PP2

TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Medical Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Science (Medical Engineering)

EEE 4530: CONTROL ENGINEERING

END OF SEMESTER EXAMINATION

SERIES: MARCH 2025

TIME: 2 HOURS

DATE: MARCH 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 30 marks)

a) Figure Q1a is a car suspension system, determine $\frac{F(s)}{X(s)}$

[13 marks]

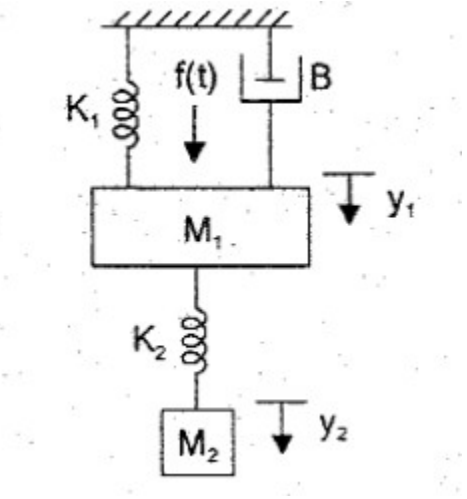


Figure Q1a

b) For a system with an open loop transfer function given by

$$G(s)H(s) = \frac{K}{s(s+1)(2s+1)}$$

i) Determine the stability when the value of K = 2

ii) Find the critical values of K for stability

[5 marks]

c) For Figure Q1c, determine from first principles

(i) The output $c(t)$ for a unit step input

(ii) Sketch the output

[12 marks]

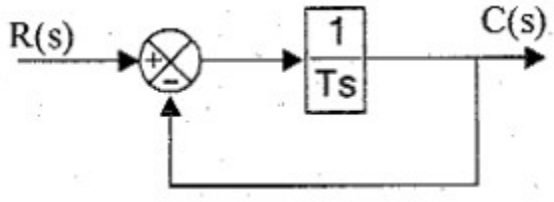


Figure Q1c

Question TWO

a) Draw a signal flow graph from the block diagram of Figure Q2a and apply masons gain formula to determine the overall transmittance.

[10 marks]

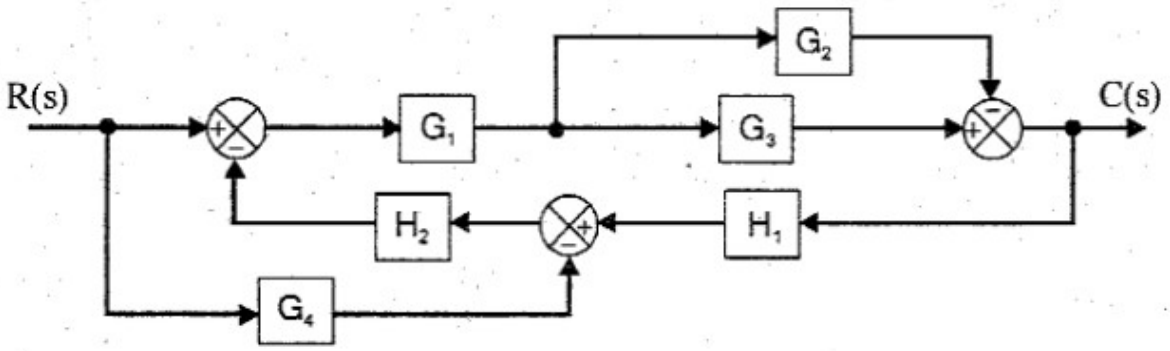


Figure Q2a

b) Determine the closed loop transfer function for figure Q2b

[6 marks]

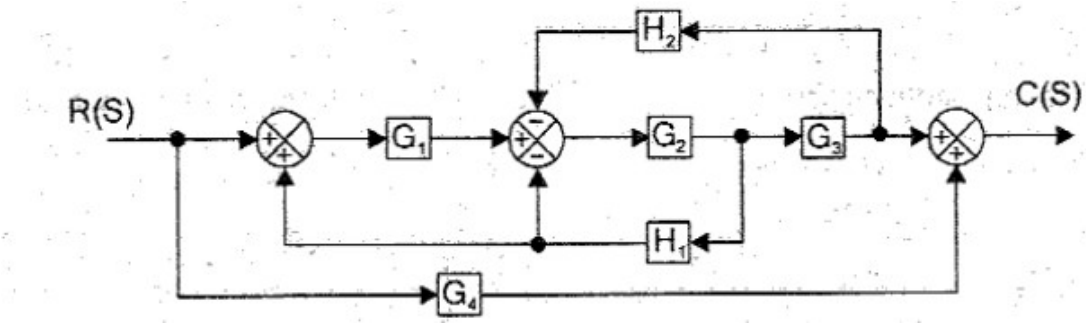


Figure Q2b

c) Define the following terms as applied to control systems

(i) Path

(ii) Loop

(iii) Branch

(iv) Node

[4 marks]

Question THREE

a) A system is described by the following differential equation

$$\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 16y = 9x$$

For a unit step input, determine;

i) Undamped natural frequency

ii) Damped natural frequency

iii) Damping ratio

iv) Rise time

v) Delay time

vi) Peak time

vii) Maximum percent overshoot

viii) Output

[16 marks]

b) State any two advantages and two disadvantages of open loop control systems

[4 marks]

Question FOUR

a) In the liquid level system of Figure Q4a the outflow rate Q m^3/sec through the outflow valve is related to the head H m by $Q = K\sqrt{H} = 0.01\sqrt{H}$ .Assume that when the inflow rate Q_i is 0.015 m^3/ sec the head stays constant . For $t < 0$ the system is at steady state (Q_i = 0.015 m^3/sec). At $t = 0$ the inflow valve is closed and so there is no inflow at $t \geq 0$. The capacitance C of the tank is 2m^2 Find the time necessary to empty the tank to half its original head.

[10 marks]

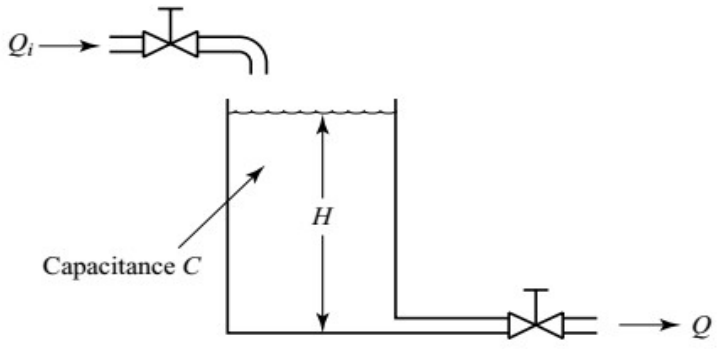
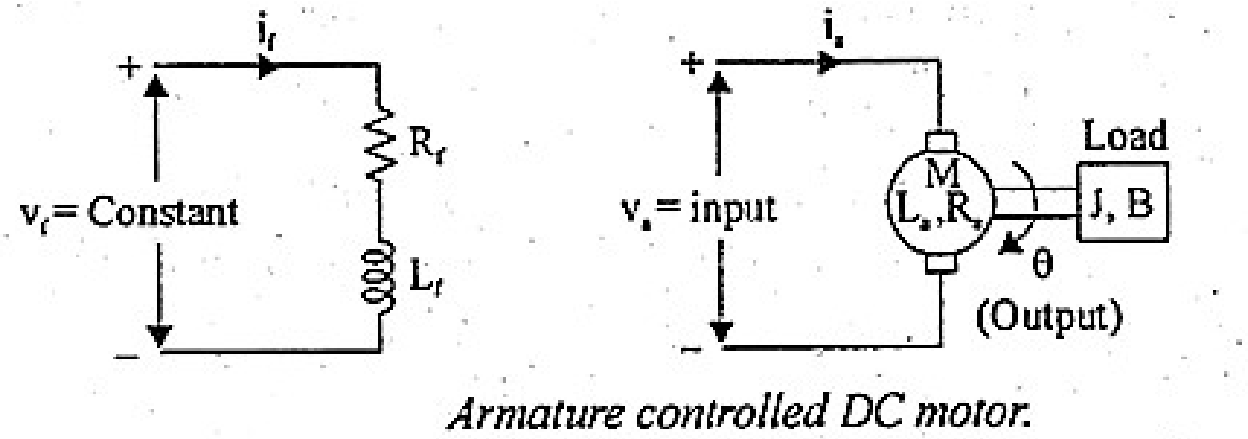


Figure Q4a

b) Obtain the transfer function of the armature controlled DC motor in Figure Q4b,

[10 marks]

Let, R_a = Armature resistance, Ω
L_a = Armature inductance, H
i_a = Armature current, A
v_a = Armature voltage, V
e_b = Back emf, V
K_t = Torque constant, N-m/A
T = Torque developed by motor, N-m
θ = Angular displacement of shaft, rad
J = Moment of inertia of motor and load, Kg-m²/rad
B = Frictional coefficient of motor and load, N-m/(rad/sec)
K_b = Back emf constant, V/(rad/sec)



Armature controlled DC motor.

Figure Q4b

Question FIVE

a) The block diagram of a space vehicle control system is shown in Figure Q5a. Determine the value of K such that the phase margin is 50^0.

[6 marks]

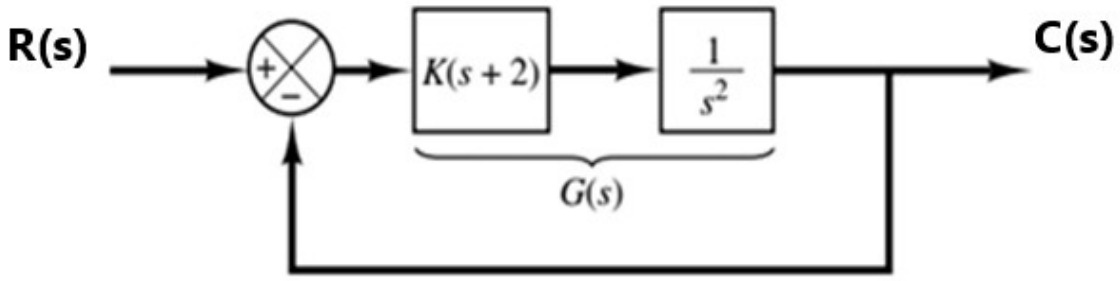


Figure Q5a

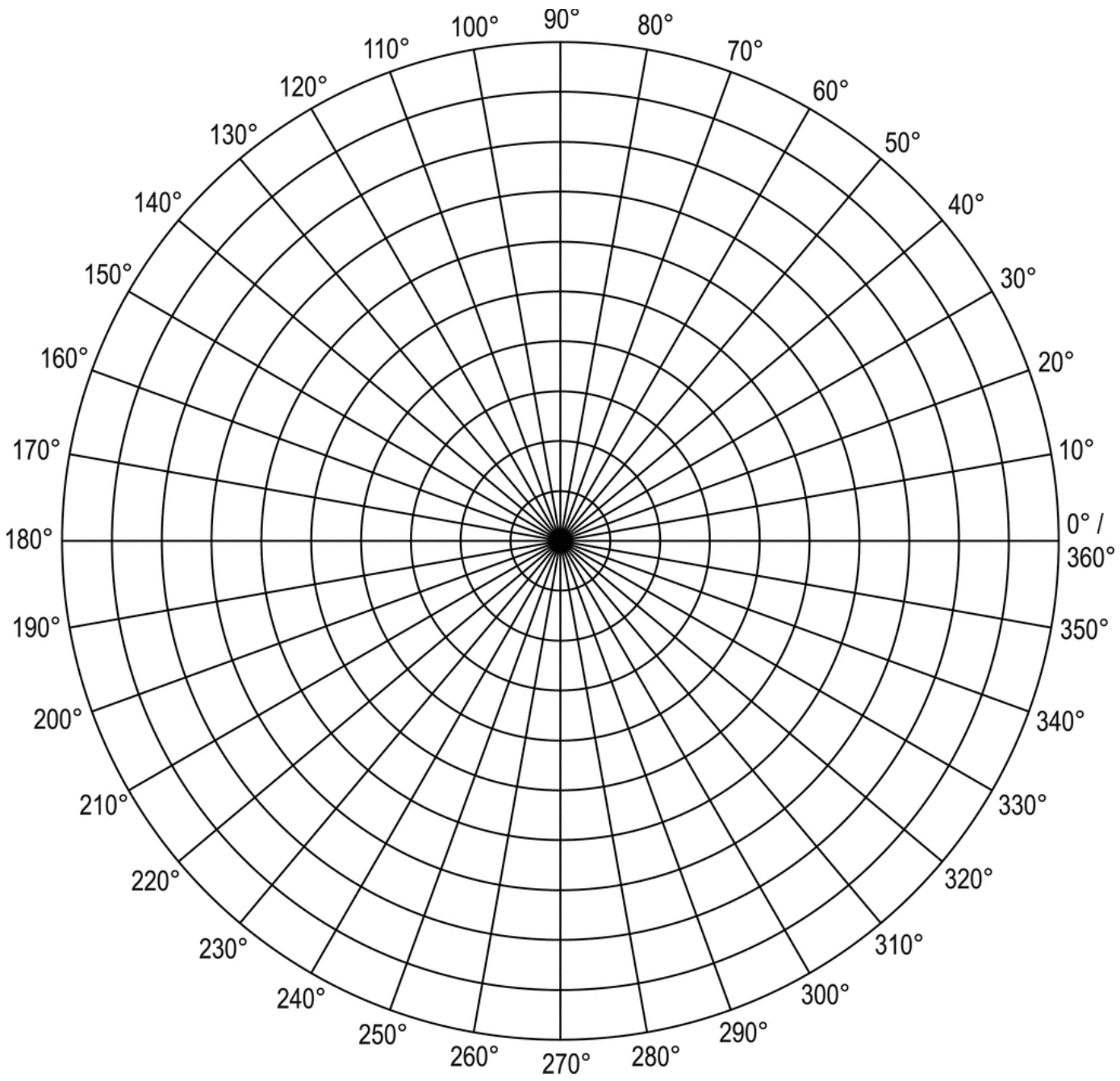
b) For the transfer function G(s) given below, sketch an open loop frequency response locus on a Nichols chart

From the sketch, determine:

i) The phase margin
ii) The gain margin
iii) Phase crossover frequency
iv) Gain crossover frequency
v) Bandwidth

$$G(s)=\frac{1}{s(s+1)(0.5s+1)}$$

[14 marks]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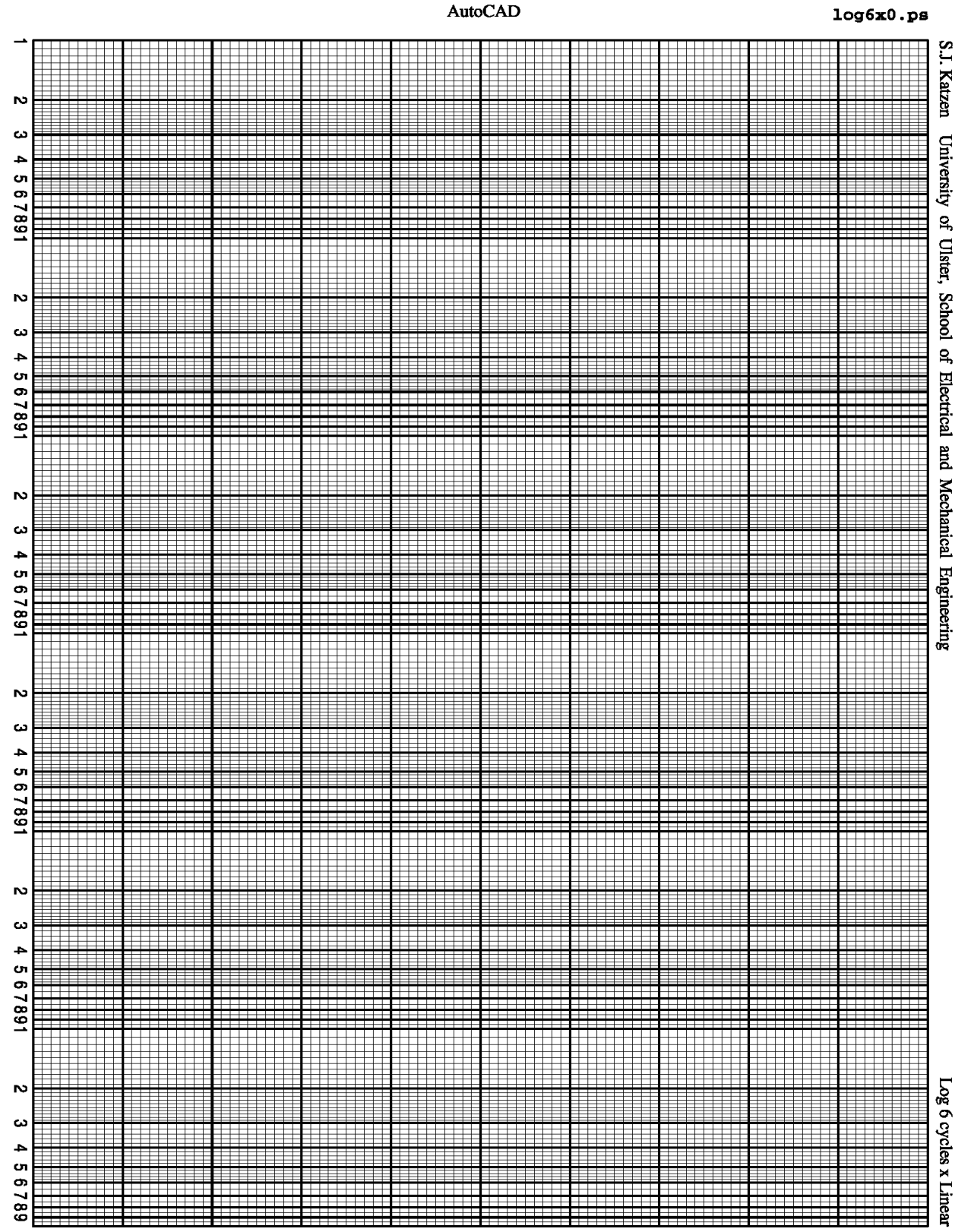
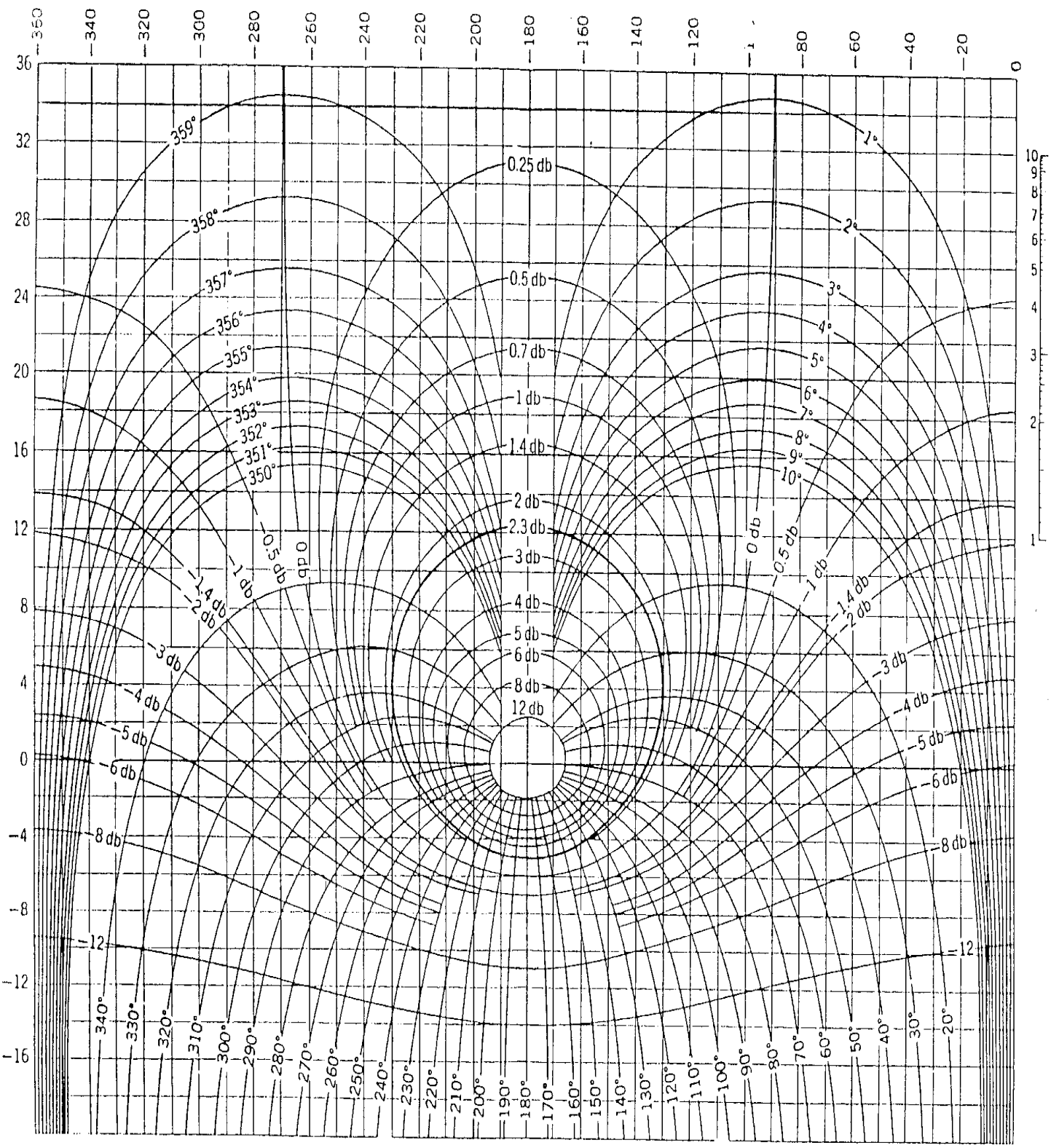

AutoCAD
log6x0.ps
S.J. Katzen University of Ulster, School of Electrical and Mechanical Engineering
Log 6 cycles x Linear
1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9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