	TEAM: 4	
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Smartphone-accelerations into physics situations	Italy	Serena Budelacci Tommaso Senni
EXPERIMENT:		

1. ORIENTATION

We want to do an experiment in which one person holds his/her phone in her hands. Then, the person will have to spin around his axis with a straightened arm. We'll do 3 different angles and compare them to each other to find a relation between the size of the angle and the orbital speed. You can see a demonstration in the following link: https://www.youtube.com/watch?v=fs-7i_fgtgI

Research question:

How does the orbital speed of a smartphone change when the size of the angle between the side of the body and the arms changes?

1.1. **Hypothesis**

How larger the angle size is, how larger the orbital speed will be. The formula of the orbital speed is $v = 2\pi r/T$. So, consequently how bigger the angle size is, the bigger the radius is and the bigger the orbital speed will be.

2. PREPARATION

2.1. **Material**:

- A smartphone with the app Phyphox
- Human being
- A set square or a ruler

2.2. Method:

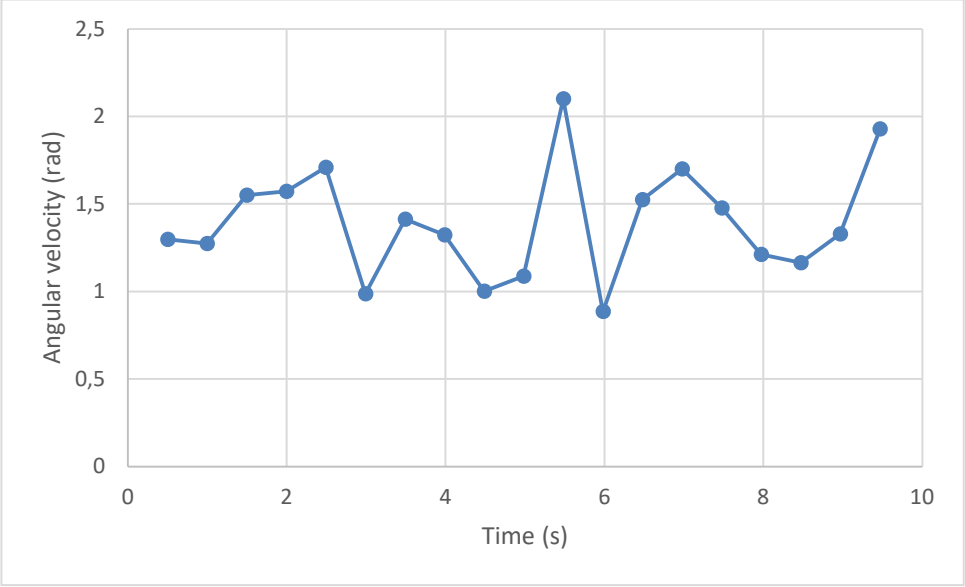
1. Open the app Phyphox on your mobile phone and choose the correct measuring instrument (= centrifugal acceleration). Press then on the three points in the right upper corner and press on timed measurement. Delayed start 5s and duration experiment 10s.
2. If you are ready to do the experiment, press on the start button and start spinning around in circles for 15s.
3. You have to do 3 different experiments, each with another angle. One experiment with an angle of 0° degrees, another one with an angle of 45° and a last one with an angle of 90°.
4. You have to hold your phone with a stretched arm. For the first measurement (angle of 0°), you hold your arm next to your body and you turn around until you have a good result in the app. Try to turn around at an equal speed the whole time. The experiment has to be done 3 times for each angle, because the experiment is more reliable when you have 3 similar measurements.
5. After this, you repeat the same with the angles of 45° and 90°. You have to make sure the angle stays the same, so your arm can't move upside or down during the experiment. Do the experiment until you have 3 good measurements.
6. Export the data (angular velocity and acceleration). With this data calculate the orbital speed and find the relation between the size of the angle and magnitude of the orbital speed.

3. DATA ANALYSIS and DISCUSSION

3.1. Observations and Measurements:

- Measurements 90°:

MEASUREMENT 1		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
0,500457375	1,298225946	2,415479397
0,998666083	1,272796714	1,504705617
1,496875083	1,549468261	0,851604182
1,99508475	1,571221962	3,529315269
2,49329375	1,708401212	2,774244115
2,99150275	0,986854739	0,568590014
3,48971075	1,411995347	2,084461293
3,987919	1,323810395	2,619003329
4,486127	1,00066632	0,661549761
4,984336375	1,087628973	0,896557762
5,482544375	2,099867236	2,292461753
5,980752458	0,885532104	1,031774928
6,478960458	1,525010595	1,424027193
6,977168208	1,700258976	1,736067329
7,475376208	1,475787306	0,926204955
7,973588083	1,210760855	0,8276514
8,471795083	1,163138168	1,859529604
8,97	1,32897254	0,971623009
9,468207	1,928019627	1,635813546



MEASUREMENT 2		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
0,500457375	1,298225946	2,415479397
0,998666083	1,272796714	1,504705617
1,496875083	1,549468261	0,851604182
1,99508475	1,571221962	3,529315269
2,49329375	1,708401212	2,774244115
2,99150275	0,986854739	0,568590014
3,48971075	1,411995347	2,084461293
3,987919	1,323810395	2,619003329
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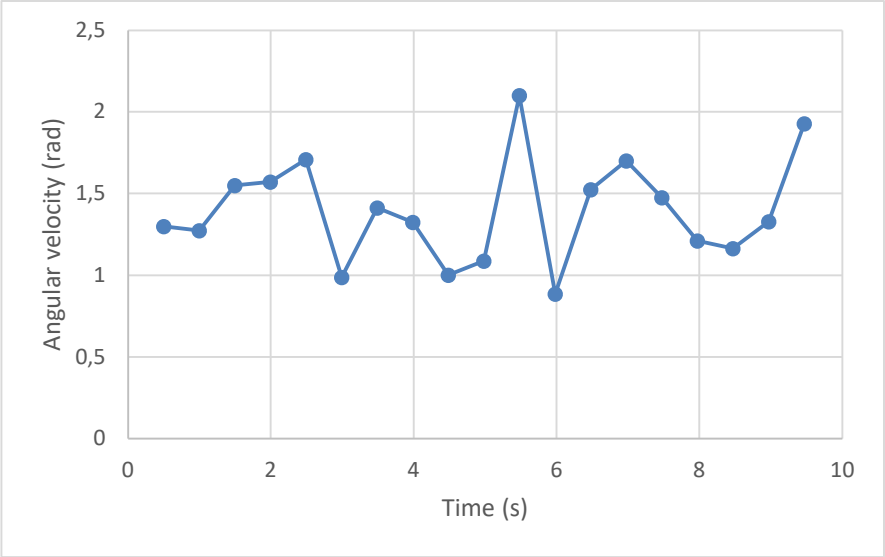
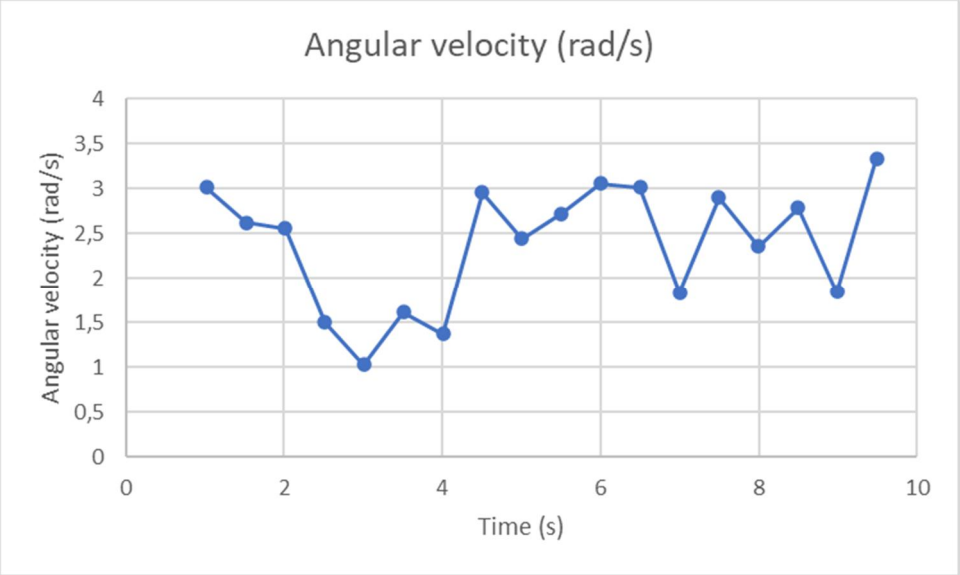
6,478960458	1,525010595	1,424027193
6,977168208	1,700258976	1,736067329
7,475376208	1,475787306	0,926204955
7,973588083	1,210760855	0,8276514
8,471795083	1,163138168	1,859529604
8,97	1,32897254	0,971623009
9,468207	1,928019627	1,635813546



Experiment

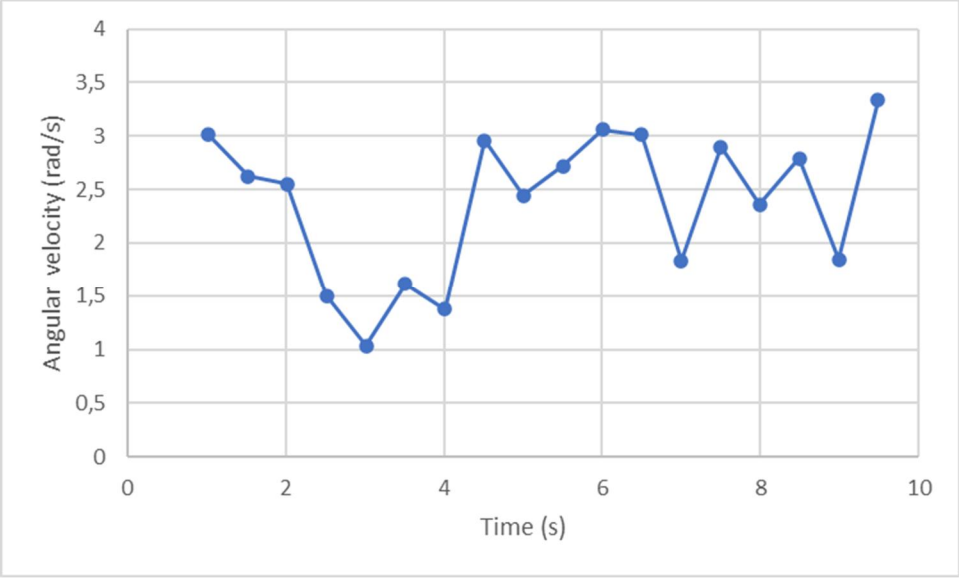
MEASUREMENT 3		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
0,500457375	1,298225946	2,415479397
0,998666083	1,272796714	1,504705617
1,496875083	1,549468261	0,851604182
1,99508475	1,571221962	3,529315269
2,49329375	1,708401212	2,774244115
2,99150275	0,986854739	0,568590014
3,48971075	1,411995347	2,084461293
3,987919	1,323810395	2,619003329
4,486127	1,00066632	0,661549761
4,984336375	1,087628973	0,896557762
5,482544375	2,099867236	2,292461753
5,980752458	0,885532104	1,031774928
6,478960458	1,525010595	1,424027193
6,977168208	1,700258976	1,736067329
7,475376208	1,475787306	0,926204955
7,973588083	1,210760855	0,8276514
8,471795083	1,163138168	1,859529604
8,97	1,32897254	0,971623009
9,468207	1,928019627	1,635813546



Experiment

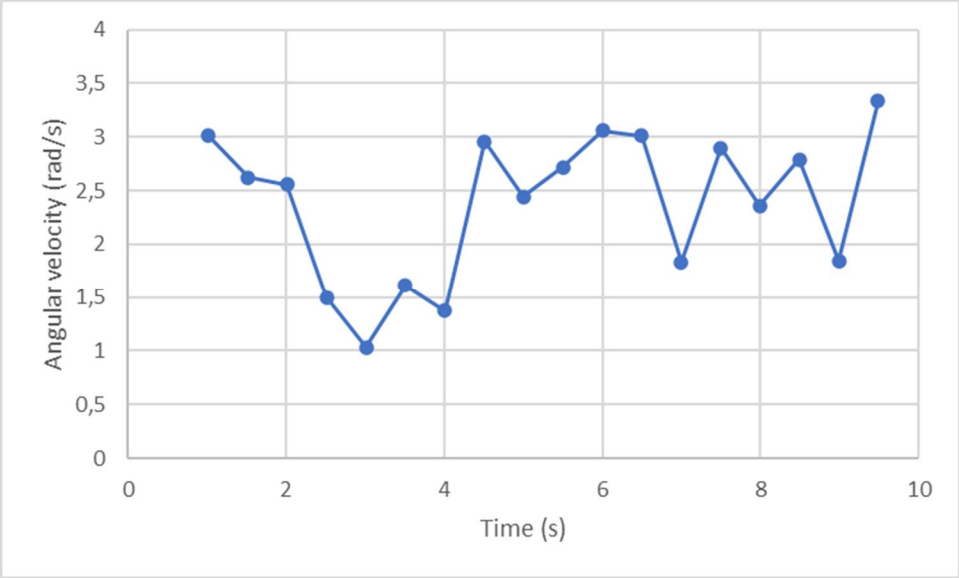
- Measurements 45°

MEASUREMENT 1		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
1,019474167	3,013368122	2,091872446
1,517672167	2,620757842	0,998279558
2,015874542	2,554395796	1,41143115
2,514073542	1,500472586	1,217336308
3,012271958	1,032545432	0,692116981
3,510471958	1,612229323	1,23350907
4,008667292	1,375423358	1,299824089
4,506868292	2,958201587	1,690006254
5,005069667	2,442609531	1,458105579
5,503270667	2,71901849	2,456960355
6,001470833	3,057102166	1,734532495
6,499672833	3,010247111	1,189501419
6,997874792	1,834663358	0,624079642
7,496076792	2,896926014	2,306157875
7,994282417	2,358438097	2,321685987
8,492485417	2,787889573	1,756418934
8,990684333	1,845915402	0,91287458
9,488887333	3,33608543	1,736264933



Experiment

MEASUREMENT 2		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
1,019474167	3,013368122	2,091872446
1,517672167	2,620757842	0,998279558
2,015874542	2,554395796	1,41143115
2,514073542	1,500472586	1,217336308
3,012271958	1,032545432	0,692116981
3,510471958	1,612229323	1,23350907
4,008667292	1,375423358	1,299824089
4,506868292	2,958201587	1,690006254
5,005069667	2,442609531	1,458105579
5,503270667	2,71901849	2,456960355
6,001470833	3,057102166	1,734532495
6,499672833	3,010247111	1,189501419
6,997874792	1,834663358	0,624079642
7,496076792	2,896926014	2,306157875
7,994282417	2,358438097	2,321685987
8,492485417	2,787889573	1,756418934
8,990684333	1,845915402	0,91287458
9,488887333	3,33608543	1,736264933



MEASUREMENT 3		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
0,500457375	1,298225946	2,415479397
0,998666083	1,272796714	1,504705617
1,496875083	1,549468261	0,851604182
1,99508475	1,571221962	3,529315269
2,49329375	1,708401212	2,774244115
2,99150275	0,986854739	0,568590014
3,48971075	1,411995347	2,084461293
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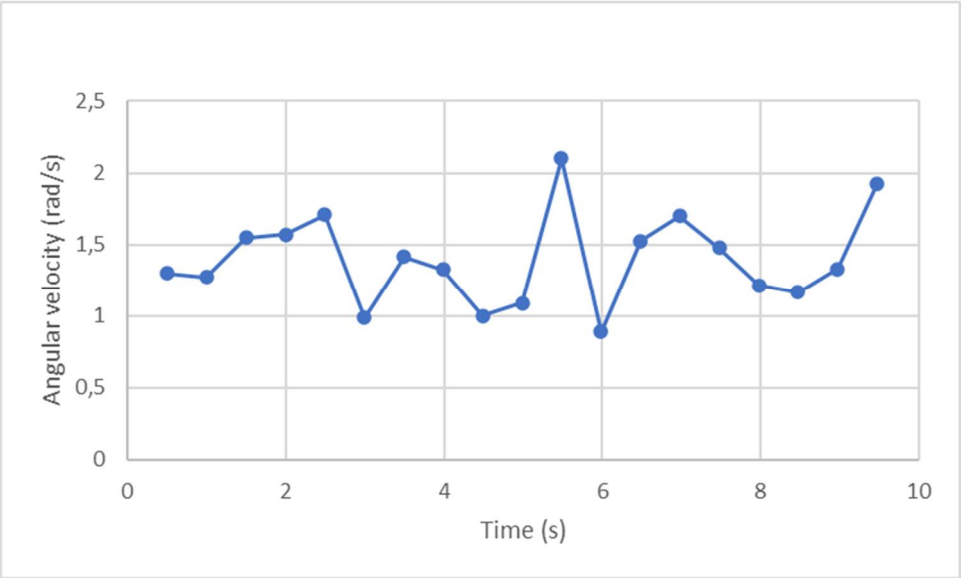
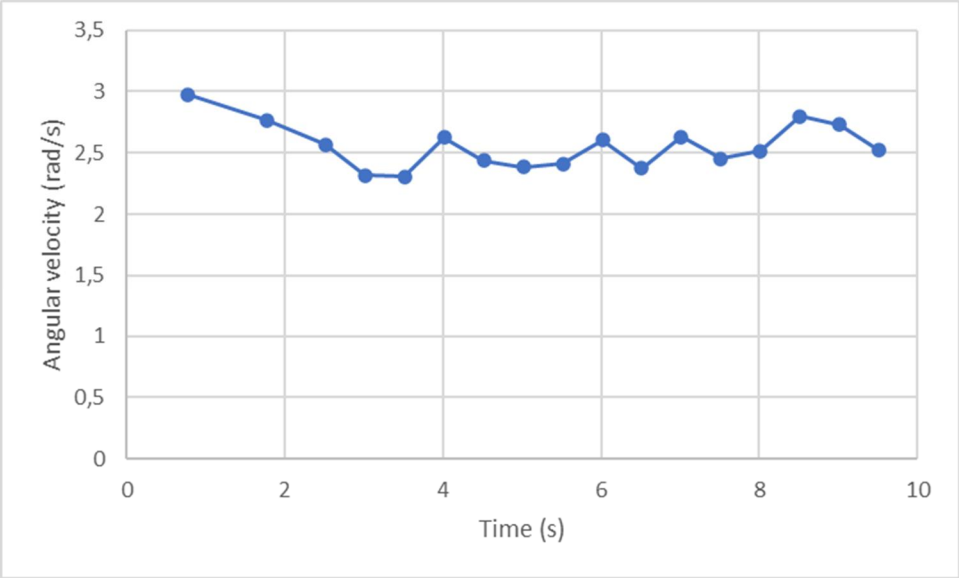
Experiment



Experiment

Measurement 0°:

MEASUREMENT 1		
Time (s)	**Angular velocity (rad/s)**	**Acceleration (m/s^2)**
0,763887602	2,977828614	0,576374811
1,763887602	2,766577203	0,932098246
2,513887602	2,566056998	0,722735028
3,013887602	2,317557867	0,29953723
3,513887602	2,307214339	0,589143858
4,013887602	2,624396016	1,302538652
4,513887602	2,438908123	0,976533738
5,013887602	2,383599688	0,562203811
5,513887602	2,41256516	0,29519772
6,013887602	2,606255541	0,817374423
6,513887602	2,372531145	0,947147528
7,013887602	2,629812233	1,152958404
7,513887602	2,451149669	0,666348284
8,013887602	2,5134889	0,536931717
8,513887602	2,796088955	1,151616411
9,013887602	2,728178567	1,173386998
9,513887602	2,521803813	1,422158884



Experiment

MEASUREMENT 2		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
1,019474167	3,013368122	2,091872446
1,517672167	2,620757842	0,998279558
2,015874542	2,554395796	1,41143115
2,514073542	1,500472586	1,217336308
3,012271958	1,032545432	0,692116981
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4,008667292	1,375423358	1,299824089
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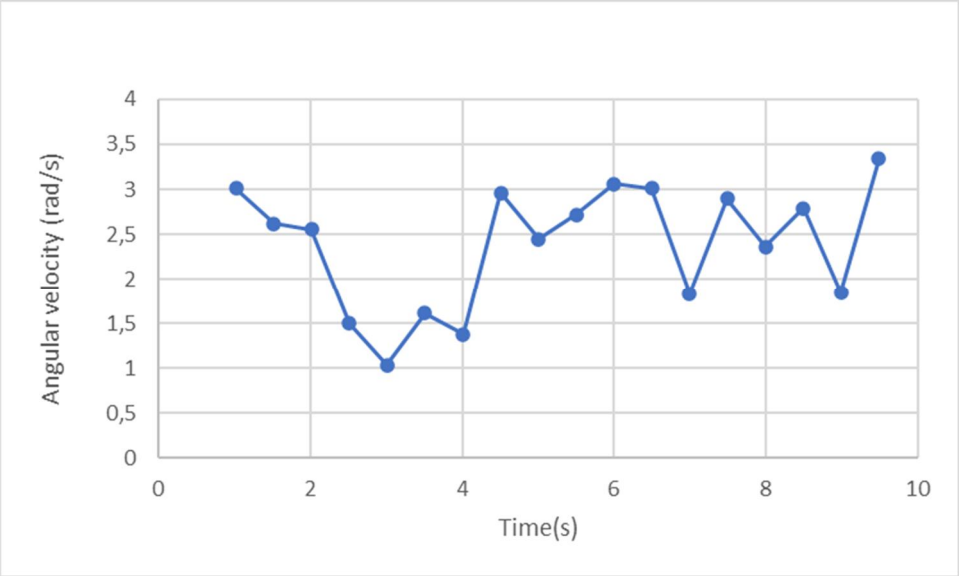
7,496076792	2,896926014	2,306157875
7,994282417	2,358438097	2,321685987
8,492485417	2,787889573	1,756418934
8,990684333	1,845915402	0,91287458
9,488887333	3,33608543	1,736264933



MEASUREMENT 3		
Time (s)	Angular velocity (rad/s)	Acceleration (m/s^2)
1,019474167	3,013368122	2,091872446
1,517672167	2,620757842	0,998279558
2,015874542	2,554395796	1,41143115
2,514073542	1,500472586	1,217336308
3,012271958	1,032545432	0,692116981
3,510471958	1,612229323	1,23350907
4,008667292	1,375423358	1,299824089
4,506868292	2,958201587	1,690006254
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6,001470833	3,057102166	1,734532495
6,499672833	3,010247111	1,189501419
6,997874792	1,834663358	0,624079642
7,496076792	2,896926014	2,306157875
7,994282417	2,358438097	2,321685987
8,492485417	2,787889573	1,756418934
8,990684333	1,845915402	0,91287458
9,488887333	3,33608543	1,736264933

Experiment

3.2. Discussion:

We can see that the angular velocity drops when we choose for a bigger angle.

Measurements 90°	Measurement 1	Average: 1,396	Average: 1,400
	Measurement 2	Average: 1,396	
	Measurement 3	Average: 1,409	
Measurements 45°	Measurement 1	Average: 2,386	Average: 2,056
	Measurement 2	Average: 2,386	
	Measurement 3	Average: 1,396	
Measurements 0°	Measurement 1	Average: 2,554	Average: 2,442
	Measurement 2	Average: 2,386	
	Measurement 3	Average: 2,386	

We see that the 3th measurement in the experiment of 45° has a completely different value (big difference). This happened because It's still a person who did the experiment, so Lise may have spinned around her axis faster or slower than the other 2 times.

Length of the arm:

90°	0,75 m
45°	0,67 m
0°	0,60 m

If we want to become the orbital speed, we have to multiply the angular velocity with the radius. That is the same as the length of the arm of the person who did the experiment. The formula is: v = w * r. So we get the following:

90°	1,050
45°	1,378
0°	1,465

If we want to calculate the orbital speed, we have to multiply the angular velocity with the radius. That is the same of the length of the arm of the person who did the experiment. The values per angle are close to each other. We did the experiment precise and accurate.

If the arms are close to the body, then the value of the radius is smaller. If we put this in the formula, the angular velocity will be smaller. If we spread our arms (90°), the value of radius will be bigger.

The graphics are very similar, but the values are for example closer together at the first measurement of 0° then measurement 2 of 0°.

4. REFLECTION

Conclusion:

If we lower the size of the angle, the angular velocity will become bigger.

1.1. Comparison of the results of the different countries

1.2. Reflection: The hypothesis does not match our conclusion. How smaller the angle (between the side of the body and hand), how larger the orbital speed. We have made a false hypothesis, because we didn't really know what the results would be.

2. REFERENCES

Experiment with your phone! OM! What happens to the Centripetal Acceleration?

Experiment