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There is a house with air ventilation with heat recovery.  
There are 3 air outlets to different rooms.  
The air channel is 200 mm high and 150 mm width.  
The air channel to the different rooms has 4 m, 8 m, 9 m in length.  
When the total airflow is 100 m<sup>3</sup> / h,  
how much air would reach the 3 rooms?

To calculate how much air reaches each of the three rooms, we need to consider the airflow distribution in a heat recovery ventilation system with a single air channel splitting into three branches of different lengths (4 m, 8 m, and 9 m). The total airflow is 100 m<sup>3</sup>/h, and the main air channel has a cross-sectional area determined by its dimensions (200 mm height × 150 mm width). Here's the step-by-step solution:

### Step 1: Understand the system and airflow distribution

In a ventilation system, when a main duct splits into multiple branches, the airflow divides based on the resistance to flow in each branch. The resistance depends primarily on:

- **Length of the duct:** Longer ducts have higher resistance due to friction losses.
- **Cross-sectional area of the ducts:** Assuming the branch ducts have the same cross-section as the main duct (200 mm × 150 mm), this factor is constant across all branches.
- **Other factors:** Bends, fittings, or differences in duct diameter could affect resistance, but since the problem doesn't specify these, we assume straight ducts with identical cross-sections and no additional fittings.

The problem asks for the airflow to each room, so we need to distribute the total airflow (100 m<sup>3</sup>/h) across the three branches. A common simplifying assumption in such problems is that airflow is inversely proportional to the resistance, which is dominated by duct length when cross-sectional areas are the same.

### Step 2: Calculate the cross-sectional area of the duct

The main duct dimensions are 200 mm × 150 mm. Convert to meters for consistency:

- Height = 200 mm = 0.2 m
- Width = 150 mm = 0.15 m

Cross-sectional area ( A ):

$$A = \text{height} \times \text{width} = 0.2\text{m} \times 0.15\text{m} = 0.03\text{m}^2$$

Assuming the branch ducts have the same cross-section (since no other dimensions are provided), each branch has the same cross-sectional area,  $A = 0.03\text{m}^2$ .

### Step 3: Model airflow distribution

The resistance to airflow in a duct is approximately proportional to its length when the cross-sectional area and air velocity are the same. The pressure drop due to friction in a duct can be modeled using the Darcy-Weisbach equation, where pressure loss  $\Delta P$  is:

$$\Delta P = f \cdot \frac{L}{D_h} \cdot \frac{\rho v^2}{2}$$

Where:

- ( f ): Friction factor (depends on duct roughness and Reynolds number)
- ( L ): Duct length
- $D_h$  : Hydraulic diameter
- $\rho$ : Air density
- ( v ): Air velocity

For simplicity, since the ducts have the same cross-section, the hydraulic diameter  $D_h$  and friction factor ( f ) are the same for all branches. The air velocity ( v ) depends on the airflow, which we're solving for. The key variable affecting resistance is the duct length ( L ).

In a parallel duct system, the total airflow splits such that the pressure drop across each branch is equal. The airflow through each branch is inversely proportional to its resistance, and since resistance is proportional to length, the airflow  $Q_i$  through each branch is approximately:

$$Q_i = Q_{\text{total}} \cdot \frac{\frac{1}{L_i}}{\sum \frac{1}{L_j}}$$

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- $Q_i$  : Airflow through branch ( i )
- $L_i$  : Length of branch ( i )
- $Q_{\text{total}} = 100\text{m}^3/\text{h}$
- $\sum \frac{1}{L_i}$ : Sum of the reciprocals of the lengths of all branches

#### Step 4: Assign duct lengths and calculate

The duct lengths are:

- Branch 1:  $L_1 = 4\text{m}$
- Branch 2:  $L_2 = 8\text{m}$
- Branch 3:  $L_3 = 9\text{m}$

Calculate the reciprocal of each length:

$$\frac{1}{L_1} = \frac{1}{4} = 0.25$$

$$\frac{1}{L_2} = \frac{1}{8} = 0.125$$

$$\frac{1}{L_3} = \frac{1}{9} \approx 0.1111$$

Sum of the reciprocals:

$$\sum \frac{1}{L_i} = 0.25 + 0.125 + 0.1111 \approx 0.4861$$

Now, calculate the airflow for each branch:

- Branch 1 (4 m):

$$Q_1 = 100 \cdot \frac{0.25}{0.4861} \approx 100 \cdot 0.5143 \approx 51.43\text{m}^3/\text{h}$$

- Branch 2 (8 m):

$$Q_2 = 100 \cdot \frac{0.125}{0.4861} \approx 100 \cdot 0.2571 \approx 25.71\text{m}^3/\text{h}$$

- Branch 3 (9 m):

$$Q_3 = 100 \cdot \frac{0.1111}{0.4861} \approx 100 \cdot 0.2286 \approx 22.86\text{m}^3/\text{h}$$

#### Step 5: Verify the total airflow

Sum the airflows to ensure they equal the total:

$$Q_1 + Q_2 + Q_3 \approx 51.43 + 25.71 + 22.86 = 100.00\text{m}^3/\text{h}$$

The sum matches the total airflow, confirming the calculations are consistent.

#### Step 6: Consider simplifying assumptions

The above calculation assumes:

- The branch ducts have the same cross-sectional area as the main duct.
- No additional losses from bends, fittings, or outlet restrictions.
- The system is balanced such that pressure drops are equal across branches.

In real systems, other factors (e.g., duct roughness, bends, or differences in outlet design) could slightly alter the distribution. However, since the problem provides only duct lengths and assumes a straightforward split, the inverse-length approximation is reasonable.

If the branch ducts had different diameters (e.g., smaller ducts for individual rooms), the resistance would depend on the cross-sectional area, and we'd need to adjust the calculations. Since the problem doesn't specify branch duct sizes, we assume they match the main duct for simplicity.

#### Final Answer

The airflow to each room is approximately:

- Room 1 (4 m duct): **51.4 m³/h**



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- Room 2 (8 m duct): **25.7 m³/h**
- Room 3 (9 m duct): **22.9 m³/h**

These values are rounded to one decimal place for clarity and sum to the total airflow of 100 m³/h.



What could be done to have a more similar airflow to each room?

To achieve a more similar airflow to each room in a ventilation system with a total airflow of 100 m³/h and three outlet ducts of different lengths (4 m, 8 m, and 9 m), we need to reduce the variation in airflow caused by differing duct resistances. The current airflow distribution (approximately 51.4 m³/h, 25.7 m³/h, and 22.9 m³/h) is uneven because longer ducts have higher resistance, reducing airflow. Here are practical methods to balance the airflow, listed from most effective and common to more complex or situational, ensuring minimal repetition and clear explanations:

### 1. Install Balancing Dampers

- **What:** Adjustable dampers (valves) installed in each branch duct to control airflow by adding resistance where needed.
- **How:** Partially close the damper in the shortest duct (4 m) to increase resistance, forcing more air through the longer ducts (8 m and 9 m). Adjust dampers iteratively while measuring airflow at each outlet until flows are similar.
- **Why it works:** Dampers allow fine-tuning of resistance without altering duct lengths or diameters, directly balancing the pressure drop across branches.
- **Practicality:** Common in HVAC systems, relatively inexpensive, and easy to install and adjust. Requires airflow measurement tools (e.g., anemometer) for precise balancing.
- **Example:** Restrict the 4 m duct to reduce its airflow from 51.4 m³/h, redistributing the excess to the 8 m and 9 m ducts, aiming for ~33.3 m³/h per room.

### 2. Modify Duct Diameters

- **What:** Adjust the cross-sectional area of the branch ducts to balance resistance.
- **How:** Use a smaller diameter duct for the shortest branch (4 m) and larger diameters for the longer branches (8 m and 9 m). Resistance is inversely proportional to the fifth power of diameter in turbulent flow (per the Darcy-Weisbach equation), so small changes in diameter have a large impact.
- **Why it works:** Reducing the diameter of the 4 m duct increases its resistance, while increasing the diameter of the 8 m and 9 m ducts decreases their resistance, evening out airflow.
- **Practicality:** Requires replacing or retrofitting ducts, which is more invasive and costly than dampers. May need professional design to calculate exact diameters.
- **Example:** If the current ducts are 200 mm × 150 mm, reduce the 4 m duct to a smaller cross-section (e.g., 150 mm × 100 mm) and slightly increase the others, then recalculate airflow distribution.

### 3. Add Duct Length or Artificial Resistance

- **What:** Increase the effective resistance of the shorter duct by extending its length or adding obstructions.
- **How:** Extend the 4 m duct by adding bends or a longer route to make its effective length closer to 8 m or 9 m. Alternatively, insert flow restrictors (e.g., orifice plates) in the 4 m duct to mimic the resistance of longer ducts.
- **Why it works:** Increasing the resistance of the low-resistance (shorter) duct forces more air through the higher-resistance (longer) ducts, balancing airflow.
- **Practicality:** Adding duct length requires space and modifications, which may not be feasible. Flow restrictors are simpler but less adjustable than dampers.
- **Example:** Route the 4 m duct through a longer path to reach ~8 m, reducing its airflow advantage.

### 4. Use a Fan or Booster

- **What:** Install small booster fans in the longer ducts to overcome their higher resistance.
- **How:** Place low-power inline fans in the 8 m and 9 m ducts to increase airflow through them, compensating for their higher friction losses.
- **Why it works:** Fans actively push more air through the longer ducts, equalizing the flow rates across all branches.
- **Practicality:** More expensive due to equipment and power costs, and requires maintenance. Best for systems where passive solutions (dampers, duct changes) are insufficient.
- **Example:** A fan in the 9 m duct increases its airflow from 22.9 m³/h to approach 33.3 m³/h, with adjustments to match other ducts.



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## 5. Redesign the Duct Layout

- **What:** Reconfigure the duct system to equalize branch lengths or optimize the layout.
- **How:** Redesign the ventilation system so all ducts have similar lengths (e.g., all ~7 m) or use a manifold system where each branch starts equidistant from the main fan. This may involve relocating outlets or the main duct.
- **Why it works:** Equal duct lengths result in equal resistances, naturally balancing airflow without additional components.
- **Practicality:** Highly effective but costly and disruptive, requiring major renovations. Suitable for new installations or major retrofits.
- **Example:** Reroute ducts so each is approximately 7–8 m long, achieving near-equal airflow of ~33.3 m³/h per room.

## Key Considerations

- **Target Airflow:** Perfectly equal airflow (33.3 m³/h per room) is ideal but may be limited by system constraints. Aim for flows within 10–20% of each other (e.g., 30–36 m³/h).
- **Measurement and Adjustment:** Use an anemometer or flow meter to measure airflow at each outlet after implementing changes. Adjust dampers or other components iteratively.
- **System Pressure:** Adding resistance (e.g., dampers, smaller ducts) increases the overall system pressure, which the main fan must handle. Ensure the fan has sufficient capacity.
- **Room Requirements:** If rooms have different ventilation needs (e.g., larger rooms need more air), slightly uneven airflow may be acceptable or desirable. The problem assumes equal demand, so we aim for balance.
- **Maintenance:** Dampers and fans require periodic checks to ensure consistent performance. Duct modifications are low-maintenance once installed.

## Recommended Approach

The most practical and cost-effective solution is **installing balancing dampers** in each branch duct. This method:

- Is widely used in HVAC systems.
- Allows adjustable and precise control of airflow.
- Requires minimal structural changes.
- Can be implemented without replacing ducts or adding fans.

### Steps:

- Install a damper in each branch near the outlet or junction.
- Measure initial airflow at each outlet (e.g., using an anemometer).
- Gradually close the damper in the 4 m duct to reduce its airflow, redirecting air to the 8 m and 9 m ducts.
- Adjust dampers in the longer ducts if needed to fine-tune.
- Verify total airflow remains 100 m³/h and each room receives ~30–36 m³/h.

If dampers alone are insufficient (e.g., due to extreme resistance differences), combine with **duct diameter adjustments** for the 4 m duct to further balance resistance.

## Final Answer

To achieve more similar airflow to each room:

- **Primary Solution:** Install **balancing dampers** in each branch duct and adjust to equalize airflow, aiming for ~33.3 m³/h per room.
- **Alternatives:** Reduce the diameter of the 4 m duct, extend its length, add booster fans to longer ducts, or redesign the duct layout for equal lengths.
- **Best Practice:** Use dampers first, as they are cost-effective and adjustable. Measure airflow after adjustments to ensure balance.

This approach minimizes modifications while effectively balancing airflow across the three rooms.



What influence has a 90° angel on the calculated length?



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In a ventilation system, a 90° bend in an エア duct introduces additional resistance to airflow, equivalent to adding a certain length of straight duct. This "equivalent length" accounts for the pressure loss caused by the



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bend and can be used to adjust the effective length of the duct when calculating airflow distribution. The original problem involves a ventilation system with three branch ducts (4 m, 8 m, and 9 m) delivering a total airflow of 100 m³/h, and we need to understand how a 90° bend affects the calculated duct lengths and, consequently, the airflow to each room.

### Step 1: Understand the Effect of a 90° Bend

A 90° bend increases resistance due to turbulence and flow separation as air changes direction. The additional resistance is typically expressed as an **equivalent length** of straight duct, which depends on:

- **Duct dimensions:** The main duct is 200 mm × 150 mm (rectangular, cross-sectional area = 0.03 m²). For rectangular ducts, the hydraulic diameter is used to estimate bend losses.
- **Bend radius:** A sharper bend (smaller radius) causes more resistance than a gradual one. The problem doesn’t specify the bend radius, so we’ll use standard HVAC values.
- **Air velocity:** Determined by the airflow and duct cross-section, but since the total airflow (100 m³/h) splits across branches, velocity varies.

In HVAC design, the equivalent length of a 90° bend for a rectangular duct is often provided in tables or estimated based on the duct’s hydraulic diameter. For a rough estimate, a 90° bend in a rectangular duct (with a typical radius of 1–1.5 times the duct width) adds an equivalent length of **10–30 times the hydraulic diameter**, depending on the bend’s sharpness and duct roughness.

### Step 2: Calculate the Hydraulic Diameter

The duct dimensions are 200 mm × 150 mm (0.2 m × 0.15 m). The hydraulic diameter  $D_h$  for a rectangular duct is:

$$D_h = \frac{2 \cdot (\text{height} \cdot \text{width})}{\text{height} + \text{width}}$$
$$D_h = \frac{2 \cdot (0.2 \cdot 0.15)}{0.2 + 0.15} = \frac{2 \cdot 0.03}{0.35} \approx 0.1714\text{m}$$

### Step 3: Estimate the Equivalent Length of a 90° Bend

For a 90° bend in a rectangular duct, HVAC standards (e.g., ASHRAE or SMACNA) suggest an equivalent length of approximately **15–25 times the hydraulic diameter** for a typical bend (radius ≈ duct width). Let’s use a mid-range value of **20 × D<sub>h</sub>** for a standard 90° bend:

$$L_{\text{equivalent}} = 20 \cdot 0.1714 \approx 3.428\text{m}$$

So, each 90° bend is equivalent to adding **~3.4 m** of straight duct. If the problem implies one 90° bend per branch (e.g., at the junction where the branch splits from the main duct), we add this length to each branch’s physical length to get the **effective length** for airflow calculations.

### Step 4: Adjust the Duct Lengths

Assume one 90° bend is added to each branch (since the problem mentions “a 90° angle” without specifying which duct, this is a reasonable interpretation). The original lengths are:

- Branch 1: 4 m
- Branch 2: 8 m
- Branch 3: 9 m

Add the equivalent length of one 90° bend (3.4 m) to each:

- Branch 1: 4 + 3.4 = 7.4m
- Branch 2: 8 + 3.4 = 11.4m
- Branch 3: 9 + 3.4 = 12.4m

### Step 5: Recalculate Airflow Distribution

The airflow distribution is inversely proportional to the duct’s effective length (as resistance is proportional to length for ducts of the same cross-section). Using the original method:

Calculate the reciprocal of the effective lengths:

$$\frac{1}{L_1} = \frac{1}{7.4} \approx 0.1351$$



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$$\frac{1}{L_2} = \frac{1}{11.4} \approx 0.0877$$

$$\frac{1}{L_3} = \frac{1}{12.4} \approx 0.0806$$

Sum of the reciprocals:

$$\Sigma \frac{1}{L_j} \approx 0.1351 + 0.0877 + 0.0806 = 0.3034$$

Calculate the airflow for each branch (total airflow = 100 m³/h):

- Branch 1 (7.4 m):

$$Q_1 = 100 \cdot \frac{0.1351}{0.3034} \approx 100 \cdot 0.4453 \approx 44.53 \text{ m}^3/\text{h}$$

- Branch 2 (11.4 m):

$$Q_2 = 100 \cdot \frac{0.0877}{0.3034} \approx 100 \cdot 0.2891 \approx 28.91 \text{ m}^3/\text{h}$$

- Branch 3 (12.4 m):

$$Q_3 = 100 \cdot \frac{0.0806}{0.3034} \approx 100 \cdot 0.2657 \approx 26.57 \text{ m}^3/\text{h}$$

Verify the total:

$$44.53 + 28.91 + 26.57 \approx 100.01 \text{ m}^3/\text{h}$$

The sum is effectively 100 m³/h, accounting for rounding.

### Step 6: Compare with Original Airflow

Original airflow (without bends):

- Branch 1 (4 m): 51.4 m³/h
- Branch 2 (8 m): 25.7 m³/h
- Branch 3 (9 m): 22.9 m³/h

New airflow (with one 90° bend per branch):

- Branch 1 (7.4 m): 44.5 m³/h
- Branch 2 (11.4 m): 28.9 m³/h
- Branch 3 (12.4 m): 26.6 m³/h

**Influence:**

- The 90° bend increases the effective length of each duct, particularly impacting the shortest duct (4 m → 7.4 m, an 85% increase) more significantly than the longer ducts (8 m → 11.4 m, 42.5% increase; 9 m → 12.4 m, 37.8% increase).
- This reduces airflow in the shortest duct (from 51.4 to 44.5 m³/h) and increases airflow in the longer ducts (from 25.7 to 28.9 m³/h and 22.9 to 26.6 m³/h), making the distribution **more balanced**.
- The airflow range narrows from 22.9–51.4 m³/h (28.5 m³/h difference) to 26.6–44.5 m³/h (17.9 m³/h difference), a more even split.

### Step 7: Assumptions and Clarifications

- Number of bends:** The problem mentions “a 90° angle” without specifying which duct or how many bends. We assumed one bend per branch, as this is common at duct junctions. If only one branch has a bend, only that duct’s length increases by 3.4 m, and the others remain unchanged.
- Bend radius:** We used an equivalent length of ~3.4 m (20 × D\_h). For sharper bends (smaller radius), the equivalent length could be higher (e.g., 25 × D\_h ≈ 4.3 m); for smoother bends, it could be lower (e.g., 15 × D\_h ≈ 2.6 m).
- Duct uniformity:** Assumed all branches have the same cross-section (200 mm × 150 mm) as the main duct. If branches have different sizes, resistance calculations would change.
- Other losses:** Ignored minor losses from junctions or fittings, as not specified.

If the bend applies to only one duct (e.g., the 4 m duct), the effective length for that duct becomes 7.4 m, while the others remain 8 m and 9 m, and the airflow would be recalculated accordingly. For example:

- Branch 1: 7.4 m
- Branch 2: 8 m
- Branch 3: 9 m



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Reciprocals:

$$\frac{1}{7.4} \approx 0.1351, \quad \frac{1}{8} = 0.125, \quad \frac{1}{9} \approx 0.1111$$

Sum:  $0.1351 + 0.125 + 0.1111 \approx 0.3712$

Airflows:

- $Q_1 = 100 \cdot \frac{0.1351}{0.3712} \approx 36.39 \text{ m}^3/\text{h}$
- $Q_2 = 100 \cdot \frac{0.125}{0.3712} \approx 33.69 \text{ m}^3/\text{h}$
- $Q_3 = 100 \cdot \frac{0.1111}{0.3712} \approx 29.93 \text{ m}^3/\text{h}$

This results in an even more balanced distribution (29.9–36.4 m³/h).

## Final Answer

A 90° bend adds an **equivalent length** of approximately **3.4 m** to the duct’s calculated length, based on the hydraulic diameter (0.1714 m) of the 200 mm × 150 mm duct. If one 90° bend is added to each branch:

- Effective lengths become 7.4 m, 11.4 m, and 12.4 m.
- Airflows adjust to ~44.5 m³/h, 28.9 m³/h, and 26.6 m³/h, respectively, making the distribution more balanced compared to 51.4, 25.7, and 22.9 m³/h without bends.
- If only one duct (e.g., 4 m) has a bend, the distribution becomes even closer (e.g., 36.4, 33.7, 29.9 m³/h).

The exact impact depends on which duct(s) have the bend and the bend’s radius, but generally, bends increase resistance, reduce airflow in affected ducts, and redistribute air to others, aiding balance. For precise results, confirm the number of bends and bend radius in the

What an influence has a 90° curve with 500 mm radius?  
So a 90° angel at the in the 4 m pipe,  
The other with a 90° curve with 500 mm radius.

To determine the influence of a 90° bend and a 90° curve with a 500 mm radius on the airflow distribution in a ventilation system, we need to adjust the effective lengths of the ducts and recalculate the airflow. The system has three branch ducts (4 m, 8 m, and 9 m) with a total airflow of 100 m³/h, and the ducts are rectangular (200 mm × 150 mm). The query specifies:

- A 90° “angle” (interpreted as a standard 90° bend) in the 4 m duct.
- A 90° “curve” with a 500 mm radius in the other ducts (8 m and 9 m).

We’ll calculate the equivalent length added by each type of bend/curve, adjust the duct lengths, and recompute the airflow distribution.

## Step 1: Clarify Terminology and Assumptions

- **90° angle (bend):** A standard 90° bend in the 4 m duct, likely with a typical radius for rectangular ducts (e.g., ~1–1.5 times the duct width). From the previous response, we estimated the equivalent length as ~3.4 m based on  $20 \times$  hydraulic diameter ( $D_h \approx 0.1714 \text{ m}$ ).
- **90° curve with 500 mm radius:** A 90° bend in the 8 m and 9 m ducts with a specified centerline radius of 500 mm (0.5 m). This is a smoother bend, reducing resistance compared to a standard bend. The equivalent length depends on the radius and duct dimensions.
- **Duct dimensions:** Rectangular, 200 mm × 150 mm (0.2 m × 0.15 m), with hydraulic diameter  $D_h = 0.1714 \text{ m}$ .
- **Assumptions:**
  - The “curve” refers to a 90° bend with a larger radius (0.5 m), not a curved duct path.
  - Each duct has one bend/curve as specified (4 m: standard bend; 8 m and 9 m: curve with 500 mm radius).
  - All ducts have the same cross-section (200 mm × 150 mm), and no other fittings are considered.
  - Airflow splits inversely proportional to duct resistance, which is dominated by effective length.

## Step 2: Equivalent Length of a Standard 90° Bend (4 m Duct)

For a rectangular duct, the equivalent length of a 90° bend depends on the bend radius and hydraulic diameter. Previously, we used:

$$D_h = \frac{2 \cdot (0.2 \cdot 0.15)}{0.2 + 0.15} \approx 0.1714 \text{ m}$$

A standard 90° bend (radius ~1–1.5 × duct width, i.e., ~150–225 mm) has an equivalent length of  $\sim 15\text{--}25 \times D_h$ . Using the mid-range value ( $20 \times D_h$ ):

$$L_{\text{bend}} = 20 \cdot 0.1714 \approx 3.428 \text{ m}$$

For consistency, we’ll use **3.4 m** as the equivalent length for the 90° bend in the 4 m duct. If the bend radius differs significantly, we’ll adjust later if needed.



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### Step 3: Equivalent Length of a 90° Curve with 500 mm Radius (8 m and 9 m Ducts)

A 90° bend with a 500 mm (0.5 m) centerline radius is smoother than a standard bend, reducing turbulence and pressure loss. The equivalent length for a bend in a rectangular duct depends on the **radius-to-width ratio** ( $R/D$ ) or radius-to-hydraulic-diameter ratio ( $R/D_h$ ).

- Duct width = 150 mm = 0.15 m.
- Bend radius  $R = 0.5\text{m}$ .
- $R/D_h = 0.5/0.1714 \approx 2.92$ .

For circular ducts, ASHRAE and SMACNA provide equivalent lengths based on  $R/D$  (where ( D ) is the duct diameter). For rectangular ducts, the approach is similar but uses  $D_h$  . For a smooth 90° bend with  $R/D_h \approx 2\text{--}3$ , the equivalent length is typically **5–10 ×  $D_h$** , lower than a standard bend due to reduced turbulence.

Let’s estimate using **7.5 ×  $D_h$**  for  $R/D_h \approx 2.92$ , based on typical HVAC data for smooth bends:

$$L_{\text{curve}} = 7.5 \cdot 0.1714 \approx 1.2855\text{m}$$

So, the 90° curve with a 500 mm radius adds **~1.3 m** of equivalent length to the 8 m and 9 m ducts. This is significantly less than the 3.4 m for the standard bend, reflecting the smoother airflow.

### Step 4: Adjust Effective Duct Lengths

Add the equivalent lengths to the physical lengths:

- 4 m duct (standard 90° bend):**

$$L_1 = 4 + 3.4 = 7.4\text{m}$$

- 8 m duct (90° curve, 500 mm radius):**

$$L_2 = 8 + 1.3 = 9.3\text{m}$$

- 9 m duct (90° curve, 500 mm radius):**

$$L_3 = 9 + 1.3 = 10.3\text{m}$$

### Step 5: Recalculate Airflow Distribution

Airflow is inversely proportional to the effective length (since resistance is proportional to length for ducts of the same cross-section). Calculate the reciprocals of the effective lengths:

$$\frac{1}{L_1} = \frac{1}{7.4} \approx 0.135135$$

$$\frac{1}{L_2} = \frac{1}{9.3} \approx 0.107527$$

$$\frac{1}{L_3} = \frac{1}{10.3} \approx 0.097087$$

Sum of the reciprocals:

$$\sum \frac{1}{L_j} \approx 0.135135 + 0.107527 + 0.097087 = 0.339749$$

Calculate the airflow for each branch (total airflow = 100 m³/h):

- 4 m duct (7.4 m effective):**

$$Q_1 = 100 \cdot \frac{0.135135}{0.339749} \approx 100 \cdot 0.3977 \approx 39.77\text{m}^3/\text{h}$$

- 8 m duct (9.3 m effective):**

$$Q_2 = 100 \cdot \frac{0.107527}{0.339749} \approx 100 \cdot 0.3165 \approx 31.65\text{m}^3/\text{h}$$

- 9 m duct (10.3 m effective):**

$$Q_3 = 100 \cdot \frac{0.097087}{0.339749} \approx 100 \cdot 0.2858 \approx 28.58\text{m}^3/\text{h}$$

Verify the total:

$$39.77 + 31.65 + 28.58 \approx 100.00\text{m}^3/\text{h}$$

The sum matches 100 m³/h, confirming accuracy.



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### Step 6: Compare with Original and Previous Cases







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- The smoother 500 mm radius curves add less resistance to the 8 m and 9 m ducts, increasing their airflows (from 25.7 m³/h to 31.7 m³/h and 22.9 m³/h to 28.6 m³/h).
- The distribution is more balanced (range: 28.6–39.8 m³/h, 11.2 m³/h difference) than without bends (28.5 m³/h difference) or with standard bends in all ducts (17.9 m³/h difference).

For precise results, consult HVAC tables for rectangular ducts with a 500 mm radius bend, but the smoother curves consistently reduce resistance, aiding airflow balance.



You calculated the 500 mm curve like 0.86 m more length. What would it be with 1000 mm radius?

To determine the influence of a 90° curve with a 1000 mm (1 m) radius on the airflow distribution in the ventilation system, we need to calculate the equivalent length it adds to the 8 m and 9 m ducts, then recalculate the airflow. The system has three branch ducts (4 m, 8 m, and 9 m) with a total airflow of 100 m³/h, rectangular ducts (200 mm × 150 mm), and:

- A standard 90° bend in the 4 m duct (previously calculated as adding ~3.4 m).
- A 90° curve with a 500 mm radius in the 8 m and 9 m ducts (previously estimated as adding ~1.3 m, with a sensitivity test at ~0.86 m).
- Now, the 8 m and 9 m ducts have a 90° curve with a 1000 mm radius.

The query references the 0.86 m equivalent length from the sensitivity test (5 × hydraulic diameter). We'll calculate the equivalent length for a 1000 mm radius curve, update the effective duct lengths, and recompute the airflow distribution.

### Step 1: System Recap and Hydraulic Diameter

- **Duct dimensions:** 200 mm × 150 mm (0.2 m × 0.15 m).
- **Hydraulic diameter ( $D_h$ ):**

$$D_h = \frac{2 \cdot (0.2 \cdot 0.15)}{0.2 + 0.15} = \frac{0.06}{0.35} \approx 0.1714\text{m}$$

- **4 m duct:** Has a standard 90° bend, adding ~3.4 m (based on  $20 \times D_h$ , as calculated previously).
- **8 m and 9 m ducts:** Now have a 90° curve with a 1000 mm (1 m) radius, replacing the 500 mm radius curve.

### Step 2: Equivalent Length of a Standard 90° Bend (4 m Duct)

From previous calculations, a standard 90° bend (radius ~150–225 mm) adds:

$$L_{\text{bend}} = 20 \cdot 0.1714 \approx 3.428\text{m} \approx 3.4\text{m}$$

So, the 4 m duct's effective length remains:

$$L_1 = 4 + 3.4 = 7.4\text{m}$$

### Step 3: Equivalent Length of a 90° Curve with 1000 mm Radius (8 m and 9 m Ducts)

A 90° curve with a 1000 mm (1 m) radius is smoother than one with a 500 mm radius, further reducing turbulence and pressure loss. The equivalent length depends on the ratio of the bend radius to the hydraulic diameter ( $R/D_h$ ):

- Bend radius  $R = 1\text{m}$ .
- $R/D_h = 1/0.1714 \approx 5.83$ .

For rectangular ducts, the equivalent length of a 90° bend is approximated using HVAC standards (e.g., ASHRAE, SMACNA). For smooth bends in circular ducts, the equivalent length decreases as  $R/D$  increases. For  $R/D_h \approx 2.92$  (500 mm radius), we used  $7.5 \times D_h \approx 1.3\text{m}$  in the main calculation and  $5 \times D_h \approx 0.86\text{m}$  in the sensitivity test, reflecting typical values for smooth bends.

For  $R/D_h \approx 5.83$ , the bend is even smoother, and the equivalent length is typically lower. HVAC data for circular ducts suggest that for  $R/D > 3$ , the equivalent length can be as low as **3–5 × (D)** for very smooth bends. For rectangular ducts, we adapt this conservatively. Since the sensitivity test used  $5 \times D_h$  for  $R = 0.5\text{m}$ , let's use **3 ×  $D_h$**  for  $R = 1\text{m}$ , reflecting the reduced resistance:

$$L_{\text{curve}} = 3 \cdot 0.1714 \approx 0.5142\text{m} \approx 0.51\text{m}$$

This is lower than the 0.86 m ( $5 \times D_h$ ) for the 500 mm radius, consistent with a smoother bend reducing pressure loss.



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### Step 4: Adjust Effective Duct Lengths

Update the effective lengths:

- 4 m duct (standard 90° bend):

$$L_1 = 4 + 3.4 = 7.4\text{m}$$

- 8 m duct (90° curve, 1000 mm radius):

$$L_2 = 8 + 0.51 = 8.51\text{m}$$

- 9 m duct (90° curve, 1000 mm radius):

$$L_3 = 9 + 0.51 = 9.51\text{m}$$

### Step 5: Recalculate Airflow Distribution

Airflow splits inversely proportional to the effective length. Calculate the reciprocals:

$$\frac{1}{L_1} = \frac{1}{7.4} \approx 0.135135$$

$$\frac{1}{L_2} = \frac{1}{8.51} \approx 0.117509$$

$$\frac{1}{L_3} = \frac{1}{9.51} \approx 0.105152$$

Sum of the reciprocals:

$$0.135135 + 0.117509 + 0.105152 \approx 0.357796$$

Calculate the airflow (total = 100 m³/h):

- 4 m duct (7.4 m effective):

$$Q_1 = 100 \cdot \frac{0.135135}{0.357796} \approx 100 \cdot 0.3777 \approx 37.77\text{m}^3/\text{h}$$

- 8 m duct (8.51 m effective):

$$Q_2 = 100 \cdot \frac{0.117509}{0.357796} \approx 100 \cdot 0.3284 \approx 32.84\text{m}^3/\text{h}$$

- 9 m duct (9.51 m effective):

$$Q_3 = 100 \cdot \frac{0.105152}{0.357796} \approx 100 \cdot 0.2939 \approx 29.39\text{m}^3/\text{h}$$

Verify the total:

$$37.77 + 32.84 + 29.39 \approx 99.99\text{m}^3/\text{h}$$

The sum is effectively 100 m³/h, accounting for rounding.

### Step 6: Compare with Previous Cases

- Original (no bends):

- 4 m: 51.4 m³/h
- 8 m: 25.7 m³/h
- 9 m: 22.9 m³/h
- Range: 22.9–51.4 m³/h (28.5 m³/h difference)

- 500 mm radius (1.3 m added to 8 m and 9 m, 3.4 m to 4 m):

- 4 m (7.4 m): 39.8 m³/h
- 8 m (9.3 m): 31.7 m³/h
- 9 m (10.3 m): 28.6 m³/h
- Range: 28.6–39.8 m³/h (11.2 m³/h difference)

- 500 mm radius, sensitivity test (0.86 m added to 8 m and 9 m):

- 4 m (7.4 m): 38.7 m³/h
- 8 m (8.86 m): 32.3 m³/h
- 9 m (9.86 m): 29.0 m³/h
- Range: 29.0–38.7 m³/h (9.7 m³/h difference)

- 1000 mm radius (0.51 m added to 8 m and 9 m):

- 4 m (7.4 m): 37.8 m³/h
- 8 m (8.51 m): 32.8 m³/h
- 9 m (9.51 m): 29.4 m³/h
- Range: 29.4–37.8 m³/h (8.4 m³/h difference)



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**Influence:**

- The 1000 mm radius curve adds only **0.51 m** to the 8 m and 9 m ducts (vs. 0.86 m or 1.3 m for 500 mm), further reducing their resistance.
- This increases airflow to the 8 m and 9 m ducts (32.8 m³/h and 29.4 m³/h) compared to the 500 mm case (31.7 m³/h and 28.6 m³/h at 1.3 m, or 32.3 m³/h and 29.0 m³/h at 0.86 m).
- The 4 m duct’s airflow decreases slightly (from 39.8 m³/h or 38.7 m³/h to 37.8 m³/h) due to more air flowing through the less-resistant longer ducts.
- The distribution is **more balanced** (range: 8.4 m³/h) than the 500 mm case (9.7 m³/h or 11.2 m³/h) and much better than the original (28.5 m³/h).

### Step 7: Sensitivity and Assumptions

- **Equivalent length estimate:** We used  $3 \times D_h \approx 0.51\text{m}$  for  $R/D_h \approx 5.83$ , reflecting a very smooth bend. If HVAC tables suggest a different multiplier (e.g.,  $4 \times D_h \approx 0.69\text{m}$ ), the effective lengths increase slightly:
  - 8 m: 8.69 m
  - 9 m: 9.69 m
  - Airflows: ~38.2 m³/h, 32.6 m³/h, 29.2 m³/h (range: 9.0 m³/h, still balanced).
- **Rectangular ducts:** The 1000 mm radius is large relative to the duct width (150 mm), making the bend very smooth. Equivalent length estimates are approximate, as rectangular duct data for such large radii are less common.
- **Standard bend:** The 3.4 m for the 4 m duct’s bend is unchanged. If its radius were specified, we could refine it.
- **Other losses:** Ignored junction or outlet losses, as not specified.

### Final Answer

A 90° curve with a **1000 mm radius** in the 8 m and 9 m ducts adds **~0.51 m** of equivalent length (vs. 0.86 m for a 500 mm radius in the sensitivity test). With the 4 m duct having a standard 90° bend (adding 3.4 m), the effective lengths are 7.4 m, 8.51 m, and 9.51 m, yielding:

- 4 m duct: **37.8 m³/h**
- 8 m duct: **32.8 m³/h**
- 9 m duct: **29.4 m³/h**

**Influence:**

- The 1000 mm radius reduces resistance in the 8 m and 9 m ducts more than the 500 mm radius, increasing their airflows (from 32.3 m³/h and 29.0 m³/h to 32.8 m³/h and 29.4 m³/h).
- The 4 m duct’s airflow decreases slightly (from 38.7 m³/h to 37.8 m³/h).

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So now this configuration:  
to room 1:  
1 m straight  
180° left 500 mm radius  
180° right 500 mm radius  
90° left 500 mm radius  
0.7 m straight  
to room 2  
2.2 m straight  
90° left 500 mm radius  
7.7 m straight  
to room 3:  
90° left 500 m radius  
2.4 m straight  
90° right 500 m radius  
7 m straight

To calculate the airflow distribution to three rooms in a ventilation system with a total airflow of 100 m³/h, we need to determine the effective length of each branch duct, accounting for the specified straight sections and bends/curves, and then distribute the airflow inversely proportional to the resistance (approximated by effective length). The ducts are rectangular (200 mm × 150 mm), and the branches have the following configurations:

- **Room 1:** 1 m straight, 180° left (500 mm radius), 180° right (500 mm radius), 90° left (500 mm radius), 0.7 m straight.
- **Room 2:** 2.2 m straight, 90° left (500 mm radius), 7.7 m straight.
- **Room 3:** 90° left (500 mm radius), 2.4 m straight, 90° right (500 mm radius), 7 m straight.



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We'll calculate the equivalent lengths of the bends, compute the total effective length for each branch, and determine the airflow distribution.

### Step 1: System Parameters

- **Duct dimensions:** 200 mm × 150 mm (0.2 m × 0.15 m).
- **Hydraulic diameter** ( $D_h$ ):

$$D_h = \frac{2 \cdot (0.2 \cdot 0.15)}{0.2 + 0.15} = \frac{0.06}{0.35} \approx 0.1714\text{m}$$

- **Total airflow:** 100 m³/h.
- **Assumptions:**
  - All ducts have the same cross-section (200 mm × 150 mm), so resistance is proportional to effective length.
  - Bends are smooth with a 500 mm (0.5 m) centerline radius.
  - No additional losses from junctions or outlets are specified.
  - Airflow splits inversely proportional to effective length, as in previous calculations.

### Step 2: Equivalent Length of Bends

The bends are 90° or 180° with a 500 mm radius. We need their equivalent lengths for the rectangular duct.

#### 90° Bend (500 mm radius)

From previous calculations, a 90° bend with a 500 mm radius ( $R/D_h = 0.5/0.1714 \approx 2.92$ ) has an equivalent length of approximately  $7.5 \times D_h$  for a smooth bend in a rectangular duct:

$$L_{90^\circ} = 7.5 \cdot 0.1714 \approx 1.2855\text{m} \approx 1.29\text{m}$$

The sensitivity test used  $5 \times D_h \approx 0.86\text{m}$ , but  $7.5 \times D_h$  was the primary estimate for  $R = 500\text{mm}$ . We'll use **1.29 m** for consistency and test with 0.86 m later if needed.

#### 180° Bend (500 mm radius)

A 180° bend is equivalent to two 90° bends in terms of pressure loss, assuming the same radius and no additional turbulence from the continuous curve. Thus, the equivalent length is approximately:

$$L_{180^\circ} = 2 \cdot L_{90^\circ} = 2 \cdot 1.29 \approx 2.58\text{m}$$

This assumes the 180° bend is a smooth, continuous curve with a 500 mm radius, doubling the resistance of a 90° bend. HVAC standards (e.g., ASHRAE) support this for smooth bends, though actual losses may vary slightly for rectangular ducts.

### Step 3: Calculate Effective Lengths for Each Branch

Sum the straight lengths and equivalent lengths of bends for each branch.

#### Room 1

- **Path:** 1 m straight, 180° left (500 mm), 180° right (500 mm), 90° left (500 mm), 0.7 m straight.
- **Straight lengths:**  $1 + 0.7 = 1.7\text{m}$ .
- **Bends:**
  - Two 180° bends:  $2 \cdot 2.58 = 5.16\text{m}$ .
  - One 90° bend:  $1.29\text{m}$ .
  - Total bend equivalent:  $5.16 + 1.29 = 6.45\text{m}$ .
- **Effective length:**

$$L_1 = 1.7 + 6.45 = 8.15\text{m}$$

#### Room 2

- **Path:** 2.2 m straight, 90° left (500 mm), 7.7 m straight.
- **Straight lengths:**  $2.2 + 7.7 = 9.9\text{m}$ .
- **Bends:** One 90° bend:  $1.29\text{m}$ .
- **Effective length:**

$$L_2 = 9.9 + 1.29 = 11.19\text{m}$$

#### Room 3

- **Path:** 90° left (500 mm), 2.4 m straight, 90° right (500 mm), 7 m straight.
- **Straight lengths:**  $2.4 + 7 = 9.4\text{m}$ .
- **Bends:** Two 90° bends:  $2 \cdot 1.29 = 2.58\text{m}$ .
- **Effective length:**



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$$L_3 = 9.4 + 2.58 = 11.98\text{m}$$

#### Step 4: Calculate Airflow Distribution

Airflow is inversely proportional to effective length. Calculate the reciprocals:

$$\frac{1}{L_1} = \frac{1}{8.15} \approx 0.122699$$

$$\frac{1}{L_2} = \frac{1}{11.19} \approx 0.089366$$

$$\frac{1}{L_3} = \frac{1}{11.98} \approx 0.083472$$

Sum of reciprocals:

$$0.122699 + 0.089366 + 0.083472 \approx 0.295537$$

Calculate airflow (total = 100 m³/h):

- Room 1 (8.15 m):

$$Q_1 = 100 \cdot \frac{0.122699}{0.295537} \approx 100 \cdot 0.4152 \approx 41.52\text{m}^3/\text{h}$$

- Room 2 (11.19 m):

$$Q_2 = 100 \cdot \frac{0.089366}{0.295537} \approx 100 \cdot 0.3023 \approx 30.23\text{m}^3/\text{h}$$

- Room 3 (11.98 m):

$$Q_3 = 100 \cdot \frac{0.083472}{0.295537} \approx 100 \cdot 0.2825 \approx 28.25\text{m}^3/\text{h}$$

Verify total:

$$41.52 + 30.23 + 28.25 \approx 100.00\text{m}^3/\text{h}$$

The sum matches 100 m³/h, confirming accuracy.

#### Step 5: Sensitivity Test with 90° Bend at 0.86 m

If the 90° bend’s equivalent length is 0.86 m ( $5 \times D_h$ , as used in the sensitivity test for 500 mm radius):

- 180° bend:  $2 \cdot 0.86 = 1.72\text{m}$ .
- Room 1:
  - Bends:  $2 \cdot 1.72 + 0.86 = 4.3\text{m}$ .
  - Effective length:  $1.7 + 4.3 = 6.0\text{m}$ .
- Room 2:
  - Bend: 0.86 m.
  - Effective length:  $9.9 + 0.86 = 10.76\text{m}$ .
- Room 3:
  - Bends:  $2 \cdot 0.86 = 1.72\text{m}$ .
  - Effective length:  $9.4 + 1.72 = 11.12\text{m}$ .

Reciprocals:

$$\frac{1}{6.0} \approx 0.166667, \quad \frac{1}{10.76} \approx 0.092937, \quad \frac{1}{11.12} \approx 0.089928$$

Sum:  $0.166667 + 0.092937 + 0.089928 \approx 0.349532$

Airflows:

- $Q_1 = 100 \cdot \frac{0.166667}{0.349532} \approx 47.68\text{m}^3/\text{h}$
- $Q_2 = 100 \cdot \frac{0.092937}{0.349532} \approx 26.58\text{m}^3/\text{h}$
- $Q_3 = 100 \cdot \frac{0.089928}{0.349532} \approx 25.73\text{m}^3/\text{h}$   
Total:  $47.68 + 26.58 + 25.73 \approx 99.99\text{m}^3/\text{h}$   
Range: 25.7–47.7 m³/h (22.0 m³/h difference).

The 0.86 m estimate increases Room 1’s airflow and widens the distribution, suggesting 1.29 m is more balanced.

#### Step 6: Compare with Previous Configurations

- Original (4 m, 8 m, 9 m, no bends):
  - 51.4, 25.7, 22.9 m³/h (range: 28.5 m³/h).



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- **Previous (4 m: 3.4 m bend; 8 m, 9 m: 500 mm curve, 1.29 m):**
  - 39.8, 31.7, 28.6 m³/h (range: 11.2 m³/h).
- **Current (detailed paths, 1.29 m for 90°):**
  - 41.5, 30.2, 28.3 m³/h (range: 13.2 m³/h).

Influence:

- Room 1’s multiple bends (two 180°, one 90°) increase its resistance (8.15 m effective), reducing airflow compared to the original but similar to the previous case.
- Room 2 and 3 have longer straight runs and fewer bends, resulting in higher effective lengths (11.19 m, 11.98 m) and lower airflows.
- The distribution is less balanced than the previous case due to Room 1’s shorter straight length offset by multiple bends.

Step 7: Assumptions and Notes

- **180° bend:** Assumed as two 90° bends. If treated as a single U-shaped bend, the equivalent length may be slightly different (e.g., 1.5–2 × 90°), but 2 × is standard.
- **Bend estimate:** Used 1.29 m for 90° bends. The 0.86 m test shows a wider distribution, suggesting 1.29 m is more realistic for balance.
- **Duct uniformity:** Assumed same cross-section for all branches.
- **Balancing:** To equalize airflow (~33.3 m³/h), install dampers, as discussed previously.

Final Answer

With the specified configuration and 90° bends (500 mm radius) adding 1.29 m, 180° bends adding 2.58 m, the effective lengths are 8.15 m, 11.19 m, and 11.98 m. The airflow distribution is:

- **Room 1: 41.5 m³/h**
- **Room 2: 30.2 m³/h**
- **Room 3: 28.3 m³/h**

The multiple bends in Room 1’s duct increase its resistance, balancing the shorter straight length, while Rooms 2 and 3 have similar airflows due to comparable effective lengths. The distribution is moderately balanced (range: 13.2 m³/h). For more equal airflow, use balancing dampers.

Correct room 1:  
to room 1:  
1 m straight  
180° left 500 mm radius  
0.7 m straight  
180° right 500 mm radius  
90° left 500 mm radius  
0.7 m straight

Thank you for providing the corrected configuration for Room 1's duct. We'll recalculate the effective length for Room 1’s duct, keep the configurations for Rooms 2 and 3 unchanged, and recompute the airflow distribution for the ventilation system with a total airflow of 100 m³/h. The ducts are rectangular (200 mm × 150 mm), and the configurations are now:

- **Room 1:** 1 m straight, 180° left (500 mm radius), 0.7 m straight, 180° right (500 mm radius), 90° left (500 mm radius), 0.7 m straight.
- **Room 2:** 2.2 m straight, 90° left (500 mm radius), 7.7 m straight.
- **Room 3:** 90° left (500 mm radius), 2.4 m straight, 90° right (500 mm radius), 7 m straight.

We'll use the same equivalent lengths for bends as before (90° bend: 1.29 m; 180° bend: 2.58 m), calculate the effective lengths, and distribute the airflow inversely proportional to the effective lengths.

Step 1: System Parameters

- **Duct dimensions:** 200 mm × 150 mm (0.2 m × 0.15 m).
- **Hydraulic diameter ( $D_h$ ):**

$$D_h = \frac{2 \cdot (0.2 \cdot 0.15)}{0.2 + 0.15} = \frac{0.06}{0.35} \approx 0.1714\text{m}$$

- **Total airflow:** 100 m³/h.
- **Assumptions:**
  - All ducts have the same cross-section (200 mm × 150 mm).
  - Bends have a 500 mm radius; equivalent lengths are 1.29 m for a 90° bend and 2.58 m for a 180° bend (from previous calculations: 90° =  $7.5 \times D_h$ , 180° =  $2 \times 90^\circ$ ).



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- Airflow splits inversely proportional to effective length.
- No additional losses from junctions or outlets.

## Step 2: Equivalent Lengths of Bends

- **90° bend (500 mm radius):**  $L_{90^\circ} = 7.5 \cdot 0.1714 \approx 1.29\text{m}$ .
- **180° bend (500 mm radius):**  $L_{180^\circ} = 2 \cdot 1.29 = 2.58\text{m}$ .

## Step 3: Calculate Effective Lengths for Each Branch

### Room 1 (Corrected)

- **Path:** 1 m straight, 180° left (500 mm), 0.7 m straight, 180° right (500 mm), 90° left (500 mm), 0.7 m straight.
- **Straight lengths:**  $1 + 0.7 + 0.7 = 2.4\text{m}$ .
- **Bends:**
  - Two 180° bends:  $2 \cdot 2.58 = 5.16\text{m}$ .
  - One 90° bend:  $1.29\text{m}$ .
  - Total bend equivalent:  $5.16 + 1.29 = 6.45\text{m}$ .
- **Effective length:**

$$L_1 = 2.4 + 6.45 = 8.85\text{m}$$

### Room 2 (Unchanged)

- **Path:** 2.2 m straight, 90° left (500 mm), 7.7 m straight.
- **Straight lengths:**  $2.2 + 7.7 = 9.9\text{m}$ .
- **Bends:** One 90° bend:  $1.29\text{m}$ .
- **Effective length:**

$$L_2 = 9.9 + 1.29 = 11.19\text{m}$$

### Room 3 (Unchanged)

- **Path:** 90° left (500 mm), 2.4 m straight, 90° right (500 mm), 7 m straight.
- **Straight lengths:**  $2.4 + 7 = 9.4\text{m}$ .
- **Bends:** Two 90° bends:  $2 \cdot 1.29 = 2.58\text{m}$ .
- **Effective length:**

$$L_3 = 9.4 + 2.58 = 11.98\text{m}$$

## Step 4: Calculate Airflow Distribution

Airflow is inversely proportional to effective length. Calculate the reciprocals:

$$\frac{1}{L_1} = \frac{1}{8.85} \approx 0.112994$$

$$\frac{1}{L_2} = \frac{1}{11.19} \approx 0.089366$$

$$\frac{1}{L_3} = \frac{1}{11.98} \approx 0.083472$$

Sum of reciprocals:

$$0.112994 + 0.089366 + 0.083472 \approx 0.285832$$

Calculate airflow (total = 100 m³/h):

- **Room 1 (8.85 m):**

$$Q_1 = 100 \cdot \frac{0.112994}{0.285832} \approx 100 \cdot 0.3952 \approx 39.52\text{m}^3/\text{h}$$

- **Room 2 (11.19 m):**

$$Q_2 = 100 \cdot \frac{0.089366}{0.285832} \approx 100 \cdot 0.3126 \approx 31.26\text{m}^3/\text{h}$$

- **Room 3 (11.98 m):**

$$Q_3 = 100 \cdot \frac{0.083472}{0.285832} \approx 100 \cdot 0.2920 \approx 29.20\text{m}^3/\text{h}$$



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Verify total:

$$39.52 + 31.26 + 29.20 \approx 99.98\text{m}^3/\text{h}$$

The sum is effectively 100 m³/h, accounting for rounding.

### Step 5: Compare with Previous Configurations

- **Original (4 m, 8 m, 9 m, no bends):**
  - 51.4, 25.7, 22.9 m³/h (range: 28.5 m³/h).
- **Previous (4 m: 3.4 m bend; 8 m, 9 m: 500 mm curve, 1.29 m):**
  - 39.8, 31.7, 28.6 m³/h (range: 11.2 m³/h).
- **Incorrect Room 1 (8.15 m effective):**
  - 41.5, 30.2, 28.3 m³/h (range: 13.2 m³/h).
- **Current (corrected Room 1, 8.85 m effective):**
  - 39.5, 31.3, 29.2 m³/h (range: 10.3 m³/h).

#### Influence of Correction:

- The corrected Room 1 configuration increases the straight length (from 1.7 m to 2.4 m) but keeps the same bends, raising the effective length from 8.15 m to 8.85 m.
- This slightly increases resistance, reducing Room 1’s airflow from 41.5 m³/h to 39.5 m³/h.
- Airflow to Rooms 2 and 3 increases slightly (from 30.2 to 31.3 m³/h and 28.3 to 29.2 m³/h) due to redistribution.
- The distribution is **more balanced** (range: 10.3 m³/h) than the incorrect Room 1 case (13.2 m³/h) and similar to the earlier 500 mm radius case (11.2 m³/h).

### Step 6: Sensitivity Test (90° Bend at 0.86 m)

If the 90° bend’s equivalent length is 0.86 m ( $5 \times D_h$ ), then 180° bend =  $2 \cdot 0.86 = 1.72\text{m}$ :

- **Room 1:**
  - Bends:  $2 \cdot 1.72 + 0.86 = 4.3\text{m}$ .
  - Effective length:  $2.4 + 4.3 = 6.7\text{m}$ .
- **Room 2:**
  - Bend: 0.86 m.
  - Effective length:  $9.9 + 0.86 = 10.76\text{m}$ .
- **Room 3:**
  - Bends:  $2 \cdot 0.86 = 1.72\text{m}$ .
  - Effective length:  $9.4 + 1.72 = 11.12\text{m}$ .

Reciprocals:

$$\frac{1}{6.7} \approx 0.149254, \quad \frac{1}{10.76} \approx 0.092937, \quad \frac{1}{11.12} \approx 0.089928$$

Sum:  $0.149254 + 0.092937 + 0.089928 \approx 0.332119$

Airflows:

- $Q_1 = 100 \cdot \frac{0.149254}{0.332119} \approx 44.93\text{m}^3/\text{h}$
  - $Q_2 = 100 \cdot \frac{0.092937}{0.332119} \approx 27.98\text{m}^3/\text{h}$
  - $Q_3 = 100 \cdot \frac{0.089928}{0.332119} \approx 27.08\text{m}^3/\text{h}$
- Total:  $44.93 + 27.98 + 27.08 \approx 99.99\text{m}^3/\text{h}$   
Range: 27.1–44.9 m³/h (17.8 m³/h).

The 0.86 m estimate widens the distribution, confirming 1.29 m is more appropriate for balance.

### Step 7: Assumptions and Notes

- **180° bend:** Assumed as two 90° bends (2.58 m). If a single U-shaped bend, the equivalent length might be slightly lower (e.g.,  $1.5\text{--}2 \times 90^\circ$ ), but  $2 \times$  is standard.
- **Bend estimate:** 1.29 m for 90° bends aligns with previous balanced results. The 0.86 m test increases imbalance.
- **Balancing:** For equal airflow (~33.3 m³/h), install balancing dampers, especially restricting Room 1’s duct.

### Final Answer

With the corrected Room 1 configuration (effective length: 8.85 m) and unchanged Rooms 2 and 3 (11.19 m, 11.98 m), using 1.29 m for 90° bends and 2.58 m for 180° bends (500 mm radius), the airflow distribution is:



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- **Room 1:** 39.5 m³/h
- **Room 2:** 31.3 m³/h
- **Room 3:** 29.2 m³/h

The correction increases Room 1's effective length, slightly reducing its airflow and improving balance (range: 10.3 m³/h) compared to the incorrect configuration (13.2 m³/h). Use dampers to further equalize airflow if needed.

Correct room 1:  
to room 1:  
1 m straight  
180° left 500 mm radius  
0.7 m straight  
180° right 500 mm radius  
0.7 m straight  
90° left 500 mm radius  
0.7 m straight

Thank you for providing the corrected configuration for Room 1's duct. The new configuration for Room 1 is slightly different from the previous one, with an additional 0.7 m straight section before the 90° bend. We'll recalculate the effective length for Room 1's duct, keep the configurations for Rooms 2 and 3 unchanged, and recompute the airflow distribution for the ventilation system with a total airflow of 100 m³/h. The ducts are rectangular (200 mm × 150 mm), and the configurations are:

- **Room 1:** 1 m straight, 180° left (500 mm radius), 0.7 m straight, 180° right (500 mm radius), 0.7 m straight, 90° left (500 mm radius), 0.7 m straight.
- **Room 2:** 2.2 m straight, 90° left (500 mm radius), 7.7 m straight.
- **Room 3:** 90° left (500 mm radius), 2.4 m straight, 90° right (500 mm radius), 7 m straight.

We'll use the same equivalent lengths for bends (90° bend: 1.29 m; 180° bend: 2.58 m, based on previous calculations), compute the effective lengths, and distribute the airflow inversely proportional to the effective lengths.

### Step 1: System Parameters

- **Duct dimensions:** 200 mm × 150 mm (0.2 m × 0.15 m).
- **Hydraulic diameter ( $D_h$ ):**

$$D_h = \frac{2 \cdot (0.2 \cdot 0.15)}{0.2 + 0.15} = \frac{0.06}{0.35} \approx 0.1714\text{m}$$

- **Total airflow:** 100 m³/h.
- **Equivalent lengths of bends** (500 mm radius, from previous calculations):
  - 90° bend:  $7.5 \cdot 0.1714 \approx 1.29\text{m}$ .
  - 180° bend:  $2 \cdot 1.29 = 2.58\text{m}$ .
- **Assumptions:**
  - All ducts have the same cross-section (200 mm × 150 mm).
  - Airflow splits inversely proportional to effective length (resistance is proportional to length).
  - No additional losses from junctions or outlets.
  - Date and time (11:07 PM CEST, May 18, 2025) are irrelevant to the calculation.

### Step 2: Calculate Effective Lengths for Each Branch

#### Room 1 (Corrected)

- **Path:** 1 m straight, 180° left (500 mm), 0.7 m straight, 180° right (500 mm), 0.7 m straight, 90° left (500 mm), 0.7 m straight.
- **Straight lengths:**  $1 + 0.7 + 0.7 + 0.7 = 3.1\text{m}$ .
- **Bends:**
  - Two 180° bends:  $2 \cdot 2.58 = 5.16\text{m}$ .
  - One 90° bend: 1.29m.
  - Total bend equivalent:  $5.16 + 1.29 = 6.45\text{m}$ .
- **Effective length:**

$$L_1 = 3.1 + 6.45 = 9.55\text{m}$$

#### Room 2 (Unchanged)

- **Path:** 2.2 m straight, 90° left (500 mm), 7.7 m straight.
- **Straight lengths:**  $2.2 + 7.7 = 9.9\text{m}$ .
- **Bends:** One 90° bend: 1.29m.
- **Effective length:**



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$$L_2 = 9.9 + 1.29 = 11.19\text{m}$$

#### Room 3 (Unchanged)

- **Path:** 90° left (500 mm), 2.4 m straight, 90° right (500 mm), 7 m straight.
- **Straight lengths:**  $2.4 + 7 = 9.4\text{m}$ .
- **Bends:** Two 90° bends:  $2 \cdot 1.29 = 2.58\text{m}$ .
- **Effective length:**

$$L_3 = 9.4 + 2.58 = 11.98\text{m}$$

### Step 3: Calculate Airflow Distribution

Airflow is inversely proportional to effective length. Calculate the reciprocals:

$$\frac{1}{L_1} = \frac{1}{9.55} \approx 0.104712$$

$$\frac{1}{L_2} = \frac{1}{11.19} \approx 0.089366$$

$$\frac{1}{L_3} = \frac{1}{11.98} \approx 0.083472$$

Sum of reciprocals:

$$0.104712 + 0.089366 + 0.083472 \approx 0.277550$$

Calculate airflow (total = 100 m³/h):

- **Room 1 (9.55 m):**

$$Q_1 = 100 \cdot \frac{0.104712}{0.277550} \approx 100 \cdot 0.3772 \approx 37.72\text{m}^3/\text{h}$$

- **Room 2 (11.19 m):**

$$Q_2 = 100 \cdot \frac{0.089366}{0.277550} \approx 100 \cdot 0.3220 \approx 32.20\text{m}^3/\text{h}$$

- **Room 3 (11.98 m):**

$$Q_3 = 100 \cdot \frac{0.083472}{0.277550} \approx 100 \cdot 0.3008 \approx 30.08\text{m}^3/\text{h}$$

Verify total:

$$37.72 + 32.20 + 30.08 \approx 100.00\text{m}^3/\text{h}$$

The sum matches 100 m³/h, confirming accuracy.

### Step 4: Compare with Previous Configurations

- **Original (4 m, 8 m, 9 m, no bends):**
  - 51.4, 25.7, 22.9 m³/h (range: 28.5 m³/h).
- **Previous with 500 mm radius bends (Room 1: 8.85 m effective):**
  - 39.5, 31.3, 29.2 m³/h (range: 10.3 m³/h).
- **Current (Room 1: 9.55 m effective):**
  - 37.7, 32.2, 30.1 m³/h (range: 10.0 m³/h).

#### Influence of Correction:

- The corrected Room 1 configuration adds a 0.7 m straight section, increasing the straight length from 2.4 m to 3.1 m and the effective length from 8.85 m to 9.55 m.
- This increases Room 1’s resistance, reducing its airflow from 39.5 m³/h to 37.7 m³/h.
- Airflow to Rooms 2 and 3 increases slightly (from 31.3 to 32.2 m³/h and 29.2 to 30.1 m³/h) due to redistribution.
- The distribution is **slightly more balanced** (range: 10.0 m³/h vs. 10.3 m³/h), as the effective lengths are closer (9.55, 11.19, 11.98 m).

### Step 5: Sensitivity Test (90° Bend at 0.86 m)

If the 90° bend’s equivalent length is 0.86 m ( $5 \times D_h$ ), then 180° bend =  $2 \cdot 0.86 = 1.72\text{m}$ :

- **Room 1:**
  - Bends:  $2 \cdot 1.72 + 0.86 = 4.3\text{m}$ .



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• Effective length:  $3.1 + 4.3 = 7.4\text{m}$ .

• **Room 2:**

• Bend:  $0.86\text{ m}$ .

• Effective length:  $9.9 + 0.86 = 10.76\text{m}$ .

• **Room 3:**

• Bends:  $2 \cdot 0.86 = 1.72\text{m}$ .

• Effective length:  $9.4 + 1.72 = 11.12\text{m}$ .

Reciprocals:

$$\frac{1}{7.4} \approx 0.135135, \quad \frac{1}{10.76} \approx 0.092937, \quad \frac{1}{11.12} \approx 0.089928$$

Sum:  $0.135135 + 0.092937 + 0.089928 \approx 0.318000$

Airflows:

•  $Q_1 = 100 \cdot \frac{0.135135}{0.318000} \approx 42.50\text{m}^3/\text{h}$

•  $Q_2 = 100 \cdot \frac{0.092937}{0.318000} \approx 29.22\text{m}^3/\text{h}$

•  $Q_3 = 100 \cdot \frac{0.089928}{0.318000} \approx 28.28\text{m}^3/\text{h}$

Total:  $42.50 + 29.22 + 28.28 \approx 100.00\text{m}^3/\text{h}$

Range:  $28.3\text{--}42.5\text{ m}^3/\text{h}$  ( $14.2\text{ m}^3/\text{h}$ ).

The  $0.86\text{ m}$  estimate widens the distribution, confirming  $1.29\text{ m}$  yields a more balanced result.

Step 6: Assumptions and Notes

• **180° bend:** Assumed as two  $90^\circ$  bends ( $2.58\text{ m}$ ). A single U-shaped bend might have a slightly lower equivalent length, but  $2 \times 90^\circ$  is standard.

• **Bend estimate:**  $1.29\text{ m}$  for  $90^\circ$  bends aligns with balanced distributions in prior calculations.

• **Balancing:** For equal airflow ( $\sim 33.3\text{ m}^3/\text{h}$ ), install balancing dampers, particularly restricting Room 1's duct to reduce its airflow.

Final Answer

With the corrected Room 1 configuration (effective length:  $9.55\text{ m}$ ) and unchanged Rooms 2 and 3 ( $11.19\text{ m}$ ,  $11.98\text{ m}$ ), using  $1.29\text{ m}$  for  $90^\circ$  bends and  $2.58\text{ m}$  for  $180^\circ$  bends ( $500\text{ mm}$  radius), the airflow distribution is:

• **Room 1:  $37.7\text{ m}^3/\text{h}$**

• **Room 2:  $32.2\text{ m}^3/\text{h}$**

• **Room 3:  $30.1\text{ m}^3/\text{h}$**

The additional  $0.7\text{ m}$  straight section in Room 1 increases its effective length, slightly reducing its airflow (from  $39.5\text{ m}^3/\text{h}$  to  $37.7\text{ m}^3/\text{h}$ ) and improving balance (range:  $10.0\text{ m}^3/\text{h}$  vs.  $10.3\text{ m}^3/\text{h}$ ). Use balancing dampers to achieve more equal airflow if needed.

Correct room 1:  
to room 1:  
1 m straight  
180° left 500 mm radius  
0.5 m straight  
180° right 500 mm radius  
0.5 m straight  
90° left 500 mm radius  
0.7 m straight

Thank you for providing the updated correction for Room 1's duct configuration. The new configuration for Room 1 adjusts the straight sections between and after the bends. We'll recalculate the effective length for Room 1's duct, keep the configurations for Rooms 2 and 3 unchanged, and recompute the airflow distribution for the ventilation system with a total airflow of  $100\text{ m}^3/\text{h}$ . The ducts are rectangular ( $200\text{ mm} \times 150\text{ mm}$ ), and the configurations are:

• **Room 1:** 1 m straight,  $180^\circ$  left ( $500\text{ mm}$  radius),  $0.5\text{ m}$  straight,  $180^\circ$  right ( $500\text{ mm}$  radius),  $0.5\text{ m}$  straight,  $90^\circ$  left ( $500\text{ mm}$  radius),  $0.7\text{ m}$  straight.

• **Room 2:**  $2.2\text{ m}$  straight,  $90^\circ$  left ( $500\text{ mm}$  radius),  $7.7\text{ m}$  straight.

• **Room 3:**  $90^\circ$  left ( $500\text{ mm}$  radius),  $2.4\text{ m}$  straight,  $90^\circ$  right ( $500\text{ mm}$  radius),  $7\text{ m}$  straight.

We'll use the previously established equivalent lengths for bends ( $90^\circ$  bend:  $1.29\text{ m}$ ;  $180^\circ$  bend:  $2.58\text{ m}$ ), compute the effective lengths, and distribute the airflow inversely proportional to the effective lengths.

Step 1: System Parameters

• **Duct dimensions:**  $200\text{ mm} \times 150\text{ mm}$  ( $0.2\text{ m} \times 0.15\text{ m}$ ).

• **Hydraulic diameter** ( $D_h$ ):



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$$D_h = \frac{2 \cdot (0.2 \cdot 0.15)}{0.2 + 0.15} = \frac{0.06}{0.35} \approx 0.1714\text{m}$$

- **Total airflow:** 100 m³/h.
- **Equivalent lengths of bends** (500 mm radius, from previous calculations):
  - 90° bend:  $7.5 \cdot 0.1714 \approx 1.29\text{m}$ .
  - 180° bend:  $2 \cdot 1.29 = 2.58\text{m}$ .
- **Assumptions:**
  - All ducts have the same cross-section (200 mm × 150 mm).
  - Airflow splits inversely proportional to effective length (resistance is proportional to length).
  - No additional losses from junctions or outlets.
  - The date and time (11:20 PM CEST, May 18, 2025) are irrelevant to the calculation.

## Step 2: Calculate Effective Lengths for Each Branch

### Room 1 (Corrected)

- **Path:** 1 m straight, 180° left (500 mm), 0.5 m straight, 180° right (500 mm), 0.5 m straight, 90° left (500 mm), 0.7 m straight.
- **Straight lengths:**  $1 + 0.5 + 0.5 + 0.7 = 2.7\text{m}$ .
- **Bends:**
  - Two 180° bends:  $2 \cdot 2.58 = 5.16\text{m}$ .
  - One 90° bend: 1.29m.
  - Total bend equivalent:  $5.16 + 1.29 = 6.45\text{m}$ .
- **Effective length:**

$$L_1 = 2.7 + 6.45 = 9.15\text{m}$$

### Room 2 (Unchanged)

- **Path:** 2.2 m straight, 90° left (500 mm), 7.7 m straight.
- **Straight lengths:**  $2.2 + 7.7 = 9.9\text{m}$ .
- **Bends:** One 90° bend: 1.29m.
- **Effective length:**

$$L_2 = 9.9 + 1.29 = 11.19\text{m}$$

### Room 3 (Unchanged)

- **Path:** 90° left (500 mm), 2.4 m straight, 90° right (500 mm), 7 m straight.
- **Straight lengths:**  $2.4 + 7 = 9.4\text{m}$ .
- **Bends:** Two 90° bends:  $2 \cdot 1.29 = 2.58\text{m}$ .
- **Effective length:**

$$L_3 = 9.4 + 2.58 = 11.98\text{m}$$

## Step 3: Calculate Airflow Distribution

Airflow is inversely proportional to effective length. Calculate the reciprocals:

$$\frac{1}{L_1} = \frac{1}{9.15} \approx 0.109290$$

$$\frac{1}{L_2} = \frac{1}{11.19} \approx 0.089366$$

$$\frac{1}{L_3} = \frac{1}{11.98} \approx 0.083472$$

Sum of reciprocals:

$$0.109290 + 0.089366 + 0.083472 \approx 0.282128$$

Calculate airflow (total = 100 m³/h):

- **Room 1 (9.15 m):**

$$Q_1 = 100 \cdot \frac{0.109290}{0.282128} \approx 100 \cdot 0.3874 \approx 38.74\text{m}^3/\text{h}$$

- **Room 2 (11.19 m):**

$$Q_2 = 100 \cdot \frac{0.089366}{0.282128} \approx 100 \cdot 0.3168 \approx 31.68\text{m}^3/\text{h}$$

- **Room 3 (11.98 m):**



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$$Q_3 = 100 \cdot \frac{0.083472}{0.282128} \approx 100 \cdot 0.2958 \approx 29.58\text{m}^3/\text{h}$$

Verify total:

$$38.74 + 31.68 + 29.58 \approx 100.00\text{m}^3/\text{h}$$

The sum matches 100 m³/h, confirming accuracy.

#### Step 4: Compare with Previous Configurations

- **Original (4 m, 8 m, 9 m, no bends):**
  - 51.4, 25.7, 22.9 m³/h (range: 28.5 m³/h).
- **Previous with 500 mm radius bends (Room 1: 8.85 m effective):**
  - 39.5, 31.3, 29.2 m³/h (range: 10.3 m³/h).
- **Previous with 500 mm radius bends (Room 1: 9.55 m effective):**
  - 37.7, 32.2, 30.1 m³/h (range: 10.0 m³/h).
- **Current (Room 1: 9.15 m effective):**
  - 38.7, 31.7, 29.6 m³/h (range: 10.1 m³/h).

#### Influence of Correction:

- The corrected Room 1 configuration reduces the straight length from 3.1 m to 2.7 m (replacing two 0.7 m sections with 0.5 m sections), decreasing the effective length from 9.55 m to 9.15 m.
- This slightly reduces Room 1’s resistance, increasing its airflow from 37.7 m³/h to 38.7 m³/h.
- Airflow to Rooms 2 and 3 decreases slightly (from 32.2 to 31.7 m³/h and 30.1 to 29.6 m³/h) due to redistribution.
- The distribution remains well-balanced (range: 10.1 m³/h), very close to the previous case (10.0 m³/h) and better than the earlier 8.85 m case (10.3 m³/h).

#### Step 5: Sensitivity Test (90° Bend at 0.86 m)

If the 90° bend’s equivalent length is 0.86 m ( $5 \times D_h$ ), then 180° bend =  $2 \cdot 0.86 = 1.72\text{m}$ :

- **Room 1:**
  - Bends:  $2 \cdot 1.72 + 0.86 = 4.3\text{m}$ .
  - Effective length:  $2.7 + 4.3 = 7.0\text{m}$ .
- **Room 2:**
  - Bend: 0.86 m.
  - Effective length:  $9.9 + 0.86 = 10.76\text{m}$ .
- **Room 3:**
  - Bends:  $2 \cdot 0.86 = 1.72\text{m}$ .
  - Effective length:  $9.4 + 1.72 = 11.12\text{m}$ .

Reciprocals:

$$\frac{1}{7.0} \approx 0.142857, \quad \frac{1}{10.76} \approx 0.092937, \quad \frac{1}{11.12} \approx 0.089928$$

Sum:  $0.142857 + 0.092937 + 0.089928 \approx 0.325722$

Airflows:

- $Q_1 = 100 \cdot \frac{0.142857}{0.325722} \approx 43.86\text{m}^3/\text{h}$
- $Q_2 = 100 \cdot \frac{0.092937}{0.325722} \approx 28.53\text{m}^3/\text{h}$
- $Q_3 = 100 \cdot \frac{0.089928}{0.325722} \approx 27.60\text{m}^3/\text{h}$   
Total:  $43.86 + 28.53 + 27.60 \approx 99.99\text{m}^3/\text{h}$   
Range: 27.6–43.9 m³/h (16.3 m³/h).

The 0.86 m estimate widens the distribution, confirming that 1.29 m for a 90° bend provides a more balanced result.

#### Step 6: Assumptions and Notes

- **180° bend:** Assumed as two 90° bends (2.58 m). A single U-shaped bend might have a slightly lower equivalent length (e.g.,  $1.5\text{--}2 \times 90^\circ$ ), but  $2 \times 90^\circ$  is standard in HVAC practice.
- **Bend estimate:** The 1.29 m for 90° bends ( $7.5 \times D_h$ ) aligns with balanced distributions in prior calculations and is consistent with HVAC standards for smooth bends with  $R/D_h \approx 2.92$ .
- **Balancing:** To achieve equal airflow ( $\sim 33.3\text{m}^3/\text{h}$ ), install balancing dampers, particularly restricting Room 1’s duct to reduce its airflow, as its effective length is the shortest.
- **Configuration change:** The reduction in straight length (from 3.1 m to 2.7 m) slightly lowers Room 1’s resistance, but the multiple bends keep its effective length comparable to Rooms 2 and 3, maintaining



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balance.

### Final Answer


With the corrected Room 1 configuration (effective length: 9.15 m) and unchanged Rooms 2 and 3 (11.19 m, 11.98 m), using 1.29 m for 90° bends and 2.58 m for 180° bends (500 mm radius), the airflow distribution is:


- Room 1: 38.7 m³/h
- Room 2: 31.7 m³/h
- Room 3: 29.6 m³/h


The correction reduces Room 1’s straight length (from 3.1 m to 2.7 m), lowering its effective length from 9.55 m to 9.15 m, increasing its airflow from 37.7 m³/h to 38.7 m³/h, and slightly adjusting Rooms 2 and 3. The distribution is well-balanced (range: 10.1 m³/h). To achieve more equal airflow, use balancing dampers to adjust flow, particularly restricting Room 1.


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