

# A249: Laser Gyroscope

April 3, 2022

In here we will present the tasks that we have to complete before conducting the lab.

## 1 Getting Started with Gyroscopes

We downloaded the phyphox app made by RWTH Aachen University, and we played around with the Gyroscope function. We rotated the phone in several directions to observe the relationship between the orientation of the phone and the corresponding coordinates used in the application. This is shown in Fig. 1. Fig. 2 - 4 show the corresponding time series for the  $x, y, z$  coordinates for each rotation that we performed.

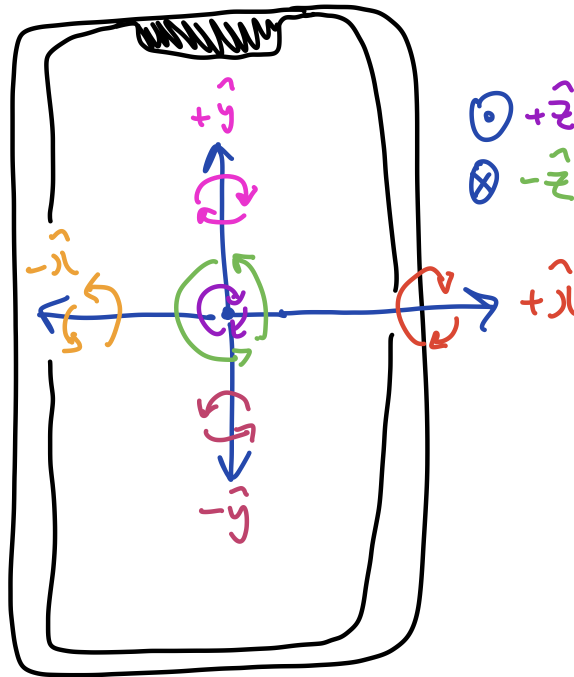


Figure 1: Sketch of the phone used to measure the gyroscope with its relevant  $x, y, z$  coordinates and sense of rotation. The sense of rotation is color coded with each rotation axis, and the direction of the axis is indicated by the blue arrows.

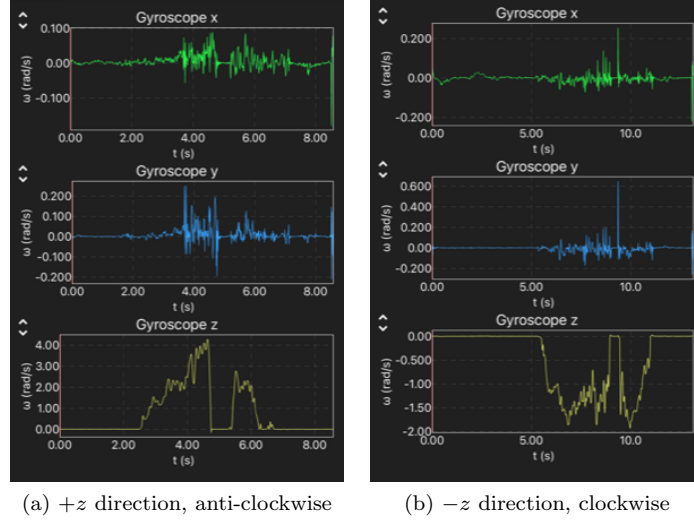


Figure 2: The time series of the  $x, y, z$  coordinates shown from the **phyphox** application when the phone was rotated parallel to the surface. This corresponds to rotations in the  $z$ -direction. Note the large amplitudes in the time series, which indicates rotations in the relevant axis.

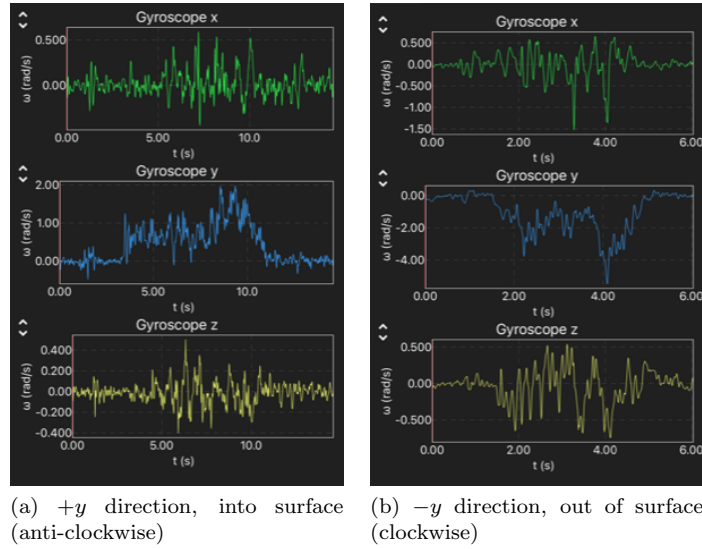


Figure 3: Same as Fig. 2 but for rotations into / out of the surface, corresponding to rotations in  $y$ -direction.

To save the rotation rates and import it into the computer for further analysis, the **Export Data** feature can be utilized. This will save the data as a **.zip** file that contains the raw data, the software and specifics regarding the device used, and the system time in which the experiment was started and finished. All such files are saved as **.csv** formats. An example for the raw data is shown in the Appendix section.

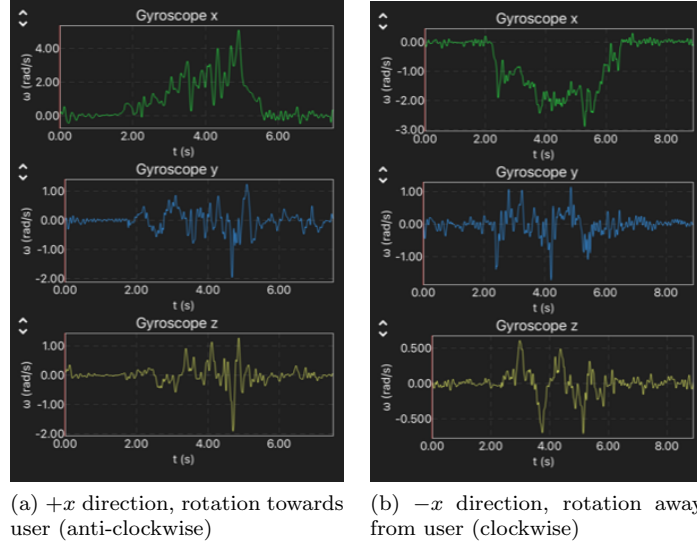


Figure 4: Same as Fig. 2 but for rotations towards / away the user, corresponding to rotations in  $x$ -direction.

To obtain a faster rotation rate, we applied maximal torque on each end of the phone such that the rotation at each axis was maximal. This was done at an adequate height to ensure the rotation rate was properly measured. Several cushions were placed on top of a bed to ensure that the phone does not break. Fig. 5 show the time series of the  $x, y, z$  coordinates in the  $+y$  and  $-z$  directions. Performing the measurement in such a way yields a more notable and stable measurement of the rotation rate

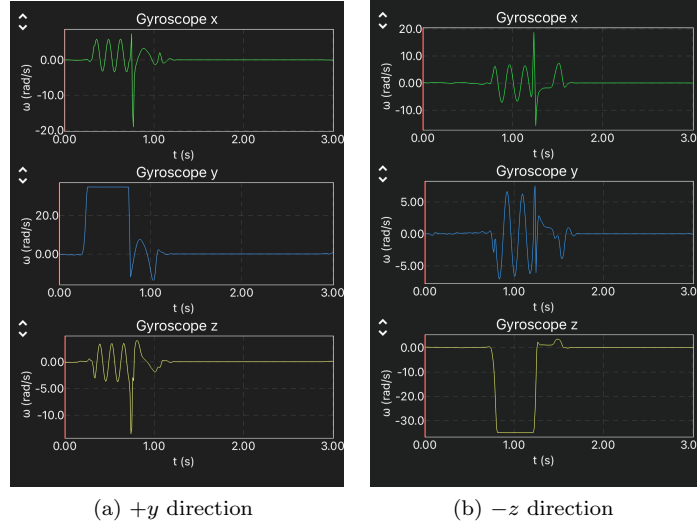


Figure 5: Same as Fig. 2 but for fast rotations in the (a)  $+y$  and (b)  $-z$  direction.

## 2 Appendix

Below the raw data imported from the `phyphox` application for fast rotations in the  $+y$  direction (corresponding to the time series in [5a](#)) is shown.

Time (s)	Gyroscope x(rad/s)	Gyroscope y(rad/s)	Gyroscope z(rad/s)	Absolute(rad/s)
6.767499995E-3	-1.010426786E-2	-2.324782610E-1	-8.401471376E-2	2.473998993E-1
1.681750000E-2	-4.476520233E-3	-2.514493167E-1	-1.048773974E-1	2.724813142E-1
2.686650000E-2	-5.002761260E-3	-2.558797300E-1	-1.042318493E-1	2.763399035E-1
3.691650000E-2	-1.232061721E-2	-2.315417826E-1	-1.004440412E-1	2.526903245E-1
4.696550000E-2	-1.514143683E-2	-2.187458277E-1	-9.285589308E-2	2.381201737E-1
5.701449999E-2	-3.160101548E-2	-2.359628826E-1	-9.338636696E-2	2.557305607E-1
6.706450000E-2	-4.849477857E-2	-2.816651165E-1	-1.120228991E-1	3.069790080E-1
7.711350000E-2	-4.799867794E-2	-3.520550728E-1	-1.132196411E-1	3.729146477E-1
8.716250000E-2	-4.955183342E-2	-4.466729164E-1	-1.066344455E-1	4.618906618E-1
9.721250000E-2	-7.474593818E-2	-4.910189509E-1	-1.147160977E-1	5.097512614E-1
1.072615000E-1	-1.012153625E-1	-4.642693698E-1	-1.109495908E-1	4.879553351E-1
1.173105000E-1	-1.143684387E-1	-4.120182097E-1	-8.564193547E-2	4.360890804E-1
1.273605000E-1	-1.186878234E-1	-3.871080875E-1	-7.599277049E-2	4.119640422E-1
1.374095000E-1	-1.142060608E-1	-3.996090293E-1	-7.642972469E-2	4.225776892E-1
1.474595000E-1	-1.142915487E-1	-4.720688462E-1	-4.730672389E-2	4.880056145E-1
1.575085000E-1	-1.201705858E-1	-5.596361160E-1	6.058456376E-3	5.724248920E-1
1.675575000E-1	-9.741094708E-2	-5.834802389E-1	6.109268218E-2	5.947019402E-1
1.776075000E-1	-8.800595254E-2	-4.699653685E-1	1.133963764E-1	4.913972257E-1
1.876565000E-1	-7.030151784E-2	-2.996791303E-1	1.166337207E-1	3.291706387E-1
1.977055000E-1	-5.914305523E-2	-2.122400105E-1	7.882495224E-2	2.340023422E-1
2.077555000E-1	-3.155750036E-2	-2.722881734E-1	5.201544613E-2	2.790023868E-1
2.178045000E-1	9.016429074E-3	-4.376586080E-1	3.718788177E-2	4.393282277E-1
2.278545000E-1	4.824479297E-2	-5.677084327E-1	3.008522838E-2	5.705484603E-1
2.379035000E-1	7.523760945E-2	-4.890623689E-1	3.054252826E-2	4.957575461E-1
2.479525000E-1	8.370779455E-2	2.174204681E-3	8.641111851E-2	1.203270686E-1
2.580025000E-1	9.438323975E-2	1.216244459E0	2.356295884E-1	1.242449228E0
2.680515000E-1	-7.097269595E-2	3.820101738E0	5.026485324E-1	3.853682649E0
2.781005000E-1	-5.254991651E-1	9.453613281E0	5.492578149E-1	9.484125558E0
2.881505000E-1	-5.141525269E-1	1.864735222E1	2.359068245E-1	1.865593068E1
2.981995000E-1	-9.473021328E-2	2.966942215E1	2.527566552E-1	2.967064998E1
3.082495000E-1	3.024823964E-1	3.467776489E1	-1.060227957E-2	3.467908571E1
3.182985000E-1	1.728109956E0	3.469539261E1	-9.836845398E-1	3.475232751E1
3.283475000E-1	3.912374735E0	3.468914032E1	-2.733624220E0	3.501593685E1
3.383975000E-1	3.959633589E0	3.468838882E1	-3.113049507E0	3.505216248E1
3.484465000E-1	5.372694969E0	3.469185638E1	-1.891298771E0	3.515633317E1
3.584955000E-1	5.937077522E0	3.469684601E1	-2.589103580E-1	3.520208867E1
3.685455000E-1	5.467035294E0	3.470188904E1	1.397370219E0	3.515767656E1
3.785945000E-1	4.081363678E0	3.470701599E1	2.698941231E0	3.505023213E1
3.886435000E-1	2.078161001E0	3.470975113E1	3.367098570E0	3.493455208E1
3.986935000E-1	-9.281348437E-2	3.470960617E1	3.245755911E0	3.486115756E1
4.087425000E-1	-1.940731168E0	3.470664597E1	2.367740393E0	3.484141080E1

4.187925000E-1	-3.065381289E0	3.470300293E1	9.394860268E-1	3.485079065E1
4.288415000E-1	-3.225343704E0	3.469737625E1	-7.240287662E-1	3.485448290E1
4.388905000E-1	-2.388404608E0	3.469202423E1	-2.256279945E0	3.484726418E1
4.489405000E-1	-7.486303449E-1	3.468806076E1	-3.330857515E0	3.485565404E1
4.589895000E-1	1.350484371E0	3.468660736E1	-3.704498053E0	3.490999633E1
4.690385000E-1	3.438069582E0	3.468748093E1	-3.296389103E0	3.501296669E1
4.790885000E-1	5.068341732E0	3.469080734E1	-2.197571754E0	3.512790235E1
4.891375000E-1	5.890420437E0	3.469539642E1	-6.455185413E-1	3.519778800E1
4.991883333E-1	5.728639126E0	3.470049667E1	1.029703498E0	3.518525352E1
5.092373333E-1	4.570291042E0	3.470565414E1	2.467080355E0	3.509211415E1
5.192863333E-1	2.690009356E0	3.470869446E1	3.335690498E0	3.497222401E1
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6.901263333E-1	-3.351980448E0	3.470206833E1	5.879026651E-1	3.486853809E1
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7.102243333E-1	-2.299769163E0	3.469059372E1	-2.601125479E0	3.486390805E1
7.202743333E-1	-5.198692679E-1	3.468753433E1	-3.587562084E0	3.487643766E1
7.303233333E-1	-2.503413558E-1	3.468051529E1	-5.854587078E0	3.517210544E1
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7.604713333E-1	-1.443788052E1	3.469276428E1	-2.943640232E0	3.769224463E1
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7.805703333E-1	-5.491428375E0	-1.201170254E1	1.969563007E0	1.335349999E1
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8.006693333E-1	-1.389210820E0	-6.708069324E0	3.925371170E0	7.895355571E0
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8.308173333E-1	1.083305597E0	1.071845055E0	3.313244581E0	3.646915477E0
8.408663333E-1	1.711766005E0	3.252794027E0	2.617074728E0	4.512193698E0
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8.710143333E-1	3.135825157E0	7.282157421E0	8.494066596E-1	7.974001994E0

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9.212613333E-1	2.564073801E0	5.402130604E0	-8.722321130E-3	5.979763005E0
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1.051903333E0	7.952358723E-1	-9.861535072E0	-9.631808996E-1	9.940321500E0
1.061952333E0	2.042278051E0	-4.529119968E0	-1.129982948E0	5.095163274E0
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1.132298333E0	-5.704004765E-1	7.663825154E-1	2.259402573E-1	9.817066076E-1
1.142347333E0	-3.243055642E-1	5.705752373E-1	2.114297450E-1	6.895163068E-1
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1.172495333E0	3.215813041E-1	-2.829181254E-1	-9.373442829E-2	4.384556350E-1
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1.192594333E0	2.693289816E-1	-2.234597355E-1	-9.706206620E-2	3.631713073E-1
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1.212693333E0	9.171537124E-3	3.590933979E-2	1.934759552E-3	3.711254601E-2
1.222742333E0	-7.754447311E-2	9.806238115E-2	1.755588688E-2	1.262441487E-1
1.232792333E0	-6.290747225E-2	8.656844497E-2	1.573188789E-2	1.081616292E-1
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1.252890333E0	8.254743181E-3	-4.386002570E-2	-2.397355158E-3	4.469440627E-2
1.262940333E0	1.322495658E-2	-5.961582810E-2	-2.167008119E-3	6.110353803E-2
1.272989333E0	5.140664987E-3	-3.947508521E-3	6.082720356E-4	6.509935092E-3
1.283038333E0	-1.169895520E-3	3.957801312E-2	2.282892587E-3	3.966105617E-2
1.293088333E0	-4.547582474E-3	3.285486251E-2	1.618966460E-3	3.320758271E-2
1.303137333E0	-1.544627245E-3	-9.064143524E-5	-1.957566943E-3	2.495226950E-3
1.313187333E0	-3.233071417E-3	-1.565016061E-2	-7.357088034E-4	1.599754810E-2
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1.343335333E0	1.423688256E-3	5.111299455E-3	-4.451746936E-4	5.324514145E-3
1.353384333E0	4.026927985E-3	-5.228956230E-3	-6.744728307E-4	6.634232876E-3
1.363433333E0	-3.350605839E-4	-2.339757979E-3	-1.817867626E-3	2.981840992E-3
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1.383532333E0	8.454063209E-4	2.936933655E-3	3.313302994E-3	4.507578937E-3
1.393582333E0	-3.188750008E-3	1.317465678E-3	-9.038128192E-4	3.566611843E-3
1.403631333E0	7.810481475E-4	2.771242522E-3	-9.454243700E-4	3.030453524E-3
1.413680333E0	4.105738364E-3	3.550483845E-3	-2.425076673E-3	5.945083676E-3
1.423730333E0	2.326878952E-3	-1.629599370E-3	7.504364476E-6	2.840777372E-3
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