B&W PRODUCTIONS · CREW TRAINING · MODULE 3

Line Arrays and Subwoofers

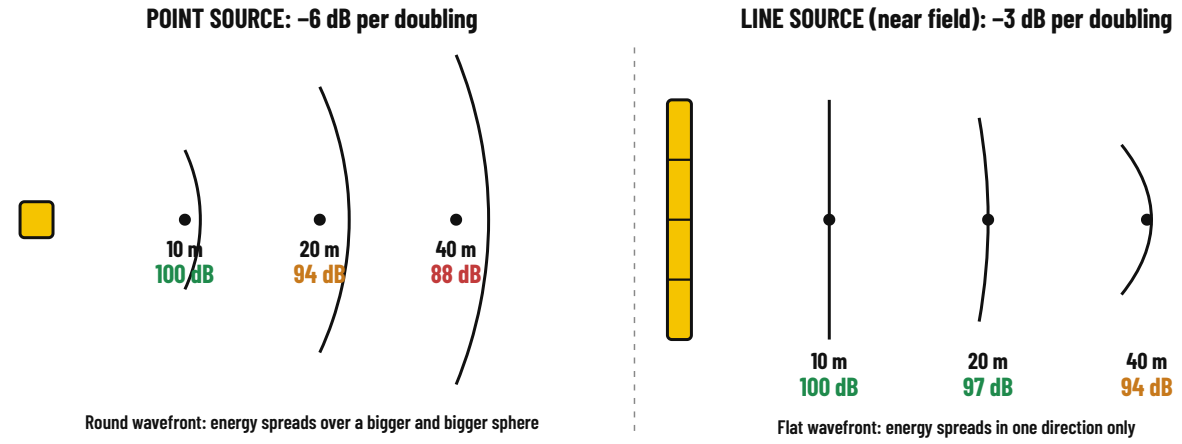
Why a line of speakers throws further than a single box, how column arrays and true line-array elements work, and how to place, align and tune subwoofers. Covers the key rule on two subs together or apart, cardioid setups and safe ground stacking. Written for beginners. Read it, try the sub spacing tool, then pass the quiz.

B&W Productions · Proper Planning, Prevents Poor Performance



01 Point source vs line source

A single speaker box spreads its sound in a sphere. That is why it dies off so fast with distance. A tall row of drivers spreads sound differently, and it holds its level much further. This one idea is the reason line arrays exist.



Same level at 10 m, then the distances double. The point source loses 12 dB by 40 m. The line source loses 6 dB. Not to scale; the levels are the textbook case.

Why the line source loses less

A point source sends energy out in every direction, so each doubling of distance spreads the same energy over four times the area: –6 dB. A tall line of drivers that work together pushes the sound out sideways and not up and down. The energy spreads over twice the area, not four times: –3 dB.

The catch: the line only behaves like a line in its **near field**. Past a certain distance it turns back into a point source and loses 6 dB per doubling again. For a small array that distance is not far, so the real gain is a few dB, not a miracle. The gain is real, and it is cheap, because the sound lands on the audience and not on the ceiling or the floor.

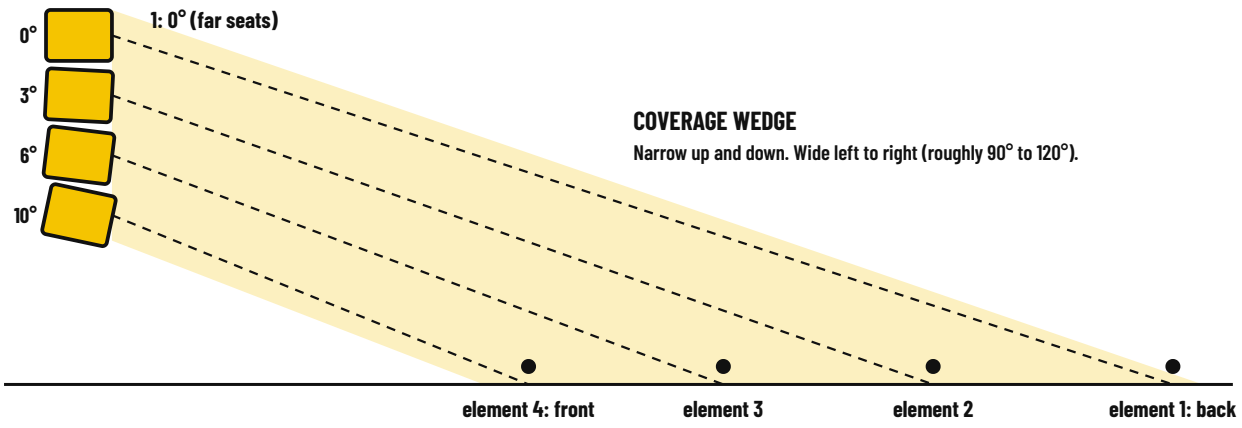
What "throw" means

Throw is how far a speaker can send usable sound before it is too quiet or too muddy. A long throw means the back row hears nearly what the front row hears. Line arrays are the long-throw tool.

> **FIELD RULE**
> Never fix a quiet back row by turning the whole system up. The front row suffers. Fix it with the right tool: a longer array, a delay speaker, or aim the top of the array further back.

02 What a line array is

A line array is a vertical stack of identical speaker elements, hung or stacked so close together that their sound combines into one tall source. The elements are not spread out. They touch, and that is what lets them couple.



Side view. The top element aims furthest. Each element below tilts a little more, so each one covers its own slice of the audience. Angles are exaggerated in the drawing. Real splay is a few degrees.

The three things that define it

- **Identical elements, tight spacing.** Close enough that the sound of neighbouring boxes adds up and does not fight.
- **Narrow vertical, wide horizontal.** The stack shapes the sound into a wedge: tall and thin when seen from the side, wide when seen from above. It lands on people and misses ceilings and floors.
- **Splay angle.** The small angle between one element and the next. It is set with pins or a bar on the hardware. More splay widens the vertical coverage and lowers the level. Less splay narrows it and throws further.

Why small arrays suit small rooms

You do not need ten boxes. Two to four small elements already give a tidy wedge for a hall of 100 to 300 people. In a low room the benefit is simple: less sound hits the ceiling, so less echo and less feedback.

03 Column arrays



RCF Evox 8: column on a 12" sub



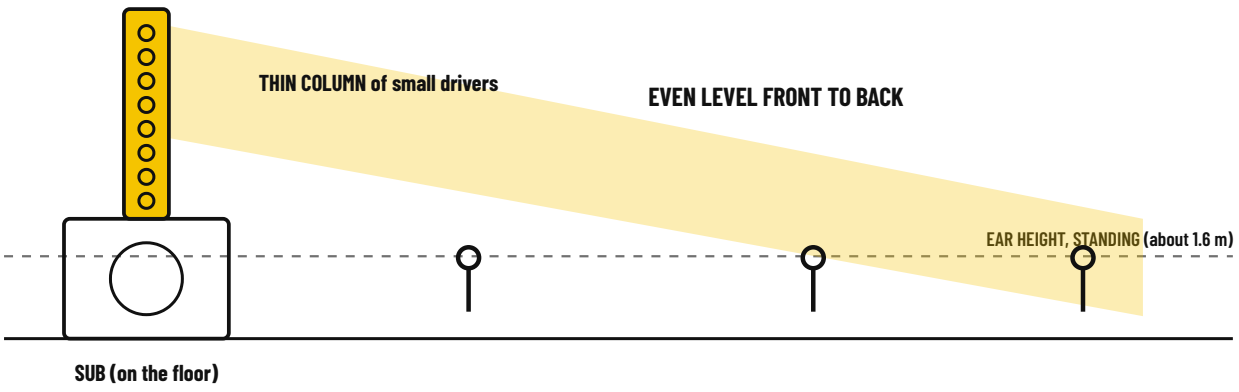
RCF Evox 12: taller column, 15" sub



Evox column head, rear

The column arrays in the kit. Each is a powered sub with the amp inside and a slim column of small drivers on a pole. Manufacturer photos: RCF.

A column array is the small-event version of a line array: a sub on the floor and a thin vertical column of small drivers on top. One person can set it up in minutes. For speeches, corporate functions and a DJ for a modest crowd, it is often the right answer.



The column's height shapes the beam. The sub does the bass; the column does voice and music. The beam is aimed at ear height from front to back.

Why they are tidy

- **Even coverage.** People near the column and people at the back hear a similar level.
- **Less spill to the walls.** The beam is narrow vertically, so less goes up to the ceiling.
- **Small footprint.** The column is slim and sits on the sub. Nothing blocks the audience's view.

Their limits

Be honest with the client and with yourself. A column array is **not very loud**. It is not a dance-floor system for 500 people. A short column has a short near field, so it cannot throw far. Sound check shows you the limit: if the front is comfortable and the back is quiet, the room is too big for it.

RIGHT JOB

Speeches, awards, background music, a small DJ set, rooms up to roughly 150 to 250 people. In the B&W kit: RCF Evox 8 (on the music bus) and Evox 12 column arrays.

WRONG JOB

Outdoor festivals, big halls, a loud dance night. Use real line-array elements with subs, or add delay speakers.

FIELD RULE

Put the column on the sub, the sub on a solid floor, and stand back at the back of the room before the doors open. If you cannot hear it clearly there, the system is too small for the room. Say so before the event, not during.

04 True line-array elements



DAS Event-208A: two 8" drivers + horn, powered



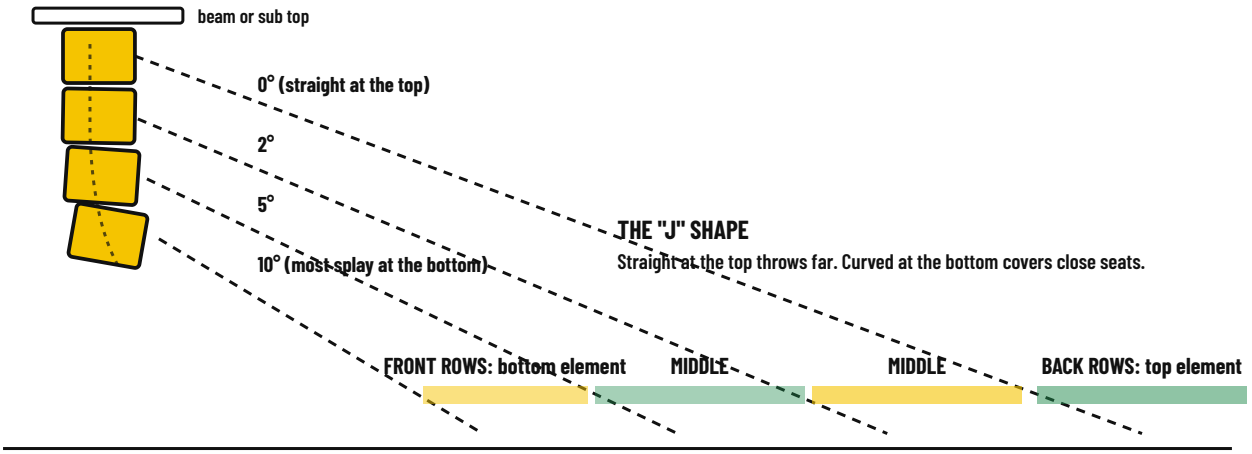
Four 208As on the rigging frame



A flown array, J curve visible

The kit's true line-array element, the DAS Event-208A ("the little array"). Each box is a three-way powered element; they pin together at set angles on the frame. Product photos: DAS Audio dealers. Crew ground-stack; flying is for certified riggers.

A real line-array element is bigger than a column driver. A typical one is a pair of 8" woofers and a horn in one angled box, built so that it stacks with its neighbours at a set angle. It is much louder than a column and throws much further.



Angles are exaggerated in the drawing. The top of the array is straight (or nearly) so those elements throw far. Lower elements tilt down more, so they spread their sound across the nearer seats.

Ground stack or flown

These elements are used two ways. **Flown** means hung from a truss or a motor. **Ground-stacked** means built up from the floor, usually two to four elements high on a sub. At a small event the crew ground-stack. Ground stacks are shorter, so they cover a smaller area, but they are safer to build and cheaper to run.

FLYING IS FOR CERTIFIED RIGGERS ONLY

Nothing hangs over people unless a qualified rigger has set it, signed it off and taken responsibility for the motors, the pins and the load. Crew do not fly arrays. Crew ground-stack, inside the maker's stacking limits.

The J curve

The splay between elements is set with pins. Top elements: almost no splay. Lower elements: more. That gives the J shape. The result: every row of seats gets roughly the same level, because each slice of audience has its own part of the array aimed at it.

TOP ELEMENTS

Nearly straight. Aimed at the back rows. Longest throw.

BOTTOM ELEMENTS

More splay, aimed down at the front rows. Short throw, wide spread.

In the B&W kit: the DAS Event-208A rack, a powered double-8" and horn line-array element ("the little array").

05 Subwoofers



Subs together in the centre, tops on poles at the sides. The two subs couple and give even bass across the floor.

A subwoofer ("sub") handles the lowest part of the sound: kick drum, bass guitar, the thump you feel in the chest. It plays below about 100 Hz. Tops play everything above. The point where one hands over to the other is the **crossover point**.

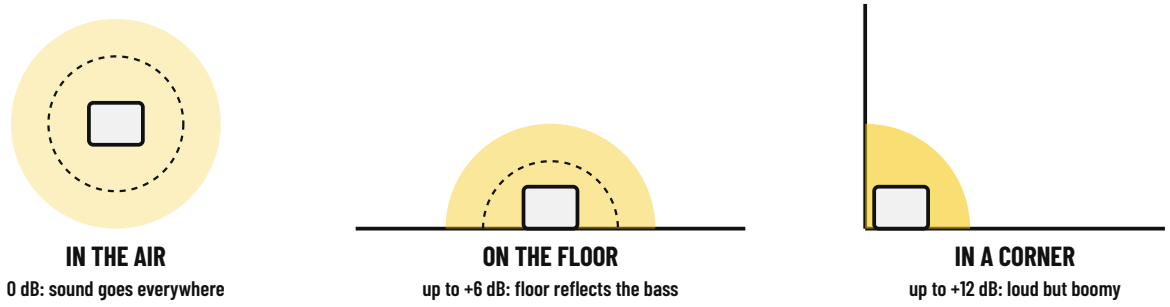
Crossover points

Most small PAs cross over between 80 and 120 Hz. Lower crossover: subs do less, tops do more. Higher crossover: subs do more, and they start to be heard as a source in the room. If a powered sub has a switch or a preset, use it. Do not invent your own number.

Why bass goes everywhere

A low note has a long wavelength. A 60 Hz note is about 5.7 m long from peak to peak. A sub box is much smaller than that, so it cannot aim its sound. Bass spreads out in all directions, behind the box too. That is why you can feel bass on stage, in the next room, and in the car park.

Why subs sit on the floor



The floor and walls stop bass escaping. They bounce it back in the same direction, and the sound adds up. This is free gain. No extra amplifier needed.

That free gain is called **boundary gain**. A sub on the floor gains up to 6 dB. A sub against a wall gains more. A sub in a corner gains the most, but the bass can turn boomy and uneven. A sub on a stand in free air gains nothing.

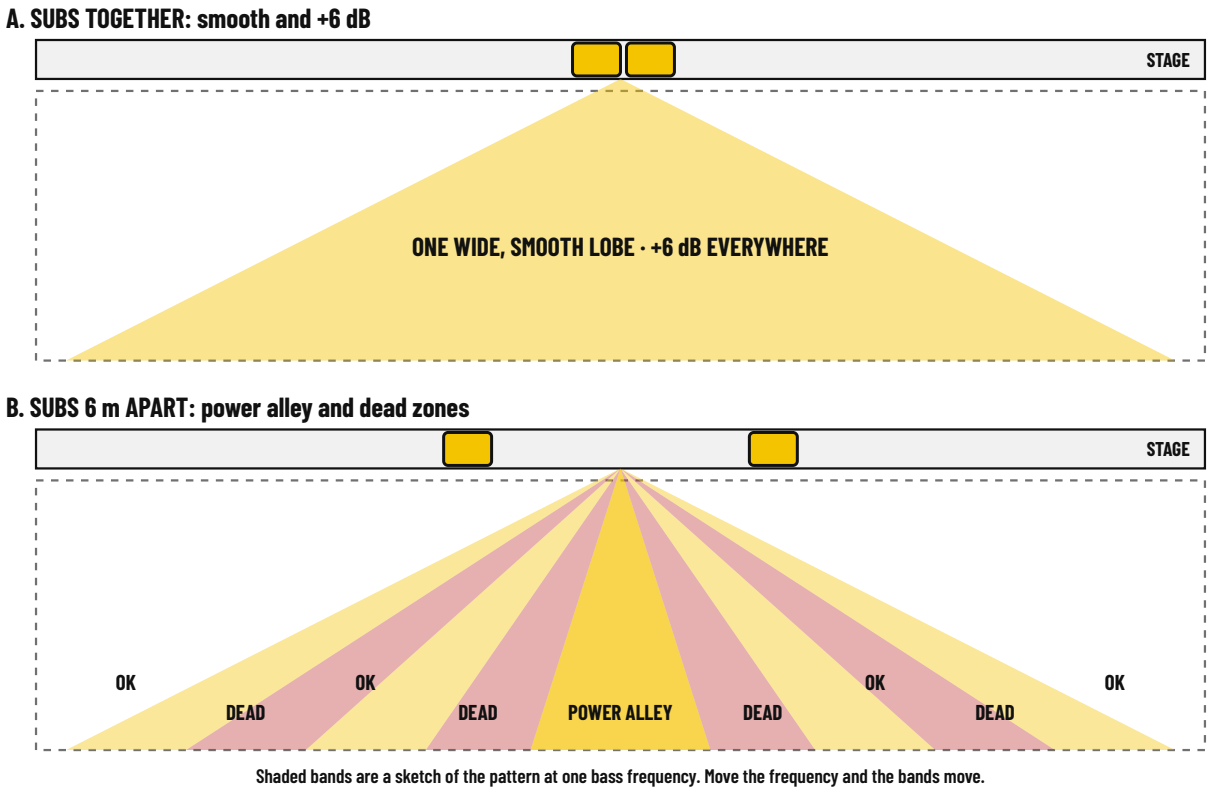
FIELD RULE

Subs go on the floor. Not on a table, not on a stage riser if you can help it, and not wedged into a corner unless the client wants a rumble. If the subs sound boomy, move them 1 m out from the wall.

In the B&W kit: JBL single-8" and double-8" powered subs.

06 Two subs: together or apart

This is the lesson that separates crew who know what they are doing from crew who just carry boxes. Where you put two subs changes the sound more than which subs you buy.



Top view looking down on the audience. In B the two subs are 6 m apart. In the middle both are the same distance away, so they add. To the side, one sub is further than the other and the two bass waves can arrive out of step.

Together: coupling

Put two subs side by side, touching. They act like one bigger sub. Their sound waves line up and add: twice the sound pressure, which is **+6 dB**, for the same amplifier on each box. No cancellation. The pattern is smooth across the room. This is the default for a small PA.

Apart: power alley and comb filtering

Put the same two subs 6 m apart (one each side of the stage). Standing in the exact middle, both are the same distance away, so they add: +6 dB. A "power alley" down the centre. But move sideways and one sub gets closer than the other. At some spots the bass from one arrives half a wavelength late and **cancels** the other. That is a **dead zone**. Further out, it adds again. The result is a series of loud and dead strips across the room. This is **comb filtering**.

WHY DEAD ZONES

A null forms where the difference in distance to the two subs is half a wavelength. 60 Hz has a wavelength of 5.7 m. 100 Hz has 3.4 m. The wider the spacing, the more nulls fit across the room.

TRY IT: HOW FAR APART ARE YOUR SUBS?

Rough model: audience 20 m wide, 15 m from the subs, 343 m/s. Coupled when the spacing is under about 1.7 m, half a wavelength at 100 Hz.

SPACING	WHAT YOU GET	DEAD ZONES AT 60 HZ	AT 100 HZ
0 to 1.6 m	Coupled, smooth, +6 dB	0	0
2 m	Power alley, uneven sides	0	0
4 m	Power alley and nulls	0	2
6 m	Power alley and nulls	2	2
8 m	Power alley and nulls	2	2
12 m	Power alley and nulls	2	4

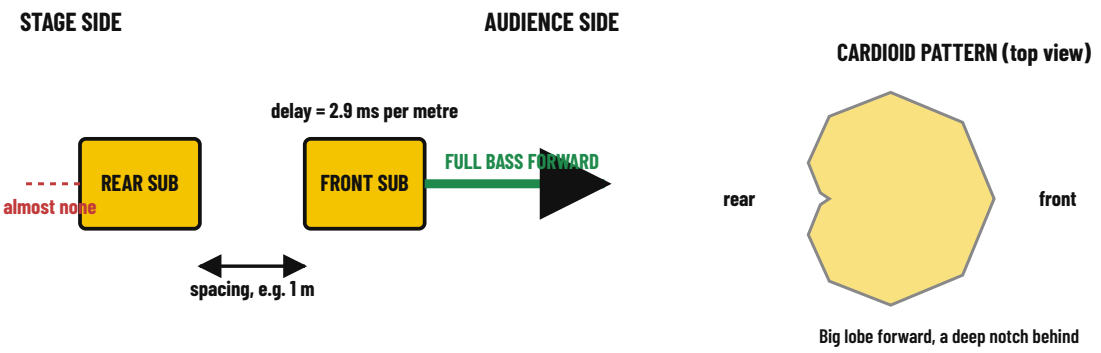
FIELD RULE

Two subs? Put them together, in the middle or on one side. Only split them if a technician has set processing for it or the client insists. Walk the room with bass music playing. If you find a spot where the bass vanishes, you have found a null: move the subs closer.

In the B&W kit: stack the JBL subs side by side, touching, and treat them as one big sub.

07 Cardioid sub setups

Bass goes everywhere, including onto the stage. That causes muddy sound for the band, feedback in vocal mics and noise in the building behind. A **cardioid** sub setup uses two or more subs and a delay to steer bass forward and cancel it behind. The name comes from the heart-shaped pattern.



End-fire: the subs sit one behind the other, both facing the audience. The front sub is delayed so its sound lines up with the rear sub's sound going forward. Behind the stack, the two cancel.

Two ways to do it

SETUP	HOW	GOOD	WATCH OUT
End-fire	Two subs in a line, both facing the audience, 1 m or so apart. Delay the front sub by the spacing: 2.9 ms per metre.	Strong forward, deep notch behind	Needs floor depth. Works best around one frequency. Measure the spacing.
Gradient	One sub faces the audience. A second faces backwards, polarity reversed and delayed by the spacing.	Compact, one footprint	Wrong polarity or delay and you cancel the front. Costs output.

What you get

- **Less bass on stage.** Performers hear themselves instead of boom.
- **Less feedback into mics.** Quiet low end behind the subs means fewer problems with open mics.
- **Tighter sound.** Less bass bouncing off the back wall and returning.

CHECK YOUR POWERED SUBS FIRST

Many modern powered subs have a cardioid preset. Use it. It sets the delay, polarity and filter for you. Only set it by hand when you have no preset, and then follow the maker's manual.

08 Setting up and tuning

A sub that is not lined up with the tops can make the system sound worse than tops alone. Tuning takes ten minutes. Do it every time the subs move.

Aligning subs with tops

1. Pre-set both tops and subs to the manufacturer's recommended crossover. Set subs and tops at a safe starting level.
2. Play music with a steady bass line, or a test tone around the crossover frequency. Stand where the audience will be.
3. Walk slowly toward the stage. Listen in the crossover region, around 80 to 120 Hz, where the subs and tops both play.
4. Flip the **polarity** switch on the subs. One position is clearly fuller. The other sounds thin, as if a chunk is missing.
5. Leave it on the louder, fuller position. If neither is clear, ask for a technician to set a delay.

Tops and subs: the rules

- **High-pass the tops** when subs are present. Around 80 to 100 Hz. The tops stop wasting power on bass, and they get louder and cleaner.
- **Aux-fed subs** get their own mix on an aux send, so you choose what goes to the subs. A sub that gets the vocal mic gets boom. **Full-range** feeding sends the whole mix to the sub, and the sub's own crossover does the filtering. Fine for a DJ; for live speech use the aux.
- **Limiter and DSP presets.** Many powered speakers have a built-in limiter and a preset menu. Leave the limiter on. It protects the drivers.

PRESET	WHEN TO USE IT
Speech	Talks, awards, MC. Cuts low boom so voices stay clear. Subs often off.
Music	Playback, band, DJ. Full range with subs on.
Sub on / extended	When a sub is connected. Tops are high-passed for you.
Cardioid	Two or more subs where bass on stage is a problem.
Flat / user	Only when a technician is tuning with a measurement mic.

Preset names vary between makers. Read the one-page quick guide for the box in front of you.

The listening routine

1. **Pink noise** at low level. Walk the room. It should sound the same everywhere. Listen for spots that go thin.
2. **A familiar track** you know well, with real bass. Does the kick punch and the bass line stay clear?
3. **A voice.** Speak into the mic from the podium. Words should be clear and the feedback should hold at working level.

> **FIELD RULE**
> Never run through a sound check with the subs off and decide later. Do the whole check with everything on, because a sub changes how the tops sound.

09 Rigging and safety for ground stacks

Speakers fall on people. A stacked array is heavy and tall. The risk is highest in wind, on soft ground, and in the last ten minutes of a long day. Ground-stacking is crew work. It still has rules.

> **NEVER STACK HIGHER THAN THE MAKER'S RATING**
> Every sub and array element has a stacking limit in its manual. Know it. If you do not have it, ask before you build. Stacks fall over from one wobble, and a falling stack can kill.

THE GROUND

- Flat, hard and firm
- Soft grass or a sloped floor: ask for a base or deck
- Check the stage deck rating before loading it

BUILD

- Heavy sub at the bottom, lighter elements on top
- Use the maker's pins, plates or bars
- Strap or ratchet-strap the stack to itself, and to the stage or a weight if the manual says so

WIND

- Outdoor stages: tall stacks act like a sail
- Check wind at set-up and during the show
- Lower or strap the stack down when the wind picks up

CABLES

- Strain relief: loop the cable and tape it to the stand or case
- Never let the weight of a cable pull on a connector
- Ramp or cover every cable the public walks over

Ground-stack checklist

1. Is the ground flat and firm?
2. Is the stack within the maker's rated height and weight?
3. Are all pins, plates or bars fitted and locked?
4. Are the straps tight, and tied off to something solid?
5. Is the stack out of the public's reach, with a barrier if needed?
6. Has the wind been checked, and is there a plan if it rises?
7. Are cables relieved, routed and covered?
8. Are two people on hand to lift and lower? Never one.

> **STOP-WORK RULE**
> If a stack looks unsafe, stop. Tell the supervisor. Nobody is ever in trouble for building it lower.

10 Check what you learnt

Ten questions. Circle one answer for each. The answer key is on the last page. Pass mark: 8 out of 10.

1. Each time you double the distance from a single speaker box, the level drops by about...

- ○ **A** 3 dB
- ○ **B** 6 dB
- ○ **C** 10 dB
- ○ **D** It stays the same

2. What does "throw" mean?

- ○ **A** How far a speaker can send usable sound
- ○ **B** How loud the amplifier is
- ○ **C** How wide the speaker spreads sound
- ○ **D** How heavy the box is

3. What does a line array's coverage look like?

- ○ **A** Narrow left to right, wide up and down
- ○ **B** Round, in every direction
- ○ **C** Narrow up and down, wide left to right
- ○ **D** The same as a single box

4. A column array is best suited to...

- ○ **A** A 500-person outdoor dance night
- ○ **B** Speeches and small functions in a modest room
- ○ **C** Replacing the subs
- ○ **D** Flying over the audience

5. **In a J-shaped array, which elements get the most splay?**

- ○ **A** The top ones, to throw far
- ○ **B** None of them
- ○ **C** The bottom ones, to cover near seats
- ○ **D** All the same

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6. **Who is allowed to fly (hang) a line array?**

- ○ **A** Any crew member with a ratchet strap
- ○ **B** The sound engineer on the night
- ○ **C** A certified rigger only
- ○ **D** Anyone over 21

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7. **Why do subs sit on the floor?**

- ○ **A** It makes them quieter
- ○ **B** The floor adds boundary gain, up to about 6 dB
- ○ **C** The cable is shorter
- ○ **D** They cannot stand on stands

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8. **Two subs placed side by side and touching give...**

- ○ **A** No change in level
- ○ **B** +6 dB with smooth coverage
- ○ **C** Dead zones across the room
- ○ **D** A cardioid pattern

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9. **Two subs are 6 m apart, one each side of the stage. What happens?**

- ○ **A** A power alley in the middle and dead zones either side
- ○ **B** Perfect even bass everywhere
- ○ **C** No bass in the middle
- ○ **D** Twice as much bass at the sides

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10. **What is the delay for a spacing of 1 m between two subs in an end-fire setup?**

- ○ **A** About 0.3 ms
- ○ **B** About 2.9 ms
- ○ **C** About 29 ms
- ○ **D** No delay

Answer key

1. **B**. A point source loses 6 dB per doubling. A line source loses only about 3 dB in its near field.
2. **A**. Throw is the distance a speaker can send usable sound before it is too quiet or muddy. Line arrays are the long-throw tool.
3. **C**. A line array makes a wedge: narrow vertically, wide horizontally. It lands on people and misses the ceiling and floor.
4. **B**. Column arrays are even and tidy, but not very loud. They suit speeches and small events, not big rooms.
5. **C**. The top is straight to throw far. The bottom is angled down more to cover the front rows.
6. **C**. Flying is for certified riggers. Crew ground-stack within the maker's limits.
7. **B**. The floor bounces bass back, adding up to about 6 dB for free. A corner adds more but can sound boomy.
8. **B**. Close together, the subs couple. Their pressure doubles: +6 dB, with no cancellation.
9. **A**. In the centre both are equidistant and add. To the side the waves arrive out of step and cancel in places (comb filtering).
10. **B**. Sound travels about 343 m/s, which is roughly 2.9 ms per metre.

Photos: product images courtesy of the manufacturers (RCF, Neutrik) and their distributors; scene photographs are AI-generated illustrations and do not show B&W Productions equipment or events.