```
%% Q1.1.i
clc;
close all;

r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
myu = 398603; % [km^3/sec^2]
R_E = 6378; % [km]

simulation_time = 864e3; % [sec]
simulation_start_time = 0; % [sec]
simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
integration_step_time = 10; % [sec]

simQ1_1_i = sim("simulink_modelQ1.slx");

[x_sphere, y_sphere, z_sphere] = sphere(30);
x_sphere = x_sphere*R_E;
y_sphere = y_sphere*R_E;
z_sphere = z_sphere*R_E;

fig1 = figure ("Name","The Orbit of the↙
Satellite",'Position',[100 350 900 500]);
hold all
grid on
axis equal

plot3(simQ1_1_i.x.signals.values, simQ1_1_i.y.signals.↙
values, simQ1_1_i.z.signals.values, "LineWidth",2, "Color","↙
#7E2F8E")
s = surf(x_sphere, y_sphere, z_sphere, EdgeColor="none");

title ("The Orbit of the Satellite");
subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
```

```
325021152")
 32 ylabel("y [km]")
 33 xlabel("x [km]")
 34 zlabel("z [km]")
 35
 36 legend({'The Orbit'},'FontSize',11↙
,'Location','northeast')
 37 %exportgraphics(fig1, 'Q1.1grap1.png','Resolution',1200);
 38 disp("Finished Q.1.1.i")
 39 %% Q1.1.ii
 40
 41 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
 42 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
 43 myu = 398603; % [km^3/sec^2]
 44 R_E = 6378; % [km]
 45
 46 simulation_time = 864e3; % [sec]
 47 simulation_start_time = 0; % [sec]
 48 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
 49 integration_step_time = 10; % [sec]
 50
 51 simQ1_1_ii = sim("simulink_modelQ1.slx");
 52 r = [simQ1_1_ii.x.signals.values, simQ1_1_ii.y.signals.↙
values, simQ1_1_ii.z.signals.values];
 53 v = [simQ1_1_ii.x_dot.signals.values, simQ1_1_ii.y_dot.↙
signals.values, simQ1_1_ii.z_dot.signals.values];
 54
 55 epsilon = zeros(length(simQ1_1_ii.x.signals.values),1);
 56 for i = 1:length(simQ1_1_ii.x.signals.values)
 57     epsilon(i) = norm(v(i,:))^2/2 - myu/norm(r(i,:));
 58 end
 59
 60 fig2 = figure ("Name","The Specific Orbital Energy of the↙
Satellite as a Function of Time",'Position',[250 350 900↙
```

```
500]);
 61 hold all
 62 grid on
 63 grid minor
 64
 65 plot(simQ1_1_ii.x.time,epsilon, "LineWidth",2, "Color","↙
#7E2F8E");
 66
 67 title ("The Specific Orbital Energy of the Satellite as a↙
Function of Time");
 68 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
 69 ylabel("epsilon(t) [km^2/sec^2]")
 70 xlabel("t [sec]")
 71
 72 legend({'epsilon(t)'},'FontSize',11↙
,'Location','southeast')
 73 %exportgraphics(fig2, 'Q1.1grap2.png','Resolution',1200);
 74 disp("Finished Q.1.1.ii")
 75 %% Q1.1.iii
 76
 77 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
 78 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
 79 myu = 398603; % [km^3/sec^2]
 80 R_E = 6378; % [km]
 81
 82 simulation_time = 864e3; % [sec]
 83 simulation_start_time = 0; % [sec]
 84 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
 85 integration_step_time = 10; % [sec]
 86
 87 simQ1_1_iii = sim("simulink_modelQ1.slx");
 88 r = [simQ1_1_iii.x.signals.values, simQ1_1_iii.y.signals.↙
values, simQ1_1_iii.z.signals.values];
```

```
 89 v = [simQ1_1_iii.x_dot.signals.values, simQ1_1_iii.y_dot.↙
signals.values, simQ1_1_iii.z_dot.signals.values];
 90
 91 h = zeros(length(simQ1_1_iii.x.signals.values),3);
 92 for i = 1:length(simQ1_1_iii.x.signals.values)
 93     h(i,:) = cross(r(i,:), v(i,:));
 94     i;
 95 end
 96 magintude_h = zeros(length(simQ1_1_iii.x.signals.values),↙
1);
 97 for i = 1:length(simQ1_1_iii.x.signals.values)
 98     magintude_h(i) = norm(h(i,:));
 99     i;
100 end
101
102 fig3 = figure ("Name","The Specific Angular Momentum of↙
the Satellite as a Function of Time",'Position',[400 350 900↙
500]);
103 hold all
104 grid on
105 grid minor
106
107 plot(simQ1_1_iii.x.time,magintude_h, "LineWidth",2,↙
"Color","#7E2F8E");
108
109 title ("The Specific Angular Momentum of the Satellite as↙
a Function of Time");
110 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
111 ylabel("h(t) [km^2/sec]")
112 xlabel("t [sec]")
113
114 legend({'h(t)'},'FontSize',11 ,'Location','southeast')
115 % exportgraphics(fig3, 'Q1.1grap3.png','Resolution',1200);
116 disp("Finished Q.1.1.iii")
```

```
117 %% Q1.1.iv
118
119 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
120 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
121 myu = 398603; % [km^3/sec^2]
122 R_E = 6378; % [km]
123
124 simulation_time = 864e3; % [sec]
125 simulation_start_time = 0; % [sec]
126 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
127 integration_step_time = 10; % [sec]
128
129 simQ1_1_iv = sim("simulink_modelQ1.slx");
130 r = [simQ1_1_iv.x.signals.values, simQ1_1_iv.y.signals.↙
values, simQ1_1_iv.z.signals.values];
131 v = [simQ1_1_iv.x_dot.signals.values, simQ1_1_iv.y_dot.↙
signals.values, simQ1_1_iv.z_dot.signals.values];
132
133 magintude_r = zeros(length(simQ1_1_iv.x.signals.values),↙
1);
134 for i = 1:length(simQ1_1_iv.x.signals.values)
135     magintude_r(i) = norm(r(i,:));
136     i;
137 end
138
139 fig4 = figure ("Name","The Magnitude of r as a Function of↙
Time",'Position',[550 350 900 500]);
140 hold all
141 grid on
142 grid minor
143
144 plot(simQ1_1_iv.x.time,magintude_r, "LineWidth",1.5,↙
"Color","#7E2F8E");
145
```

```
146 title ("The Magnitude of r as a Function of Time");
147 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
148 ylabel("r(t) [km]")
149 xlabel("t [sec]")
150
151 legend({'r(t)'},'FontSize',11 ,'Location','northeast')
152 %exportgraphics(fig4, 'Q1.1grap4.png','Resolution',1200);
153 disp("Finished Q.1.1.iv")
154 %% Q1.1.v
155
156 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
157 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
158 myu = 398603; % [km^3/sec^2]
159 R_E = 6378; % [km]
160
161 simulation_time = 864e3; % [sec]
162 simulation_start_time = 0; % [sec]
163 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
164 integration_step_time = 10; % [sec]
165
166 simQ1_1_v = sim("simulink_modelQ1.slx");
167 r = [simQ1_1_v.x.signals.values, simQ1_1_v.y.signals.↙
values, simQ1_1_v.z.signals.values];
168 v = [simQ1_1_v.x_dot.signals.values, simQ1_1_v.y_dot.↙
signals.values, simQ1_1_v.z_dot.signals.values];
169
170 magintude_v = zeros(length(simQ1_1_v.x.signals.values),1);
171 for i = 1:length(simQ1_1_v.x.signals.values)
172     magintude_v(i) = norm(v(i,:));
173     i;
174 end
175
176 fig5 = figure ("Name","The Magnitude of v as a Function of↙
```

```
Time",'Position',[700 350 900 500]);
177 hold all
178 grid on
179 grid minor
180
181 plot(simQ1_1_v.x.time,magintude_v, "LineWidth",1.5,↙
"Color","#7E2F8E");
182
183 title ("The Magnitude of v as a Function of Time");
184 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
185 ylabel("v(t) [km/sec]")
186 xlabel("t [sec]")
187
188 legend({'v(t)'},'FontSize',11 ,'Location','northeast')
189 %exportgraphics(fig5, 'Q1.1grap5.png','Resolution',1200);
190 disp("Finished Q.1.1.v")
191 %% Q1.1.vi
192
193 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
194 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
195 myu = 398603; % [km^3/sec^2]
196 R_E = 6378; % [km]
197
198 simulation_time = 864e3; % [sec]
199 simulation_start_time = 0; % [sec]
200 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
201 integration_step_time = 10; % [sec]
202
203 simQ1_1_vi = sim("simulink_modelQ1.slx");
204 r = [simQ1_1_vi.x.signals.values, simQ1_1_vi.y.signals.↙
values, simQ1_1_vi.z.signals.values];
205 v = [simQ1_1_vi.x_dot.signals.values, simQ1_1_vi.y_dot.↙
signals.values, simQ1_1_vi.z_dot.signals.values];
```

```
206
207 h = zeros(length(simQ1_1_vi.x.signals.values),3);
208 % for i = 1:length(simQ1_1_vi.x.signals.values)
209 %     h(i,:) = cross(r(i,:), v(i,:));
210 %     i
211 % end
212
213 phi = zeros(length(simQ1_1_vi.x.signals.values),1);
214 for i = 1:length(simQ1_1_vi.x.signals.values)
215     h(i,:) = cross(r(i,:), v(i,:));
216     phi(i) = acos(norm(h(i,:)/(norm(r(i,:)*norm(v↙
(i,:))))));
217     if dot(r(i,:), v(i,:)) < 0
218         phi(i) = -phi(i);
219     end
220     i;
221 end
222
223 fig6 = figure ("Name","The flight path angle φ as a↙
Function of Time",'Position',[100 200 900 500]);
224 hold all
225 grid on
226 grid minor
227
228 plot(simQ1_1_vi.x.time,phi, "LineWidth",1.5, "Color","↙
#7E2F8E");
229
230 title ("The flight path angle φ as a Function of Time");
231 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
232 ylabel("φ(t) [rad]")
233 xlabel("t [sec]")
234
235 legend({'φ(t)'},'FontSize',11 ,'Location','northeast')
236 %exportgraphics(fig6, 'Q1.1grap6.png','Resolution',1200);
```

```
237 disp("Finished Q.1.1.vi")
238 %% Q.1.vii
239
240 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
241 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
242 myu = 398603; % [km^3/sec^2]
243 R_E = 6378; % [km]
244
245 simulation_time = 864e3; % [sec]
246 simulation_start_time = 0; % [sec]
247 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
248 integration_step_time = 10; % [sec]
249
250 simQ1_1_vii = sim("simulink_modelQ1.slx");
251 r = [simQ1_1_vii.x.signals.values, simQ1_1_vii.y.signals.↙
values, simQ1_1_vii.z.signals.values];
252 v = [simQ1_1_vii.x_dot.signals.values, simQ1_1_vii.y_dot.↙
signals.values, simQ1_1_vii.z_dot.signals.values];
253
254 h = zeros(length(simQ1_1_vii.x.signals.values),3);
255 epsilon = zeros(length(simQ1_1_vii.x.signals.values),1);
256 magintude_h = zeros(length(simQ1_1_vii.x.signals.values),↙
1);
257 for i = 1:length(simQ1_1_vii.x.signals.values)
258     h(i,:) = cross(r(i,:), v(i,:));
259     magintude_h(i) = norm(h(i,:));
260     epsilon(i) = norm(v(i,:))^2/2 - myu/norm(r(i,:));
261     i;
262 end
263
264 epsilon_avg = sum(epsilon)/length(epsilon);
265 magintude_h_avg = sum(magintude_h)/length(magintude_h);
266
267 a = -myu/(2*epsilon_avg);
```

```
268 e = sqrt(1+(2*epsilon_avg*magintude_h_avg^2)/(myu^2));
269 disp("Finished Q.1.1.vii")
270 %% Q1.1
271
272 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
273 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
274 myu = 398603; % [km^3/sec^2]
275 R_E = 6378; % [km]
276
277 simulation_time = 864e3; % [sec]
278 simulation_start_time = 0; % [sec]
279 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
280 integration_step_time = 10; % [sec]
281
282 integration_step_time_vector = [300, 200, 100, 50, 10, 1,↙
0.1];
283 colors = ["#0072BD", "#D95319", "#EDB120", "#7E2F8E",↙
"#77AC30", "#4DBEEE", "#A2142F"];
284
285 fig7 = figure ("Name","Convergence Check for Orbital↙
Energy of the Satellite",'Position',[250 200 900 500]);
286 hold all
287 grid on
288 grid minor
289
290 for index = 1:length(integration_step_time_vector)
291     integration_step_time = integration_step_time_vector↙
(index);
292     simQ1_1 = sim("simulink_modelQ1.slx");
293
294     r = [simQ1_1.x.signals.values, simQ1_1.y.signals.↙
values, simQ1_1.z.signals.values];
295     v = [simQ1_1.x_dot.signals.values, simQ1_1.y_dot.↙
signals.values, simQ1_1.z_dot.signals.values];
```

```
296
297     epsilon = zeros(length(simQ1_1.x.signals.values),1);
298     for i = 1:length(simQ1_1.x.signals.values)
299         epsilon(i) = norm(v(i,:))^2/2 - myu/norm(r(i,:));
300     end
301
302     if index == 6
303         plot(simQ1_1.x.time,epsilon,"--", "LineWidth",1.5,↙
"Color",colors(index));
304     elseif index == 7
305         plot(simQ1_1.x.time,epsilon,":", "LineWidth",1.5,↙
"Color",colors(index));
306     else
307         plot(simQ1_1.x.time,epsilon, "LineWidth",1.5,↙
"Color",colors(index));
308     end
309 end
310 title ("Convergence Check for Orbital Energy of the↙
Satellite");
311 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
312 ylabel("epsilon(t) [km^2/sec^2]")
313 xlabel("t [sec]")
314
315 legend({'Integration Step Time = 300', 'Integration Step↙
Time = 200', 'Integration Step Time = 100', 'Integration Step↙
Time = 50', 'Integration Step Time = 10', 'Integration Step↙
Time = 1', 'Integration Step Time = 0.1'},'FontSize',11↙
,'Location','northwest')
316 %exportgraphics(fig7, 'Q1.1grap7.png','Resolution',1200);
317 disp("Finished Q.1.1")
318
319 %% Q1.2.i
320
321 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
```

```
322 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
323 myu = 398603; % [km^3/sec^2]
324 R_E = 6378; % [km]
325 J_2 = 1.082e-3; % [-]
326
327 simulation_time = 864e3; % [sec]
328 simulation_start_time = 0; % [sec]
329 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
330 integration_step_time = 10; % [sec]
331
332 simQ1_2_i = sim("simulink_modelQ1_2.slx");
333
334 r = [simQ1_2_i.x.signals.values, simQ1_2_i.y.signals.↙
values, simQ1_2_i.z.signals.values];
335 v = [simQ1_2_i.x_dot.signals.values, simQ1_2_i.y_dot.↙
signals.values, simQ1_2_i.z_dot.signals.values];
336
337 [x_sphere, y_sphere, z_sphere] = sphere(30);
338 x_sphere = x_sphere*R_E;
339 y_sphere = y_sphere*R_E;
340 z_sphere = z_sphere*R_E;
341
342 fig8 = figure ("Name","The Orbit of the Satellite - No↙
Perfect Sphere",'Position',[400 200 900 500]);
343 hold all
344 grid on
345 axis equal
346
347 plot3(simQ1_2_i.x.signals.values, simQ1_2_i.y.signals.↙
values, simQ1_2_i.z.signals.values, "LineWidth",0.5, "Color","↙
#7E2F8E")
348 s = surf(x_sphere, y_sphere, z_sphere, EdgeColor="none");
349
350 title ("The Orbit of the Satellite - No Perfect Sphere");
```

```
351 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
352 ylabel("y [km]")
353 xlabel("x [km]")
354 zlabel("z [km]")
355
356 legend({'The Orbit - No Perfect Sphere'},'FontSize',11↙
,'Location','northeast')
357 %exportgraphics(fig8, 'Q1.2grap1.png','Resolution',1200);
358 disp("Finished Q.1.2.i")
359
360 %% Q1.2.ii
361
362 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
363 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
364 myu = 398603; % [km^3/sec^2]
365 R_E = 6378; % [km]
366 J_2 = 1.082e-3; % [-]
367
368 simulation_time = 864e3; % [sec]
369 simulation_start_time = 0; % [sec]
370 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
371 integration_step_time = 10; % [sec]
372
373 simQ1_2_ii = sim("simulink_modelQ1_2.slx");
374
375 r = [simQ1_2_ii.x.signals.values, simQ1_2_ii.y.signals.↙
values, simQ1_2_ii.z.signals.values];
376 v = [simQ1_2_ii.x_dot.signals.values, simQ1_2_ii.y_dot.↙
signals.values, simQ1_2_ii.z_dot.signals.values];
377
378 epsilon = zeros(length(simQ1_2_ii.x.signals.values),1);
379 for i = 1:length(simQ1_2_ii.x.signals.values)
380     epsilon(i) = norm(v(i,:))^2/2 - myu/norm(r(i,:));
```

```
381 end
382
383 fig9 = figure ("Name","The Specific Orbital Energy of the↙
Satellite as a Function of Time - No Perfect↙
Sphere",'Position',[550 200 900 500]);
384 hold all
385 grid on
386 grid minor
387
388 plot(simQ1_2_ii.x.time,epsilon, "LineWidth",1, "Color","↙
#7E2F8E");
389
390 title ("The Specific Orbital Energy of the Satellite as a↙
Function of Time - No Perfect Sphere");
391 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
392 ylabel("epsilon(t) [km^2/sec^2]")
393 xlabel("t [sec]")
394
395 legend({'epsilon(t) - No Perfect Sphere'},'FontSize',11↙
,'Location','southeast')
396 %exportgraphics(fig9, 'Q1.2grap2.png','Resolution',1200);
397 disp("Finished Q.1.2.ii")
398
399 %% Q1.2.iii
400 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
401 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
402 myu = 398603; % [km^3/sec^2]
403 R_E = 6378; % [km]
404 J_2 = 1.082e-3; % [-]
405
406 simulation_time = 864e3; % [sec]
407 simulation_start_time = 0; % [sec]
408 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
```

```
409 integration_step_time = 10; % [sec]
410
411 simQ1_2_iii = sim("simulink_modelQ1_2.slx");
412 r = [simQ1_2_iii.x.signals.values, simQ1_2_iii.y.signals.↙
values, simQ1_2_iii.z.signals.values];
413 v = [simQ1_2_iii.x_dot.signals.values, simQ1_2_iii.y_dot.↙
signals.values, simQ1_2_iii.z_dot.signals.values];
414
415 h = zeros(length(simQ1_2_iii.x.signals.values),3);
416 for i = 1:length(simQ1_2_iii.x.signals.values)
417     h(i,:) = cross(r(i,:), v(i,:));
418     i;
419 end
420 magintude_h = zeros(length(simQ1_2_iii.x.signals.values),↙
1);
421 for i = 1:length(simQ1_2_iii.x.signals.values)
422     magintude_h(i) = norm(h(i,:));
423     i;
424 end
425
426 fig10 = figure ("Name","The Specific Angular Momentum of↙
the Satellite as a Function of Time - No Perfect↙
Sphere",'Position',[700 200 900 500]);
427 hold all
428 grid on
429 grid minor
430
431 plot(simQ1_2_iii.x.time,magintude_h, "LineWidth",1,↙
"Color","#7E2F8E");
432
433 title ("The Specific Angular Momentum of the Satellite as↙
a Function of Time - No Perfect Sphere");
434 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
435 ylabel("h(t) [km^2/sec]")
```

```
436 xlabel("t [sec]")
437
438 legend({'h(t) - No Perfect Sphere'},'FontSize',11↙
,'Location','northeast')
439 %exportgraphics(fig10, 'Q1.2grap3.png','Resolution',1200);
440 disp("Finished Q.1.2.iii")
441
442 %% Q1.2.iv
443
444 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
445 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
446 myu = 398603; % [km^3/sec^2]
447 R_E = 6378; % [km]
448 J_2 = 1.082e-3; % [-]
449
450 simulation_time = 864e3; % [sec]
451 simulation_start_time = 0; % [sec]
452 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
453 integration_step_time = 10; % [sec]
454
455 simQ1_2_iv = sim("simulink_modelQ1_2.slx");
456 r = [simQ1_2_iv.x.signals.values, simQ1_2_iv.y.signals.↙
values, simQ1_2_iv.z.signals.values];
457 v = [simQ1_2_iv.x_dot.signals.values, simQ1_2_iv.y_dot.↙
signals.values, simQ1_2_iv.z_dot.signals.values];
458
459 magintude_r = zeros(length(simQ1_2_iv.x.signals.values),↙
1);
460 for i = 1:length(simQ1_2_iv.x.signals.values)
461     magintude_r(i) = norm(r(i,:));
462     i;
463 end
464
465 fig11 = figure ("Name","The Magnitude of r as a Function↙
```

```
of Time - No Perfect Sphere",'Position',[100 50 900 500]);
hold all
grid on
grid minor

plot(simQ1_2_iv.x.time,magintude_r, "LineWidth",1,"Color","#7E2F8E");

title ("The Magnitude of r as a Function of Time - No Perfect Sphere");
subtitle("Almog Dobrescu 214254252 & Ronel Nawy 325021152")
ylabel("r(t) [km]")
xlabel("t [sec]")

legend({'r(t) - No Perfect Sphere'},'FontSize',11,'Location','northeast')
%exportgraphics(fig11, 'Q1.2grap4.png','Resolution',1200);
disp("Finished Q.1.2.iv")

%% Q1.2.v

r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
myu = 398603; % [km^3/sec^2]
R_E = 6378; % [km]
J_2 = 1.082e-3; % [-]

simulation_time = 864e3; % [sec]
simulation_start_time = 0; % [sec]
simulation_end_time = simulation_start_time + simulation_time; % [sec]
integration_step_time = 10; % [sec]

simQ1_2_v = sim("simulink_modelQ1_2.slx");
```

```
495 r = [simQ1_2_v.x.signals.values, simQ1_2_v.y.signals.↙
values, simQ1_2_v.z.signals.values];
496 v = [simQ1_2_v.x_dot.signals.values, simQ1_2_v.y_dot.↙
signals.values, simQ1_2_v.z_dot.signals.values];
497
498 magintude_v = zeros(length(simQ1_2_v.x.signals.values),1);
499 for i = 1:length(simQ1_2_v.x.signals.values)
500     magintude_v(i) = norm(v(i,:));
501     i;
502 end
503
504 fig12 = figure ("Name","The Magnitude of v as a Function↙
of Time - No Perfect Sphere",'Position',[250 50 900 500]);
505 hold all
506 grid on
507 grid minor
508
509 plot(simQ1_2_v.x.time,magintude_v, "LineWidth",1.5,↙
"Color","#7E2F8E");
510
511 title ("The Magnitude of v as a Function of Time - No↙
Perfect Sphere");
512 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
513 ylabel("v(t) [km/sec]")
514 xlabel("t [sec]")
515
516 legend({'v(t) - No Perfect Sphere'},'FontSize',11↙
,'Location','northeast')
517 %exportgraphics(fig12, 'Q1.2grap5.png','Resolution',1200);
518 disp("Finished Q.1.2.v")
519
520 %% Q1.2.vi
521
522 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
```

```
523 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
524 myu = 398603; % [km^3/sec^2]
525 R_E = 6378; % [km]
526 J_2 = 1.082e-3; % [-]
527
528 simulation_time = 864e3; % [sec]
529 simulation_start_time = 0; % [sec]
530 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
531 integration_step_time = 10; % [sec]
532
533 simQ1_2_vi = sim("simulink_modelQ1_2.slx");
534 r = [simQ1_2_vi.x.signals.values, simQ1_2_vi.y.signals.↙
values, simQ1_2_vi.z.signals.values];
535 v = [simQ1_2_vi.x_dot.signals.values, simQ1_2_vi.y_dot.↙
signals.values, simQ1_2_vi.z_dot.signals.values];
536
537 h = zeros(length(simQ1_2_vi.x.signals.values),3);
538 % for i = 1:length(simQ1_1_vi.x.signals.values)
539 %     h(i,:) = cross(r(i,:), v(i,:));
540 %     i
541 % end
542
543 phi = zeros(length(simQ1_2_vi.x.signals.values),1);
544 for i = 1:length(simQ1_2_vi.x.signals.values)
545     h(i,:) = cross(r(i,:), v(i,:));
546     phi(i) = acos(norm(h(i,:)/(norm(r(i,:)*norm(v↙
(i,:))))));
547     if dot(r(i,:), v(i,:)) < 0
548         phi(i) = -phi(i);
549     end
550     i;
551 end
552
553 fig13 = figure ("Name","The flight path angle φ as a↙
```

```
Function of Time - No Perfect Sphere",'Position',[400 50 900↙
500]);
554 hold all
555 grid on
556 grid minor
557
558 plot(simQ1_2_vi.x.time,phi, "LineWidth",1.5, "Color","↙
#7E2F8E");
559
560 title ("The flight path angle φ as a Function of Time - No↙
Perfect Sphere");
561 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
562 ylabel("φ(t) [rad]")
563 xlabel("t [sec]")
564
565 legend({'φ(t) - No Perfect Sphere'},'FontSize',11↙
,'Location','northeast')
566 %exportgraphics(fig13, 'Q1.2grap6.png','Resolution',1200);
567 disp("Finished Q.1.2.vi")
568
569 %% Diff.i
570
571 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
572 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
573 myu = 398603; % [km^3/sec^2]
574 R_E = 6378; % [km]
575 J_2 = 1.082e-3; % [-]
576
577 simulation_time = 864e3; % [sec]
578 simulation_start_time = 0; % [sec]
579 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
580 integration_step_time = 10; % [sec]
581
```

```
582 simQ1_2_i = sim("simulink_modelQ1_2.slx");
583 simQ1_1_i = sim("simulink_modelQ1.slx");
584
585 [x_sphere, y_sphere, z_sphere] = sphere(30);
586 x_sphere = x_sphere*R_E;
587 y_sphere = y_sphere*R_E;
588 z_sphere = z_sphere*R_E;
589
590 fig14 = figure ("Name","The Orbit of the Satellite -↙
Differences",'Position',[550 50 900 500]);
591 hold all
592 grid on
593 axis equal
594
595 plot3(simQ1_2_i.x.signals.values, simQ1_2_i.y.signals.↙
values, simQ1_2_i.z.signals.values, "LineWidth",0.5, "Color","↙
#7E2F8E")
596 s = surf(x_sphere, y_sphere, z_sphere, EdgeColor="none");
597 plot3(simQ1_1_i.x.signals.values, simQ1_1_i.y.signals.↙
values, simQ1_1_i.z.signals.values, "LineWidth",2, "Color","↙
#FF0000")
598
599 title ("The Orbit of the Satellite - Differences");
600 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
601 ylabel("y [km]")
602 xlabel("x [km]")
603 zlabel("z [km]")
604
605 legend({'The Orbit - No Perfect Sphere','The Earth','The↙
Orbit - Perfect Sphere'},'FontSize',11↙
,'Location','northeast')
606 %exportgraphics(fig14, 'Q.Diff_grap1.png','Resolution',↙
1200);
607 disp("Finished Diff.i")
```

```
608
609 %% Diff.ii
610
611 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
612 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
613 myu = 398603; % [km^3/sec^2]
614 R_E = 6378; % [km]
615 J_2 = 1.082e-3; % [-]
616
617 simulation_time = 864e3; % [sec]
618 simulation_start_time = 0; % [sec]
619 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
620 integration_step_time = 10; % [sec]
621
622 simQ1_2_ii = sim("simulink_modelQ1_2.slx");
623 simQ1_1_ii = sim("simulink_modelQ1.slx");
624
625 r1 = [simQ1_1_ii.x.signals.values, simQ1_1_ii.y.signals.↙
values, simQ1_1_ii.z.signals.values];
626 v1 = [simQ1_1_ii.x_dot.signals.values, simQ1_1_ii.y_dot.↙
signals.values, simQ1_1_ii.z_dot.signals.values];
627 r2 = [simQ1_2_ii.x.signals.values, simQ1_2_ii.y.signals.↙
values, simQ1_2_ii.z.signals.values];
628 v2 = [simQ1_2_ii.x_dot.signals.values, simQ1_2_ii.y_dot.↙
signals.values, simQ1_2_ii.z_dot.signals.values];
629
630 epsilon1 = zeros(length(simQ1_1_ii.x.signals.values),1);
631 for i = 1:length(simQ1_1_ii.x.signals.values)
632     epsilon1(i) = norm(v1(i,:))^2/2 - myu/norm(r1(i,:));
633 end
634 epsilon2 = zeros(length(simQ1_2_ii.x.signals.values),1);
635 for i = 1:length(simQ1_2_ii.x.signals.values)
636     epsilon2(i) = norm(v2(i,:))^2/2 - myu/norm(r2(i,:));
637 end
```

```
638
639 fig15 = figure ("Name","The Specific Orbital Energy of the↙
Satellite as a Function of Time - Differences",'Position',[700↙
50 900 500]);
640 hold all
641 grid on
642 grid minor
643
644 plot(simQ1_2_ii.x.time,epsilon2, "LineWidth",1, "Color","↙
#7E2F8E");
645 plot(simQ1_1_ii.x.time,epsilon1, "LineWidth",2, "Color","↙
#FF0000");
646
647 title ("The Specific Orbital Energy of the Satellite as a↙
Function of Time - Differences");
648 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
649 ylabel("epsilon(t) [km^2/sec^2]")
650 xlabel("t [sec]")
651
652 legend({'epsilon(t) - No Perfect Sphere','epsilon(t) -↙
Perfect Sphere'},'FontSize',11 ,'Location','southeast')
653 %exportgraphics(fig15, 'Q.Diff_grap2.png','Resolution',↙
1200);
654 disp("Finished Diff.ii")
655
656 %% Diff.iii
657
658 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
659 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
660 myu = 398603; % [km^3/sec^2]
661 R_E = 6378; % [km]
662 J_2 = 1.082e-3; % [-]
663
664 simulation_time = 864e3; % [sec]
```

```
665 simulation_start_time = 0; % [sec]
666 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
667 integration_step_time = 10; % [sec]
668
669 simQ1_1_iii = sim("simulink_modelQ1.slx");
670 simQ1_2_iii = sim("simulink_modelQ1_2.slx");
671
672 r1 = [simQ1_1_iii.x.signals.values, simQ1_1_iii.y.signals.↙
values, simQ1_1_iii.z.signals.values];
673 v1 = [simQ1_1_iii.x_dot.signals.values, simQ1_1_iii.y_dot.↙
signals.values, simQ1_1_iii.z_dot.signals.values];
674 r2 = [simQ1_2_iii.x.signals.values, simQ1_2_iii.y.signals.↙
values, simQ1_2_iii.z.signals.values];
675 v2 = [simQ1_2_iii.x_dot.signals.values, simQ1_2_iii.y_dot.↙
signals.values, simQ1_2_iii.z_dot.signals.values];
676
677 h1 = zeros(length(simQ1_1_iii.x.signals.values),3);
678 for i = 1:length(simQ1_1_iii.x.signals.values)
679     h1(i,:) = cross(r1(i,:), v1(i,:));
680     i;
681 end
682 h2 = zeros(length(simQ1_2_iii.x.signals.values),3);
683 for i = 1:length(simQ1_2_iii.x.signals.values)
684     h2(i,:) = cross(r2(i,:), v2(i,:));
685     i;
686 end
687
688 magintude_h1 = zeros(length(simQ1_1_iii.x.signals.values),↙
1);
689 for i = 1:length(simQ1_1_iii.x.signals.values)
690     magintude_h1(i) = norm(h1(i,:));
691     i;
692 end
693 magintude_h2 = zeros(length(simQ1_2_iii.x.signals.values),↙
```

```
1);
694 for i = 1:length(simQ1_2_iii.x.signals.values)
695     magintude_h2(i) = norm(h2(i,:));
696     i;
697 end
698
699 fig16 = figure ("Name","The Specific Angular Momentum of↙
the Satellite as a Function of Time - Differences",'Position',↙
[100 350 900 500]);
700 hold all
701 grid on
702 grid minor
703
704 plot(simQ1_2_iii.x.time,magintude_h2, "LineWidth",1,↙
"Color","#7E2F8E");
705 plot(simQ1_1_iii.x.time,magintude_h1, "LineWidth",2,↙
"Color","#FF0000");
706
707 title ("The Specific Angular Momentum of the Satellite as↙
a Function of Time - Differences");
708 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
709 ylabel("h(t) [km^2/sec]")
710 xlabel("t [sec]")
711
712 legend({'h(t) - No Perfect Sphere','h(t) - Perfect↙
Sphere'},'FontSize',11 ,'Location','northeast')
713 %exportgraphics(fig16, 'Q.Diff_grap3.png','Resolution',↙
1200);
714 disp("Finished Diff.iii")
715
716 %% Diff.iv
717
718 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
719 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
```

```
720 myu = 398603; % [km^3/sec^2]
721 R_E = 6378; % [km]
722 J_2 = 1.082e-3; % [-]
723
724 simulation_time = 864e3; % [sec]
725 simulation_start_time = 0; % [sec]
726 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
727 integration_step_time = 10; % [sec]
728
729 simQ1_1_iv = sim("simulink_modelQ1.slx");
730 simQ1_2_iv = sim("simulink_modelQ1_2.slx");
731
732 r1 = [simQ1_1_iv.x.signals.values, simQ1_1_iv.y.signals.↙
values, simQ1_1_iv.z.signals.values];
733 v1 = [simQ1_1_iv.x_dot.signals.values, simQ1_1_iv.y_dot.↙
signals.values, simQ1_1_iv.z_dot.signals.values];
734 r2 = [simQ1_2_iv.x.signals.values, simQ1_2_iv.y.signals.↙
values, simQ1_2_iv.z.signals.values];
735 v2 = [simQ1_2_iv.x_dot.signals.values, simQ1_2_iv.y_dot.↙
signals.values, simQ1_2_iv.z_dot.signals.values];
736
737 magintude_r1 = zeros(length(simQ1_1_iv.x.signals.values),↙
1);
738 for i = 1:length(simQ1_1_iv.x.signals.values)
739     magintude_r1(i) = norm(r1(i,:));
740     i;
741 end
742 magintude_r2 = zeros(length(simQ1_2_iv.x.signals.values),↙
1);
743 for i = 1:length(simQ1_2_iv.x.signals.values)
744     magintude_r2(i) = norm(r2(i,:));
745     i;
746 end
747
```

```
748 fig17 = figure ("Name","The Magnitude of r as a Function↙
of Time - Differences",'Position',[250 350 900 500]);
749 hold all
750 grid on
751 grid minor
752
753 plot(simQ1_2_iv.x.time,magintude_r2, "LineWidth",1.5,↙
"Color","#7E2F8E");
754 plot(simQ1_1_iv.x.time,magintude_r1,":", "LineWidth",1,↙
"Color","#FF0000");
755
756 title ("The Magnitude of r as a Function of Time -↙
Differences");
757 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
758 ylabel("r(t) [km]")
759 xlabel("t [sec]")
760
761 legend({'r(t) - No Perfect Sphere', 'r(t) - Perfect↙
Sphere'},'FontSize',11 ,'Location','northeast')
762 %exportgraphics(fig17, 'Q.Diff_grap4.png','Resolution',↙
1500);
763 disp("Finished Diff.iv")
764
765 %% Diff.v
766
767 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
768 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
769 myu = 398603; % [km^3/sec^2]
770 R_E = 6378; % [km]
771 J_2 = 1.082e-3; % [-]
772
773 simulation_time = 864e3; % [sec]
774 simulation_start_time = 0; % [sec]
775 simulation_end_time = simulation_start_time +↙
```

```
simulation_time; % [sec]
776 integration_step_time = 10; % [sec]
777
778 simQ1_1_v = sim("simulink_modelQ1.slx");
779 simQ1_2_v = sim("simulink_modelQ1_2.slx");
780
781 r1 = [simQ1_1_v.x.signals.values, simQ1_1_v.y.signals.↙
values, simQ1_1_v.z.signals.values];
782 v1 = [simQ1_1_v.x_dot.signals.values, simQ1_1_v.y_dot.↙
signals.values, simQ1_1_v.z_dot.signals.values];
783 r2 = [simQ1_2_v.x.signals.values, simQ1_2_v.y.signals.↙
values, simQ1_2_v.z.signals.values];
784 v2 = [simQ1_2_v.x_dot.signals.values, simQ1_2_v.y_dot.↙
signals.values, simQ1_2_v.z_dot.signals.values];
785
786 magintude_v1 = zeros(length(simQ1_1_v.x.signals.values),↙
1);
787 for i = 1:length(simQ1_1_v.x.signals.values)
788     magintude_v1(i) = norm(v1(i,:));
789     i;
790 end
791 magintude_v2 = zeros(length(simQ1_2_v.x.signals.values),↙
1);
792 for i = 1:length(simQ1_2_v.x.signals.values)
793     magintude_v2(i) = norm(v2(i,:));
794     i;
795 end
796
797 fig18 = figure ("Name","The Magnitude of v as a Function↙
of Time - Differences",'Position',[400 350 900 500]);
798 hold all
799 grid on
800 grid minor
801
802 plot(simQ1_2_v.x.time,magintude_v2, "LineWidth",1.5,↙
```

```
"Color","#7E2F8E");
803 plot(simQ1_1_v.x.time,magintude_v1,":", "LineWidth",1,↙
"Color","#FF0000");
804
805 title ("The Magnitude of v as a Function of Time -↙
Differences");
806 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
807 ylabel("v(t) [km/sec]")
808 xlabel("t [sec]")
809
810 legend({'v(t) - No Perfect Sphere','v(t) - Perfect↙
Sphere'},'FontSize',11 ,'Location','northeast')
811 %exportgraphics(fig18, 'Q.Diff_grap5.png','Resolution',↙
1500);
812 disp("Finished Diff.v")
813
814 %% Diff.vi
815
816 r_0_vector = [-2.1 4.2 6.5]*10^3; % [km]
817 v_0_vector = [-6.8 -1.5 -0.43]; % [km/sec]
818 myu = 398603; % [km^3/sec^2]
819 R_E = 6378; % [km]
820 J_2 = 1.082e-3; % [-]
821
822 simulation_time = 864e3; % [sec]
823 simulation_start_time = 0; % [sec]
824 simulation_end_time = simulation_start_time +↙
simulation_time; % [sec]
825 integration_step_time = 10; % [sec]
826
827 simQ1_1_vi = sim("simulink_modelQ1.slx");
828 simQ1_2_vi = sim("simulink_modelQ1_2.slx");
829
830 r1 = [simQ1_1_vi.x.signals.values, simQ1_1_vi.y.signals.↙
```

```
values, simQ1_1_vi.z.signals.values];
v1 = [simQ1_1_vi.x_dot.signals.values, simQ1_1_vi.y_dot.signals.values, simQ1_1_vi.z_dot.signals.values];
r2 = [simQ1_2_vi.x.signals.values, simQ1_2_vi.y.signals.values, simQ1_2_vi.z.signals.values];
v2 = [simQ1_2_vi.x_dot.signals.values, simQ1_2_vi.y_dot.signals.values, simQ1_2_vi.z_dot.signals.values];

h1 = zeros(length(simQ1_1_vi.x.signals.values),3);
phi1 = zeros(length(simQ1_1_vi.x.signals.values),1);
for i = 1:length(simQ1_1_vi.x.signals.values)
    h1(i,:) = cross(r1(i,:), v1(i,:));
    phi1(i) = acos(norm(h1(i,:)/(norm(r1(i,:)*norm(v1(i,:))))));
    if dot(r1(i,:), v1(i,:)) < 0
        phi1(i) = -phi1(i);
    end
    i;
end
h2 = zeros(length(simQ1_2_vi.x.signals.values),3);
phi2 = zeros(length(simQ1_2_vi.x.signals.values),1);
for i = 1:length(simQ1_2_vi.x.signals.values)
    h2(i,:) = cross(r2(i,:), v2(i,:));
    phi2(i) = acos(norm(h2(i,:)/(norm(r2(i,:)*norm(v2(i,:))))));
    if dot(r2(i,:), v2(i,:)) < 0
        phi2(i) = -phi2(i);
    end
    i;
end

fig19 = figure ("Name","The flight path angle φ as a Function of Time - Differences",'Position',[550 350 900 500]);
hold all
grid on
```

```
859 grid minor
860
861 plot(simQ1_2_vi.x.time,phi2, "LineWidth",1.5, "Color","↙
#7E2F8E");
862 plot(simQ1_1_vi.x.time,phi1,":", "LineWidth",1, "Color","↙
#FF0000");
863
864 title ("The flight path angle φ as a Function of Time -↙
Differences");
865 subtitle("Almog Dobrescu 214254252 & Ronel Nawy↙
325021152")
866 ylabel("φ(t) [rad]")
867 xlabel("t [sec]")
868
869 legend({'φ(t) - No Perfect Sphere','φ(t) - Perfect↙
Sphere'},'FontSize',11 ,'Location','northeast')
870 %exportgraphics(fig19, 'Q.Diff_grap6.png','Resolution',↙
1500);
871 disp("Finished Diff.vi")
872
```