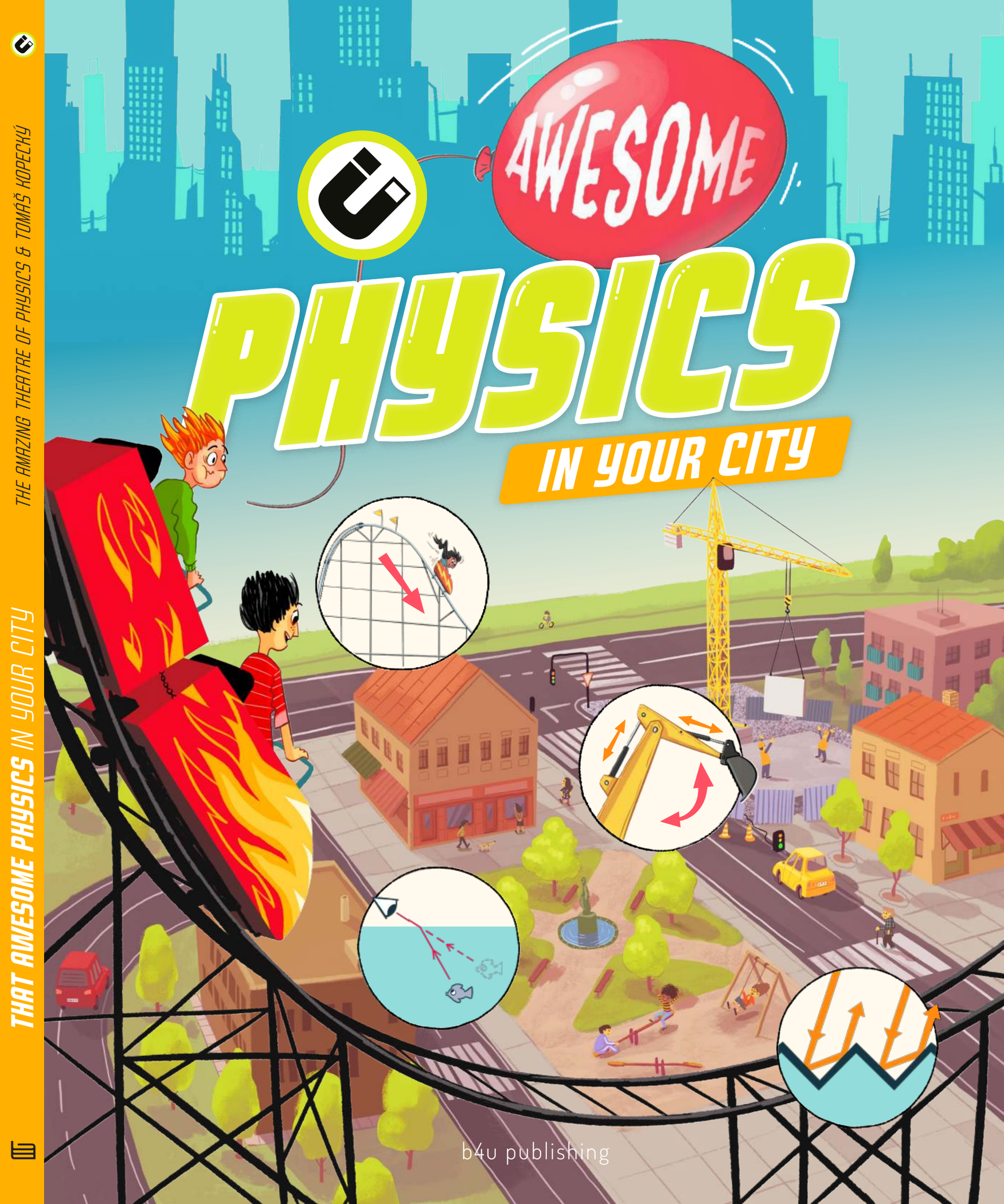

AWESOME
PHYSICS
IN YOUR CITY
THE AMAZING THEATRE OF PHYSICS & TOMÁŠ KOPECKÝ
THAT AWESOME PHYSICS IN YOUR CITY
b4u publishing

1. IN THE STREET

An ambulance wailing, a car beeping its horn, a pneumatic drill pounding... The street is full of noise, movement and sensations. Sometimes you don't know which way to turn first. At the same time, you need to be really careful on the street. But if you take a calm look around, you might be surprised at all the interesting things you can find in the street.

ELECTRICITY

Lightning on cables

Are there trolleybuses or trams in the city where you live? If so, you've probably noticed how sometimes when it's dark there'll be a bright flash of light and a faint rumble by the overhead line. This always happens when the trolley poles move away from the cable ever so slightly. It's similar to what happens during a storm. There's so much electricity in the cables that it can even jump through the air onto the nearby poles of a trolleybus. Notice how this happens more often in winter. Ice coats the cable, pushing the trolley poles away. Then the lightning has to arc across for the electricity to flow. Not only does this damage the poles, but the effect doesn't last long, so the tram often stops. For trams, cold weather can be a real disaste

ELECTRICITY

Underground

If you started digging beneath a pavement or a road, you'd probably be amazed at all the stuff you'd find down there. A city is a tangled web of sewers, pipes and cables that make it possible for us to turn on the taps, switch on the lights in the evening or cook dinner on a gas stove. All of this has to get into our homes somehow. And it wouldn't be very practical if we had to step over water pipes on the road, had all the cables for electricity and the internet hanging above our heads or were surrounded by pipes full of...well, you know what. That's why it's all hidden underground.

Seeing round corners

At some junctions and bends in the road, you can't see very far, and there's often a building or a tall fence in the way. We have to be able to see round corners so we don't drive into the path of an oncoming car. And rounded mirrors allow us to do just that. Notice how they bulge outwards. The shape is actually similar to an inverted spoon. You can see much more in a convex mirror than a flat one. Light hits the mirror from around the corner and is reflected towards you. But it also works the other way. Whoever's round the corner can see you too, because the light coming from your direction is reflected round the corner in the mirror.

LIGHT

SOUND

Blaring sirens

Have you ever noticed that when a vehicle is coming towards you, it sounds different than when it's moving away? It's probably most obvious when an ambulance's siren is wailing to let everyone know it's there. As it comes closer, you hear it blaring in a higher pitch. As it gets further away, you hear the pitch of the siren getting lower. But it's not because the driver's pressing some kind of button. Sound always changes when things move closer to or further away from each other. The faster this happens, the more noticeable it is. And it's not just sound that does this, but light as well. Our eyes might not be able to detect it, but it's important to astronomers, for example. They look at the sky using special instruments that can see the shift in light, and this allows them to tell if the stars around us are getting closer or further away.

LIGHT

A rainbow on the road

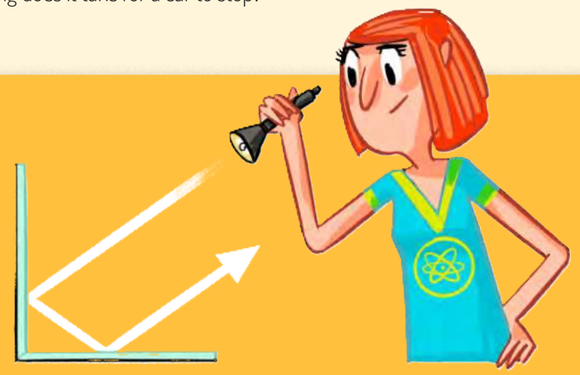
Sometimes, after it's been raining, you might see a beautiful rainbow on the road. It's not so beautiful for the environment though. That's because this rainbow forms on spilled oil which spreads out over a puddle. A rainbow can only appear on an oil slick when the slick is really thin. Then light interacts with it and conjures up a particular colour depending on how thick the layer of oil is. This gives rise to those beautiful rainbow streaks you also see when you blow bubbles.

The loud experiment

Try changing the pitch of a sound at home by getting closer and further away. Don't worry, you don't have to run around a speaker at top speed, though that would work too. Install any "tone generator" app on your mobile and play a tone. Get a pair of tights and place the mobile right down at the far end with the sound playing. Then spin the tights with the mobile above your head and listen. The pitch will rise and fall, and you'll hear something similar to a siren.

Staying safe on the road

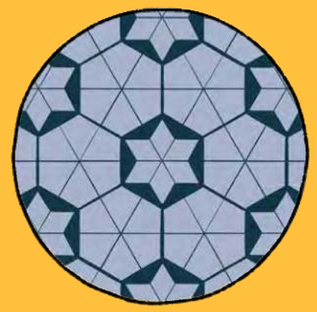
The most important thing about road traffic is for cars, cyclists and pedestrians to be aware of each other. Everyone needs to be clearly visible and know the rules of the road so that nothing happens to anyone. It's definitely useful for you to know the answer to these two questions: How can I be clearly visible even in the dark? And how long does it take for a car to stop?



Corner mirrors

The best way to be seen on the road during the day or at night is by wearing retroreflectors. These include all kinds of reflectors on bikes as well as reflective bands and reflective strips on bags and jackets. On building sites it's actually compulsory for people to wear high-visibility vests as well as helmets. And you'll also find these reflective vests in cars. But what is it that makes them so highly visible? It's most obvious in a reflector.

Try taking a really close look at one sometime. Inside it you'll see lots of little corners that are good at reflecting light. They're actually like tiny mirrors. Because there are three of them and they're arranged in a clever way, they have a superpower. They always reflect light back to exactly where it came from. So if you shine a torch on the reflector, the light will come back to you. And it's similar with the reflective strips on vests, it's just that the corners in them are much smaller.



A reflector close up.

How a reflector reflects light as viewed from the side.

TO SEE AND BE SEEN

We need light to reflect back to us when we're driving at night and shining our headlights in front of us. If a person dressed in black appears in front of a car at night, it'll be impossible to see them. But if they have a reflector or a reflective strip, this will reflect the light from the headlights back to the driver. They will literally see the pedestrian light up and can avoid them in time.

If you fancy trying it, you can arrange mirrors to form a corner and gaze into it. If you look at it close up, you'll see your eye in the middle. Try moving your head – your eye will still be in the middle. You can have a lot of fun with mirrors.

Before a car stops

Be extremely careful when it comes to cars. Although it's easy for you to see a car, you can never be totally sure that the driver knows you're there. When the driver starts to brake, it still takes the car a little while to come to a complete stop. This is known as stopping distance. Even a car travelling slowly through town can take as much as thirty metres to stop. Try measuring this out with thirty large steps.

BRAKING

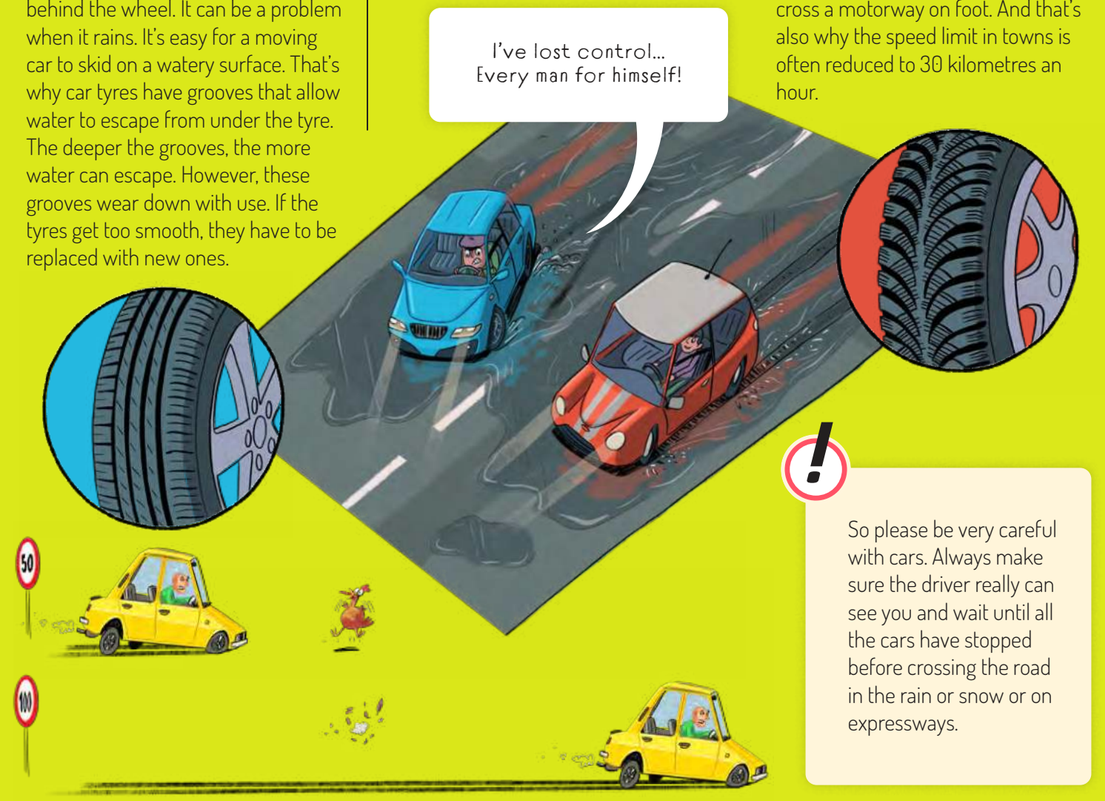
When a driver steps on the brake, the wheels of the car start to slow down. The more force the driver applies to the brake pedal, the faster the braking. However, the car's wheels mustn't start to skid on the road. If that happened, the driver would be powerless behind the wheel. It can be a problem when it rains. It's easy for a moving car to skid on a watery surface. That's why car tyres have grooves that allow water to escape from under the tyre. The deeper the grooves, the more water can escape. However, these grooves wear down with use. If the tyres get too smooth, they have to be replaced with new ones.

SLIPPERY WHEN WET

When it's rainy or there's snow and ice, tyres don't grip the road nearly as well and it takes the car longer to stop. That's why if it's raining you should be a lot more careful crossing the road and preferably wait until all the cars have gone past. It's even worse on ice, which is why in countries where it snows and temperatures fall below zero, cars are fitted with winter tyres. These have an even deeper pattern of grooves and can grip the snow better and brake more quickly. Even so, braking on ice and snow still takes much longer. In town it can easily be as much as eighty metres. That's the equivalent of several houses in a row.

SPEED

However, the thing that has the biggest effect on how a car brakes is how fast it's going. The faster a car is moving, the longer it takes to stop. Speed becomes more important the faster you're travelling. Just look at the figures. When a car is travelling at 50 kilometres an hour on a dry road in town, it will stop after 30 metres. Outside of town, if a car is travelling at 80 kilometres an hour, it will stop after 60 metres. The stopping distance has doubled, even though the speed definitely wasn't twice as much. On a motorway, where a car might be doing 130 kilometres an hour, it can take as much as 130 metres to stop. The stopping distance increases much more than the speed. That's why you're not allowed to cross a motorway on foot. And that's also why the speed limit in towns is often reduced to 30 kilometres an hour.



So please be very careful with cars. Always make sure the driver really can see you and wait until all the cars have stopped before crossing the road in the rain or snow or on expressways.

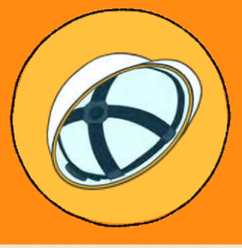
2. ON A BUILDING SITE

The whole city had to take shape house by house. The bustle of construction work never stops. There's always something being built. New buildings are added brick by brick, one load of cement after another. It's a fascinating sight, especially when it involves big yellow diggers, bulldozers and other machines.

PRESSURE

No helmet, no entry

Every worker on a building site has to wear a helmet to protect their head. How does it do that? Inside the hollow plastic shell, all you'll find is a couple of plastic straps. If something hits the helmet with a large amount of force, the impact is transferred to the straps. They grip the worker's head on every side, but with a small amount of force. The shell of the helmet might crack, but that's OK too, because that will also reduce the impact. For the helmet to work properly, it has to fit closely around your head. That's why you shouldn't wear a helmet that doesn't fit you properly and you should always fasten it tightly.



SOUND

Racket, din and noise

One of the first things you'll notice about a building site is the noise. All those machines, diggers, bulldozers and pneumatic drills make a real racket. So anyone who's working on a building site should protect their hearing using ear protectors or earplugs. If we listen to a very loud noise for too long, it can damage our ears. The damage can even be permanent. Then people end up with a ringing in their ears for the rest of their lives.

FORCES

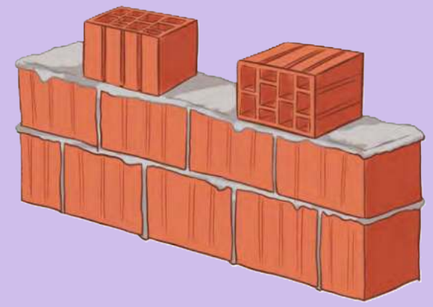
An excavator's arm

Digging a hole takes a lot of work. Rather than slaving away doing it by hand, it's better to leave it to a machine called a digger or excavator. If you watch an excavator digging, you might notice how similar its arm is to a human arm. An excavator also has a shoulder, an elbow and a wrist. The difference is it has a bucket at the end instead of a hand and fingers. Each of the excavator's joints has a piston which can extend or contract to bend or straighten the joint. An excavator makes do with just one piston for each joint, while our arms need two different muscles for each joint. One muscle bends the arm and the other straightens it. We can only shorten our muscles; we can't lengthen them.

PRESSURE

How much can a wall bear?

The bricks we use to build houses are often full of holes. Inside them are hollow tubes filled with air which help to keep heat inside the house. Above all, a brick has to be strong, since the lowest row of masonry has to bear the weight of everything above it. So even a brick with cavities in it can take a lot of weight from top to bottom. But if you were to lay it on its side, you wouldn't even be able to sit on it. That doesn't matter, though, as the bricks in a wall only have weight pressing on them from the top down, never from the sides. Well, if you put them in the wall the right way, that is.



EQUILIBRIUM

Piles of sand

On a building site, there are usually piles of different materials. You'll find sand, gravel and sometimes even rocks there. But each pile has a different angle of steepness. When you pour sand out of a bag, it will always form the same shape of cone, which will never be wider or narrower. If you try to shovel sand onto the top of the pile, it'll just tumble back down. Each type of material forms a pile with a different steepness. Sand and gravel, but also sugar, salt and flour, always form their typical cone when you pour them out. It works the same way when you're digging a hole as well. If it's too deep and steep-sided, the walls will collapse inwards. That's why the walls of deep trenches are lined with planks to keep the earth in place.

WORK

Slow but strong

Every type of work follows the same rule. Either we have to put in a lot of effort or else we can be fast. If you're carrying a light rucksack, you can run easily. But if you have to carry a lot of heavy shopping, you have to go slowly. Machines are similar to people in this way. If they need to carry out heavy work, they have to do it slowly. That's why diggers, bulldozers, cranes and steamrollers move at a snail's pace.

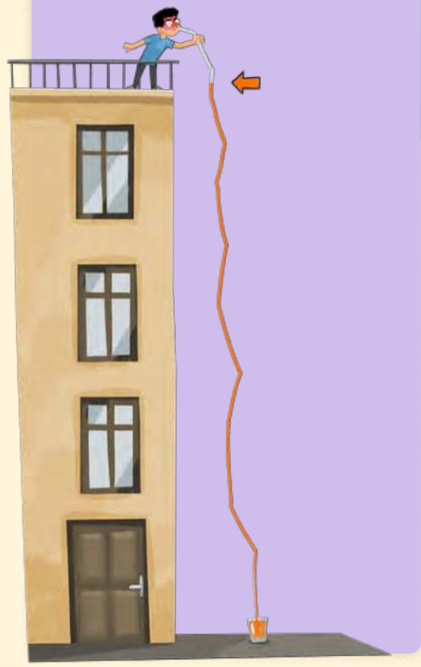
4. IN A RESTAURANT

In a restaurant there are always loads of nice things to eat and drink. When you're having a family lunch or coffee and cake, there's always something to explore. Everyone can order what they fancy. Once the grown-ups start talking about things you're not interested in yet, here are a few tips for things to look out for or even show to your parents.

PRESSURE

Drinking through a straw

Drinking through a straw is always fun! Everyone likes watching their drink gradually rising higher and higher up the straw. But how high up can it go? There is a limit. Here on Earth, the straw could only be ten metres tall. You wouldn't be able to get the water higher than that, even if you sucked at the straw with all your might. That's because you're being helped by the atmosphere, which pushes down with its full weight on everything on Earth, including your drink. If there were more of it above us, you'd be able to drink from a straw even more than ten metres tall.



Loads of bubbles

Bubbles are added to fizzy drinks for flavour. It isn't air, it's the familiar and tasty gas carbon dioxide. It gets put into soft drinks under really high pressure. It literally pushes its way in between the water molecules. But how much of it is there? You might find it hard to believe, but there can be as much of it as there is of the actual drink. Have you noticed that bubbles mainly form on the sides of the glass? It's easier for bubbles to get out of water when they can form on something. Try sprinkling a little salt into a fizzy drink. Bubbles will start rushing out of the drink because they finally have loads of surfaces that they can easily form on.

PRESSURE

BUOYANCY

Who's for coffee?

There's an art to making good coffee, though you might not appreciate it yet. However, you can still observe how coffee always forms layers. When you pour milk into your mum's coffee, it'll stay at the bottom for a moment before mixing in with the coffee. And if you do it skilfully, you can turn a coffee into a latte macchiato. Pour warm milk on the bottom, then carefully add the coffee, and finally top it off with airy foamed milk. Do you know why the layers in coffee are arranged this way?

BUOYANCY

Pour yourself a cuppa

When you pour yourself a cup of hot tea, you'll notice how the whole thing changes colour in no time. But if you accidentally use cold water, it'll happen more slowly and it'll probably just change colour at the bottom. In hot water, the water particles move much faster than they do in cold water, and they also carry particles of tea with them. In cold water, everything moves more slowly. That's why the tea stays at the bottom. For the same reason, you have to stir sugar into cold water for much longer, whereas in warm water it'll dissolve much more easily.

The (un)spilt experiment

Play at being a magician. Take a glass and fill it with water. This experiment works best when the water is right up to the top. Then cut out a piece of card or stiff plastic film and cover the glass with it. Now turn the glass upside down. Keep hold of the card while you do so. Once the glass has been turned over, try slowly letting go of the card. It will stay there as if stuck on. But you should definitely try this experiment over a sink, because accidents can happen. As with the straw, the water is being held in the glass by the atmosphere. There's a very thin layer of water between the edge of the glass and the card that won't let any air in, so the water has no way to get out.

5. AT THE PLAYGROUND

There's loads of fun to be had at a playground. You can swing, spin round, slide and climb up almost into the clouds. But none of this comes for free, so it's no wonder that after a whole day playing, you're fit to drop. However, you can give your brain a workout as well as your muscles. A playground can be even more interesting if you think about the best way to approach it.

FORCES

Climb up into the clouds

Have you ever tried to scale a climbing wall? It doesn't just take strong arms and legs but also a bit of thought. When climbing, it's important not to slip and to have a firm grasp of whatever you've taken hold of. When it comes to your feet, you just need a good pair of shoes that don't slip. They usually have rubber toes. But it's more difficult with your hands. They often get sweaty, which is why climbers use a kind of white powder that increases the friction a lot so your hands grip the wall better. They call this, a little inaccurately, chalk.

SPEED

Feeling dizzy

On a roundabout it can seem as if an invisible monster that doesn't want children to play is trying to pull us off it. You don't have to worry – there's no such thing. But if you want to take a ride on a roundabout without going flying off, it's important to hold on tightly. The further you sit from the middle, the tighter you have to hold on. The roundabout has to turn in a much bigger circle with you than if you're almost in the centre. And in order to do that, the edge of the roundabout has to turn faster. A roundabout can really make your head spin!

EQUILIBRIUM

Sticking to the wall

Climbers are careful to keep their body as close to the wall as possible. Try to do the same. The further your body is from the wall, the more your arms will strain and the more quickly they'll tire. If you want to climb safely, don't forget the three-point method. Always have three of your limbs securely positioned on one of the rungs or holds. Only move the fourth one. Wait until it's securely in place before freeing up another hand or foot. If you only held on in two places, it'd be much easier to lose your balance.

ENERGY TRANSFORMATIONS

Slow going up, quick coming down

Going up all the steps to the top of a slide can be pretty hard work. But the higher the slide is, the better. All the energy you put into climbing up will be given back to you by the slide. Even if friction does steal a little bit of it, it's still worth it. It's the same on a bike as well. It's really hard work getting to the top of a big hill, but that makes it all the better coming back down. It's worse when you put a lot of energy into lifting something heavy, the thing slips and the energy comes back to you by it falling on your foot.

FORCES

How to dress for a slide

Not that there's a dress code for a slide like there is, say, at the theatre. But if you're wearing the right sort of material, going down the chute will be child's play. On the other hand, if you've got shorts on and you're mainly sliding on your bare legs, you won't glide nearly as well. And it's not just that you'll go more slowly – you can even get nasty friction burns. That's why there's water pouring down a flume. It reduces the friction so we can enjoy the ride.

Fearlessly written by:
THE AMAZING THEATRE OF PHYSICS
Amusing and soothing illustrations by:
TOMÁŠ KOPECKÝ

How does the world around us work? That's what physics is all about. You might catch sight of it behind the curved mirror at a road junction. Another time it'll be playing with you at a playground or on a fairground ride. It also helps doctors to see what your bones look like. But how does it actually work? What people fear most is the unknown. So forget your fears and take a look inside. This book will show you how amazingly interesting physics is and, most importantly, that it can be found everywhere – and we mean everywhere.Take a good look around you as you make your way across the city. From a building site to a public pool, an ordinary shop or a concert hall. Discover all the places where changes of state, electricity, radiation or various forces are lurking. And look out for some entertaining experiments! You can try these at home, and you can also take them with you on your journey around the city.

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