REPORT EXPERIMENT ETWINNING

EXPERIMENT:
We want to do an experiment in which we put a phone in a bucket attached to a rope, so we can search for a relation between the length of the rope and the centripetal force in a uniform circular motion. One person holds this rope in his hands and starts to turn in circles. That way we can calculate the centripetal force with the data of the app on the phone (in the bucket). We will try to keep the angular velocity constant and of course we will adjust the length of the rope during the experiment.

Research question:
What is the relation between the length of the rope (radius) and the centripetal force in a uniform circular motion?

Sub-question:
How does the centripetal acceleration change if you change the length of the rope?

HYPOTHESIS:
1. If you increase the length of the rope and keep the mass and angular velocity the same, the centripetal force will also increase.
2. If you increase the length of the rope and keep the angular velocity the same, the centripetal acceleration will decrease for the same reason above.

MATERIAL:
- ➢ Bucket
- ➢ Rope
- ➢ Smartphone
- ➢ Phyphox
- ➢ Tape
- ➢ Ruler
- ➢ Scale

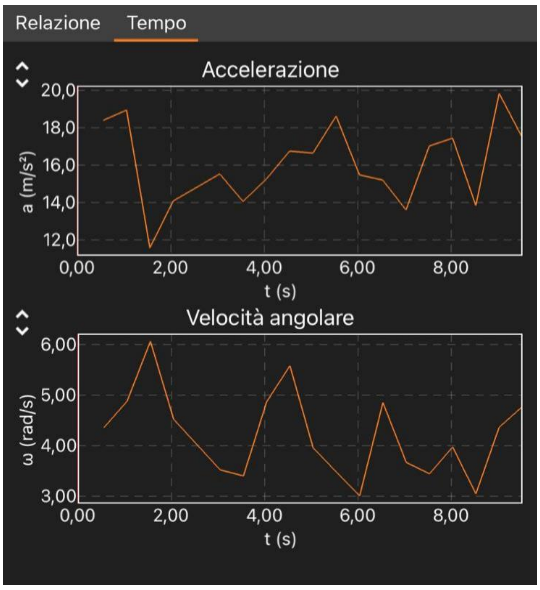
	Arianna	Angelica
length of the arm	0,50 m	0,70 m
mass of the bucket	0,481 kg	0,292 kg
mass of the phone	0,189 kg	0.204 kg
total mass	0,67 kg	0,496 kg
length of the rope 1	0,74 m	0,74 m

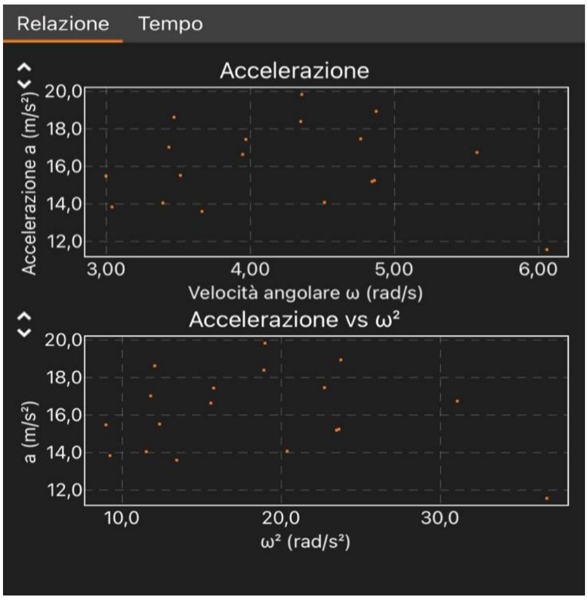
length of the rope 2	0,88 m	0,88 m
length of the rope 3	0,95 m	0,95 m
radius 1	1,24 m	1,44 m
radius 2	1,38 m	1,58 m
radius 3	1,45 m	1,65 m

METHOD:
We both did the experiment at home by following the steps. First of all, we put our smartphone in the bucket and made sure that it was well attached to it with tape and we also attached a rope to the bucket . Then, we started the Phyphox program on our phone, we went to centripetal acceleration and after doing a timed run we pressed on the start button, in order to start spinning around in circles for 15s. Lastly, we pressed again on the three points and exported the data to excel. We changed the length of the rope and repeated the experiment 3 times with every length, for a total of 9 times; clearly, we tried to turn each time with the same velocity.

OBSERVATIONS AND MEASUREMENTS:

Graphs of one of the three measurements with length of the rope 3 (0,95 m):





Data of one of the three measurements with length of the rope 1 (0,74 m):

	A	B	C	D	E	F	G
1	**Time (s)**	**Angular**	**Acceleration (m/s^2)**				
2	0,685299	4,014458	13,23885				
3	1,186866	3,990670	26,57150				
4	1,688433	3,426644	27,17838				
5	2,691567	3,888209	22,41446				
6	3,193134	3,730294	25,74901				
7	4,196268	4,309651	26,38416				
8	4,947835	3,725829	24,38530				
9	5,449402	3,872685	22,64455				
10	5,950969	4,102143	25,04445				
11	6,452536	3,782425	24,07597				
12	6,954103	3,917871	23,75045				
13	7,455670	4,296530	26,42025				
14	7,957236	3,805027	26,02398				
15	8,458803	4,090785	25,96516				
16	8,960370	4,306347	27,31198				
17	9,461937	3,721750	24,74828				
18							

Data of one of the three measurements with length of the rope 2 (0,88 m):

	A	B	C	D	E	F	G
1	**Time (s)**	**Angular**	**Acceleration (m/s^2)**				
2	0,703592	4,404046	25,48970				
3	1,203592	4,522852	47,09400				
4	1,703592	4,395724	36,11400				
5	2,203592	4,549409	32,56123				
6	2,703592	4,525695	38,52909				
7	3,203592	4,185266	32,33719				
8	3,703592	4,348180	32,91435				
9	4,203592	4,168708	35,16493				
10	4,703592	4,52579	35,10544				
11	5,203592	4,604374	36,40599				
12	5,703592	4,408460	35,03711				
13	6,203592	4,185068	32,04917				
14	6,703592	4,213869	32,99744				
15	7,203592	4,226602	33,73873				
16	7,703592	4,253213	31,63816				
17	8,203592	4,169685	30,60364				
18	8,703592	4,099609	31,29944				
19	9,203592	4,234275	31,22049				
20							

Data of one of the three measurements with length of the rope 3 (0,95 m):

	A	B	C	D	E	F	G
1	**Time (s)**	**Angular**	**Acceleration (m/s^2)**				
2	0,702379	4,656660	26,90656				
3	1,202379	4,531317	46,43986				
4	1,702379	4,689868	40,37641				
5	2,202379	4,243953	33,88033				
6	2,702379	4,626930	41,19423				
7	3,202379	4,425833	35,75478				
8	3,702379	4,255880	33,63610				
9	4,202379	4,697484	39,98259				
10	4,702379	4,604242	35,74042				
11	5,202379	4,427221	36,46820				
12	5,702379	4,486972	38,77940				
13	6,202379	4,430107	35,41685				
14	6,702379	4,287014	36,53464				
15	7,202379	4,373132	36,19730				
16	7,702379	4,640503	36,91766				
17	8,202379	4,467267	37,49049				
18	8,702379	4,538009	37,45580				
19	9,202379	4,398486	36,26052				
20							

$F_c = m \cdot \omega^2 \cdot r$ → centripetal force formula

	Centripetal force with length of the rope 1	Centripetal force with length of the rope 2	Centripetal force with length of the rope 3
Arianna	13,16	16,15	20,20
Angelica	15,09	18,21	22,87

$a_c = v^2/r$ - $a_c = \omega^2 \cdot r$ → centripetal acceleration formulas

	Centripetal acceleration average with length of the rope 1	Centripetal acceleration average with length of the rope 2	Centripetal acceleration average with length of the rope 3
Arianna	25,60 m/s²	31,47 m/s²	38,83 m/s²
Angelica	22,92 m/s²	26,74 m/s²	31,86 m/s²

DISCUSSION:

Although the second hypothesis said that if the length of the rope increases, the centripetal acceleration will decrease, we have noticed that increasing the length of the rope, and consequently also the length of the radius, increase both centripetal force and centripetal acceleration.

The results that we have obtained are similar, there is some difference in the average of the centripetal acceleration, since probably one of us has turned faster, while the main cause of the slightly different results in the centripetal force is the difference in the total mass and in the length of the rays, in fact one of us has the longest arm of the other. In addition, as we said before, one of us probably has turned faster, therefore the angular velocity is not exactly the same. In general, the measurements may not be perfect also because of the app that we used: actually it measures with a time gap, so sometimes there are extremes.

CONCLUSION AND REFLECTION:

In conclusion, we can note that our first hypothesis was correct, because the relation between the length of the rope (part of the radius) and the centripetal force in a uniform circular motion is that if you increase the length of the rope and keep the mass and angular velocity constant, the centripetal force will also increase. In this regard, we want to clarify that we did our best to keep the angular velocity constant, but between the various values there are small differences. When it comes to the second hypothesis instead, it's clearly wrong, in fact we see that if you increase the length of the rope (part of the radius) and keep the angular velocity constant, the centripetal acceleration will also increase. At the beginning we thought that if you increase the length of the rope and keep the angular velocity constant, the centripetal acceleration will decrease because of the formula $a_c = v^2 / r$: the centripetal acceleration and the radius are inversely proportional, so if you increase the radius, the centripetal acceleration will decrease and the other way round. However, in this case we're talking about angular velocity and not tangential: that's why we have to consider the following centripetal acceleration formula $a_c = \omega^2 \cdot r$.

REFERENCES:

To do this experiment, which has been invented by our Belgium teammates, we followed the protocol steps that they uploaded to the eTwinning site. With reference instead to the calculations we have made to find the centripetal force and the average of the centripetal acceleration, we used the data tables exported in excel from Phyphox and the measurements we have made before. Lastly, the centripetal force formula was already in the protocol, whereas we checked for the centripetal acceleration formulas on the internet.