Some Feasible Lecture Notes

1. HRT434 Uzay Jeodezisi, https://orhankurt.jimdofree.com/undergraduate/spring-bahar/hrt434-space-geodesy/
2. HRT414 GNSS Gözlemlerinin Değerlendirilmesi, https://orhankurt.jimdofree.com/undergraduate/spring-bahar/hrt414-processing-of-gnss-observations/
3. HRT305 Temel Koordinat Sistemleri, https://orhankurt.jimdofree.com/undergraduate/autumn-g%C3%BCz/hrt305-fundamental-coordinate-systems/
4. HRT409 Dengelemede Özel Konular, https://orhankurt.jimdofree.com/undergraduate/autumn-g%C3%BCz/hrt409-advanced-topics-in-adjustment/
5. JJM513 Jeodezik Verilerin İrdelenmesi, https://orhankurt.jimdofree.com/graduate/autumn/jjm513-estimation-of-geodetic-quantities-and-hypothesis-testing-in-linear-models/
6. MUH201 Sayısal Çözümleme, https://orhankurt.jimdofree.com/undergraduate/autumn-g%C3%BCz/muh201-numerical-analysis/
7. GIP119 Teknolojinin Bilimsel İlkeleri, https://orhankurt.jimdofree.com/vocational/autumn-g%C3%Bcz/gip119-scientific-principles-of-technology/

Some Feasible GNU Compilers and Software

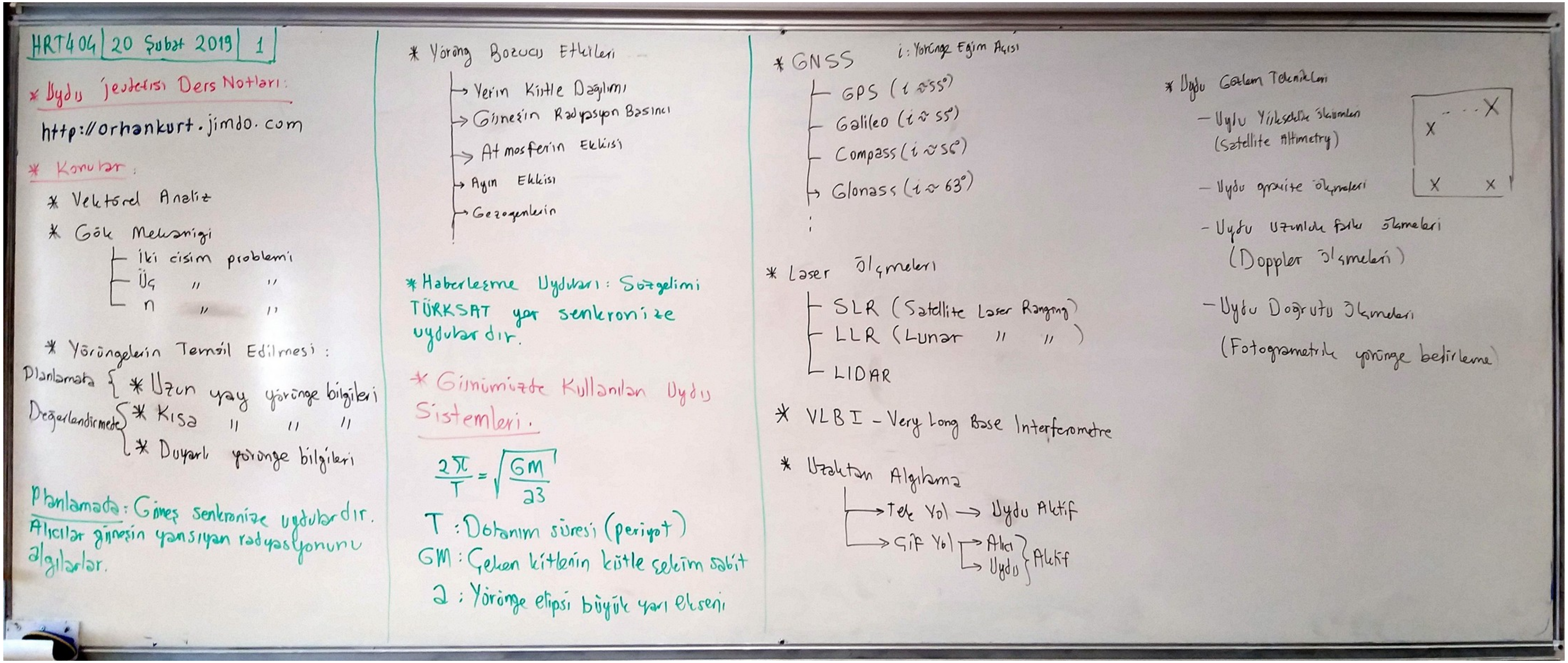
8. Code::Blocks, The free C/C++ and FORTRAN IDE, https://www.codeblocks.org/
9. The Julia Programming Language (compile to the codes via LLVM), https://julialang.org/
10. Python Programming Language, https://www.python.org/
11. GNU Octave, Scientific Programming Language, https://www.gnu.org/software/octave/index
12. GNU Plot, a portable command-line driven graphing utility, http://www.gnuplot.info/
13. LibreOffice, a free and powerful office suite, https://www.libreoffice.org/
14. QGIS, a free and open sources GIS, https://www.qgis.org/en/site/
15. Falcon, a web browser, https://www.falkon.org/
16. FileZilla, a free FTP solution, https://filezilla-project.org/

Some Feasible Tubes for Space Geodesy

17. NASA (National Aeronautics and Space Administration), ***Space Flight: The Application of Orbital Mechanics***, 21 Sep 2011, https://www.youtube.com/watch?v=Am7EwmxBAW8.
18. Christopher Scott VAUGHEN (2020), ***Orbital Inclination, Launch Azimuth and Latitude***, SpaceX Demo 2 – May 2020, https://www.youtube.com/watch?v=ot5YmhhPSsQ.
19. Arvin ASH (2020), ***Rocket Science explained in 15 minutes! And How do Satellites work?***, 10 Oct 2020, https://www.youtube.com/watch?v=hZ5mobRcXAU.
20. ***Geostationary, Molniya, Tundra, Polar & Sun Synchronous Orbits Explained***, 10 January 2019, https://www.youtube.com/watch?v=PZAkiXNJIqc

01. HAFTA - 1

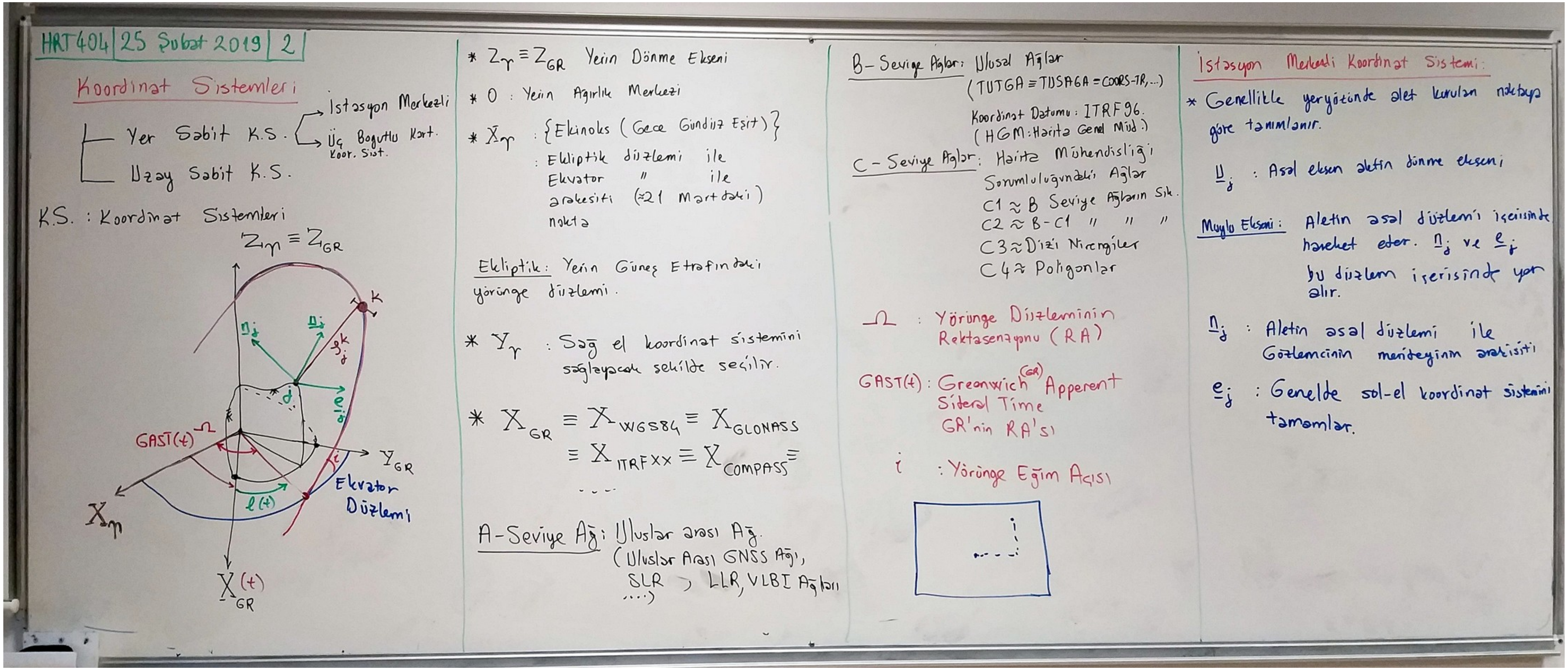
Subjects in Space Geodesy



02. HAFTA - 1a

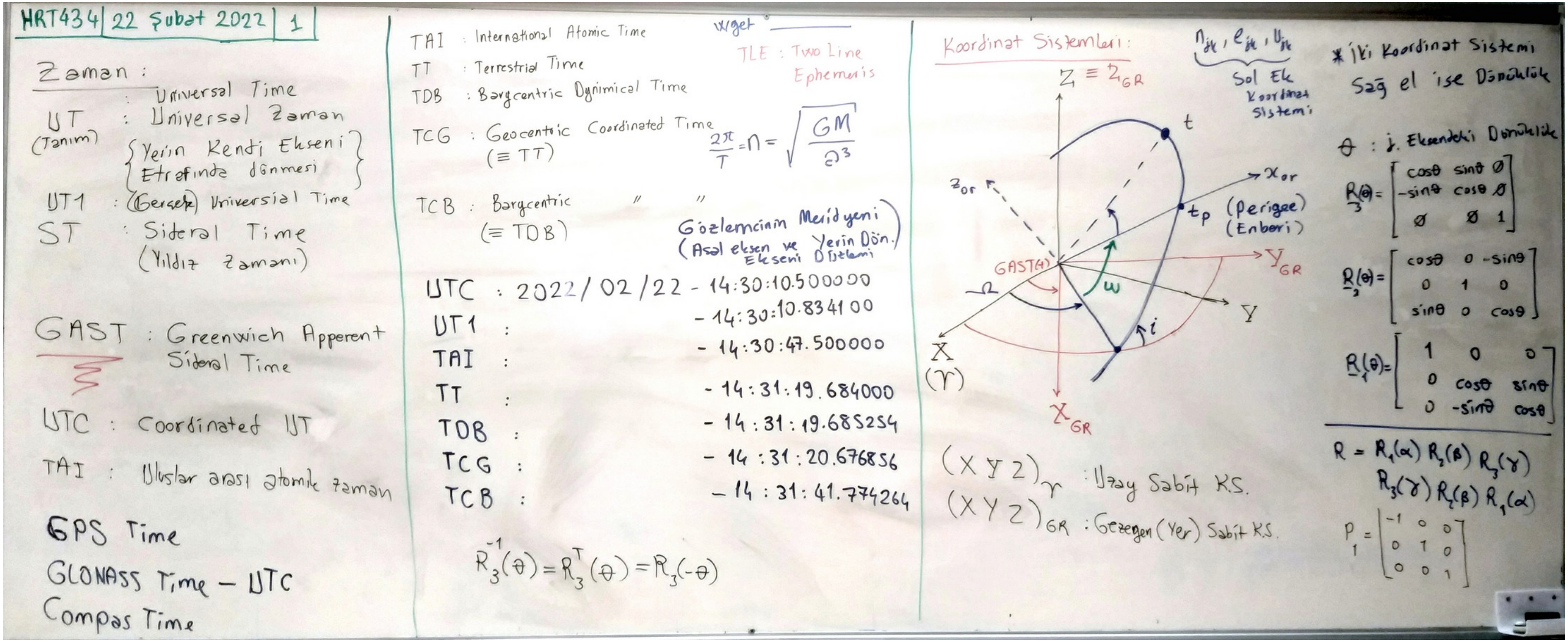
Space and Earth Fixed Coordinate Systems

https://orhankurt.jimdofree.com/undergraduate/autumn-g%C3%BCz/hrt305-fundamental-coordinate-systems/

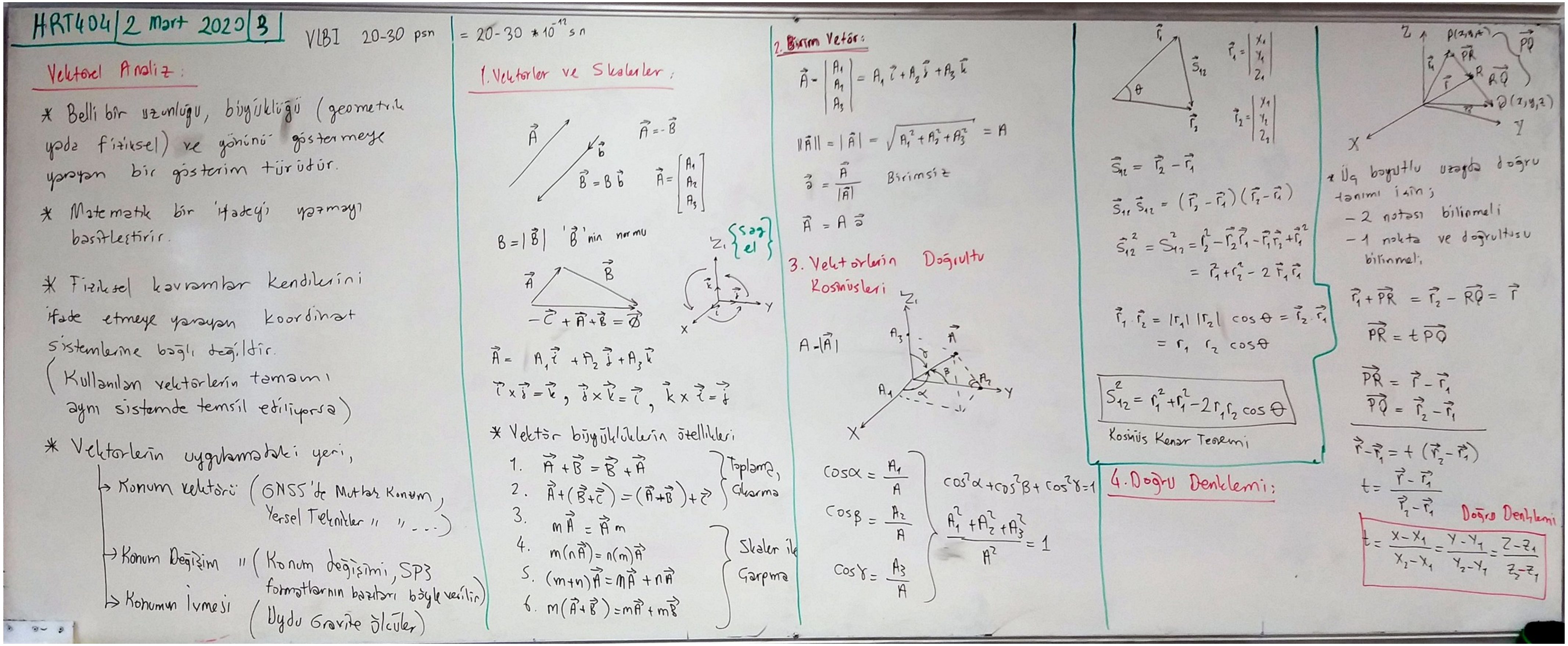


02. HAFTA - 1c

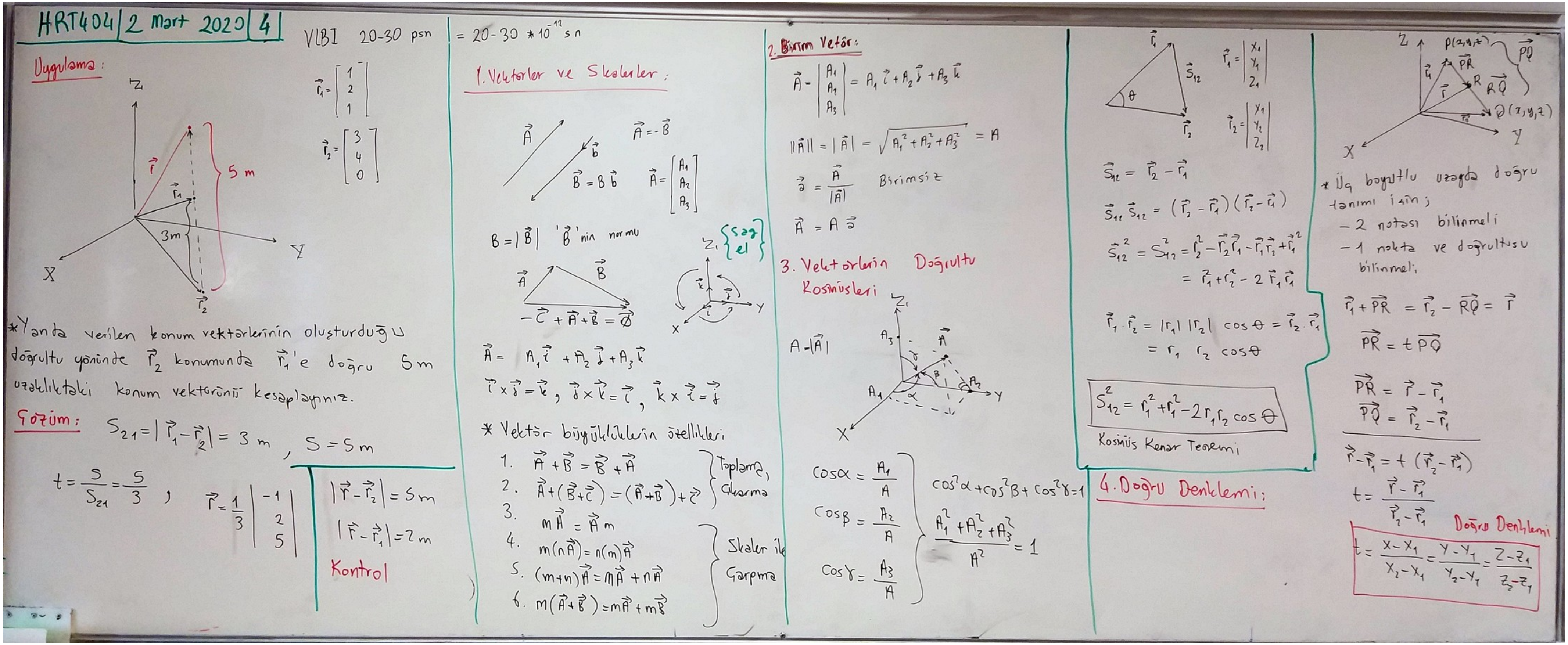
Space and Earth Fixed Coordinate Systems
https://orhankurt.jimdofree.com/undergraduate/autumn-g%C3%BCz/hrt305-fundamental-coordinate-systems/



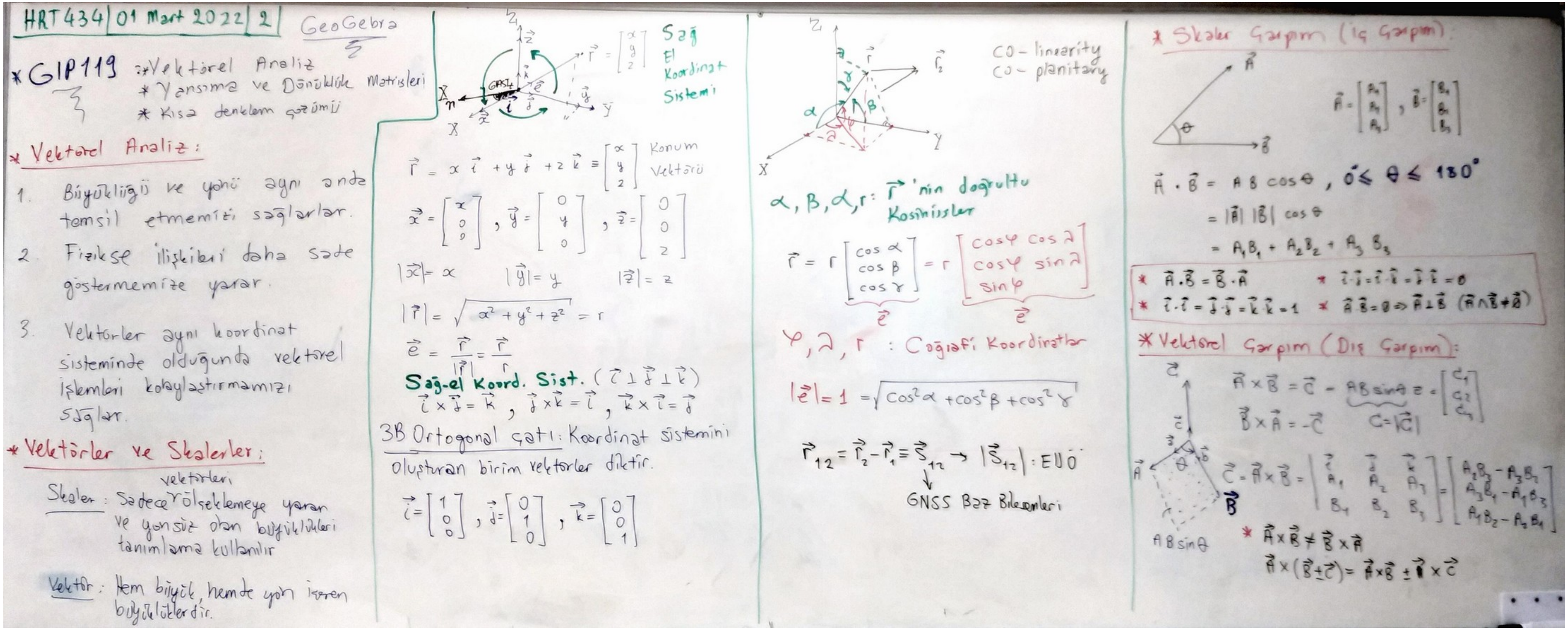
03. HAFTA - 1a
Vectorial Analysis



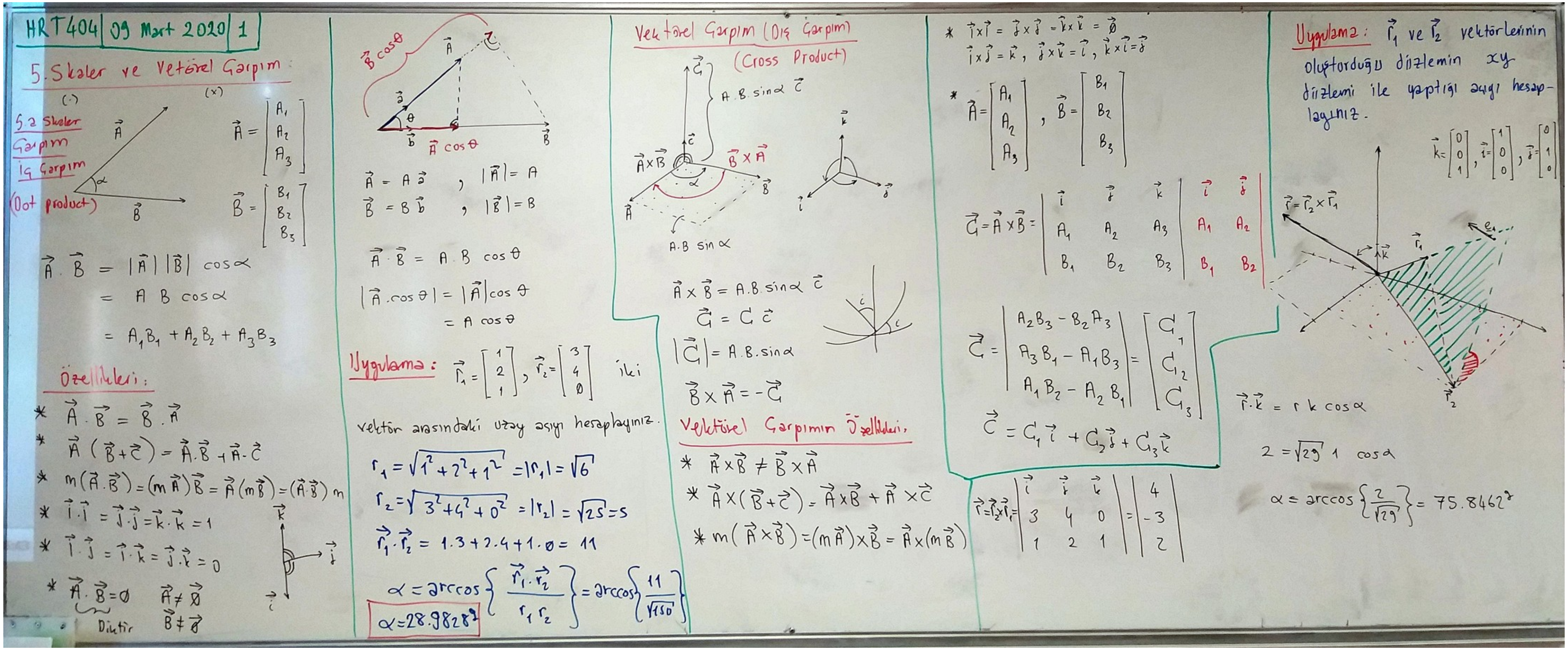
03. HAFTA - 1b
Vectorial Analysis



03. HAFTA - 1c
Vectorial Analysis

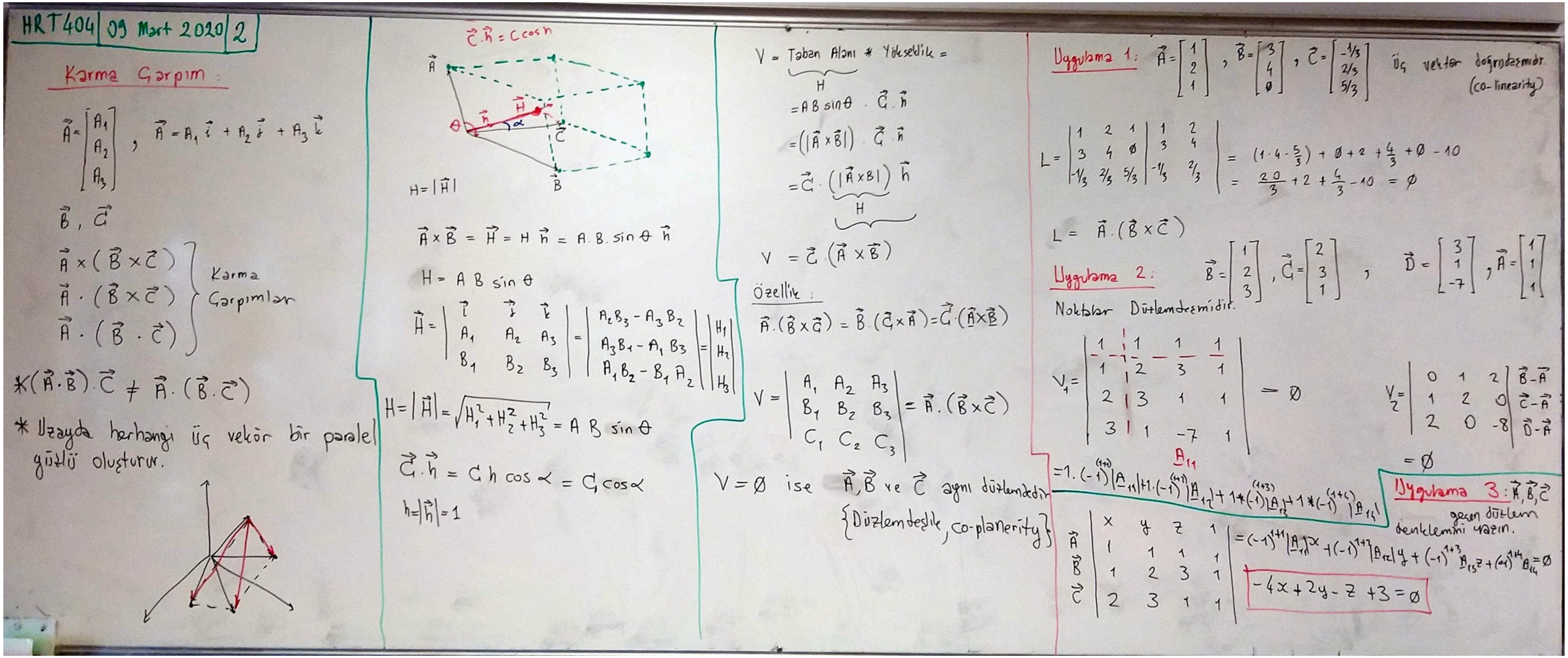


03. HAFTA - 2
Vectorial Analysis



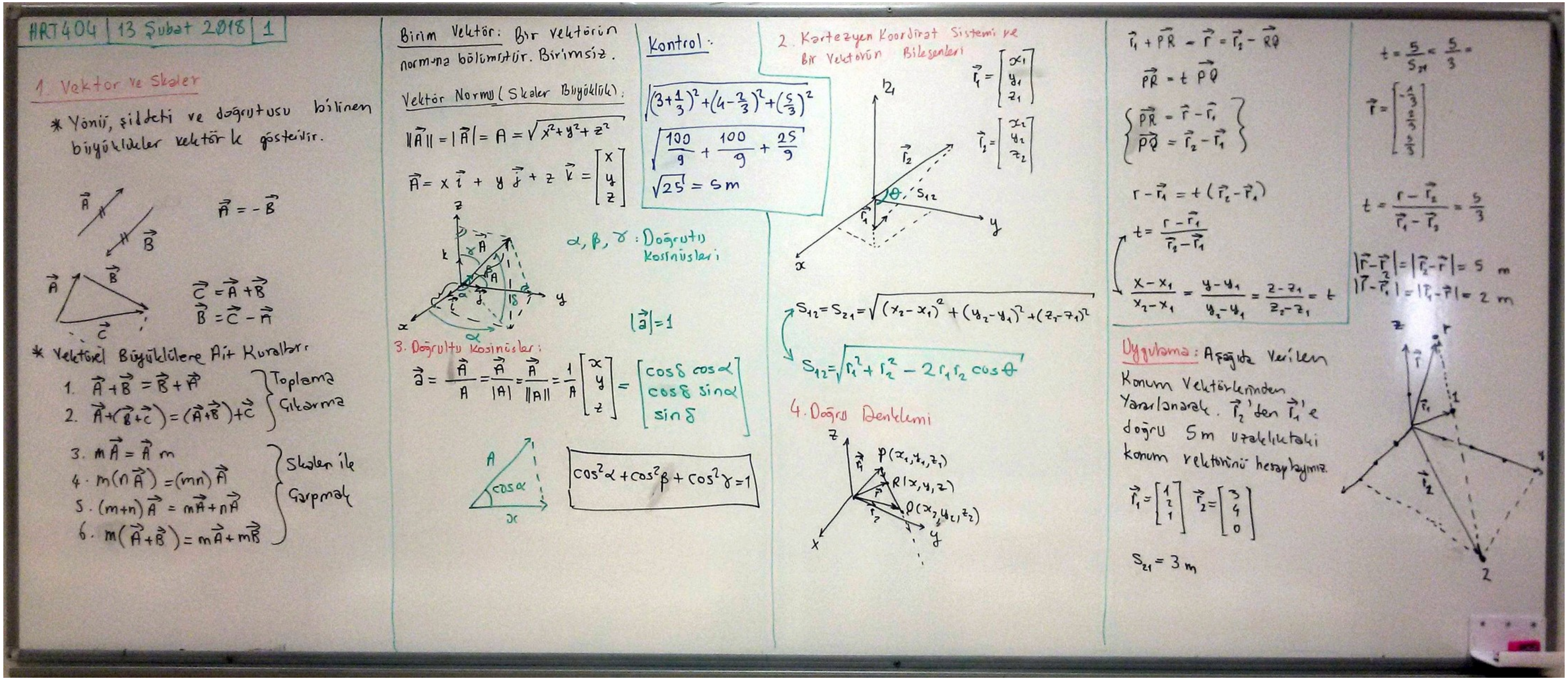
03. HAFTA – 3

Vectorial Analysis



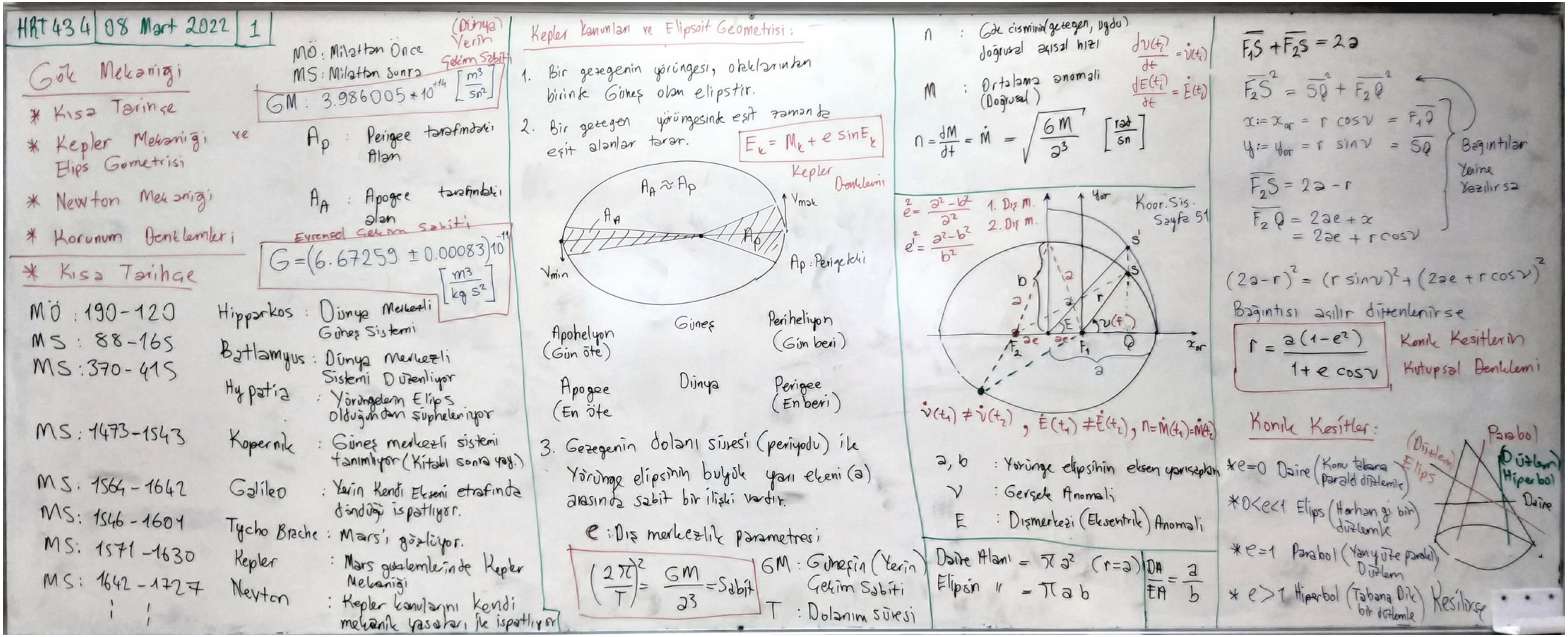
03. HAFTA – 4

Vectorial Analysis



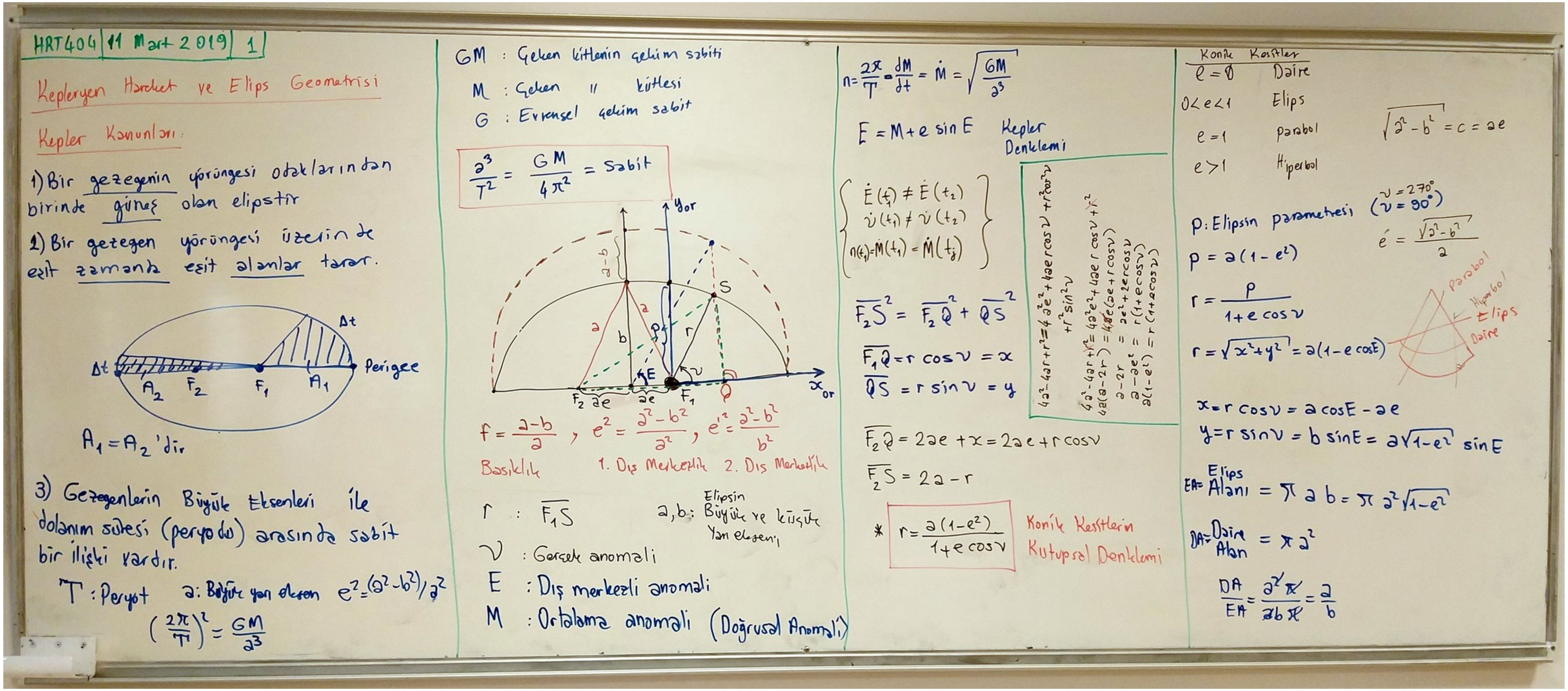
04. HAFTA - 1a

Keplerian Motion and Geometry of Ellipse



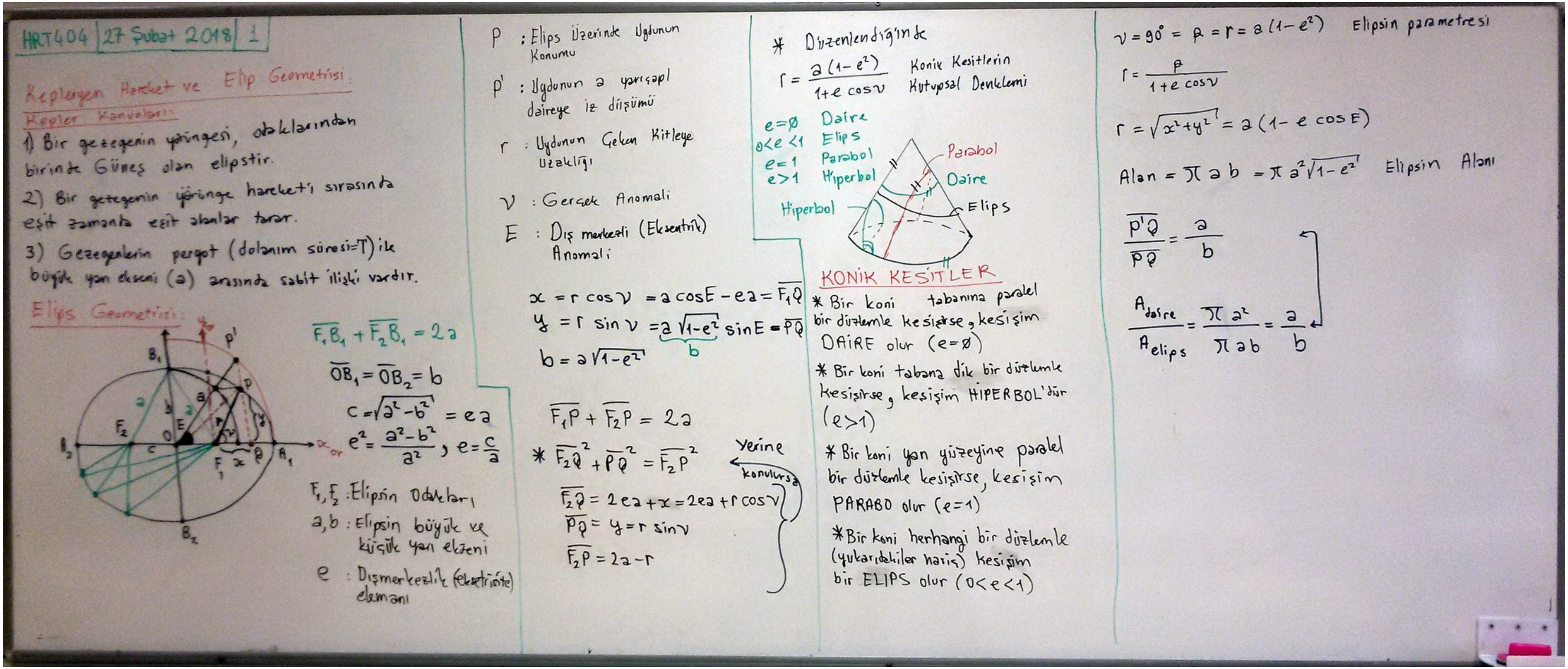
04. HAFTA - 1b

Keplerian Motion and Geometry of Ellipse



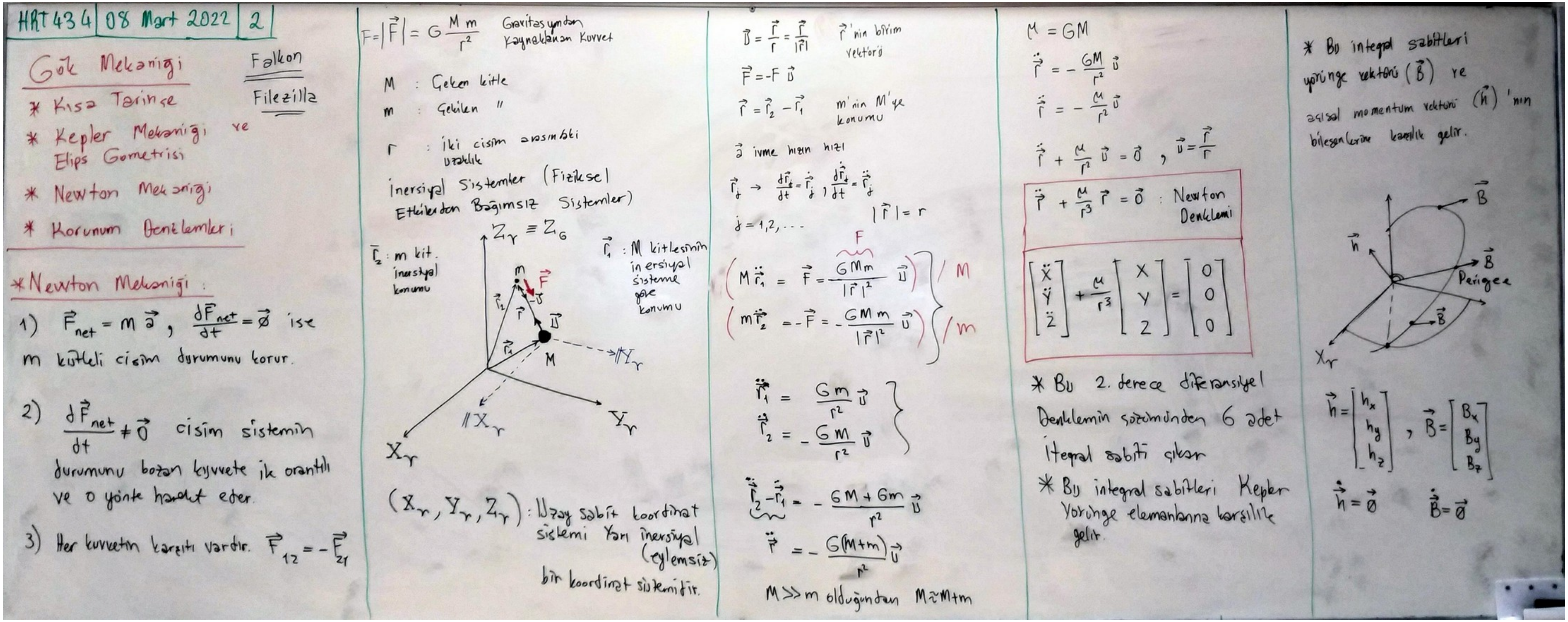
04. HAFTA - 1c

Keplerian Motion and Geometry of Ellipse



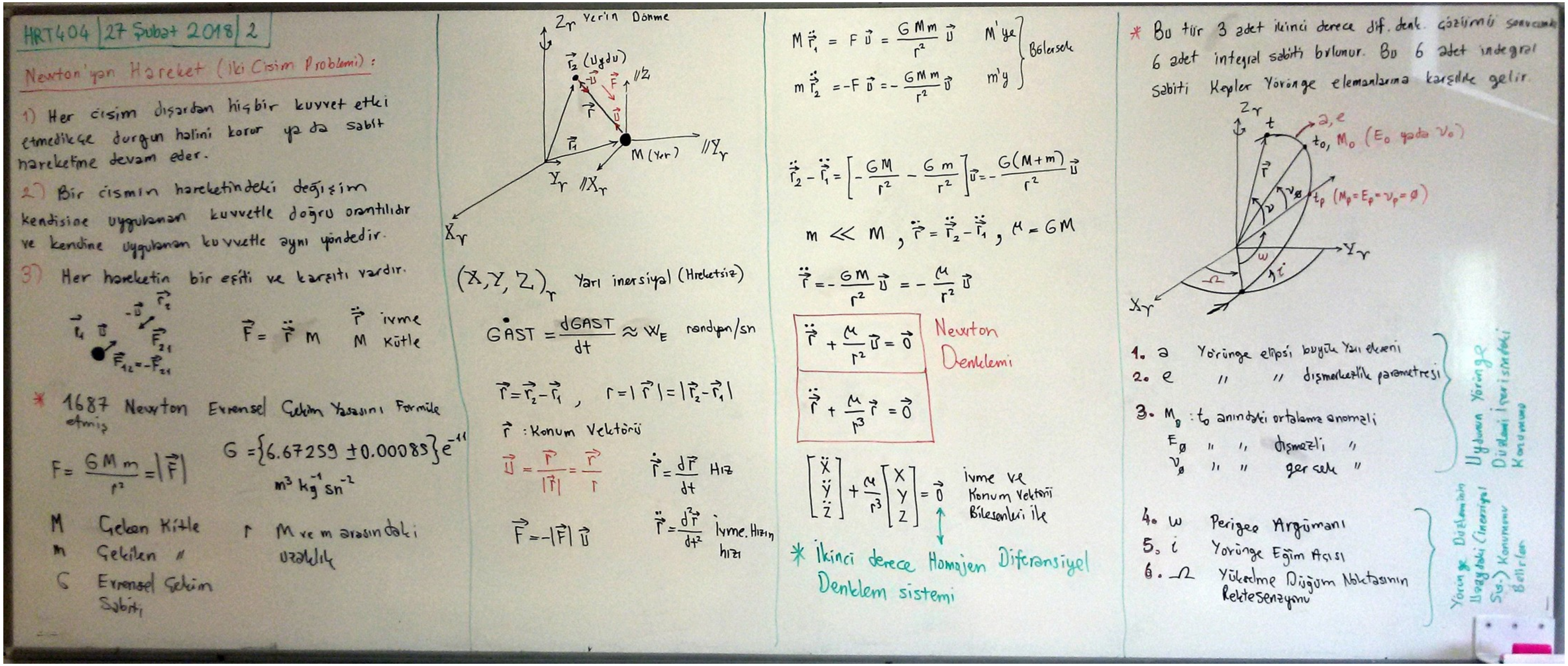
04. HAFTA - 2a

Celestial Mechanics
Newtonian Motion (two-body problem)



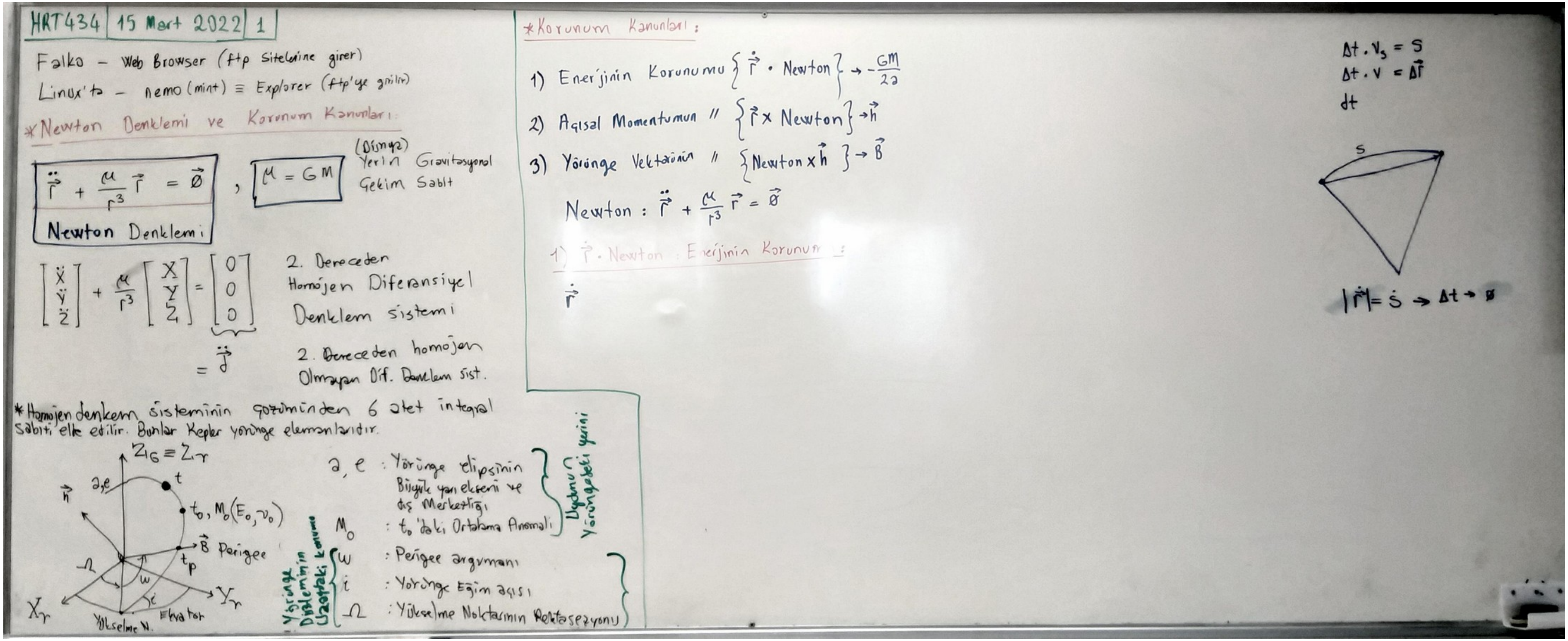
04. HAFTA - 2b

Celestial Mechanics
Newtonian Motion (two-body problem)



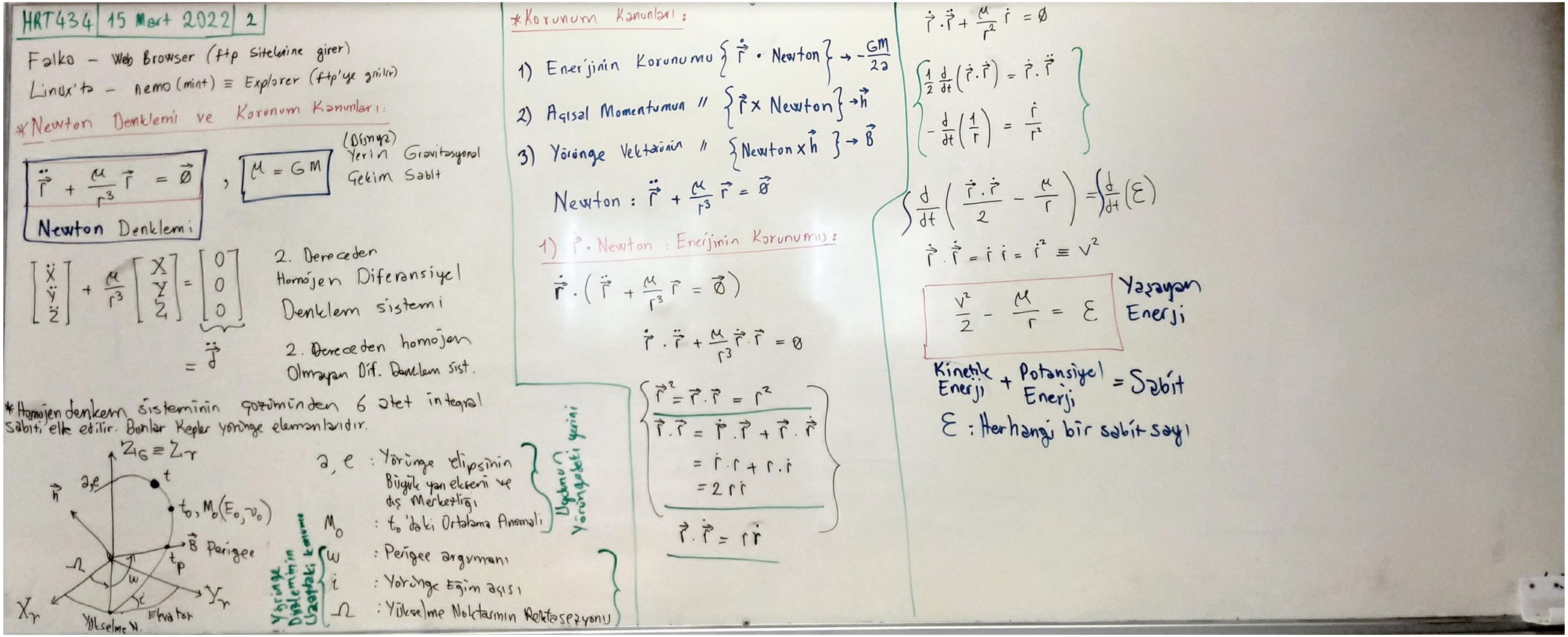
05. HAFTA - 1a

Celestial Mechanics
Newtonian Motion (two-body problem)



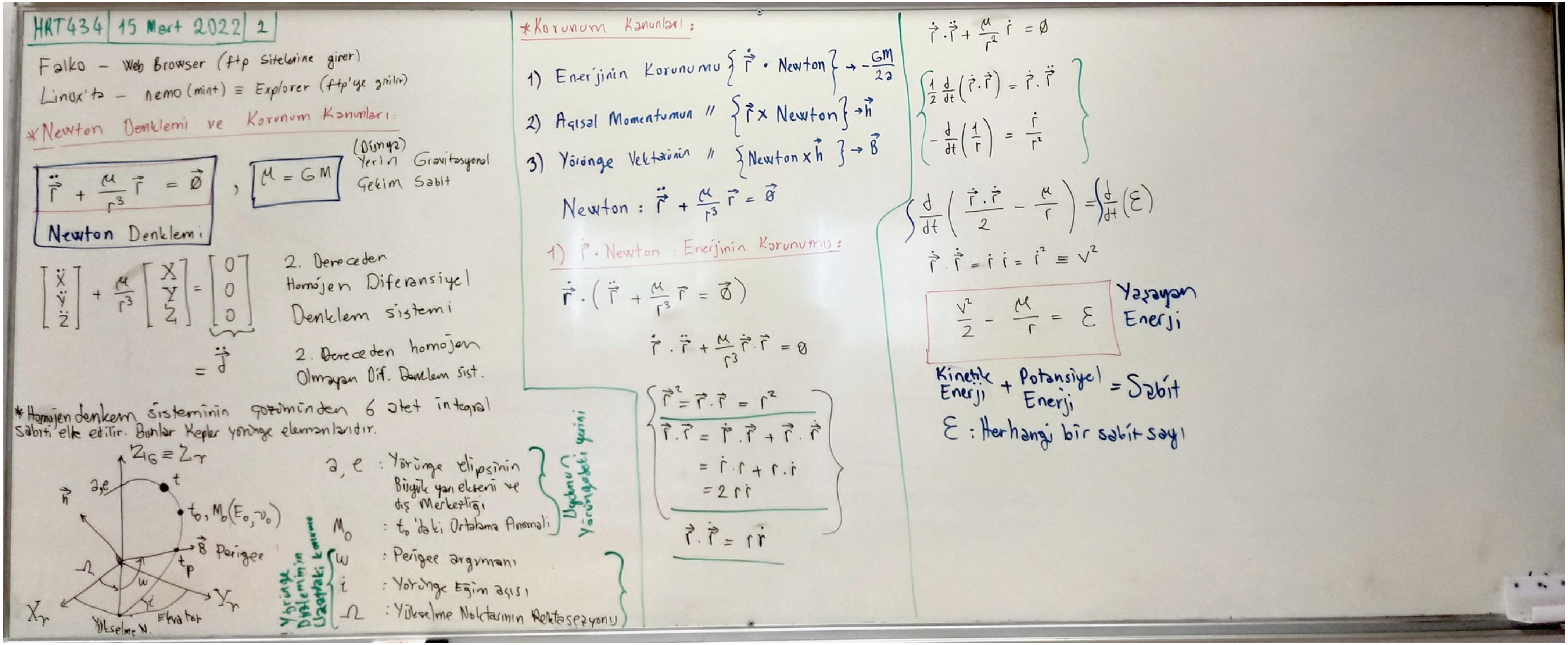
05. HAFTA - 2a

Celestial Mechanics
Newtonian Motion (two-body problem)



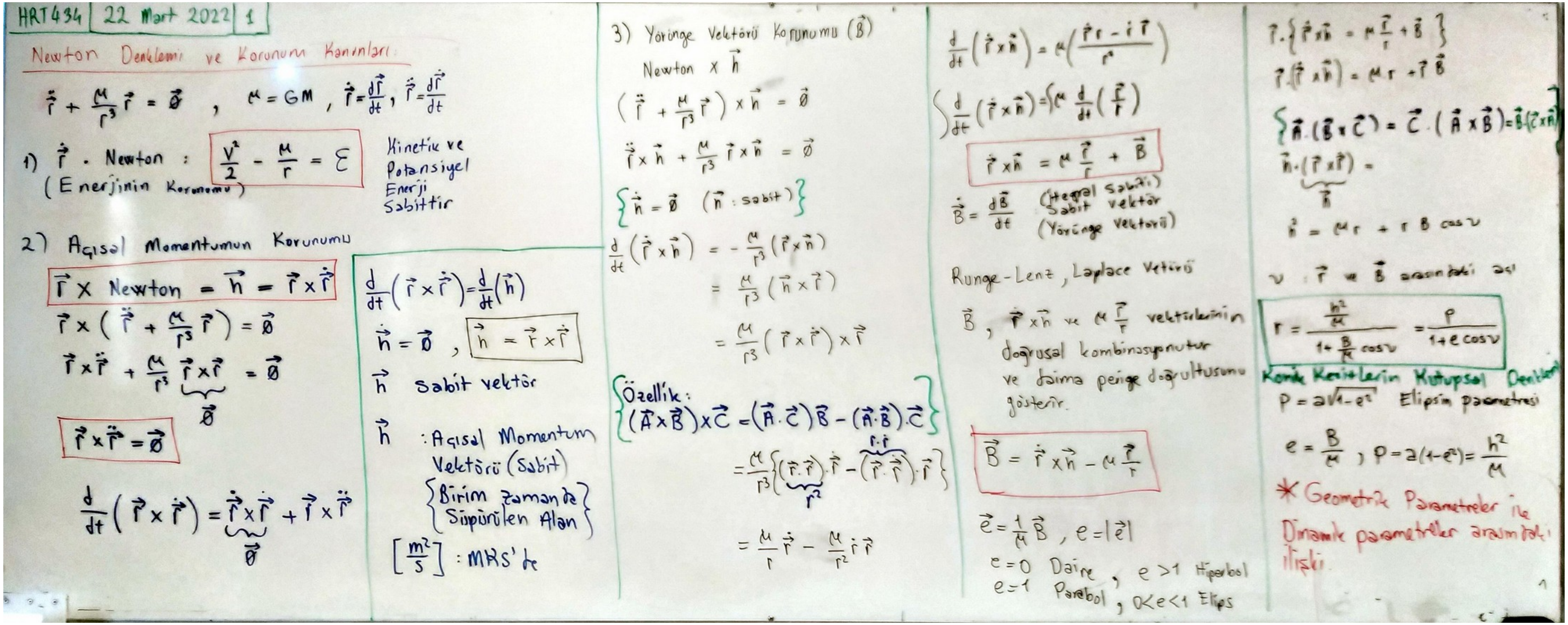
05. HAFTA - 3a

Celestial Mechanics
Newtonian Motion (two-body problem)



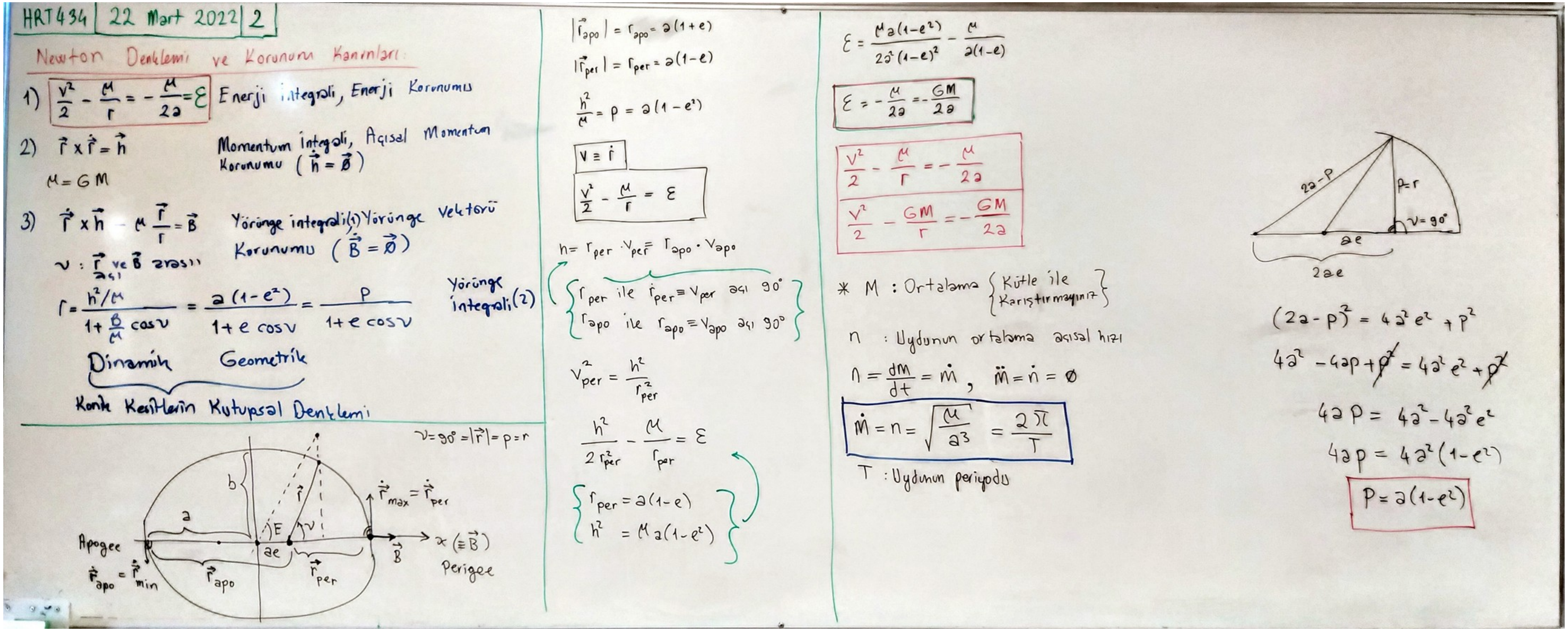
06. HAFTA - 1a

Celestial Mechanics
Newtonian Motion (two-body problem)



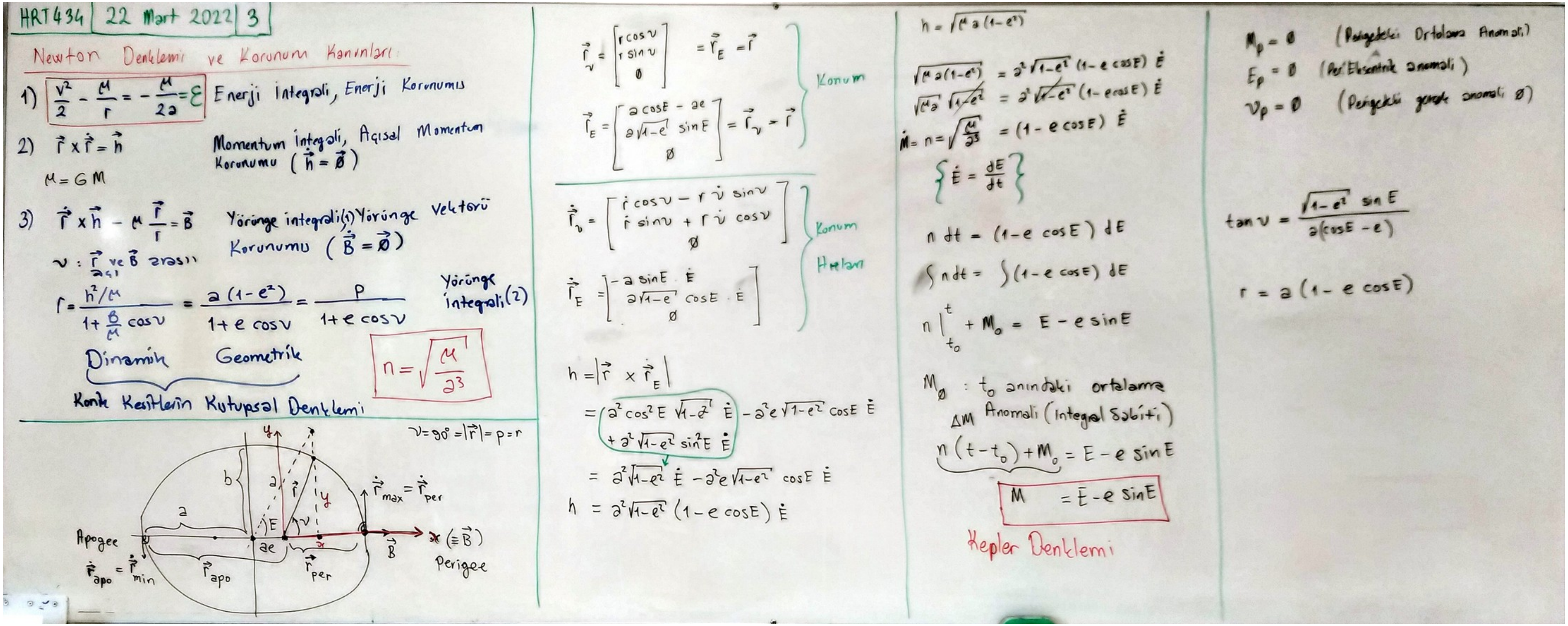
06. HAFTA - 2a

Celestial Mechanics
Newtonian Motion (two-body problem)



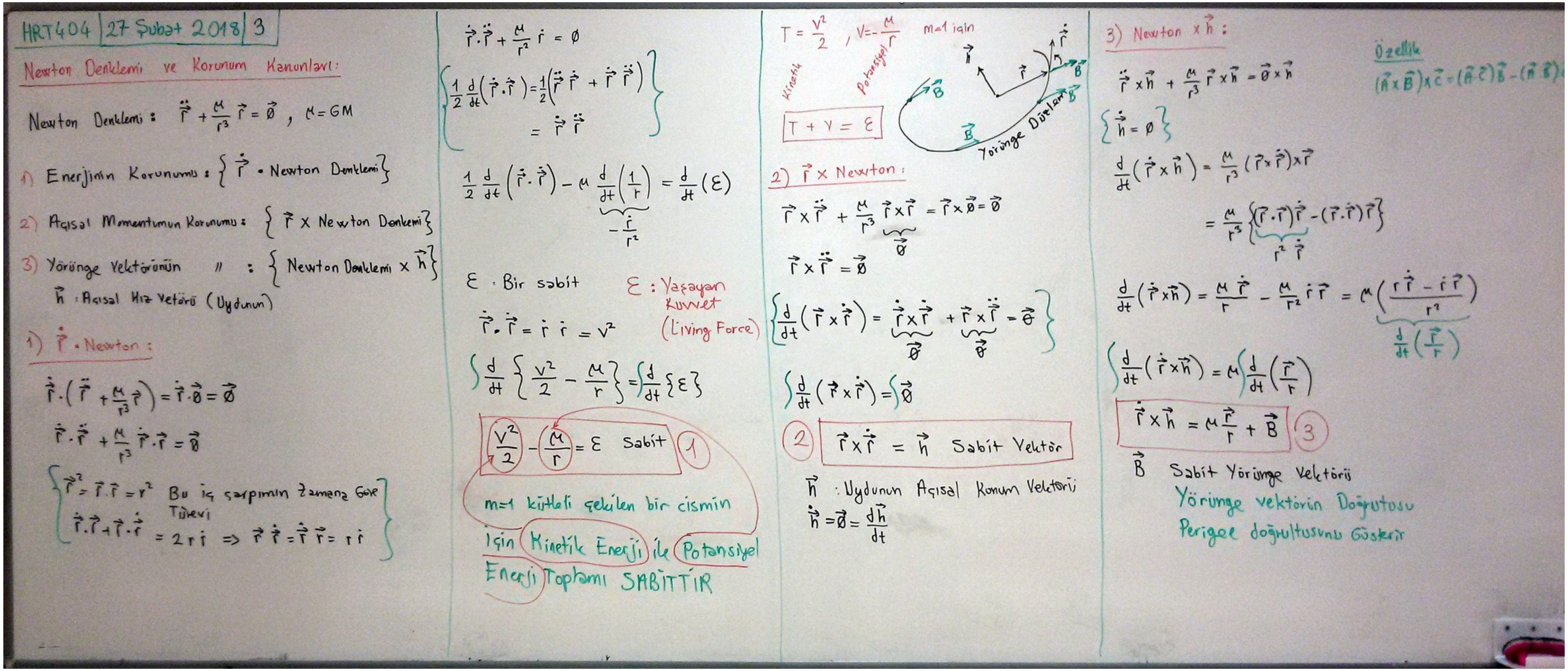
06. HAFTA - 3a

Celestial Mechanics
Newtonian Motion (two-body problem)



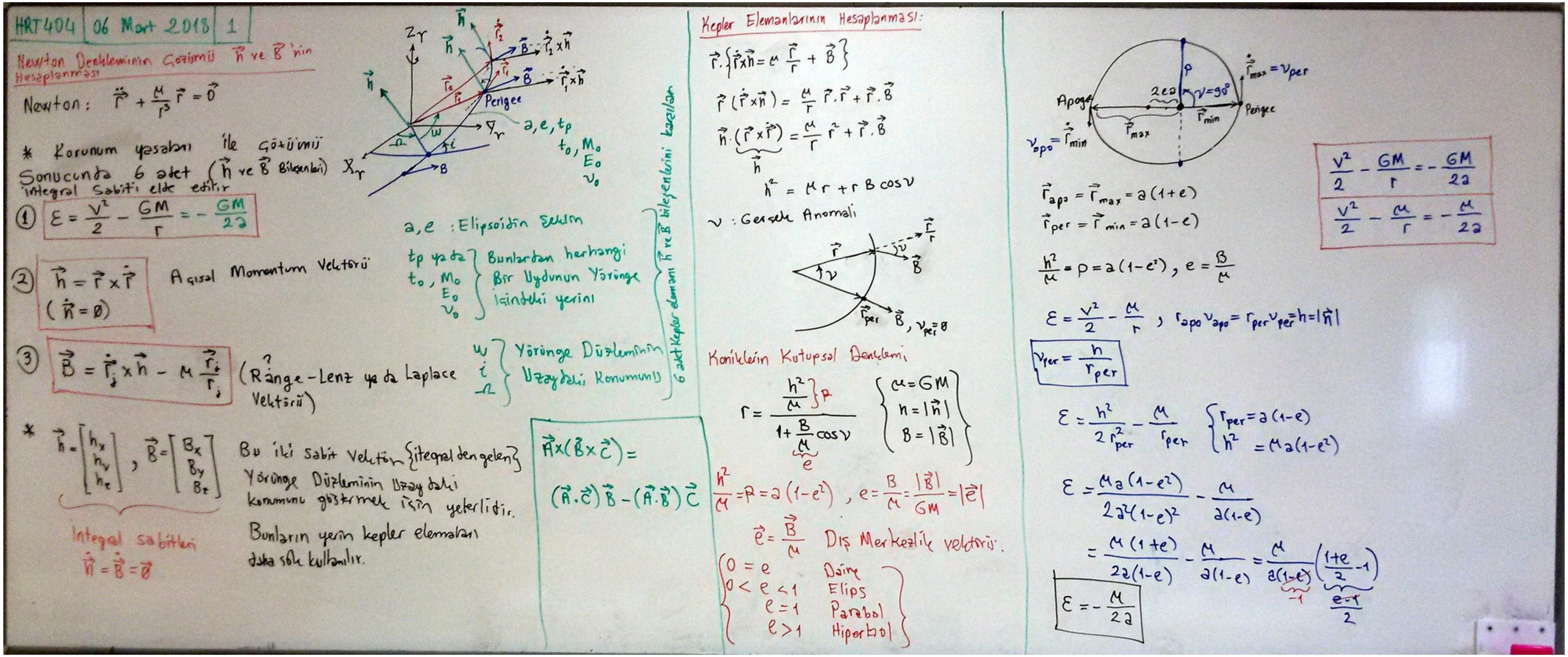
06. HAFTA - 3b

Newtonian Motion (two-body problem)
Conservation Laws



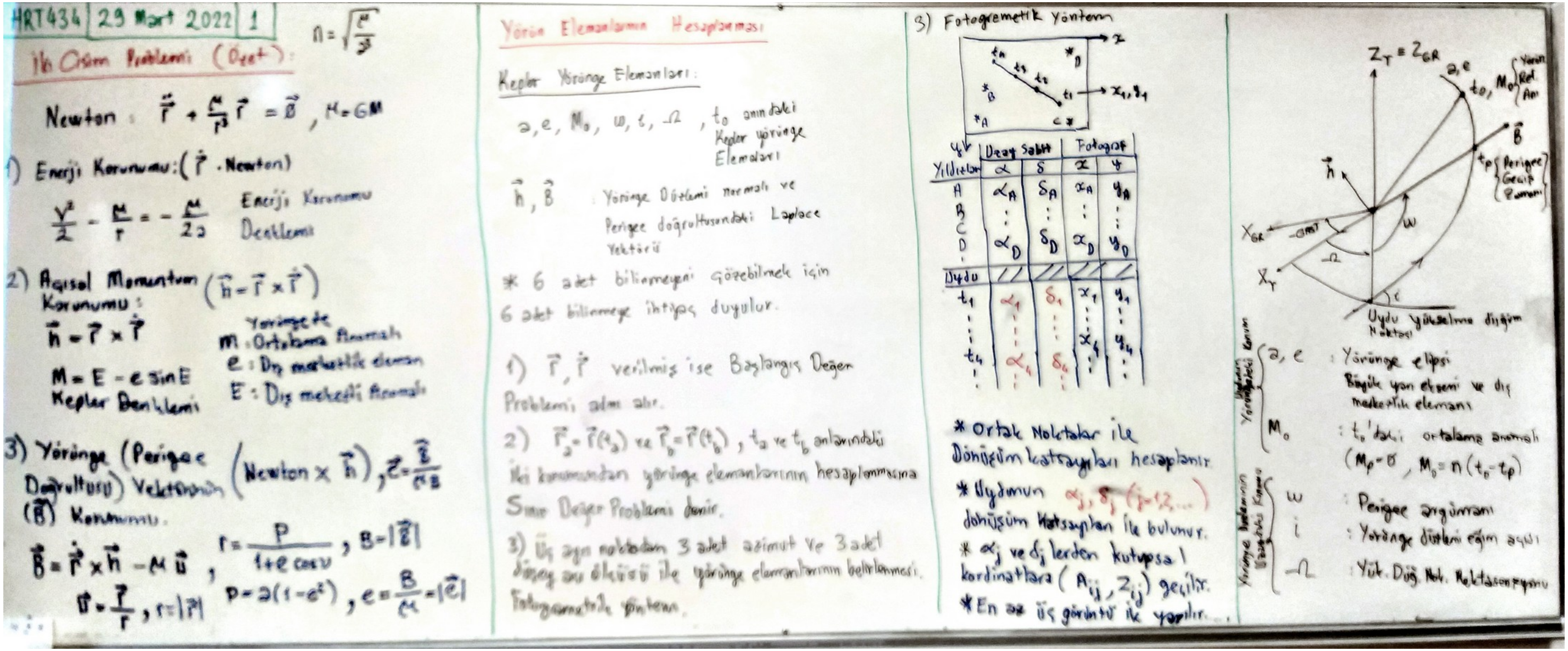
06. HAFTA - 3c

Newtonian Motion (two-body problem)
Conservation Laws



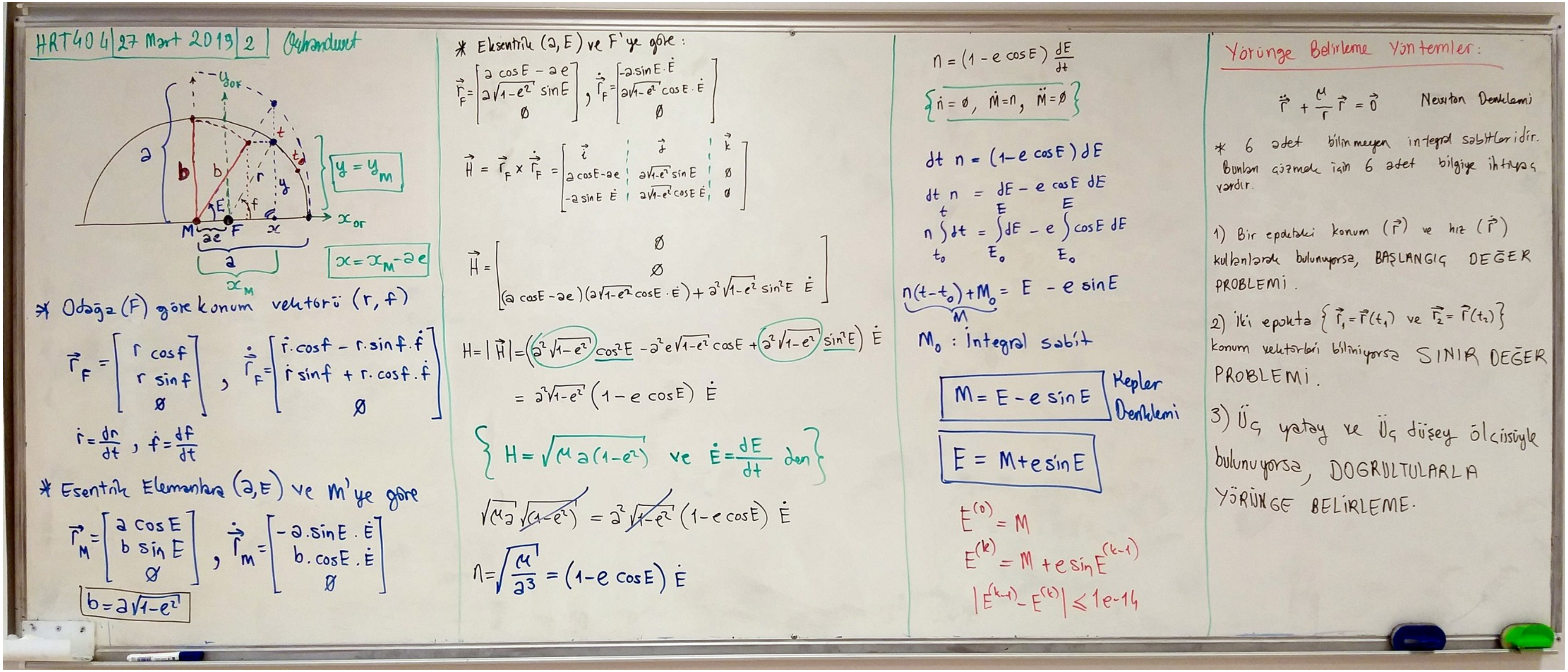
07. HAFTA - 1a

Orbit Determination and Photogrammetric Method



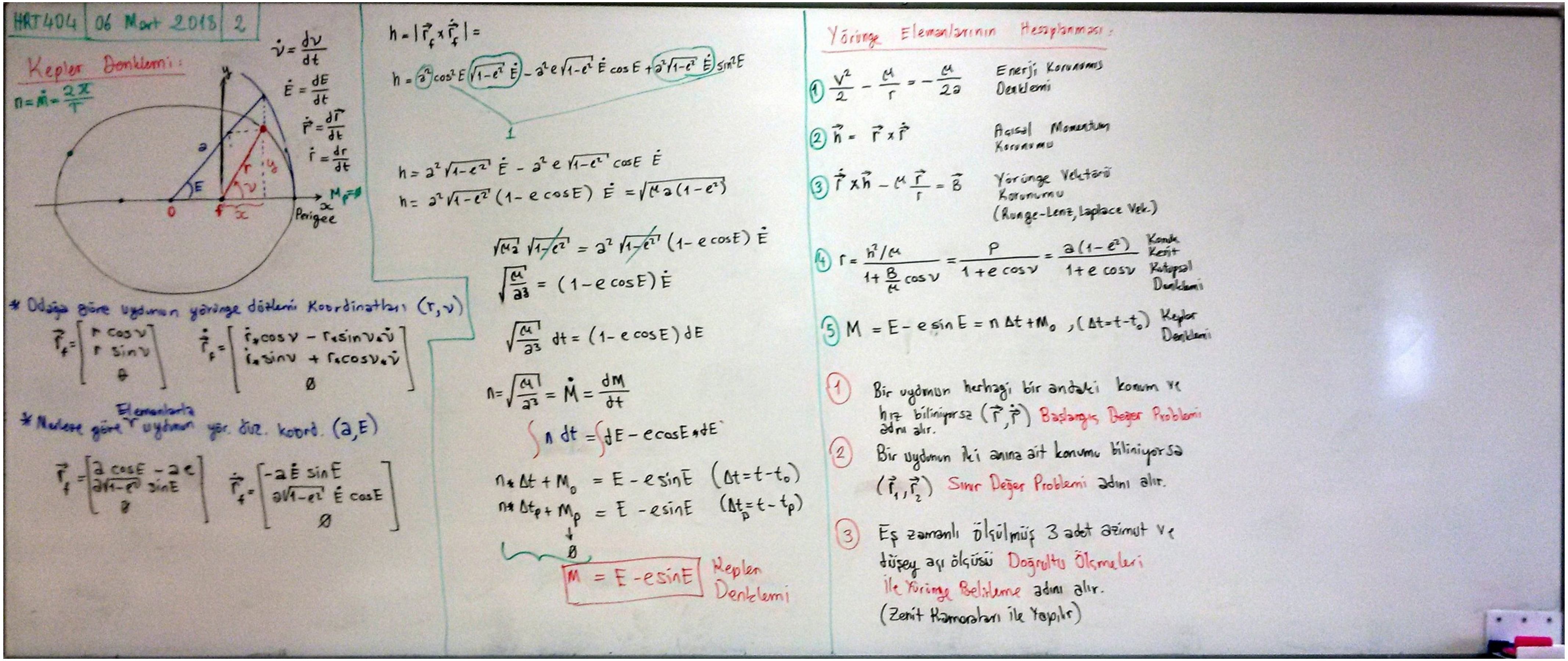
07. HAFTA - 1b

Orbit Determination



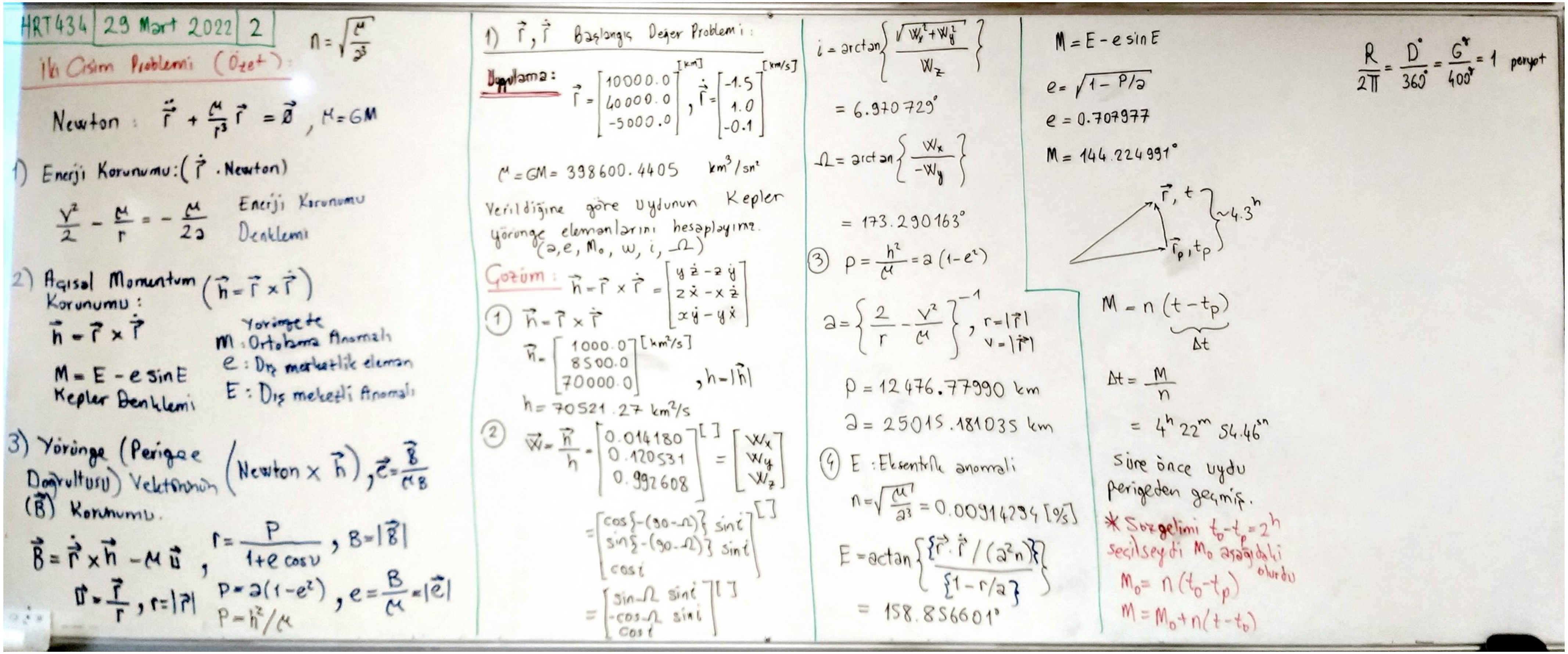
07. HAFTA - 1c

Orbit Determination



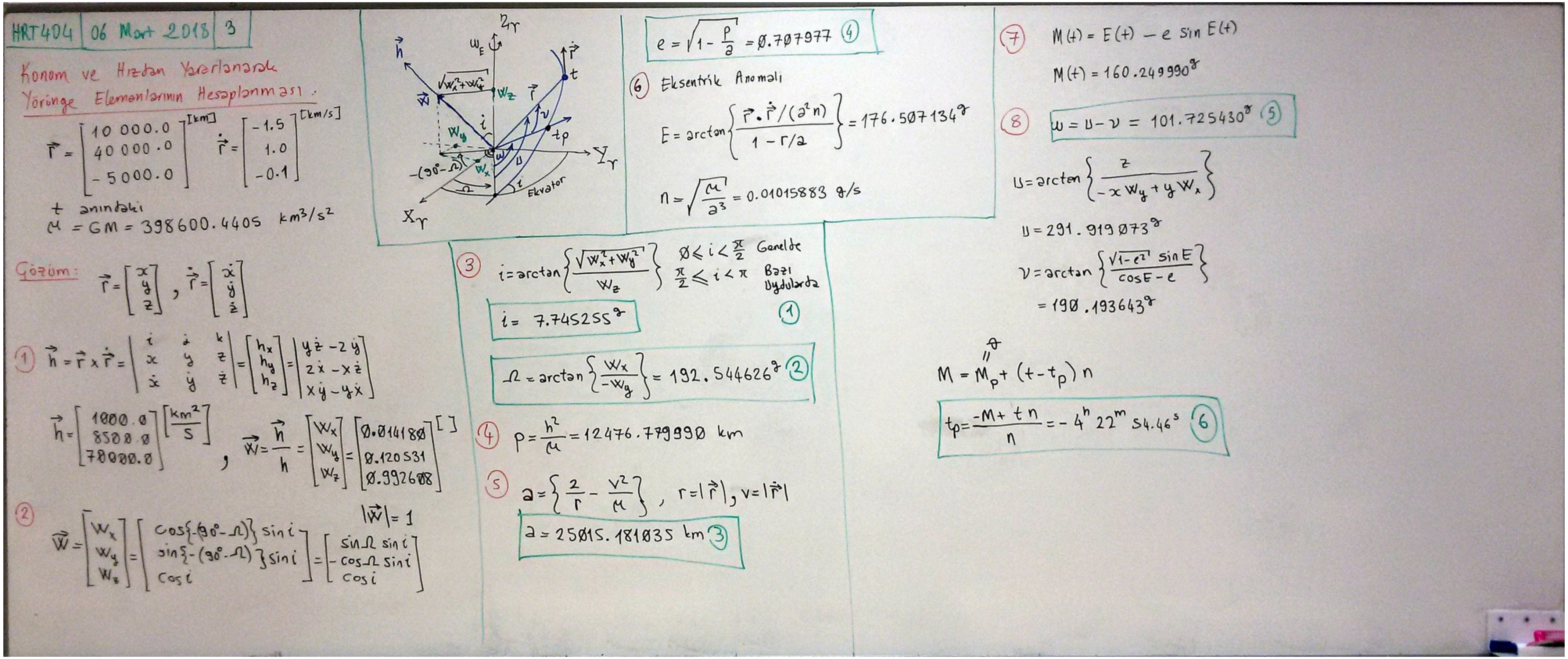
07. HAFTA - 2a

Orbit Determination
Initial Value Problem - HRT434 - Example 1



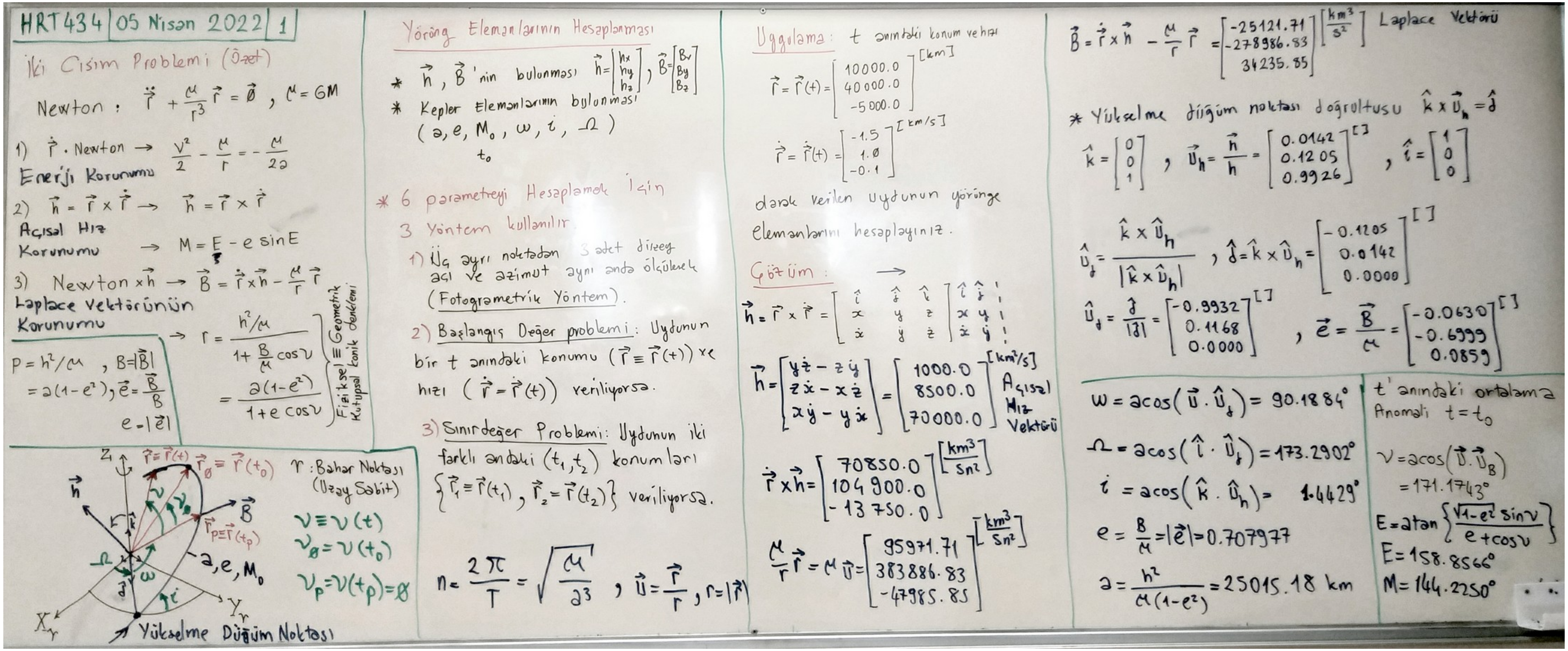
07. HAFTA - 2b

Orbit Determination
Initial Value Problem - HRT434 - Example 1



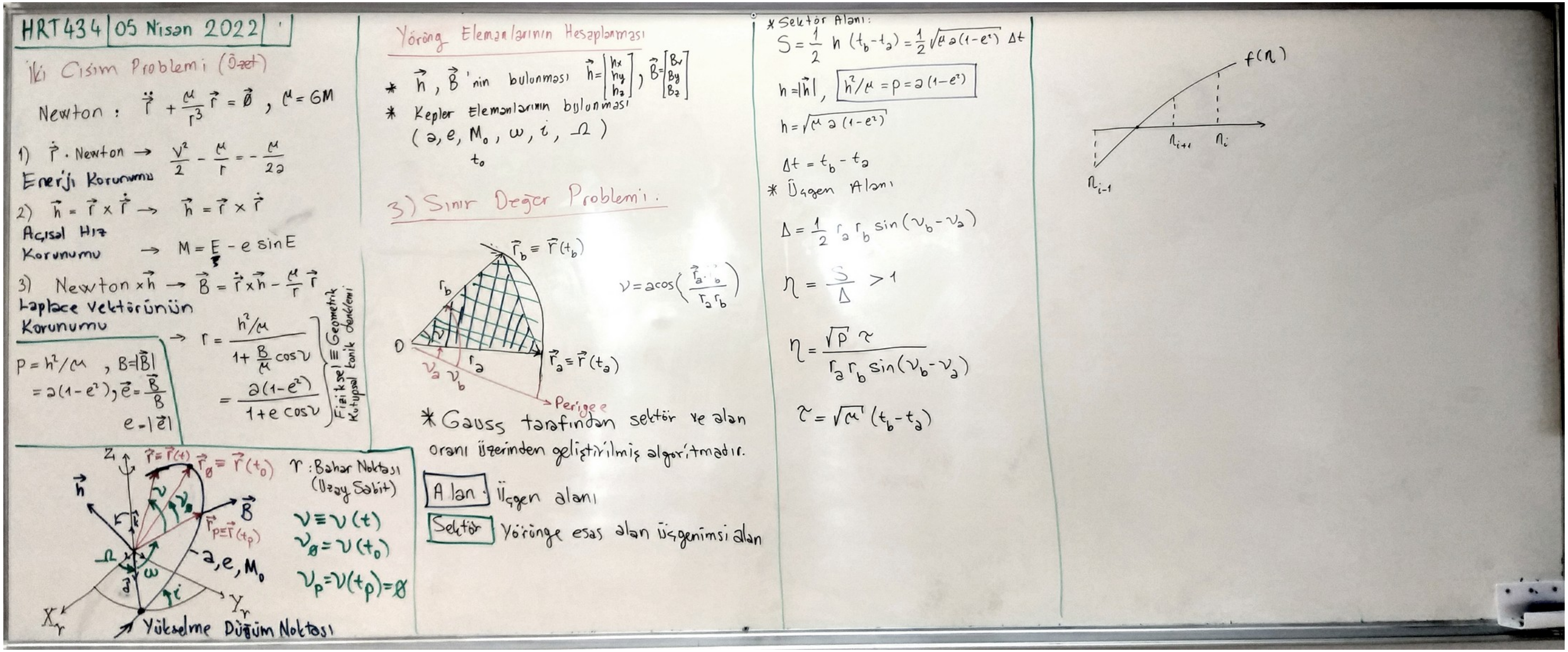
08. HAFTA - 1a

Orbit Determination



08. HAFTA - 2a

Orbit Determination

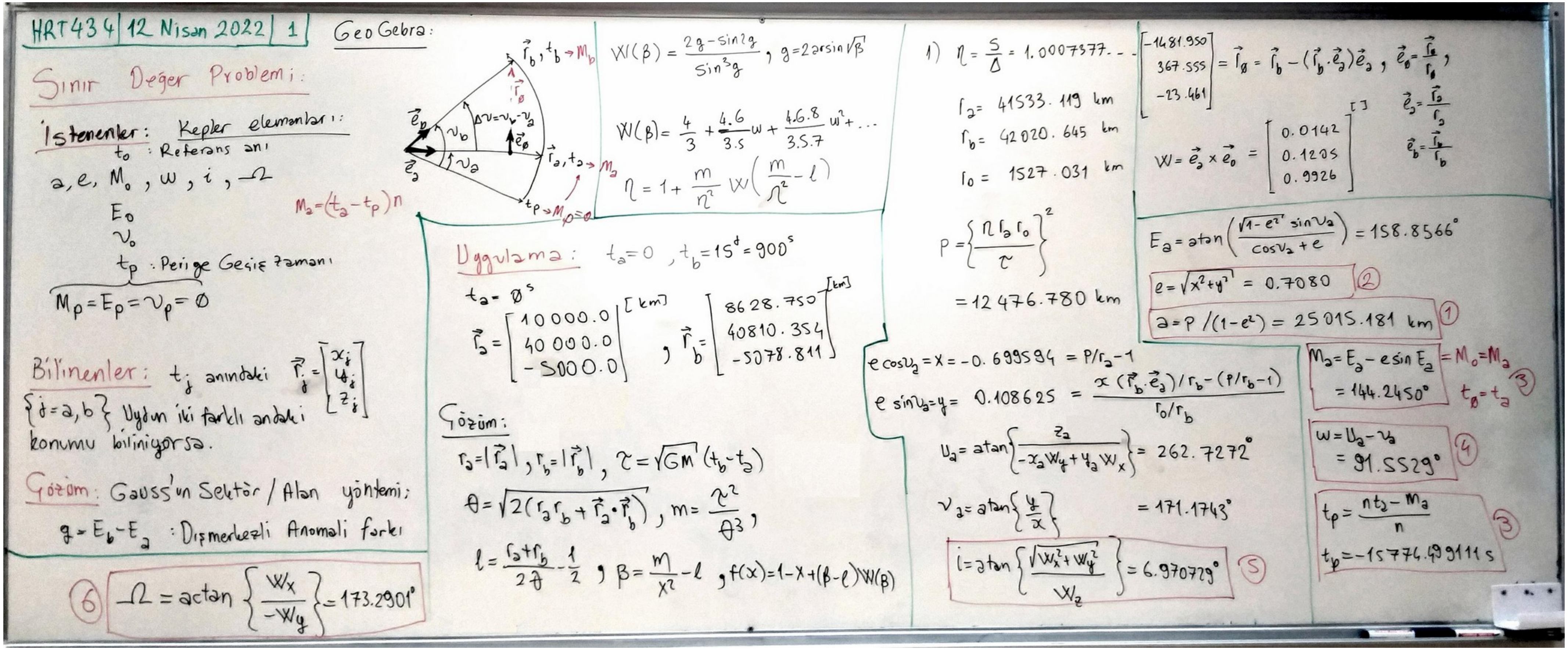


09. HAFTA - 1a

Orbit Determination

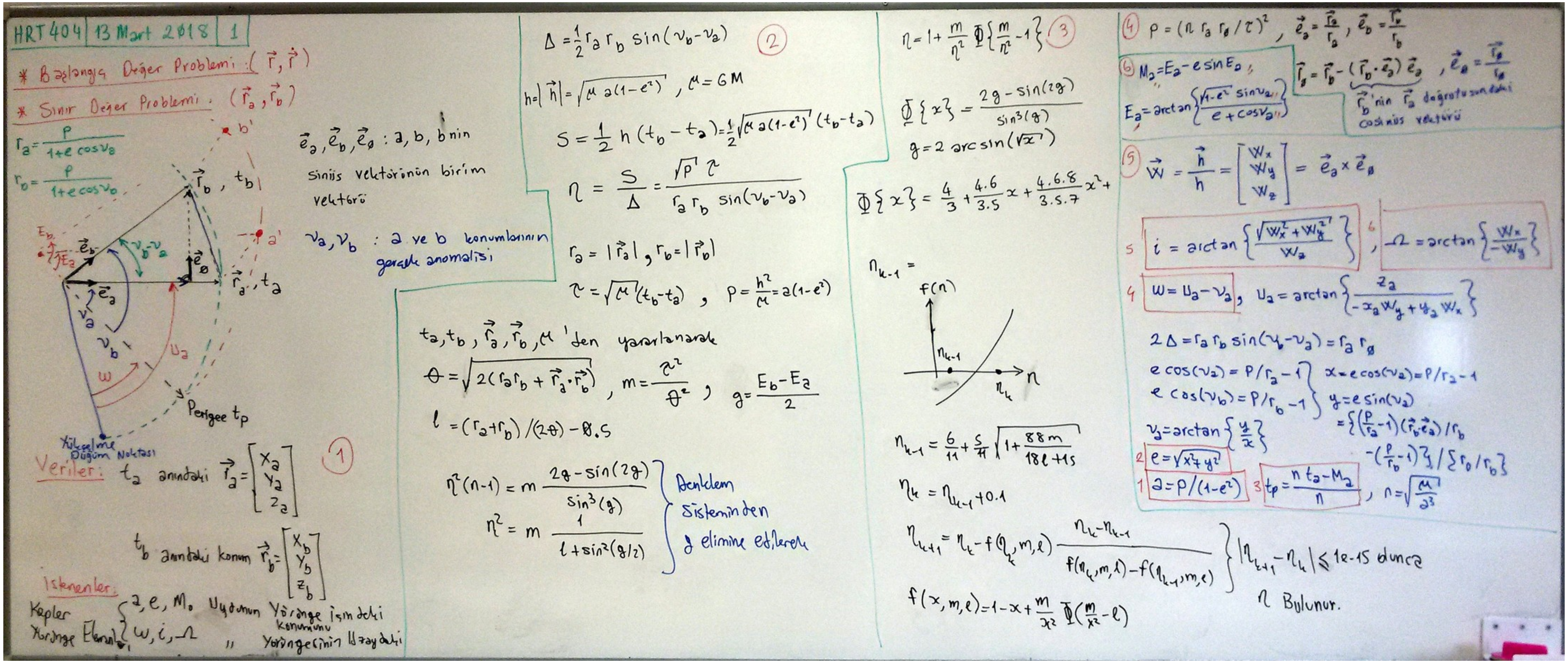
Boundary Value Problem

HRT404 - Example 2

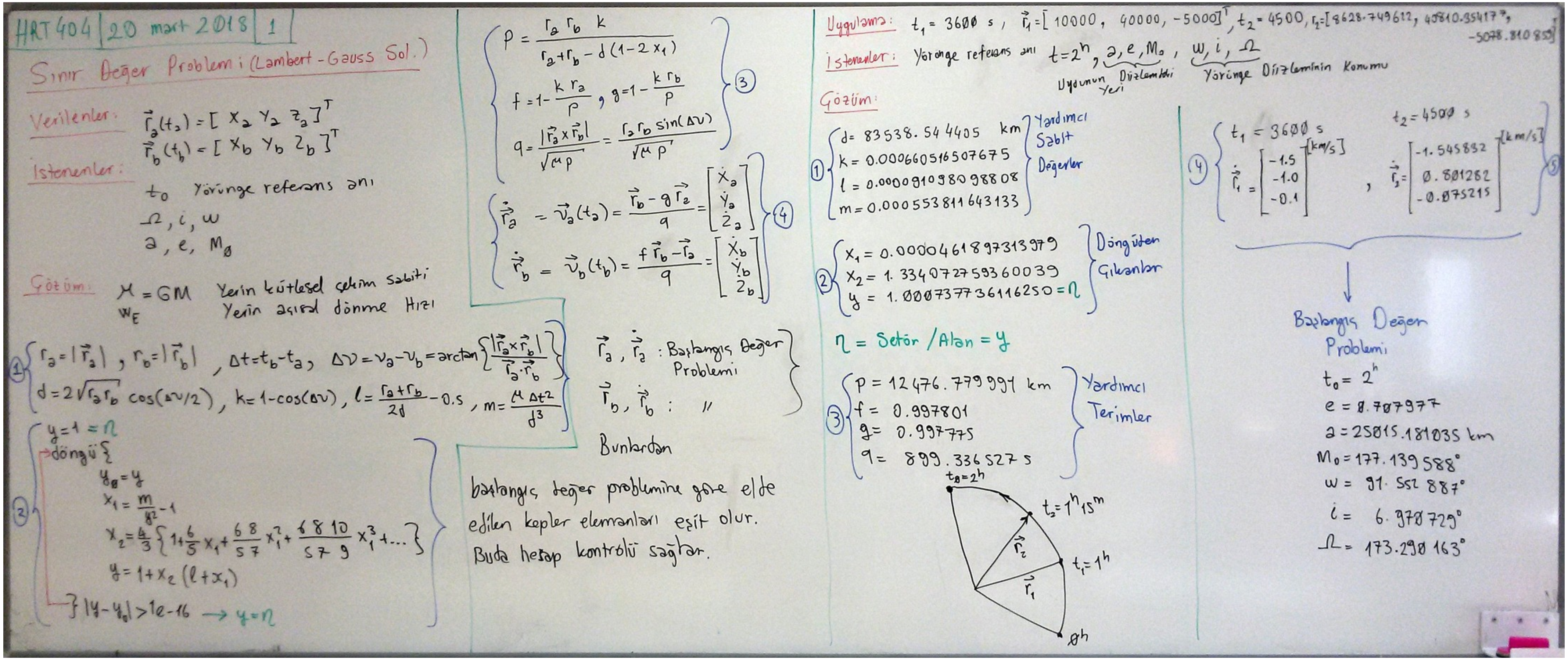


09. HAFTA - 1b

Orbit Determination
Boundary Value Problem
HRT404 - Example 2

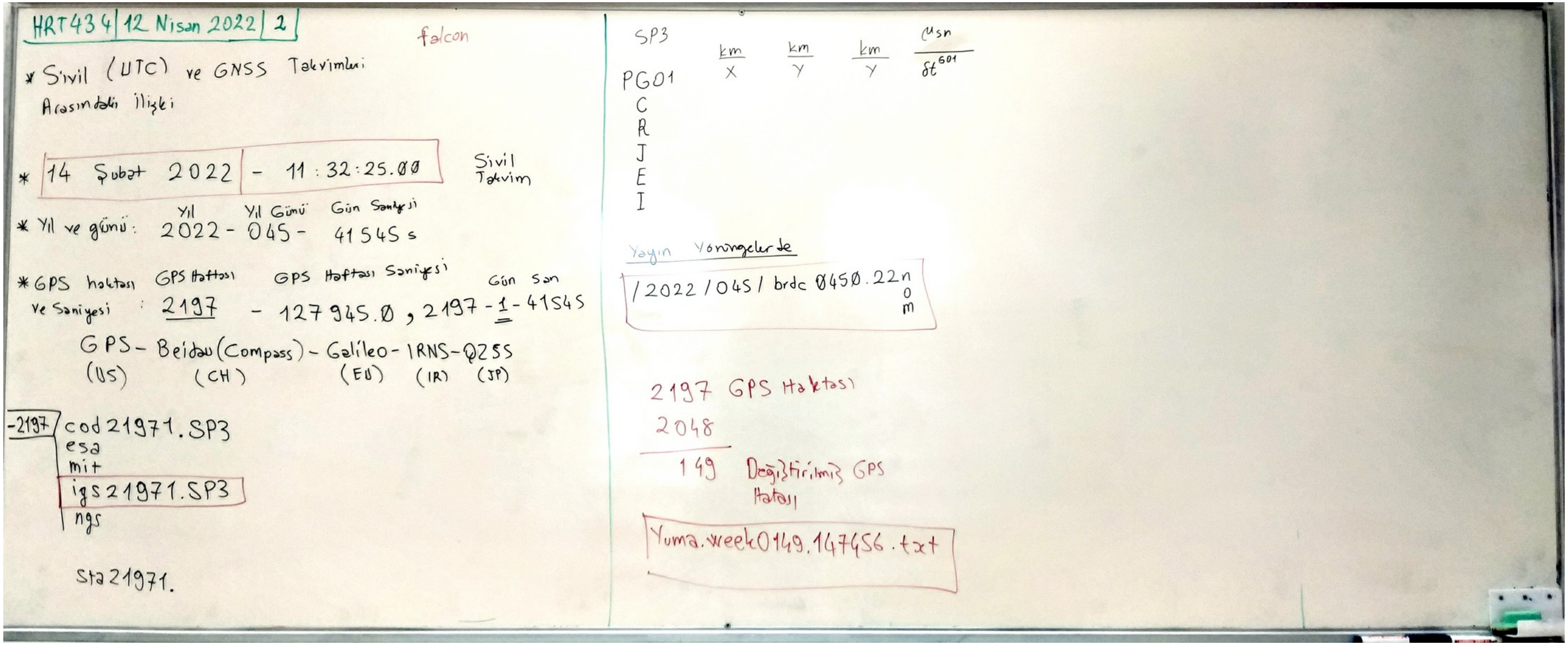


09. HAFTA – 1c
Orbit Determination
Boundary Value Problem
HRT404 - Example 2b



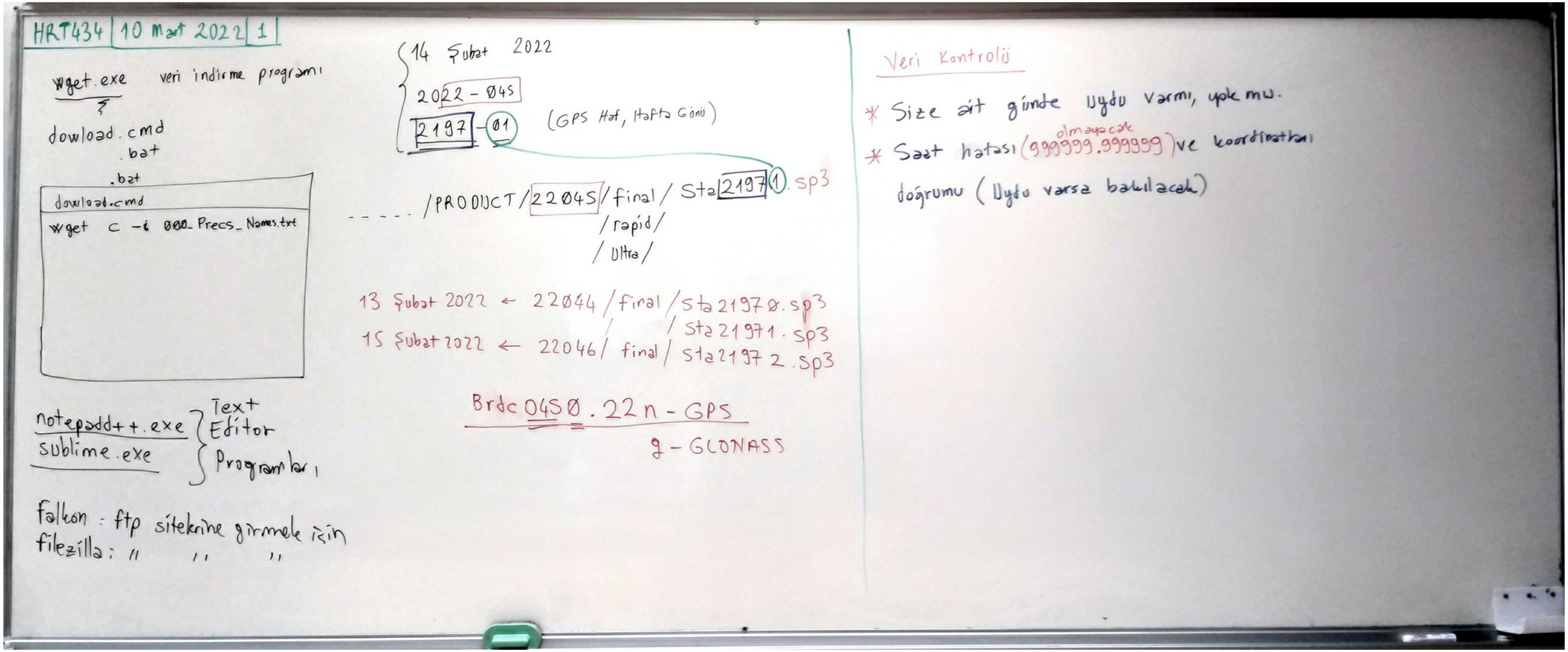
09. HAFTA – 2c

Civil and GNSS Calendar, and Orbit Formats



01.HRT434 – 2

Explanation for Midterm Homework



1) Broadcast Ephemeris from IAC - ftp://ftp.glonass-iac.ru/MCC/PRODUCTS/

2) Broadcast Ephemeris from IAC - ftp://ftp.glonass-iac.ru/MCC/BRDC/

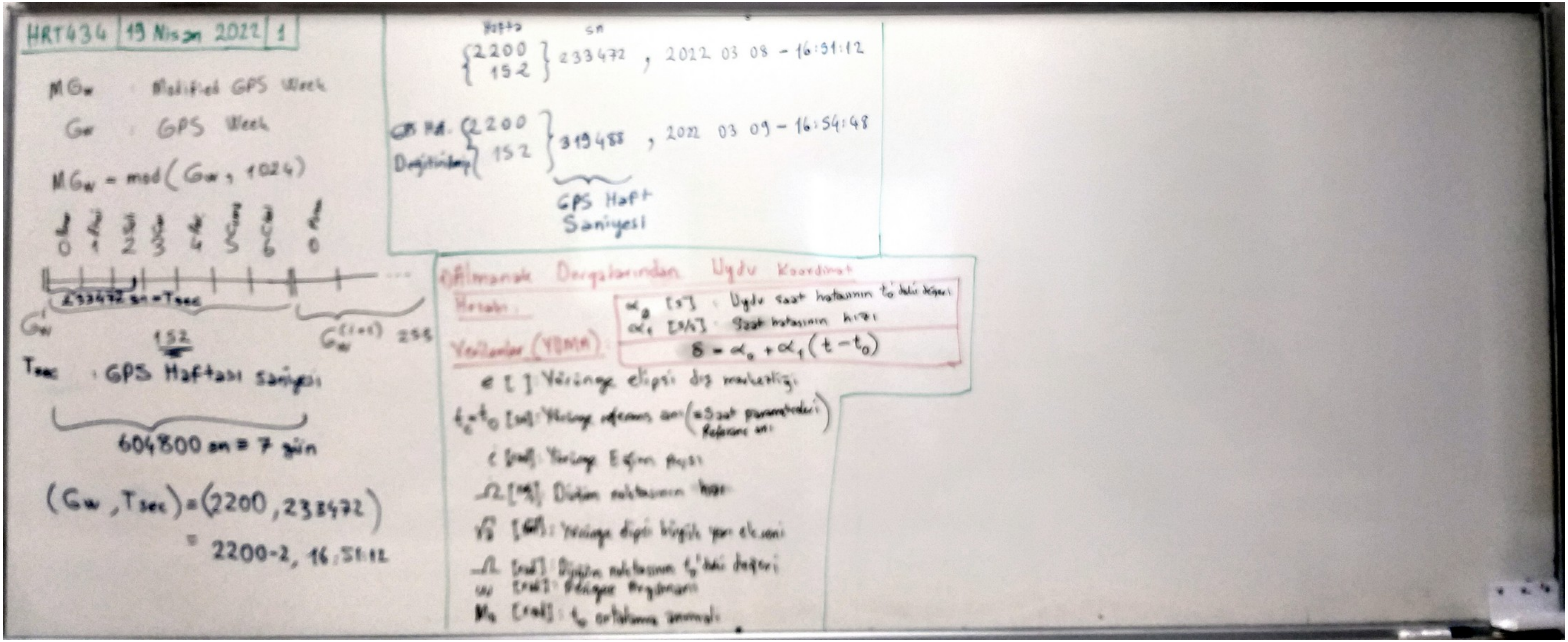
3) YUMA Almanac from CelesTrak - YUMA Almanacs from CelesTrak

4) 2022 Civil & GNSS Calendar

5) An executable software to separate a desired satellite from a SP3 file

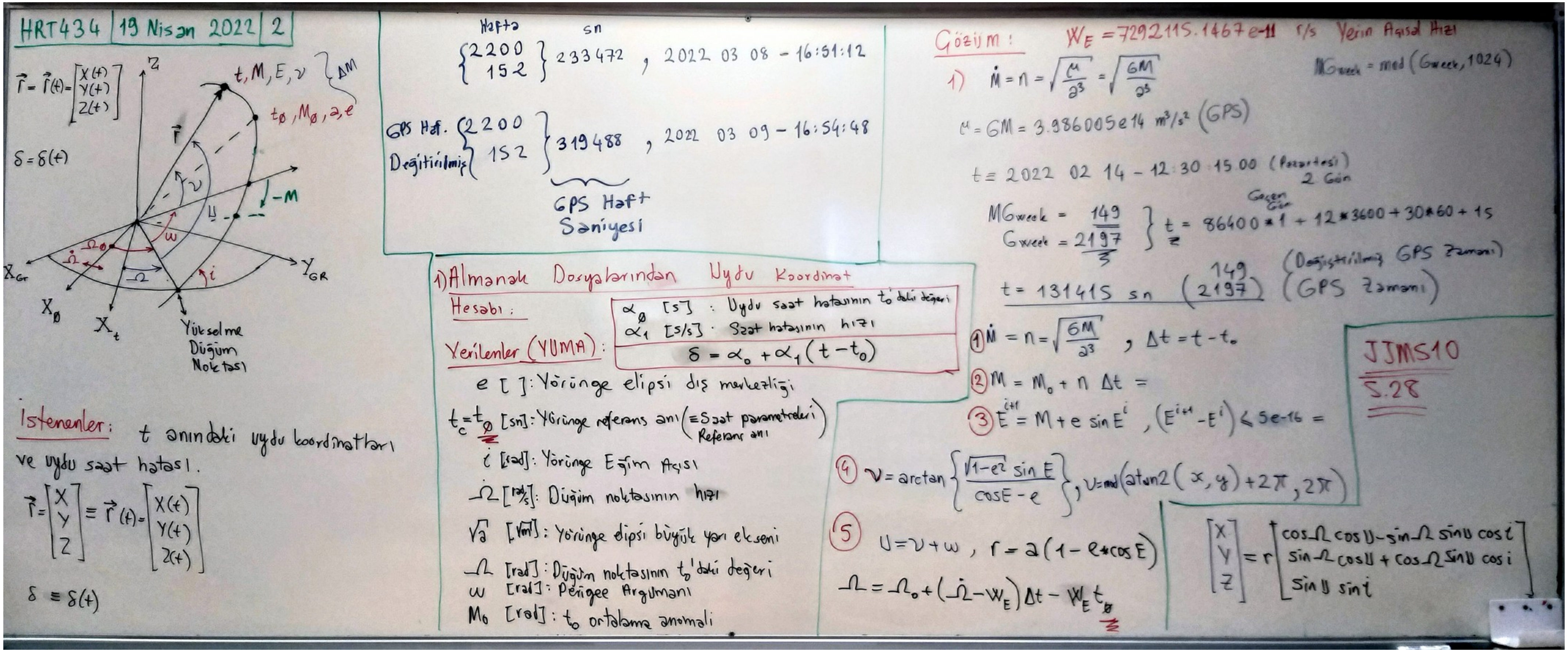
10.HRT434 – 1

Computation of a Satellite Position from Kepler Orbit Elements



10.HRT434 – 2

Computation of a Satellite Position from Kepler Orbit Elements



Uygulama

(+) International Reference Ellipsoid:
a_grs = 6378137.00000 m
b_grs = 6356752.31414 m

(+) Cartesian Coordinates (X,Y,Z) & Orthometric Height (H):
X = 3818682.4594 m   Y = 3068056.5571 m   Z = 4071183.8593 m   H = 39.2876 m

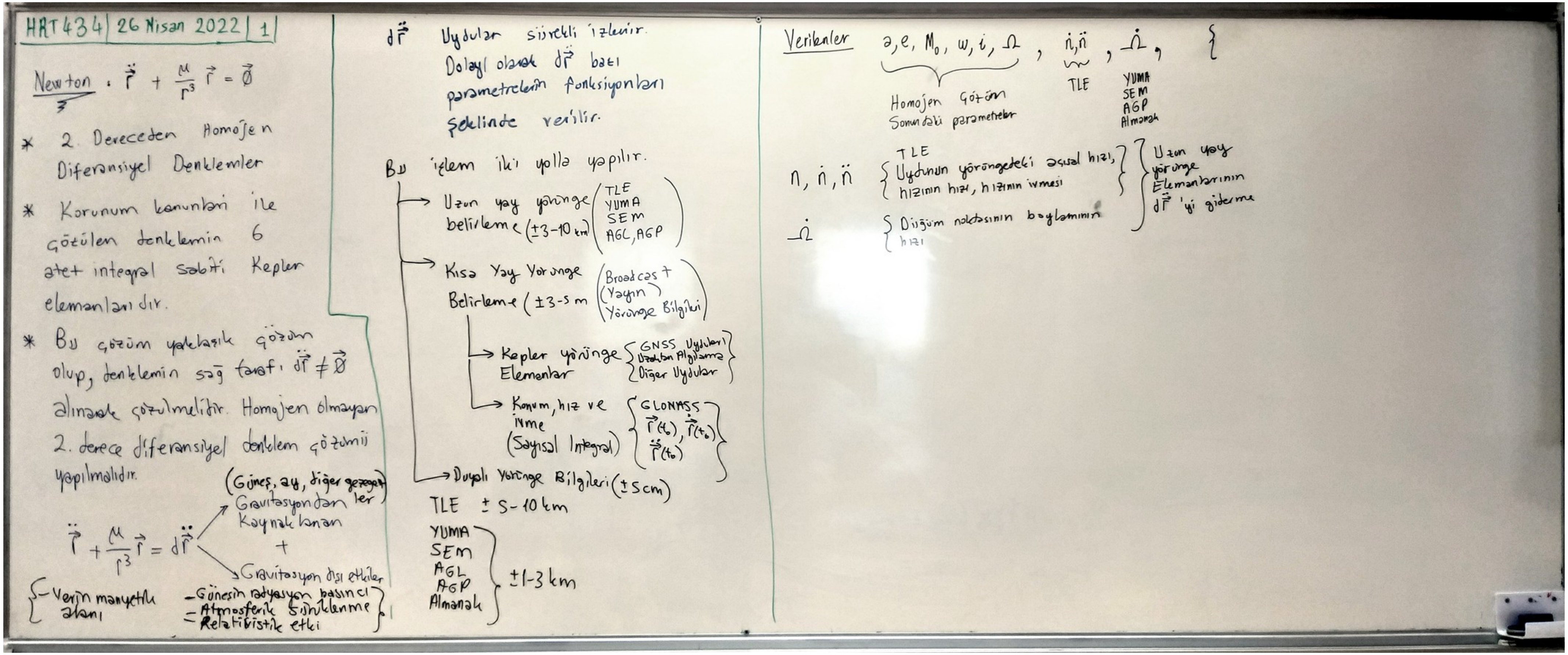
(+) Geodetic Coordinates (B,L,h) & Geoid Undulation (N):
B = 39.919539°   L = 38.779554°   h = 71.8050 m   N = 32.5174 m

(+) 3° Gauss-Kruger (x,y) & UTM Coordinates (Up, Right, m0= 1.0000):
Lo = 39.00° in 3°
x = 4420618.4012 m   y = -18846.8187 m
Up = 4420618.4012 m   Right = 481153.1813 m

(+) 6° Gauss-Kruger (x,y) & UTM Coordinates (Up, Right, m0= 0.9996):
Lo = 39.00° in 6°
x = 4420618.4012 m   y = -18846.8187 m
Up = 4418850.1538 m   Right = 481160.7200 m

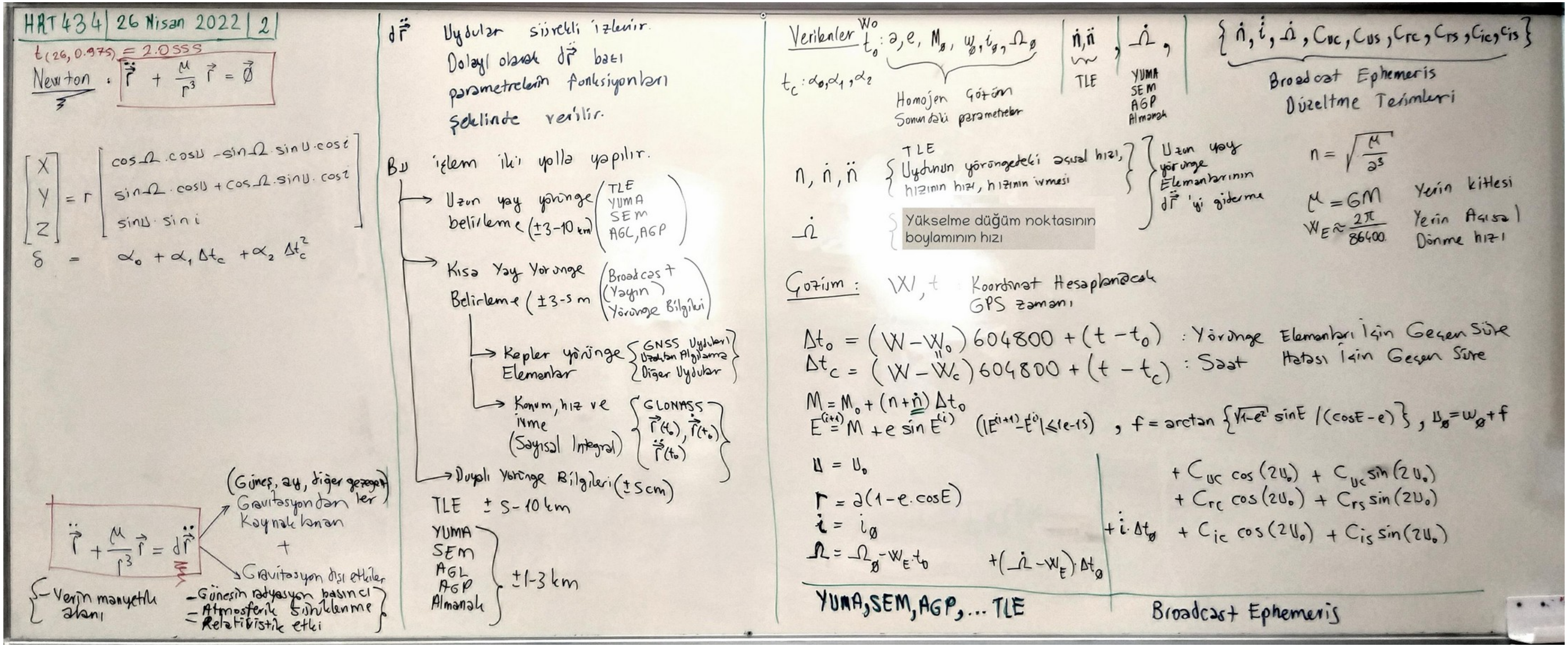
11.HRT434 – 1

Computation of a Satellite Position from Kepler Orbit Elements



11.HRT434 – 2

Computation of a Satellite Position from Kepler Orbit Elements



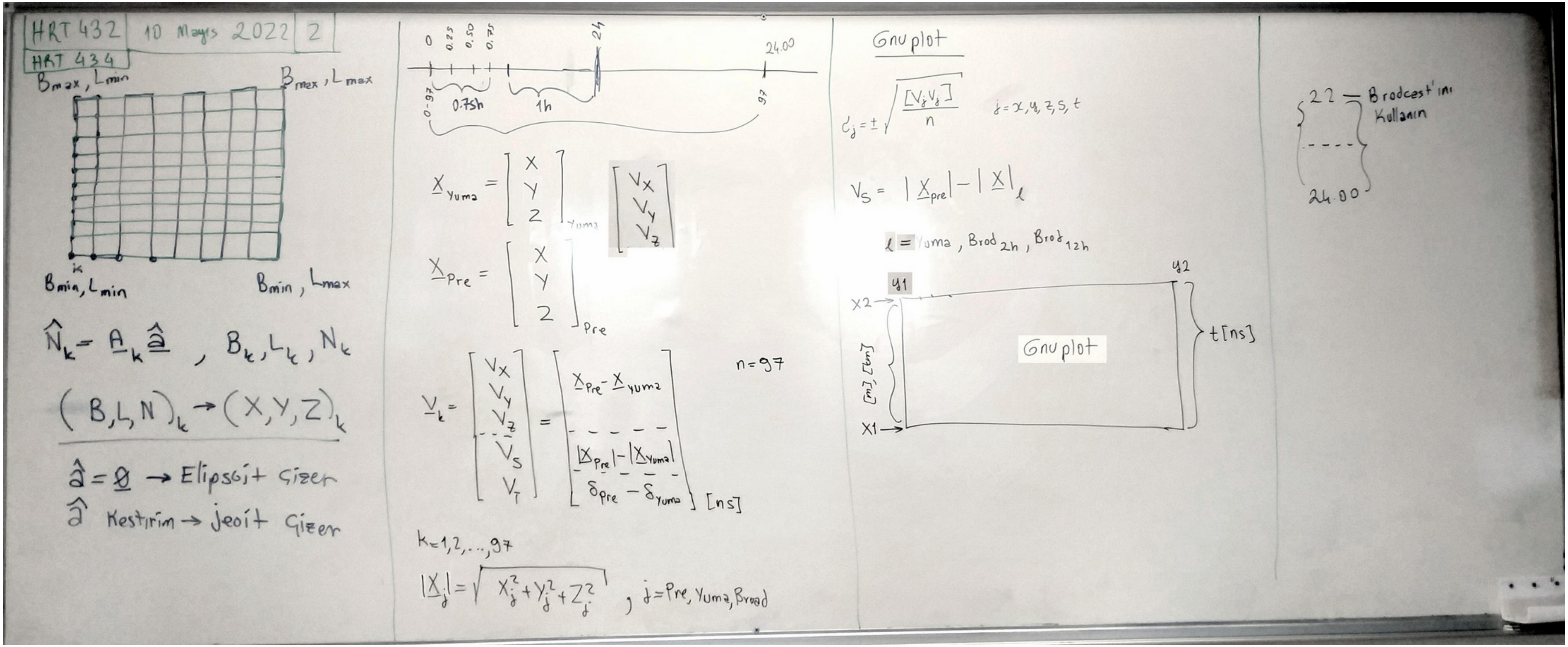
12.HRT434 - 1

Orbit Representation (Yörünge Temsili)

Almanac Data (Long-Arc Ephemeris) – Almanak Verileri (Uzun Yay Yörünge Bilgileri) (± 0.5 – 5 km)

Broadcast Ephemerides (Short-Arc Ephemeris) – Yayın Yörünge Bilgileri (Kısa Yay Yörünge Bilgileri) (± 1 – 5 m)

Precise Ephemeris – Duyarlı Yörünge Bilgileri (± 1 – 5 cm)



12.HRT434 - 2

Plotting in GnuPlot

Figure-1.txt ***

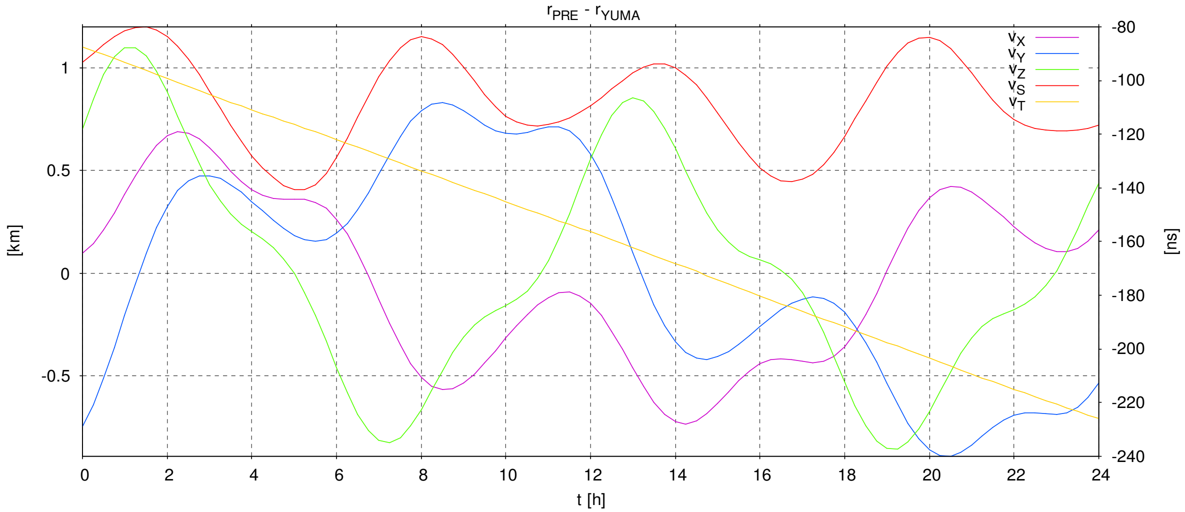
# t[h]	vX[km]	vY[km]	vZ[km]	vS[km]	T[ns]
# ====	======	======	======	======	======
0.000	0.096	-0.744	0.702	1.028	-87.50
0.250	0.143	-0.640	0.848	1.072	-88.91
0.500	0.210	-0.511	0.968	1.115	-90.35
0.750	0.292	-0.363	1.054	1.152	-91.82
1.000	0.383	-0.206	1.098	1.181	-93.25
1.250	0.474	-0.050	1.099	1.198	-94.75
1.500	0.557	0.096	1.059	1.200	-96.23
1.750	0.624	0.223	0.984	1.186	-97.72
2.000	0.669	0.325	0.882	1.154	-99.24
2.250	0.689	0.402	0.766	1.106	-100.74
2.500	0.684	0.451	0.646	1.043	-102.24
2.750	0.656	0.474	0.533	0.969	-103.71
3.000	0.611	0.476	0.433	0.887	-105.17
3.250	0.556	0.461	0.352	0.803	-106.66
3.500	0.499	0.432	0.289	0.720	-108.12
3.750	0.448	0.394	0.241	0.643	-109.54
4.000	0.407	0.350	0.203	0.574	-110.97
4.250	0.380	0.304	0.168	0.515	-112.49
4.500	0.366	0.260	0.126	0.466	-113.75
4.750	0.362	0.220	0.071	0.429	-115.18
5.000	0.362	0.186	-0.002	0.407	-116.36
5.250	0.359	0.164	-0.095	0.406	-117.74
5.500	0.346	0.156	-0.206	0.432	-119.18
5.750	0.316	0.165	-0.330	0.486	-120.59
6.000	0.264	0.194	-0.458	0.564	-122.00
6.250	0.191	0.243	-0.581	0.658	-123.43
6.500	0.098	0.310	-0.687	0.760	-124.87
6.750	-0.011	0.392	-0.767	0.862	-126.33
7.000	-0.127	0.484	-0.814	0.956	-127.80
7.250	-0.243	0.578	-0.825	1.036	-129.31
7.500	-0.349	0.666	-0.799	1.097	-130.79
7.750	-0.439	0.740	-0.743	1.136	-132.24
8.000	-0.506	0.794	-0.663	1.152	-133.63
8.250	-0.549	0.825	-0.570	1.143	-135.09
8.500	-0.566	0.832	-0.474	1.113	-136.53
8.750	-0.560	0.819	-0.386	1.065	-137.96
9.000	-0.533	0.792	-0.311	1.004	-139.40
9.250	-0.491	0.757	-0.253	0.937	-140.84
9.500	-0.437	0.722	-0.212	0.871	-142.29
9.750	-0.378	0.695	-0.182	0.812	-143.72
10.000	-0.316	0.681	-0.157	0.766	-145.13
10.250	-0.255	0.679	-0.127	0.736	-146.67
10.500	-0.199	0.687	-0.085	0.721	-148.05
10.750	-0.152	0.701	-0.023	0.718	-149.48
11.000	-0.116	0.712	0.061	0.724	-150.83
11.250	-0.095	0.713	0.168	0.738	-152.26
11.500	-0.092	0.694	0.291	0.758	-153.55
11.750	-0.109	0.651	0.424	0.785	-154.98
12.000	-0.147	0.581	0.555	0.817	-156.40
12.250	-0.205	0.486	0.674	0.856	-157.87
12.500	-0.281	0.369	0.768	0.897	-159.33
12.750	-0.368	0.237	0.830	0.938	-160.78
13.000	-0.460	0.101	0.853	0.975	-162.32
13.250	-0.549	-0.032	0.838	1.003	-163.70
13.500	-0.627	-0.153	0.787	1.018	-165.19
13.750	-0.686	-0.254	0.707	1.018	-166.73
14.000	-0.722	-0.332	0.607	1.000	-168.22
14.250	-0.733	-0.385	0.498	0.966	-169.58
14.500	-0.719	-0.413	0.390	0.916	-171.11
14.750	-0.683	-0.419	0.293	0.853	-172.64
15.000	-0.633	-0.406	0.213	0.782	-174.14
15.250	-0.577	-0.380	0.153	0.707	-175.76
15.500	-0.521	-0.344	0.111	0.634	-177.29
15.750	-0.474	-0.303	0.084	0.568	-178.75
16.000	-0.439	-0.259	0.065	0.514	-180.26
16.250	-0.420	-0.217	0.045	0.475	-181.72
16.500	-0.415	-0.178	0.017	0.452	-183.15
16.750	-0.420	-0.147	-0.028	0.446	-184.62
17.000	-0.429	-0.124	-0.093	0.457	-186.03
17.250	-0.434	-0.115	-0.180	0.484	-187.49
17.500	-0.428	-0.121	-0.286	0.529	-188.95
17.750	-0.404	-0.145	-0.405	0.590	-190.32
18.000	-0.358	-0.190	-0.528	0.666	-191.75
18.250	-0.290	-0.254	-0.644	0.751	-193.21
18.500	-0.202	-0.336	-0.743	0.840	-194.63
18.750	-0.099	-0.432	-0.815	0.928	-196.10
19.000	0.011	-0.535	-0.853	1.007	-197.58
19.250	0.121	-0.636	-0.855	1.073	-198.90
19.500	0.221	-0.729	-0.822	1.121	-200.37
19.750	0.305	-0.806	-0.758	1.147	-201.86
20.000	0.368	-0.859	-0.672	1.151	-203.39
20.250	0.407	-0.887	-0.575	1.133	-204.85
20.500	0.423	-0.890	-0.478	1.095	-206.32
20.750	0.419	-0.871	-0.389	1.041	-207.82
21.000	0.397	-0.835	-0.315	0.977	-209.29
21.250	0.362	-0.792	-0.260	0.909	-210.78
21.500	0.319	-0.750	-0.221	0.845	-212.21
21.750	0.273	-0.715	-0.196	0.790	-213.64
22.000	0.227	-0.691	-0.175	0.748	-215.05
22.250	0.184	-0.680	-0.150	0.720	-216.44
22.500	0.148	-0.679	-0.115	0.705	-217.85
22.750	0.121	-0.684	-0.061	0.697	-219.20
23.000	0.106	-0.686	0.013	0.695	-220.59
23.250	0.106	-0.678	0.107	0.695	-221.93
23.500	0.123	-0.653	0.215	0.698	-223.31
23.750	0.158	-0.605	0.330	0.707	-224.64
24.000	0.212	-0.533	0.441	0.723	-225.97

Figure-1.txt ***

12.HRT434 – 3 , Plotting in GnuPlot (.EPS)

```
draw.plt ***********************************************************************
# Ploting for HRT434 class in gnuplot.
set terminal postscript eps size 20.0,10.0 enhanced color font 'Helvetica,40' linewidth 2
set output "figure-1.eps"
#set tmargin 3
set tics out
set grid x y
set x2label " r_{PRE} – r_{YUMA} "
set xtics  0,2,24
set ylabel "[km]"
set ytics -3,0.5,3
set ytics nomirror
set y2label "[ns]"
set y2tics
set xlabel " t [h] \n\n Sekil-1 PRE-YUMA duzeltme vektorlerinin ( v_X , v_Y , v_Z , v_S [km] ve v_T [ns] ) grafikleri. "
plot \
"figure-1.txt" u 1:2 title "v_X" with lines axes x1y1 linewidth 2 lt rgb "#CC00CC", \
"figure-1.txt" u 1:3 title "v_Y" with lines axes x1y1 linewidth 2 lt rgb "#0055FF", \
"figure-1.txt" u 1:4 title "v_Z" with lines axes x1y1 linewidth 2 lt rgb "#55FF00", \
"figure-1.txt" u 1:5 title "v_S" with lines axes x1y1 linewidth 2 lt rgb "#FF0000", \
"figure-1.txt" u 1:6 title "v_T" with lines axes x1y2 linewidth 2 lt rgb "#FFCC00"
draw.plt ***********************************************************************
```

1) Dosyanın (figure-1.txt) ve draw.plt dosyalarının olduğu dizinde comut satırı açın.
2) Komut satırında, |> gnuplot draw.plt yazın ve çalıştırın. "figure-1.eps" dosyasında aşağıdaki şekil oluşur.

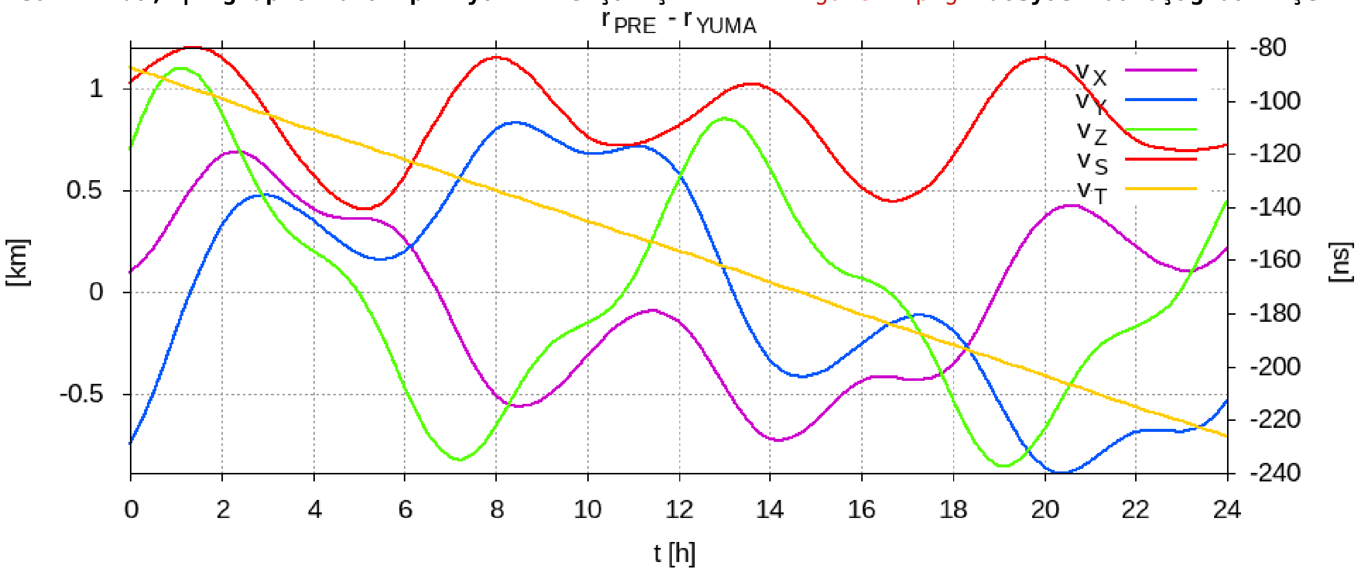


Sekil-1 PRE-YUMA duzeltme vektorlerinin (v_X , v_Y , v_Z , v_S [km] ve v_T [ns]) grafikleri.

12.HRT434 – 4 , Plotting in GnuPlot , (.PNG)

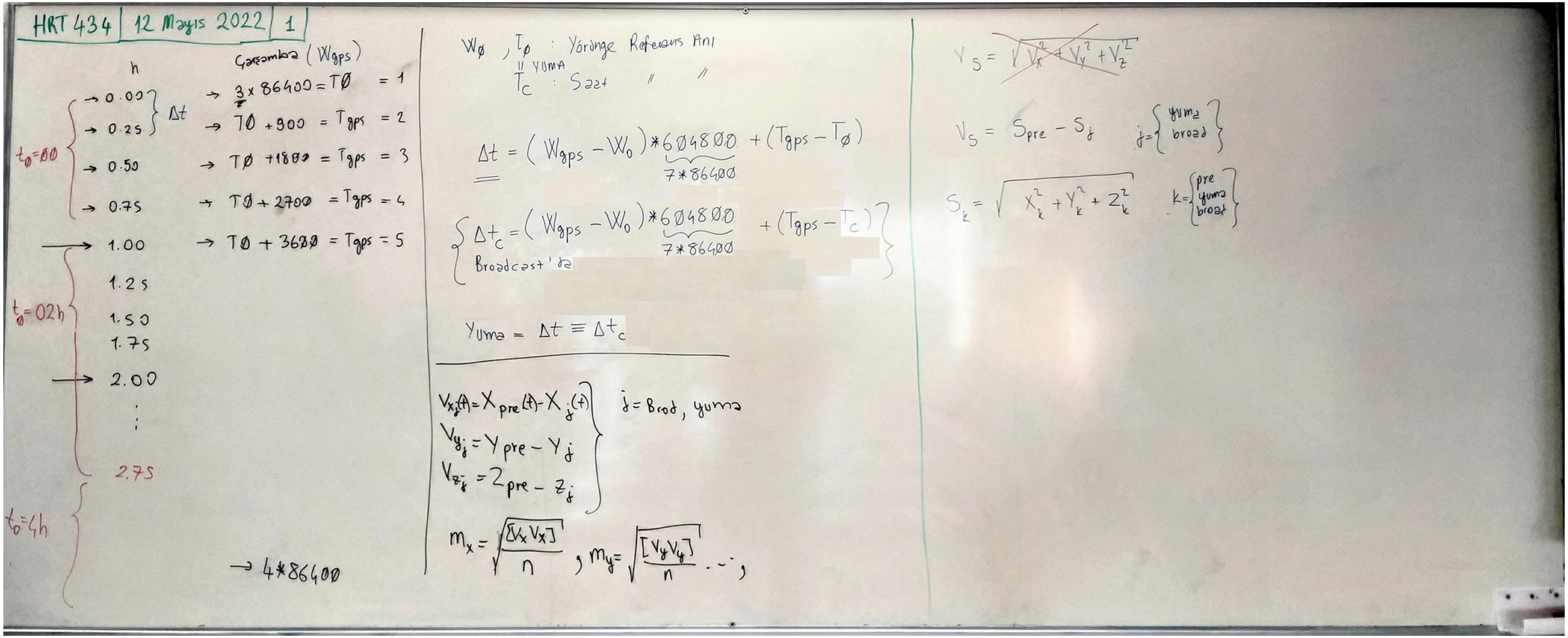
draw_png.plt **
```
# Ploting for HRT434 class in gnuplot.
set term png font arial 14 size 1000,500
set output "figure-1.png"
set tmargin 3
set tics out
set grid x y
set x2label " r_{PRE} – r_{YUMA} "
set xtics 0,2,24
set ylabel "[km]"
set ytics -3,0.5,3
set ytics nomirror
set y2label "[ns]"
set y2tics
set xlabel " t [h] \n Sekil-1 PRE-YUMA duzeltme vektorlerinin ( v_X , v_Y , v_Z , v_S [km] ve v_T [ns] ) grafikleri. "
plot \
"figure-1.txt" u 1:2 title "v_X" with lines axes x1y1 linewidth 2 lt rgb "#CC00CC", \
"figure-1.txt" u 1:3 title "v_Y" with lines axes x1y1 linewidth 2 lt rgb "#0055FF", \
"figure-1.txt" u 1:4 title "v_Z" with lines axes x1y1 linewidth 2 lt rgb "#55FF00", \
"figure-1.txt" u 1:5 title "v_S" with lines axes x1y1 linewidth 2 lt rgb "#FF0000", \
"figure-1.txt" u 1:6 title "v_T" with lines axes x1y2 linewidth 2 lt rgb "#FFCC00"
```
draw.plt **

1) Dosyanın (figure-1.txt) ve draw.plt dosyalarının olduğu dizinde comut satırı açın.
2) Komut satırında, |> gnuplot draw.plt yazın ve çalıştırın. "figure-1.png" dosyasında aşağıdaki şekil oluşur.

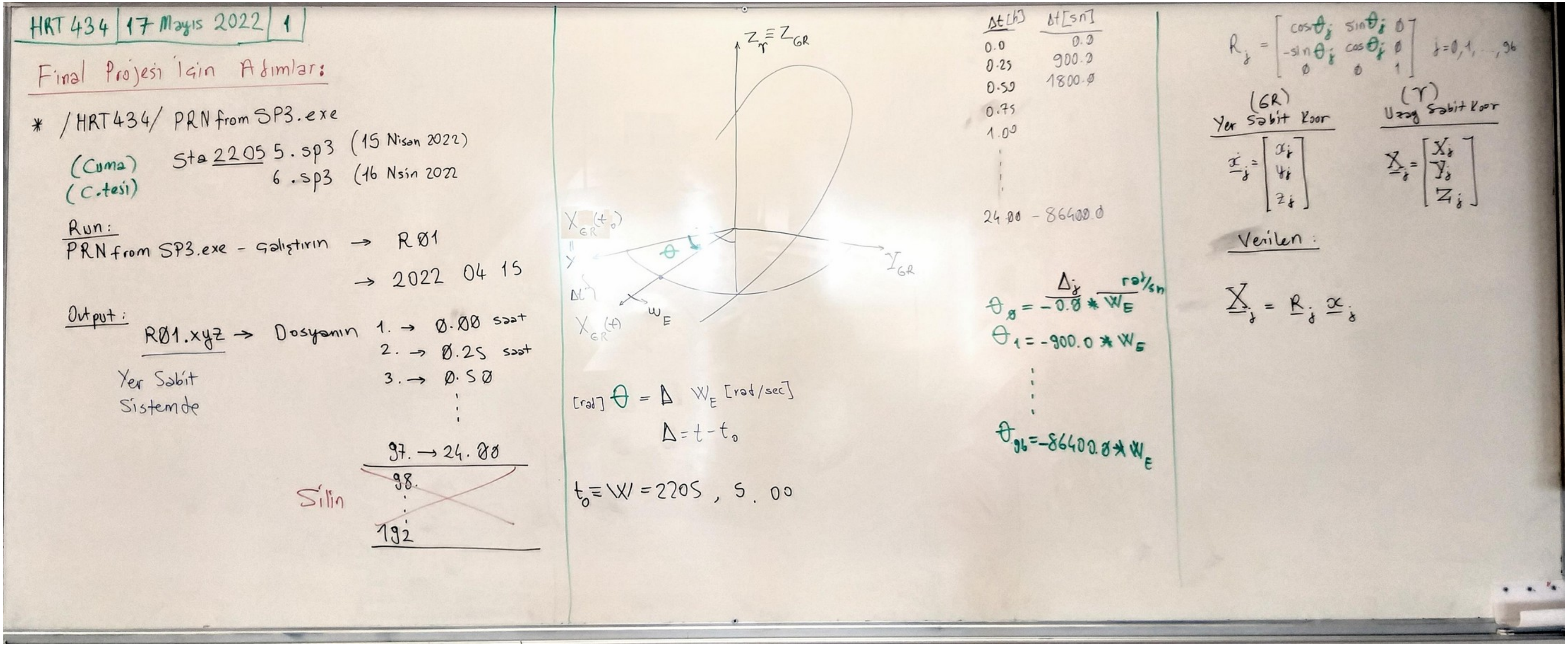


Sekil-1 PRE-YUMA duzeltme vektorlerinin (v_X , v_Y , v_Z , v_S [km] ve v_T [ns]) grafikleri.

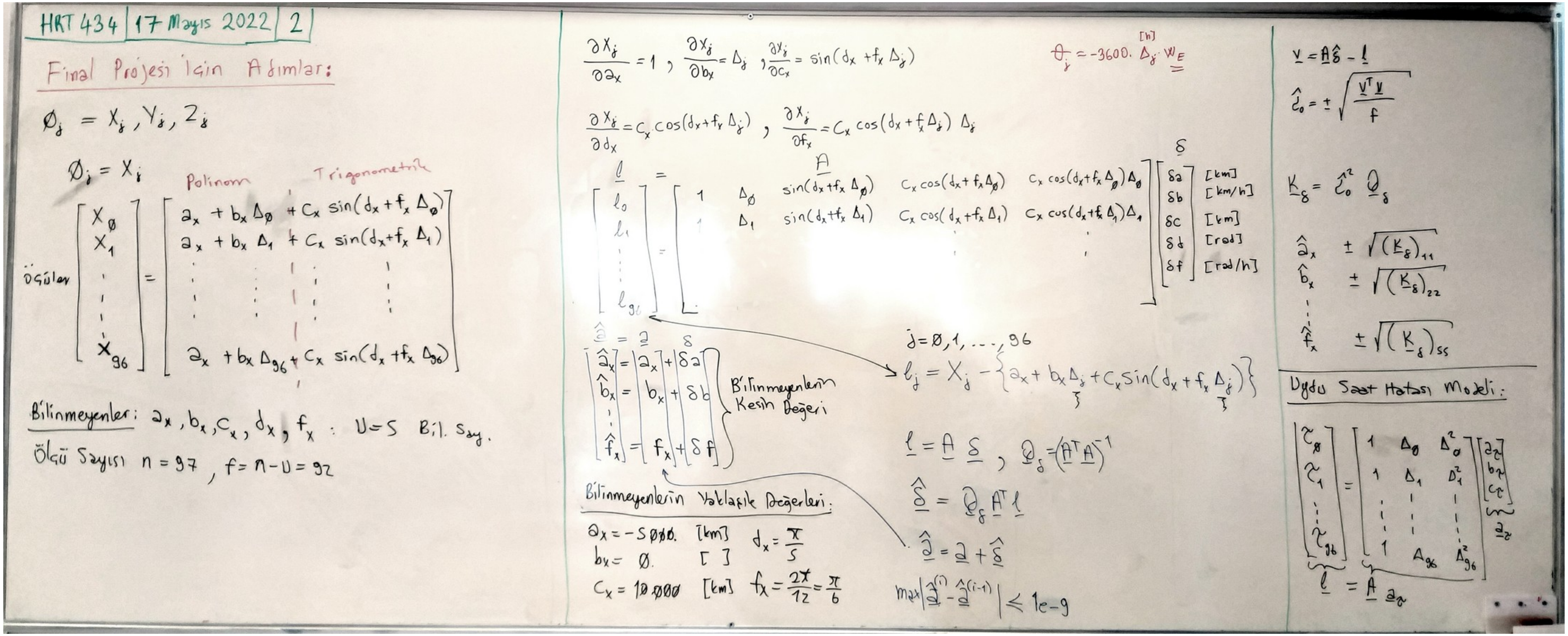
13.HRT434 – 1


HRT 434 | 12 Mayıs 2022 | 1
h
Çarşamba (Wgps)
0.00
0.25
Δt
3 x 86400 = TØ = 1
TØ + 900 = Tgps = 2
TØ + 1800 = Tgps = 3
TØ + 2700 = Tgps = 4
TØ + 3600 = Tgps = 5
tø=00
0.50
0.75
1.00
1.25
tø=02h
1.50
1.75
2.00
2.75
to=4h
4*86400
Wø , Tø : Yörünge Referans Anı
YUMA
Tc : Saat
Δt = (Wgps − W0)*604800 + (Tgps − Tø)
7*86400
Δtc = (Wgps − W0)*604800 + (Tgps − Tc)
7*86400
Broadcast'ta
Yuma = Δt ≡ Δtc
Vxj(t) = Xpre(t) − Xj(t)
Vyj = Ypre − Yj
Vzj = Zpre − Zj
j = Brod, yuma
mx = √([VxVx]/n) , my = √([VyVy]/n) ...,
VS = √(Vx² + Vy² + Vz²)
VS = Spre − Sj
j = { yuma, broad }
Sk = √(Xk² + Yk² + Zk²)
k = { pre, yuma, broad }

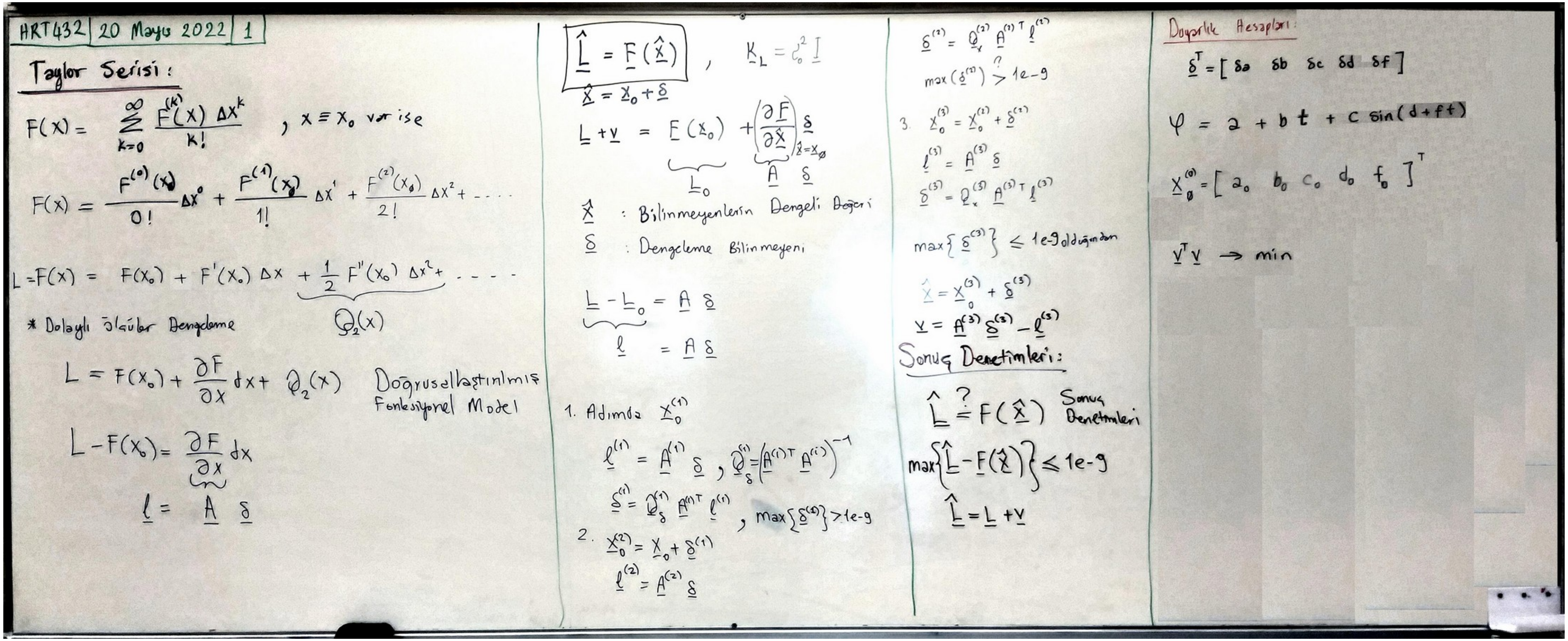
14.HRT434 – 1


HRT 434 | 17 Mayıs 2022 | 1
Final Projesi İçin Adımlar:
* /HRT434/ PRNfromSP3.exe
(Cuma) Sta 2205 5.sp3 (15 Nisan 2022)
(C.tesi) 6.sp3 (16 Nsin 2022
Run:
PRNfromSP3.exe - çalıştırın → R01
→ 2022 04 15
Output:
R01.xyz → Dosyanın
1. → 0.00 saat
2. → 0.25 saat
3. → 0.50
97. → 24.00
98.
192
Yer Sabit Sistemde
Silin
Z_γ ≡ Z_GR
Y_GR
W_E
θ = Δ W_E [rad/sec]
Δ = t - t_0
t_0 = W = 2205 , 5 . 00
Δt[h] Δt[sn]
0.0 0.0
0.25 900.0
0.50 1800.0
0.75
1.00
24.00 - 86400.0
θ_0 = -0.0 * W_E
θ_1 = -900.0 * W_E
θ_96 = -86400.0 * W_E
R_j = [cos θ_j sin θ_j 0; -sin θ_j cos θ_j 0; 0 0 1] j=0,1,...,96
(GR) Yer Sabit Koor
(γ) Uzay Sabit Koor
x_j = [x_j y_j z_j]
X_j = [X_j Y_j Z_j]
Verilen:
X_j = R_j x_j

14.HRT434 – 2


HRT 434 | 17 Mayıs 2022 | 2
Final Projesi İçin Adımlar:
Polinom
Trigonometrik
Ölçüler
Bilinmeyenler: ax, bx, cx, dx, fx : U=5 Bil. Say.
Ölçü Sayısı n = 97 , f = n−U = 92
Bilinmeyenlerin Kesin Değeri
Bilinmeyenlerin Yaklaşık Değerleri:
ax = −5000. [km]
bx = 0. [ ]
cx = 10.000 [km]
dx = π/5
fx = 2π/12 = π/6
[km]
[km/h]
[km]
[rad]
[rad/h]
j = 0, 1, ..., 96
max|â(i) − â(i−1)| ≤ 1e−9
Uydu Saat Hatası Modeli:

15.HRT434 – 1


HRT432 | 20 Mayıs 2022 | 1
Taylor Serisi :
, x ≡ x0 var ise
* Dolaylı ölçüler Dengeleme
Doğrusallaştırılmış Fonksiyonel Model
K_L = σ0² I
: Bilinmeyenlerin Dengeli Değeri
: Dengeleme Bilinmeyeni
1. Adımda
max(δ(2)) ?> 1e-9
max{δ(3)} ≤ 1e-9 olduğundan
Sonuç Denetimleri :
Sonuç Denetimleri
max{L̂ − F(X̂)} ≤ 1e-9
L̂ = L + v
Doğruluk Hesapları :
φ = a + b t + c sin(d + f t)
vᵀv → min