Pendant Loudspeakers

Design Guide

English

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Overview

Introduction

Using this design guide, you will be able to create designs for applications that utilize pendant loudspeakers. We offer additional design guides for surface-mount and in-ceiling loudspeakers, as well as dedicated design guides for EdgeMax and FreeSpace 3 sub-satellite systems. To learn more about our loudspeakers and technology capabilities, as well as access additional trainings and tutorials, visit **BoseProfessional.com**.

System Design Resources

In addition to this guide, we offer the following tools at **BoseProfessional.com** on the software and individual loudspeaker product pages:

Modeler: Advanced acoustical design simulation tool, with direct and reflected energy, and Speech Transmission Index (STI). Free to download at **BoseProfessional.com/Modeler**

EASE GLL files: For use in the AFMG EASE application, and the EASE GLL Viewer application. EASE allows the simulation of reverberation times, speech intelligibility, and other acoustical parameters. EASE is a paid download. EASE GLL Viewer is free to download.

EASE Address files: For use in the AFMG EASE Address (2D tool, direct field coverage) or EASE Evac. EASE Address is free.

BIM files: Includes the Revit format. Revit is a paid download.

Overview

All system designs begin with a set of requirements. The system requirements can be as simple as, “it has to sound great” or as detailed as, “it must play background-level music at 5 dB above the ambient noise level of the restaurant's main dining room, which is 65 dB.” The challenge is to gather the right set of requirements, and then turn them into a set of criteria that you can use to create your design. It is important to remember that you are the designer and should use your own intuition and decision skills when planning a project in addition to calculations. Applications with mounting heights between 2.4 meters and 10 meters (8 feet and 32 feet) are supported through the pendant-mount loudspeaker models listed in this guide.

There are four key requirements that need to be identified to deliver the right system:

Loudness: What sound pressure level (SPL) is required for this application?

Mounting Height: What loudspeakers will work best for my planned mounting height?

Response: What bandwidth is required for the type of program material that will be used?

Coverage: How consistent must the sound be across the entire coverage area?

Each of these requirements can be easily converted into a specification that we can use to create our system design. If we understand the customer’s needs in these four areas, we can deliver a design that will — at a minimum — meet their needs and — at best — exceed their expectations.

For the purposes of this design guide, we will assume that you are familiar with the system requirements for a commercial audio system and are ready to focus on loudspeaker selection, creation of a loudspeaker layout, and defining the necessary amplifier power needed to power the design.

Design Guidelines

When creating a design, you should consider the following:

Mounting Height (Grille-to-floor distance)

Maximum SPL for the application (for example 70 dB-SPL, Z-weighted)

Design Worksheet

Use the following worksheet to create a design using Bose Professional loudspeakers.

Choosing a Model

Step 1: Loudness

Maximum SPL Capability

Confirm that your chosen loudspeaker model will meet your loudness requirement. Find your mounting height and follow the column down until you reach your desired maximum continuous output level. Models with a higher sensitivity and higher tap settings will be able to play at higher levels. Individual model tap charts are available at the end of this document.

Example: *For a mounting height of 5 meters (16 feet) in a project that requires 90 dB, you would choose DM5P.*

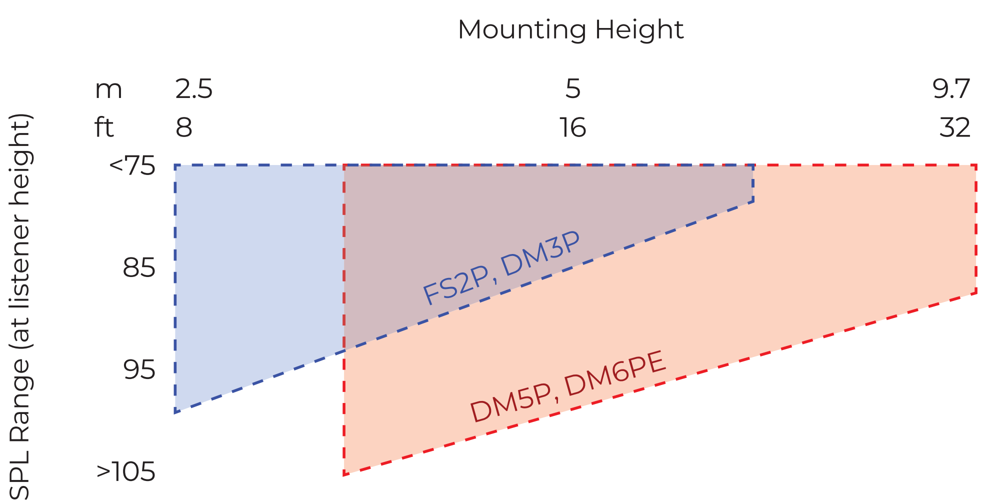
Pendant Models: Maximum Continuous Output Level														
Mounting Height	m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
	ft	8	9	10	12	13	14	16	18	20	22	26	32	
DM3P	25W tap	99	96	94	91	90	89	87	86	85	84	82	80	dB-SPL
FS2P	16W	100	97	95	92	91	90	88	87	86	85	83	81	
DM5P	50W	105	102	100	97	96	95	93	92	91	90	88	86	
DM6PE	80W	109	106	104	101	100	99	97	96	95	94	92	90	
	8Ω	110	107	105	102	101	100	98	97	96	95	93	91	

Note: *The above table assumes standing ear height at 1.5 meters (5 feet), in minimum overlap configuration. Room reverberation could add as much as 4 dB system gain, which is not factored into the measurements above. Use of the transformer on 70/100V systems will introduce an insertion loss of 1 to 2 dB.*

Step 2: Mounting Height

Average Conical Coverage and Woofer Sizes

Smaller woofer models have wider average conical coverage and provide better results at low mounting heights. Larger woofer models with narrower average coverage angles are better suited for higher mounting heights. Choose the models that will work with your mounting heights and rule out the other models.



Woofer Size	Model	Sensitivity (dB)	Highest Tap / Power Handling	Recommended Mounting Heights
2–4 in	DM3P	84	25W	2.5 m–6.1 m (8'–20')
	FS2P	87	16W	
5–6.5 in	DM5P	87	50W	3 m–10 m (10'–32')
	DM6PE (70/100V)	89	80W	
	DM6PE (8Ω)		100W	

Step 3: Response

Confirm that the chosen loudspeaker will meet your low frequency response requirement.

Vocal-range	Low Frequency (–10 dB)
FS2P	83 Hz
DM3P	75 Hz

Full-range	Low Frequency (–10 dB)
DM5P	65 Hz
DM6PE	62 Hz

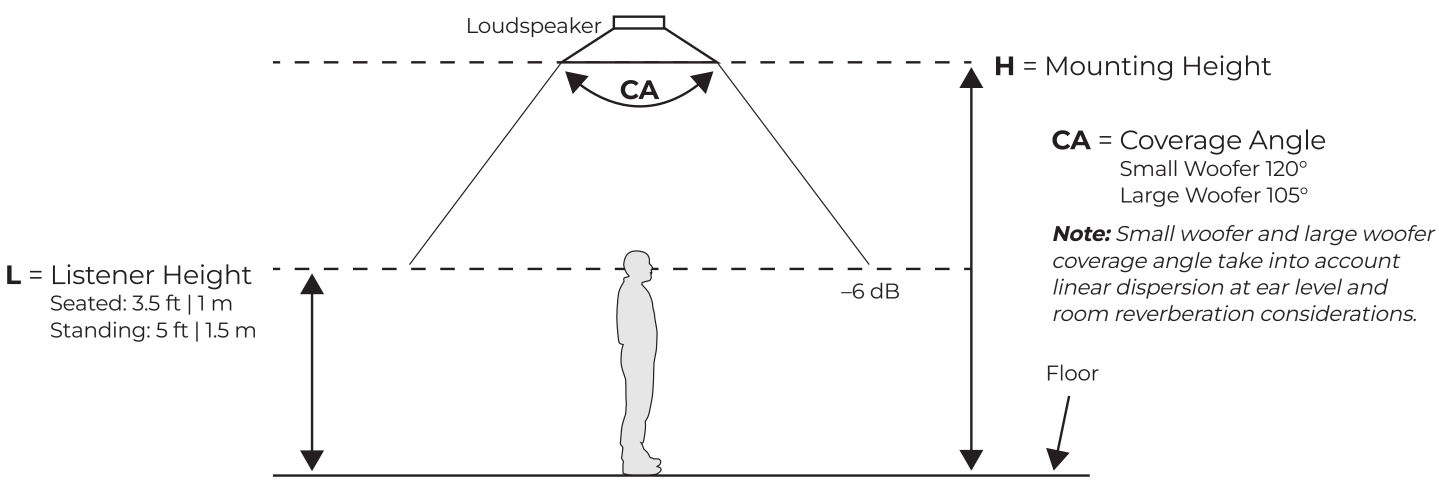
Extended-range	Low Frequency (–10 dB)
Any vocal-range or full-range loudspeaker combined with DM10P-SUB subwoofer	40 Hz

Step 4: Coverage

Determining Loudspeaker Quantity and Spacing

The goal is to fill a rectangle-shaped room with coverage circles at your desired density. Using the graph paper on the last page, create a sketch layout of the room. Using your sketch of the room, follow the steps below to create a layout with the loudspeaker spacing that meets your coverage requirement. Calculators or software can simplify this process. Medium-sized or larger distributed installed systems for background music or voice typically have four or more pendant loudspeakers in a room. Use **Loudspeaker Spacing Distance (LSD)** for small rooms that only need one.

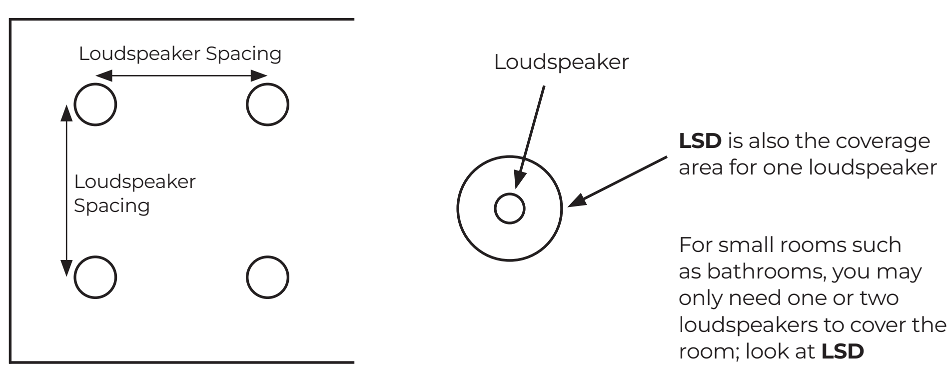
A. Calculate the Loudspeaker Spacing Distance (LSD)



LSD = Spacing Distance

M = Multiplier

LSD = (H – L) × M



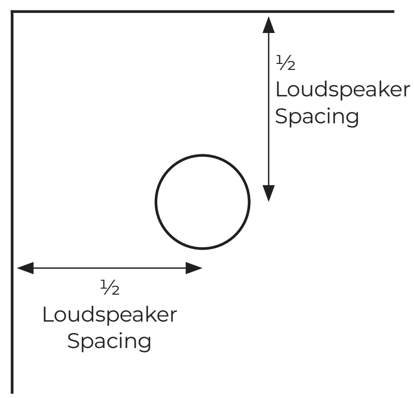
2–4 in. Small Woofer Coverage	M (multiplier)	Models
Edge-to-edge	3.46	FS2P DM3P
Minimum Overlap	2.45	
Center-to-center	1.73	

5–8 in. Large Woofer Coverage	M (multiplier)	Models
Edge-to-edge	2.61	DM5P DM6PE
Minimum Overlap	1.84	
Center-to-center	1.30	

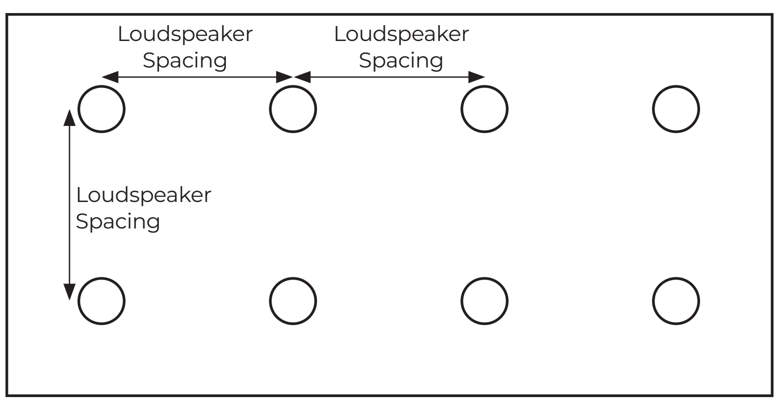
Multipliers are created from **Coverage Angles (CA)**. These are multipliers we have found to work for most applications. For more precise results, and to adjust for obstructions, use **Modeler**, **EASE**, **EASE Address** or **EASE Evac** software or another calculator.

Edge-to-edge coverage can provide fidelity in fixed-location seating/standing and can generally work well for installations on a budget. It also works well for ambient-level and low-level background music. Center-to-center installations will have higher density and can accommodate people listening in many different positions and moving floor plans due to uniform coverage. They will also have fewer dead zones. Minimum overlap (or center-to-center) may also be needed if critical communication is happening over the system. **Modeler** or **EASE Evac** software can help with speech intelligibility evaluation.

B. Place the first loudspeaker at ½ LSD from any corner of the room.

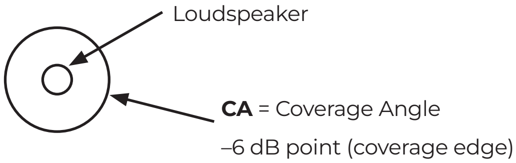


C. The remaining loudspeakers are arranged on a square grid pattern using the LSD. If a loudspeaker would be placed on or beyond the perimeter of the room, delete that row/column of loudspeakers.



D. After the last loudspeaker is placed, center the loudspeakers in that row to create new offset distances out from each wall, which may be unique from ½ LSD.

E. (Optional) To quickly calculate the total **Loudspeaker Quantity (LQ)** needed to fill the rectangular room without using graph paper, follow this method. In square layouts, the final total is sometimes slightly reduced as you lay out rows. You can also determine final quantity by following Step B on graph paper until the room is filled.



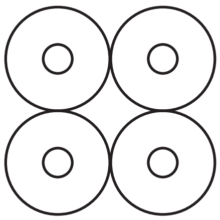
Area = Square footage of room

(Length × Width)

$$\mathbf{LQ} = \frac{\mathbf{Area}}{[(\mathbf{H} - \mathbf{L})\frac{\mathbf{M}}{2}]^2}$$

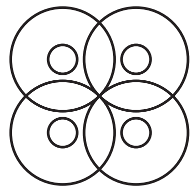
Edge-to-edge = LQ/4

–6 dB touching



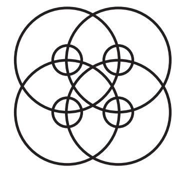
Minimum overlap = LQ/4

–3 dB touching



Center-to-center = LQ/4

–1.5 dB touching



Subwoofers: Quantity and Placement of Subwoofers

The number of subwoofers to use, where to position them, and how loud to set them can vary depending on the individual situation. Details such as placement, boundary loading, room size, coupling quantity of multiple loudspeakers to subwoofers, type of music, type of activity, budget, and the expectations of the listeners should all be considered. The following guidelines are general rules to follow.

Add one subwoofer for every group of four vocal- or full-range loudspeakers.

Subwoofer spacing should be as far apart as is practical. 12.2 meters (40 feet) or greater subwoofer-to-subwoofer spacing distance within the same zone is desirable.

When the suggested subwoofer count is two within a single zone, it may be preferable to use either one in a corner to avoid audible interference; or increase the count to three, which creates more audible interference locations but limits them to smaller sizes where the reverberant field (added room reflections) tends to mask them.

Placing a ceiling subwoofer within 0.9 meters (3 feet) of a wall increases its output by 3 dB. Placing it within 0.9 meters (3 feet) of a corner increases its output by another 3 dB (6 dB total) and also reduces reflections that can create audible interference (bass cancellations) in the listening area.

Listening positions located below the subwoofer should be supported by a nearby vocal- or full-range loudspeaker to provide better tonal balance in the low-frequency pressure zone.

Step 5: Calculate Required Amplifier Size

All FreeSpace FS and DesignMax loudspeakers are compatible with 70-volt, 100-volt, and low-impedance amplifiers.

Use the Tap Charts to determine which loudspeaker tap is required for this design

A. Locate the loudspeaker tap chart and find the column for mounting height for this design.

B. Follow the column to the desired maximum SPL.

C. Follow the row across the chart to determine the required loudspeaker tap.

D. Calculate the required amplifier power:

____________	×	____________	=	____________
Number of Loudspeakers Required		Required Loudspeaker Tap		Power Required

E. Calculate the required amplifier size:

____________	×	1.10	=	____________
Power Required		Headroom		Amplifier Size

Amplifiers: Example Amplifier Configurations

Modern amplifiers come in a variety of channel counts and configuration options to allow for different output configurations, zoning options, and varying loudspeaker quantities. A properly optimized system may only need a low 1- or 2-watt tap setting to achieve 70 dB in a typical room. The below example lists how many FS2P loudspeakers can be handled at the loudspeaker's highest 70/100V tap setting.

FreeSpace FS2P Loudspeaker Amplifier Example	Maximum Loudspeakers at Higher Tap Settings	EQ Preset	Average SPL*
FreeSpace IZA 190-HZ	5 at 16W, 10 at 8W tap	FS2C/SE/P	88 dB at 16W, 85 dB at 8W
FreeSpace IZA 2120-HZ	6 at 16W, 13 at 8W	FS2C/SE/P	
PowerShare PS404D	22 at 16W, 45 at 8W	FS2P	
PowerSpace P4150+	8 at 16W, 17 at 8W	FS2P	

* 3 meter (10 foot) mounting height room with edge-to-edge density, standing listener, 12 dB crest factor of pink noise/compressed music, direct-field, no room gain.

SmartBass: Application of SmartBass processing

If your design is using a PowerSpace+ amplifier; or your design utilizes a dedicated Bose Professional DSP, such as the Commercial Sound Processor CSP models; or any of the ControlSpace ESP or EX models; you have the option of applying SmartBass to your loudspeaker output channel. This uses Bose Professional EQ presets, dynamic EQ, and excursion limiting tuned to each model and room calibration. This will prevent lower background-level music from sounding thin, but also ensures the sound is consistent at various SPL levels. At louder levels, SmartBass also allows for more musical limiting than traditional voltage limiters.

Tap Charts

Individual Loudspeaker Continuous Output Level

Note: *The following tap charts assume standing ear height at 1.5 meters (5 feet) in minimum overlap spacing. Room reverberation could add as much as 4 dB system gain, which is not factored into the measurements. Designing without room gain will ensure you don't under-plan your design, and amp attenuation is possible at the job site if you exceed the average room SPL target during measurement. Values below 70 dB are omitted, select a higher tap.*

FS2P

FS2P (standing listener height)														
Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
TAP	1W		88	85	83	80	79	78	76	75	74	73	71	—	dB-SPL
	2W		91	88	86	83	82	81	79	78	77	76	74	76	
	4W		94	91	89	86	85	84	82	81	80	79	77	79	
	8W		97	94	92	89	88	87	85	84	83	82	80	82	
	16W		100	97	95	92	91	90	88	87	86	85	83	85	
	16Ω		100	97	95	92	91	90	88	87	86	85	83	81	

DM3P

DM3P (standing listener height)														
Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
TAP	3W		89	87	85	82	81	80	78	77	76	74	73	70	dB-SPL
	6W		92	90	88	85	84	83	81	80	79	77	76	73	
	12W		95	93	91	88	87	86	84	83	82	80	79	76	
	25W		99	96	94	91	90	89	87	86	85	84	82	80	
	8Ω		99	96	94	91	90	89	87	86	85	84	82	80	

DM5P

DM5P (standing listener height)														
Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
TAP	3W		92	90	88	85	84	83	81	80	79	77	76	73	dB-SPL
	6W		95	93	91	88	87	86	84	83	82	80	79	76	
	12W		98	96	94	91	90	89	87	86	85	83	82	79	
	25W		102	99	97	94	93	92	90	89	88	87	85	83	
	50W		105	102	100	97	96	95	93	92	91	90	88	86	
	8Ω		105	102	100	97	96	95	93	92	91	90	88	86	

DM6PE

DM6PE (standing listener height)														
Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
TAP	2.5W		94	91	89	86	85	84	82	81	80	79	77	75	dB-SPL
	5W		97	94	92	89	88	87	85	84	83	82	80	78	
	10W		100	97	95	92	91	90	88	87	86	85	83	81	
	20W		103	100	98	95	94	93	91	90	89	88	86	84	
	40W		106	103	101	98	97	96	94	93	92	91	89	87	
	80W		109	106	104	101	100	99	97	96	95	94	92	90	
	8Ω		110	107	105	102	101	100	98	97	96	95	93	91	

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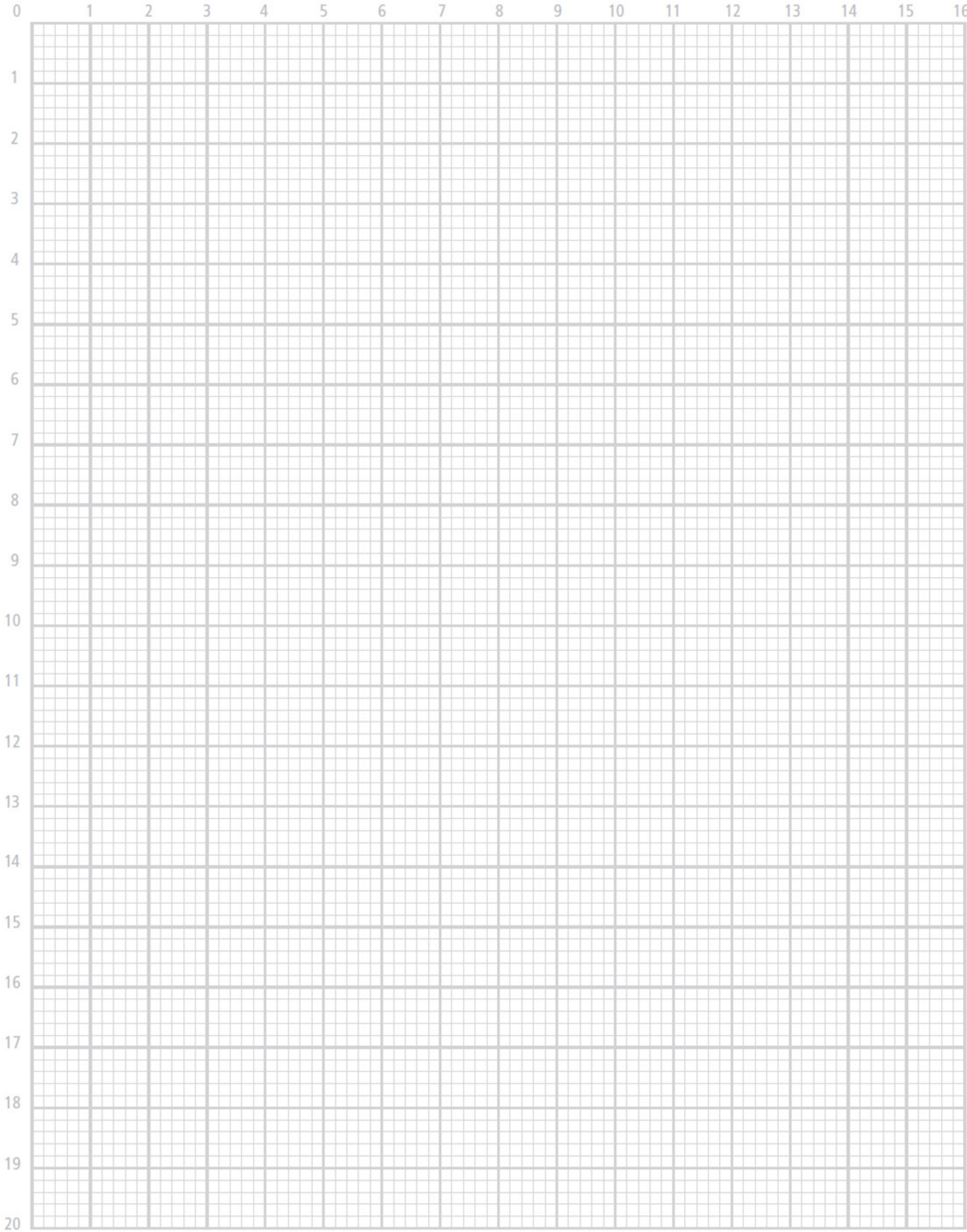
Graph Paper


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20