PP II

TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Electrical & Electronic Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Technology (Electrical & Electronic Engineering)

TEE 4309: CONTROL ENGINEERING I.

END OF SEMESTER EXAMINATION

SERIES: JULY 2025

TIME: 2 HOURS

DATE: JULY 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) Define the term 'control systems'

[3 marks]

b) A closed-loop control system is used to regulate the speed of an electric motor that drives a conveyor belt on which castings are transported from one location to another. The control system has an error actuated amplifier that operates a high power relay and subsequently this relay drives 1hp electric motor. The motor speed is monitored by a taco-generator which feeds a voltage signal negatively to the error detector. The gains of the current amplifier, the relay and the electric motor are respectively stated as 50 mA/V, 1 60_ V/A, 80 rev/min/V and the tachogenerator has a sensitivity of 2 mV/rev/min.

(i) Draw a block diagram of the arrangement.

(ii) Determine the (input) voltage that is necessary to maintain a motor speed of 1 500 rev/min with a particular load on the conveyor belt.

(iii) If the load on the belt suddenly increases so that speed falls to 1 250 rev/min, determine the instantaneous change in the error voltage.

[12 marks]

c) With the aid of diagrams explain the Nyquist Stability Criterion used in determination of the stability of a control system

[10 marks]

d) 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) (**i**) State the Routh stability criterion.

(**ii**) Outline the procedure of obtaining then Routh array in determination of stability of a control system.

[7 marks]

b) The system shown has the oscillation of 2.5 rad/sec determine the values of K_{max} and p

[7 marks]

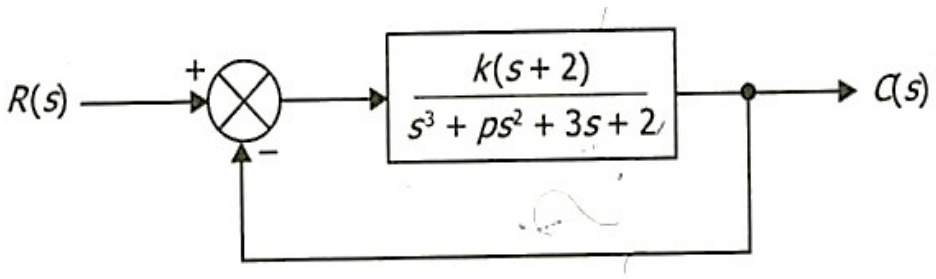


Figure Q2b

c) The pole zero configurations of a closed loop transfer function is plotted as in figure Q2b. Determine:

(i) The band width of the system

(ii) The band width of the system after a zero is added to the closed loop transfer function as in figure Q2bii

[6 marks]

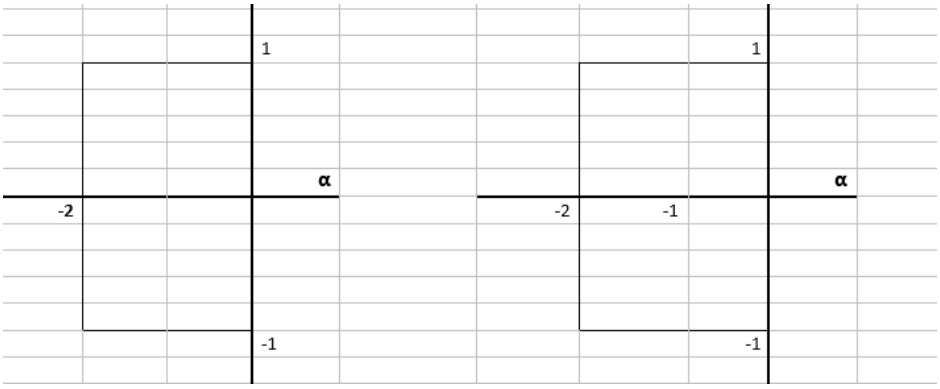


Figure Q2b

Question THREE

a) A unity feedback control system of **Figure Q3a** has an amplifier with gain K_A = 10 and a gain ratio G(s) = 1/s(s+2) in the feedback path. A derivative feedback, H(s) = sK_o = is introduced in the minor loop around G(s). Determine the derivative feedback constant K_o so that the system damping factor is 0.6.

[13 marks]

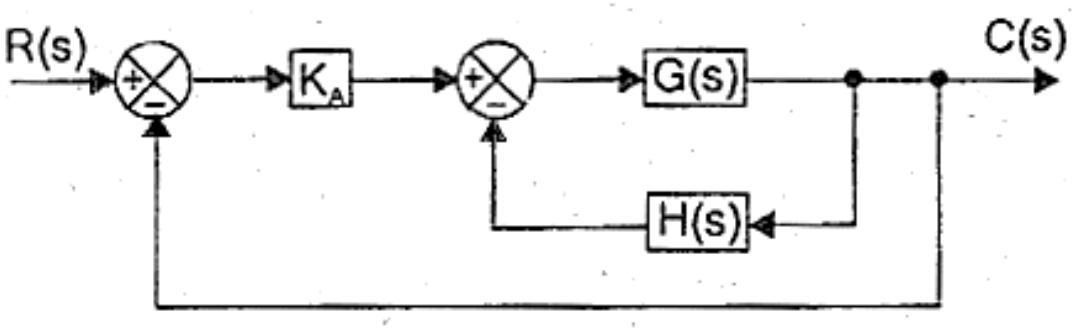


Figure Q3a

b) A closed loop servo system is represented by the differential equation

$$\frac{d^2c}{dt^2}+8\frac{dc}{dt}=¿\ 64e$$

Where c is the displacement of the output shaft
r is the displacement of the input shaft
e = r – c.

Determine for a unit step input

(i) Undamped natural frequency
(ii) Damping ratio
(iii) Percentage maximum overshoot

[7 marks]

Question FOUR

a) The permanent magnet establishes a radial field in the cylindrical gap between the poles of the magnet. The force on the conductor wound on the bobbin causes the voice coil to move, producing sound. The effects of the air can be modeled as if the cone had equivalent mass M and viscous friction coefficient b. Assume that the magnet establishes a uniform field B of 0.5 tesla and the bobbin has 20 turns at a 2-cm diameter. Determine the equations of motion of the device

[10 marks]

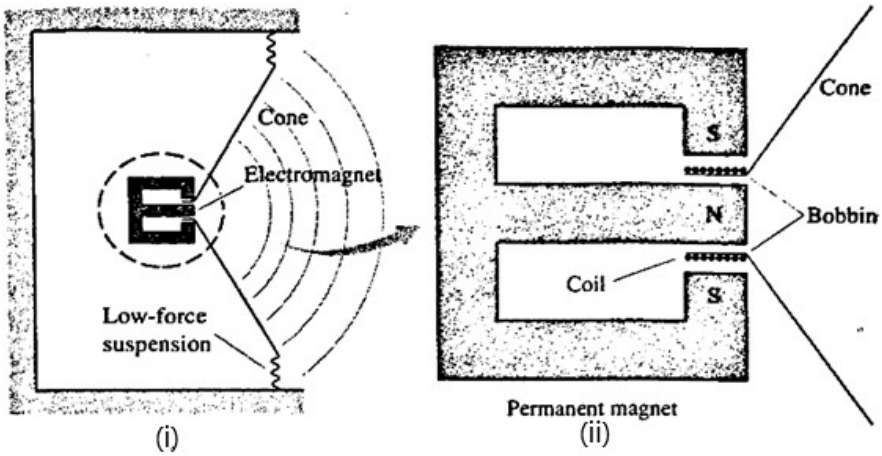


Figure Q4a

b) For the loudspeaker in **Figure Q4b** and the circuit driving it in, determine the differential equations relating the input voltage v_0 to the output cone displacement *x*. Assume the effective circuit resistance is Rand the inductance is L.

[10 marks]

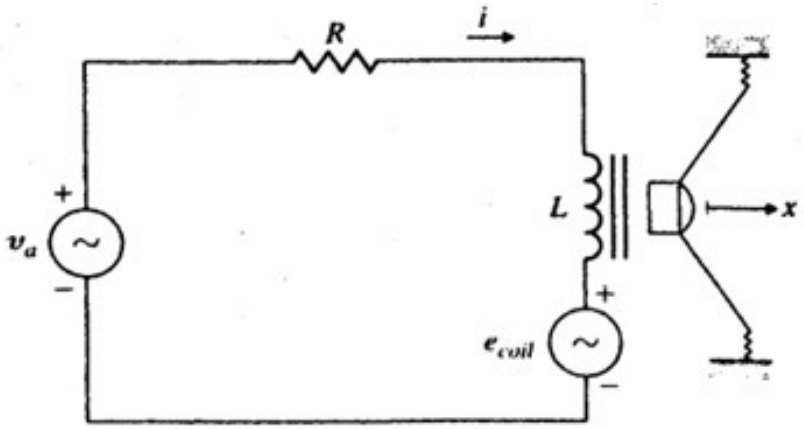


Figure Q4b

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]

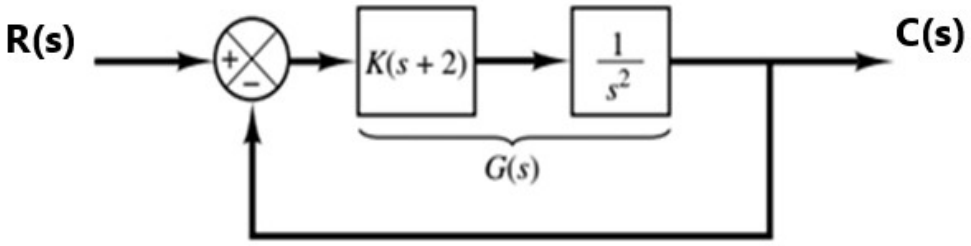


Figure Q5a

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

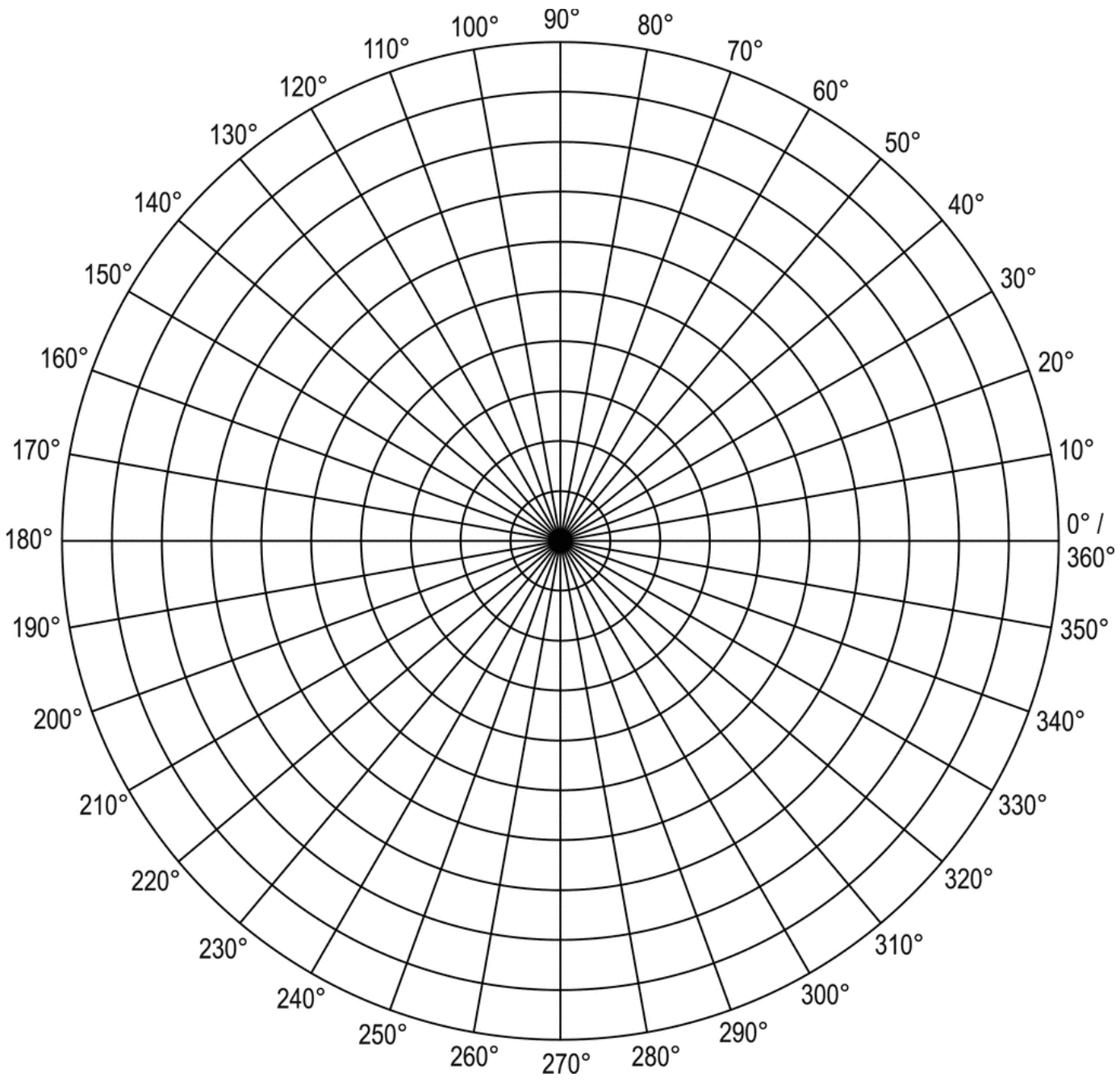
iii) Phase crossover frequency

iv) Gain crossover frequency

v) Bandwidth

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

[14 marks]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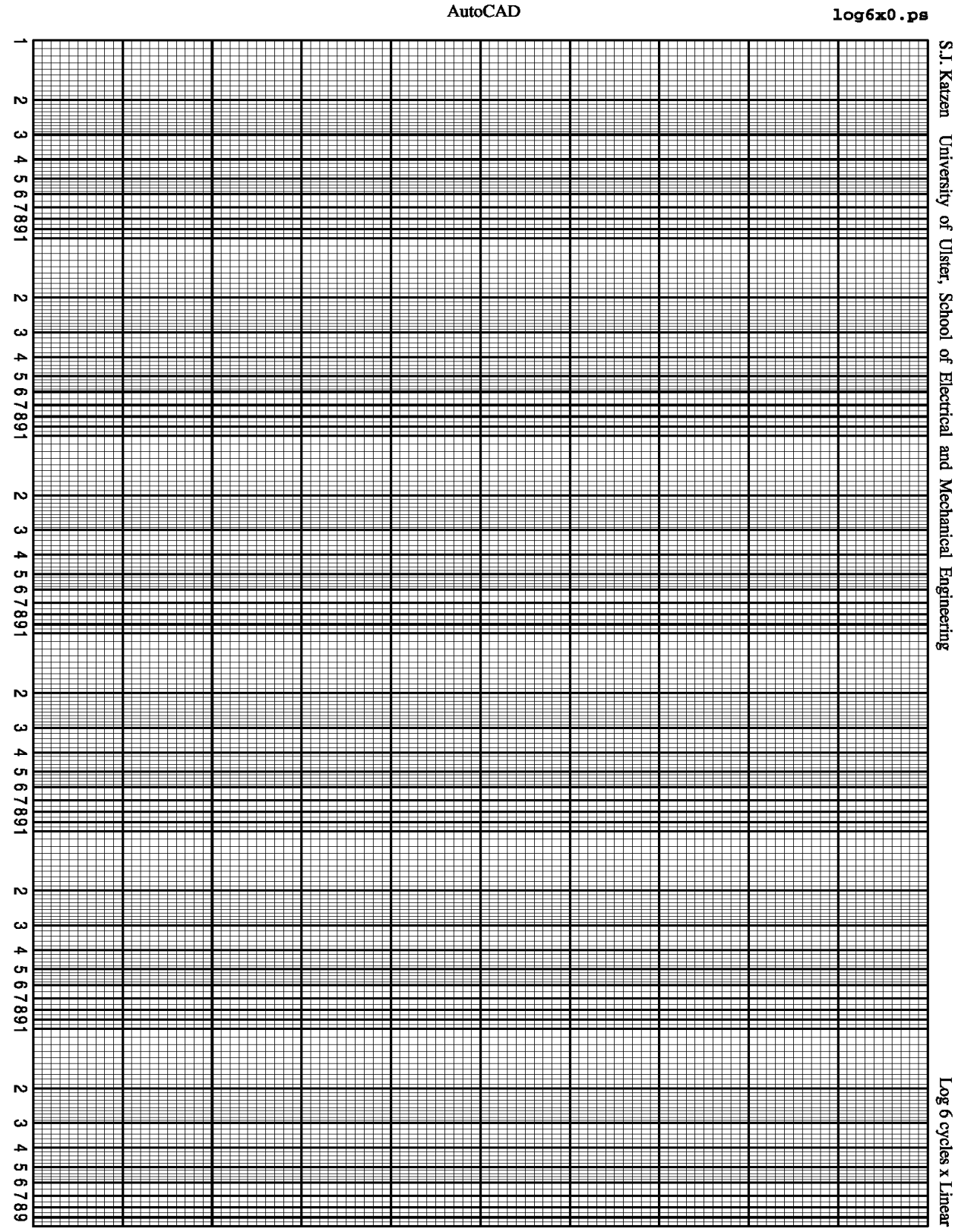
AutoCAD
log6x0.ps
S.J. Katzen University of Ulster, School of Electrical and Mechanical Engineering
Log 6 cycles x Linear
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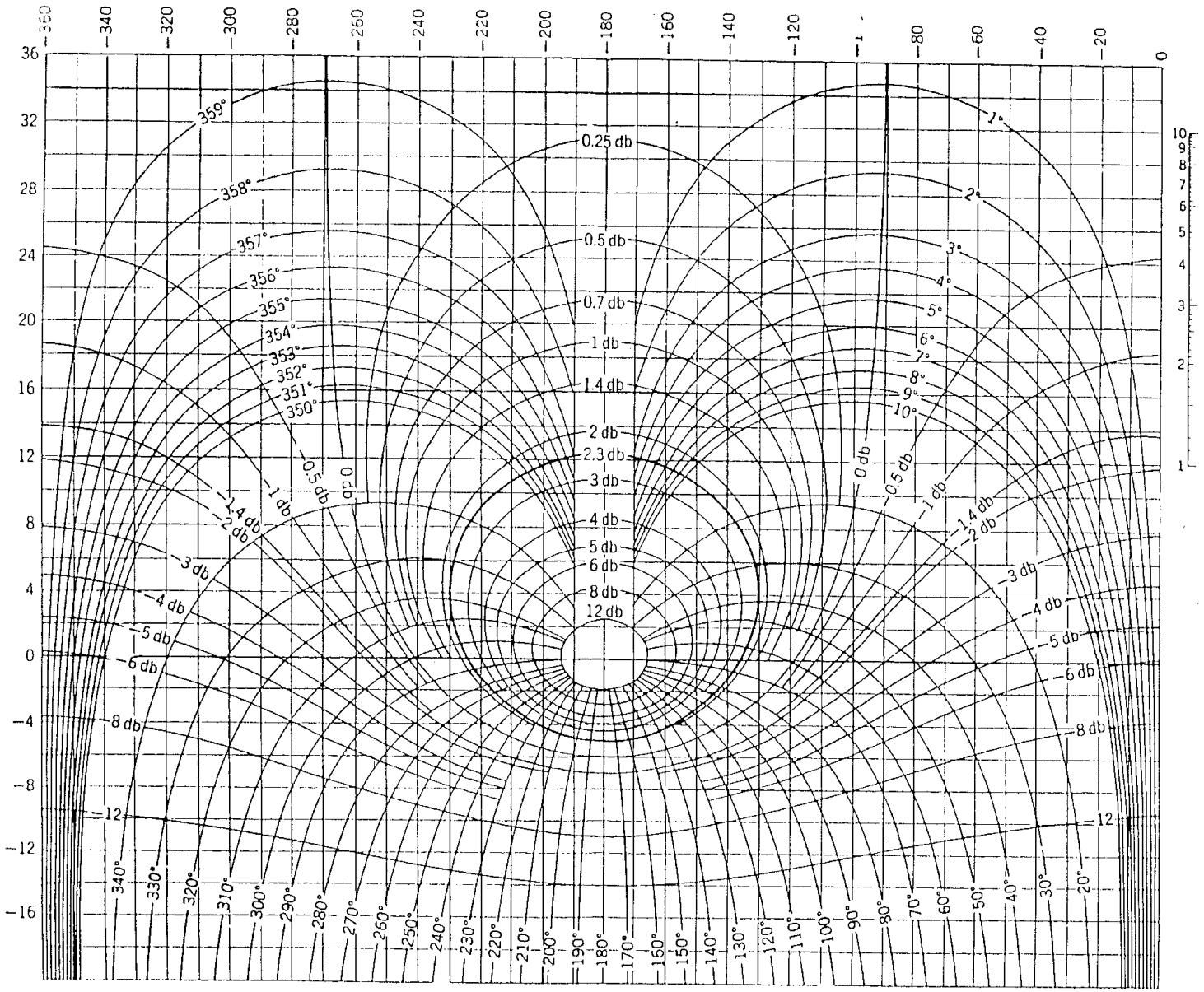
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