2024 Asia and Pacific Mathematical Contest in Modeling

Problem B

Optimization of the Shape of Air conditioner

With the continuous improvement of people's requirements for quality of life, products that combine air conditioning, humidifiers, and air purifiers have gradually been developed. It is a multifunctional environmental conditioning device. The three in one product only occupies the space of one device, instead of placing air conditioners, humidifiers, and air purifiers separately like traditional methods.

Figure 1. Schematic diagram of air conditioner, humidifier, and air purifier.

Air conditioning may make indoor air dry while regulating temperature. The humidifier in the three in one product can replenish moisture in a timely manner and maintain suitable indoor humidity. Air purifiers can filter harmful pollutants such as dust, pollen, smoke, and formaldehyde in the air. When the air conditioner is running and causing indoor air circulation, the air purifier can better function, purify the circulating air, and improve indoor air quality. Users can simultaneously control the opening, closing, and adjusting related parameters of three functions without the need to operate three different devices separately. The three in one product

2024 年亚太地区建模数学竞赛

问题 B

空调形状的优化

随着人们对生活品质要求的不断提高，产品将空调、加湿器和空气净化器相结合的逐渐发展起来。它是一种多功能的环境调节装置。三合一产品只占用一个设备的空间，而不是放置空调、加湿器和空气净化器分开。

图 1.空调、加湿器和空气净化器的示意图。

空调可能会在调节温度的同时使室内空气干燥。加湿器三合一产品可及时补充水分，保持适合室内湿度。空气净化器可以过滤灰尘、花粉、烟雾等有害污染物，以及空气中的甲醛。当空调运转并引起室内空气流通时，空气净化器可以更好地发挥作用，净化循环空气，改善室内空气质量。用户可以同时控制三个的打开、关闭和调整相关参数功能无需分别操作三个不同的设备。三合一产品

of air conditioner, humidifier and air purifier also reduces the power and connection wires of multiple devices, reduces the complexity of wiring, makes the indoor environment more concise and beautiful, and also reduces the safety hazards that may be caused by too many lines.

The optimal design of the three in one air conditioner, humidifier, and air purifier is closely related to aerodynamics. The overall shape, placement, position and quantity of air inlet and outlet, direction and angle, wind speed and air volume of the three in one environmental conditioning equipment will all affect its effectiveness.

There is currently a room that is about to be renovated, which can be approximated as a long square with a spatial volume of 5m×8m×3m. The maximum volume of the limited three in one air conditioner is 0.1 m^3, the rated power consumption is 1800W, the maximum air outlet speed is 8.0 m/s, the maximum inlet flow rate of the airflow is 600 m^3/hour, and the maximum outlet flow rate of the airflow is also 600 m^3/hour.

As the manager of the APMCM three-in-one air conditioner appearance optimization team, please collect and research relevant data on air conditioners, humidifiers, and air purifiers in the market, and then establish a mathematical model for optimizing the appearance of the three in one air conditioner. Answer the following questions:

Question 1: Please analyze the influence of factors such as the placement of air conditioning, the position and quantity of air inlet and outlet, direction and angle, wind speed and air volume on the efficiency of air conditioning, and simulate the changes in indoor temperature over time and space under different conditions in summer and winter. Then consider the different shapes of the air conditioner, establish an optimization model for the shape of the air conditioner, and design the optimal shape and size of the air conditioner to achieve the best temperature regulation effect.

Question 2: Please analyze the influence of the shape of the air purifier on the purification effect, consider different shapes of the air purifier, establish an optimization model for the shape of the air purifier, design the optimal shape and size of the air purifier to maximize the purification effect, and draw the shape and size parameters of the optimal shape.

Question 3: Please analyze the influence of the shape of the air humidifier on the humidification effect, consider different shapes of the air humidifier, establish an optimization model for the shape of the air humidifier, design the optimal shape of the air humidifier to maximize the humidification effect, and draw the shape and size parameters of the optimal shape.

Question 4: Based on the models and results in questions 1-3, please establish an

空调、加湿器和空气净化器还减少了
多种设备，降低布线复杂度，让室内环境更
简洁美观，也减少了线路过多可能带来的安全隐患。

空调、加湿器、空气净化器三合一的优化设计与空气动力学密切相关。三合一环保设备的整体形状、位置、进风口和出风口的位置和数量、方向和角度、风速和风量都会影响其效果。

目前有一个房间即将装修，可以近似为
空间体积为 5m×8m×3m 的长方形。限三的最大音量
三合一空调 0.1 米，额定功耗 1800W，最大出风口
3 速度为 8.0 m/s，气流的最大入口流量为 600 m/h，最大
3气流的出口流量也是 600 m/h。

作为 APMCM 三合一空调外观优化团队的经理，
请收集和研究空调、加湿器和空气净化器的相关数据
市场，然后创建一个数学模型来优化这三个外观
在一台空调里。请回答以下问题：

问题 1：请分析空气放置等因素的影响
调节、进风口和出风口的位置和数量、方向和角度、风速
和风量对空调效率的影响，并模拟室内的变化
夏季和冬季不同条件下随时间和空间变化的温度。然后
考虑空调的不同形状，创建优化模型
空调的形状，并设计空调的最佳形状和尺寸
达到最佳的温度调节效果。

问题 2：请分析空气净化器的形状对净化效果的影响，考虑空气净化器的不同形状，创建空气净化器形状的优化模型，设计空气净化器的最佳形状和尺寸，以最大限度地发挥净化效果，并绘制出最佳形状的形状和尺寸参数。

问题 3：请分析空气加湿器形状对加湿效果的影响，考虑空气加湿器的不同形状，创建空气加湿器形状的最优模型，设计空气加湿器的最佳形状以最大化加湿效果，并绘制最佳形状的形状和尺寸参数。

问题 4：根据问题 1-3 中的模型和结果，请创建一个

optimized design model for the appearance of the three in one air conditioner, humidifier, and air purifier, while maximizing energy efficiency, human comfort, purification effect, and humidification effect. Design the optimal appearance of the three in one device and draw the shape and size parameters of the optimal appearance.

Glossary :

Aerodynamics: Aerodynamics is a branch of fluid mechanics that mainly studies the interaction forces between gases and objects when objects move in air or other gases, as well as the flow of gases around objects. Simply put, it focuses on the dynamic relationship between air and objects, including the generation of forces, energy conversion, and flow patterns, among many other aspects.

三合一空调、加湿器外观优化设计模型
空气净化器，同时最大限度地提高能源效率、人体舒适度、净化效果和加湿效果。设计三合一设备的最佳外观，并绘制
形状和大小参数。

词汇表：

空气动力学：空气动力学是流体力学的一个分支，主要研究当物体在空气或其他气体中移动时，气体和物体之间的相互作用力作为物体周围气体的流动。简单地说，它侧重于
空气和物体，包括力的产生、能量转换和流动模式等
许多其他方面。