Experiment P-8 Pulley System



Objectives

- To learn about pulley systems: fixed, movable and compound pulleys.
- To measure the effort force and the load force.
- To measure the distance the force sensor has to be pulled in order to move the load 10 cm and calculate the velocity ratio.
- To calculate the mechanical advantage of each system.
- To find the relationship between the mechanical advantage and the velocity ratio.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-211 Force sensor

Equipment and Accessories

35 cm track	1
Track leg	2
20" rod	2
Track rider	2
Boss head	2
100 g slotted mass	2
Slotted mass hanger	1
Rod with pulley	1
(perpendicular)	
Pulley with hook	1
Thread (~1m)	1
3 m measuring tape	1

 The items above are included in the NeuLog Mechanics kit, MEC-KIT and also in the NeuLog Pulley kit, PUL-KIT.



Introduction

A pulley is a grooved wheel firmly attached to an axle. A rope or a cable fits into the groove and passes over the wheel. A **fixed pulley** is fastened to one spot. The fixed pulley has no gains in force or distance, but it changes the direction of the force. A **movable pulley** moves along a rope. It decreases the force, but the rope must be pulled for a longer distance. A **compound pulley** (also known as a block and a tackle) is the combination of fixed and movable pulleys. The fixed pulley changes the direction of the force and the movable pulley decreases the applied force.

In this experiment, you will study these three types of pulley systems. You will use a force sensor to measure the effect of each type of pulley on the force that must be applied to perform work. You will also find the velocity ratio of each system.



Procedure

Experiment setup

1. Set up the experiment as shown in the picture below.



- 2. Attach the track legs to the track.
- 3. Slide the track rider to the middle of the track.
- 4. Insert the 20" rod in the track rider.
- 5. Attach the boss head to the top of the 20" rod.
- 6. Attach the rod with the pulley to the boss head.
- 7. Place the 100 g slotted mass on the slotted mass hanger.
- 8. Make sure you have a ~1 m long thread.



Sensor setup

- 9. Connect the USB module **1** to the PC.
- 10. Connect the Force sensor **S** to the USB-200 module.

Note:

The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

11. Run the NeuLog application and check that the force sensor is identified.



Settings

- 12. Click on the force **sensor's module** box.
- 13. Select the +/-10 N button to set the sensor's mode.

NeuLog		(C) Main		
ID 1	Display	Left	+/-10 N	0
	Range	+/-10 N	+/-50 N	
	Duration	10 Seconds		
	Rate	10 per second		
	Trigger	Off		
	Extra comman	ıd		

14. Click on the **Extra command** button and then on the **Push=Negative** button to get positive values when hanging the cart from the force sensor's hook.

NeuLog		Force (ID 1)		() Main	
O.00 Force ID 1	Display Range Duration	Left +/-10 N 10 Seconds	Push	Reset = Positive = Negative	
	Trigger Extra comman	Off			



- 15. Click on the Sicon to go back to the graph.
- 16. Click on the **Run Experiment** icon and set the:

Experiment duration to 10 seconds Sampling rate to 10 per second



Testing and measurements

Note:

The orientation of the sensor is very important. Before each measurement, hold the sensor in the same orientation you will use for the specific experiment and zero it.

17. **Sensor Zeroing:** hold the sensor in the proper orientation (the hook should be facing downwards for the first measurements) and press the button in the sensor's box for about 3 seconds.

Alternatively, you can click on the **Extra command** button in the **Module Setup** box menu and then on **Reset**.

18. When using a pulley, the rope is 'pulled' on the effort side; the weight lifted on the other side is called the 'load'. This is a fixed pulley:





Measure the <u>Load force</u>: Put a 100 g on the mass holder and then hang these on the force sensor.



- 19. Click on the **Record** icon **O** to start the measurement.
- 20. Your graph should be similar to the following:





- 21. Click on the **Export** Icon and then on the **Save value** table (.CSV) button to save your graph.
- 22. Click on the Sicon to go back to the graph.
- 23. Click on the **Experiment module box** on the left of the screen.
- 24. Insert the average value you see in the menu on the following table.



No pulley	Measured force (with mass holder) [N]	Measured force [N] (with mass holder and movable pulley)
100 g	1.024	1.19
(sample		
experiment)		
100 g		
200 g		

- 25. Click on the \bigcirc icon to go back to the graph.
- 26. Add another 100 g slotted mass (you will now have 200 g).



- 27. Click on the **Run Experiment** icon and the on the **Record** icon.
- 28. Insert the new data to the table above.
- 29. Make a measurement with the 100 g mass together with the movable pulley and with the 200 g mass together with the movable pulley.
- 30. Insert the values in the previous table.

For some pulley setups we include the pulley with the load force because it is directly attached to the load and moves with the load.

- 31. Set up the experiment as shown in the following picture.
- 32. Remember to zero the sensor in this new orientation, with the hook facing upwards before putting on any load.



33. This is a fixed pulley. Hang a 100 g slotted mass on it. The length of the thread is not important.

- 34. In order to measure the effort force, click on the **Record** icon to start the measurement.
- 35. Your graph should be similar to the following:



- 36. Repeat the measurement with a 200 g slotted mass (without erasing the first graph).
- 37. Click on the **Export** Icon and then on the **Save value** table (.CSV) button to save your graph.
- 38. Click on the \bigcirc icon to go back to the graph.



39. Write the average force values in the following data table.

Fixed pulley							
Slotted mass	Load force (N) (without a movable pulley)	Effort force (N)	Mechanical advantage (Load/Effort)	Distance moved by the effort [cm] (Distance moved by load is 10 cm)	Velocity ratio		
100 g (sample experiment)	1.024	1.019	~1				
100 g							
200 g							

The ratio of the Load to the Effort (Load/Effort) is called the Mechanical Advantage (MA) of a pulley system. A system with MA>1 decreases the effort (Effort<Load) while a pulley system with MA<1 increases the effort (Effort>Load).

- 40. Calculate the Mechanical Advantage (MA) for each mass and write it in the previous table.
- 41. Lift the load 10 cm up. What distance did you have to move the force sensor in order to lift the load? Insert the distance value in the table above.

The velocity ratio is equal to the distance moved by the effort divided by the distance moved by the load. Calculate the velocity ratio and insert the data in the previous table. 42. Assemble a second system as shown in the following picture.



- 43. This is a movable pulley. Put the sensor in place with the right orientation (without the slotted mass) and zero it again.
- 44. Hang a 100 g slotted mass and click on the **Record** icon **O** to start the measurement.
- 45. Repeat the measurement with two 100 g slotted masses without erasing the first measurement.



46. Write the results in the following data table.

Movable pulley							
Slotted mass	Load force (N) (with a movable pulley)	Effort force (N)	Mechanical advantage (Load/Effort)	Distance moved by the effort [cm] (Distance moved by load is 10 cm)	Velocity ratio		
100 g (sample experiment)	1.19	0.641	~2				
100 g							
200 g							

- 47. Calculate the MA and insert the value into the table above.
- 48. Lift the load 10 cm up. What distance did you have to move the force sensor in order to lift the load? Insert the distance value in the table above.
- 49. Calculate the velocity ratio and insert the data in the previous table.

50. Assemble a third system as shown in the following picture:



- 51. This is a compound pulley system. Put the sensor in place with the right orientation and zero it again (without the slotted mass).
- 52. Hang a 100 g slotted mass and click on the **Record** icon **O** to start the measurement.
- 53. Repeat the measurement with two 100 g slotted masses without erasing the first measurement.



54. Write the results in the following data table.

Compound pulley							
Slotted	Load		Effort	Mechanical	Distance	Velocity	
mass	force	(N)	force (N)	advantage	moved by	ratio	
	(with	a		(Load/Effort)	the effort		
	movab	le			[cm]		
	pulley)				(Distance		
					moved by load is 10 cm)		
100 g							
200 g							

- 55. Calculate the MA and insert the value into the table above.
- 56. Lift the load 10 cm up. What distance did you have to move the force sensor in order to lift the load? Insert the distance value in the table above.
- 57. Calculate the velocity ratio and insert the data in the previous table.

Summary questions

- 1. Which system decreased the effort? Explain what causes the effort to decrease.
- 2. What is the advantage of using the pulley that does not decrease the effort over just lifting the weight without a pulley?
- 3. What is the advantage of the compound pulley over the movable pulley?
- 4. What is the connection between the mechanical advantage and the velocity ratio?
- 5. What force do you have to exert to lift a 70 Kg weight using a system with a mechanical advantage of 3?