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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) (1:17) (1:59) (2:13)	**Tools:** computer with IP Coach, track, carts and force meter, scale, weights, links, string 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. 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. 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

	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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