 2020].

(Nagranie przedstawia jazdę testową kolejki Hyperion w Energylandii, którą być może studenci znają z własnego doświadczenia.)

II. Read the beginning of the article and define the underlined phrases.
inertial force – *the resistance of any physical object to any change in its velocity*
gravitational force – *the natural phenomenon by which all objects with mass or energy are brought toward the Earth*
centripetal force – *a force that makes the body follow a curved path (as Newton described it, "bodies are drawn towards a point as to the center")*
up the ante – *raise the expectations*

III. What are the basic roller coaster components? Read your part of the text and tell your partner about it by answering the questions that follow.

A.
1. How is the coaster train moved, in general?
By gravity and momentum.
2. What is the traditional way of getting the train up the first hill?
By a long chain or chains running up the hill.
3. Why doesn't the train roll back accidentally?
Anti-rollback dogs [pol. "zaczep", "klamra"] *hold the train at all times, even if the chain breaks.*
4. What's the new way of setting the train in motion?
A catapult launch.
5. What are the benefits of using electromagnets?
Speed, efficiency, durability, precision and controllability.

B.
1. What are the two reasons why the train is slowed or stopped?
For safety reasons and to add suspense.
2. What are the kinds of brakes for these two actions called?
Trim brakes for slowing down, block brakes for stopping.
3. Where are the brakes?
They're built into the track.
4. What are fin brakes?
The fin is on the train, the clamps are in the track. A computer-operated hydraulic system closes the clamps and the friction gradually slows down the train until it stops.

5. How do magnetic brakes work?

They create a magnetic field between the track and the train that forces the train to slow down & stop.

IV. What's the physics behind the roller coaster? Fill in the gaps with the words/phrases from the box, then watch the video to check.

catch-car // conductor // dissipated = *rozproszony* // Eddy Current = *prąd wirowy* // free fall = *swobodne spadanie* // friction = *tarcie* // gravity // heat energy // incompressible // kinetic energy // lift hill // magnetic field // motor // nitrogen // permanent magnets = *magnesy trwałe* // piston = *tłok* // pressure // propelled forward // sinking feeling // valve = *zawór* // weightless = *w stanie nieważkości* // winch = *korba*

START: Most roller coasters start with a (1) *lift hill*, but some are (2) *propelled forward* thanks to hydraulics. The hydraulic launch system uses a cable attached to a (3) *catch-car* on the train and a giant (4) *winch* under the track. The hydraulic fluid and the (5) *nitrogen* gas are separated by a (6) *piston* inside the accumulator. Since liquids are (7) *incompressible*, the hydraulic fluid compresses the gas and increases its (8) *pressure*. Then a (9) *valve* is opened and the fluid goes through the pipe to power the (10) *motor* that starts the system.
GOING DOWN: Once you get to the top of the hill and you start plunging down, you get a (11) *sinking feeling* and you might feel (12) *weightless*. That's because you're in (13) *free fall* and the (14) *gravity* is the only force acting on your body.
STOP: Traditionally, roller coasters use brakes that rely on (15) *friction* which turns the (16) *kinetic energy* of the movement into (17) *heat energy*. Newer ones use magnetic brakes that move a (18) *conductor* (a metal fin) through a (19) *magnetic field*, produced by electric currents. There are rows of (20) *permanent magnets* on the tracks. The fin passing through them causes an (21) *Eddy Current*. The train stops because the energy of the moving train is (22) *dissipated* as heat by the current.

Find the video at: https://www.youtube.com/watch?v=J8pJiV44hVM [accessed: 10 July 2020].

V. How do roller coasters work on your body? Read the text and answer the questions in pairs.

1. How do you feel acceleration?

You feel the push from the opposite direction than the force accelerating you.

2. When do you feel weightless? Why?

Going down the hill, gravity pulls you down while acceleration pulls you up. When these two forces balance, you feel weightless.

3. Why does your body weight seem to change during the ride?

Going down, you feel weightless. Going up, acceleration and gravity pull you the same way and you feel twice as heavy as usual.

4. What is "air time"? Why does it happen?
If you let go of the safety bar at the top of the hill, the train will go down and you'll stay up for a split second, actually slightly lifted off your seat. It's because of inertia.
5. How do you know the coaster is moving?
Because everything is passing quickly in front of your eyes. You don't actually feel the speed.

VI. Watch a video about Fahrenheit, a terrifying roller coaster from Pennsylvania. What do these numbers stand for?

97 degrees – *drop from the lift hill (7 degrees back from vertical!), you feel as if falling out of the train*
90 degrees – *the first climb, creates a huge sense of anticipation*
2700 feet – *(=823m) the total length of the track (it's really compact)*
28.4 degrees – *the articulation of the train (= the space between the cars that allows the train to move freely)*
12 – *the max number of people on the train*
24 tons – *the weight of the train as it goes down the first hill (6 tons x 4Gs = 24 tons)*
400 pounds – *(=181.5 kilos) it's how you feel going down the first drop if you weigh 100 pounds (= 45 kilos), as it's x 4Gs*
50 pounds – *(=23 kilos) it's how you feel going up the next hill if you weigh 100 pounds (x ½G)*
a few milliseconds – *the max duration of the exposure to 4Gs (otherwise the riders would black out)*
1500 miles – *(= 2414 km) the distance the train goes every week (12 hours a day, 7 days a week)*

Find the video at: https://www.youtube.com/watch?v=dBdj7Lcz2Xc (0–6:28) [accessed: 10 July 2020].

VII. Discuss.
1. Would you dare to get on that roller coaster?
→ *As explained at the beginning of the video, "Fahrenheit is a coaster taking human fear in a completely new direction"*