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) (3:56)	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?
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

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(4:36)	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. 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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