% preparation

% 4.2 a)

M = 1 / 17.13;

K\_p = 2.46\*M;

A = [0 1;0 -1/M];

B = [0;K\_p/M];

C = [1 0];

D = 0;

T = 0.1;

[A\_d, B\_d] = c2d(A,B,T)

A\_d = 2×2

1.0000 0.0479

0 0.1803

B\_d = 2×1

0.0075

0.1177

% 4.2 b)

Qc = [B A\*B]

Qc = 2×2

0 2.4600

2.4600 -42.1398

rank\_Qc = rank(Qc)

rank\_Qc = 2

% 4.2 c)

Qo = [C;C\*A]

Qo = 2×2

1 0

0 1

rank\_Qo = rank(Qo)

rank\_Qo = 2

% 4.2 d)

K\_d = acker(A\_d, B\_d,[0.3, 0.4])

K\_d = 1×2

35.6804 1.8104

% 4.2 e)

L\_d = (acker(A\_d.', C.', [0.3, 0.4])).'

L\_d = 2×1

0.4803

0.5494

Ad\_hat\_100 = A\_d - L\_d\*C

Ad\_hat\_100 = 2×2

0.5197 0.0479

-0.5494 0.1803

Bd\_hat\_100 = [B\_d L\_d]

Bd\_hat\_100 = 2×2

0.0075 0.4803

0.1177 0.5494

% 4.2 f)

% DIGITAL CONTROLLERS

% controller for T = 100ms is seen above

% T = 10ms

T=0.01;

[A\_d\_10, B\_d\_10] = c2d(A,B,T);

K\_d\_10 = acker(A\_d\_10, B\_d\_10,[0.3, 0.4])

K\_d\_10 = 1×2

103 ×

1.8577 0.0410

L\_d\_10 = (acker(A\_d\_10.', C.', [0.3, 0.4])).'

L\_d\_10 = 2×1

1.1426

26.1277

Ad\_hat\_10 = A\_d\_10 - L\_d\_10\*C

Ad\_hat\_10 = 2×2

-0.1426 0.0092

-26.1277 0.8426

Bd\_hat\_10 = [B\_d\_10 L\_d\_10]

Bd\_hat\_10 = 2×2

0.0001 1.1426

0.0226 26.1277

% T = 20ms

T=0.02;

[A\_d\_20, B\_d\_20] = c2d(A,B,T);

K\_d\_20 = acker(A\_d\_20, B\_d\_20,[0.3, 0.4])

K\_d\_20 = 1×2

504.1119 18.9151

L\_d\_20 = (acker(A\_d\_20.', C.', [0.3, 0.4])).'

L\_d\_20 = 2×1

1.0099

7.5023

Ad\_hat\_20 = A\_d\_20 - L\_d\_20\*C

Ad\_hat\_20 = 2×2

-0.0099 0.0169

-7.5023 0.7099

Bd\_hat\_20 = [B\_d\_20 L\_d\_20]

Bd\_hat\_20 = 2×2

0.0004 1.0099

0.0417 7.5023

% T = 50ms

T=0.05;

[A\_d\_50, B\_d\_50] = c2d(A,B,T);

K\_d\_50 = acker(A\_d\_50, B\_d\_50,[0.3, 0.4])

K\_d\_50 = 1×2

101.6638 5.8702

L\_d\_50 = (acker(A\_d\_50.', C.', [0.3, 0.4])).'

L\_d\_50 = 2×1

0.7246

0.0915

Ad\_hat\_50 = A\_d\_50 - L\_d\_50\*C

Ad\_hat\_50 = 2×2

0.2754 0.0336

-0.0915 0.4246

Bd\_hat\_50 = [B\_d\_50 L\_d\_50]

Bd\_hat\_50 = 2×2

0.0024 0.7246

0.0826 0.0915

% CONTINUOUS-TIME CONTROLLERS

K\_ct = acker(A, B, [0.3, 0.4])

K\_ct = 1×2

0.0488 -7.2480

L\_ct = (acker(A.', C.', [0.3 0.4])).'

L\_ct = 2×1

-17.8300

305.5479

% discretizing the observer

% Euler discretization scheme

T=0.1;

A\_hat = A - L\_ct\*C;

B\_hat = [B L\_ct];

A\_d\_hat = eye(2) + T\*A\_hat

A\_d\_hat = 2×2

2.7830 0.1000

-30.5548 -0.7130

B\_d\_hat = T\*B\_hat

B\_d\_hat = 2×2

0 -1.7830

0.2460 30.5548

C\_d\_hat = eye(2)

C\_d\_hat = 2×2

1 0

0 1

D\_d\_hat = [0 0; 0 0]

D\_d\_hat = 2×2

0 0

0 0

Chart

Description automatically generated

As T increases, the time taken for convergence to the equilibrium position (30cm) increases.

Chart

Description automatically generated

As T increases, the overshoot in velocity decreases. However, the time taken for convergence to zero increases.

The observed positions and velocities for each sampling time T were identical to the real positions and velocities.

% 5.2

clear

M = 1 / 17.13;

K\_p = 2.46\*M;

A\_hat = [0 1 0 0;0 -1/M 0 0;0 0 0 -1;0 0 1 0];

B\_hat = [0;K\_p/M;0;0];

T = 0.1;

[Ad\_hat, Bd\_hat] = c2d(A\_hat,B\_hat,T)

Ad\_hat = 4×4

1.0000 0.0479 0 0

0 0.1803 0 0

0 0 0.9950 -0.0998

0 0 0.0998 0.9950

Bd\_hat = 4×1

0.0075

0.1177

0

0

F1 = -acker(Ad\_hat(1:2,1:2),Bd\_hat(1:2,:), [0.3, 0.4])

F1 = 1×2

-35.6804 -1.8104