CMA test S2B

Weighting: 15%

This is summative test S2B covering Modules 1 – 9 of the course ELE2101 – *Control and Instrumentation*.

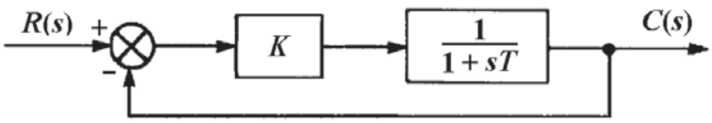
Before you attempt this assessment you should have attempted formative CMA test F3.

This assessment has 50 CMA multiple-choice questions to be attempted.

STUDENTS PLEASE NOTE:

This computer marked assessment available from the course Study Desk allows you to work interactively on your computer and receive FEEDBACK AND RESULTS within a week of the due date

QUESTION 1



For the closed-loop control system shown above the gain, *K*, is changed from 1 to 10. The effect on the closed-loop system time constant will be to:

(1) leave it unchanged

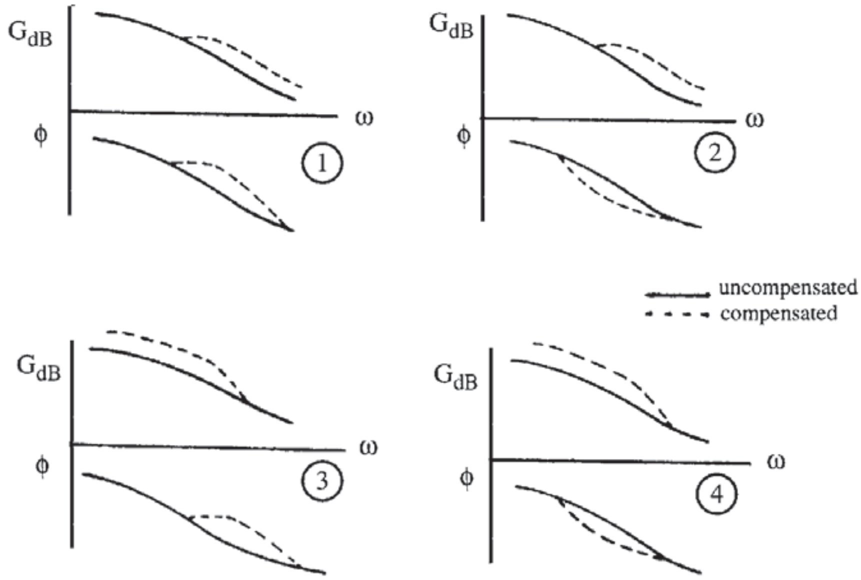
(2) increase it by a factor of 10

(3) decrease it by a factor of 10

(4) decrease it by a factor of 5.5

(5) increase it by a factor of 5.5

QUESTION 2



The diagrams above show four Bode plots of uncompensated and compensated performance for a particular control system. Which diagram shows the effects of adding **phase-lag** compensation?

(1) the diagram labelled 1

(2) the diagram labelled 2

(3) the diagram labelled 3

(4) the diagram labelled 4

QUESTION 3

A **phase-lead** compensator could be added to a control system when it is desirable to:

(1) improve the steady-state accuracy

(2) speed up the system response

(3) improve the system stability margin(s)

(4) both (1) and (3) above

(5) both (2) and (3) above

QUESTION 4

Part(s) of the characteristics of an 'ideal' controller can best be described as:

(1) high gain at low frequencies to reduce steady-state errors

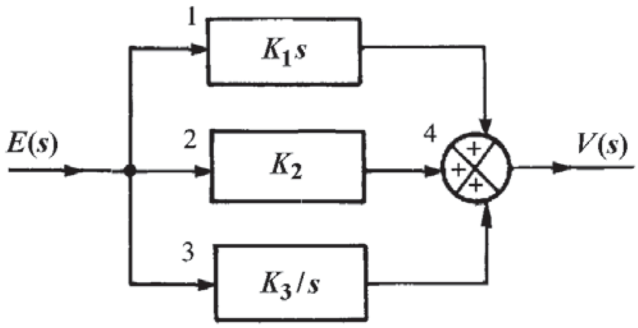
(2) high gain at mid frequencies for rapid response to transient changes

(3) low gain at high frequencies so that oscillations (overshoots) die out rapidly

(4) all of the above

(5) none of the above

QUESTION 5



The diagram above shows a block diagram of a three-term controller. Which one of the blocks corresponds to the **derivative action** term?

(1) the block labelled 1

(2) the block labelled 2

(3) the block labelled 3

(4) the block labelled 4

(5) none of the above

QUESTION 6

The major advantage(s) of pneumatic control systems over hydraulic control systems is/are:

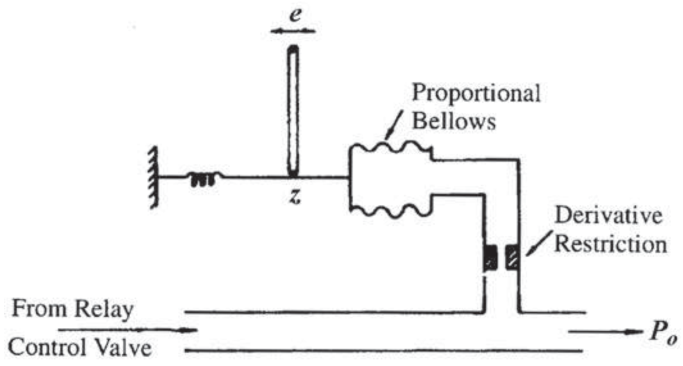
(1) air is not flammable

(2) air, being compressible, is easier to control

(3) air can be recycled more easily

(4) all of the above

QUESTION 7



A pneumatic P-D controller is shown in the diagram above. This controller is being used to control an output that shows excessive overshoot. To decrease this overshoot it would be best to:

(1) reduce the opening through the derivative restriction

(2) increase the opening through the derivative restriction

(3) reduce the 'stiffness' of the bellows

(4) increase the overall supply pressure

QUESTION 8

The same pneumatic P-D controller as in question 7, is in use. To reduce the controller output pressure it would be best to:

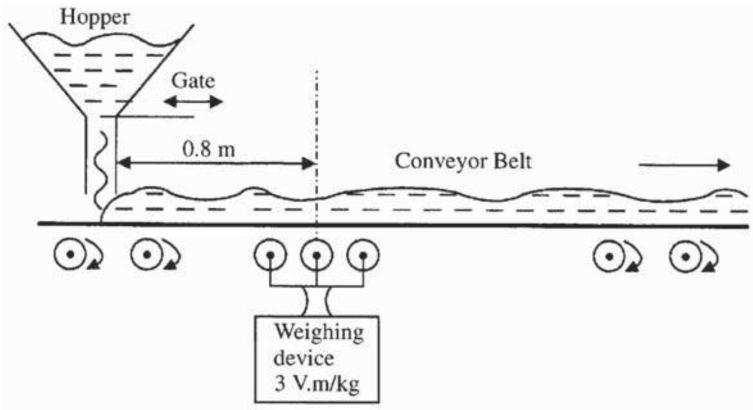
(1) reduce the opening through the derivative restriction

(2) increase the opening through the derivative restriction

(3) reduce the 'stiffness' of the bellows

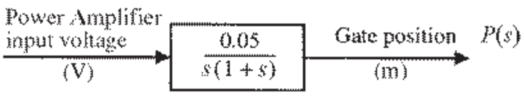
(4) increase the overall supply pressure

Data for questions 9–11



The above system is meant to control the amount of material (mass/unit length) being fed onto a conveyor belt moving at a speed of 1.2 m/s.

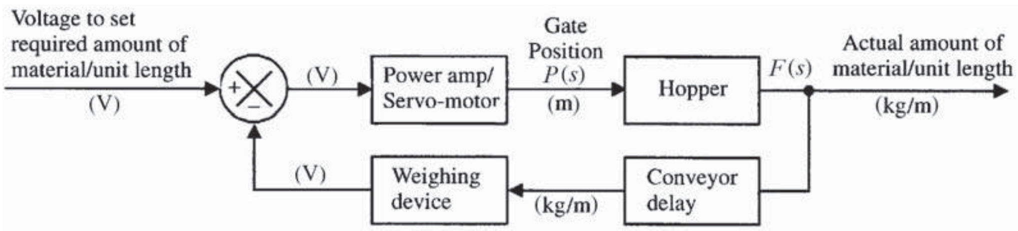
The hopper gate can be opened or closed by a power amplifier/servo-motor combination driving through a rack-and-pinion arrangement. The transfer function of this part of the system is:



The relationship between gate position, P, and the rate of deposition of material on the conveyor belt, F, is:

$$\text{Hopper TF}(s) = \frac{F(s)}{P(s)} = 5 \text{ kg/m}^2$$

The system can be represented by the following block diagram:



Sketch, on 4-cycle semi-log graph paper, the open-loop Bode plot for this conveyor-belt system and answer the following questions 9 – 20.

Scales for the Bode plot: 20 mm ≡ 10 dB;   60 mm ≡ 90°.

A pair of dividers and a flexicurve are useful tools for plotting the phase response accurately.

QUESTION 9

The time delay between material being fed onto the conveyor belt and arriving at the weighing station is:

(1) there is no delay

(2) 0.67 s

(3) 0.80 s

(4) 0.96 s

(5) 1.20 s

QUESTION 10

The direct transmission gain of the system is:

(1) $\frac{0.05}{s(1+s)}$

(2) $\frac{0.15}{s(1+s)}$

(3) $\frac{0.25}{s(1+s)}$

(4) $\frac{0.06}{s(1+s)}$

(5) $\frac{0.75}{s(1+s)}$

QUESTION 11

The loop gain of the system (expressing any time delay as τ seconds) is:

(1) $\frac{0.05}{s(1+s)}e^{-s\tau}$

(2) $\frac{0.15}{s(1+s)}e^{-s\tau}$

(3) $\frac{0.25}{s(1+s)}e^{-s\tau}$

(4) $\frac{0.06}{s(1+s)}e^{-s\tau}$

(5) $\frac{0.75}{s(1+s)}e^{-s\tau}$

Data for questions 12–14

The following questions 12 – 14 refer to the open-loop Bode plot for the system given.

QUESTION 12

The gain cross-over frequency for this system is best estimated as:

(1) not specified: the gain is always less than 0 dB
(2) 0.75 rad/s
(3) 0.9 rad/s
(4) 1 rad/s
(5) 1.2 rad/s

QUESTION 13

The open-loop system phase margin is best estimated as:

(1) 17°
(2) 21°
(3) 50°
(4) 90°
(5) 120°

QUESTION 14

The gain margin of the system is best estimated as:

(1) 4 dB
(2) 17 dB
(3) 20 dB
(4) 23 dB
(5) 40 dB

Data for questions 15–17

The system is assumed to be running as a closed-loop system.

A step change of size 5 units (volts) is made in the required amount of material/unit-length setting.

The following questions 15 – 17 refer to the effects of this change.

QUESTION 15

The system response would be best described as:

(1) sluggish
(2) almost critically damped
(3) slightly underdamped
(4) lightly damped
(5) unstable

QUESTION 16

The amount of peak-percentage overshoot exhibited by the system would best be estimated as:

(1) none
(2) 20%
(3) 40%
(4) 60%
(5) 100%

QUESTION 17

The change in the actual amount of material per unit length will be:

(1) 0
(2) 1.25 kg/m
(3) 1.67 kg/m
(4) 3.0 kg/m
(5) 5.0 kg/m

Data for questions 18–20

A change in the plant layout means the weighing station has to be shifted 0.3 m further away from the hopper.

QUESTION 18

Which one of the following statements best expresses the effect of this change on the control system performance?

(1) There will be no change in system performance.

(2) The overall system performance will be improved.

(3) The overall system performance will be made worse.

QUESTION 19

The change in plant layout mentioned in question 18 has been made.

The system is required to respond to changes with less overshoot.

Which one of the following options would be the best to choose?

(1) P-I control

(2) P-I-D control

(3) proportional control

(4) phase-lead compensation

(5) phase-lag compensation

QUESTION 20

A fault causes the conveyor belt to suddenly run at a lower speed.

Which one of the following statements best describes the response of the system to this fault?

(1) Less material/unit length is delivered.

(2) More material/unit length is delivered.

(3) There should be no long-term change in the rate of material delivery.

Data for question 21

A unity-feedback temperature-control system has the following open-loop transfer function:

$$HG(s) = \frac{K}{(1+sT)^3} \quad T = 1 \text{ second}$$

Sketch the open-loop Bode plot for this system using the following scales:

60 mm ≡1 decade;   20 mm ≡ 10 dB;   40 mm ≡ 90°.

Hints:

1. As a first step, sketch the straight-line approximations to the Bode plot.
2. At the corner frequency, compared with the actual gain response, the straight-line approximation to the gain response has an error of 3 dB per order of the system. Sketch the **actual** gain response; but use the straight-line approximation to the phase response.

QUESTION 21

From the Bode plot, the value of *K* required to give an open-loop phase margin of 60° is estimated as:

(1) 1.4

(2) 2.2

(3) 2.8

(4) 12.6

(5) none of the above

Data for questions 22–27

The system gain is adjusted to the value of K estimated in question 21.

The following questions 22 – 27 refer to the Bode-plot sketch for this value of system gain.

QUESTION 22

The best estimate of the gain cross-over frequency is:

(1) 0.7 rad/s
(2) 0.8 rad/s
(3) 0.9 rad/s
(4) 1.0 rad/s
(5) not defined

QUESTION 23

The gain margin of the open-loop system is estimated as:

(1) 6 dB
(2) 9 dB
(3) 16 dB
(4) 22 dB
(5) not defined

QUESTION 24

The peak time for the system time response to a step input is estimated as:

(1) There would be no oscillation, and hence no peak time, for this value of K
(2) 0.5 s
(3) 1.3 s
(4) 3.9 s
(5) 7.9 s

QUESTION 25

The settling time for the system time response to a step input is estimated as:

(1) 1.25 s
(2) 6.7 s
(3) 7.9 s
(4) 8.3 s
(5) none of the above

QUESTION 26

The phase lag of the system at a frequency of 1 Hz is estimated as:

(1) –65°

(2) –135°

(3) –160°

(4) –245°

(5) –270°

QUESTION 27

For a step input of 15 units, the closed-loop-system steady-state output is:

(1) 10.3 units

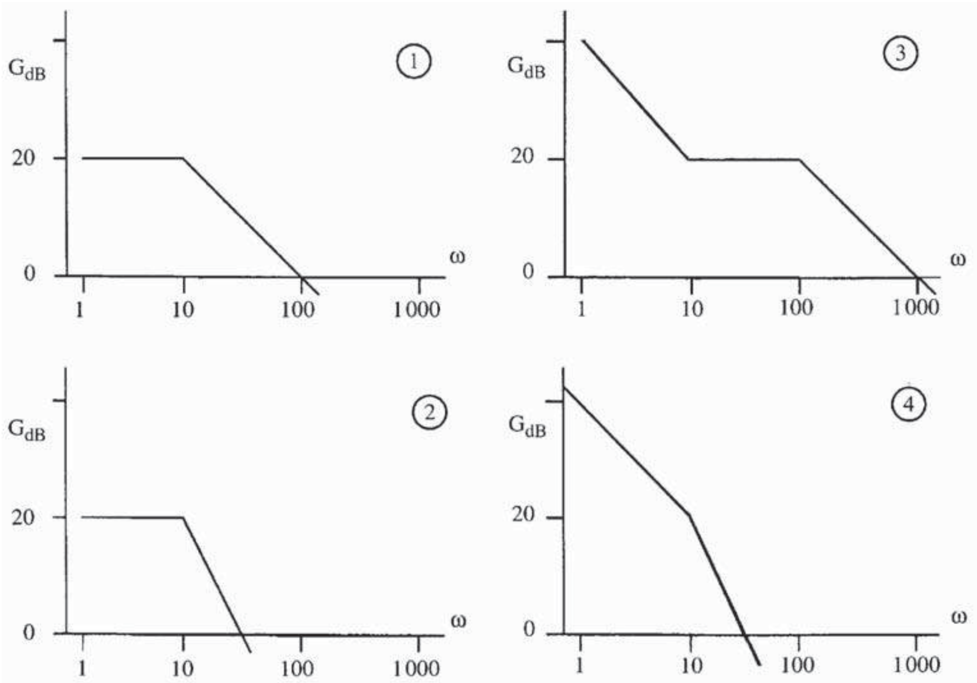
(2) 15 units

(3) 30 units

(4) 33 units

(5) none of the above

QUESTION 28



Four Bode gain plots are shown above. Which one of the four plots would be that of a system with a loop gain of

$$\frac{10}{(1+0.1s)^2}?$$

(1) the plot labelled 1

(2) the plot labelled 2

(3) the plot labelled 3

(4) the plot labelled 4

(5) none of the 4 plots

QUESTION 29

Which one of the four plots shown in question 28 would be that of a system with a loop gain of

$$\frac{100(1+0.1s)}{s(1+0.3s)}?$$

(1) the plot labelled 1

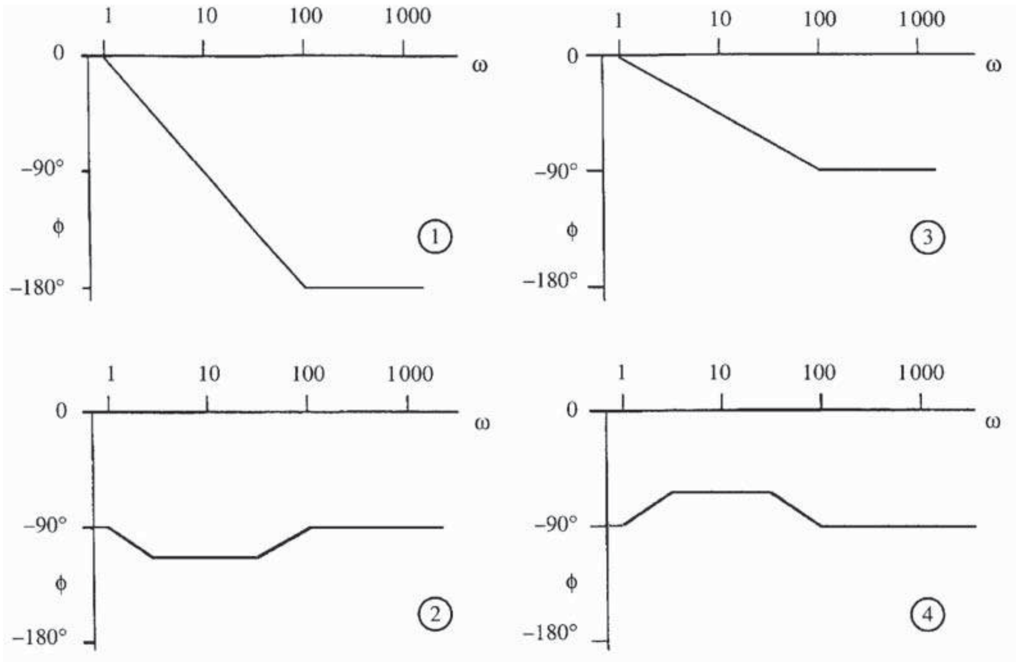
(2) the plot labelled 2

(3) the plot labelled 3

(4) the plot labelled 4

(5) none of the 4 plots

QUESTION 30



Four Bode phase plots are shown above. Which one of the four plots would be that of a system with a loop gain of

$$\frac{10}{(1+0.1s)^2}?$$

(1) the plot labelled 1

(2) the plot labelled 2

(3) the plot labelled 3

(4) the plot labelled 4

(5) none of the 4 plots

QUESTION 31

Which one of the four plots shown in question 30 would be that of a system with a loop gain of

$$\frac{100(1+0.1s)}{s(1+0.3s)}?$$

(1) the plot labelled 1

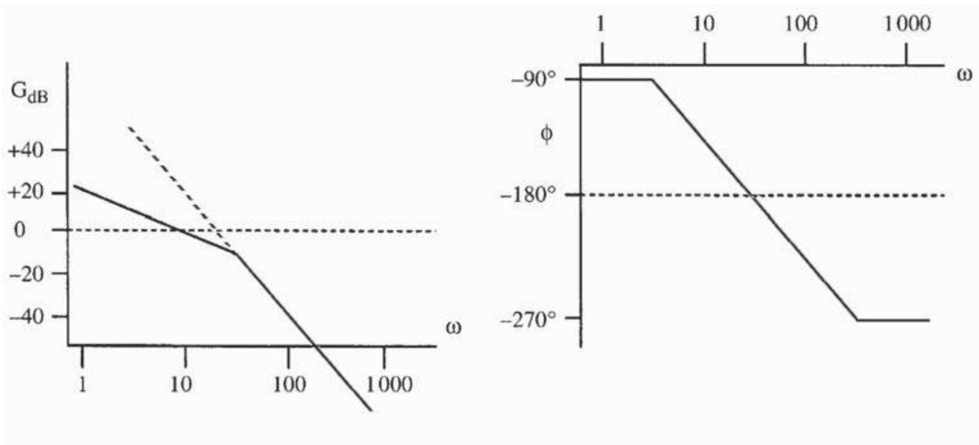
(2) the plot labelled 2

(3) the plot labelled 3

(4) the plot labelled 4

(5) none of the 4 plots

QUESTION 32



The open-loop Bode plot of a particular unity-feedback control system is shown above. The system phase margin is:

(1) –90°

(2) –45°

(3) 45°

(4) 90°

(5) 135°

QUESTION 33

The gain margin of the system depicted in question 32 is:

(1) –20 dB

(2) –10 dB

(3) 0 dB

(4) 10 dB

(5) 20 dB

QUESTION 34

The open-loop Bode plot of a particular unity-feedback control system is shown in question 32.

A unit-step change of input is applied to this system (closed loop). The best estimate of the size of the change that would occur in the system output is:

(1) no change

(2) 10/11 units

(3) 1 unit

(4) 10 units

(5) 20 units

QUESTION 35

The open-loop Bode plot of a particular unity-feedback control system is shown in question 32.

A unit-step change of input is applied to this system (closed loop). The best description of the system response is:

(1) the system would respond sluggishly.

(2) the system would respond with a small amount of overshoot.

(3) the system would respond with a moderate amount of overshoot.

(4) the system would burst into oscillation (be unstable).

QUESTION 36

A second-order control system has a damping ratio of 0.5 and a response time of 2 seconds. A small amount of rate feedback is added to the system. The principal effects of this change would be to:

(1) speed up the response and increase the damping ratio

(2) speed up the response and decrease the damping ratio

(3) slow down the response and decrease the damping ratio

(4) slow down the response and increase the damping ratio

(5) not change the speed of response but increase the damping ratio

QUESTION 37

A control system has a phase margin of 30° and a gain cross-over frequency of 5 rad/s.

A **phase-lead** compensator is used to improve the system performance. The principal effects of this change would be to:

(1) speed up the response and increase the damping ratio

(2) speed up the response and decrease the damping ratio

(3) slow down the response and decrease the damping ratio

(4) slow down the response and increase the damping ratio

(5) not change the speed of response but increase the damping ratio

QUESTION 38

A control system has a phase margin of 30° and a gain cross-over frequency of 5 rad/s.

A **phase-lag** compensator is used to improve the system performance. The principal effects of this change would be to:

(1) speed up the response and increase the damping ratio

(2) speed up the response and decrease the damping ratio

(3) slow down the response and decrease the damping ratio

(4) slow down the response and increase the damping ratio

(5) not change the speed of response but increase the damping ratio

QUESTION 39

A control system has no steady-state error and responds just rapidly enough, but has an excessive amount of overshoot. Which one of the following options could be used to reduce the overshoot to acceptable levels without adversely affecting the other characteristics?

(1) phase-lead compensation

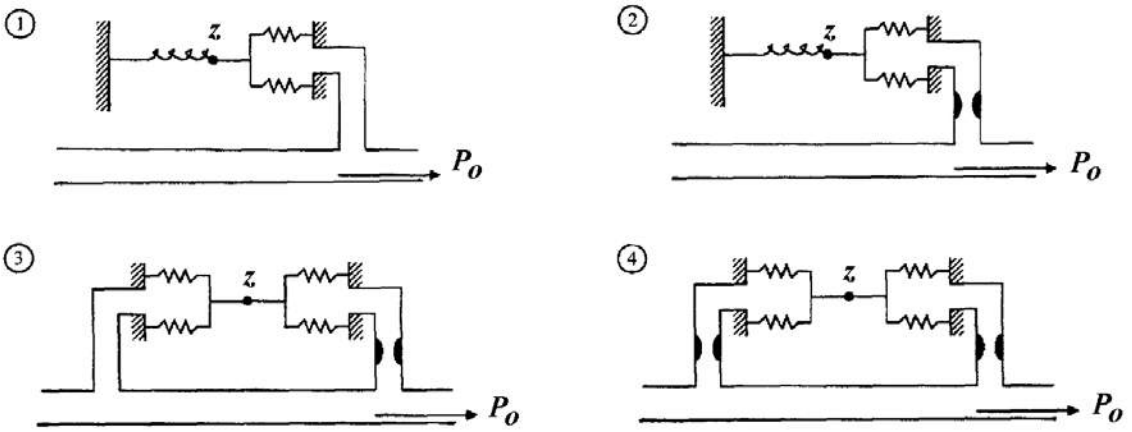
(2) P-D control

(3) either of the above

(4) none of the above

QUESTION 40

Four different forms of providing feedback around a flapper-valve nozzle in a pneumatic control system are shown below.



Which one of the diagrams would correspond to a pneumatic P-I controller?

(1) the diagram labelled 1

(2) the diagram labelled 2

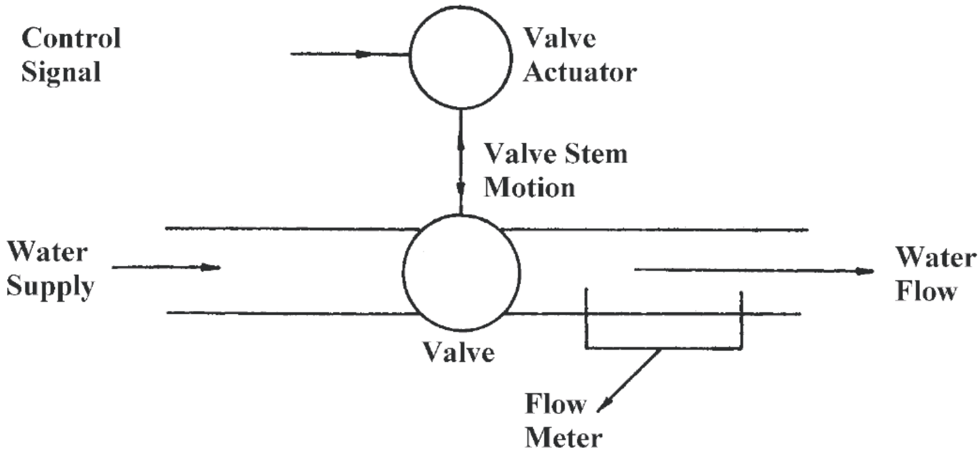
(3) the diagram labelled 3

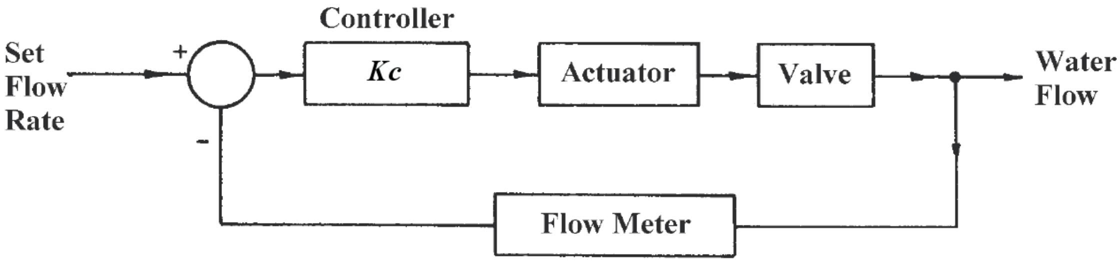
(4) the diagram labelled 4

(5) none of the diagrams

Data for questions 41 – 44

A control system is being used to control the rate of flow of water along a pipe.





The valve has a transfer function of $Kv = 3.5$

The flow meter has a transfer function of $Kf = 2$

The actuator to be used is a d.c. servo-motor driving the valve stem by a rack and pinion gear arrangement.

The actuator has a transfer function given by

$$\frac{0.2}{s(1+0.3s)}$$

Sketch the open-loop system Bode plot with a controller gain of unity ($Kc = 1$).

(Assume the step change in input was applied at time $t = 0$.)

Questions 41 – 44 refer to the Bode plot.

QUESTION 41

The system gain cross-over frequency is:

(1) 0.14 rad/s

(2) 0.33 rad/s

(3) 1.0 rad/s

(4) 3.3 rad/s

(5) 1.4 rad/s

QUESTION 42

The system phase margin is:

(1) 155°

(2) 65°

(3) 35°

(4) –35°

(5) –65°

QUESTION 43

The closed-loop system would have a damping ratio of:

(1) 1

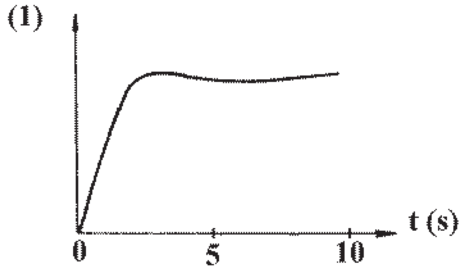
(2) 0.8

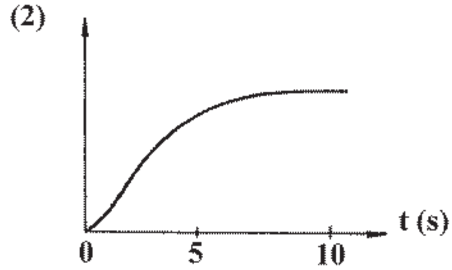
(3) 0.7

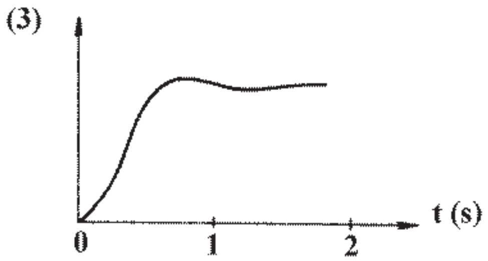
(4) 0.6

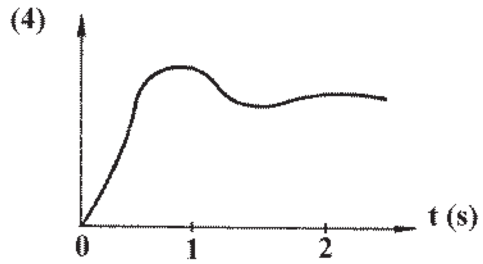
QUESTION 44

Which one of the four sketches below best illustrates the step response of the closed-loop system?









(1) The sketch labelled 1

(2) The sketch labelled 2

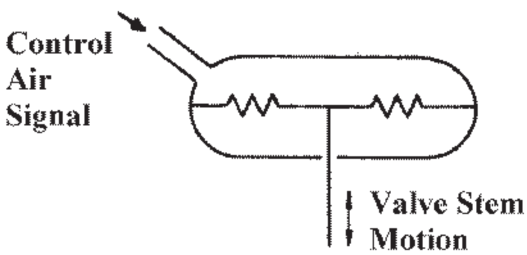
(3) The sketch labelled 3

(4) The sketch labelled 4

Data for questions 45 – 48

The controller gain is kept at $Kc = 1$.

The actuator is now changed to a pneumatic unit.



Assuming the pneumatic actuator has a gain of 0.2 units, and a time constant of 0.3 seconds, sketch the new open-loop system Bode plot.

Questions 45 – 48 refer to these new Bode plot sketches.

QUESTION 45

The new system gain cross-over frequency is:

(1) 0.33 rad/s

(2) 1.0 rad/s

(3) 1.4 rad/s

(4) 3.3 rad/s

(5) 4.5 rad/s

QUESTION 46

The new system phase margin will be:

(1) 38°

(2) 52°

(3) 128°

(4) –52°

(5) –128°

QUESTION 47

Which one of the following statements best describes the dynamic performance of the new system (i.e. the closed-loop-system step response)?

(1) The response will be sluggish.

(2) The response will be slightly underdamped.

(3) The response will be reasonably underdamped.

(4) The system will be unstable.

QUESTION 48

Which of the following statements best describes the differences in steady-state performance that occur between the closed-loop step responses of the original and the new systems?

(1) The new system has a larger gain.

(2) The new system has a small steady-state error.

(3) The new system has a larger steady-state error.

Data for questions 49 and 50

It is a requirement that the pneumatic system (of questions 45 – 48) be altered to produce the same closed-loop step response as the electro-mechanical system (of questions 41 – 44).

QUESTION 49

If you were only concerned with making the dynamic response similar (i.e. same amount of overshoot), which one of the following controller/compensator options could you choose?

(1) Increase the loop gain – makes *Kc* larger.

(2) Apply rate feedback.

(3) Add a phase lead compensator.

(4) Add a phase lag compensator.

(5) None of the above.

QUESTION 50

If you are concerned with both dynamic and steady-state performance, which one of the following controller/compensator options would you choose?

(1) P-I controller.

(2) Phase lead compensator.

(3) Phase lag compensator.

(4) P-D controller

(5) Increasing the loop gain.

END OF ELE2101 CMA TEST S2B

There were 50 multiple-choice questions for this assessment.