Tutorial Letter 101/0/2018

Control Systems III – (Theory)

CSY3601

Year module

Department of Electrical and Mining Engineering

This tutorial letter contains important information about your module.

BARCODE

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CONTENTS

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1 INTRODUCTION

Dear Student

Welcome to the subject **Control Systems III (Theory) (CSY3601)** at UNISA. This tutorial letter serves as a guideline to this subject. It provides you with general administrative information as well as specific information about the subject. Read it carefully and keep it safe for future reference. We trust that you will enjoy this course.

2 PURPOSE OF AND OUTCOMES

2.1 Purpose

Automatic control is one of today's most significant areas of science and technology. This can be attributed to the fact that automation is linked to the development of almost every form of technology. By its very nature, automatic control is a multidisciplinary subject; it constitutes a core course in many engineering departments, such as electrical, electronic, mechanical, chemical, and aeronautical.

Automatic control requires both a rather strong mathematical foundation, and implementation skills to work with controllers in practice. The goal of this subject is to present control engineering methods using only the essential mathematical tools and to stress the application procedures and skills by giving insight into physical system behavior and characteristics. Overall, the approach used herein is to help the student understand and assimilate the basic concepts in control system modelling, analysis, and design.

2.2 Outcomes

After this subject, the students are supposed to grasp the following knowledge and techniques:

Basic automatic control systems conceptions;

Laplace transform including a necessary mathematical background for studying continuous-time systems;

Describes and analyses linear time-invariant systems by using the following mathematical models: differential equations, transfer functions, impulse response, and state-space equations; the topics of block diagrams and signal-flow graphs are also covered.

Classical time-domain analysis, covering topics such as time response, model simplification, comparison of open- and closed-loop systems, model reduction, sensitivity analysis, steady-state errors, and disturbance rejection;

The algebraic criteria of Ruth, Hurwitz, and continuous fraction, and the stability of linear systems;

Root locus method;

Frequency response of linear time-invariant systems, introducing the three well known frequency domain methods: those of Nyquist, Bode, and Nichols;

The classical design techniques, emphasizing controller design methods using controllers of the following types: PID, phase-lead, phase-lag, and phase lead-lag.

3 LECTURER(S) AND CONTACT DETAILS

3.1 Lecturer(s)

Your Lecturer for Control Systems III is Prof. Z Wang. He can be contacted at the following number for any theoretical questions:

wangz@unisa.ac.za
Telephone number 011 471 3513
Monday to Friday from 9:00 am to 12:00 am (please keep to the contact hours, the lecturer prefer communication via e-mail when you have theoretical questions.)

3.2 Department

Department of Electrical and Mining Engineering: electrical&mining@unisa.ac.za

3.3 University

If you need to contact the University about matters not related to the content of this module, please consult the publication *My studies @ Unisa* that you received with your study material. This brochure contains information on how to contact the University (e.g. to whom you can write for different queries, important telephone and fax numbers, addresses and details of the times certain facilities are open).Always have your student number at hand when you contact the University.

4 RESOURCES

4.1 Prescribed books

Ogata, K. 2010. Modern Control Engineering. Fifth Edition. USA. Prentice Hall.

Content is the sections highlighted

Contents

4.2 Recommended books

Norman S Nise. Control System Engineering. 6th Ed, John Wiley & Sons, Inc.

4.3 Electronic Reserves (e-Reserves)

There are no electronic reserves for this module.

4.4 Library services and resources information

For brief information, go to www.unisa.ac.za/brochures/studies
For detailed information, go to the Unisa website at http://www.unisa.ac.za/ and click on **Library**.
For research support and services of personal librarians, go to http://www.unisa.ac.za/Default.asp?Cmd=ViewContent&ContentID=7102.

The Library has compiled numerous library guides:

- finding recommended reading in the print collection and e-reserves – http://libguides.unisa.ac.za/request/undergrad
- requesting material – http://libguides.unisa.ac.za/request/request
- postgraduate information services – http://libguides.unisa.ac.za/request/postgrad
- finding , obtaining and using library resources and tools to assist in doing research – http://libguides.unisa.ac.za/Research_Skills
- how to contact the library/finding us on social media/frequently asked questions – http://libguides.unisa.ac.za/ask

5 STUDENT SUPPORT SERVICES

Important information appears in your *my Studies @ Unisa* brochure.

6 STUDY PLAN

Use your *my Studies @ Unisa* brochure for general time management and planning skills.

7 PRACTICAL WORK AND WORK-INTEGRATED LEARNING

The practical part of this module will be covered in the module CSYPRA3.

8 ASSESSMENT

8.1 Assessment criteria

Your final mark will be calculated by using a ratio of 20% year mark and 80% examination mark.

8.2 Assessment plan

You will find your assignments for this subject in this Tutorial Letter. **Assignment 1, 2 and 3 are compulsory and** all assignments will be used in the calculation of your year mark. Please send the completed assignments to UNISA before the closing dates stated in this section.

Note: Assignment no. 1 must be completed on the “Mark Reading Sheet”

The mark for Control Systems III (Theory) (CSY3601) is calculated as follows:

- The year mark contributes to 20%.
- The examination mark contributes to 80%

The year mark is based on all the assignment marks obtained and their contribution towards the final year mark are as shown in the table below:

ASSIGNMENT NUMBER	CONTRIBUTION TOWARDS YEAR MARK
1 (Compulsory)	10%
2 **(Compulsory)**	45%
3 **(Compulsory)**	45%
TOTAL	**= 100 %**

8.3 Assignment numbers

8.3.1 General assignment numbers

Assignments are numbered consecutively per module, starting from 01.

8.3.2 Unique assignment numbers

Assignment 1:	830452
Assignment 2:	594423
Assignment 3:	779289

8.4 Due dates for assignments

THE CUT-OFF SUBMISSION DATES FOR THE ASSIGNMENTS ARE :	
Assignment 1: **Assignment 2:** **Assignment 3:**	**22 May 2018** **18 July 2018** **5 September 2018**

8.5 Submission of assignments

ALL ASSIGNMENTS (submitted) HAVE TO BE ATTEMPTED!!!!!!!

THE SUBMISSION OF AN EMPTY ASSIGNMENT COVER IS UNACCEPTABLE.

IT IS VERY IMPORTANT TO CONSIDER THE FOLLOWING POINTS :

- NO LATE ASSIGNMENT SUBMISSIONS WILL BE ACCEPTED.
- KEEP A CLEAR COPY OF THE ASSIGNMENT FOR YOUR OWN REFERENCE. THIS IS IMPORTANT, AS ASSIGNMENTS DO GET LOST.
- SUBMISSIONS OF ASSIGNMENTS MUST BE IN ACCORDANCE WITH "MY STUDIES @ UNISA".

Please note that model answers for the assignments will be dispatched to all students within 1 week of the closing date of the assignment. This implies that you cannot submit your assignment later than the stipulated submission date.

Note: Assignment no. 1 must be completed on the “Mark Reading Sheet”

For detailed information and requirements as far as assignments are concerned, see the brochure *my Studies @ Unisa* that you received with your study material.

To submit an assignment **via *myUnisa*:**

- Go to *myUnisa*.
- Log in with your student number and password.
- Select the module.
- Click on assignments in the menu on the left-hand side of the screen.
- Click on the assignment number you wish to submit.
- Follow the instructions.

8.6 The assignments

THE CUT-OFF SUBMISSION DATES FOR THE ASSIGNMENTS ARE :	
Assignment 1: (Compulsory)	**22 May 2018**
Assignment 2: (Compulsory)	**18 July 2018**
Assignment 3: (Compulsory)	**5 September 2018**

ASSIGNMENT 1 (monomial-choice)

Question 1

Which of these statements is false?

1) An example of a close-loop system is the case of a PID controller.

2) An example of a close-loop system is the case of an air conditioning system.

3) An example of a close-loop system is the case of an intelligent washing machine.

4) An example of a close-loop system is the case of the altitude-hold autopilot system.

Question 2

Which is not the primary objectives of the control system analysis and design?

1) Producing the desired transient response

2) Determining the functional block diagram

3) Reducing steady-state errors

4) Achieving stability

Question 3

Which is the transfer function $\frac{Y(s)}{R(s)}$ of system shown in Figure 1.1.

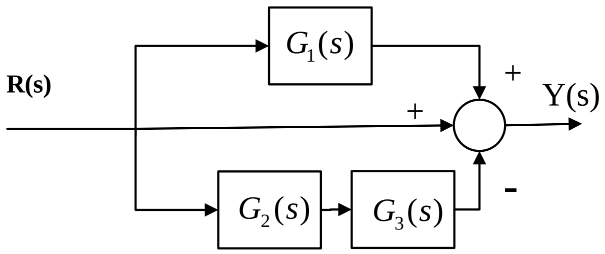


Figure 1.1 System for Question 3.

1) $G_1(s)+G_2(s)+G_3(s)+1$

2) $1+G_1(s)-G_2(s)G_3(s)$

3) $(G_1(s)+1)/(G_2(s)G_3(s))$

4) $G_1(s)G_2(s)G_3(s)+1$

Question 4

Which is the transfer function $\frac{Y(s)}{R(s)}$ of system shown in Figure 1.2.

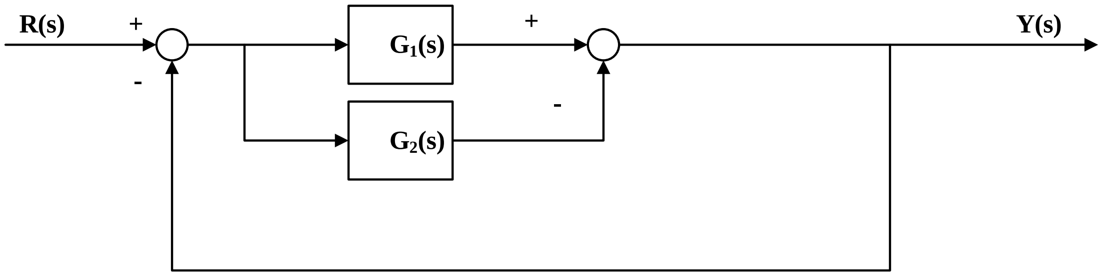


Figure 1.2 System structure for question 4

1) $G_1(s)+G_2(s)$

2) $G_1(s)-G_2(s)+1$

3) $\dfrac{G_1(s)-G_2(s)}{1-G_1(s)+G_2(s)}$

4) $\dfrac{G_1(s)-G_2(s)}{1+G_1(s)-G_2(s)}$

Question 5

Which is the transfer function $\frac{V_2(s)}{I_1(s)}$ of the circuit shown in Figure 1.3?

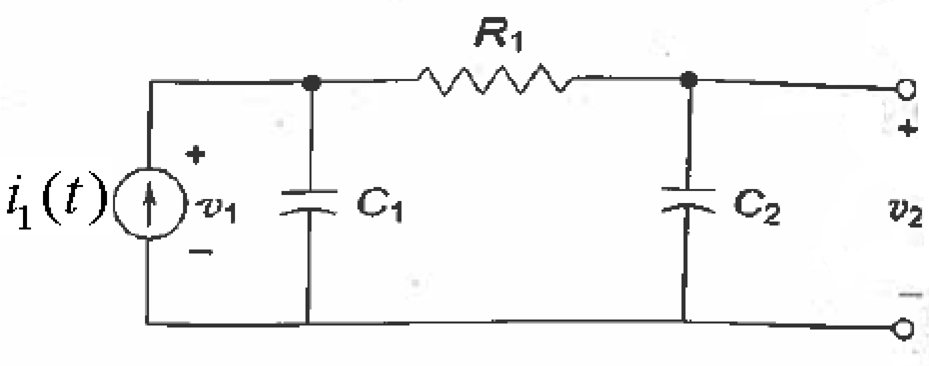


Figure 1.3 Circuit for Question 5

Here, $V_{c1}(0^-) = V_{c2}(0^-) = 0$.

1) $\dfrac{1}{R_1C_1C_2s^2 + (C_1 - C_2)s}$

2) $\dfrac{1}{R_1C_1C_2s^2 - (C_1 + C_2)s}$

3) $\dfrac{1}{R_1C_1C_2s^2 + (C_1 + C_2)s}$

4) $R_1C_1C_2s^2 - (C_1 + C_2)s$

Question 6

Which is the transfer function $\dfrac{E_o(s)}{E_i(s)}$ of the circuit shown in Figure 1.4.

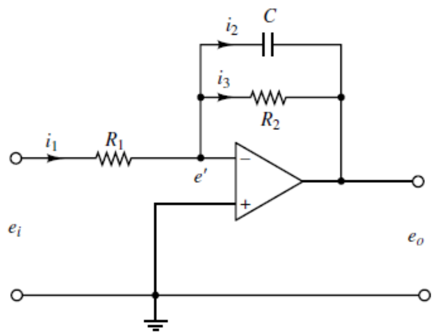


Figure 1.4 Circuit for Question 6

Here the zero initial condition applies.

1) $-\dfrac{R_2}{R_1}\dfrac{1}{R_2Cs+1}$

2) $\frac{R_2}{R_1}\frac{1}{R_2Cs+1}$

3) $\frac{R_2}{R_1}\frac{1}{R_2Cs-1}$

4) $-\frac{R_1}{R_2}\frac{1}{R_2Cs+1}$

Question 7

Which is the Laplace transfer function of $2t+\delta(t)$?

1) $\frac{1}{s^2}$

2) $\frac{2}{s^2}+t$

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

4) $\frac{2}{s^2}+1$

Question 8

How many poles in the plant with a transfer function $G(s)=\frac{1}{(s+0.1)(s^2+2s-8)}$? Is this plant stable?

1) 2, stable

2) 3, unstable

3) 3, stable

4) 2, unstable

Question 9

For the first-order system $\frac{1}{Ts+1}$, which is steady error of its unit-ramp response?

1) T

2) 2T

3) 3T

4) 4T

Question 10

For the second order system $\frac{\omega_n^2}{s^2 + 2\zeta\omega_n + \omega_n^2}$, which is its peak time if this system is underdamped?

1) $\frac{1}{\zeta\omega_n}$

2) $\frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

3) $e^{-(\zeta/\sqrt{1-\zeta^2})\pi}$

4) $\frac{4}{\zeta\omega_n}$

ASSIGNMENT 2

Question 1

Use block-diagram-reduction techniques to find the transfer function $T(s)=\frac{C(s)}{R(s)}$ of the system represented by the block diagram shown in Figure 2.1.

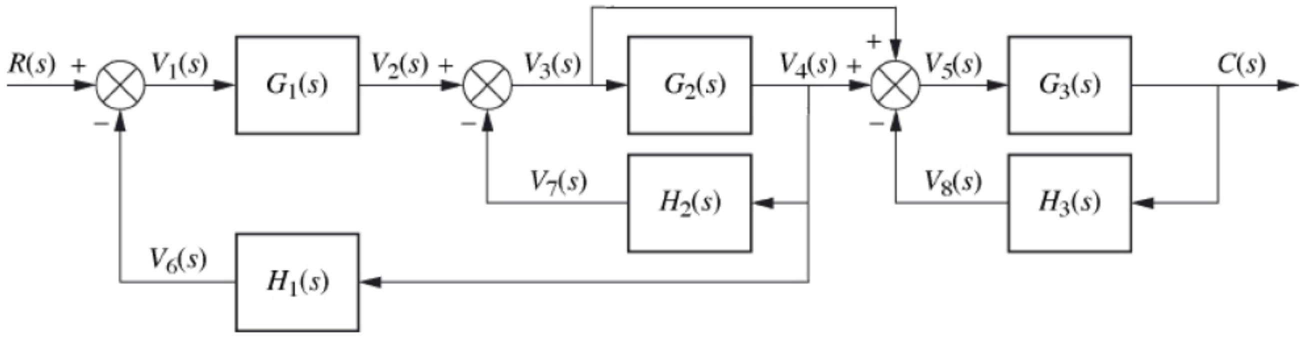


Figure 2.1 Block diagram for Question 1

[20]

Question 2

Convert the block diagram in Figure 2.2 to a signal-flow graph and use Mason's Rule to find the transfer function $T(s)=\frac{C(s)}{R(s)}$

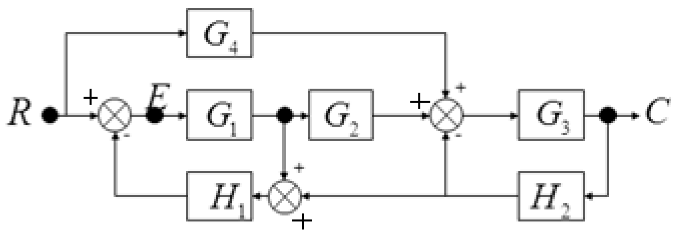


Figure 2.2 Block diagram for Question 2

Hint: use the website materials to find how you can use Mason's gain formula.

[30]

Question 3

Solve the following differential equation using Laplace transform

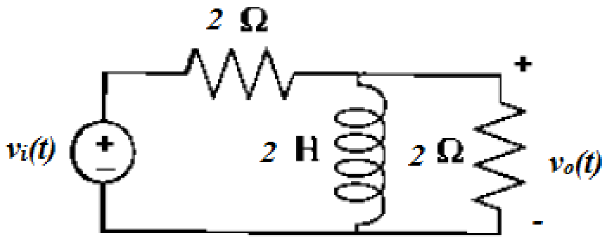
$$\frac{d^2x}{dt^2}+4x=t^2$$

$$x(0)=2, x'(0)=3$$

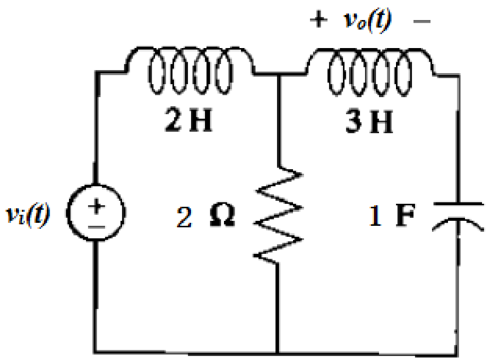
[20]

Question 4

Find the transfer functions, $V_O(s)/V_i(s)$,for the following circuits.



(a) Circuit 1 for Question 4



(b) Circuit 2 for Question 4

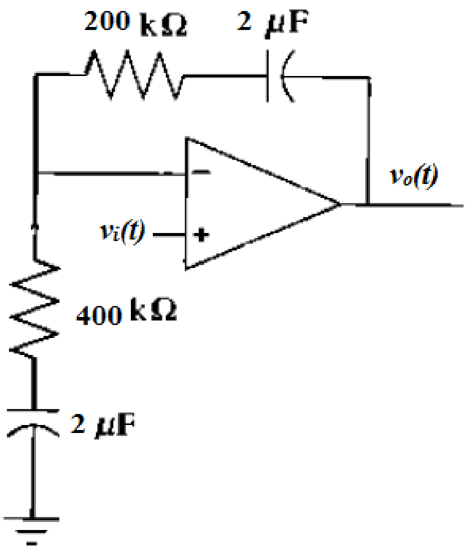
[30]

Total: 100

ASSIGNMENT 3

Question 1

Find the transfer function, $G(s) = V_o(s)/V_i(s)$, for the operational amplifier circuits as shown in the following figure.



[12]

Question 2

Assume that the motor, whose transfer functions is shown in the following figures, is used as the forward path of a closed-loop, unity feedback system.

a. Calculate the percent overshoot and settling time that could be expected.

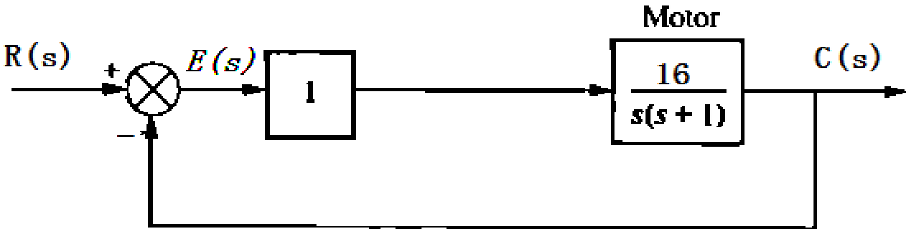
(15)

b. Find the values of K_1 and K_2 to yield a 14% overshoot and a settling time of 0.3 second.

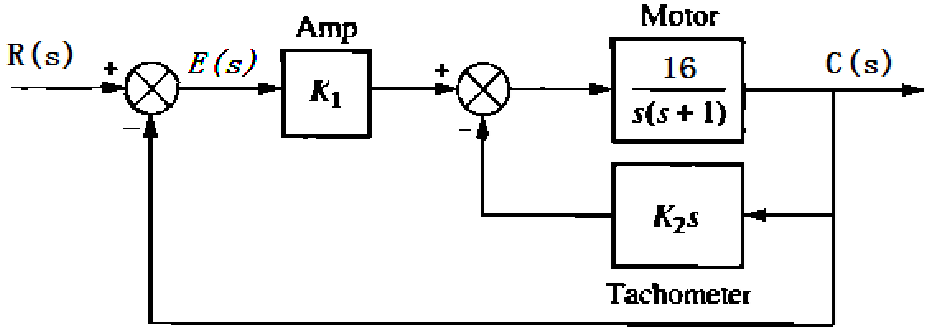
(17)

[32]

Here 5% criterion is used.



(a)



(b)

Question 3

For the unity negative feedback system with closed-loop transfer function

$$G(s) = \frac{2}{s^4 + 5s^3 + s^2 + 10s + 1}$$

Determine the closed-loop system is stable or not based on Routh's stability criterion, and how many poles are in the right half-plane if this system is unstable.

[16]

Question 4

For the unity negative feedback system with a closed-loop transfer function

$$G(s) = \frac{1}{s^3 + 3s^2 + 3s + 1 + k}$$

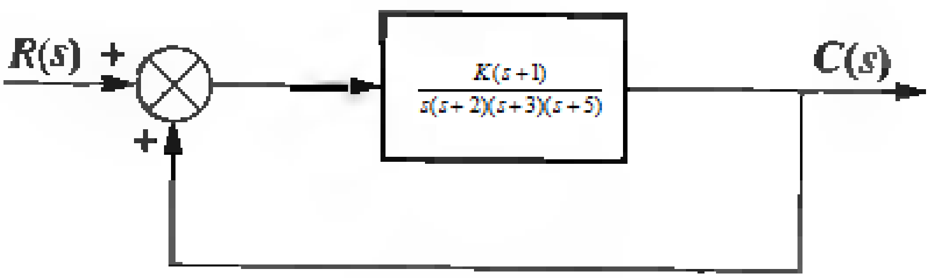
Find the range of K for closed-loop stability based on Routh's stability criterion.

Here, k can be negative.

[15]

Question 5

Sketch the root locus for the **positive-feedback** control system shown in the following figure.

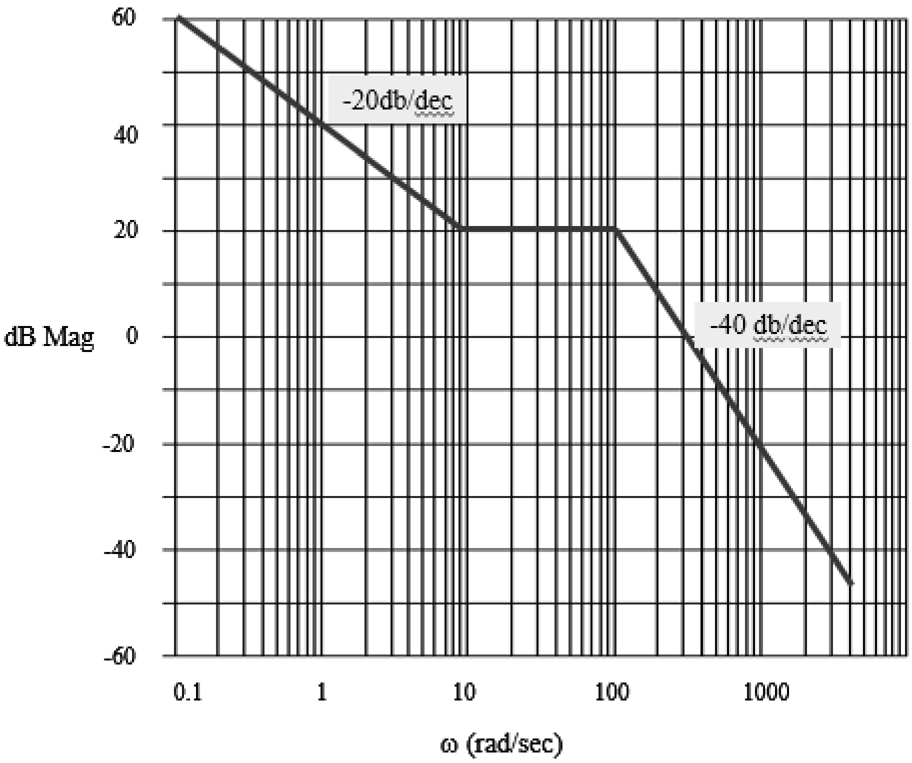


[10]

Question 6

The Bode diagram of a minimum phase system is given in the following figure.

Find the open loop transfer function of the system;



[15]
Total:100

8.7 Other assessment methods

None

8.8 The examination

Use your *my Studies @ Unisa* brochure for general examination guidelines and examination preparation guidelines.

Examination type: Partial open book

Examination duration: 3 hours

Examination language: English

Calculators allowed: Yes

9 FREQUENTLY ASKED QUESTIONS

The my Studies @ Unisa brochure contains an A-Z guide of the most relevant study information.

10 SOURCES CONSULTED

None

11 IN CLOSING

Please ensure that you have all the tutorial letters and prescribed book available before starting with your studies.

12 ADDENDUM

None