

etwinning experiment: team 1

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|---------|-----------------------------------|
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- **ORIENTATION**

We are going to measure the speed of the bicycle wheel. Therefore we will change the gears. We will also calculate the angular velocity and track speed change of the bicycle wheel. We will do this experiment by attaching a smartphone to a bicycle wheel. With the app we will measure the angular velocity and the acceleration. We will calculate the track speed.

research question: When you change the gears of the bike, how does it affect the speed of the wheel?

sub - questions: What happens with the angular velocity and track speed, when you change the gears of the bike?

- **HYPOTHESIS**

The angular velocity will be smaller when you turn the gear up (so when the chain is on a bigger sprocket). The track speed will also be smaller when you turn the gear up, because the speed will reduce. This is because your rear wheel then does less revs each time you pedal on the bike.

The angular velocity will be bigger when you turn the gear down (when the chain is on a smaller sprocket). The track speed will also be bigger when you turn the gear up because the speed will increase. That's because your rear wheel revs more each time you pedal on the bike's pedals.

PREPARATION

material:

- bicycle with gears
- phyphox app
- smartphone
- tape
- ruler (to measure the radius of the wheel)

method:

- turn the bike upside down (don't actually ride the bike, but just turn the pedals. this is much safer for your phone);
- measure the radius of the wheel;
- attach the smartphone to the back wheel with tape;
- turn on the app phyphox (the experiment on the app that we will use is centrifugal acceleration > mechanics);
- make the wheel spin by pushing the pedals;

using phyphox:

- press on the three points in the right upper corner and press on timed measurement;
- delayed start 5s and duration experiment 10s;
- press on the start button and start spinning around in circles for 15s;
- watch the results of this experiment on the phyphox app and export the data;
- repeat the experiment 3 times;

2nd part of the experiment:

- change the gears;
- repeat the previous steps (also do this experiment 3 times);
- change the gears one last time (so you have 3 different gear settings in total);
- repeat the previous steps (also do this experiment 3 times);
- **DATA ANALYSIS and DISCUSSION**

observations and measurements:

- measurements of the first part of the experiment:

(measurement 1)

(measurement 2)

| Data | Metadata Device | Metadata Time |
|------------|--------------------------|----------------------------------|
| Time (s) | Angular velocity (rad/s) | Acceleration (m/s ²) |
| 1,09237962 | 0,00852470 | 0,03340045 |
| 1,59269262 | 0,00404970 | 0,03291948 |
| 2,09300787 | 0,01151063 | 0,08050255 |
| 2,59331987 | 0,00895060 | 0,01296660 |
| 3,09363154 | 0,00071378 | 0,04594193 |
| 3,59394354 | 0,00877354 | 0,01990721 |
| 4,09425429 | 0,48460868 | 0,55105153 |
| 4,59456429 | 0,00445706 | 0,03167854 |
| 5,094874 | 0,01333044 | 0,04215694 |
| 5,595183 | 0,00881966 | 0,03578292 |
| 6,59579837 | 0,02071702 | 0,05351463 |
| 7,09610525 | 0,04604432 | 0,04196800 |
| 7,59641225 | 0,00860450 | 0,30574990 |
| 8,096718 | 0,03374410 | 0,24014045 |
| 9,10835058 | 3,57380511 | 3,40500001 |
| 9,60855254 | 4,52404812 | 3,00802118 |
| 10,1087565 | 4,41455609 | 5,54777106 |
| 10,6089616 | 4,17788102 | 4,36831152 |
| 11,1091656 | 4,52073052 | 4,69831950 |
| 11,6093697 | 4,40688678 | 5,36952411 |
| 12,1095737 | 4,00325857 | 2,68035265 |
| 12,6097785 | 4,23982462 | 4,02472104 |
| 13,1099825 | 4,15141669 | 5,16357814 |
| 13,6101875 | 3,28816630 | 6,25534494 |
| 14,1103915 | 3,73372954 | 2,30272533 |
| 14,6105961 | 4,12277267 | 5,54330171 |
| 15,1108011 | 3,28800828 | 2,69240036 |
| 15,6110055 | 3,84814825 | 1,44569890 |
| 16,1112105 | 4,18388818 | 3,70898669 |
| 16,6114139 | 3,40536415 | 3,53427512 |
| 17,1116189 | 3,22931564 | 1,83469405 |
| 17,6118222 | 3,74998605 | 2,63798705 |
| 18,1120272 | 4,00617776 | 3,74073706 |

| Data | Metadata Device | Metadata Time |
|------------|--------------------------|----------------------------------|
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| 1,09237962 | 0,00852470 | 0,03340045 |
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| 2,59331987 | 0,00895060 | 0,01296660 |
| 3,09363154 | 0,00071378 | 0,04594193 |
| 3,59394354 | 0,00877354 | 0,01990721 |
| 4,09425429 | 0,48460868 | 0,55105153 |
| 4,59456429 | 0,00445706 | 0,03167854 |
| 5,094874 | 0,01333044 | 0,04215694 |
| 5,595183 | 0,00881966 | 0,03578292 |
| 6,59579837 | 0,02071702 | 0,05351463 |
| 7,09610525 | 0,04604432 | 0,04196800 |
| 7,59641225 | 0,00860450 | 0,30574990 |
| 8,096718 | 0,03374410 | 0,24014045 |
| 9,10835058 | 3,57380511 | 3,40500001 |
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| 10,1087565 | 4,41455609 | 5,54777106 |
| 10,6089616 | 4,17788102 | 4,36831152 |
| 11,1091656 | 4,52073052 | 4,69831950 |
| 11,6093697 | 4,40688678 | 5,36952411 |
| 12,1095737 | 4,00325857 | 2,68035265 |
| 12,6097785 | 4,23982462 | 4,02472104 |
| 13,1099825 | 4,15141669 | 5,16357814 |
| 13,6101875 | 3,28816630 | 6,25534494 |
| 14,1103915 | 3,73372954 | 2,30272533 |
| 14,6105961 | 4,12277267 | 5,54330171 |
| 15,1108011 | 3,28800828 | 2,69240036 |
| 15,6110055 | 3,84814825 | 1,44569890 |
| 16,1112105 | 4,18388818 | 3,70898669 |
| 16,6114139 | 3,40536415 | 3,53427512 |
| 17,1116189 | 3,22931564 | 1,83469405 |
| 17,6118222 | 3,74998605 | 2,63798705 |
| 18,1120272 | 4,00617776 | 3,74073706 |

(measurement 3)

| Data | Metadata Device | Metadata Time |
|------------|--------------------------|----------------------------------|
| Time (s) | Angular velocity (rad/s) | Acceleration (m/s ²) |
| 1,09237962 | 0,00852470 | 0,03340045 |
| 1,59269262 | 0,00404970 | 0,03291948 |
| 2,09300787 | 0,01151063 | 0,08050255 |
| 2,59331987 | 0,00895060 | 0,01296660 |
| 3,09363154 | 0,00071378 | 0,04594193 |
| 3,59394354 | 0,00877354 | 0,01990721 |
| 4,09425429 | 0,48460868 | 0,55105153 |
| 4,59456429 | 0,00445706 | 0,03167854 |
| 5,094874 | 0,01333044 | 0,04215694 |
| 5,595183 | 0,00881966 | 0,03578292 |
| 6,59579837 | 0,02071702 | 0,05351463 |
| 7,09610525 | 0,04604432 | 0,04196800 |
| 7,59641225 | 0,00860450 | 0,30574990 |
| 8,096718 | 0,03374410 | 0,24014045 |
| 9,10835058 | 3,57380511 | 3,40500001 |
| 9,60855254 | 4,52404812 | 3,00802118 |
| 10,1087565 | 4,41455609 | 5,54777106 |
| 10,6089616 | 4,17788102 | 4,36831152 |
| 11,1091656 | 4,52073052 | 4,69831950 |
| 11,6093697 | 4,40688678 | 5,36952411 |
| 12,1095737 | 4,00325857 | 2,68035265 |
| 12,6097785 | 4,23982462 | 4,02472104 |
| 13,1099825 | 4,15141669 | 5,16357814 |
| 13,6101875 | 3,28816630 | 6,25534494 |
| 14,1103915 | 3,73372954 | 2,30272533 |
| 14,6105961 | 4,12277267 | 5,54330171 |
| 15,1108011 | 3,28800828 | 2,69240036 |
| 15,6110055 | 3,84814825 | 1,44569890 |
| 16,1112105 | 4,18388818 | 3,70898669 |
| 16,6114139 | 3,40536415 | 3,53427512 |
| 17,1116189 | 3,22931564 | 1,83469405 |
| 17,6118222 | 3,74998605 | 2,63798705 |
| 18,1120272 | 4,00617776 | 3,74073706 |

- measurements of the second part of the experiment:

(measurement 1)

| Data | Metadata Device | Metadata Time |
|------------|--------------------------|----------------------------------|
| Time (s) | Angular velocity (rad/s) | Acceleration (m/s ²) |
| 0,30590941 | 2,26085190 | 2,20122774 |
| 0,80613562 | 6,43582532 | 3,72700522 |
| 1,30636262 | 2,53706756 | 3,65252777 |
| 1,80659037 | 2,86843785 | 6,76632862 |
| 2,30681637 | 4,24620505 | 3,92000655 |
| 2,8070415 | 4,74052338 | 5,33896077 |
| 3,3072675 | 3,26368409 | 2,86438229 |
| 3,80749391 | 3,12768102 | 1,73581298 |
| 4,30771991 | 5,10630465 | 1,62829948 |
| 4,80794429 | 3,15123845 | 2,87182893 |
| 5,30816929 | 7,53982924 | 6,59312782 |
| 5,80839366 | 3,67978448 | 0,70334004 |
| 6,30861666 | 3,41691311 | 2,29750089 |
| 6,80883991 | 1,92589598 | 2,92264706 |
| 7,30906291 | 4,61958979 | 1,59082489 |
| 7,80928612 | 3,98698691 | 3,27203153 |
| 8,30951012 | 4,11928559 | 8,47749739 |
| 8,80973391 | 7,81476609 | 10,6370712 |
| 9,30995991 | 3,42114391 | 1,05713673 |

(measurement 2)

| Data | Metadata Device | Metadata Time |
|------------|--------------------------|----------------------------------|
| Time (s) | Angular velocity (rad/s) | Acceleration (m/s ²) |
| 0,30590941 | 2,26085190 | 2,20122774 |
| 0,80613562 | 6,43582532 | 3,72700522 |
| 1,30636262 | 2,53706756 | 3,65252777 |
| 1,80659037 | 2,86843785 | 6,76632862 |
| 2,30681637 | 4,24620505 | 3,92000655 |
| 2,8070415 | 4,74052338 | 5,33896077 |
| 3,3072675 | 3,26368409 | 2,86438229 |
| 3,80749391 | 3,12768102 | 1,73581298 |
| 4,30771991 | 5,10630465 | 1,62829948 |
| 4,80794429 | 3,15123845 | 2,87182893 |
| 5,30816929 | 7,53982924 | 6,59312782 |
| 5,80839366 | 3,67978448 | 0,70334004 |
| 6,30861666 | 3,41691311 | 2,29750089 |
| 6,80883991 | 1,92589598 | 2,92264706 |
| 7,30906291 | 4,61958979 | 1,59082489 |
| 7,80928612 | 3,98698691 | 3,27203153 |
| 8,30951012 | 4,11928559 | 8,47749739 |
| 8,80973391 | 7,81476609 | 10,6370712 |
| 9,30995991 | 3,42114391 | 1,05713673 |

(measurement 3)

| Data | Metadata Device | Metadata |
|------------|--------------------------|----------------------------------|
| Time (s) | Angular velocity (rad/s) | Acceleration (m/s ²) |
| 0,30590941 | 2,26085190 | 2,20122774 |
| 0,80613562 | 6,43582532 | 3,72700522 |
| 1,30636262 | 2,53706756 | 3,65252777 |
| 1,80659037 | 2,86843785 | 6,76632862 |
| 2,30681637 | 4,24620505 | 3,92000655 |
| 2,8070415 | 4,74052338 | 5,33896077 |
| 3,3072675 | 3,26368409 | 2,86438229 |
| 3,80749391 | 3,12768102 | 1,73581298 |
| 4,30771991 | 5,10630465 | 1,62829948 |
| 4,80794429 | 3,15123845 | 2,87182893 |
| 5,30816929 | 7,53982924 | 6,59312782 |
| 5,80839366 | 3,67978448 | 0,70334004 |
| 6,30861666 | 3,41691311 | 2,29750089 |
| 6,80883991 | 1,92589598 | 2,92264706 |
| 7,30906291 | 4,61958979 | 1,59082489 |
| 7,80928612 | 3,98698691 | 3,27203153 |
| 8,30951012 | 4,11928559 | 8,47749739 |
| 8,80973391 | 7,81476609 | 10,6370712 |
| 9,30995991 | 3,42114391 | 1,05713673 |

- measurement taken after changing the gears the second time;

(measurement 1)

(measurement 2)

| Data | Metadata Device | Metadata |
|------------|--------------------------|----------------------------------|
| Time (s) | Angular velocity (rad/s) | Acceleration (m/s ²) |
| 0,30590941 | 2,26085190 | 2,20122774 |
| 0,80613562 | 6,43582532 | 3,72700522 |
| 1,30636262 | 2,53706756 | 3,65252777 |
| 1,80659037 | 2,86843785 | 6,76632862 |
| 2,30681637 | 4,24620505 | 3,92000655 |
| 2,8070415 | 4,74052338 | 5,33896077 |
| 3,3072675 | 3,26368409 | 2,86438229 |
| 3,80749391 | 3,12768102 | 1,73581298 |
| 4,30771991 | 5,10630465 | 1,62829948 |
| 4,80794429 | 3,15123845 | 2,87182893 |
| 5,30816929 | 7,53982924 | 6,59312782 |
| 5,80839366 | 3,67978448 | 0,70334004 |
| 6,30861666 | 3,41691311 | 2,29750089 |
| 6,80883991 | 1,92589598 | 2,92264706 |
| 7,30906291 | 4,61958979 | 1,59082489 |
| 7,80928612 | 3,98698691 | 3,27203153 |
| 8,30951012 | 4,11928559 | 8,47749739 |
| 8,80973391 | 7,81476609 | 10,6370712 |
| 9,30995991 | 3,42114391 | 1,05713673 |

| Data | Metadata Device | Metadata |
|------------|--------------------------|----------------------------------|
| Time (s) | Angular velocity (rad/s) | Acceleration (m/s ²) |
| 0,30590941 | 2,26085190 | 2,20122774 |
| 0,80613562 | 6,43582532 | 3,72700522 |
| 1,30636262 | 2,53706756 | 3,65252777 |
| 1,80659037 | 2,86843785 | 6,76632862 |
| 2,30681637 | 4,24620505 | 3,92000655 |
| 2,8070415 | 4,74052338 | 5,33896077 |
| 3,3072675 | 3,26368409 | 2,86438229 |
| 3,80749391 | 3,12768102 | 1,73581298 |
| 4,30771991 | 5,10630465 | 1,62829948 |
| 4,80794429 | 3,15123845 | 2,87182893 |
| 5,30816929 | 7,53982924 | 6,59312782 |
| 5,80839366 | 3,67978448 | 0,70334004 |
| 6,30861666 | 3,41691311 | 2,29750089 |
| 6,80883991 | 1,92589598 | 2,92264706 |
| 7,30906291 | 4,61958979 | 1,59082489 |
| 7,80928612 | 3,98698691 | 3,27203153 |
| 8,30951012 | 4,11928559 | 8,47749739 |
| 8,80973391 | 7,81476609 | 10,6370712 |
| 9,30995991 | 3,42114391 | 1,05713673 |

(measurement 3)

| Data | Metadata Device | M |
|------------|-----------------|----------------------|
| Time (s) | Angular velot | Acceleration (m/s^2) |
| 0,30590941 | 2,26085190 | 2,20122774 |
| 0,80613562 | 6,43582532 | 3,72700522 |
| 1,30636262 | 2,53706756 | 3,65252777 |
| 1,80659037 | 2,86843785 | 6,76632862 |
| 2,30681637 | 4,24620505 | 3,92000655 |
| 2,8070415 | 4,74052338 | 5,33896077 |
| 3,3072675 | 3,26368409 | 2,86438229 |
| 3,80749391 | 3,12768102 | 1,73581298 |
| 4,30771991 | 5,10630465 | 1,62829948 |
| 4,80794429 | 3,15123845 | 2,87182893 |
| 5,30816929 | 7,53982924 | 6,59312782 |
| 5,80839366 | 3,67978448 | 0,70334004 |
| 6,30861666 | 3,41691311 | 2,29750089 |
| 6,80883991 | 1,92589598 | 2,92264706 |
| 7,30906291 | 4,61958979 | 1,59082489 |
| 7,80928612 | 3,98698691 | 3,27203153 |
| 8,30951012 | 4,11928559 | 8,47749739 |
| 8,80973391 | 7,81476609 | 10,6370712 |
| 9,30995991 | 3,42114391 | 1,05713673 |

- **DISCUSSION**

During the experiment we could see how, changing the gears of the bicycle, in all the measurements, the speed continued to increase.

Another thing that we noticed in doing the experiment is that, when we change the gears of the bicycle, in addition to increasing the speed also the angular velocity increases.

| | | | |
|--------------------------------------|---------------|---------------|---------------|
| first part of the experiment | measurement 1 | average: 0.06 | average: 2.16 |
| | measurement 2 | average: 2.56 | |
| | measurement 3 | average: 3.88 | |
| second part of the experiment | measurement 1 | average: 3.66 | average: 3.91 |
| | measurement 2 | average: 3.87 | |

| | | | |
|---|---------------|---------------|--------------|
| | measurement 3 | average: 4.22 | |
| last part (when we last changed the gears) | measurement 1 | average: 4.11 | average: 4.6 |
| | measurement 2 | average: 5.47 | |
| | measurement 3 | average: 4.22 | |

- **REFLECTION**

Conclusion: By doing the experiment we understood that by changing the gears of the bicycle (from the lightest to the toughest) the speed of the means of transport increases and, with it, also the angular speed.

Comparison of the results of the different countries