```
clc;

K_gain1 = 13.41;
K_gain2 = 12.034;
p1 = 5.99;
p2 = -10.31;
p3 = -1.876;
z1 = -7.795;
z2 = 5.394;

G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) * tf(1,[1 -p3]));
G2 = (K_gain2 * tf([1 -z1],1) * tf([1 -z2],1)) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) * tf(1,[1 -p3]))*tf(1,[1 0]);

%% Q3.1.
K_gain1 = 13.41;
K_gain2 = 12.034;
p1 = 5.99;
p2 = -10.31;
p3 = -1.876;
z1 = -7.795;
z2 = 5.394;

G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) * tf(1,[1 -p3]));

fig1 = figure ("Name","Q3.1 - Nyquist and Root-Locus of G1",'Position',[100 350 900 500]);

subplot(1,2,1)
grid on
grid minor
nyquist(G1)
title("Nyquist Diagram | "+"Almog Dobrescu 214254252")
```

```
 32 legend({'G1(s)'},'FontSize',11 ,'Location','southeast')
 33
 34 subplot(1,2,2)
 35 grid on
 36 grid minor
 37 rlocus(G1,-G1)
 38 title("Root Locus | "+"Almog Dobrescu 214254252")
 39 legend({'RL','ZARL'},'FontSize',11↙
,'Location','southeast')
 40 %exportgraphics(fig1, '3.1grap1.png','Resolution',1200);
 41
 42 %% Q3.2.
 43
 44 K_gain1 = 13.41;
 45 K_gain2 = 12.034;
 46 p1 = 5.99;
 47 p2 = -10.31;
 48 p3 = -1.876;
 49 z1 = -7.795;
 50 z2 = 5.394;
 51
 52 G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) *↙
tf(1,[1 -p3]));
 53
 54 a = 4;
 55 Cp_PI_no_Kp = tf([1 a],[1 0]);
 56
 57 fig2 = figure ("Name","Q3.2 - Nyquist and Root-Locus of↙
G1*Cp_PI",'Position',[250 350 900 500]);
 58
 59 subplot(1,2,1)
 60 grid on
 61 grid minor
 62 nyquist(G1*Cp_PI_no_Kp)
 63 title("Nyquist Diagram | "+"Almog Dobrescu 214254252")
```

```
 64 legend({'G1*Cp_PI(s)'},'FontSize',11↙
,'Location','southwest')
 65
 66 subplot(1,2,2)
 67 grid on
 68 grid minor
 69 rlocus(G1*Cp_PI_no_Kp,-G1*Cp_PI_no_Kp)
 70 title("Root Locus | "+"Almog Dobrescu 214254252")
 71 legend({'RL','ZARL'},'FontSize',11↙
,'Location','southwest')
 72 %exportgraphics(fig2, '3.2grap1.png','Resolution',1200);
 73
 74 %% Q3.3.
 75
 76 K_gain1 = 13.41;
 77 K_gain2 = 12.034;
 78 p1 = 5.99;
 79 p2 = -10.31;
 80 p3 = -1.876;
 81 z1 = -7.795;
 82 z2 = 5.394;
 83
 84 G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) *↙
tf(1,[1 -p3]));
 85
 86 a = -p3;
 87 Cp_PI_no_Kp = tf([1 a],[1 0]);
 88 % rltool(G1*Cp_PI_no_Kp)
 89 Kp = 5.5;
 90 Cp_PI = Cp_PI_no_Kp*Kp;
 91 Q33_H = G1*Cp_PI/(1+G1*Cp_PI);
 92 Q33_H = minreal(Q33_H,1e-6);
 93 minreal(G1*Cp_PI,1e-6);
 94
 95 t = 0:0.01:7;
```

```
 96 [Q33y, Q33time] = step(Q33_H,t);
 97
 98 fig3 = figure ("Name","Q3.3 - Step Response of Transfer↙
Function From ϕ_ref to ϕ",'Position',[400 350 900 500]);
 99
100 plot(Q33time, Q33y,'LineWidth',2,'Color',"#0072BD")
101
102 grid on
103 grid minor
104 ylabel("ϕ(t) [rad]")
105 xlabel("t [sec]")
106 title("Q3.3 - Step Response of Transfer Function From↙
ϕ_ref to ϕ")
107 subtitle("Almog Dobrescu 214254252")
108 legend({'ϕ/ϕ_ref'},'FontSize',11 ,'Location','southwest')
109 %exportgraphics(fig3, '3.3grap1.png','Resolution',1200);
110
111 fig4 = figure ("Name","Q3.3 - Nyquist of G1*Cp↙
(s)",'Position',[550 350 900 500]);
112
113 nyquist(minreal(G1*Cp_PI,1e-6))
114
115 grid on
116 grid minor
117 title("Nyquist Diagram | Almog Dobrescu 214254252")
118 legend({'G1*Cp(s)'},'FontSize',11 ,'Location','northeast')
119 %exportgraphics(fig4, '3.3grap2.png','Resolution',1200);
120
121 Q33_H2 = Cp_PI/(1+G1*Cp_PI);
122 Q33_H2 = minreal(Q33_H2,1e-6);
123 zpk(Q33_H2);
124 pole(Q33_H2);
125
126 %% Q3.4.
127
```

```
128 K_gain1 = 13.41;
129 K_gain2 = 12.034;
130 p1 = 5.99;
131 p2 = -10.31;
132 p3 = -1.876;
133 z1 = -7.795;
134 z2 = 5.394;
135
136 G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) *↙
tf(1,[1 -p3]));
137
138 a = -p3;
139 Cp_PI_no_Kp = tf([1 a],[1 0]);
140 Kp = 5.5;
141 Cp_PI = Cp_PI_no_Kp*Kp;
142 Q34_H = G1*Cp_PI/(1+G1*Cp_PI);
143 Q34_H = minreal(Q34_H,1e-6);
144 pole(Q34_H);
145
146 %% Q3.5.
147
148 K_gain1 = 13.41;
149 K_gain2 = 12.034;
150 p1 = 5.99;
151 p2 = -10.31;
152 p3 = -1.876;
153 z1 = -7.795;
154 z2 = 5.394;
155
156 G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) *↙
tf(1,[1 -p3]));
157
158 a = -p3;
159 Cp_PI_no_Kp = tf([1 a],[1 0]);
160 Kp = 5.5;
```

```
161 Cp_PI = Cp_PI_no_Kp*Kp;
162 G3 = G1*Cp_PI/(1+G1*Cp_PI);
163 G3 = minreal(G3,1e-6);
164
165 fig5 = figure ("Name","Q3.5 - Bode of G3(s)",'Position',↙
[700 350 900 500]);
166
167 bode(G3)
168
169 grid on
170 grid minor
171 title("Bode Diagram  | Almog Dobrescu 214254252")
172 legend({'G3'},'FontSize',11 ,'Location','northeast')
173 %exportgraphics(fig5, '3.5grap1.png','Resolution',1200);
174
175 tao_ld = 0.108959;
176 alpha_ld = 0.21058;
177 w = 20;
178 s = i*w;
179
180 syms k
181
182 eqn = k*abs((tao_ld*s+1)*(73.75)/((alpha_ld*tao_ld*s+1)*↙
(s^2+4.32*s+12))) == 1;
183 k_ld = double(solve(eqn));
184
185 Cp_ld = k_ld*tf([tao_ld 1],[alpha_ld*tao_ld 1]);
186 Q35_H = Cp_ld*G3/(1+Cp_ld*G3);
187 Q35_H = minreal(Q35_H,1e-6);
188
189 fig6 = figure ("Name","Q3.5 - Bode of G3*Cp_ld↙
(s)",'Position',[100 200 900 500]);
190
191 bode(Cp_ld*G3)
192
```

```
193 grid on
194 grid minor
195 title("Bode Diagram  | Almog Dobrescu 214254252")
196 legend({'G3*Cp_ld(s)'},'FontSize',11↙
,'Location','northeast')
197 %exportgraphics(fig6, '3.5grap2.png','Resolution',1200);
198
199 t = 0:0.001:4;
200 [G3y, G3time] = step(G3,t);
201 [Q35_H_y, Q35_H_time] = step(Q35_H,t);
202
203 fig7 = figure ("Name","Q3.5 - Step Response of the System↙
With and Without the Lead Compensation",'Position',[250 200↙
900 500]);
204 hold all
205
206 step(G3,Q35_H,t)
207
208 grid on
209 grid minor
210 title("Step Response of the System With and Without the↙
Lead Compensation | Almog Dobrescu 214254252")
211 legend({'ϕ/ϕ_ref No Lead Compenstion', 'ϕ/ϕ_ref with Lead↙
Compensation'},'FontSize',11 ,'Location','southeast')
212 %exportgraphics(fig7, '3.5grap3.png','Resolution',1200);
213
214 Q35finle_H = (Cp_PI*Cp_ld) / (1+Cp_PI*G1*(1+Cp_ld));
215 Q35finle_H = minreal(Q35finle_H,1e-6);
216 zpk(Q35finle_H);
217 pole(Q35finle_H);
218 pole(Q35_H);
219
220 %% Q4.1.
221
222 K_gain1 = 13.41;
```

```
223 K_gain2 = 12.034;
224 p1 = 5.99;
225 p2 = -10.31;
226 p3 = -1.876;
227 z1 = -7.795;
228 z2 = 5.394;
229
230 G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) *↙
tf(1,[1 -p3]));
231 G2 = (K_gain2 * tf([1 -z1],1) * tf([1 -z2],1)) * (tf(1,[1↙
-p1]) * tf(1,[1 -p2]) * tf(1,[1 -p3]))*tf(1,[1 0]);
232 a = -p3;
233 Cp_PI_no_Kp = tf([1 a],[1 0]);
234 Kp = 5.5;
235 Cp_PI = Cp_PI_no_Kp*Kp;
236
237 tao_ld = 0.108959;
238 alpha_ld = 0.21058;
239 w = 20;
240 s = i*w;
241 syms k
242 eqn = k*abs((tao_ld*s+1)*(73.75)/((alpha_ld*tao_ld*s+1)*↙
(s^2+4.32*s+12))) == 1;
243 k_ld = double(solve(eqn));
244 Cp_ld = k_ld*tf([tao_ld 1],[alpha_ld*tao_ld 1]);
245
246 G4 = (Cp_PI*Cp_ld*G2) / (1+Cp_PI*G1*(1+Cp_ld));
247 G4 = minreal(G4,1e-6);
248 zpk(G4);
249
250 %% Q4.2.
251
252 K_gain1 = 13.41;
253 K_gain2 = 12.034;
254 p1 = 5.99;
```

```
255 p2 = -10.31;
256 p3 = -1.876;
257 z1 = -7.795;
258 z2 = 5.394;
259
260 G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) *↙
tf(1,[1 -p3]));
261 G2 = (K_gain2 * tf([1 -z1],1) * tf([1 -z2],1)) * (tf(1,[1↙
-p1]) * tf(1,[1 -p2]) * tf(1,[1 -p3]))*tf(1,[1 0]);
262 a = -p3;
263 Cp_PI_no_Kp = tf([1 a],[1 0]);
264 Kp = 5.5;
265 Cp_PI = Cp_PI_no_Kp*Kp;
266
267 tao_ld = 0.108959;
268 alpha_ld = 0.21058;
269 w = 20;
270 s = i*w;
271 syms k
272 eqn = k*abs((tao_ld*s+1)*(73.75)/((alpha_ld*tao_ld*s+1)*↙
(s^2+4.32*s+12))) == 1;
273 k_ld = double(solve(eqn));
274 Cp_ld = k_ld*tf([tao_ld 1],[alpha_ld*tao_ld 1]);
275
276 G4 = (Cp_PI*Cp_ld*G2) / (1+Cp_PI*G1*(1+Cp_ld));
277 G4 = minreal(G4,1e-6);
278
279 fig8 = figure ("Name","Q4.2 - Bode of G4(s)",'Position',↙
[400 200 900 500]);
280
281 bode(G4)
282
283 grid on
284 grid minor
285 title("Bode Diagram  | Almog Dobrescu 214254252")
```

```
286 legend({'G4'},'FontSize',11 ,'Location','northeast')
287 %exportgraphics(fig8, '4.2grap1.png','Resolution',1200);
288
289 alpha_a_ld = 0.21744;
290 tao_a_ld = 0.536127;
291 w = 4*1.1;
292 s = i*w;
293
294 syms k
295
296 eqn = k*abs(((tao_a_ld*s+1) / ((alpha_a_ld*tao_a_ld*s+1))*↙
((777.4*(s-5.934)*(s+7.795)*(s+9.178))/(s^2*(s+14.6)*(s^2+33.↙
3*s+580.3))))) == 1;
297 k_a_ld = double(solve(eqn));
298
299 Ca_ld = -k_a_ld*tf([tao_a_ld 1],[alpha_a_ld*tao_a_ld 1]);
300
301 fig9 = figure ("Name","Q4.2 - Bode of G4*Ca_ld↙
(s)",'Position',[550 200 900 500]);
302
303 bode(minreal(G4*Ca_ld,1e-6))
304
305 grid on
306 grid minor
307 title("Bode Diagram  | Almog Dobrescu 214254252")
308 legend({'G4*Ca_ld(s)'},'FontSize',11↙
,'Location','northeast')
309 %exportgraphics(fig9, '4.2grap2.png','Resolution',1200);
310
311 Q42_H = G4*Ca_ld/(1+G4*Ca_ld);
312 Q42_H = minreal(Q42_H,1e-6);
313
314 fig10 = figure ("Name","Q4.2 - Bode of↙
Θ/Θ_ref",'Position',[700 200 900 500]);
315
```

```
316 bode(Q42_H)
317
318 grid on
319 grid minor
320 title("Bode Diagram  | Almog Dobrescu 214254252")
321 legend({'Θ/Θ_ref'},'FontSize',11 ,'Location','northeast')
322 %exportgraphics(fig10, '4.2grap3.png','Resolution',1200);
323
324 %% Q4.4.
325
326 K_gain1 = 13.41;
327 K_gain2 = 12.034;
328 p1 = 5.99;
329 p2 = -10.31;
330 p3 = -1.876;
331 z1 = -7.795;
332 z2 = 5.394;
333
334 G1 = tf([K_gain1 0],1) * (tf(1,[1 -p1]) * tf(1,[1 -p2]) *↙
tf(1,[1 -p3]));
335 G2 = (K_gain2 * tf([1 -z1],1) * tf([1 -z2],1)) * (tf(1,[1↙
-p1]) * tf(1,[1 -p2]) * tf(1,[1 -p3]))*tf(1,[1 0]);
336 a = -p3;
337 Cp_PI_no_Kp = tf([1 a],[1 0]);
338 Kp = 5.5;
339 Cp_PI = Cp_PI_no_Kp*Kp;
340
341 tao_ld = 0.108959;
342 alpha_ld = 0.21058;
343 w = 20;
344 s = i*w;
345 syms k
346 eqn = k*abs((tao_ld*s+1)*(73.75)/((alpha_ld*tao_ld*s+1)*↙
(s^2+4.32*s+12))) == 1;
347 k_ld = double(solve(eqn));
```

```
348 Cp_ld = k_ld*tf([tao_ld 1],[alpha_ld*tao_ld 1]);
349
350 G4 = (Cp_PI*Cp_ld*G2) / (1+Cp_PI*G1*(1+Cp_ld));
351 G4 = minreal(G4,1e-6);
352
353 alpha_a_ld = 0.21744;
354 tao_a_ld = 0.536127;
355 w = 4*1.1;
356 s = i*w;
357
358 syms k
359
360 eqn = k*abs(((tao_a_ld*s+1) / ((alpha_a_ld*tao_a_ld*s+1))*↙
((777.4*(s-5.934)*(s+7.795)*(s+9.178))/(s^2*(s+14.6)*(s^2+33.↙
3*s+580.3))))) == 1;
361 k_a_ld = double(solve(eqn));
362
363 Ca_ld = -k_a_ld*tf([tao_a_ld 1],[alpha_a_ld*tao_a_ld 1]);
364
365 Q44_sim = sim("Q43_sim.slx");
366
367 fig11 = figure ("Name","Q4.4 - Plots of the Response of↙
the System to Θ_r_e_f(t)",'Position',[100 50 900 500]);
368
369 subplot(1,2,1)
370 hold all
371
372 plot(Q44_sim.Theta.time, Q44_sim.Theta.signals.↙
values,'LineWidth',1.5,'Color',"#0072BD")
373 plot(Q44_sim.Phi.time, Q44_sim.Phi.signals.↙
values,'LineWidth',1.5,'Color',"#A2142F")
374 plot(Q44_sim.Phi_ref.time, Q44_sim.Phi_ref.signals.↙
values,':','LineWidth',2,'Color',"#77AC30")
375
376 grid on
```

```
377 grid minor
378 ylabel("Amplitude [rad]")
379 xlabel("t [sec]")
380 title("Q4.4 - Plots of the Response of the System to↙
Θ_r_e_f(t)")
381 subtitle("Almog Dobrescu 214254252")
382 legend({'Θ(t)', 'ϕ(t)', 'ϕ_r_e_f(t)'},'FontSize',11↙
,'Location','northeast')
383
384 subplot(1,2,2)
385 hold all
386
387 plot(Q44_sim.u.time, Q44_sim.u.signals.values,'LineWidth',↙
1.5,'Color',"#0072BD")
388
389 grid on
390 grid minor
391 ylabel("u(t) [rad]")
392 xlabel("t [sec]")
393 title("Q4.4 - Plot of the Response of u(t) to Θ_r_e_f(t)")
394 subtitle("Almog Dobrescu 214254252")
395 legend({'u(t)'},'FontSize',11 ,'Location','northeast')
396
397 %exportgraphics(fig11, '4.4grap1.png','Resolution',1200);
```