PPI

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: AUGUST 2024

TIME: 2 HOURS

DATE: AUGUST 2024

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) The motor of the Figure Q1a is functioning under a constant field current. The parameters of the motor are:

$$R_a = 0.5\ \Omega,\quad L_a = 0.05\text{H},\quad k_\omega = 2\text{V/r/s},\quad k_t = 5\text{N}\cdot\text{m/A},\quad \text{B} = 1\text{N}\cdot\text{m/r/s}$$

$$\text{and}\ \ J = 45\text{N}\cdot\text{m/r/s}^2$$

(i) Draw the block diagram and the SFG of the system.

(ii) Determine the transfer function G(s) = Ω(s)/V_i(s).

(iii) If Vi(t) = 200u(t) V, compute the steady-state angular velocity of the motor

(iv) Determine the new steady-state velocity of the motor if a load torque T′(t) = 40 Nm is applied on the axis of the motor.

[25 marks]

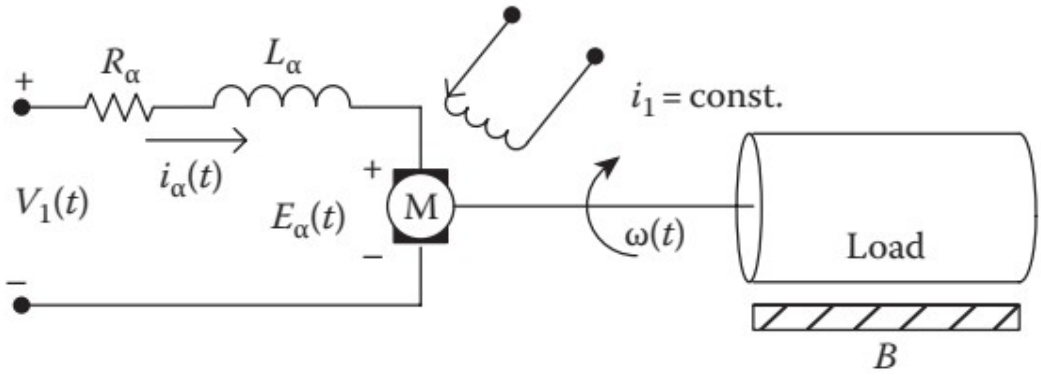


Figure Q1a

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]

Question TWO

a) Compute the transfer function of the depicted block diagram of Figure Q2a

(i) By reduction

(ii) By plotting the relevant SFG and applying Mason's gain formula

[10 marks]

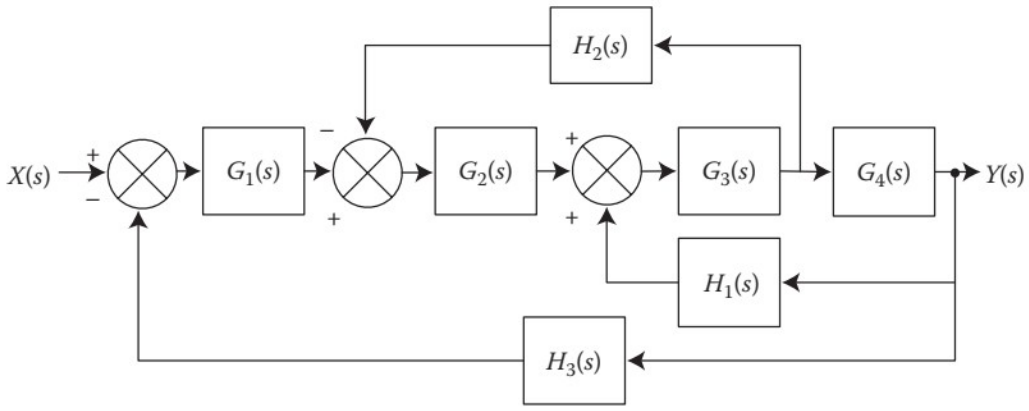


Figure Q2a

b) The equations that describe an automatic control system are

(i) Plot the SFG of the system.

(ii) Compute the transfer function $G(s) = X_5(s)/X_1(s)$ of the system by applying Mason's Gain formula**.**

[10 marks]

$$x_2 = x_1 t_{12} - x_2 t_{22} - x_4 t_{42} - x_3 t_{32}$$

$$x_3 = x_2 t_{23} - x_3 t_{33} - x_4 t_{43}$$

$$x_4 = x_2 t_{24} + x_3 t_{34} - x_4 t_{44}$$

$$x_5 = x_4 t_{45}$$

Question THREE

a) Figure Q3a is a positional control system with a velocity feedback. Determine the response of the system for a unit step input.

[16 marks]

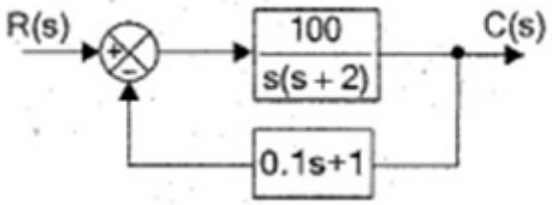


Figure Q3a

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

[4 marks]

Question FOUR

a) Given a closed-loop control system with negative feedback and having

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

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

(i) Write down an expression for the open loop transfer function.

(ii) Sketch the Nyquist diagram and

(iii) Determine (I) phase margin

(II) gain margin

[14 marks]

b) State any **three advantages** and **three disadvantages** of clodsed loop systems

[6 marks]

Question FIVE

a) Determine the transfer function $\frac{X_1(s)}{F(s)}$ of the mechanical translational system of figure Q5a.

[14 marks]

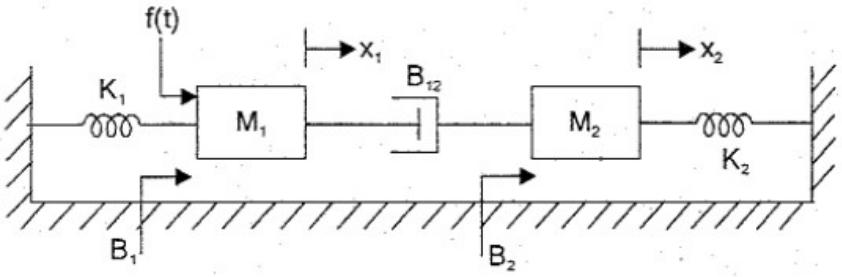


Figure Q5a

b) With the aid of diagrams explain the following test signals

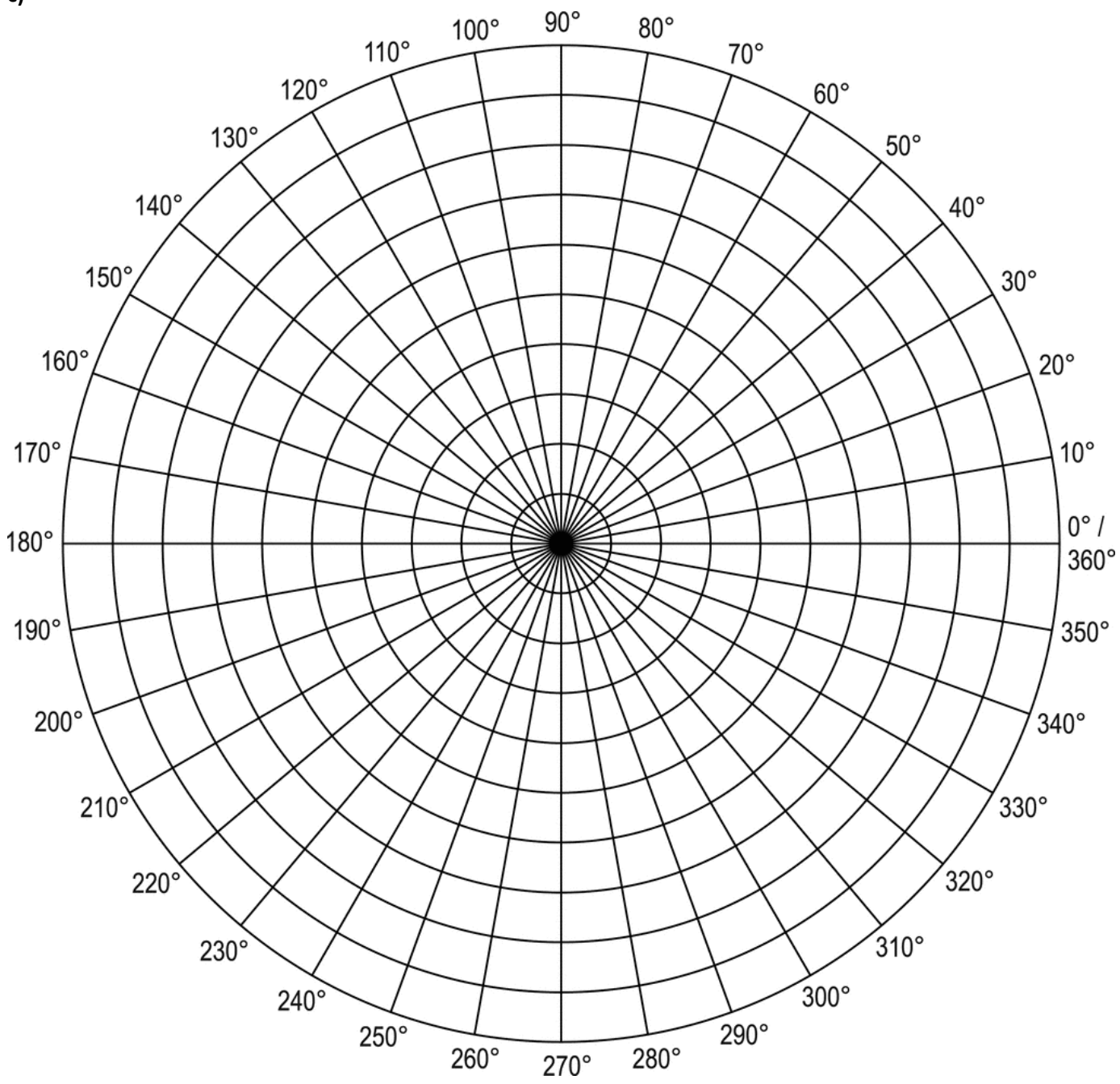
(i) Unit step function

(ii) Unit impulse function

(iii) Parabolic function

[6 marks]

c)


90°
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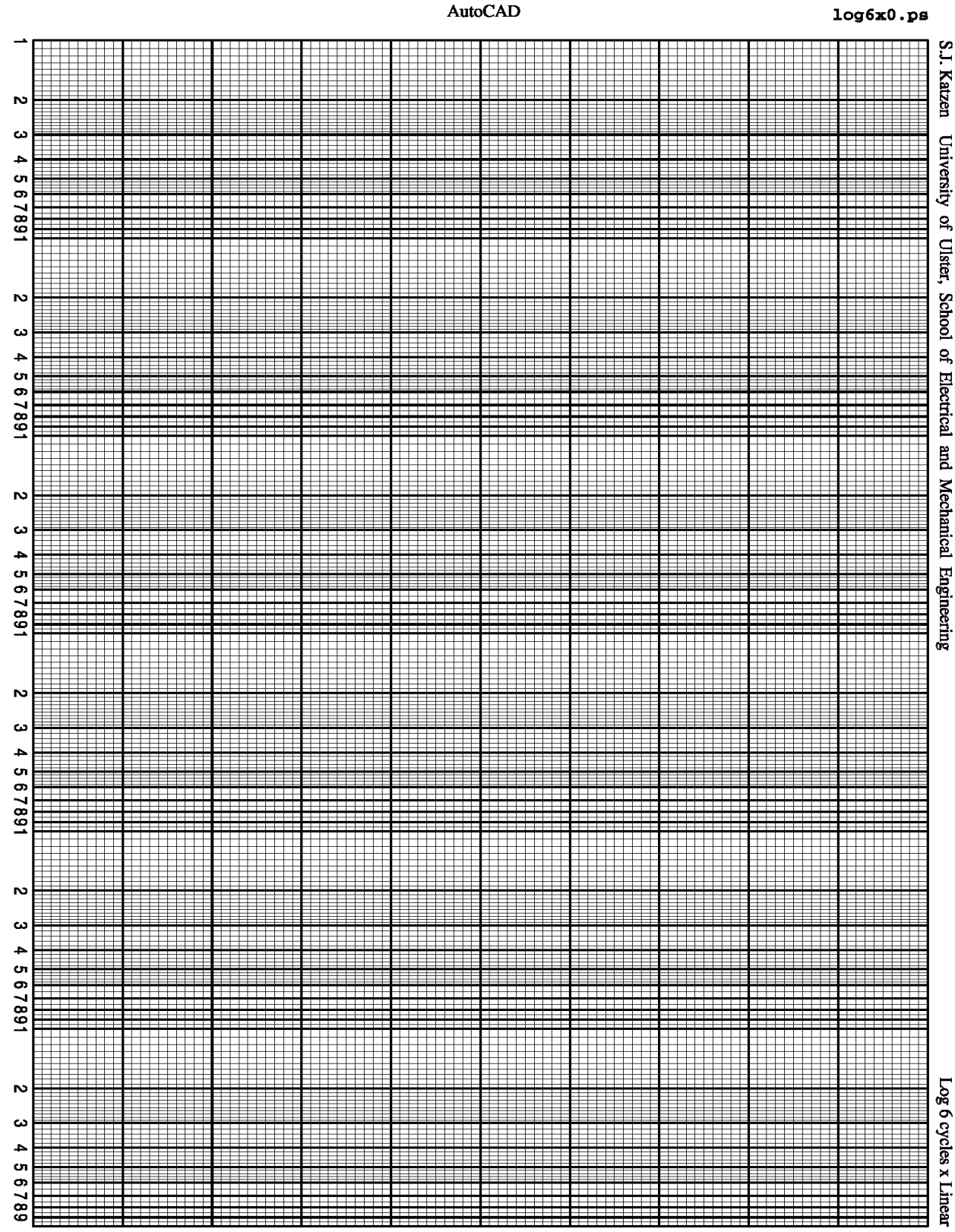
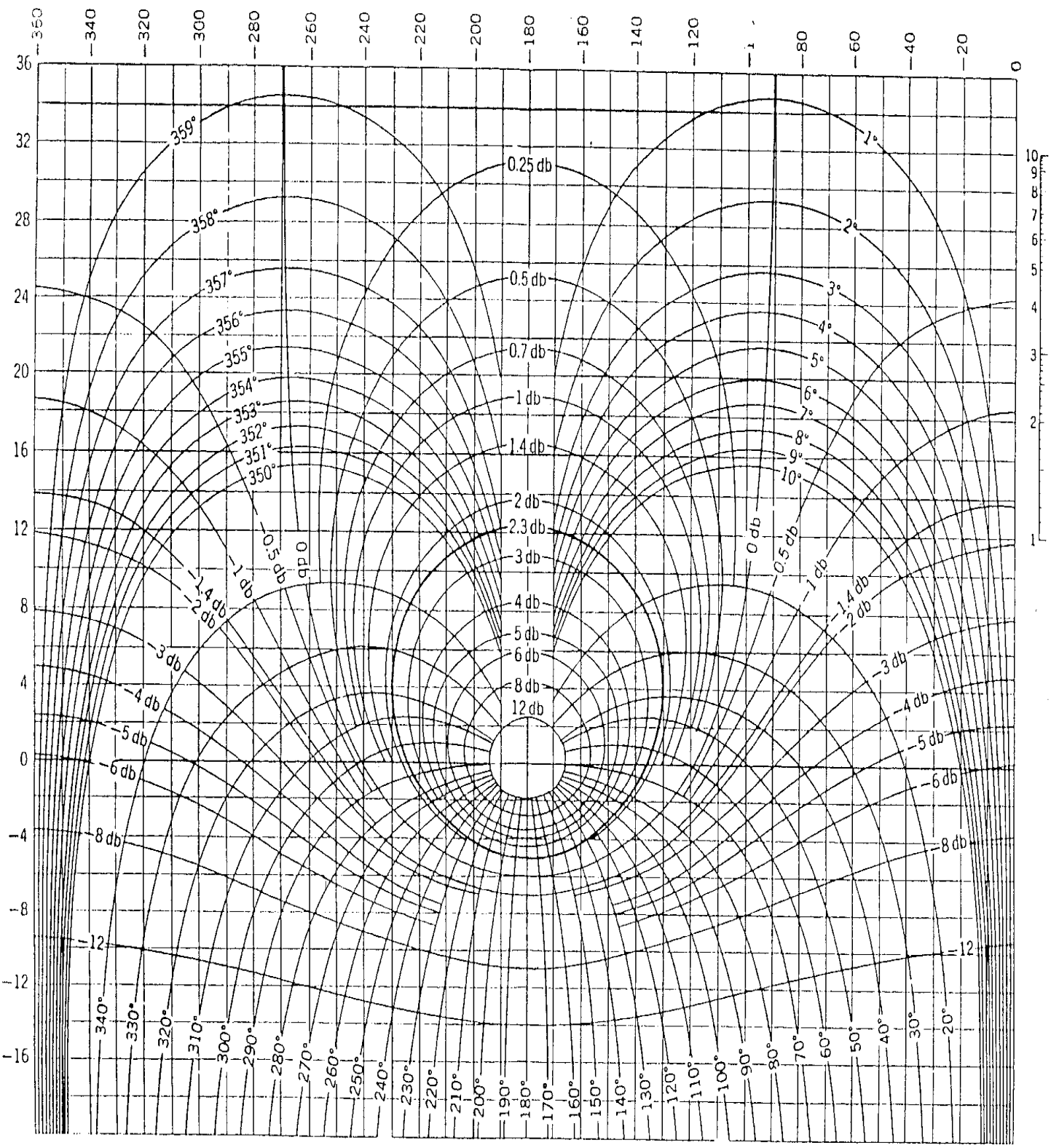

AutoCAD
log6x0.ps
S.J. Katzen University of Ulster, School of Electrical and Mechanical Engineering
Log 6 cycles x Linear
1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9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36 32 28 24 20 16 12 8 4 0 -4 -8 -12 -16
359° 358° 357° 356° 355° 354° 353° 352° 351° 350°
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10 9 8 7 6 5 4 3 2 1