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Physics

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The scenario

Subject	Mechanics / Newton's cradle
Length	3:41
Main objectives	Applications of physical laws of conservation of energy and momentum.
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of elastic collisions, the transformation of potential energy into kinetic energy and vice versa, changes in the momentum of the system.
2. Main subject	Description: Understand the law of conservation of mechanical energy, the law of conservation of momentum.
Part 1	
(0:40), **Experiment 1 (0:46),** **Experiment 2 (1:23),** **Experiment 3 (2:04),** **Experiment 4 (2:55)**	**Tools:** Newton's cradle **Description:** If we deflect the rightmost ball, release it and let it hit the next ball, only the leftmost ball will bounce. Others (the middle balls do not move). And then the whole process is repeated, after the impact of the left ball on the neighbouring one, only the far right ball bounces off. And the whole process is repeated over and over. After the two balls on the right side are deflected and then released and hit by the rest of the balls, the two balls on the left side are also deflected. The question is how many balls will be deflected if we carry out the experiment by deflecting three balls, since only two balls will remain in the original position. After three balls are deflected and subsequently hit two balls, the whole situation is repeated, three balls are deflected again, even if the system of three balls hits only two balls. We will repeat the experiment with the deflection of four balls. Pupils and students themselves could predict and answer how many balls will now deviate after the impact. **Questions:** What does the Law of Conservation of Mechanical Energy and Momentum say? **Conclusions:** In an isolated physical system, the total energy is unchanging, energy does not arise or disappear, but is only transformed from one form of energy to another form of energy or to other forms of energy.
3. Summary, evaluation and notes	**Application:** flexible collisions, pool, billiards,

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	After some time, the balls stop bouncing, as the mechanical energy decreases during impacts, it turns into internal energy, heat. **Level:** secondary school (ISCED 3 / 1st year)

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The scenario

Subject	Mechanics / Frictional Forces
Length	2:42
Main objectives	To analyse the properties of frictional forces, what they depend on and what they do not depend on
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of acting forces and frictional forces.
2. Main subject	Description: Understand that the frictional force depends only on the magnitude of the compressive force perpendicular to the pad, it does not depend on the size of the surface.
Part 1	
(0:40) **Experiment 1 (1:30),** **Experiment 2 (1:48),** **Experiment 3 (2:04),** **(2:23).**	**Tools:** Scales, force meter, block, weights **Description:** The body - the block can be placed on the floor so that it touches the surface S, 2S, ½ S. Body with base ½ S we place it on the mat, load it with a weight and pull on the mat with a force meter in a uniform movement. We subtract the magnitude of the applied force. We place the body with the base 2 S on the mat, load it with a weight and pull on the mat with a force meter in a uniform movement. We subtract the magnitude of the applied force. We place the body with the base S on the mat, load it with a weight and pull on the mat with a force meter in a uniform movement. We subtract the magnitude of the applied force. We will then compare the magnitudes of the acting forces in all three cases. The force meter in the given three cases shows roughly the same amount of applied force. **Questions:** The size of the friction force depends on the size of the friction surface ? (2x, ½x)? **Conclusions:** The size of the friction force does not depend on the friction surface, but only on the size of the pressure force perpendicular to the pad .
3. Summary, evaluation and notes	The system needs to be set in motion, for the system to start, a greater force must be overcome than when the system moves in a uniform motion. **Level:** primary school (ISCED 2 / 8th grade)

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The scenario

Subject	**Mechanics / Newton´s 3rd Law**
Length	2:08
Main objectives	To analyse the properties of interacting forces, what are their magnitudes.
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of the interaction of forces.
2. Main subject	Description: Understand Newton's 3rd law, the interaction of forces, the terms action and reaction.
Part 1	
(0:40) **Experiment 1 (0:44),** **Experiment 2 (0:58),** **Experiment 3 (1:16),** **(1:28),**	**Tools:** force meters **Description:** There are several force meters on the table that we will use to verify/understand Newton's 3rd law. The force meters are connected to each other and the hand on the right begins to act, the hand on the left is at rest. After a short action, when the springs of the force meters are stretched, the hand on the right stops acting. The force meters are connected to each other and the hand on the left begins to act, the hand on the right is at rest. After a short action, when the springs of the force meters are stretched again, the hand on the left stops acting and the force meters return to their original state. The force meters are connected to each other and both hands begin to act. After a short action, when the springs of the force meters are stretched again, the hands stop acting and the force meters return to their original state. We will then compare the magnitudes of the acting forces in all three cases. The force meters in the given three cases show the same great acting force. **Questions:** What is the force action in all three cases ? **Conclusions:** The mutual force action is always the same, it does not depend on who moves the force meter and who keeps it at rest. Forces arise and disappear at the same time, they are called action and reaction.
3. Summary, evaluation and notes	In a given experiment, it is advisable to choose a taller child (presumably stronger) and a smaller one (who appears weaker). Children should discover whether the pull is "stronger" or "weaker", the interaction is always the same.

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	Level: ELEMENTARY SCHOOL (ISCED 2 / 8th grade)

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The scenario

Subject	Mechanics / Action and Reaction
Length	2:02
Main objectives	Action and reaction
Detailed objectives	Force
Structure and description of experiments:	
1. Introduction	Description: Collision of two different carts with different weights. Measurement of the magnitude of the acting forces.
2. Main subject	Description: To show that when two bodies collide, they exert the same force on each other, regardless of their mass.
Part 1	Collision of two carts with different weights
(0:54) **(1:04)**	Tools: track, carts, weights, force meter **Description:** A cart with a smaller mass (0.8 kg) collides with a cart with a larger mass (1.52 kg). We see that after the collision, the heavier one is reflected in the direction of movement and the lighter one is reflected slowly back. From the time course of the forces acting during the collision, we clearly see that the carts act on each other with the same force, the maximum of which reaches approximately 2.8 N. We also see from the course that the forces act only during the collision. The force first increases until the cart with the smaller weight stops, the maximum force is reached, and then the carts move away from each other, corresponding to a decrease in force to zero. In the second part, the situation is the opposite, the heavier cart collides with the lighter one. In this case, the heavier truck continues in the direction of movement after the collision, because only part of its energy was transferred during the collision with the lighter truck. In this case, the course of the force during the collision is like the previous case - that is, the acting forces are the same, but the maximum force was only 2.1 N smaller. This is due to the fact that in this case we acted on a lighter truck and its start less force is needed than for a heavier cart. **Questions:** Why is the maximum force different in the second case of collision? What would change in maximum strength if we used heavier/lighter carts?
Part 2	**Collision of trucks moving against each other.**
(1:20)	**Tools:** track, carts, weights, force meter **Description:**

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	In this video, two carts with different weights (0.8 kg and 2.52 kg) that are simultaneously moving towards each other collide. After the collision, the heavier cart stops and the lighter one bounces off and moves in the opposite direction. Again, we see that the acting forces are equal, so one cart exerts the same force on the other regardless of its weight. The maximum force reaches a value of around 4.3 N, because we have heavier carts and they move against each other. **Questions:** What is next reason for the increase in the force applied when two carts collide.
Part 3	**Reflecting carts on an inclined plane.**
(1:29)	Tools: track, mat, carts, weights, force meter **Description:** Let's prepare an inclined plane where the angle is α = arcsin(0.065/0.8) =4.7°. On the inclined plane, we have a cart (the center of the cart with the force meter at the distance of 65 cm from the end of the track) with a mass of 520 g, and at the end is a second cart with a mass of 753 g. When moving on an inclined plane, the cart accelerates until it hits the cart at the end of the track. A collision occurs and after the bounce the cart moves up, not returning to its original position, but a little lower, only up to the distance of 42 cm. This is due to the energy lost in the collision and also the energy that caused the book to shift slightly. Subsequently, the cart moves down again and bounces again. After each bounce, it travels a smaller distance, due to the loss of energy in the collision, the energy needed to deform the spring and friction in motion. During the first and then subsequent collisions, we see that the acting forces are the same, they increase to a maximum and then decrease to zero. With each rebound, the maximum force is smaller and smaller. **Questions:** Why does the cart move upwards after the collision? **Conclusions:** The action/reaction force is always the same regardless of the weight of the objects and type of movement.
3. Summary, evaluation and notes	In a collision, bodies applies the same force on each other regardless of their mass and state of motion. The mutual force action does not depend on the inclination of the pad. ISCED 3 – 2 Force and movement - Force as a measure of interaction. Newton's third law of motion

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The scenario

Subject	**Mechanics - Push and Pull Forces**
Length	5:03
Main objectives	Pull and push
Detailed objectives	Force
Structure and description of experiments:	
1. Introduction	Description: Pushing and pulling one cart with another with different weights. Measurement of the magnitude of the acting forces.
2. Main subject	Description: To show that during tension and compression, two bodies exert the same force on each other, regardless of their mass.
Part 1	**Pressure: An experiment on a plane**
(0:40)	**Tools:** computer with IP Coach, track, trolleys and force meter, scale, weights, links, string
(1:24)	At the beginning, we will weigh the cart with the siding, which has a weight of 435 g. Other weights causing movement have a weight of 160 g.
(2:12)	Lighter trolley no. 2 (0.935 kg) is connected by a string to a weight of 200 g, which is initially placed on the ground. The force meters show a force of 0 N. When we start moving the heavier trolley no. 1 (2.435 kg) in the direction of the lighter one, after their contact we see the same increase in both pressure forces. Their size depends on the speed of the resulting movement. After reaching a suitable distance, we stop and hold both carts at rest with a force of approximately 2 N (equivalent to a weight of 200 g). Here we can see that the force causing the movement is greater than the force required to hold the carts. After releasing the heavier cart no. 2 lighter cart no. 1 pushes it with a force of approximately 0.9 N. This force is less than the force needed to keep the carts at rest. In approximately 1 s, the carts hit an obstacle. We observe a peak in force and then a drop to zero.
(2:29)	In the second case, the heavier trolley no. 2 (2.435 kg) and is also connected by a thread to a weight of 200 g. Lighter trolley no. 1 (0.935 kg) will be moved to a stable position. From the comparison of the forces, we see that the forces required to keep them at rest are approximately the same as in the previous case. After releasing the hand, the heavier cart pushes the lighter one and the resulting pressure force is approximately 0.4 N, less than in the previous case. In both cases, the pressure forces (action/reaction) are the same, regardless of the weight of the cart. Hitting the obstacle in about 1 s again was since the movement of both carts was caused by the same external force of 2N (200 g weight).
	Questions:

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	Why is the force causing the motion greater than the force needed to keep the carts at rest? Why is the compressive force during free movement less than 2 N after the carriages are released?
Part 2	**Traction - An experiment on the plane**
(2:52) **(3:15)**	Heavier trolley no. 1 (2.435 kg) is connected by a string to a weight of 200 g, which is initially placed on the ground. The carts are connected by a metal link. The force meters initially show a force of 0 N. When we start pulling the lighter cart no. 2 (0.935 kg) we see the same increase in both tensile forces. Their size depends on the speed of the resulting movement. After reaching a suitable distance, we stop and hold the lighter cart at rest with a force of approximately 2.4 N. The negative force is because now it is a tensile force and the other one is a pressure force. Here we can see that the force causing the movement is greater than the force required to hold the carts. After releasing the lighter trolley no. 2 the heavier cart no. 1 pulls it with a force of approximately 0.3 N. This force is different from the force required to keep the carts at rest. In approximately 1.5 seconds, the carts hit an obstacle. We observe a peak of the force and then a decrease of the force to a zero value. Otherwise, the lighter trolley no. 1 (0.935 kg) and is again connected with a thread to a weight of 200 g. Heavier trolley no. 2 (2.435 kg) will be moved to a stable position. From the comparison of the forces, we see that the forces required to keep them at rest are approximately the same as in the previous case. After releasing the hand, the lighter cart pulls heavier, therefore the resulting pulling force, approximately 0.9 N, is greater than in the previous case. In both cases, the traction forces (action/reaction) are the same, regardless of the weight of the truck. Hitting the obstacle again in approximately 1.5 s was caused by the fact that the movement of both carts was caused by the same external force of 2N (200 g weight). **Questions:** Why is the force causing the motion greater than the force needed to keep the carts at rest? Why is the compressive force during free movement less than 2 N after the carriages are released? **Conclusions:** The action/reaction force is always the same regardless of the weight of the objects and whether it is a pull or a push. The mutual force action affects the influence of the external force causing the movement of the system of objects/carts.

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Part 3 -	Pressure - an experiment on an inclined plane
(3:35)	Heavier trolley no. 2 (1.435 kg) is connected by a string to a weight weighing 300 g, which initially hangs in the air, therefore the force meters show a force of 3 N. When we start moving the lighter cart (0.935 kg) in the direction of the heavier one, after their contact we see the same increase in both pressure strength. Their size depends on the speed of the resulting movement. After reaching a suitable distance, we stop and hold both carts at rest with a force of approximately 3 N. Here we can see that the force causing the movement is greater than the force required to hold the carts. After releasing the lighter trolley no. 1 the heavier trolley no. 2 pushes it with a force of approximately 1.3 N. This force is less than the force required to keep the carts at rest. In about 2 seconds, the carts hit an obstacle. We observe peak forces and then a return to 3 N. Otherwise, the lighter trolley no. 2 (0.935 kg) again connected with a thread to a weight of 300 g. Heavier trolley no. 2 (1.435 kg) will be moved to a stable position. From the comparison of the forces, we see that the forces required to keep them at rest are approximately the same as in the previous case. After releasing the hand, the lighter cart pushes heavier, therefore the resulting pressure force, approximately 2.2 N, is greater than in the previous case. In both cases, the pressure forces (action/reaction) are the same, regardless of the weight of the cart. The collision with the obstacle again in about 2 s was because the movement of both carts was caused by the same external force of 3N (300 g weight). **Questions:** Why is the force causing the motion greater than the force needed to keep the carts at rest? Why is the compressive force during free movement less than 3 N after the carriages are released?
(3:56)	
Part 4 –	**Traction - an experiment on an inclined plane**
(4:18)	Lighter trolley no. 1 (0.935 kg) is supported by a stop and a string with a weight of 300 g, which is initially hanging in the air, therefore the force meters show only a force of 1.5 N. When we start pulling down the heavier cart (1.435 kg) we see the same increase in both tensile forces. Their size depends on the speed of the resulting movement. After reaching a suitable distance, we stop and hold both carts at rest with a force of approximately 3.5 N. Here we can see that the force causing the movement is greater than the force required to hold the carts. After releasing the heavier trolley no. 2 lighter cart no. 1 pulls it with a force of approximately 2.3 N. This force is less than the force required to keep the carts at rest. In approximately 2 seconds, the carts will hit a stop. We observe a peak of the force and then a decrease of the force to a zero value.

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(4:36)	Otherwise, the heavier trolley no. 1 (1.435 kg) and is again connected with a thread to a weight of 360 g. Lighter trolley no. 2 (0.935 kg) will be moved to a stable position. From the comparison of the forces, we see that the forces required to keep them at rest are approximately the same as in the previous case. After releasing the hand, the heavier cart pulls the lighter one, so the resulting pulling force, approximately 1.6 N, is lower than in the previous case. In both cases, the traction forces (action/reaction) are the same, regardless of the weight of the truck. The collision with the obstacle again in about 2 s was since the movement of both carts was caused by the same external force of 3N (360 g weight). We observe a peak of the force and then a decrease of the force to a zero value. **Questions:** Why is the force causing the motion greater than the force needed to keep the carts at rest? Why is the traction force in free movement less than 3 N after the carriages are released? **Conclusions:** The action/reaction force is always the same regardless of the weight of the objects and whether it is a pull or a push. The mutual force action affects the influence of the external force causing the movement of the system of objects/carts.
3. Summary, evaluation and notes	When bodies are pushed, a pressure force is created, while both bodies exert the same pressure force on each other. When a body is pulled by another body, a pulling force is created, while both bodies exert the same pulling force on each other. The mutual force action does not depend on the inclination of the pad. ISCED 3 – 2 Force and movement - Force as a measure of interaction. Newton's third law of motion.

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The scenario

Subject	**Mechanics - Magnitude of Different Forces**
Length	3:37
Main objectives	Action of various forces
Detailed objectives	Force
Structure and description of experiments:	
1. Introduction	Description: Pushing and pulling one cart with another with different weights under the action of different external forces. Measurement of the magnitude of the acting forces.
2. Main subject	Description: To show that the magnitude of the pull and pressure between two bodies depends on the magnitude of the external force, while it does not depend on their mass.
Part 1	**Pressure under the action of various external forces**
(0:40)	**Tools:** computer with IP Coach, track, carts and force meter, scale, weights, links, string
(1:17)	At the beginning, we will weigh the cart with the siding, which has a weight of 435 g. Other weights causing movement have a weight of 160 g.
(1:59)	Lighter trolley no. 2 (0.935 kg) is connected by a string to a weight of 300 g, which is initially placed on the ground. The force meters show a force of 0 N. When we start moving the heavier trolley no. 1 (2.435 kg) in the lighter direction after their contact, we see the same increase in both pressure forces. Their size depends on the speed of the resulting movement. After reaching a suitable distance, we stop and hold both carts at rest with a force of approximately 3.2 N (equivalent to a weight of 300 g). Here we can see that the force causing the movement is greater than the force required to hold the carts. After releasing the cart, the carts move in the direction of the external force - to the left. Lighter trolley no. 2 pushes the heavier cart no. 1 with a force of approximately 1.7 N. This force is less than the force required to keep the carts at rest with weeight. In approximately 1.3 seconds, the carts hit an obstacle. We observe a peak in force and then a drop to zero.
(2:13)	In this case, the situation is repeated, but we used a lighter weight of 200 g to pull both carts. The decrease in the external acting force can be seen immediately when pulling the carts, where we observe a decrease in both acting forces between the carts. To keep the carts at rest with weight, we need a smaller force of approximately 2.1 N, which corresponds to the weight of a 200 g weight. After releasing the cart, we observe an accelerated movement, while the lighter cart

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	pushes the heavier one with the same force of approximately 1 N, but less than in the previous case. Since the external force is smaller, the movement takes longer, less than 2 s. **Questions:** Why is the force causing the carts to move greater than the force needed to keep them at rest? Why is the pressure force less during free movement, after releasing the carriages? Why does the movement take longer when a smaller external force is applied?
Part 2	**Traction under the action of various external forces**
(2:35) **(2:52)** **(3:10)**	Lighter trolley no. 1 (0.935 kg) is connected by a string to a weight of 300 g, which is initially placed on the ground. The force meters initially show a force of 0 N. The trolleys are connected by a metal link. When we start pulling the heavier cart no. 2 (2.435 kg) we see the same increase in both tensile forces. The negative force is because now it is a tensile force and the other one is a pressure force. Their size depends on the speed of the resulting movement. After reaching a suitable distance, we stop and hold the heavier cart at rest with a force of approximately 3.3 N. Here we can see that the force causing the movement is greater than the force required to hold the carts. After releasing the cart, the carts move in the direction of the external force - to the left. Lighter trolley no. 1 pulls heavier cart no. 2 with a force of approximately 1.5 N. This force is less than the force required to keep the carts with weight stationary. In approximately 1.5 seconds, the carts hit an obstacle. We observe a peak of the force and then a decrease of the force to a zero value. In this case, the situation is repeated, but we used a lighter weight of 200 g to pull both carts. The decrease in the external acting force can be seen immediately when pulling the carts, where we observe a decrease in both acting forces between the carts. We also need a smaller force of approximately 2.5 N to keep the carts at rest with weight. When the cart is released, the carts move faster due to a force of 1 N, but smaller than in the previous case. Since the external force is smaller, the movement takes longer, approximately - 2s. In the next case, the situation is repeated, but we used an even lighter weight of 160 g. When moving the carts, we observe a decrease in traction forces, but to a lesser extent than in the previous case, a change in the weight of the weight by only 40 g. Even to keep the carts at rest, we need a slightly smaller force of approximately 2.2 N. After releasing the hand, the carts move faster, while the acting tensile forces are around 0.7 N. Since the external

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	force is even smaller, the movement also takes longer, approx. – 2.2 s. **Questions:** Why is the force causing the carts to move greater than the force needed to keep them at rest? Why is the pressure force less during free movement, after releasing the carriages? Why does movement take longer when smaller external forces are applied? **Conclusions:** The action/reaction force is always the same regardless of the weight of the objects and whether it is a pull or a push. The mutual force action affects the influence of the external force causing the movement of the system of objects/carts. As the value of the external force decreases, the value of the interacting forces also decreases.
3. Summary, evaluation and notes	When an external force is applied to a system of bodies, mutual action between the bodies arises, either tensile or compressive forces. Their size depends on the size of the external force. Regardless of size, the interaction of internal forces is always the same. ISCED 3 – 2 Force and movement - Force as a measure of interaction. Newton's second and third laws of motion.

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The scenario

Subject	**Dynamics/Centrifugal force**
Length	3:41
Main objectives	Centrifugal force
Detailed objectives	Force, Gravitational force, Frictional force, Centrifugal force
Structure and description of experiments:	
1. Introduction	Description: Centrifugal force is encountered during rotating motion, and its magnitude increases with the square of the speed and decreases with the radius of the circular path.
2. Main subject	Description: Determine the speed of the car to go through the looping. Determine the maximum speed at which the car can go through a classic and a banked turn.
Part 1	**Movement in a plane and in a curve**
(0:39) **(0:55)** **(1:10)** **(1:31)** **(2:13)**	**Tools:** Track, scale, weight, controller, car **Description:** First, we weigh the car and the weight used in the test. We place the weight on the car. We place the toy car on a simple car track with four 90o turns, two of which are tilted (15o) and two normal and set it in motion. At a speed of 1.3 m/s, we can see that the toy car moves along the track without any problems or flying out of the corner. As the speed increases to 1.7 m/s, we can see that the transition through the tilted turn is still without problems, but in a classic turn, the car flies out. In a classic corner, only friction keeps the car in curved motion, while in a banked track it is also the normal component of gravity. We will weigh the car and the weight used in the test. We place the weight on the car. When the weight is increased, we see that it goes through a tilted turn at a speed of 1.6 m/s without any problems, while it takes off almost immediately in a classic turn. **Questions:** What is the relationship for gravity, friction, and centrifugal force? When will the toy car pass safely through loping? Why is a tilted turn safer? **Conclusions:** In a banked turn, we can go at a higher speed, because the normal weight component helps us.
Part 2	**Movement after loping**

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(2:32) **(3:01)** **(3:21)**	**Tools:** Loping track, scale, controller, cars (36g and 48g) **Description:** Place the car at the beginning of the looping track. We press the controller fully and observe whether the car passes through the loop. When moving up, we observe a slight deceleration of speed, due to the increase of potential energy at the expense of kinetic energy (blue from 2.2 m/s to 1.5 m/s, gray from 2.5 m/s to 2 m/s). Both cars pass without problems at full power. When moving through a loping, we consider two forces, centrifugal Fc and gravitational G. If Fc is greater than G, the car passes through the loping without falling. When the controller is pressed less, the cars move slower (1.8 m/s and 2.2 m/s) and when going up, the gravitational force prevails over the centrifugal force (1 m/s), which pressed them to the track, and the cars fall from different heights. **Questions:** How to determine the minimum speed to pass a loping? Does this speed depend on the weight of the car? **Conclusions:** Centrifugal force increases quadratically with velocity and decreases with radius.
3. Summary, evaluation and notes	**Application:** Movement on a carousel or in a bus in a curve. Example of a non-inertial system. Centrifugal force is applied during circular motion, carousel or when driving around a curve. When loading the car, it is better to put the weight inside so that the resulting center of gravity is as low as possible. The movement of the toy car on the track is held by a guide pin, so the friction-only calculations may not match. When setting the correct speed, which is still sufficient to drive through loping, more attempts are needed. **Level:** gymnasiums, secondary vocational schools (1st year, ISCED 3)

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The scenario

Subject	**Mechanics - Moment of Inertia**
Length	1:39
Main objectives	Determine the angular acceleration and moment of inertia of the wheel .
Detailed objectives	Rotational motion, Moment of inertia, angular velocity and acceleration
Structure and description of experiments:	
1. Introduction	Description: When the weight falls, it is a uniformly accelerated motion and the wheel rotates with a uniformly accelerated motion.
2. Main subject	Description: Defining moment of force and moment of inertia.
Part 1	**Turning the wheel using a constant force**
(0:40) **(0:49)**	**Tools:** wheel, stand, meter, weights, scales, string **Description:** We fix the wheel on the stand so that it can rotate freely. We measure the diameter of the wheel ($2*R$ = 0,65 m), the weight of the weight (m_z = 55 g) and wheel (m_k = 1,65 kg). We place the weight on the string and fasten it to the wheel so that it can fall freely on the mat. We set the weight so that it is at a height h above the mat. After the wheel is released, the weight starts to fall down with acceleration a and at the same time spins the wheel with angular acceleration ε. The weight takes time to fall t and from the traveled path $\boldsymbol{h = ½\, a\, t^2}$ we can determine the acceleration a. When the weight hit the pad, the wheel turned by an angle $\boldsymbol{\alpha = ½\, \varepsilon\, t^2}$, from which we can determine the angular acceleration. By comparing the results, we can confirm the relationships: $\boldsymbol{h = \alpha R}$- the length of the circular section after turning is equal to the length of the path of fall $\boldsymbol{a = \varepsilon R}$. - the angular acceleration is proportional to the tangential acceleration times the radius When the weight falls, an equal the torque acts on the wheel $\boldsymbol{M = R\,.\,G = R\,.\,(m\,g)}$. The relation also applies to the torque $\boldsymbol{M = I\,\varepsilon}$, where I is the moment of inertia of the wheel. By comparing the moments and the known angular velocity, we can determine the moment of inertia of the wheel. t = 1.56 s, h = 0.71 m, $\alpha = 126^o$, a = 0.587 m/s^2, ε = 1.81 rad/s^2, I = 0,097 kg.m^2 $a = g\,.\,2\,.\, m_z / (m^*_k + 2\,.\, m_z)$ In the second attempt, we use a weight with twice the weight (m_z = 110 g), while the other conditions of the experiment do not change.

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	Since the weight is twice as heavy, the moment of force should be twice as much and the acceleration with angular acceleration should be increase by approximately by two times. What will be the fall time? **Questions:** What is the relationship between **h** and α? After the impact of the weight, will the rotational movement be uniform or accelerated? Where should a weight of twice the mass be placed so that the wheel rotates at the same angular speed? **Conclusions:** The fall of the weight causes a constant force and the torque that turns the wheel.
3. Summary, evaluation and notes	Comparison of rotational and accelerated motion. It is also possible to determine the moment of inertia based on a theoretical relationship. **Level:** gymnasiums, secondary vocational schools (1st Year, ISCED 3

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The scenario

Subject	Mechanics - Angular Momentum
Length	2:35
Main objectives	Angular momentum
Detailed objectives	Rotating motion, Moment of inertia of the wheel. Law of conservation of angular momentum. Torque.
Structure and description of experiments:	
1. Introduction	Description: The spinning wheel has a moment of momentum, which, when is tilted, can spin a person on a chair.
2. Main subject	Description: Explain angular momentum, determine its direction, and show the law of conservation of angular momentum
Part 1	Spinning in a chair
(0:40) (0:44) (1:08)	**Tools:** Wheel, swivel chair, motor **Description:** First, we spin the wheel at high speeds so that it has the greatest possible momentum $\boldsymbol{L = J \omega}$, where $\boldsymbol{J}$ is the moment of inertia and $\boldsymbol{\omega = 2 \pi f}$ is the angular velocity. Direction $\boldsymbol{L}$ depends on the direction of rotation of the wheel. In this case, the wheel rotates down, so that the L points away from the wall towards us. An experiment on a swivel chair demonstrates the vector nature of the moment of momentum. The experiment shows that if the system is not acted upon by external moments of forces, not only the magnitude of the moment of momentum is conserved ***L,*** but also its direction. When sitting on a chair, the teacher holds the wheel in front of him with both outstretched hands. The wheel is turning towards us, so the angular momentum is to the left. The axis of the wheel and the chair are perpendicular to each other, so the teacher does not turn on the chair. After tilting the axis of the wheel down to the right, the chair and the teacher will start turning to the same right side. When the wheel is tilted to one side, the angular momentum vector has a component parallel to the axis of the chair, but upwards. As a result of the law of conservation of angular momentum, the chair starts to rotate to the right, i.e. the direction of its angular momentum is downward. The resulting component of the moment of momentum of the system: wheel + chair with person is zero. When the wheel is returned to the horizontal position, the rotation of the chair stops due to friction, since the component of the moment of momentum of the wheel parallel to the axis of the chair is zero. When the wheel is turned to the right, a component of the moment of momentum parallel to the axis of the chair arises again, but in this case it points upwards. Since the component of the vector is upward, the moment of momentum of the chair with the teacher

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	must be downward, which corresponds to turning to the opposite side, i.e. to the right. **Questions:** When the wheel turns by 90° will the effect be stronger or weaker? Why? Can we do the experiment in the opposite way? First, the axis of the wheel with the axis of the chair and then a 90° turn. **Conclusions:** During the rotating movement of the body, we must distinguish the direction of rotation in order to correctly determine the direction of the moment of momentum.
Part 2	**Precession**
(1:34) **(2:02)**	**Tools**: Wheel, motor, suspended rope with eyelet **Description:** First, we spin the wheel at high speeds so that it has the greatest possible momentum ***L***. Direction ***L*** depends on the direction of rotation of the wheel. In this case, the wheel rotates down, so that the L points away from the wall towards us. The experiment serves to demonstrate the validity of the second equation of motion: $\boldsymbol{M = \Delta L/\Delta t}$, where ***M*** is a torque. Carefully hang the spun wheel by the eyelet at the end of the extended axle. We hang the well-spinned wheel by the eyelet, with the axis in a horizontal position. The moment of angular momentum of the wheel is directed towards the hinge point. When the axle is released, the wheel does not tilt as we would normally expect, but the axle slowly rotates in a horizontal plane towards us. Gravitational force acts on the suspension wheel at the end of the axle $\boldsymbol{G = mg}$ acting in the center of gravity of the wheel. This force causes a torque of gravity: $\boldsymbol{M = r \times mg}$, where *r* is the distance from the hinge point to the center of gravity of the wheel. As the wheel rotates, it has angular momentum ***L*** pointing perpendicular to the plane of the wheel. The torque ***M*** subsequently causes a change in the moment of momentum $\boldsymbol{\Delta L = M \Delta t}$, which causes the wheel to rotate/precess gradually around the hinge point.

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	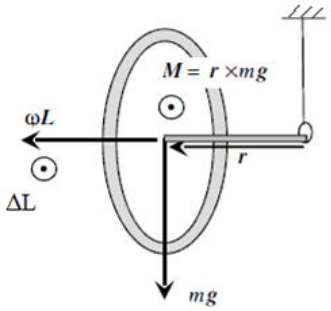 **Questions:** What happens to the wheel when the end of the extended axle is placed in the palm of the hand? What will happen when we perform the experiment on a space station in the orbit of the planet Earth? **Conclusions:** Precession is observed only when the wheel is spinning, and its direction depends on the direction of rotation of the wheel.
3. Summary, evaluation and notes	If we want the effect to be more pronounced, when sitting on a chair we hold the wheel so that the axis of rotation of the wheel is parallel to the axis of the chair. When turning the wheel slowly by 180 degrees, the entire momentum of the wheel is transformed into the momentum of the chair with person and the rotation is faster. **Level:** gymnasiums, secondary vocational schools (1st Year, ISCED 3)

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The scenario

Subject	**Mechanics / Solid Mechanics**
Length	3:27
Main objectives	Analyse the properties of the rotating motion of a rigid body, the moment of inertia.
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of the movement of bodies on an inclined plane and the impact after leaving the inclined plane.
2. Main subject	Description: Analyse the movement of bodies on an inclined plane, understand the concept of moment of inertia.
Part 1	
(0:40)	**Tools:** solids in the shape of a cylinder, sphere, disc, scale, meter **Description:** At the beginning, we weigh the body of different shapes - cylinder, sphere and disk .
Experiment 1 (2:08),	Let the ball-shaped body roll on an inclined plane and observe the movement after leaving the inclined plane. Subsequently, from the same position, we launch a 35x heavier ball and observe and analyse the movement compared to the previous movement of a smaller ball.
Experiment 2 (2:22),	Let the cylindrical body roll on the inclined plane and observe the movement after leaving the inclined plane. Subsequently, from the same position, we launch a 2.5x heavier cylinder and observe and analyse the movement compared to the previous movement of the cylinder of smaller weight.
Experiment 3 (2:04),	Let the disc-shaped body roll on an inclined plane and observe the movement after leaving the inclined plane. Subsequently, from the same position, we launch a 5.7x heavier disc and observe and analyse the movement compared to the previous movement of the cylinder of smaller weight.
Experiment 4 (2:53)	We repeat the experiment by simultaneously releasing both cylinders from the top of the inclined plane and watching their movement, then we simultaneously launch the cylinder and disk, the ball and cylinder, and finally the ball and disk . **Questions:** Does movement on an inclined plane depend on the weight of bodies of a given shape? Does the impact distance of bodies of the same shape from the wall depend on the weight of the bodies? (Will a ball 35 times heavier fall closer/farther than a ball of lesser weight?)

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	Conclusions: The movement on an inclined plane and the distance from the wall upon impact do not depend on the weight of the body of the given shape. The differences in speed when moving on an inclined plane and the distance from the wall at impact are related to the shape of the body and a quantity we call the moment of inertia.
3. Summary, evaluation and notes	During the implementation of the experiment, it is possible to stop the video and ask the students for their opinion on how the body will move and at what distance from the wall a several times heavier/lighter body will fall. **Level:** primary school (ISCED 3 / 1st grade)

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The scenario

Subject	**Pascal´s Law, Fluid Mechanics**
Length	1:40
Main objectives	Pascal's law, model of hydraulic equipment.
Detailed objectives	
Structure and description of experiments	
1. Introduction	Description: Experiment to demonstrate the principle of operation of hydraulic devices.
2. Main subject	Description: Demonstration and understanding of how pressure is created in a liquid by the action of an external force on the surface of the liquid in the container (liquid body). Show that the pressure in a liquid enclosed in a container due to an external force is the same at all points.
Part 1	
(0:39) **Experiment 1 (0:42)** **(1:21)**	**Utilities:** Two syringes of different cross-sections connected by a tube, liquid (we used water, do not use sticky liquid so that the piston does not stick), stand, two holders. **Description:** We will prepare the experiment by first filling the syringes connected by a tube with water as follows. Move the piston of one syringe to the lower position, fill the syringe-beaker system with liquid (water) so that there are no air bubbles under the pistons. Then we place the syringes on the stand by fixing them in the holders. If we press the piston, which is in the upper position, towards the syringe, the other piston moves upwards. By pressing one of the pistons, we exert pressure on the surface of the liquid. Upon close observation, we see that the volume of liquid that we push out with the piston in one syringe is the same as the volume of liquid that pushes out the piston in the other syringe . **Questions:** Why does the piston move? **Conclusions:** By pressing the piston of one syringe, we induce a pressure on the surface of the liquid through the action of force in the liquid, which is the same in all places of the liquid. The liquid is almost incompressible .
3. Summary, evaluation and notes	**Application:** The property of liquids expressed by Pascal's law is used in technical practice in hydraulic devices . **Notes:** The experiment can also be carried out without a stand. We let the model of the hydraulic device circulate among the children so that they can try out its functions. **Level:** elementary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Fluid Mechanics / Atmospheric pressure**
Length	1:40
Main objectives	Air pressure caused by gravity, atmospheric pressure force, atmospheric pressure.
Detailed objectives	
Structure and description of experiments	
1. Introduction	Description: Demonstration of the existence and effect of the atmospheric pressure force on the water level in the tank and the direction of the atmospheric pressure force.
2. Main subject	Description: Understanding the concepts of atmospheric pressure, atmospheric pressure force.
Part 1	
(0:39) **Experiment 1 (0:52)**	**Utilities:** Cup, measuring cylinder with water, sheet of paper. **Description:** Cut out a square or a circle from a sheet of paper, the diameter of which will be approximately 1 cm larger than the diameter of the opening of the glass . Fill a glass with a straight edge with water. Place the paper that we have prepared on top of the glass and press it gently with your fingers. Keep the paper still pressed against the glass and turn the glass with both hands by 180° to a vertical position with the bottom of the glass up. Then move the hand that was holding the paper away. We observe that the water does not flow out of the glass. **Questions:** Why water does not flow out of the glass, container? **Conclusions:** The water does not flow out of the glass, because the atmospheric pressure force of the surrounding air acts on it from the bottom up, perpendicular to the paper. This atmospheric pressure force is greater than the hydrostatic pressure force (weight of water) acting on the paper downwards. The result of the action of the Earth's gravity on all particles of the atmosphere is the atmospheric pressure force, which acts perpendicularly to the surface of bodies immersed in the air. The pressure caused by the atmospheric pressure force is called atmospheric pressure.
3. Summary, evaluation and notes	**Application:** A body located in the air, in the Earth's atmosphere, is affected by the atmospheric pressure force (analogy to the hydrostatic pressure force). **Notes:** We can carry out the experiment by changing, for example, the amount of water in the glass. Without paper or another "cap" of the glass, the attempt will not succeed. In accordance with the laws of physics, water will flow out of the glass when the game is turned. **Level:** elementary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Fluid Mechanics / Archimedes' Principle
Length	6:00
Main objectives	Archimedes' principle
Detailed objectives	
Structure and description of experiments	
1. Introduction	Description: The experiment verifies the validity of Archimedes' principle.
2. Main subject	Description: Formulation of Archimedes' principle based on experimental results.
Part 1	
(0:39) **Experiment 1 (1:00)** **(1:44)** **(2:25)**	**Utilities:** Stand, force meter, measuring cylinder with water, water container, one hollow and one solid body . **Description:** By inserting a solid body into a hollow body, we make sure that the volume of the body and the cavity are the same. We hang the bodies on the load cell suspended on the stand and measure them also G = 0.62 N. We immerse the whole body in water and measure the force F = 0.42 N, with which the body acts on the force meter. We will determine the size of the hydrostatic buoyancy force Fvz = G – F = 0.20 N from the measured drafts. Fill the cavity of the second body with water. We will measure the magnitude of the force F', which the system of bodies now acts on the force meter. We compare this force with the weight G of bodies immersed in water and we see that the magnitudes of both forces are the same, i.e. F'= G. **Questions:** What is Archimedes' principle? How to verify the validity of Archimedes' principle? **Conclusions:** A body immersed in a liquid is buoyed by hydrostatic buoyancy. The magnitude of the hydrostatic buoyancy force is equal to the weight of liquids of the same volume as the volume of the submerged part of the body .
Part 2	
(2:42) **Experiment 1 (3:04)** **Experiment 2 (5:20)**	**Utilities:** Stand, hanger, containers for making isosceles scales, identical bodies/weights with a hook, water collection container, water drain container, electronic scales, measuring cylinder . **Description:** We will make isosceles scales from hangers, containers and weights, with one container on each side and a weight suspended below it.

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	Pour water into the drain pan. We take isosceles scales and dip one body into the drainage container. The water that the body pushed out after immersion drained into the collection container. Pour the water from the collection container into the container above the submerged body. The balance of the scales has changed again. The body that we immersed in the water pushed out as much water as was necessary to bring the scales into balance. I.e. A body immersed in water is buoyed by a force equal to the weight of the water displaced by the body. **Questions:** What do we observe on isosceles scales? How does the balance change? **Conclusions:** A body immersed in a liquid is lightened by buoyancy. The magnitude of the hydrostatic buoyancy force is equal to the weight of liquids of the same volume as the volume of the submerged part of the body.
3. Summary, evaluation and notes	**Application:** Swimming bodies **Notes:** A solid body immersed in a substance in a gaseous state is, just like in a liquid, lightened by the force of buoyancy. For a body with density ρ_t, which is immersed in a gas of density V with its entire volume ρ_p the aerostatic buoyancy force acts. Archimedes' principle also applies to bodies immersed in gases. **Level:** elementary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Mechanics of Liquid / Floating Objects
Length	2:08
Main objectives	Analyse the properties of liquids and understand Archimedes' principle.
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of phenomena from nature - bodies swimming on the surface of liquid, bodies diving.
2. Main subject	Description: Why sometimes a body floats on the surface and other times it sinks. What does the magnitude of the buoyant force depend on? Investigating the possibility of floating bodies with a greater density than water on the surface of the liquid.
Part 1	
(0:40), **Experiment 1 (0:44),** **Experiment 2 (1:03)**	**Tools:** Water, aquarium, plasticine, scales **Description:** Model a ball from plasticine and weigh it. In a aquarium filled with water, place a ball of plasticine on the surface of the water surface and release it. We observe that the ball sinks and falls to the bottom. Subsequently, we model a boat from the ball, weigh it and place it on the surface of the water surface. We observe that the boat floats on the surface of the water. The weights of the boat and the ball are the same. The boat remains floating on the surface of the water, because the size of the displaced liquid is larger than in the case of the ball. **Questions:** Does the magnitude of the buoyant force of a liquid depend on the weight of the body? What does it depend on? **Conclusions:** The magnitude of the buoyant force depends on the amount of liquid displaced.
3. Summary, evaluation and notes	**Application:** Archimedes' principle is used when sailing ships, submarines. When modelling a boat, it is necessary to model a boat with the largest possible displacement. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Fluid Mechanics / Buoyant Force**
Length	5:18
Main objectives	Hydrostatic buoyancy force
Detailed objectives	
Structure and description of experiments	
1. Introduction	Description: The experiment verifies the existence of buoyancy.
2. Main subject	Description: Demonstrate that a body immersed in a liquid act on a hydrostatic buoyant force, determining the magnitude of the buoyant force.
Part 1	
(0:39)	**Utilities:** Stand, scales, forme meter, container with liquid of density 1 (water), two bodies-weights of the same volume of different density
(0:43)	**Description:** By weighing, we compare the masses of bodies. The bodies have the same volume, but have different densities, which is confirmed by comparing their weights. A body with more mass has more density, a body with more mass has more density.
Experiment 1 (1:16)	We hang a body with a smaller weight (density) on a forme meter and measure its weight G = 0.5 N. We immerse the whole body suspended on a force meter in a liquid of density 1 (water) in a container with water and measure the magnitude of the force F = 0.32 N, which the body acts on the force meter.
	Questions: Why does the force meter show a lower force value when the body is immersed in a liquid?
(1:59)	**Conclusion:** By comparing the magnitude of the forces measured by the force meter, we find that the force F < G. A body immersed in a liquid is overloaded, i.e. j. The hydrostatic buoyancy force acts on the body upwards F_{vz}, for which it applies $F_{vz} = G - F = 0,18$ N.
Experiment 2 (2:08)	We hang the body with greater density on the force meter and measure its weight G = 1.46. We immerse the body suspended on the force meter completely in water in a container with water and measure the magnitude of the force F = 1.28 N, which the body acts on the force meter. By comparing the magnitude of the forces measured by the force meter, we again find that the force F < G. A body immersed in a liquid is overloaded, t. j. hydrostatic buoyancy force acts on the body upwards F_{vz}, for which it applies $F_{vz} = G - F = 0,18$ N.
(2:52)	We will compare the magnitude of the buoyant force acting on bodies of the same volume with different weights (densities) immersed in the same liquid (water). **Questions:** Why does the same buoyancy force act on both bodies of different mass (density) immersed in water ?

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	Conclusion: The magnitude of the buoyant force by which a body immersed in a liquid is lightened does not depend on the density (mass) of the body.
Part 2	
(3:01)	**Utilities:** Stand, scales, force meters, container with liquid of density 1 (water), container with liquid of density 2 (glycerin) two bodies-weights of the same volume of different density .
Experiment 1 (3:19)	We hang the body on the force meter and measure its weight G = 0.53 N. We immerse the body suspended on the force meter in water in a container with water and measure the force F = 0.34 N that the body exerts on the force meter.
(4:03)	By comparing the magnitude of the forces measured by the force meter, we again find that the force F < G. A body immersed in a liquid is overloaded, i.e. j. hydrostatic buoyancy force acts on the body upwards F_{vz}, for which approximately applies $F_{vz} = G - F = 0,19$ N.
(4:05)	We repeat the experiment by immersing the body to different depths. If approximately one-third of the body is submerged, the body acts on the force meter with a force of approximately F = 0.48 N, and the magnitude of the buoyant force will be $F_{vz} = G - F = 0,05$ N. If approximately two-thirds of the body is submerged, the body acts on the force meter with a force of approximately F = 0.41 N, and the magnitude of the buoyant force will be $F_{vz} = G - F = 0,09$ N. If the entire body is submerged, the body acts on the force meter with a force of approximately F = 0.34 N, and the magnitude of the buoyant force will be $F_{vz} = G - F = 0,19$ N.
	Questions: Does the magnitude of the buoyant force depend on the depth of the bottom of the body below the free surface of the liquid?
Experiment 2 (4:13)	We hang the body on a force meter and measure its weight G = 0.53 N. We immerse the whole body suspended on the force meter in a container with a liquid with a density of 2 (glycerine) and measure the force F = 0.29 N that the body immersed in glycerin acts on the force meter .
(5:02)	By comparing the magnitude of the forces measured by the force meter, we again find that the force F < G. A body immersed in a liquid is overloaded, i.e. j. the hydrostatic buoyancy force Fvz acts on the body upwards, for which it approximately applies $F_{vz} = G - F = 0,24$ N.
(5:06)	Comparison of the magnitude of the forces with which the body acts on the force meter, in the case when it is immersed in water and in glycerin. A body immersed in water acts on the force meter with a force F = 0.34 N, i.e. $F_{vz} = 0,19$ N. A body immersed in water exerts a force on the force meter F = 0,29 N, i.e. $F_{vz} = 0,24$ N. A body immersed in liquids of different density sinks differently.

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	Conclusion: The magnitude of the buoyancy force by which a body immersed in a liquid is overburdened depends on the size of the volume of the immersed body, or the submerged part of the body, and on the density of the liquid in which the body is immersed.
3. Summary, evaluation and notes	**Application:** Immersion of bodies in liquids . **Notes:** A body immersed in a liquid is overburdened by a buoyant force, the size of which is equal to the weight of a liquid with the same volume as the volume of the immersed body or a submerged part of the body. **Level:** elementary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Mechanics of Liquids / Cartesian Diver
Length	1:49
Main objectives	Understanding Pascal's and Archimedes' laws/principles.
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be to investigate the functioning of submarines and divers.
2. Main subject	Description: Understand Archimedes and Pascal's law and their applications in practice.
Part 1	
(0:40), **Experiment 1 (0:52),** **Experiment 2 (1:16),**	**Tools:** transparent plastic bottle, water, dropper **Description:** Fill the dropper with a small amount of liquid (so that it floats in the water bottle) and close the bottle filled almost to the top with water. By pressing the bottle, the dropper will move down, when the pressure is released it will go up again. We also notice the size of the air bubble in the dropper, which changes depending on the amount of pressure on the bottle. A detailed view of the movement of the dropper and the size of the air bubble in the dropper, which shrinks when the bottle is pressed and then the dropper sinks to the bottom of the bottle. When the hand is released, the size of the air bubble changes again, the bubble in the dropper increases and the dropper points upwards. **Questions:** why does the size of the air bubble in the dropper change? **Conclusions:** Squeezing the plastic bottle increases the pressure in the liquid. The liquid is practically incompressible. The increased pressure is manifested by compressing the air in the dropper. Its volume will decrease, its density will increase. The dropper (depending on its overall density) gradually sinks to the bottom. After releasing the bottle, reducing the pressure in the liquid, the volume of the air bubble will increase and the dropper will rise to the surface.
3. Summary, evaluation and notes	**Application:** principle of operation of submarines , We can implement the experiment like a charm, we move the other hand down and the dropper follows the movement of the free hand. Then we move our hand up, release the pressure in the other hand in which we hold the bottle and the dropper moves up. We squeeze the bottle again and "command" the dropper to stop halfway. We then ask the children to explain the "magic". **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Fluid Mechanics / Swimming Bodies**
Length	2:43
Main goals	Conditions of swimming bodies
Detailed objectives	
Structure and description of experiments	
1. Introduction	Description: Demonstration of the effect of buoyancy and gravity on bodies in liquids.
2. Main subject	Description: Explanation of the conditions for swimming or diving bodies. Observing the swimming of bodies larger, smaller and the same density as water.
Part 1	
(0:39)	**Tools:** Container with water, plasticine, scales, identical fillable bodies, i.e. bodies of the same volume. **Description:** Fill the container with water and prepare the bodies. Fill one body with water, so that both parts are submerged under the water surface and connected under water. Fill the second body with plasticine. The third body will be filled only with air.
Experiment 1 (0:53)	By weighing and comparing, we can find out that the heaviest body is filled with plasticine and the lightest is the body filled with air. The volume of the bodies is the same, therefore the body filled with plasticine has the highest density and the empty body has the lowest density. Filled bodies therefore have different weights and different densities.
Experiment 1 (1:24)	We gradually submerge the bodies under the surface and observe how they behave. We found that the more dense a body is, the more it sinks, or sinks to the bottom. A body filled with water floats in water. A body with less density than water floats on the surface, on the surface of the liquid. The size of the buoyant force acting on a body located in a liquid depends on its volume and the density of the liquid in which the body is located. The magnitude of the force of gravity depends on the weight of the body. **Questions:** Why does a body of the same volume sometimes sink to the bottom and sometimes rise to the surface after being immersed in a liquid?
(1:24)	**Conclusions:** The body sinks to the bottom: the resultant of the forces acting on the body is directed downwards. The force of gravity is greater than the force of buoyancy. The density of the body is greater than the density of the liquid.
(1:37)	The body floats in the liquid: The resultant of the forces acting on the body is zero. Gravitational force is equal to buoyant force, liquid density is equal to body density.

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(1:50)	A body floats: The resultant of the forces acting on the body is directed upwards and the body rises to the free surface of the liquid. When the body reaches the surface, it partially emerges and settles. The force of gravity acting on the body is less than the buoyant force, and the density of the body is less than the density of the liquid.
3. Summary, evaluation and notes	**Application:** Swimming bodies in liquids. Archimedes' law is used when sailing ships, submarines and when measuring the density of substances with hydrometers. **Notes:** The magnitude of the buoyant force acting on bodies in the liquid is proportional to the weight of the displaced amount of liquid, or the weight of the submerged body, or the submerged part of the body. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Fluid Mechanics / Torricelli´s Law**
Length	3:28
Main objectives	Liquid flow rate.
Detailed objectives	
Structure and description of experiments	
1. Introduction	Description: Demonstration suitable for describing the outflow velocity of liquids, horizontal throw, Bernoulli's equation.
2. Main subject	Description: Explanation of the terms discharge velocity, atmospheric pressure, law of conservation of energy of flowing liquid.
Part 1	
(0:39)	**Tools:** Plastic bottle, large bowl, stand or pedestal, length measure, ruler, water, dye.
	Description: We will make a circular hole with a diameter of 1-2 mm in the plastic bottle.
Experiment 1 (0:52)	Place the bottle on a stand above the drain bowl. Pour water into the bottle.
(1:05)	We open the hole on the bottle. The water level in the bottle gradually decreases, which reduces the size of the outflow velocity of the liquid, i.e. the initial velocity of the water flowing out of the hole in the bottle. We observe that the water flows into the bowl gradually to a smaller distance.
	We will make two circular holes with a diameter of about 1.5 mm in the plastic bottle, so that they are on one vertical line. One hole will be about half the height of the bottle and the other two thirds of the height of the bottle. So the holes will be approximately 5 cm apart.
	Fill the bottle with water to the brim so that its level above the upper opening is as far as the bottom of the bottle from the lower opening.
Experiment 2 (1:44)	We open the holes on the bottle. The water flowing out of the upper opening has a lower outflow velocity (the initial velocity of the horizontal throw). Water flowing out of a lower opening has a higher flow velocity than water flowing out of a higher opening.
(1:58)	As the liquid level in the bottle decreases, the size of the outflow velocity from both openings also changes, i.e. j. the distances to which the water sprays also change depending on the height of the liquid level in the bottle.
	Questions: Why does the size of the outflow velocity change? What does the size of the outflow velocity of the liquid depend on?
	Conclusions: The length of the horizontal throw of the water jet depends on the initial speed of the thrown body. The experiment

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	shows that the length of the horizontal throw is greater, the greater the speed with which the body was thrown. We observe different trajectories of horizontal throws with different initial velocities and at different heights from which the bodies were "thrown" using the water jet. If we observe the length of individual horizontal throws in the plane of the bottle, we see. That the longest length belongs to the throw from the lower hole and the length of the throw from the upper hole is smaller.
3. Summary, evaluation and notes	**Application:** outflow velocity of liquids, horizontal throw of bodies **Notes:** Torricelli's law is a formula for calculating the flow rate of an ideal liquid. The formula can be derived from Bernoulli's equation (the law of conservation of energy of a flowing liquid) when the area of the container is assumed to be much larger than the opening through which the liquid flows, as in our experiment. Atmospheric pressure acting on the water in the container can also be considered constant with a small height difference. If the area of the container is much larger than the opening, the drop in the liquid level can also be considered negligible. Torricelli's law can only be used when the viscosity of the liquid can be neglected, which is the case of water flowing through holes in containers. **Level:** high school (1st year)

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The scenario

Subject	Mechanics of Liquid / Surface Tension
Length	1:47
Main objectives	Analyse the properties of liquids and the liquid surface layer
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of phenomena from nature - the movement of insects on the water surface.
2. Main subject	Description: Investigation of the surface layer of a liquid and the possibility of floating bodies with a greater density than the water on the surface of the liquid.
Part 1	
(0:40), **Experiment 1 (0:54),** **Experiment 2 (1:20),**	**Tools:** Water, glass, paper clips **Description:** Fill the glass with water up to the top. We take the paper clip with a fork and try to place it on the surface of the liquid. Even if the clip is made of a material that is more dense than water, the clip will stay on the surface of the water. Then we start immersing the paper clips one by one in the liquid and observe that the water does not flow out of the glass. The first drop of water will flow out of the glass only when there are enough staples in the glass. **Questions:** Why can even bodies with a greater density than the density of water remain on the surface of the liquid? Where is it used in nature? **Conclusions:** Thanks to the surface tension of the liquid, even some bodies whose density is greater than the density of water can float on the surface of the water.
3. Summary, evaluation and notes	The children carry out simple experiments on their own, in which, for example, they find out how many paper clips fit in a glass full of water or that they can place a paper clip on the surface of the water without it sinking to the bottom. **Level:** primary school (6th grade, ISCED 2 / 8th grade)

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The scenario

Subject	**Acoustics / Chladni Plates**
Length	6:18
Main objectives	To analyse the properties of bodies and sound, to recognize the resonance characteristics of the body.
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be to investigate the properties of sound, changing the frequency of sound and the effect of changing the frequency on the behaviour of vibrating bodies.
2. Main subject	Description: Get to know the resonance frequencies of oscillating plates, places that are at rest and which oscillate and the individual shapes of Chladni plates at individual resonance frequencies.
Part 1	
(0:40) **Experiment 1 (0:54)**	**Tools:** vibrating speaker, tin plate, grains of salt, frequency generator - mobile phone **Description:** Place a metal plate on the vibrating speaker, pair the speaker with a mobile phone that will generate sounds of certain frequencies. Sprinkle grains of salt evenly on the vibrating plate and watch what happens to the grains. In places where the plate vibrates, the grains bounce off and cluster in places where parts of the plate do not vibrate (we start with a frequency of 140 Hz). Then we gradually increase the frequency of the sound and watch how the individual grains of salt rearrange themselves. In the case of sound amplification - resonance, we stop the increase in frequency for a while and observe the patterns that have formed at the given resonance frequency (e.g. 390 Hz). The places where the grains of salt have settled on the board do not vibrate. If we sprinkle grains of salt on places where there is no salt, they will immediately bounce from the given positions - these are the places where the plate oscillates - vibrates. Subsequently, we increase the frequency of sound and vibrations of the board and observe how the patterns change - the vibrations of individual places of the board (e.g. 630 Hz). At the next resonance frequency (795 Hz), we sprinkle salt grains in places where they are not and observe how they bounce. We ended our experiment at 1550 Hz, but in practical implementation we can also proceed to higher frequencies. **Questions:** Why do the grains of salt stay still in some places on the board and not in others?

	Conclusions: Depending on the board and the sound frequency at certain resonant frequencies, so-called Chladni plates that characterize the places of the plate that are at rest during the vibrations of the plate.
3. Summary, evaluation and notes	The task is suitable for elementary school children who like to pour salt on the board and are unable to cover the entire board, because at the resonance frequency of the board, the grains of salt bounce off the oscillating points of the board. **Level**: primary school (ISCED 2 / 9th grade)

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The scenario

Subject	Optics / Focus
Length	3:01
Main objectives	Describe the representation of objects using a conjunction.
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be to investigate the imaging properties of lenses.
2. Main subject	Description: Understand the imaging of objects using lenses depending on the distance from the optical system.
Part 1	
(0:40), **Experiment 1 (0:51),** **Experiment 2 (1:31),** **Experiment 3 (2:21),**	**Tools:** Glass cup, water, object (1) **Description:** Fill the glass with water. The object (number 1 on the paper) is moved just behind the glass in the horizontal direction. We observe that the number 1 has the same shape (it is slightly enlarged). We then move the object back and observe the same thing again behind the glass of water. Subsequently, we move the paper with the number 1 10-20 cm back and again move it behind the glass in a horizontal direction. We observe that 1 has "turned" (right-left direction). When scrolling back, we again observe the rotation of the number 1. In the next phase, we move 1 behind the glass of water and gradually move it away from the glass. We observe that at a certain distance from the cup, 1 "turns" in the right-left direction. When we then move the paper with the number 1 back to the glass, we again observe the rotation of 1 at a certain distance from the glass. The place where the rotation of the digit 1 occurs in this experiment is called the focal point of the imaging system. **Questions:** How would the experiment change if there was no water in the glass? **Conclusions:** A glass of water acts as a lens and depending on the distance of the object - 1 from the glass it changes shape - the object rotates in the right-left direction after passing the focal length of the optical system.
3. Summary, evaluation and notes	**Application:** the working principle of lenses, magnifiers, Based on the given experiment, we can explain the functioning of the eye and the principles of imaging, the creation of a direct and inverted image. **Level:** primary school (ISCED 2 / 8th grade)

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The scenario

Subject	Nuclear physics / Ionising radiation
Length	6:02
Main goals	become familiar with radiation
Detailed goals	show that there are three basic types of nuclear radiation and show their properties regarding range and penetration
Structure and description of experiments:	
1. Introduction	Ionising radiation is everywhere and we cannot escape from it, so we should learn about it as much as we can.
2. Main subject	Ionising radiation
Experiments	This is a radiation detector with a Geiger tube. When it is turned on, it always shows some value of counts per seconds (cps). This is because everything is radioactive: the air we breathe, the desk on which radiometer stands, also we are slightly radioactive. The rate of counts increases when radiation source is placed in front of the detector. We will try to charge a conducting sphere, giving it a charge from a rod to its outer surface. But when we place paper between source and detector, cps value decreases. This source, americium-241 emits alpha particles, which are stopped by paper. Now we use beta particles emitter: potassium-40. Now paper is not enough for stopping this type of radiation, aluminium sheet is enough. The last source is thorium-232 with its radioactive daughters. It emits many types of radiation but there is huge amount of gamma rays coming out from it. Now paper does no change in cps, aluminium shows slight reduce in cps but lead stops radiation almost totally. Conclusion: indeed, there are different types of nuclear radiation with different penetration abilities: alpha particles are easily stopped by paper, beta particles needs more dense material, such as aluminium and gamma rays, the most penetrable, need very dense lead. Application: now we know, how to protect ourselves from different kind of radiation, what kind of shield is needed for sufficient protection.
3. Summary, evaluation and remarks	Americium-241 emits alpha particles but also weak gamma radiation (60 keV). This is the reason why count rate does not fall to zero when blocked with paper.

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	Potassium-40 emits beta particles but also strong gamma radiation (1461 keV). This is the reason why count rate does not fall to zero when blocked with thin aluminium sheet. **Level:** secondary school

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The scenario

Subject	**Electrostatic / Triboelectric charging**
Length	4:23
Main goals	Get familiar with electrostatic charging
Detailed goals	to show that electric charge can be produced by rubbing different materials with different clothes and by induction
Structure and description of experiments:	
1. Introduction	Charging of different types of bodies can be easily shown even using home materials.
2. Main subject	Triboelectric charging
Experiments	1. We rub a piece of amber with a cloth and show that it attracts small paper pieces. 2. We rub an acrylic rod with a cloth and show that it attracts small paper pieces. 3. We use an electroscope to show that the rubbed rod is charged – the needle of the electroscope is repelled from inner metal part. 4. We try to charge by rubbing a piece of metal (aluminium rod), there is no effect – because we hold this metal with our hand – the charge easily escapes. 5. We try to charge metal rod but now hold via insulating foam, the effect is small but exists. 6. We move charged plastic rod near the electroscope rod and see the deflection of its needle even without touching it. This is called electrostatic induction. 7. We use a charged rod to attract metallic, noncharged can.
3. Summary, evaluation and remarks	1. Electrons from insulating materials can be removed locally by the touch of different materials. 2. Electrons from conductive materials can be easily drawn only when the materia is insulated. 3. Electrons are free to move in metal – they separate when charged object is near them and are always attracted. **Level:** primary school and secondary school

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The scenario

Subject	Electrostatic / Charge distribution on a sphere
Length	2:17
Main goals	To show that electric charge on a conductive material is not spread arbitrarily
Detailed goals	to show that the charge given to a conductor resides on its outer surface entirely
Structure and description of experiments:	
1. Introduction	Conductive materials can be easily charged by touch with a charged body but there is a special way that the charge given is distributed all over the conductive material.
2. Main subject	Charge distribution on a sphere
Experiments	1. We will try to charge a conducting sphere, giving it a charge from a rod to its outer surface. Now we check if the charge resides inside or outside the sphere. Neutral probe is put inside the can in contact with it and then it is brought to touch the electroscope - there is no charge on the probe, so there is no charge on the inner surface of the sphere. Now we touch the outside surface of the sphere and find out that the charge resides there. 2. Now we remove charges from electroscope, probe and sphere and do the same experiment, but charging inner surface of the sphere. We check if the charge is inside the sphere and find out that there is still no charge, even if the sphere was charged there. Now we check if the charge is on the outer surface of the sphere - it is there, it has not disappeared.
3. Summary, evaluation and remarks	Conclusion: charge given to a hollow and empty conductor always resides on its outer surface Application: if we want to transfer all charge of a probe to an electroscope, we should use a small Faraday cap mounted on the top of it and put the probe inside. All the charge from the probe will escape towards the most outer surface. **Level:** primary school and secondary school

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The scenario

Subject	**Electrostatic / Surface charge density**
Length	2:08
Main goals	To show that electric charge on a conductive material is not spread arbitrarily
Detailed goals	to show that the charge density on the outer surface of a conductive material depends on a curvature of the surface, and that the potential of different points on this surface is the same.
Structure and description of experiments:	
1. Introduction	Conductive materials can be easily charged by touch with a charged body but there is a special way that the charge given is distributed all over the conductive material.
2. Main subject	Surface charge density
Experiments	We can see that the can is shaped so that it has a sharp one end, concave second end and locally flat surface in its middle. We show that this body is not charged by touching it with a probe ball and then touching the electroscope, using two different points of the surface. We charge the can, taking its electrons by a positively charged acrylic rod. Now we check the density of the surface charge. 1. Firstly, a neutral probe is put inside the can in contact with it and then it is brought to touch the electroscope - there is little charge on the probe, so there is little charge density on the inner surface of the sphere. We ground the probe and electroscope. 2. Secondly, we touch the outside surface of the can and find out that there is more charge on a locally flat surface. We ground the probe and electroscope. 3. Lastly, we touch the sharpie end of the can and find out that there is most charge there.
3. Summary, evaluation and remarks	Conclusion: charge given to a conducting body with different curvatures is redistributed so that the highest charge density is where the curvature is greatest. Application: if we want to have low charge density so the field and so the charge leakage is weakest we should use objects with big radius (small curvature), like the dome of Van de Graaff generator. **Level:** primary school and secondary school

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The scenario

Subject	Mechanics / Conservation of angular momentum
Length	1:59
Main goals	Get familiar with conservation of angular momentum
Detailed goals	to show that angular momentum is conserved when there is no external torque
Structure and description of experiments:	
1. Introduction	Conservation of angular momentum is one of three most important conservation laws in mechanics, alongside conservation of energy and momentum. It concerns rotation.
2. Main subject	Conservation of angular momentum
Experiments	We do have two balls with different masses. The steel one is heavy, when the plastic one is light. Both of them, when travelling along curved inclined plane, exert torque on the plane, depending on its weight. The same torque is exerted by the plane on the ball. When time taken for the balls to roll down is the same, the torque differs and so the change of angular momentum of the rotating inclined plane (or the ball) is different in both cases. From the other point of view, total angular momentum initially is zero and the same should be after the ball has gone. Angular momentum of the ball is ***mvr***, when m is the mass of the ball, ***v*** - its velocity and ***r*** - the distance between axis of rotation and the ball when it leaves inclined plane. The only difference in both cases is the mass of the ball - so the steel ball has larger angular momentum, so the turntable should achieve the same amount of angular momentum, but rotating in opposite direction, so the total angular momentum is still zero. We see that the turntable has larger velocity and makes more turns when steel ball is used. Now we use pizza turntable and a huge flask of tinged water. When it is placed on the table, nothing happens. But when we swirl water in the flash and put it on the table once more, it starts to spin. Angular momentum of water is nonzero, but water slows down, by the inner friction (viscosity) between water molecules and between water and walls of the flask. The angular momentum is then transferred to the table, through the walls of the container.
3. Summary, evaluation and remarks	Tinging is best when food colour is used. Potassium permanganate leaves marks that are very difficult to remove. **Level:** secondary school

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The scenario

Subject	**Mechanics / Conservation of momentum**
Length	2:08
Main goals	Get familiar with conservation of momentum
Detailed goals	to show that momentum is conserved when there is no external force acting on a system, especially during explosion
Structure and description of experiments:	
1. Introduction	Conservation of momentum is one of three most important conservation laws in mechanics, alongside conservation of energy and angular momentum. It concerns translational motion.
2. Main subject	Conservation of momentum
Experiments	We put some hot water inside the barrel and close it very tightly with a rubber stopper. Then we heat up the water inside by using a gas burner. Water boils, turns into steam, which has much bigger volume than water from which it was made (ca 1000 times) but it cannot expand because the barrel is sealed. So the pressure builds up, until force exerted by this pressure on the cork exceeds static friction force and the cork pops out. There was no momentum at the beginning, so after popping it's still zero. When the light cork pops with high velocity, much heavier cannon moves with lower speed in opposite direction so that the momentum is conserved.
3. Summary, evaluation and remarks	Water should fill small amount (e.g. ⅕) of volume of the barrel so that there is a lot space for steam to build up pressure. **Level:** secondary school

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The scenario

Subject	Electromagnetism / Series and parallel circuits
Length	4:10
Main goals	Get familiar with series and parallel electrical connections
Detailed goals	to show that voltage divides into several devices in series connection and switching off one of them will brake circuit; to show that voltage is the same in parallel connection and switching off one of them will make no change in the rest of the circuit
Structure and description of experiments:	
1. Introduction	Everyday life has plenty of examples of parallel connections and so few of series. We will show both of them with differences.
2. Main subject	Series and parallel circuits
Experiments	1. We put 3 lightbulbs with the same power ratings in parallel and show that each one shines independently. 2. We put those 3 lightbulbs in series and show that: 1) they shine less, which confirms that applied voltage divides into all of them equally; 2) removing any of them will cause the rest to switch off. 3. Now we use 3 lightbulbs with different power ratings; in parallel connection they shine as the ratings read (each one is stated for 230 V). 4. Now we make connection in series – surprisingly, the lowest rated bulb shines the most, the highest – emits no light. But there is still current flowing through it, what we show by removing it from the circuit, which is then open and none of the lamps shine any more.
3. Summary, evaluation and remarks	In each case described above a question can be stated: will the bulbs shine? Which one, if not all? Which will shine the most and which the least? **Level:** primary school and secondary school

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The scenario

Subject	Electromagnetism / A complex electrical circuit
Length	3:51
Main goals	Get familiar with complex electrical circuits
Detailed goals	to show that voltage divides into several devices in series connection and switching off one of them will brake circuit; to show that voltage is the same in parallel connection and switching off one of them will make no change in the rest of the circuit
Structure and description of experiments:	
1. Introduction	Everyday life has plenty of examples of parallel connections and so few of series. We will show both of them with differences.
2. Main subject	A complex electrical circuit
Experiments	1. We have 3 lightbulbs with the same power ratings, what we show connecting them in parallel (230 V) and turning on. 2. Now we put those 3 lightbulbs in a more complicated circuit having one bulb in series with two connected in parallel. 3. We observe that the one in series shines bright and those two in parallel shine less, but equally. 4. We shall swap the bulbs to show that in each configuration the result is the same and the bulbs were not changed with other ones with other power ratings. 5. If we unscrew one of the two in parallel, we will have two in series and the other from parallel connection will shine much brighter. 6. If we unscrew the one that was in series all of them go out.
3. Summary, evaluation and remarks	In each case described above a question can be stated: will the bulbs shine? Which one, if not all? Which will shine the most and which the least? **Level:** primary school and secondary school

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The scenario

Subject	Thermal properties of matter / Thermal expansion of solids
Length	2:35
Main goals	Get familiar with thermal expansion of solids
Detailed goals	to show that a typical metal expands with temperature increased and contracts with temperature decreased
Structure and description of experiments:	
1. Introduction	Most of materials that can be found around us change dimensions with temperature, each one in its own way. We will show that even minuscule expansion can be shown using not so complicated mechanical stuff.
2. Main subject	Thermal expansion of solids
Experiments	We will use a device that can show even slightly change in length – as the lower part of the device is moved, the pointer show exaggerated reading. We use a brass rod and place it inside the device. Then we heat it with a gas burner, the reading of the length increases. We can now cool it down using ice cubes – the reading goes down.
3. Summary, evaluation and remarks	As we conclude, there are some substances that will expand with temperature rise – in fact there is many of them. Counterexample – rubber band. **Level:** primary school

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The scenario

Subject	**Thermal properties of matter / Formation of dry ice as a result of rapid cooling of the gas**
Length	3:58
Main goals	Get familiar with sublimation and properties of dry ice
Detailed goals	to show that a sublimation is a process of changing solid into gas without liquid phase, to show that decompression of gas causes temperature drop
Structure and description of experiments:	
1. Introduction	Alongside naphthalene and iodine dry ice is one of most common substances which shows sublimation, even with no external heat source because of its temperature.
2. Main subject	Formation of dry ice as a result of rapid cooling of the gas
Experiments	We start with a special container, in which expanding carbon dioxide will decrease its temperature low enough to be solidified. After few seconds of decompressing we can see white powder of solid carbon dioxide - dry ice. Its temperature is below -80 degrees Celsius. What will happen if we put it into glass of water? Its floating, so its density is smaller than density of water. It creates cloud - at so low temperature water (as air humidity) freezes and creates a cloud. Can such cold material be held on someone's hand? Yes, because of so called Leidenfrost effect. Dry ice sublimates and creates thin layer of gaseous carbon dioxide which insulates skin from the piece of dry ice. The same effect causes dry ice to hover over the surface of a piece of aluminium, for instance. When forced to change state of aggregation quicker, it simply sublimates with no liquid left. We can hear the voice of gas running out from a piece of metal very quickly.
3. Summary, evaluation and remarks	During the lesson, you can present what dry ice looks like and what properties it has. **Level:** primary school

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The scenario

Subject	**Mechanics / Cart with a fan – Newton's laws of motion**
Length	1:57
Main goals	Get familiar with III law of dynamics
Detailed goals	Newton's laws of motion, inertia, acceleration, and action-reaction
Structure and description of experiments:	
1. Introduction	If there is no wind, can crew of a yacht move the yacht by blowing onto the sail?
2. Main subject	**Cart with a fan – Newton's laws of motion**
Experiments	We start with a hairdryer and show that it blows air. Then we try to set in motion a cart with a plastic „sail" by blowing with the hairdryer – it starts to move (as a yacht goes with the wind). Second experiment includes small fan mounted in front of the sail. Even when turned on and blowing air onto the sail, it cannot set it in motion. Why? If the fan pushes air, the air pushes fan backwards. In magnitude this is the same force as the air pushed pushes sail, so the two forces, acting on the fan and on the sail, cancels. Question is, can we use this fan to propel cart? Yes, if we remove sail! We use simple recoil – the air pushed by fan pushes the fan backwards and gives us motion.
3. Summary, evaluation and remarks	We neglect changing angle of the sail in this experiment, which can be used to move the cart anyway. **Level:** primary school

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The scenario

Subject	Mechanics / Rolling uphill – Resal's double cone
Length	2:48
Main goals	Get familiar with center of mass
Detailed goals	To understand that using eyes only can lead to false statements and that center of mass always tends to occupy lower possible level in uniform gravitational field.
Structure and description of experiments:	
1. Introduction	Sometimes physics look like magic – in fact, some magical tricks uses only physics laws.
2. Main subject	Rolling uphill – Resal's double cone
Experiments	There is a inclined plane of special form – it consists of two rails, both of them inclined up and outside the center line. If there is a cylinder put on them, it Rolls down. But if we use double cone, it rolls upwards! The question is, why it rolls upwards like it was defying gravity. This question is stated incorrectly. There is no such motion. If we check the height of the axis of this device in both position we will find that this one „downhill" is higher than the other one „uphill". It is because of the shape of this body. Closer the rails are, higher the center of mass is. It Rolls down but for our eyes it appears to be rolling the other way.
3. Summary, evaluation and remarks	This is a paradox – it seems to be something magical but it isn't. It can be explained very simply. **Level:** secondary school

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The scenario

Subject	**Mechanics / Levitating magnetic disks on a scale**
Length	2:30
Main goals	Get familiar with the III law of dynamics
Detailed goals	To understand that the forces are in pairs, action and reaction.
Structure and description of experiments:	
1. Introduction	Is something levitating exerting any force on anything around?
2. Main subject	Levitating magnetic disks on a scale
Experiments	First we show three magnets and put them on one wooden rod that they repel each other in pairs. Two of them are levitating in the air. If we now the mass of the rod and the magnets the question is, what will the scale show when these magnets are levitating?
3. Summary, evaluation and remarks	Oncourse the scale will show the same total mass as if the magnets were touching each other as a result of their attraction. In each case if the magnet is levitating, there is a force from magnet beneath equalling weight of the magnet – so the upper magnet exerts the same force, i.e. its weight, on the lower magnet, which lies on the scale. **Level:** primary school

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The scenario

Subject	**Mechanics / Moments of inertia**
Length	2:30
Main goals	Introduce moment of inertia
Detailed goals	To understand that the rotational motion depends not on the mass and radius of the object but also on the specific arrangement of the mass inside the body.
Structure and description of experiments:	
1. Introduction	Is mass only all that one need to know the acceleration of rotating body?
2. Main subject	Moments of inertia
Experiments	First we show that two cylindrical objects have the same outer radius and the same mass. We can see that part of each of the bodies is made of shiny aluminium (density 2.7 g/cm3) and the second part of dark grey lead (11 g/cm3). In one case lead is in the center, in the other – it forms outer surface. The question may be stated: which of these two will roll faster on the same inclined plane? The one with lead at the center has smaller moment of inertia, so it accelerates faster with the same torque (same masses, same radii).
3. Summary, evaluation and remarks	The object with greater moment of inertia will accelerate slower. **Level:** secondary school

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The scenario

Subject	**Mechanics / Moments of inertia: tube, sphere and cylinder**
Length	3:07
Main goals	Introduce moment of inertia
Detailed goals	To understand that the rotational motion depends not on the mass and radius of the object but also on the specific arrangement of the mass inside the body.
Structure and description of experiments:	
1. Introduction	Is mass only all that one need to know the acceleration of rotating body?
2. Main subject	Moments of inertia: tube, sphere and cylinder
Experiments	First we show that three bodies have the same outer radius and the same mass, all made of steel. The question may be stated: which of these bodies will roll fastest and which slowest on the same inclined plane? The one with smallest moment of inertia (ball, 0.4 mR2), then cylinder (0.5 mR2), then hollow tube (mR2).
3. Summary, evaluation and remarks	The object with greater moment of inertia will accelerate slower.

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The scenario

Subject	Mechanics / Friction blocks
Length	4:20
Main goals	Get to know about static friction coefficients for different materials
Detailed goals	To understand that the static friction coefficient depends on the material of the surface that undergoes friction.
Structure and description of experiments:	
1. Introduction	Friction force depends on normal force and type of two surfaces that are in contact. In this experiment we will examine static friction with same normal force but for different surface materials.
2. Main subject	Friction blocks
Experiments	Having one inclined plane, which angle can be increased continuously, we put same brass blocks on different surfaces on the plane: aluminium, rubber, wood, PTFE. Then we can ask, which of these blocks will start to move as the first one and what will be the order of starting. The proper order is PTFE, Al, wood, rubber.
3. Summary, evaluation and remarks	Using simple algebra one can demonstrate that the coefficient of friction equals tangent of the angle of motion start.

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The scenario

Subject	Thermal properties of matter / Temperature and pressure
Length	3:39
Main goals	Get to know about adiabatic processes
Detailed goals	To understand that quick compression or decompression of gas will lead to adiabatic process, i.e. without heat exchange.
Structure and description of experiments:	
1. Introduction	Adiabatic process is one of four main type of gas changes. It requires no heat exchange – what can be achieved by perfectly insulating walls of the gas container or by simply so quick change of pressure that the heat will not be able to flow, even with conductive walls.
2. Main subject	Temperature and pressure
Experiments	Plastic bottle with a rubber stoper and valve has water vapour inside. We increase pressure by pumping air into the bottle. Then we remove the stoper with valve and let the air decompress. Without heat exchange air does work and its temperature decreases, what is clearly seen by water condensation. In a brass syringe with an acrylic stoper we put a small piece of cotton wool. In dark place we suddenly compress the air inside the syringe; it is so quick action that heat is not exchanged, even with brass walls of the syringe. The work done on the gas causes temperature rise – so high that the cotton wool gets fire.
3. Summary, evaluation and remarks	

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The scenario

Subject	Thermal properties of matter / Bimetal
Length	2:24
Main goals	Get to know about different thermal expansion rates of different materials
Detailed goals	To understand that each body made from different material has its own thermal expansion rate.
Structure and description of experiments:	
1. Introduction	As usually, we can make use of different physical phenomena. Now we examine thermal expansion rate of different materials of the same shape, put together.
2. Main subject	Bimetal
Experiments	A bimetal strip consists of two parts: one made of steel and the other – aluminium. When heated, the strip bends towards steel strip. We conclude that aluminium expands more and steel less so the strip bends like so.
3. Summary, evaluation and remarks	This simple device miniaturized can be used, for example, as an on-off mechanism in electric irons.

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The scenario

Subject	**Thermal properties of matter / Solid expansion ball and ring (Gravesande's ring)**
Length	3:43
Main goals	Get to know about thermal expansion of metals
Detailed goals	To understand that typical metallic body will increase its dimensions when heated and decrease when cooled.
Structure and description of experiments:	
1. Introduction	Each material body will change its dimensions when its temperature is changed. Some materials will increase, some will decrease its diameter, some will show so small difference that cannot be measured with simple devices. Metals usually expands with temperature rise.
2. Main subject	Solid expansion ball and ring (Gravesande's ring)
Experiments	A brass ball and brass ring have diameters so tuned that in room temperature the balls goes freely through the ring. When the ball lies heated, it no longer goes through the ring. When cooled, it fits through the hole once more.
3. Summary, evaluation and remarks	There are many examples of use of this effect and many examples of situations, in which we must pay attention about this effect, as for example railroads, long bridges or high voltage wires.

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The scenario

Subject	Thermal properties of matter / Thermal conductivity
Length	2:53
Main goals	Get familiar with the thermal conductivity
Detailed goals	To understand that we can feel „warm" and „cold" when touching different materials with the same temperature.
Structure and description of experiments:	
1. Introduction	Touch wooden desk with one of your hand and metal leg of a desk with the other. What is warmer?
2. Main subject	Thermal conductivity
Experiments	First we show that the temperature of each of discs, wooden and aluminium, are the same. Then we put an ice cube on each disc and ask which one will melt first? Temperature is the same in both cases but thermal conductivity is not. Ice will melt very quickly on aluminium and will not melt at all on wood.
3. Summary, evaluation and remarks	Aluminium has many free electrons, which conducts heat easily. Wood is an insulator soi t has no free electrons. The same reason is why wooden desk feels warm but metal leg cold – the last one „steals" our warm more rapidly, having the same temperature difference (body-surroundings).

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The scenario

Subject	**Mechanics / Equlibrist's balance**
Length	1:37
Main goals	Statics of a rigid body, center of gravity
Detailed goals	Types of equilibrium in which the body can be: indifferent, unstable, stable,
Structure and description of experiments:	
1. Introduction	Description: Observation of the behavior of a motorcyclist balancing on a rope. Learn the rules to keep bodies in balance.
2. Main subject	Description: The aim of the experiment is to introduce students to topics related to the concept of the center of gravity and its role. Discussion of the types of equilibrium of a body (rigid body) depending on the location of the center of gravity of this body relative to its support point.
Part 1	
Experiment 1	**Materials:** • Motorcyclist - a figure made of LEGO bricks on a motorcycle without tires, • wire or rod properly bent into an arc, • plasticine to load the rod, • string/rope or flat bar, • 2 tripods, • connectors for attaching the rope/flat to the tripod **Description:** We assemble the connectors on the tripods, place them at different heights (slight difference in height). We attach the rope/twine between the tripods to the connectors, we tighten it. The rope forms an inclined plane with a small angle of inclination between the tripods. We place the motorcyclist on the rope and observe his behavior - he does not keep his balance and falls down with the motorcycle. We put a bent rod loaded with plasticine at the ends into the motorcyclist's hands. We put the motorcyclist back on the rope. The motorcyclist maintains balance, slides down the rope, stops at the end of the rope and continues to balance. Instead of a rope/string, you can use a flat bar fixed vertically (with a thin edge vertically). **Questions:** Why is a motorcyclist on a motorcycle set on a rope unable to keep his balance? Where is the motorcyclist's center of gravity relative to the fulcrum (where the motorcycle wheels meet the rope)?

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	What could help him keep his balance? What role does the bent rod play in the hands of a motorcyclist? What is the role of an umbrella or a balance in the hands of a tightrope walker? In what position relative to the fulcrum is the motorcyclist's center of gravity when we place a long rod/wire loaded at the ends in his hands. **Conclusions:** If the center of gravity of the body (motorcyclist) is below the rope, the figure will keep balance, it will balance, but it will not fall. A bent long rod, a pole, an umbrella held in the hands of a tightrope walker change the position of the center of gravity of the body/system, lowering it. The role of the long rod is to lower the center of gravity of the body/system. When the center of gravity is under the point of support of the body - the body will be in permanent equilibrium.
3. Summary, evaluation and remarks	The video can be used at the beginning of the lesson as an introduction to the lesson on the center of gravity, the question: why without a long pole the motorcyclist loses balance and with a long pole in his hands he easily moves along the rope The film can illustrate how the behavior of bodies changes under the influence of changing the position of the center of gravity. The video can be used as a control question: What happened to the position of the biker's center of gravity when a long pole was added to the system? Discussion about • circus equilibrists, • Philippe Petit - French highwire-walker and the movie "The walk" • physics in sport - change in the position of the center of gravity during high jump, race walking ect, • A tightrope walker balancing over the Brda River in Bydgoszcz in Poland. **Level of education:** secondary school

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The scenario

Subject (field/title)	Mechanics/ The center of mass of an irregularly shaped body
Length of movie	3:11
Main Goals	Rigid body statics. Determination of the center of mass/center of gravity of solids.
Detailed Goals	Determination of the center of mass/gravity of an irregularly shaped solid. Behavior of a solid supported (suspended) at the center of mass/gravity.
Structure and description of the experiments:	
1. Introduction	Description Observation of subsequent steps to determine the center of mass/gravity of an irregular body. An illustration of neutral equilibrium.
2. Main topic	Description The aim of the experiment is to familiarize students with the method of determining the center of mass/gravity of irregular solids. Indication of the role of the plumb line in determining the center of mass/gravity of bodies. Rigid body equilibrium demonstration.
Part 1	
	Tools : • *Flat, irregular shape body* • *tripod,* • *tripod adapter to attach the handle* • *handle* • *string* • *weight or other weight* **Description** : We place a handle on the tripod, on which we hang a weight fixed at the end of the string, creating a plumb line. A weight suspended on a string creates a so-called plumb line. The plumb line is a line that coincides with the direction of gravity on the Earth's surface. We hang the body on the tripod, on the same handle as the plumb line. We choose any suspension point. We pay attention to the direction of the plumb line. If possible, we can draw a straight line on the body that runs along the vertical. We hang the body at any other point and set the direction of the plumb line again. Once again, we change the suspension point of the body and mark the direction of the vertical with such a suspension. The center of mass of the solid lies at the point where all 3 lines determined by the perpendicular intersect for each suspension point of the body.

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	We suspend the body at its center of mass/gravity. We show that no matter which way we turn the body, how we tilt it, it will always remain in balance. **Questions** : How can you find the center of mass of an irregular body? What is the difference between center of mass and center of gravity? Can the location of the center of mass coincide with the location of the center of gravity? If so, under what conditions is it possible? What is a plumb line (masonry plumb)? What is the vertical? How does a body supported (suspended) at its center of mass/gravity behave? **Conclusions:** The center of mass lies at the point where the lines drawn by the plumb line for each point of suspension of the solid intersect. To determine the location of the center of mass of an irregular body, we can use a plumb line (masonry plumb). The center of mass is a point in an object that often behaves to a good approximation as if the mass of the entire object was concentrated there. This concept is very useful in mechanics because it allows you to describe the motion and behavior of a body, even of a complex shape, in a simple way. The force of gravity (gravity) is in a homogeneous gravitational field applied to the center of mass - that's why we talk about the center of gravity. Only in a heterogeneous gravitational field the center of mass and the center of gravity do not coincide. In a gravitational field, which is approximately homogeneous, like the gravitational field at the surface of the Earth, we assume that the center of gravity coincides with the center of mass. For this reason, the terms "center of gravity" and "center of mass" are often used interchangeably as synonyms.
3. Summary, evaluation and comments	**Application:** The video can be used at the beginning of the lesson as an introduction to the center of mass/gravity lesson. Question: What is the center of mass? What is the center of gravity? How to determine the center of mass of irregular solids? The film can be used in the implementation phase of the lesson as an illustration of the discussed issue. The film can be used as a repetition of the topic related to the center of mass and the way it is determined. Discussion about methods of determining the center of mass of regular and irregular bodies. You can support a solid in the center of mass on a finger and demonstrate that it remains at rest. Previously, in the same way, we can determine the location of the center of mass of regular bodies, for example, for a square, any

	triangle, an equilateral triangle, a trapezoid. We can discuss what straight lines the plumb determines in solids, when the suspension point will be in the successive vertices of a given solid. **Level of education:** secondary school

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The scenario

Subject (field/title)	**Mechanics /** **Determination of the center of mass of a hanger**
Length of movie	1:37
Main Goals	Statics of a rigid body, center of gravity
Detailed Goals	Rigid body statics. Determination of the center of mass/gravity of the hanger
Structure and description of experiments:	
1. Introduction	Description: Observation of the method of determining the center of mass/gravity of an irregular body - hanger
2. Main topic	Description: The aim of the experiment is to familiarize students with the method of determining the center of mass/gravity of irregular solids. Indication of the role of the plumb line (bricklaying plumb) in determining the center of mass/gravity of bodies. Making students aware that the center of mass/gravity does not have to be a material point and can be outside the solid. Center of mass and center of gravity.
Part 1	
Experiment 1	**Tools:** • *hanger made of wire (plastic or wood),* • *tripod,* • *tripod connector for attaching the handle* • *handle* • *twine* • *a weight* **Description:** We place a handle on the tripod. We hang a weight fixed at the end of the twine on the handle, creating a plumb line. A weight suspended on a twine creates a so-called plumb line, i.e. a device for determining the vertical direction. The plumb line determines the direction to the center of the Earth, the direction of gravity. We hang the hanger on the hook on the same handle as plumb line on the tripod. We pay attention to the direction of the plumb line inside the contours of the hanger. We hang the hanger at a different point and pay attention to the direction of the plumb line again. Once again, we change the suspension point of the hanger and look at the direction of the plumb line in such situation. We choose a total of three arbitrary points on which we hang the hanger and observe the direction of the plumb line in each case.

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	The center of mass lies at the point where all lines drawn by the plumb line for each suspension point of the body (hanger) intersect. **Questions:** How can we find the center of mass of an irregular body? What is the difference between center of mass and center of gravity? Can the location of the center of mass coincide with the location of the center of gravity? If so, under what conditions is it possible? Can the center of mass of a body be immaterial and be located outside the solid? **Conclusions:** The center of mass lies at the point where the lines drawn by the plumb line for each suspension point intersect. The center of mass may be outside the solid. We can use the plumb line to determine the location of the center of mass of an irregular body. The center of mass is a point of an object that often behaves as if all the mass of the rigid body was concentrated there. This concept is very useful in mechanics because it allows you to describe the motion and behaviour of a body, even of a complex shape, in a simple way. The force of gravity is in a homogeneous gravitational field applied to the center of mass - that's why we talk about the center of gravity. Only in a heterogeneous gravitational field the center of mass and the center of gravity do not coincide. In a gravitational field, which is approximately homogeneous, like the gravitational field at the surface of the Earth, we assume that the center of gravity coincides with the center of mass. For this reason, the terms "center of gravity" and "center of mass" are often used interchangeably as synonyms.
3. Summary, evaluation and remarks	The video can be used at the beginning of the lesson as an introduction to the center of mass/gravity lesson. **Question:** What is the center of mass? What is the center of gravity? How to determine the center of mass of irregular solids? The film can be used in the implementation phase of the lesson as an illustration of the discussed issue. The film can be used as a repetition of the topic related to the center of mass and the way it is determined. Discussion about methods of determining the center of mass of regular and irregular solids **Level of education:** secondary school

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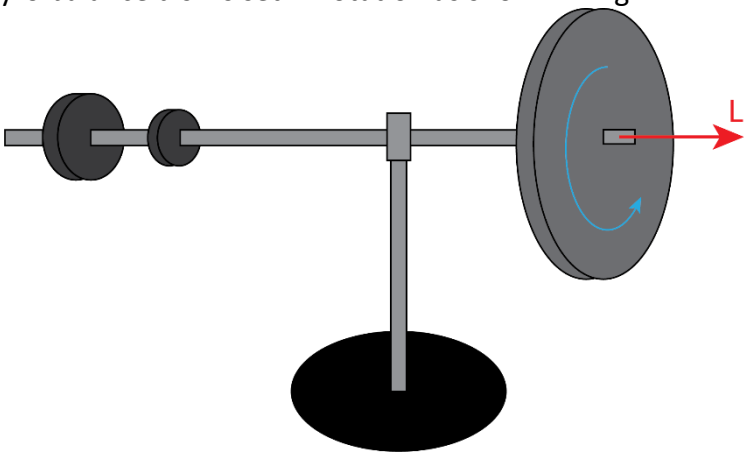
The scenario

Topic	Mechanics, Gyroscope
Movie length	4:43
Main Objectives	Rigid body dynamics
Specific goal	Explanation of precession and nutation.
Structure and description of the experiments:	
1. Introduction	Observation of the behaviour of the gyro balance when the weight distribution on its arms changes.
2. Main topic	The aim of the experiment is to introduce students to topics related to the concept of precession and nutation. Presentation of the phenomenon of precession and nutation, discussion of the moment of force.
Part 1	
Experiment 1: 1:20	***Materials*** *:* • *gyro scale,* • *weights,* • *string.* **Description** : The gyro balance disk is set in rotation as shown in Fig. 1.  Fig. 1. Initial position of the gyro scale. We turn the scale and watch what happens. We see that the axis of rotation keeps time in one direction all the time. The balance does not spin about the vertical axis. **Questions** : Why doesn't the scale spin around the vertical axis of rotation? What can we say about power coins? Where in everyday life do we deal with balancing moments of forces? **Conclusions:** *When the masses are distributed on the balance in such a way that the moments of force balances out, there are no external contributions to*

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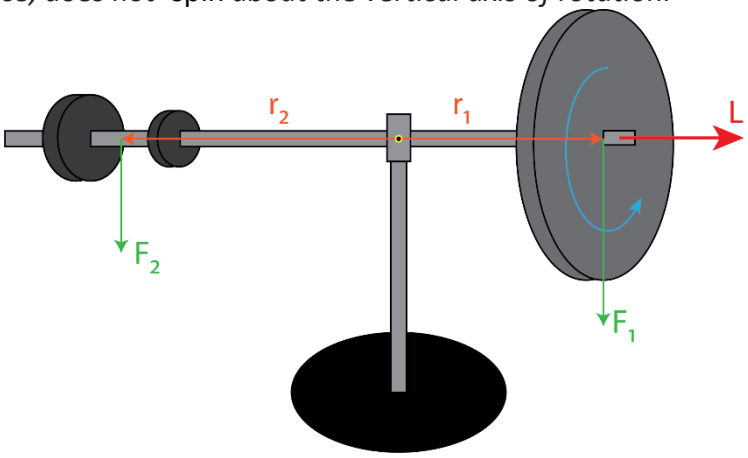
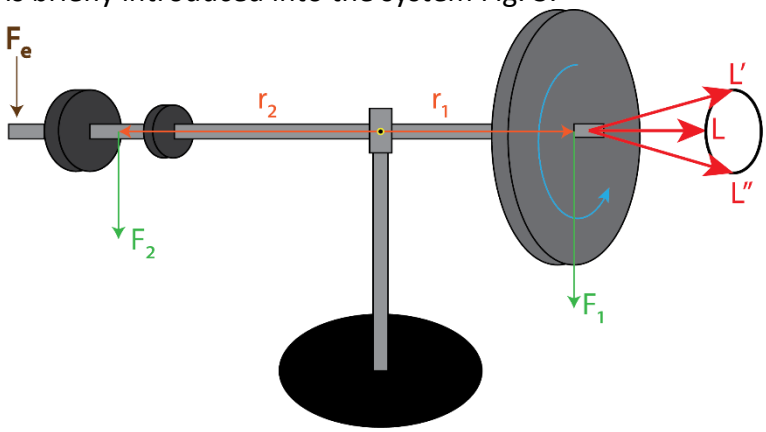
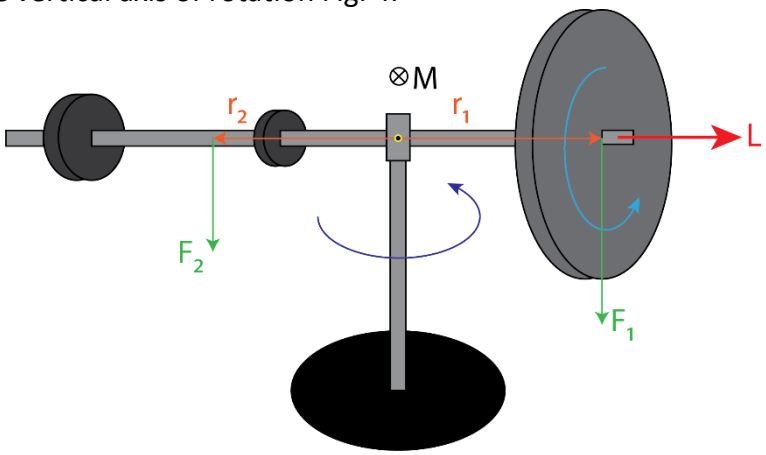
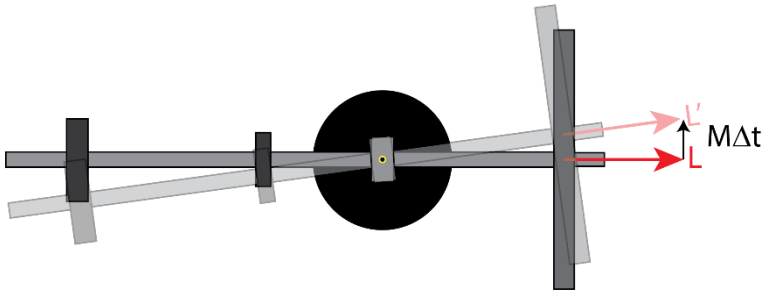
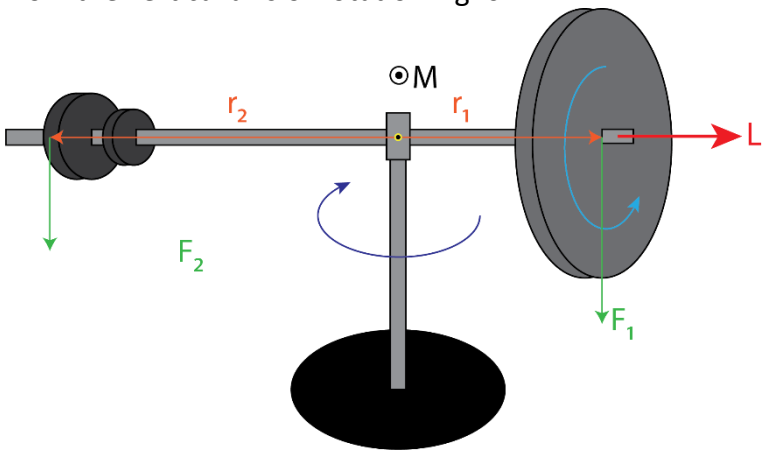
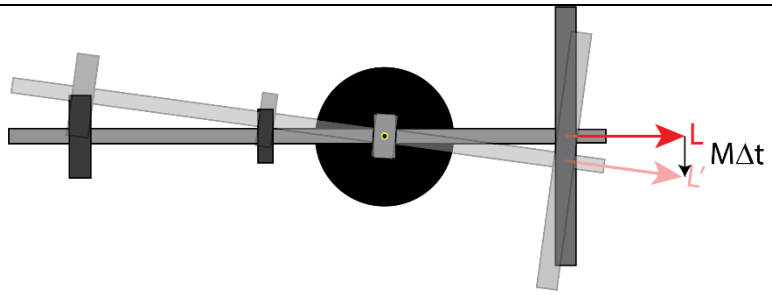
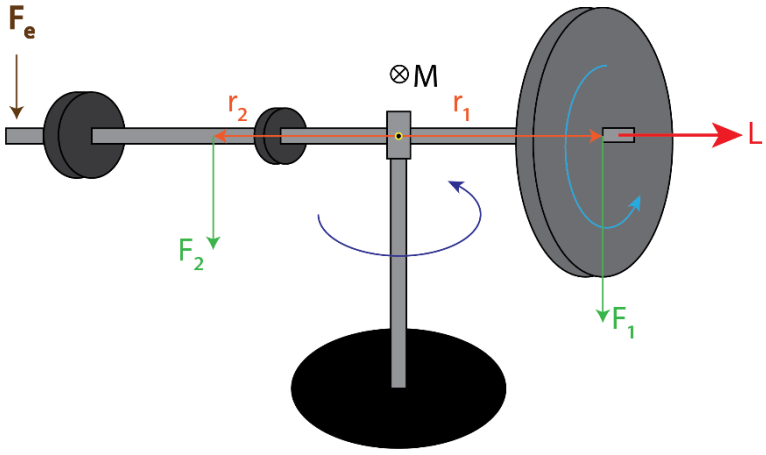
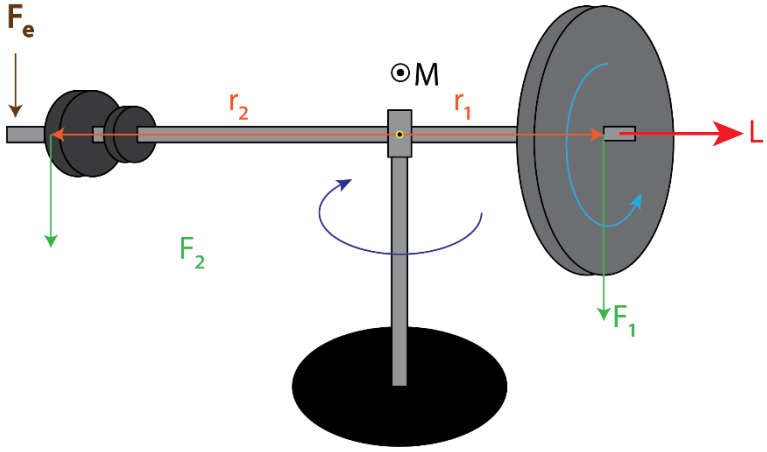
	the system and angular momentum is conserved. The scale remains in balance, does not spin *about the vertical axis of rotation.*  Fig. 2. Distribution of forces - balance in balance. $r_2 > r_1$ $m_2 < m_1$ $\vec{r}_1 \times F_1 = \vec{r}_2 \times F_2$ $\vec{M}_1 = \vec{M}_2$
Experiment 2: 1:40	***Materials*** *:* • *gyro scale,* • *weights,* • *string.* **Description** : The gyro balance disk remains spin as before. An external unbalanced force is briefly introduced into the system Fig. 3.  Fig. 3. Changing the direction of the angular momentum vector. We turn the balance around the vertical axis and observe what happens. We see that the axis of rotation keeps one direction all the time, but there is an additional movement of it. **Questions** : Why did the extra movement appear in the system?

	Where in everyday life do we face a similar situation? How long is the Earth's nutation period? What causes Earth nutation? Are there also nutations for a spinning top (toy)? Does the force of gravity from the moon and sun affect the nutation of the earth? **Conclusions:** *The introduction of a short-term external force into the system causes nutation.*
Experiment 3: 2:06	***Materials*** *:* • *gyro scale,* • *weights,* • *string.* **Description** : The gyro balance disk remains spin as before. We change the distribution of the mass on the left side. We move a small weight closer to the vertical axis of rotation Fig. 4.  Fig. 4. Distribution of forces for a gyro balance. After moving the weight to the right, the balance begins to spin with a spinning disc towards the experimenter. **Questions** : Why did the extra movement appear in the system? Where in everyday life do we face a similar situation? How long is the Earth's precession period? What is causing the Earth's precession? Is there precession for a spinning top (toy) too? **Conclusions:**

	Analysing the situation in Fig. 4, we can present the system as follows: Fig. 5.  Fig. 5. View from above for the situation in Fig. 4. As a result of the appearance of an unbalanced moment of force in the system, the balance begins to rotate - the angular momentum vector changes its direction.
Experiment 4: 2:38	***Materials*** *:* • *gyro scale,* • *weights,* • *string.* **Description** : The gyro balance disk remains spin as before. We change the distribution of the mass on the left side. Move the small weight farther away from the vertical axis of rotation Fig. 6.  Fig. 6. Distribution of forces for a gyro balance. After moving the weight to the left, the balance begins to rotate with a spinning disc from the experimenter. **Questions** : as above **Conclusions:** *Analysing the situation in Fig. 6, we can present the system as follows: Fig. 7.*

	 Fig. 7. View from above for the situation in Fig. 6. As a result of the appearance of an unbalanced moment of force in the system, the balance begins to rotate - the angular momentum vector changes its direction.
Experiment 5: 3:13	***Materials*** *:* • *gyro scale,* • *weights,* • *string.* **Description** : The gyro balance disk remains spin as before. We change the distribution of the mass on the left side. We move a small weight closer to the vertical axis of rotation and apply an external force as in Fig. 8.  Fig. 8. Distribution of forces for a gyro balance. After moving the weight to the right, the balance begins to spin with a spinning disc towards the experimenter. In addition, nutation is visible (Experiment 3). **Conclusions:** *The system is a combination of two experiments and allows to present the full motion of the gyroscope (top) taking into account external forces. The experiment can be related to the precession of the Earth with nutation.*
Experiment 6: 3:40	***Materials*** *:* • *gyro scale,* • *weights,*

	• *string.* **Description** : The gyro balance disk remains spin as before. We change the distribution of the mass on the left side. We move a small weight further from the vertical axis of rotation and apply an external force as in Fig. 9.  Fig. 9. Distribution of forces for a gyro balance. After moving the weight to the left, the balance begins to rotate with a spinning disc from the experimenter. In addition, nutation is visible (Experiment 3). **Conclusions:** *As in experiment 5.*
Summary, evaluation and comments	**Application:** The film can be used at the beginning of the lesson as an introduction to issues related to mechanics and astronomy, and as a summary to test students' knowledge. It deals with the subject of angular momentum, torque, unbalanced forces in the system. **Level:** secondary school

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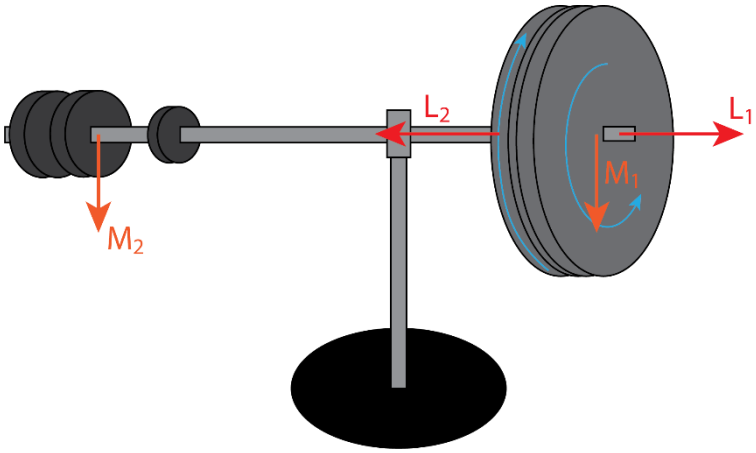
The scenario

Subject (field/title)	Mechanics / Gyroscope: two disks
Length of movie	3:33
Main Goals	Rigid body dynamics
Detailed Goals	Explanation of the principle of vector addition of angular momentum.
Structure and description of the experiments	
1. Introduction	Observation of the behavior of the gyro balance when the weight distribution on its arms changes.
2. Main topic	The purpose of the experiment is to introduce students to the subject of angular momentum. Discussion of the phenomenon of angular momentum, discussion of the issue of momentum of force. Adding vector quantities.
Part 1	
Experiment 1: 1:20	**Materials** : • gyro scale, • weights, • string. **Description** : The discs of the gyro balance spin as shown in Fig. 1.  Fig. 1. Initial position of the gyro scale. We set the discs in motion so that they spin in opposite directions. We observe what happens after moving the weight to the left and right. **Questions** : Why doesn't the balance rotate around the vertical axis of rotation as in the case of the experiment: Gyroscope? What can we say about momentum of forces? What can we say about angular momentum? **Conclusions:**

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	The angular momentum from rotating disks is resultant vector. The magnitudes of these vectors are the same but opposite in direction. The result of adding of angular momentum is equal to 0. Therefore, the system can be treated as an balanced scale (lever). Moving the weight on the left side causes the entire system to tilt from one side to the other. This move is depending of relation between the momentum of force on the right and left side.
3. Summary, evaluation and comments	**Application:** The film can be used at the beginning of the lesson as an introduction to issues related to mechanics and astronomy, and as a summary to test students' knowledge. It deals with the subject of angular momentum, torque, unbalanced forces in the system. **Level:** secondary school

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The scenario

Subject (field/title)	Air pressure / Suction pad
Length of movie	1:37
Main Goals	Fluid statics. The use of reduced pressure in daily life
Detailed Goals	Explanation of the pressure difference issue. Comparison of atmospheric pressure and pressure under the suction pad.
Structure and description of the experiments	
1. Introduction	The video shows how to move objects with a suction pad .
2. Main topic	How does a change pressure to human body? How can it be used to make easier human's work?
Part 1.	
Experiment (0:37)	***Materials*** *:* • *Suction pad with a handle for carrying e.g. glass.* • A piece of rubber to which the handle from the lid to the pots. **Description** : A piece of rubber with a handle is placed on a flat surface of different objects. We try to move them with a suction pad to another place. The suction pad applied to a flat surface does not "detach", but remains on the object all the time. We can lift it up using one of the corners. The suction pad placed on the table, despite applying quite a lot of force, does not "detach". **Questions** : Why don't objects fall off the suction pad? What is the pressure below the surface of the rubber? Where are similar items used? **Conclusions:** When we lifting a piece of rubber by the handle, a small bulge forms in its vicinity. In this space pressure is lower than the atmospheric pressure outside. The object is thus pressed against to the rubber (suction pad). To lift up the rubber, you should hold it by one of the corners. Then we don't change in pressure under its surface.
3. Summary, evaluation and comments	**Application:** Use in the classroom as introductory material to motivate students to think. After the lesson, you can ask for explanations why objects do not fall down the suction pad. **Comments:** It is important to point out to students that the common suction pad does not suck or stick objects to it. The objects are pressed against the rubber surface (suction pad) by atmospheric pressure. **Level of education:** primary school and high school

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The scenario

Topic	Air pressure / Cream cake in a vacuum
Movie length	2:02
Main Objectives	Presentation of phenomena related to pressure reduction.
Specific goal	Explanation of the issue related to the reduction of pressure and the space occupied by objects filled with air.
Structure and description of the experiments	
1. Introduction	The movie shows what happens with objects that are filled with small air bubbles.
2. Main topic	What effect does a change in atmospheric pressure have on a human body?
Part 1	
Experiment 1: 1:20	***Materials*** *:* • Vacuum pump, • vacuum chamber, • cream cake, shaving foam, whipped cream, marshmallow. **Description** : Place the cream cake inside vacuum chamber. We lower the pressure in the vacuum chamber. The cream begins to increase its volume several times. After introducing air into the chamber, the cream rapidly begins to decrease in volume. **Questions** : Why does the mass increase in volume in the initial phase? What happens to the air bubbles trapped in the mass? How does the re-air supply to the diffuser affect the mass? **Conclusions:** Air bubbles that are in the mass when the air is pumped out from under the lampshade increase their volume. We have the impression that the mass is increasing. We allow the air bubbles in the cream to retain a larger volume. Unfortunately, as a result of the rapid pressure reduction, some of the bubbles are burst and the air is removed from under the lampshade. Re-supplying air to the vacuum chamber causes equalization of pressures and the bubbles decrease their volume again. Unfortunately, the cream, due to the fact that some of the bubbles have been destroyed, is no longer so fluffy.
3. Summary, evaluation and comments	**Application:** The movie can be used at the beginning of a lesson as an introduction to a lesson about atmospheric pressure. What is indicated by the behaviour of the cake after the air has been pumped out from under the bowl of the vacuum pump?

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	The movie can be used as an illustration of the effects of negative pressure during the relevant part of the lesson. The movie can be used when reviewing material on issues related to the concept of pressure. The movie can be an introduction to a discussion about: The impact on the human body of the lack of atmospheric pressure in space. About the use of pressure in daily life. About changes in atmospheric pressure and their impact on people's well-being. **Level of education:** primary school and high school

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The scenario

Subject (field/title)	Mechanics/Balance: leaning tower
Length of movie	2:46
Main Goals	Rigid body statics. Location of the center of mass/center of gravity of the body. Types of equilibrium of a rigid body depending on the location of the center of mass/gravity relative to the support point of the body.
Detailed Goals	Description : There are three types of equilibrium: stable, unstable, and neutral. Equilibrium – conditions of remaining in equilibrium of bodies supported below their center of mass/gravity. The problem of certainty of equilibrium of a rigid body standing on the surface of the Earth. A system is said to be in stable equilibrium if, when displaced from equilibrium, it experiences a net force or torque in a direction opposite to the direction of the displacement.
Structure and description experiments :	
1. Introduction	Description : **The equilibrium of a body is a state in which all forces and moments acting on it are balanced. What happens to a rigid body when its fulcrum (suspension) is changed relative to its center of gravity.**
2. Main topic	The aim of the experiment is to show students the conditions that must be met for the solid to be in equilibrium.
Part 1	
	Tools : • *Leaning tower* - a movable, rectangular stand with a plumb line placed at the center of gravity for testing the state of equilibrium **Description** : We place the tower on its base so that all its levels are parallel to the plane of the base and the plumb line fixed in the center of gravity of the tower, on its middle level, points to the center of the base. The tower is in stable equilibrium. We move the upper plane of the tower relative to its base to the right or left (shear motion). We put the tower on the table. The tower of the table is inclined at a certain angle to the ground. It remains in a stable balance. The plumb line remains within the base of the tower. We increase the angle of inclination of the tower. The tower is still in balance. The plumb line suspended in the center of gravity of the tower still remains within the base of the tower. We increase the angle of inclination of the tower once more by moving it with the upper plane. The plumb line indicates the edge of the tower. The tower is still in balance.

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	We increase the angle of inclination of the tower again. The plumb line extends beyond the base of the tower. The tower loses its balance and falls over. **Questions** : Why do people and structures standing on the ground not lose their balance even though their center of mass/gravity is above the fulcrum? What conditions must be met for a rigid body to remain in equilibrium - from the point of view of forces and moments of forces? What conditions must be met for a rigid body to remain in equilibrium - from the point of view of potential energy. What conditions must be met for a rigid body to remain in equilibrium - from the point of view of its center of gravity relative to its fulcrum? How does a solid supported (suspended) at a point below its center of mass/gravity behave? Where is the human center of mass/gravity? Is the center of mass/gravity at exactly the same point in a woman's body as in a man's? **Conclusions:** For a rigid body to remain in static equilibrium in the field of gravity, the forces of gravity applied to the body must be balanced by the reaction forces of the body's suspension or support. The moments of forces must also be balanced by the moments of ground reaction forces. The balance of the solid is certain when the base has a large area and the center of gravity is located at a short distance from the base. The projection of the center of gravity of a solid onto its base must be within the base. If a homogeneous solid is tilted so that the direction of the vertical dropped from the center of gravity goes beyond the perimeter of the base, it will fall over on the other wall, because then a pair of forces is created that overturns the solid. Such overturning of a solid requires work to be done against the force of gravity, and thus with an increase in the potential energy of the solid. After tipping over the other wall, the potential energy reaches its previous value.
3. Summary, evaluation and comments	**Application:** The video can be used at the beginning of a lesson as an introduction to a lesson about balance and the role of center of mass/gravity. Question: What conditions must be met for the body to remain in equilibrium? The film can be used in the implementation phase of the lesson as an illustration of the discussed issue. It can serve as an illustration for the discussion of maintaining balance by man.

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	The video can be used as a conclusion to lessons and reflections on balance. The film can be an introduction to a discussion about: stability of buildings and structures stability of vehicles moving on uneven terrain. human stability when sitting down, getting up, moving, sports where the movement of the center of mass/gravity is very important **Level:** secondary school

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The scenario

Subject (field/title)	**Air pressure / Balloons in a vacuum**
Length of movie	2:01
Main Goals	Analysis of changes in gas inertness due to changes in air pressure
Detailed Goals	
Structure and description of the experiments	
1. Introduction	Description: The change in volume of partially inflated balloons due to changes in air pressure is shown
2. Main topic	Description: Changes in gas volume due to changes in pressure
Part 1	
	Tools: Balloons, Vacuum bell, vacuum pump, manometer. **Description:** Balloons inflated with a small amount of air are placed under a vacuum bell. We turn on the pump, resulting in the air being partially pumped out from under the vacuum bell and the pressure drops, which is visible on the pressure gauge. As the pressure under the bell is lowered, the volume of the balloons increases. The pump is turned off, and the valve is opened to equalise the pressure under the bell with the atmospheric pressure. As the pressure increases, the volume of the balloons can return to its initial state. The observed process is related to changes in air pressure around balloons partially filled with the same gas. By lowering the pressure under the bell, we increase the volume of the balloons so that the elastic interactions of the balloon shell and the interactions of the molecules on the outer surface of the balloon are balanced with the interactions of the molecules enclosed in the balloon on its inner surface. **Questions:** Would balloons in a perfect vacuum also expand when the air is pumped out from under the bell? If the lampshade were very large, would the balloons expand indefinitely? **Conclusions:** Due to changes in the external pressure, the pressure inside the balloons also changes, which leads to a change in their volume.
3. Summary and notes	During the experiment, you can pause the video and ask students for their opinion on how the balloons will behave under the shade **Level:** primary school and high school

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The scenario

Subject (field/title)	Thermal properties of matter / Balloons in liquid nitrogen.
Length of movie	2:51
Main Goals	Changes in state and volume due to changes in temperature
Detailed Goals	The change in the volume of gas due to a change in its temperature.
Structure and description of the experiments	
1. Introduction	Explanation: Substances change their volume as a result of temperature changes, and so do gases.
2. Main topic	Description: The film presents a change in the volume of air enclosed in a balloon due to a change in its temperature.
Part 1	
	Tools: Two large beakers, placed one inside the other and thermally insulated from each other, liquid nitrogen, inflated balloons (so that their diameter is slightly smaller than the beaker used), wooden pliers. **Description:** Pour liquid nitrogen into the beaker. Use pliers for dipping the balloons into liquid nitrogen. It can be seen that the volume of air in the balloons decreases rapidly, and the rubber from which the balloon is made stiffens. Then, one by one, we pull the balloons out of the liquid nitrogen and observe the air volume in the balloons increasing again. Using transparent balloons, it is possible to observe the liquefied air inside the balloon (the boiling point of the air is about -191°C, which is slightly more than 4°C higher than the boiling point of liquid nitrogen, therefore observation of the liquefied air is only possible for a very short time after the balloon is pulled out of the liquid nitrogen). **Questions:** Does the air in such a cooled balloon have no volume? Why does the volume of a gas decrease as the temperature decreases and increase as the temperature increases? **Conclusions:** As a result of lowering the temperature, the gas volume decreases due to the decrease in the average kinetic energy of the gas particles and, thus, the decrease in the distance between the particles. When the gas temperature is reduced below the boiling point (i.e. below the liquefaction temperature), the gas molecules will be so close together that it will become a liquid. As the temperature of the gas starts to rise again, the molecules will start to increase their average kinetic energy and start to move apart, increasing the volume of the gas.
3. Summary and notes	Students should be reminded that cooling a substance means lowering the average kinetic energy of the molecules that make up the substance. Similarly, with heating - it is an increase in the average kinetic energy of substance molecules. **Level:** primary school and high school

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The scenario

Subject (field/title)	Wave properties of sound / Bell in a vacuum
Length of movie	2:02
Main Goals	Representation of sound as a mechanical wave
Detailed Goals	Proving that a mechanical wave needs an elastic medium to propagate.
Structure and description of the experiments	
1. Introduction	Explanation: A mechanical wave needs a medium to propagate through space.
2. Main topic	Explanation: This video demonstrates the fact that a sound wave is a mechanical wave
Part 1	
	Tools: Electric bell, vacuum bell, vacuum pump, manometer, sponge. **Description:** We set the electric bell based on a vacuum cover. Turn on the bell and cover it with a vacuum bell. The sound of a bell comes from under the vacuum bell. We close the lampshade valve and turn on the vacuum pump. As the pressure decreases, which can be observed on the pressure gauge, the sound of the bell becomes quieter. Under optimal conditions, the sound of the bell may not be heard at all, but we observe how the bell trembles. Opening the valve after turning off the pump results in pushing air under the cover. The ringing tone is heard again. **Questions:** Why do we hear explosions in the Sun? **Conclusions:** By pumping out the air from under the shade, we reduced the number of particles that can transmit vibrations in space. Thus, we limited the possibility of sound wave propagation. By letting air into the diffuser again, we increased the number of particles and thus enabled the transmission of vibrations between them - that is, we allowed the propagation of the sound wave. Therefore, we have proved that a sound wave needs a medium and is a mechanical wave.
3. Summary and notes	Point out to students that mechanical waves need a medium to propagate, unlike electromagnetic waves, which can also propagate in a vacuum. **Level:** primary school and high school

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The scenario

Subject (field/title)	Thermal properties of matter / Boiling of water under reduced pressure
Length of movie	3:05
Main Goals	Changes in the state of matter
Detailed Goals	Boiling water under reduced pressure
Structure and description of the experiments	
1. Introduction	Description: The video shows the phenomenon of boiling water at a pressure below atmospheric pressure
2. Main topic	Description: The video presents boiling as evaporation in the entire volume of a liquid, the temperature of which depends on the pressure.
Part 1	
	Tools: Beaker, thermocouple (e.g. thermocouple), meter enabling temperature measurement using a thermocouple, vacuum bell with electrical feed-throughs, vacuum pump, manometer. **Description:** Pour water into the beaker. Place the beaker on the base of the vacuum bell, immerse the thermocouple in it and connect it to the electrical feed-throughs. On the other side of the feed-throughs, we connect a meter that allows temperature measurement using the used thermocouple. Put the vacuum bell on the base and turn on the vacuum pump. In the video, you can see small bubbles forming at the end of the thermocouple - air bubbles are coming out of the insulation of the thermocouple. The thermometer shows a temperature of about 24°C, and at the same time, the pressure drop under the glass cover can be observed on the manometer. At some point, when the right pressure is reached, bubbles of water vapour appear on the walls of the vessel. The phenomenon begins to occur in the entire volume of the liquid. After turning off the pump and equalising the pressure under the bell, you can see that the water stops boiling and the temperature drops slightly. The fact of lowering the temperature is due to the rapid evaporation of water. **Questions:** Is it possible to brew tasty tea on Mount Everest? Why does water boil at room temperature under reduced pressure? **Conclusions:** Boiling differs from evaporation in that the first one takes place at a constant temperature defined as the boiling point, and it is evaporation in the entire volume of the liquid. In contrast, the second one takes place at any temperature but only on the surface of the liquid. The boiling of water can occur at room temperature under

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	reduced pressure because water molecules can more easily be released from the volume of the liquid.
3. Summary and notes	Point out to students that boiling is a physical phenomenon and that every substance has a boiling point that depends on the type of substance and the pressure acting on that substance. **Level:** primary school and high school

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The scenario

Subject (field/title)	Thermal properties of matter / Freezing of liquid nitrogen (under reduced pressure)
Length of movie	3:43
Main Goals	Changes in the state of matter
Detailed Goals	Changes in phase transition temperature due to changes in pressure
Structure and description of the experiments	
1. Introduction	Explanation: This video shows the existence of liquid nitrogen in three states of matter simultaneously.
2. Main topic	Description: Changes in phase transition temperature due to pressure change.
Part 1	
	Tools: Beaker, liquid nitrogen, vacuum bell, vacuum pump, manometer, sponge (heat insulator). **Description:** When we pour liquid nitrogen into a beaker, we see condensed water vapour. Nitrogen boils in a beaker, which looks like boiling water. Nitrogen at atmospheric pressure boils at -195.8°C. The beaker is closed under a vacuum bell, and the pressure is reduced. After a while, the nitrogen stops boiling and a layer of solidified nitrogen forms on its surface. By lowering the pressure further, between the solid and liquid nitrogen, gaseous nitrogen appears. When its pressure is high enough, the solidified nitrogen layer is lifted, and gaseous nitrogen is released. The moment when a substance exists in three states of aggregation at the same temperature and pressure (three phases are in thermodynamic equilibrium) we call the triple point. **Questions:** Can other substances exist in three states of aggregation simultaneously? **Conclusions:** We can change the state of aggregation of a substance without changing its temperature because the state of aggregation of a given substance also depends on the pressure in which it is located.
3. Summary and notes	Point out to students that boiling, melting or evaporation takes place at a given temperature. However, it can change depending on the pressure around it. **Level:** secondary school

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The scenario

Subject (field/title)	Electromagnetism / Lightning Rod
Length of movie	3:58
Main Goals	The flow of electric charge in the air
Detailed Goals	The principle of operation of the lightning rod.
Structure and description of the experiments	
1. Introduction	Explanation: The video shows the flow of electric charge in a model of the atmosphere at a large difference in electric potential.
2. Main topic	Explanation: How does an electric charge flow during a lightning discharge, and what is a lightning rod used for?
Part 1	
	Tools: Ruhmkorff coil, DC power supply, pin board complete with a model of a cloud, house, kite and lightning rod. **Description:** The pin board is a model of the atmosphere that flows an electric charge during a lightning discharge. The simulation uses a Ruhmkorff coil that generates a high voltage (of the order of several hundred thousand volts). Pins allow the flow of an electric charge, as in the case of a lightning discharge.
1:00	After switching on the electricity, you can see a "lightning bolt" striking the highest point of the environment, which in this case is a man.
1:09	The flow of charge between the cloud and man is presented as the highest point in the environment.
1:34	As you can see, lightning does not strike a bird not in contact with the Earth. Earth is an infinite charge reservoir, and charge flows more readily through objects on Earth than through objects not in contact with it.
1:51	When a hovering object, such as a kite, is in contact (via a wet string and a person) with the Earth, the charge will flow more readily through the object than through the atmosphere because it has a higher electrical resistance than an object in contact with the Earth.
2.14	When we break said contact, the charge will again be more likely to flow towards the highest object in contact with the Earth.
2:44	This is why lightning more often hits the roofs/chimneys of houses that don't have a lightning rod.
3:16	To protect houses against the effects of a lightning strike, a lightning rod is used, i.e. a thick electrical conductor, one end of which is above the highest point of the roof structure, and the other end is buried

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	deep in the ground. In the event of a lightning strike, the post-iron conductor allows the charge to flow towards the Earth without damaging the house's structure and causing a possible fire. However, the lightning rod, as the primary purpose, protects the house from lightning strikes by ionising the air around the spike of the lightning rod above the roof. This allows an electric charge to flow from/to the cloud to/from the Earth without a lightning discharge carrying enormous, destructive energy. **Questions:** What material can a lightning rod be made of? Why should you not stand under a tree during a thunderstorm? How should you behave during a thunderstorm when you are outdoors? What shape of the end of the lightning rod spray ionises the air around it? **Conclusions:** A lightning rod protects a building against a lightning strike in two ways - it prevents lightning discharge over the building by ionising the air and free flow of electric charge between the cloud and the Earth. In the event of an atmospheric discharge, it safely discharges the charge to the Earth or allows it to flow from the Earth to the cloud.
3. Summary and notes	Particular attention should be drawn to the fact that the lightning rod does not "attract" lightning but is supposed to prevent lightning from striking in its immediate vicinity. **Level:** secondary school

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The scenario

Subject (field/title)	Thermal properties of matter / Boiling of water
Length of movie	3:32
Main Goals	Changes in the state of matter
Detailed Goals	The boiling of water at atmospheric pressure
Structure and description of the experiments	
1. Introduction	Description: The movie presents the phenomenon of boiling water
2. Main topic	Description: The movie presents boiling as evaporation in the entire volume of a liquid.
Part 1	
	Tools: Beaker, water, electric stove, thermometer. **Description:** Pour water into the beaker and place it on the electric stove. We heat the water by observing its temperature changes using a thermometer. When the water reaches a temperature close to 100°C, water vapour bubbles appear in the beaker, i.e. the water has started to evaporate in the entire volume of the liquid. **Questions:** Does water evaporate at temperatures other than 100°C? Can water boil at temperatures other than 100°C? **Conclusions:** Boiling differs from evaporation in that the first one takes place at a constant temperature defined as the boiling point, and it is evaporation in the entire volume of the liquid. In contrast, the second one takes place at any temperature but only on the surface of the liquid.
3. Summary and notes	Point out to students that boiling is a physical phenomenon and that every substance has a boiling point that depends on the type of substance and the pressure acting on that substance. **Level:** primary school

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The scenario

Subject (field/title)	Electromagnetism / Ruhmkorff coil
Length of movie	1:52
Main Goals	Operation of the transformer
Detailed Goals	Presentation of the principle of operation of the Ruhmkorff coil as a high-voltage transformer supplied with direct current.
Structure and description of the experiments	
1. Introduction	Description: The operation of a Ruhmkorff coil is presented, enabling the generation of high voltage with a high frequency of changes
2. Main topic	Description: Use of Maxwell's laws in a DC-powered transformer
Part 1	
	Tools: Ruhmkorff coil, DC power supply **Description:** The Ruhmkorff coil is made of a transformer whose primary winding has a much smaller number of turns than the secondary winding, and a magneto interrupting the current flow in the winding. Both windings are mounted on a common open iron core. Thanks to the magneto connected with direct voltage, changes in the current intensity (and thus the electric field) around the primary winding are obtained. Changes in the electric field cause changes in the magnetic field, which in the secondary winding causes changes in the electric field strength and charge flow. This way, a high voltage (several hundred thousand volts) with high frequency is created in the secondary winding. Changes in the magnetic field in the transformer core are used to operate the magneto, which alternately closes and opens the circuit supplying the primary winding. The alternating opening and closing of the circuit allows changes in the current intensity in the primary circuit, necessary to obtain an alternating magnetic field, which, according to Maxwell's laws, is necessary to create an alternating electric field (in the secondary winding). **Questions:** How does a classic transformer work? Will the classical transformer fulfil its role when supplied with electricity with a constant voltage? **Conclusions:** An alternating electric field is needed to generate an alternating magnetic field and vice versa, which is in accordance with Maxwell's laws and is used in the operation of the transformer and in the generation of electromagnetic waves.
3. Summary and notes	During the experiment, you can pay attention to the operation of the magneto. **Level:** secondary school

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The scenario

Subject (field/title)	Thermal properties of matter/temperature of liquid nitrogen
Length of movie	3:26
Main Goals	Changes in the state of matter
Detailed Goals	The boiling of nitrogen at atmospheric pressure
Structure and description of the experiments	
1. Introduction	Explanation: This video shows the phenomenon of nitrogen boiling
2. Main topic	Description: The video presents boiling as evaporation in the entire volume of a liquid.
Part 1	
	Tools: Transparent thermos (or two beakers placed one inside the other and thermally insulated from each other with polystyrene), liquid nitrogen, thermometer **Description:** Pour liquid nitrogen into a thermos and observe its temperature with a thermometer. We also observe the boiling of the nitrogen in the thermos. On the thermometer, we observe a decrease in temperature until it reaches a temperature of about -195.8 ° C. In the sequence, we observe the boiling of liquid nitrogen, which takes place at a constant temperature (like the boiling of water). **Questions:** Why doesn't nitrogen boil at 100°C? **Conclusions:** Boiling differs from evaporation in that the first one takes place at a constant temperature defined as the boiling point and it is evaporation in the entire volume of the liquid, while the second one takes place at any temperature but only on the surface of the liquid.
3. Summary and notes	Point out to students that boiling is a physical phenomenon and that every substance has a boiling point that depends on the type of substance and the pressure acting on that substance. **Level:** primary school and high school

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The scenario

Subject (field/title)	**Atmospheric pressure/ Scale in a vacuum**
Length of movie	1:32
Main Goals	Fluid statics. Presentation of the properties of atmospheric pressure. Archimedes' principle.
Detailed Goals	Experimental checking whether air weight. Archimedes' principle for gases. Buoyant force in gases.
Structure and description of experiments:	
1. Introduction	Description: We live at the bottom of an ocean of air. Above us is a layer of atmosphere made up of air. The question often arises, does air weigh? The film provides an answer to this question through a simple experiment.
2. Main subject	Description: Baroscope. Observation of the behaviour of the balance/baroscope placed under the pump cover, before and after the air is pumped out from the pump cover .
Part 1	
Experiment 1	**Tools:** • Baroscope with a glass bulb filled with air, • Vacuum pump • Manometer **Description:** On the arms of the lever with a low-friction bearing, a glass bubble filled with air is suspended on one side and an adjustable counterweight on the other. There is a scale by the handle. We balance the scale with a movable counterweight. We place the balanced baroscope under the cover of the vacuum pump. We close the air supply valve and pump out the air from the cover of the vacuum pump. We observe the indications of the manometer and the behaviour of the baroscope. The pressure under the cover of the vacuum pump decreases and the glass bulb of the baroscope falls down. We close the valve connecting the lampshade with the vacuum pump. We open the air supply valve. Air gets under the bell of a vacuum pump . The pressure increases (to atmospheric pressure). The baroscope returns back to balance. **Questions:** Why did the glass bubble of the baroscope fall down after the pressure under the glass was reduced?

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	Does air weigh? How can you check that air weight? What physical law can be used to explain the behaviour of the baroscope when the pressure is increased and decreased under the bell of a vacuum pump? **Conclusions:** There is a buoyant force in the air, according to Archimedes' principle. The air weight. The baroscope has been balanced in the air. The air surrounding the glass bubble, according to Pascal's principle, exerted atmospheric pressure on it from all sides. After pumping out the air from the bell of vacuum pomp (lowering the pressure), the density of the air surrounding the bubble decreased. Objects with a higher density sink, so the bubble goes down. The baroscope remained in in balance in the air - the forces acting on it are balanced: the force of gravity acting vertically downwards and the buoyancy force directed upwards (we ignore the forces related to the suspension of the bubble). After lowering the pressure of the gas surrounding the bubble, the balance is disturbed: the value of the buoyant force decreased, the force of gravity remained unchanged, the bubble sank.
3. Summary, evaluation and remarks	The video can be used as an introduction to the lesson: question: why does the air bubble fall down when the pressure under the bell is reduced? The video can illustrate the content of the lesson: Archimedes' principle for gases. The video can be used as a control question: Does air weigh? What experiment can show that air weight? The video can be used durin discussion about: the first balloon flight, which was constructed by brothers Joseph and Jacques Montgolfier, using Archimedes' principle for gases in everyday life. **Level:** primary school and high school

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The scenario

Subject (field/title)	Air pressure/ Magdeburg hemispheres
Length of movie	1:35
Main Goals	Fluid statics. Presentation of the existence of atmospheric pressure.
Detailed Goals	To familiarize students with a historical experiment proving the existence of atmospheric pressure and vacuum. The film presents the experience with the Magdeburg hemispheres. It illustrates how large are the forces exerted by atmospheric air on us and the surrounding bodies.
Structure and description of the experiments	
1. Introduction	Description: We live at the bottom of an ocean of air. There is a layer of atmosphere above us. The last traces of the presence of air begin to disappear at a distance of 500-2000 km above the Earth's surface, in the exosphere. Below 5 km above sea level, 50% of the mass of all atmospheric air is located. The column of air exerts an aerostatic pressure on the Earth's surface, depending on its height, air density and gravitational acceleration. In addition, air molecules in constant motion collide with bodies, exerting pressure on them. The air around us exerts atmospheric pressure on our bodies.
2. Main topic	Description: Repetition of the experiment carried out by the mayor of Magdeburg, Otto von Guericke. In May 1654, the German inventor, the mayor of Magdeburg - Otto von Guericke - conducted one of the most important experiments in the history of science. In the presence of the Prussian prince Frederick William, proving the existence of atmospheric pressure and vacuum . He put together two brass hemispheres with a diameter of about 42 cm . Then he pumped the air out of the resulting sphere. In order to tear these hemispheres, sixteen horses had to be used (the noise accompanying the tearing of the hemispheres resembled a cannon shot), while the reintroduction of air into the interior of the sphere meant that the hemispheres could easily be separated by one man.
Part 1	
	Tools : • *Magdeburg hemispheres with a diameter of about 12 cm,* • *Vacuum pump.* **Description** : One of the hemispheres is connected through the valve with a hose to the vacuum pump. We put both hemispheres together. We let them go. Unfortunately, the hemispheres separate. We connect the hemispheres again, close the valve attached to one of the hemispheres and start the vacuum pump. We pump out the air

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	between the hemispheres, holding the hemispheres together for a few seconds. We release the hemispheres. The hemispheres form a whole, they do not separate, they remain compressed. We close the valve and disconnect the hemispheres from the vacuum pump. We're trying to separate them. The kit can be given to students to try to separate the hemispheres. We open the valve, the hemispheres separate themselves without using force. **Questions** : What is atmospheric pressure? How to find out about the existence of atmospheric pressure? Why do hemispheres remain compressed when we pump out the air between them? What holds the hemispheres together and makes them difficult to separate? What happens when we open the valve that allows air to enter the center of the hemispheres? What is the value of atmospheric pressure? Where and when can we hear about the value of atmospheric pressure? What was the historical experiment with the Magdeburg hemispheres? How can we measure atmospheric pressure? Where do we use atmospheric pressure in everyday life? **Conclusions:** The atmosphere exerts pressure on us and all bodies. The pressure exerted by the atmospheric air on hemispheres is so great that even a strong man cannot separate the hemispheres. Between the hemispheres, after the air is pumped out, a lower pressure is created (if the air between the hemispheres is completely pumped out, there would be a vacuum between them), atmospheric pressure presses the hemispheres together.
3. Summary and notes	**Application:** The video can be used at the beginning of a lesson as an introduction to a lesson about atmospheric pressure. What is the behavior of the hemispheres after the air between them has been pumped out? The video can be used as an illustration of a historical experiment during the actual part of the lesson. The film can be used during the repetition of the material. The film can be an introduction to a discussion about: Atmospheric pressure values, normal: The atmospheric pressure value is 1013.25hPa (760mmHg). Is it a large or small value?

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	About the use of pressure in everyday life. About changes in atmospheric pressure and their impact on people's well-being. About hypotension and hypertension. About the weather: high and low pressure. On air circulation and winds. On the dependence of atmospheric pressure on height. On Pressure Measurement and Torricelli's Experiment . We can also repeat the experiment performed by Otto von Guericke by using two suction cups to carry the glass. They play the role of classic "Magdeburg hemispheres". The use of suction cups allows you to perform the experiment without using a vacuum pump. Each of the suction cups is equipped with a handle, which closing (folding both handles together) causes the rubber surface of the suction cup to become concave. Between the suction cups, the volume increases, the pressure decreases. To demonstrate the existence of atmospheric pressure, the two suction cups are placed against each other with their rubber surfaces. Then we close the handles. This causes an empty space between the suction cups (with a good approximation we can say that there is a vacuum). The suction cups are now the equivalent of the Magdeburg hemispheres put together and the air pumped out. Such folded suction cups-hemispheres can be easily disconnected by opening the handles. The pressure exerted by the atmospheric air is so great that even a strong man cannot separate the suction cups. **Level:** elementary school

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The scenario

Subject	Thermal properties of matter / Thermal expansion of coin
Length	1:38
Main goals	Get familiar with thermal expansion of solids
Detailed goals	Show that a typical metal expands with temperature increased and contracts with temperature decreased
Structure and description of experiments:	
1. Introduction	Description : Most of materials that can be found around us change dimensions with temperature. We will show that even minuscule expansion can be shown using not so complicated mechanical stuff.
2. Main subject	Description: The movie shows how we can easily show the thermal expansion.
Experiments	**Tools:** • small coin, • board with two nails, • gas burner **Description:** Put the nails in the board so that they are little wider than a coin. Put a coin between the nails. It's going down. Now heat the coin with a burner and put it on the nails again. In this case, the coin stays on the nails for some time. **Questions:** Why doesn't the coin fall down? What happens to the metal when it is heated? Can thermal expansion damage materials? **Conclusions:** As energy in particles increases, they start moving faster and faster and therefore expanding the substance. The expansion and contraction of the materials must be considered when designing large structures. It can also be used in medicine, e.g. to change the size of a stent.
3. Summary, evaluation and remarks	The film can be used in the implementation phase of the lesson as an illustration of the discussed issue. The film can be used as a repetition of the topic related to the thermal expansion. **Level:** primary school

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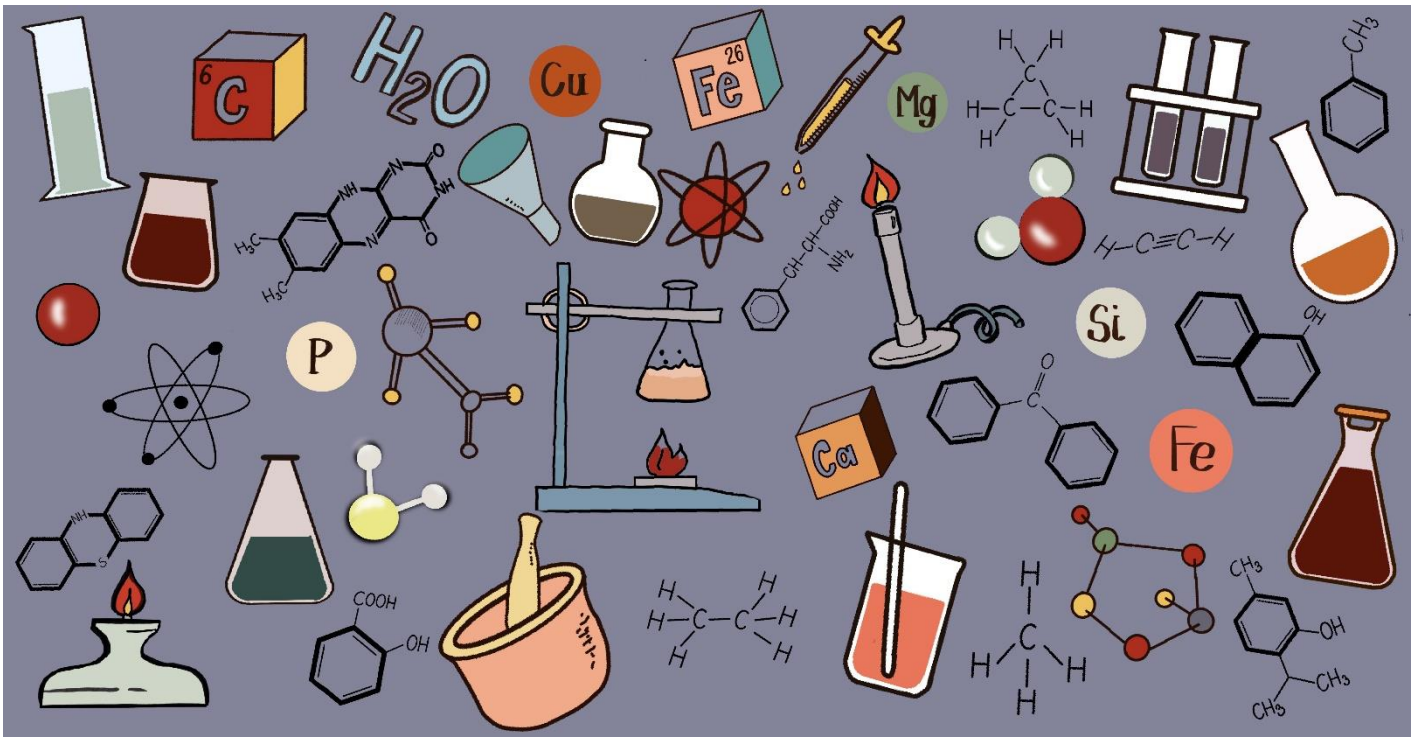
Chemistry



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The scenario

Subject	Iodine transformations
Length	3,16 min.
Main objectives	To study the properties of iodine
Detailed objectives	Observation of changes occurring during a reaction, the definition of the physical phenomenon
Structure and description of experiments:	
1. Introduction	Sublimation is a phase transition from a solid to a gaseous state, bypassing the liquid state. The phenomenon opposite to sublimation is resublimation, i.e. the transformation of a gas into a solid. Sublimation and resublimation are physical transformations involving a change in the physical properties of a given physical body.
2. Main subject	Description: Study of the phase transition from solid to gaseous phase on the example of iodine. Discussion of physical transformations. Learning the properties of iodine.
Part 1	**Materials:** test tubes, test tube holder, spirit or gas burner, glass spatula, Pasteur pipette **Reagents:** Iodine **Precautions:** iodine - toxic, corrosive**.** **Description:** Place a test tube in a holder. Pour a few iodine crystals into the test tube. Carefully place the test tube in the flame of a burner under an efficient fume hood and gently heat it up. Observe the behavior of iodine when heated. After the tube has been set aside and cooled, check the appearance of the upper parts of the tube walls. Write down your observations. After completing the experiment, place the leftovers in properly marked waste containers. **Questions**: 1. Write down your observations of the transformation taking place 2. What is the name of the transformation that iodine underwent during heating? 3. What everyday substances contain elemental iodine? **Conclusions**: Under normal conditions, iodine undergoes sublimation, i.e. changes from a solid to a gaseous phase. When the dark purple iodine crystals are heated, they turn into purple gas. When the test tube is cooled, the purple gas turns into a fine shimmering powder, i.e. the

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	reverse process to sublimation occurs, i.e. re-sublimation, i.e. the change of the gas phase into a solid. **Level:** Primary school

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The scenario

Subject	Thermal decomposition of salt
Length	7,33 min.
Main objectives	Understanding the oxides
Detailed objectives	Observation of changes occurring during the reaction Learning one of the methods of obtaining oxides Learning of the division of oxides into acidic, basic, and neutral Learning the equation notation of the reaction taking place Learning and understanding of the electron balance of oxidation-reduction reactions
Structure and description of experiments:	
1. Introduction	Oxides are inorganic chemical compounds consisting of oxygen occurring in the -II oxidation state and a chemical element. Oxides are divided into metal and non-metal oxides. Due to their chemical nature, oxides are divided into acidic, basic, neutral, and amphoteric. Oxides can be obtained by various methods. One of the methods of obtaining oxides is the thermal decomposition of salts. Other methods of obtaining oxides are decomposition of some acids and hydroxides, directly from the elements, oxidation, and reduction of oxides.
2. Main subject	Description: Learning the reaction of obtaining oxides on the example of thermal decomposition of salts.
Part 1	**Tools:** stand, test tubes, test tube holder, alcohol or gas burner, plastic spatulas, indicator paper. **Reagents:** copper(II) nitrate (V), lead(II) nitrate (V), zinc carbonate**.** **Precautions** soluble copper and lead salts - toxic compounds **Description:** To each of the three test tubes placed in the rack, use a spatula to pour a small amount (maximum 1 cm of the test tube height) of each salt separately. Then, sequentially, hold each of the test tubes in your test tube holder and carefully heat them in the flame of the burner, observing the changes taking place. The heating should be stopped when the salt has reacted completely. At the end of the heating, bring a water-moistened indicator paper to the upper part of the test tube. After completing the experiment and cooling down the test place the remains in properly marked waste containers. Do not throw the contents of the tubes down the drain. **Questions**: 1. Write down the changes taking place in each test tube. 2. How can the changes in the color of water-wet indicator paper be explained? 3. Suggest reaction equations for the transformations taking place in individual test tubes 4. Give examples of oxides occurring in nature.

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	Conclusions: Oxides can be obtained as a result of the decomposition of many substances (salts, acids, hydroxides), e.g. during heating in a test tube. How the decomposition reactions to oxides proceed depends on the type of substance subjected to the reaction and factors such as, for example, temperature. Copper (II) nitrate (V) and lead decompose under the influence of temperature to the appropriate lead and copper(II) oxides with the release of acidic nitric oxide(IV) and oxygen. The presence of oxygen can be checked by applying a glowing torch to the upper part of the test tube after each salt has been heated. Zinc carbonate decomposes to zinc oxide and carbon dioxide. $$2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + 4NO_2 + 3O_2$$ $$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + 3O_2$$ $$2ZnCO_3 \xrightarrow{\Delta} 2ZnO + 2CO_2$$ Oxides commonly found in nature are water (H_2O), silica (SiO_2), which is the main component of sand, and carbon dioxide (CO_2). **Level:** Primary school

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The scenario

Subject	Displacement of metals from solutions of their salts
Length	8,24 min.
Main objectives	Learning the activity series of metal
Detailed objectives	Observation of changes occurring during the reaction Learning about the activity series of metals and the values of electrochemical potentials of metals Comparison of the chemical activity of different metals based on the electrochemical series Learning the equation notation of the reactions taking place
Structure and description of experiments:	
1. Introduction	The electrochemical series, otherwise known as the metal activity series or the voltage series, is a ranking of chemical elements with metallic properties, according to their standard potential. The reference point for the electrochemical series is the hydrogen electrode, whose standard potential is conventionally assumed to be zero. Based on the electrochemical series and standard potential values, the more active metal (lower potential) will displace (with some exceptions) the less active metal from its salt solution.
2. Main subject	Description: Learning about the electrochemical series and activity of metals on the example of the reaction of displacing metals from their salt solutions.
Experiment	**Equipment:** test tubes, watch glass, copper plate, steel nail, penny coin – with copper, tweezers, fine sandpaper, filter paper. **Reagents:** aqueous salt solutions: copper(II) sulfate(VI), silver nitrate(V), mercury nitrate(V). **Precautions:** work with heavy metal salts - toxic! Silver nitrate(V) solution - caustic. **Description**: Clean the copper plate and iron wire to a shine with fine-grained sandpaper. Place the metal samples thus cleaned carefully in the test tubes (so as not to damage the bottom of the test tube). Place a penny coin on the watch glass. Note the appearance of metals before adding salt solutions. Then add silver nitrate(V) solution to the test tube with copper, add copper(II) sulfate (VI) solution to the test tube with iron (so that the metals are half-covered) and a watch glass with a penny coin add several drops of nitrate solution(V) mercury, this time so that it completely covers the coin. Set the tubes and slide aside for about 10 minutes. After this time, check the appearance of individual solutions and compare them with the original solutions. Then pour the solutions into the waste, carefully transfer the metal samples with tweezers to a dry piece of tissue paper, and check their appearance. Leave the metal samples on the stand to dry.

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	Questions: 1. Note your observations of the changes taking place 2. Write down the equations of the reactions taking place in each test tube or indicate that the reaction does not take place 3. What practical significance can (and have) the reactions taking place in this exercise? **Summary**: Metals have different chemical properties and different reactivity. To determine which metal is more reactive, you need to know its electrochemical potentials, which can be read from the electrochemical series, where the metals are ranked from the most reactive (lowest standard potential) to the least reactive (highest/most positive standard potential). A silver precipitate of metallic silver precipitated on the copper plate and the solution took on a slightly blue color coming from copper(II) nitrate(V). Silver(I) ions underwent a reduction reaction, while copper underwent an oxidation reaction. $Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$ The iron wire was covered with a rusty coating of metallic copper, the copper(II) ions underwent a reduction reaction, while the iron underwent an oxidation reaction. $Fe + CuSO_4 \rightarrow Cu + FeSO_4$ The penny coin, consisting mainly of copper, was covered with a silver layer of metallic mercury (it changed its color from yellow to silver). Mercury(I) ions underwent a reduction reaction, while copper underwent an oxidation reaction. $Cu + 2HgNO_3 \rightarrow 2Hg + Cu(NO_3)_2$ **Level:** Primary school

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The scenario

Subject	Extraction with an organic solvent
Length	5,52 min.
Main objectives	Learning the method of isolating a substance from a mixture or a solution in another solvent
Detailed objectives	Observation of changes taking place during extraction Understanding the extraction process
Structure and description of experiments:	
1. Introduction	Extraction involves transferring a substance from one solid or liquid phase in which the substance is dissolved to another liquid phase. Extraction refers to processes carried out in liquid-liquid or liquid-solid systems. In the case of liquid-liquid extraction, liquids should have limited solubility.
2. Main subject	Description: Studying the extraction process.
Experiment	**Equipment:** a metal ring to put the manifold aside or a large holder for a tripod, a tripod **Glass:** funnel with stopper, two conical flasks, two measuring cylinders **Reagents:** chloroform, aqueous iodine solution **Description:** Pour 10 ml of an aqueous solution of iodine into the manifold installed in the stand, with the tap in the closed position (note! Be careful when working with iodine! Wear gloves!). Then add 15ml of chloroform to the funnel (Caution! Flammable substance! Work in fume hood!). Plug the funnel with a plug and shake its content intensively (for about 5 seconds) and then gently lift the plug to equalize the pressure inside the funnel (symptom of this will be a slight hiss). Then shake the separating funnel again, repeating the process three more times. After the final shaking, place the funnel in the rack and separate the two layers by pouring each layer into a separate conical flask. Evaluate the differences in the appearance of the contents of both flasks. **Questions**: 1. Record the observations that took place in the manifold. 2. In which layer (upper or lower) was the chloroform in the separatory funnel? Justify your answer. 3. Give two examples of using extraction in everyday life. **Conclusions**: Extraction is the process of moving a substance from one solid or liquid phase in which the substance is dissolved to another liquid phase. Extraction refers to processes carried out in liquid-liquid or liquid-solid systems. In the case of liquid-liquid extraction, liquids should have limited solubility. In the experiment, iodine from the aqueous layer was extracted into the organic layer (chloroform). The change of the color of the chloroform solution from colorless to pink and the simultaneous discoloration of the water layer proves the "transition" of iodine from the water layer to the organic layer.

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	Extraction is often used to remove unwanted impurities or impurities from mixtures. An example of liquid-solid extraction is the brewing of tea, herbs and coffee. **Level**: High School

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The scenario

Subject	Alkenes reactions
Length	4,02 min.
Main objectives	Learning the reactions characteristic of unsaturated organic compounds
Detailed objectives	Observation of changes occurring during the reaction. Understanding the influence of unsaturated compounds on bromine molecules and $KMnO_4$ solution. Learning the method of detecting unsaturated compounds.
Structure and description of experiments:	
1. Introduction	Description: Unsaturated compounds are organic compounds containing double or triple bonds between two carbon atoms in their structure. The most common in everyday life are the so-called unsaturated fats, essential in the human diet. Such substances contain long-chain fatty acids which have one or more double bonds. Unsaturated bonds are more reactive than single bonds, which is why they are easily added, e.g. with bromine, or oxidized under the influence of $KMnO_4$solution, which can be easily observed as discoloration of solutions.
2. Main subject	Description: Learning about the addition reaction to the double bond and the reaction characteristic of unsaturated compounds.
Experiment	**Equipment**: test tubes, Pasteur pipettes, spatula, water wash bottle. **Reagents**: sodium oleate, bromine water, aqueous solution of potassium manganate(VII). **Precautions**: work with gloves and protective glasses! **Description**: Add a pinch of sodium oleate to two test tubes and then, using a water wash bottle, a few ml of distilled water to dissolve the compound. Now add 2 ml of bromine water to the first test tube and 2 ml of potassium manganate(VII) solution to the second test tube. Gently mix the contents of each tube. After completing the experiment, pour the solutions into the containers indicated by the teacher. **Questions**: 1. Note down the changes taking place in each test tube 2. What reaction takes place in the test tube when bromine water is added? **Conclusions**: Sodium oleate is a derivative of omega-9 fatty acid, containing a double bond at the 9th carbon atom in the chain. Such bonds are unstable and easily undergo addition, for example, of bromine atoms from bromine water or oxidation by $KMnO_4$. As a result, discoloration of these substances is observed. These reactions can be used to detect unsaturated compounds. **Level:** Secondary School

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The scenario

Subject	Precipitation and filtration of the precipitate
Length	8,00 min.
Main objectives	Learning the precipitation reaction
Detailed objectives	Observation of changes occurring during the reaction Learning the solubility of some copper(II) compounds Learning the reactions notation in ionic form
Structure and description of experiments:	
1. Introduction	Description: Precipitation reactions take advantage of the different solubility of certain chemical compounds. Compounds dissolved in water exist in the form of ions. During the reaction of copper ions and the radical of the carbonic acid, an insoluble precipitate of copper (II) carbonate is formed.
2. Main subject	Description: Learning the ion exchange reaction and the precipitation of the insoluble copper salt from an aqueous solution
Experiment	Precipitation and filtration of the precipitate **Equipment:** metal filter ring, a stand, filter paper, scissors **Glass:** glass funnel, two beakers, glass rod, measuring cylinders, water wash bottle **Reagents:** aqueous solutions $CuSO_4$ and Na_2CO_3 **Description:** Using a cylinder, measure 15 ml of the copper(II) sulphate (VI) solution and pour it into the beaker. Then, using another cylinder, measure out 15 ml of the sodium carbonate solution. After adding the second solution, mix the contents of the beaker with a rod. Filter the resulting suspension on a funnel with filter paper. Wash the sediment remaining on the funnel several times with distilled water from a wash bottle and then spread it out to dry. **Questions:** 1. Write down the equation of the reaction that took place in the beaker while mixing the solutions. 2. Why did the precipitate need to be washed with distilled water at the very end? **Conclusions**: Copper(II) compounds have different solubility in water. When dissolved in water, soluble metal salts are in ionic form. Copper(II) sulphate (VI) dissociates into copper ions (Cu^{2+}) and sulfuric acid residue (SO_4^{2-}). Similarly, dissolved sodium carbonate dissociates into sodium ions (Na^+) and carbonic acid ions (CO_3^{2-}). In the case of mixing two or more substances, we are dealing with a mixture of all ions. In such a mixture, an exchange reaction may occur. If the substance formed as a result of such a reaction is insoluble, it falls out in the form of a

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	precipitate. In the above case, insoluble copper(II) carbonate is formed and sodium ions and sulfuric (VI) acid residues remain in solution. **Level**: Primary school

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The scenario

Subject	Detection of organic substances
Length	3,05 min.
Main objectives	Learning the reducing properties of sugar.
Detailed objectives	Observation of the transformation of copper (II) oxide into a red precipitate of metallic copper Learning the methods of sugar detection
Structure and description of experiments:	
1. Introduction	Description: Sucrose heated with black copper(II) oxide decomposes while reducing the oxide to metallic copper. Sugar is oxidized during thermal decomposition. Similar reactions are used when obtaining metals from their ores (usually oxides).
2. Main subject	Description: Learning the reducing properties of sucrose.
Experiment	**Equipment:** test tube, test tube clamp, gas burner. **Reagents:** sucrose, copper(II) oxide **Precautions:** work with gloves and protective glasses! **Description:** Add a pinch of sucrose to the test tube and then, using a spatula, add about twice as much copper(II) oxide. Mix the contents of the tube by gently shaking it so that it takes on an even color. Then place the tube in the tube clamp and start heating it carefully in the flame of the burner. Heat the contents of the test tube until thick smoke appears - then stop heating and set the test tube aside to cool down. After the tube has cooled, check the appearance of the contents. **Questions:** 1. Write down the changes taking place in the test tube. 2. What reactions take place in the test tube after the start of heating? **Conclusions**: During heating, sucrose decomposes, which removes oxygen from black copper(II) oxide, reducing it to a red precipitate of metallic copper. Copper Cu^{2+} goes to the zero oxidation state and sugar decomposes into carbon dioxide and water. These transformations are observed as smoke (water vapor) and the formation of a brown-orange precipitate in the test tube. **Level:** Secondary School

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The scenario

Subject	Detection of alcohols by chromate(VI) method
Length	3,04 min.
Main objectives	Learning of the primary alcohol detection reaction
Detailed objectives	Observation of changes occurring during the reaction Learning equation notation of the reaction of alcohol with potassium chromate(VI) in an acidic environment. Learning and understanding of the electron balance of oxidation-reduction reactions. Understanding the oxidation reaction of primary and secondary alcohols.
Structure and description of experiments:	
1. Introduction	Description: Chromates (VI) are often used to detect alcohols in aqueous solutions. This reaction is one of the simplest and fastest ways to detect alcohol in aqueous solutions. Chromates (VI) are typically used to detect primary short-chain alcohols such as methanol, ethanol, and propanol and secondary alcohols such as propan-2-ol. This reaction is very sensitive and can detect small amounts of alcohol.
2. Main subject	Description: Detection of ethanol by potassium chromate(VI). Primary alcohol oxidation.
Experiment	**Equipment:** test tube, Pasteur pipettes, water wash bottle, water bath. **Reagents:** ethanol, 2M sulfuric (VI) acid solution, potassium chromate (VI) solution **Precautions:** work with gloves and protective glasses! **Description:** Add about 2 ml of potassium chromate(VI) solution to the test tube. Then add 5 drops of 2M sulfuric (VI) acid. Mix the contents of the tube carefully (by gently shaking) and then add about 2 ml of ethanol. Then place the test tube in a beaker with hot water, removing the test tube from time to time and stirring its contents**.** **Questions:** 1. Write down the changes taking place in the test tube. 2. What causes the color of the contents of the tube to change? 3. Write the equation of the reaction that took place in the test tube. Indicate which substance is the oxidant and which is the reducing agent in the above reaction. 4. What application can this reaction have? **Conclusions**: The solution in the test tube changed its color from orange, characteristic of dichromates(VI), to green-blue, characteristic of chromium(III) salts. In the above reaction, ethanol plays the role of the reducing agent, which is oxidized to acetic acid, while the function of the oxidant is potassium dichromate(VI), which is reduced to chromium(III) salts. $3CH_3CH_2OH + 2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow 3CH_3COOH + 2Cr_2(SO_4)_3 + 2K_2SO_4 + 11H_2O$

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	Primary alcohols oxidize to carboxylic acids and secondary alcohols to ketones. **Fun fact:** The reaction you performed was a "brealyser test", in this way the sobriety of drivers was checked. Changes that take place in the breathalyzer, specifically in the tube behind the mouthpiece, indicate the potential alcohol content in the exhaled air - if the color of the compound filling the tube changes from yellow to green. **Level:** High School

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The scenario

Subject	**Carbon in organic compounds**
Length	4,27 min.
Main objectives	Learning about the structure of organic compounds
Detailed objectives	Observation of changes taking place during the heating of saccharose. Analysis of carbohydrate breakdown products.
Structure and description of experiments:	
1. Introduction	Description: Organic compounds contain carbon. The inclusion of charred residue and the presence of soot during combustion can be used to confirm that the sample contains organic compounds. In the case of saccharose, thermal decomposition results in the release of carbon and water vapor.
2. Main subject	Description: Learning about the structure of organic compounds.
Experiment	**Equipment:** test tube, metal clamp with a stand, gas burner **Reagents:** saccharose. **Description:** Add a pinch of saccharose to the test tube. Heat the test tube carefully in the burner flame. Note the wall at the mouth of the tube during heating. After heating, compare the appearance of the contents of both test tubes. **Questions:** 1. Write down the changes taking place in the test tube. 2. What is the final product of the transformation in the test tube? 3. What could be the applications of this process? **Conclusions**: Organic compounds contain carbon in their composition. The presence of carbon in the residue after heating the sample proves its organic origin. Saccharose is a carbohydrate, so for every carbon atom, there are two hydrogen atoms and an oxygen atom in its molecule. During the thermal decomposition of carbohydrates, carbon and water are released. **Level:** Secondary school

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The scenario

Subject	**Saccharose dehydration**
Length	6,32 min.
Main objectives	Learning about the structure of organic compounds. Hygroscopic properties of sulfuric acid (VI)
Detailed objectives	Observation of changes taking place in saccharose under the influence of sulfuric acid.
Structure and description of experiments:	
1. Introduction	Description: Carbohydrates are organic chemical compounds belonging to the group of sugars. Their name derives from their molecular structure, in which there is a water molecule for every carbon atom (two hydrogen atoms and one oxygen atom). Under the action of concentrated sulfuric acid (VI), carbon and water are separated from them.
2. Main subject	Description: Learning about the structure of sugars.
Experiment	**Equipment:** test tubes, Pasteur pipettes, test tube holder, gas burner. **Reagents:** concentrated sulfuric acid(VI), saccharose. **Precautions:** work with gloves and protective glasses! **Description:** Add a pinch of saccharose to the test tube. Then add a few drops of concentrated sulfuric acid (VI) to the test tube using a Pasteur pipette (careful! It is highly caustic!) and set it aside. Note the upper part of the tube during heating. **Questions:** 1. Note down your observations of the transformation taking place in the test tube. 2. What is the final product of the transformation in the test tube? 3. How could this process be used? **Conclusions**: Concentrated sulfuric acid (VI) is a highly hygroscopic substance. Hygroscopic substances absorb water from the environment, so they can be used for drying. Under the influence of concentrated sulfuric acid (VI), saccharose decomposes with the release of carbon and water. This confirms the common name of this group of compounds: carbohydrates. **Level:** Secondary School

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The scenario

Subject	pH-dependent $KMnO_4$ reactions
Length	4,5 min.
Main objectives	Understanding redox reactions
Detailed objectives	Observation of changes occurring during the reaction Understanding the influence of pH on the reduction of manganate(VII) ions Learning equation notation of the reaction in ionic form Learning and understanding of the electron balance of oxidation-reduction reactions
Structure and description of experiments:	
1. Introduction	Description: Redox reactions are oxidation-reduction reactions. Oxidation and reduction are chemical processes that occur when atoms or molecules exchange electrons and change the oxidation state of the atoms of the chemical elements. Oxidation is the loss of electrons, while reduction is the acceptance of electrons by an atom or molecule. Oxidation and reduction processes occur simultaneously and neither can occur without the other.
2. Main subject	Description: Learning about the oxidation and reduction reactions on the example of the $KMnO_4$ reaction. Studying KMnO4 reaction in the presence of hydrogen and hydroxide ions, and water.
Part 1	**Equipment:** test tubes, Pasteur pipettes, automatic pipette **Reagents:** 0,1 M $KMnO_4$, 1 M H_2SO_4, 5 M NaOH, 1 M Na_2SO_3 **Description of the exercise:** Pipette 2 ml of 0.1 M $KMnO_4$ into three test tubes. To the first add 2 mL of 1 M sulfuric acid solution, to the second 2 mL of water, and to the third 2 mL of 5 M NaOH solution. Then pour 1 mL of 1 M Na_2SO_3 solution into each of them using an automatic pipette. Note the observations. After completing the experiment, transfer the contents of the test tubes to the appropriate waste containers. **Questions**: 1. Note the observations of the transformations taking place 2. Write down the equations of reactions taking place in each test tube 3. What manganese compounds were formed in test tubes 1 and 2? 4. How does pH affect the reduction of manganese(VII) ions? 5. What role does sodium sulphate(IV) play in the reactions? **Conclusions:** Manganese compounds present in the +VII oxidation state are strong oxidants, however, their oxidizing properties depend on the pH of the solution. Manganate(VII) ions in an acidic environment are reduced to Mn(II) ions, which can be observed after the violet solution becomes discoloured; in a neutral environment they are reduced to

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	Mn(IV) in the form of a brown MnO_2 precipitate; in an alkaline environment, they are reduced to ions (MnO_4^{2-}) changing the colour of the solution from violet to green. **Level:** Primary school

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The scenario

Subject	Tollens' test
Length	4,40 min.
Main objectives	Learning the reaction of making a silver mirror.
Detailed objectives	Observation of the precipitation of silver on the glass surface under the influence of simple sugars. Understanding the reducing nature of glucose.
Structure and description of experiments:	
1. Introduction	Description: Glucose has reducing properties. As a result of heating the silver solution in the presence of glucose, Ag^+ ions are reduced to metallic silver, which precipitates in the form of a characteristic silver mirror. This reaction, known as the Tollens' test, is used to detect simple sugars and to produce a silver layer on the glass surface, e.g. when silvering Christmas tree decorations.
2. Main subject	Description: Understanding the silver ion reduction reaction under the influence of simple sugars.
Experiment	**Equipment:** test tube, beaker with hot water, Pasteur pipettes **Reagents:** 0.3 M silver nitrate (V) solution, 0.3 M NaOH solution, 3 M ammonia solution, saturated glucose solution, 10% hydrochloric acid solution. **Precautions:** sodium hydroxide, ammonia, and sulfuric acid - toxic and caustic – make the experiment with extreme caution - work under a fume hood. **Description:** In a clean test tube (glass purity is critical here for the success of the reaction!) place 2 ml of 0.3 M silver nitrate (V) solution, then add 2 drops of 0.3 M NaOH solution to the same test tube. Observe the changes in the contents of the tube at this stage. Then add 3M ammonia solution dropwise to the test tube using a pipette, while swirling the contents of the test tube until complete dissolution of the precipitate. Remember to avoid using excess ammonia! Add a few drops of aqueous glucose solution to the solution obtained in this way, mix the contents of the test tube with a swirling motion, and then place the test tube with the mixture in a beaker with hot water for a few minutes. After precipitating the silver mirror, pour the contents of the test tube into a small beaker and rinse the test tube carefully with a small amount of distilled water using a wash bottle. Add a few ml of hydrochloric acid to the post-reaction solution collected in the beaker to precipitate the remaining silver in the form of chloride. **Questions:** 1. Write down the equation of the reaction taking place in the test tube, leading to the formation of a silver mirror. 2. What practical applications does this method of obtaining metallic silver have? 3. Why is it important to neutralize the post-reaction solution with hydrochloric acid?

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	4. Which of the following substances will give a positive effect on the Tollens' test: formaldehyde, acetone, saccharose, fructose? **Conclusions**: Aldehyde-containing sugars are oxidized to carboxylic acids while Ag^+ silver ions are reduced to metallic silver. This is observed as the formation of a metallic mirror on the surface of the glass. The reactions taking place are typical redox reactions. Ketones give a negative test result. The exceptions are sugars belonging to ketoses, e.g. fructose. $2Ag^+ + 2OH^- \rightarrow Ag_2O\downarrow + H_2O$ $Ag_2O\downarrow + H_2O + 4NH_3 \rightarrow 2\,[Ag(NH_3)_2]^+ + 2OH^-$ $RCHO + 2\,[Ag(NH_3)_2]^+ + 3OH^- \rightarrow RCOO^- 2Ag + 2H_2O + 4NH_3$ **Level:** Secondary School

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The scenario

Subject	Trommer's test
Length	3,54 min.
Main objectives	Understanding the reducing properties of simple sugars.
Detailed objectives	Observation of changes taking place during the Trommer's reaction Learning to write reactions notation in ionic form
Structure and description of experiments:	
1. Introduction	Description: Simple sugars containing an aldehyde group have reducing properties. This is used to detect them in the presence of copper (II) hydroxide. The aldehyde group is oxidized to the carboxylic acid, while copper in the second oxidation state is reduced to copper (I) oxide. As a result of this reaction, a characteristic brick-red Cu_2O precipitate appears. Simple sugars containing an aldehyde group and other aldehydes undergo this reaction. Ketones in the Trommer's reaction give a negative result.
2. Main subject	Description: Understanding the reaction of detecting simple sugars.
Experiment	**Equipment:** a test tube, a beaker with hot water, Pasteur pipettes **Reagents:** copper(II) sulphate (VI) solution, NaOH solution, saturated glucose solution. **Description:** Put 2 ml of copper (II) sulphate (VI) solution in a clean test tube, then add a few drops of NaOH solution to the same test tube. Observe the changes in the contents of the tube at this stage. Add a few drops of aqueous glucose solution to the suspension thus obtained and mix the contents of the tube. Place the test tube with the mixture in a beaker with hot water for a few minutes. **Questions:** 1. Write down the equations of reactions taking place in the test tube, after adding NaOH and after adding glucose. 2. Which of the following substances will give a positive effect on the Trommer test: formaldehyde, acetone, saccharose, or fructose? **Conclusions**: During the reaction, copper(II) hydroxide is formed, visible as a blue colloidal precipitate. On heating with glucose, this precipitate transforms into an orange and brick-red precipitate of copper(I) oxide. Glucose and other simple sugars contain an aldehyde group and therefore have reducing properties. $CuSO_4 + NaOH \rightarrow Cu(OH)_2$ $C_6H_{12}O_6 + Cu(OH)_2 \rightarrow C_6H_{12}O_7 + Cu_2O\downarrow$ **Level:** Secondary School

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The scenario

Subject	Zinc reactions
Length	5,06 min.
Main objectives	Learning the reactivity of zinc
Detailed objectives	Observation of changes occurring during the reaction Learning the properties of zinc Learning equation notation of the reactions in ionic form Learning and understanding of the electron balance of oxidation-reduction reactions
Structure and description of experiments:	
1. Introduction	Description: Zinc is a brittle metal with a blue-white colour. Zinc is in the d block (group 12) in the zinc group. Zinc reacts with acids, e.g. HCl, dil. nitric (V) acid, dil. sulfuric (VI) acid, forming salts. Zinc reacts with concentrated solutions of strong bases in a neutral environment to form coordination compounds. Zinc reacts with oxygen at elevated temperatures. The reaction produces a white powder of zinc (II) oxide, which has amphoteric properties. Zinc does not react with water.
2. Main subject	Description: Learning the reaction of zinc with acids, bromine water, and salts.
Experiment	**Equipment:** test tubes, Pasteur pipettes, a stand **Reagents:** bromine water, aqueous copper(II) sulphate (VI) solution, 1 M sulfuric (VI) acid solution, zinc dust **Precautions:** bromine water, sulfuric acid - toxic and corrosive - be especially careful - work under a fume hood. **Description**: Pipette 3 ml of the following solutions into three test tubes: bromine water, 1 M sulfuric acid solution (VI), and 1 M copper (II) sulphate (VI) solution. To each of them, add a pinch of zinc dust using a spatula. Write down the observations. After completing the experiment, transfer the contents of the test tubes to the appropriate waste containers. **Questions:** 1. Write down your observations of the changes taking place 2. Write down the equations of reactions taking place in each test tube 3. Write the equations of the reactions in the ionic form 4. Write the equations of the corresponding half-reactions of reduction and oxidation. **Conclusions**: Zinc reacts with bromine water, which is observed after the decolorization of the brown solution of bromine water and the formation of a gray-white zinc bromide precipitate. $Zn + Br_{2\ aq} \rightarrow ZnBr_2$

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	Zinc reacts with dilute sulfuric acid (VI) displacing hydrogen (a colourless gas is released in the test tube) and forming gray-white zinc sulphate (VI). $Zn + H_2SO_{4\ rozc.} \rightarrow H_2 + ZnSO_4$ Zinc reacts with copper(II) sulphate(VI). Zinc is a more active metal than copper (voltage series) so it displaces copper from its salts. After adding zinc to the blue solution of copper sulphate (VI), the solution becomes discoloured (a colourless solution of zinc sulphate (VI) is formed), and a rusty metallic copper precipitate is observed at the bottom of the test tube. $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$ **Level**: Primary school

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The scenario

Subject	Properties of selected organic compounds: alcohols, unsaturated compounds
Length	5,06 min.
Main objectives	Learning about some properties of organic compounds
Detailed objectives	Observation of changes occurring during the reaction Learning the properties of organic compounds Learning the properties of salts of weak acids and strong bases
Structure and description of experiments:	
1. Introduction	Description: Ethyl alcohol, phenol and sodium hydroxide contain a hydroxyl group in their structure. However, only the last compound produces the characteristic dark red color with phenolphthalein. Sodium oleate, although it does not have a hydroxyl group, also gives a positive result in this reaction. Alcohols and phenols do not dissociate in the same way in water as inorganic hydroxides, so they are not alkaline. Sodium oleate as a salt of a weak acid and a strong hydroxide undergoes hydrolysis with the release of oleic acid and ionized sodium hydroxide. Therefore, the last test tube also gives a positive reaction to phenolphthalein.
2. Main subject	Description: Learning about the properties of alcohols and phenols. Learning about the properties of salts formed from weak acids and strong hydroxides.
Experiment	**Equipment:** test tubes, Pasteur pipettes, spatula, water wash bottle. **Reagents:** ethyl alcohol, sodium hydroxide solution, sodium oleate, phenol solution, phenolphthalein solution. **Precautions:** work with gloves and protective glasses! **Description: U**sing a Pasteur pipette add successively, approximately 1 ml of ethyl alcohol, phenol solution, and sodium hydroxide to three test tubes placed in a stand. To the fourth test tube, add a pinch of solid sodium oleate and add a few ml of water from the wash bottle. Then add a few drops of the phenolphthalein solution to each test tube. After completing the exercise, pour the solutions into the containers indicated by the teacher. **Questions:** 1. Note down the changes taking place in each test tube 2. Why did some test tubes fail to react? 3. Explain why the reaction in the test tube with sodium oleate is so different? **Conclusions**: Phenolphthalein in an alkaline environment gives a characteristic dark red color. This reaction takes place in a test tube containing sodium hydroxide. In test tubes with alcohol and phenol, the reaction does not occur even though these compounds also have OH (hydroxyl) groups. The sodium oleate tube also shows a dark red color even

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	though it does not contain hydroxyl groups. The formation of an alkaline reaction requires the hydrolysis of sodium hydroxide to form the hydroxide ion OH-. Alcohols and phenols do not form such ions in aqueous solutions. A solution of sodium oleate as a salt of a weak acid and a strong hydroxide undergoes hydrolysis and OH- ions are formed, which causes the raspberry color. The aqueous solution of sodium oleate is alkaline. **Level:** Secondary School

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The scenario

Subject	Identification of selected groups of organic compounds
Length	4,49 min.
Main objectives	Learning the reactions characteristic of phenols and proteins
Detailed objectives	Observation of changes occurring during the reaction Learning the methods of detecting proteins and phenols in unknown substances
Structure and description of experiments:	
1. Introduction	Description: Phenols are aromatic alcohols, i.e. compounds with an aromatic ring and a hydroxyl group attached to it. In the presence of iron(III) ions, they form colored hexaphenyliron(III) complexes, in which the metal atom is surrounded by six phenol molecules. Aliphatic alcohols do not form such connections, so this reaction can be used to distinguish aliphatic alcohols from aromatic alcohols - phenols. Copper(II) sulfate (VI) in the presence of sodium hydroxide forms copper(II) hydroxide visible as a flocculent blue precipitate. After adding the protein, the content of the tube turns purple. Copper binds to the peptide groups present in the protein. Free amino acids and simple peptides do not undergo this reaction, so they can be used to distinguish between complex polypeptides (proteins). This is the so-called biuret reaction and can be used to determine protein in the urine.
2. Main subject	Description: Complex reactions for the detection of groups of chemical compounds.
Experiment	**Equipment:** test tubes, Pasteur pipettes, water wash bottle. **Reagents:** copper(II) sulfate(VI) aqueous solution, sodium hydroxide solution, iron(III) chloride aqueous solution, protein solution, phenol aqueous solution. **Precautions:** work with gloves and protective glasses! **Description:** To two test tubes, add successively 1 ml of phenol solution (tube I) and 2 ml of copper(II) sulphate(VI) solution (tube II). Then add a few drops of iron(III) chloride solution to test tube I. To test tube II, add about 2 ml of NaOH solution and 1 ml of protein solution. After completing the exercise, pour the solutions into the containers indicated by the teacher. **Questions:** **1.** Note down the changes taking place in each test tube **2.** What reaction takes place in test tube II? **Conslusion**: The content of test tube I takes on a violet color. This proves the formation of a colored complex between phenol molecules and iron(III) ions. In test tube II, a light blue precipitate of copper(II) hydroxide turns the protein solution purple-blue. Copper, like other heavy metals, binds

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	strongly to proteins, creating their denaturation. This phenomenon is the mechanism of heavy metal toxicity. This reaction can also be used for protein detection. **Level**: Secondary School

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The scenario

Subject	Properties of organic compounds: hydrocarbons
Length	3,06 min.
Main objectives	Learning some properties of organic compounds
Detailed objectives	Observation of changes occurring during the reaction Learning about the properties of chlorinated hydrocarbons Learning about exchange reactions in solutions of inorganic salts
Structure and description of experiments:	
1. Introduction	Description: Unlike inorganic salts, organic compounds do not hydrolyze into ions. 1-chlorobutane does not react with silver nitrate(V) and does not form a precipitate, as is the case with a solution of table salt (sodium chloride). In a test tube containing sodium chloride, an ion exchange reaction takes place, and an insoluble white precipitate of silver chloride is formed. The chlorine atom in an organic compound is not detached in an aqueous environment.
2. Main subject	Description: Understanding the reactivity of organic compounds
Experiment	**Equipment:** test tubes, Pasteur pipettes, spatula, water wash bottle. **Reagents:** 1-chlorobutane, silver nitrate(V) aqueous solution, sodium chloride aqueous solution **Precautions:** work with gloves and protective glasses! **Description:** Using a Pasteur pipette add about 1 ml of 1-chlorobutane and sodium chloride solution to two test tubes placed in a rack. Then add a few drops of $AgNO_3$solution to both test tubes with 1-chlorobutane and sodium chloride solution. After completing the exercise, pour the solutions into the containers indicated by the teacher. **Questions:** 1. Write down your observations of the transformations taking place in the test tubes 2. Why did the reaction not take place in the first test tube? **Conclusions**: After mixing a solution of silver nitrate(V) with a solution containing chloride ions, a white-gray precipitate is released, darkening in the air. This is a characteristic reaction for detecting chloride ions. Organic compounds such as 1-chlorobutane do not dissociate and do not produce such ions, so the reaction does not take place in test tube No. 1.

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The scenario

Subject	Paper chromatography of food dyes
Length	7,43 min.
Main objectives	Learning the method of separation of chemical substances
Detailed objectives	Observation of changes occurring during separation methods. Getting to know paper chromatography.
Structure and description of experiments:	
1. Introduction	The chromatography method is used to separate, identify and quantify chemical substances. It consists in separating the components of the mixture between the mobile phase (eluent) and the stationary phase by their different division. The mobile phase can be a gas (gas chromatography) or a liquid (liquid chromatography). Thin layer chromatography (TLC) and paper chromatography are liquid or planar chromatography because the separation process is carried out on a plane and the mobile phase is a liquid or liquid system. Thin-layer chromatography is carried out on aluminium plates coated with a suitable adsorber which is the stationary phase, usually silica gel or alumina, while in paper chromatography the stationary phase is paper. In thin-layer and paper chromatography, the mobile phase (developing system, eluent, washing agent) can be one solvent or a system of liquids miscible with each other in a specific volume ratio.
2. Main subject	Description: Learning the method of substance separation - chromatography
Experiment	**Equipment:** filter paper, dryer **Glass:** watch glasses, Pasteur pipette, small beaker, tweezers, scissors, pencil, water wash bottle **Reagents:** colourful candies, e.g. skittles **Attention! Treat the candies in the stand as a chemical reagent - they are not suitable for consumption!** **Description:** Cut out discs from the filter paper that are the size of the watch glasses. Prepare as many discs as there are types of candy colours on the stand. Place the discs on the watch glasses. Then, using tweezers, place one candy in the center of each disc, having previously dipped it in a beaker of water for a few seconds. After placing all the candies on the paper, use a water spray to gently wet each candy. When the water has travelled about 3/4 of the way from the center of the disc, remove the candies and dry the discs with a hair dryer. **Questions:** 1. Describe the differences observed on individual discs after drying them. What do you think these differences are due to? 2. What role did water play in this experiment? **Conclusions**: After drying the tissue paper on several discs, after unrolling there are several bands of colours - this means nothing else than that the dye used in the candy is a mixture of substances. Depending on the number of colours that appeared on the paper, we can determine how many different substances there are in the dye of a given candy. Distilled water acted as the mobile phase.

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	Chromatography provides the chemist with two very important pieces of information: qualitative - the number of spots determines the amount of substance in the sample; quantitative - the size of the spot, as well as its surface, allows you to calculate the mass of the substance in the test sample. The use of TLC and paper chromatography allows the detection of metal ions and dyes. Liquid and gas chromatography is widely used in biochemical research as a tool for separating and detecting chemical compounds as well as quality control and monitoring of environmental pollution. **Level:** Secondary School

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The scenario

Subject	Haloform reaction
Length	3,13 min.
Main objectives	Learning the haloform reaction
Detailed objectives	Observation of changes occurring during the reaction of acetone with iodine. Learning the method of detecting methyl ketones
Structure and description of experiments:	
1. Introduction	Description: The haloform reaction is a method for detecting ketones having a methyl group in the vicinity of a carbonyl group. In this reaction, methyl ketones in an alkaline environment are oxidized under the influence of halogen (iodine, chlorine, bromine) to carboxylic acids with the formation of a haloform. The haloform reaction of methyl ketones with iodine is also called the iodoform test because the product of the reaction is iodoform.
2. Main subject	Description: Learning the haloform reaction
Experiment	**Equipment:** test tube, Pasteur pipettes. **Reagents:** iodine solution in potassium iodide, aqueous NaOH solution, acetone **Precautions:** work with gloves and protective glasses! **Description:** Add about 1 ml of the iodine solution in potassium iodide to the test tube. Then, using a Pasteur pipette, add the NaOH solution dropwise until the colour disappears. Then add about 1 ml of acetone and mix well. Set the test tube aside for a few minutes. After completing the exercise, pour the solutions into the containers indicated by the teacher. **Questions:** **3.** Note down the changes taking place in the test tube. **4.** What application can this reaction have? **Conclusions**: The haloform reaction produces a haloform with the general formula CHX3, where X is Br, Cl or I. The reaction of acetone with iodine in an alkaline medium produces a light yellow precipitate of iodoform. $CH_3COCH_3 + 3I_2 + 4NaOH \rightarrow CH_3COONa + 3NaI + CHI_3\downarrow + 3H_2O$ The haloform reaction is a method for detecting methyl ketones, i.e. having a carbonyl group at the 2nd carbon atom, acetaldehyde, ethanol, acetic acid and all alcohols containing a hydroxyl group at the carbon atom connected to the methyl group. **Level**: Secondary School

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The scenario

Subject	Amphotericity
Length	4,48 min.
Main objectives	Learning amphoteric compounds
Detailed objectives	Observation of changes occurring during the reaction Learning the properties of amphoteric compounds Learning the notation of reaction equation
Structure and description of experiments:	
1. Introduction	Description: Amphotericity is the ability of chemical compounds to react with both acids and hydroxides, i.e. these compounds act as an acid in some reactions or a hydroxide in others. Amphoteric compounds do not react with water. Elements forming amphoteric compounds (oxides, hydroxides) have medium electronegativity and are found in the middle part of the periodic table, e.g. Zn, Al., Sn, Pb, As, Mn, Cr.
2. Main subject	Description: Learning amphoteric compounds and their properties
Experiment	**Equipment**: test tubes, Pasteur pipettes **Reagents**: aqueous solution of zinc nitrate(V), 5 M NaOH solution, 10% HCl solution **Precautions**: Caustic NaOH and HCl solutions - work with gloves and protective glasses! **Description**: Using a Pasteur pipette, pour about 2 ml of zinc nitrate(V) solution into two test tubes placed in a stand. Then, using a Pasteur pipette, add approximately 1 ml of 5 M NaOH solution to both test tubes, observing the appearance of zinc hydroxides. Then, add another portion of NaOH solution (minimum 2 ml) to the first test tube, and then drop about 2 ml of 10% hydrochloric acid solution to the second test tube. After noting down the observations, pour the contents of the tubes into the container indicated by the teacher, wash the tubes, and leave them to dry. **Questions:** 1. Write down the reaction equations (in full form) that take place in the test tubes after adding the first portion of NaOH. 2. Write down the reaction equation (in full form) that takes place in the test tube after adding the acid. 3. Write down the reaction equation (in full form) that takes place in the test tube after adding the second portion of NaOH. **Conclusions**: Związki amfoteryczne w zależności od środowiska reakcji — kwasowego lub zasadowego — mogą zachowywać się jak zasada lub jak kwas. W reakcji azotanu(V) cynku z wodorotlenkiem sodu powstaje galaretowaty biały osad wodorotlenku cynku o charakterze amfoterycznym. $Zn(NO_3)_2 + 2NaOH \rightarrow Zn(OH)_2\downarrow + 2NaNO_3$ After adding acid and excess hydroxide to the resulting zinc hydroxide, the precipitate in both tubes dissolved.

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	Zinc hydroxide in hydrochloric acid solution behaves as a base and forms a salt: $Zn(OH)_2\downarrow + 2HCl \rightarrow ZnCl_2 + 2H_2O$ However, in sodium hydroxide solution, it behaves like an acid and forms a salt-sodium zincate(II): $Zn(OH)_2\downarrow + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$ or the coordination compound sodium tetrahydroxozincnate(II). $Zn(OH)_2\downarrow + 2NaOH \rightarrow Na_2[Zn(OH)_4]$ Amphoteric oxides and hydroxides include: Al_2O_3, ZnO, BeO, Cr_2O_3, MnO_2, As_2O_3, PbO, PbO_2, CuO, Cu_2O, FeO, Fe_2O_3, SnO_2, $Zn(OH)_2$, $Be(OH)_2$, $Cu(OH)_2$, $Pb(OH)_2$, $Fe(OH)_2$, $Sn(OH)_2$, $Al(OH)_3$, $Fe(OH)_3$, $Sn(OH)_4$. **Level**: Primary school

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The scenario

Subject	Inorganic chemistry/Crystallization
Length	4:39
Main objectives	Learn the technique of crystallization
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of the crystallization of a salt solution into a solid
2. Main subject	Description: How to transform a liquid into a solid? How do you separate a soluble solid from a liquid and purify it? Is temperature important to achieve crystallization? Investigating the crystallization of alum salt in water at a certain temperature
Part 1	
(0:40), **Experiment 1 (0:42)**	**Tools:** Alum salt, water, beaker, stir plate, thermometer **Description:** Add water to a beaker and stir and heat in the stir plate. With the thermometer check that the water is now hot and add 50 mg of alum salt. The mixture is heated until some of the liquid evaporates, and small crystals begin to form on the surface of the liquid. Subsequently, stop the stirring and heating and wait for the crystallization process to occur for 12 hours. After the salt dissolved in water, the molecules were able to reattach during the next 12 hours. When the molecules reattached, they solidified again, but into a new form (crystals) **Questions:** Does the crystallization process depend on the temperature or the solubility of the salt? – Yes, it depends on the temperature to be able to make the salt soluble and then transform into crystals at hot temperatures, and at cold temperatures form the crystals. **Conclusions:** Salt crystallization occurs when the salt concentration in a solution exceeds its solubility in a solvent (in this experiment, water), which is dependent on the temperature
3. Summary, evaluation and notes	**Application:** The main use of crystallization in the organic chemistry laboratory is for purification of impure solids: either reagents that have degraded over time, or impure solid products from a chemical reaction Is a separation process very commonly used in the industry of many different materials. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Chemical reactions/Dehydration reaction of biomass
Length	5:44
Main objectives	To show how a dehydration by an acid works
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of the dehydration of biomass.
2. Main subject	Description: What happens when biomass is exposed to an acid? What reaction occurs? What can we physically observe?
Part 1	
(0:40), **Experiment 1 (0:46),**	**Tools:** Sugar, H_2SO_4, beaker **Description:** Pour the sugar into the beaker. Carefully add the H_2SO_4 and mix. After a few seconds of mixing, the mixture will darken. Subsequently, the mixture will start to boil. A reaction is occurring and produces vaporized water and carbon dioxide. The vaporized water and carbon dioxide are responsible for the expansion of the mixture inside the beaker. Meanwhile, the formation of a black spongy mass of carbon, known as sugar charcoal, occurs. **Questions:** What is the name of the reaction that occurs in the experiment that causes the generation of heat and causes the mixture to boil? – exothermic reaction **Conclusions:** The dehydration of biomass by acid results in the vaporization of the water and the formation of a black spongy mass of carbon
3. Summary, evaluation and notes	**Application:** This reaction is useful to prepare carbon materials form biomass wastes, this issue can be discussed in class, as well as the advantages of activated carbons for water purification, among other uses **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Biochemistry/Protein denaturation
Length	4:07
Main objectives	To show how prepare a fried egg at ambient temperature
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of the effect of placing an egg with an alcohol at ambient temperature
2. Main subject	Description: Did you know that you can cook an egg without heat? Why does an egg change colour when you add alcohol to it?
Part 1	
(0:40), **Experiment 1 (0:44)**	**Tools:** Plate, one egg, ethanol **Description:** Crack the egg and place it on the plate. then add ethanol and wait for about an hour to observe changes. You will observe that the white part of the egg suffers some changes that are like those obtained when you fry the egg, due to the protein denaturation that, in this case, is caused by the alcohol and not by the heat. Depending on the percentage of alcohol, the reaction takes at least an hour. The egg yolk contains some proteins that are denatured by the alcohol in the same way as heat, by breaking the bonds that hold parts of the protein in a folded shape. **Questions:** What is in the egg that is not affected by alcohol? - a lot of fat **Conclusions:** The alcohol participates in a chemical reaction, denaturing the conformation of the protein molecules so they can form new linkages with each other.
3. Summary, evaluation and notes	**Application:** When you cook eggs and meat, the digestion, and the use of alcohol for disinfection. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Chemistry reactions/Acid-base reaction
Length	4:48
Main objectives	To show how may occur an acid-base reaction that produces CO_2
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of the acid-base reaction and how can we see the production of CO_2 with a balloon
2. Main subject	Description: What happens when $NaHCO_3$ and vinegar react? How can we observe the formation of one of these products?
Part 1	
(0:40), **Experiment 1 (0:41)**	**Tools:** Balloon, $NaHCO_3$, vinegar, test tube **Description:** Pour vinegar into a test tube, then pour some $NaHCO_3$ into the balloon and place it in the mouth of the test tube. Subsequently, shake the test tube and wait for the reaction to start. Vinegar and $NaHCO_3$ react to carbon dioxide, water, and sodium acetate. The solid baking soda was placed in liquid vinegar producing carbon dioxide gas, which is evident because the balloon began to inflate because it was filled with carbon dioxide (which is a gas). **Questions:** Why do $NaHCO_3$ and vinegar react? - Because one is a base while the other is an acid, this reaction calls an acid-base or neutralization reaction **Conclusions:** When the $NaHCO_3$ reacts with vinegar, a neutralization reaction takes place, and an aqueous salt of sodium bicarbonate is formed along with the evolution of carbon dioxide gas.
3. Summary, evaluation and notes	**Application:** Acid-base reaction is used in wastewater treatment to reduce the damage created by effluents. Moreover, is used in the manufacturing of antacid tablets. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Chemistry reactions/Reaction retardant**
Length	2:41
Main objectives	To show how citric acid may act as retardant of an oxidation reaction
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation oxidation reaction in an apple and how it can be retarded with citric acid (lemon)
2. Main subject	Description: Why do fruits like apples brown in contact with air? What type of reaction and how can it be retarded?
Part 1	
(0:41), **Experiment 1 (0:44)**	**Tools:** Apple, lemon **Description:** First, cut the apple in half. One slice of apple will be untreated with the acid citric and drops of lemon in the slice of apple that will be treated. After two hours, the slice of apple that was not treated it has browned and the other slice that was treated with acid citric did not brown. The addition of lemon (acid citric) retards the browning process, which is an oxidation reaction. **Questions:** Why do fruits like apples brown when exposed to air – The enzyme polyphenol oxidase, in contact with the oxygen in the air, catalyzes one step of the biochemical conversion of plant phenolic compounds to brown pigments known as melanin. **Conclusions:** Lemon juice contains acid citric, which is a natural antioxidant. Therefore, when you apply lemon juice to the apple slice, it helps to prevent the oxidation process.
3. Summary, evaluation and notes	**Application:** As preservative in the food industry. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Osmotic Equilibrium/ Osmotic equilibrium
Length	5:12
Main objectives	To show the effect of osmotic equilibrium on the vegetal cells
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: Explain the effect of osmotic equilibrium on membranes and on vegetal cells
2. Main subject	Description: Will the carrots absorb more or less of a certain concentration of water over the course of one day?
Part 1	
(0:40), **Experiment 1 (0:45),**	**Tools:** Water, salt, 3 carrots **Description:** In a beaker add salt and water and mix, in another beaker adds only water. Place a carrot in each of the beakers (with and without salt). After 10 hours, it is observed that the carrot submerged in salt water reduced its size. Carrots contain water inside. Water molecules move across a membrane to higher levels of salt concentration through a process called osmosis. **Questions:** Why does the water inside the carrot prefer to move out of the carrot in salt water? – Water molecules move across a membrane to higher levels of salt concentration through osmosis. So, if a carrot is placed in very salty water, it will be less salty than the water around it. **Conclusions:** Vegetables such as Carrots and celery are crisp largely because of water (freshwater) trapped within them. If placed in fresh water, the carrot is saltier than the surrounding water, so the water moves into the carrot. This causes the carrot to stiffen if it was previously limp or preserve its crispness if it was crisp before.
3. Summary, evaluation and notes	**Application:** By diffusion of water or solutes, osmotic balance ensures that optimal concentrations of electrolytes and non-electrolytes are maintained in cells, body tissues, and in interstitial fluid. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Chemical reactions/Acid-base reaction
Length	5:19
Main objectives	To create an erupting volcano
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment is to prepare an erupting volcano and explain the acid-base reactions
2. Main subject	Description: Why does mixing vinegar and $NaHCO_3$ create an eruption? What type of reaction occurs?
Part 1	
(0:40), **Experiment 1 (0:40),**	**Tools:** Clay, $NaHCO_3$, vinegar, colorant **Description:** Make two „volcanoes“ with the clay. mix $NaHCO_3$ and colorant and add to the volcano. You can use two different colors if you want, and you can create different colored eruptions in this way. Add some vinegar into the slot of the volcano. And make the volcano erupt. The water in the vinegar acts as a host where the base and acid react. During the reaction, when the baking soda is mixed with the vinegar, the baking soda (Base) takes a proton from the vinegar (Acid). The reaction causes the baking soda to transform into water and carbon dioxide. Carbon dioxide is a gas which is released during the reaction, which gives it the bubbling effect, and it expands. **Questions:** What reaction occurs? – Acid-base reaction. What is in vinegar that causes the acid-base reaction with, $NaHCO_3$ to occur? **Conclusions:** When vinegar and $NaHCO_3$ are first mixed together, hydrogen ions in the vinegar react with the $NaHCO_3$ ions in the baking soda. The result of this initial reaction are carbonic acid and sodium acetate. The second reaction is a decomposition reaction. The carbonic acid formed because of the first reaction immediately begins to decompose into water and carbon dioxide gas.
3. Summary, evaluation and notes	**Application:** Used in cleaning (refining) metals, in the maintenance of swimming pools, and for household cleaning. Used in car batteries, and in the manufacture of fertilizers. Used in the manufacture of fertilizers, explosives and in the extraction of gold. The main ingredient in vinegar. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	Properties of fluids/ Fluid displacement by capillarity
Length	3:53
Main objectives	To show how a fluid can move through a solid by capillarity
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The objective of this experiment is to observe and understand the phenomenon of capillarity of a liquid through a porous material.
2. Main subject	Description: Why can a liquid be transported through a porous material? What phenomenon occurs? Investigate the capillarity of a water paints through kitchen paper
Part 1	
(0:40), **Experiment 1 (0:41)**	**Tools:** Water paints, three glasses and kitchen paper **Description:** Mix water paints with water in 3 glasses using primary colors: yellow, blue and red. Then, connect the glasses with some kitchen paper and wait to observe how the liquids move through the kitchen paper. A few seconds later, we can observe how the liquids move through the paper, that phenomenon is call capillarity, which is the result of surface, or interfacial, forces. So, capillarity is defined as the movement of water within the spaces of a porous material due to the forces of adhesion, cohesion, and surface tension. That is why we can observe how the water paints "rises" through the paper. **Questions:** Does density affect capillarity action? – Capillarity rise is inversely proportional to the density of the liquid **Conclusions:** Capillary action is a scientific phenomenon in which a liquid seemingly defies gravity to flow upward within a solid and depends on the attraction between water molecules and the material (glass walls of a tube or a porous material like paper), called adhesion, as well as on the interactions between water molecules (cohesion).
3. Summary, evaluation and notes	**Application:** Plants and trees couldn't thrive without capillary action. Plants put down roots into the soil which can carry water from the soil up into the plant. Water, which contains dissolved nutrients, gets inside the roots, and starts climbing up the plant tissue. The ink in pen and the oil in wicks rises due to capillarity. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Physical magnitudes (pressure) - Effect of atmospheric pressure**
Length	2:09
Main objectives	To show the effect of the atmospheric pressure
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the demonstration of the effect of atmospheric pressure.
2. Main subject	Description: How is a candle flame affected by placing a glass over the candle? What happens to the water inside the glass when the candle goes out?
Part 1	
(0:40), **Experiment 1 (0:41)**	**Tools:** Plate, water, a glass & a candle. **Description:** Put very little water on a plate. Then, Place a candle in the middle of the plate, and light it. Slowly bring a glass down on top of the candle until it is standing in the water, on the plate. Water is drawn into the glass until the pressure is equalized. After some time, the candle dims and goes out. Just before the candle dies, the water level rises a bit. The candle heats the air and expands it. This cancels the depletion of oxygen temporarily and the water level stays down. When the oxygen is depleted, the candle goes out and the air cools. The volume of the air decreases and the water rises. **Questions:** What is happening in this experiment? – the candle heats the air and expands it, which led to higher air pressure and the water level stays down. When the oxygen is depleted, the candle goes out and the air cools. The volume of the air decreases and the water rises. **Conclusions:** In this experiment, a pressure difference between the air inside the glass and air outside the glass is created. This pressure difference caused the high-pressure air outside the glass to push the water down into the plate allowing the water to be pushed upwards into the inside of the glass towards the lower-pressure air inside.
3. Summary, evaluation and notes	**Application:** Ink is filled in the pen because of atmospheric pressure. Wall lizards walk on the wall due to atmospheric pressure. The feet of lizard's act like suction pads. We can drink soft drinks easily with a straw. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Redox reactions - Redox reactions may occur or not depending on the conditions**
Length	4:16
Main objectives	Check how two isolated reactants are “harmless”, but constitute a real danger when they are mixed
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for doing this experiment is to physically observe a redox reaction in the presence of copper
2. Main subject	Description: What reactions occur when HCl and H_2O_2 are placed separately with Cu? What happens when they are mixed in the presence of Cu?
Part 1	
(0:40), **Experiment 1 (0:44)**	**Tools:** Cu wires, HCl, H_2O_2 **Description:** In three containers, place a copper wire. In the first of them pour hydrochloric acid solution. In the second pour hydrochloric acid and hydrogen peroxide. In the third pour hydrogen peroxide. Copper belongs to the less active metals within the oxidation scale, so it is not attacked by acids through their hydrogen cations. Nor is copper oxidized by hydrogen peroxide in a neutral medium. When mixing hydrochloric acid and hydrogen peroxide, an effect is produced “devastating”: we promote an acid medium for the oxidizing action of water oxygenated and cause the formation of elemental chlorine -in the reaction between water oxygenated and chloride ions, which is a very strong oxidant. This explains the oxidation of copper in the second flask and not in the first and third ones. Due precisely to the formation of chlorine, special care must be taken with the second flask: the emanation of chlorine gas can be tremendously harmful due to its irritating and toxic effect on the respiratory tract. Indispensable the safety measures and work in the fume hood. **Questions:** Why are vapors generated during the reaction? - The hydrochloric acid catalyzes an exothermic decomposition of hydrogen peroxide into oxygen and water. Why does the mixture turn blue when mixing peroxide and hydrochloric acid? – Due to the redox reaction that occurs between HCl and H_2O_2, where cooper is being oxidized because of this reaction **Conclusions:** The copper wire does not undergo an apparent physical change with HCl and H_2O_2 separately, but when they are mixed and a redox reaction occurs, the copper begins to oxidize and the solution turns blue, demonstrating the reaction

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3. Summary, evaluation and notes	**Application:** Redox reactions are used in the electroplating process to apply a thin layer of a substance to an item. Gold-plated jewellery is made using an electroplating process. Electrolysis, which is dependent on redox processes, is used to purify metals. **Level:** primary school (ISCED 2 / 6th, 8th grade)

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The scenario

Subject	**Physicochemical properties of fluids/How does fluid density affect buoyancy**
Length	2:58
Main objectives	To study the effect of density on buoyancy
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment will be the investigation of phenomena from nature - bodies swimming on the surface of liquid, bodies diving.
2. Main subject	Description: Why sometimes a body floats on the surface and other times it sinks. What does the magnitude of the buoyant force depend on? Investigating the possibility of floating bodies with a greater density than water on the surface of the liquid.
Part 1	
(0:40), **Experiment 1 (0:44)**	**Tools:** 3 glasses, eggs, sugar, and salt **Description:** Place an egg in water, another one in water with sugar and the third one in water with salt. Then mix the glasses that have sugar and salt. Notice how the eggs float differently in each of the glasses. The egg will sink in the freshwater because it has greater density than the water. The egg will float in the saltwater because when salt is added to water its density becomes greater than that of the egg. That makes the egg float. However, an egg will float in the water with sugar added to it because the sugar-water combination has a higher density than the egg. The sugar-water also has a higher density than plain water. It will float, but not as much as the egg in salty water. **Questions:** What property affects whether an object floats in a fluid such as water? – the density of the liquid Is salt denser than sugar? – yes, that's why the egg buoyed much more in salt water than sugar-water. **Conclusions:** Generally, substances float if their density is less than the density of the medium, they are placed in. Adding a substance to water or liquid will change its density. Remember that it also depends on the temperature.
3. Summary, evaluation and notes	**Application:** Density affects everyday life in many ways, such as how clouds float at different altitudes, why an object floats or sinks in water, and how gases move in Earth's atmosphere Another application of density is determining whether or not an object will float on water.

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	Level: secondary school

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The scenario

Subject	Chemical reactions/How to prepare a soap?
Length	6:25
Main objectives	To show the reaction between an oil and NaOH
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment is to make soap via the saponification reaction
2. Main subject	Description: how to make soap from a base and oil? what happens during the reaction?
Part 1	
(0:40), **Experiment 1 (0:44)**	**Tools:** Oil, NaOH, stir plate **Description:** Prepare a solution of 42 g of NaOH in 250 mL of water. Slowly add the NaOH because it will start to heat due to an exothermic reaction occurring. Be careful. Once the NaOH is dissolved, add 250 mL of oil. Then stir for around 40 minutes at room temperature. The mixture will slowly become smoother and opaquer; it should thicken to a pudding-like consistency. The reaction between oil and NaOH is exothermic in nature because heat is liberated during the reaction. Subsequently, the suspension formed is made up of soap and glycerol. After the process where triglycerides are combined with a strong base like NaOH to form fatty acid metal salts during the soap-making process. In three days, the soap will be hard enough. **Questions:** What is the saponification reaction? – is the process of converting esters into soaps and alcohols by the action of an aqueous alkali like NaOH solution. **Conclusions:** Slowly add the sodium, because it will begin to heat due to an exothermic reaction occurring.
3. Summary, evaluation and notes	**Application:** Saponification is used by wet chemical fire extinguishers to convert burning fats and oils into non-combustible soap which helps in extinguishing the fire. Further, the reaction is endothermic and lowers the temperature of the flames by absorbing heat from the surroundings. In the manufacture of soaps, serve different purposes like laundry, cleaning, and lubrication. **Level:** secondary school

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The scenario

Subject	**Solubility equilibrium/How does temperature affect solubility?**
Length	7:19
Main objectives	To study how temperature increases K_s value
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for the experiment is to determine how solubility is affected by temperature
2. Main subject	Description: Why does temperature influence solubility?
Part 1	
(0:40), **Experiment 1 (0:42)**	**Tools:** KNO_3, stir plate and thermometer **Description:** Add water in a beaker, then add KNO_3 and stir. Then, increase the temperature of the solution and observe how the solid solves (disappear), and more salt can be added. Repeat the operation at several temperatures. Solubility increases with temperature; this is because higher temperatures increase the vibration or kinetic energy (K_s) of the solute molecules. Solute molecules are held together by intermolecular attractions. In the end, let the saturated solution cool down and observe the crystals formed. The start of crystallization indicates that the solution has become saturated at this temperature. **Questions:** Does the solubility change with temperature? – Yes, the solubility of most solid substances can change with temperature; at higher temperatures, most solids are more soluble. Why do KNO_3 crystals form on cooling? – When you dissolve as much KNO_3 as you can at high temperatures, it is forced to crystallize as the liquid cools. **Conclusions:** The higher the temperature is, the easier a solid will be able to dissolve. Likewise, the lower the temperature the harder is for a solid element to dissolve.
3. Summary, evaluation and notes	**Application:** In the pharmaceutical field, solubility parameters are primarily used to guide organic solvent selection, cocrystals and salt screening, lipid-based delivery, solid dispersions, and nano- or microparticulate drug delivery systems. Solubility provides fundamental information necessary to make predictions of transport path- ways in aqueous systems. **Level:** secondary school

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The scenario

Subject	Chemical reactions /Factors that affect the pH of an acid solution
Length	4:49
Main objectives	To study acid strength
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The objective of this practice is to determine the acidity of different compounds and observe how the pH value changes when changing the concentration.
2. Main subject	Description: Why are some substances more acidic than others? What does this acidity depend on? The pH of three compounds will be measured and the pH value of one of these will be compared by changing the concentration by adding water.
Part 1	
(0:40), **Experiment 1 (0:41)**	**Tools:** HCl, CH_3COOH, vinegar, pH paper **Description:** Add vinegar to a beaker and measure the pH, which has a value of 6. Add acid acetic to a beaker and measure the pH, which has a value of 2. Add HCl to a beaker and measure the pH, which has a value of 1. As you can see, the HCl is more acidic than vinegar and acid acetic. Then, add 20 mL of water and then add a few drops of HCl. The pH value is like that of acetic acid (2). Changing the concentration of HCl by adding water, caused its acidity to decrease. **Questions:** Does the concentration of the solution change its acidity? – Yes, the overall concentration of hydrogen ions is inversely related to its pH. **Conclusions:** The strength of an acid is determined by the concentration of hydrogen ions in the solution, and the more hydrogen ions present, the stronger the acid. You can change the presence of hydrogen ions by changing the concentration of the solution, and consequently, changing its acidity.
3. Summary, evaluation and notes	**Application:** Acid/base chemistry is a pervasive scientific concept used across many engineering disciplines. Engineers use their knowledge of acids and bases to design non-corrosive material combinations, car batteries, chemical fertilizers, and food preservation techniques. Knowing this information helps to design non-corrosive substances or modify those that are. **Level:** secondary school

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The scenario

Subject	**Analytical chemistry/Determination of the acidity of vinegar**
Length	6:07
Main objectives	To show how titrations work
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: This experiment had the objective of showing the titration of vinegar with NaOH
2. Main subject	Description: How to know the acidity of a substance with a strong base and an indicator like phenolphthalein?
Part 1	
(0:40), **Experiment 1 (0:43)**	**Tools:** Vinegar, NaOH, phenolphthalein, pipettes, burettes **Description:** First, prepare 1 L of 0,001 M of NaOH and put the solution in the burette. Then, add 10 mL of vinegar to a volumetric flask and fill it with water to the mark. Take 20 mL of the vinegar solution, add 3 drops of phenolphthalein, and do the titration with NaOH. Mix while titrating with NaOH. Phenolphthalein is colorless in acidic solutions like vinegar, and deep pink in basic solutions like NaOH, so when the solution starts to turn pink, this is the equivalence point of the titration, and you must stop adding NaOH to the solution. Observe how many mL of NaOH were used to reach the equivalence point. **Questions:** What will happen to the solution if more NaOH is added? – the solution will turn completely dark pink, indicating that the solution is basic. What is happening during NaOH + Vinegar reaction? – the vinegar donates a proton to the hydroxide ion and acts as an acid. The hydroxide ion accepts a proton and acts as a base. **Conclusions:** Phenolphthalein is an indicator that begins to turn pink in the presence of a basic. The amount of NaOH used indicates the acidity of the sample.
3. Summary, evaluation and notes	**Application:** Titration is an analytical method for determining the concentration of an unknown substance in a sample. It is a form of quantitative chemical analysis and is used in various industries including food, dairy, and water. **Level:** secondary school

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The scenario

Subject	**Analytical chemistry/Determination of the exact concentration of HCl**
Length	3:12
Main objectives	To show how titrations works
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The objective of this experiment is to understand the titration process
2. Main subject	Description: What is the titration process?
Part 1	
(0:40), **Experiment 1 (0:42)**	**Tools:** HCl , NaOH, phenolphthalein, pipettes, burettes **Description:** Add 10 mL of HCl 0,1 M in a beaker and add water to a volume of 50 mL, then add some drops of phenolphthalein. Titrate with a normalized NaOH solution to determine the exact HCl concentration. The solution just begins to turn pink as the pH reaches 7, indicating that the base neutralized the acid. **Questions:** At what point has the acid titration been achieved? – When the solution beings to turn pink. **Conclusions:** Titration is a technique where a solution of known concentration is used to determine the concentration of an unknown solution.
3. Summary, evaluation and notes	**Application:** Food processing, chemical manufacturing, and pharmaceutical manufacturing are the three businesses in the manufacturing sector that heavily rely on titration methods. These are used in several important areas, including product research and development, quality control, and large-scale production. **Level:** secondary school

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The scenario

Subject	Solubility equilibrium/Precipitation reactions
Length	4:08
Main objectives	To show how a precipitation reaction can indicate the presence of Cl in tap water
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The reason for this experiment is to demonstrate how the formation of a precipitate can indicate the presence of Cl in a substance.
2. Main subject	Description: Is it easy to determine the presence of Chlorine in water? The presence of Cl will be demonstrated due to the precipitation that occurs when reacting with $AgNO_3$
Part 1	
(0:40), **Experiment 1 (0:41)**	**Tools:** $AgNO_3$, NaCl **Description:** Prepare two solutions, one with NaCl and the other with a small amount of $AgNO_3$, then, put both together and pay attention to the white solid to be formed. This occurs when a few drops of $AgNO_3$ are added to a solution containing chloride ions, and a white precipitate of silver chloride forms. Then, mix tap water with the $AgNO_3$ solution. The presence of Cl in tap water is demonstrated due to the precipitate that is formed when $AgNO_3$ reacts with chloride ions. **Questions:** Is it possible to confirm the presence of chloride ions in water? - Yes, precipitation with $AgNO_3$ would indicate the presence of these ions. Why does tap water have chloride ions? - due to the purification process where chloride is added. **Conclusions:** The test of chloride ions is based on the precipitation of an insoluble chloride salt with $AgNO_3$.
3. Summary, evaluation and notes	**Application:** Precipitation often is used to remove metal ions from aqueous solutions. In pharmaceuticals, precipitation is used as a method of purification to isolate pure crystalline pharmaceutical intermediate, ingredient, or excipient after bioprocesses. **Level:** secondary school

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The scenario

Subject	**Analytical chemistry/Determination of the exact concentration of H_2SO_4 solution**
Length	2:33
Main objectives	To show how titrations work
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The objective of this experiment is to understand the titration process
2. Main subject	Description: What is the titration process?
Part 1	
(0:40), **Experiment 1 (0:42),**	**Description:** Add 20 mL of H_2SO_4 in a beaker and then, add some drops of phenolphthalein. Titrate with a normalized NaOH solution to determine the exact H_2SO_4 concentration. The solution just begins to turn pink as the pH reaches 7, indicating that the base neutralized the acid. **Questions:** At what point has the acid titration been achieved? – When the solution beings to turn pink. **Conclusions:** Titration is a technique where a solution of known concentration is used to determine the concentration of an unknown solution. The use of an indicator such as phenolphthalein helps to identify when the base has neutralized the acid.
3. Summary, evaluation and notes	**Application:** Titration can analyse purity and content. It supports the preparation of pharmaceutical products and the manufacturing of biodiesel fuel from vegetable oil. It is used extensively in product development and quality control. In food processing, acid or base titration determines the acidity of fruit juice. **Level:** secondary school

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The scenario

Subject	Separation operations/Adsorption
Length	4:09
Main objectives	To show how adsorption process works
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation to carry out this experiment is to show how the adsorption process works.
2. Main subject	Description: Why sometimes a body floats on the surface and other times it sinks. What does the magnitude of the buoyant force depend on? Investigating the possibility of floating bodies with a greater density than water on the surface of the liquid.
Part 1	
(0:40), **Experiment 1 (0:42)**	**Tools:** Activated carbon, crystal violet colorant, funnel, and filter paper **Description:** In two beakers add water and a few drops of violet colorant. Then, in a beaker pour one of the solutions with the colorant. Then add activated charcoal and mix generously. Subsequently, with a funnel and filter paper, filter the mixture. As the mixture is filtered, the activated carbon is retained on the filter paper, and the water falls into the beaker. The water is transparent once it is filtered. **Questions:** Why is the colorant not visible in the water once it is filtered? – activated carbon adsorption acts as an accumulation of a liquid onto the surface of the activated carbon and inert solid material. What is the adsorption process of activated carbon and colorant? – during the filtration through activated carbon, colorant adhere to the surface of these carbon granules or become trapped in the small pores of the activated carbon. **Conclusions:** The adsorption is a method for removing dissolved organic substances.
3. Summary, evaluation and notes	**Application:** Adsorption is a process used to remove diverse, dissolved contaminants from water, air, and gaseous streams. **Level:** secondary school

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The scenario

Subject	**Inorganic chemistry/Grow salt crystals**
Length	8:31
Main objectives	To show the crystallization process
Detailed objectives	
Structure and description of experiments:	
1. Introduction	Description: The motivation for conducting the experiment is to investigate the crystallization process.
2. Main subject	Description: Why are salt crystals formed? The principle of crystallization is based on the limited solubility of a compound in a solvent at certain temperature and pressure.
Part 1	
(0:40), **Experiment 1 (0:42)**	**Tools:** $Na_2S_2O_3$, tubes, lighter **Description:** Put $Na_2S_2O_3$ in a tube (3-4 cm), add some drops of water and heat until the complete solution. Cool down the solution in crystallization with a crystal seed. **Questions:** Does the crystallization process depend on the temperature or the solubility of the salt? – Yes, the evaporation of water in the formation of salts. How does crystallization occur? - Crystallization occurs in two major steps. The first is nucleation, the appearance of a crystalline phase from either a supercooled liquid or a supersaturated solvent. The second step is known as crystal growth, which is the increase in the size of particles and leads to a crystal state. **Conclusions:** Crystallization is a laboratory technique used for purifying the impure form of a substance into a more pure, solid product.
3. Summary, evaluation and notes	**Application:** Crystallization is primarily employed as a separation technique to obtain pure crystals of a substance from an impure mixture. **Level:** secondary school

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