**2022 ASHRAE 3D Modeling COMPETITION**

**Competition**

Welcome to the world of Heating, Ventilation, and Air Conditioning (HVAC) design. This competition will provide you with the opportunity to take the first steps in designing a building’s HVAC system. This competition will expose students to the process that designers and engineers go through when designing building systems. ASHRAE is a global engineering society that supports the HVAC industry. To learn more about ASHRAE please go to [ashrae.org](https://www.ashrae.org).

As you work through this competition you will use an engineering design process that will involve systematic problem-solving with criteria and constraints. This process is used to develop multiple solutions to the problem described, and then require you to narrow those possible solutions to find one final solution for your design. As part of the process, you will be required to determine summer cooling requirements for the different spaces in the building, select the HVAC equipment to be installed, and design a building ventilation system. Owner requirements, design assumptions, a general building description, heating loads, equipment information, necessary equations, and ductwork sizing information is provided to assist you in your design efforts.

**Project Description**

“ Engineering, Inc.” is an HVAC design firm located in Atlanta, Georgia. They have outgrown their current office space and are interested in constructing a new building. They have 19 employees: 4 Professional Engineers, 10 Designers, 4 Interns, and 1 Receptionist. Each of the Professional Engineers needs a private office and the Designers and Interns would like to be set up in two separate team open office areas.

Each employee needs adequate desk space for a computer with two large monitors and paperwork including building plans, which are typically 30” by 42” in size. The employees like to cook their own meals instead of eating out, so they require cooking appliances in their break room and space for 8 people to sit and eat during lunch. The firm needs a storage room that is at least 150 square feet (SF). If possible, they would like to have a game room with enough room for a ping pong table. A conference room is required with enough space for 12 people to meet; ideally it would be located near the entrance to the office where the Receptionist’s desk is typically located. Restrooms and an area for their copy machine are required, preferably in an area that is easy for everyone to access.

One of the complaints that the employees have about their old office is that the air conditioning equipment was located on the roof, right above their conference room and it made a lot of noise. They would like you to show in your model where you would recommend locating the equipment to reduce noise concerns. They would also like their ceilings to be as high as possible but understand that there will need to be space for ductwork. The employees have noted they would like the air conditioning system to provide 75°F in all the spaces.

Atlanta is a moderate climate, with summers that are very hot and humid, so having certain rooms in specific locations is a very important aspect of the building layout. Keep in mind that building shape and proper orientation can help reduce the energy costs associated with air conditioning the spaces.

**Design Guidelines**

Note that airflows to spaces and buildings are generally sized based on peak design conditions. A building space gains heat from many different internal and external sources, such as lights, occupants, solar radiation, and the difference in temperature from inside to outside. The sum of all these sources is referred to as the heat gain for the building. In the summer, the peak cooling load is the amount of heat you need to remove from a space on the hottest day of the year to maintain a room’s temperature. Heating and cooling loads are typically expressed in units of measure such as BTU/hour or watts.

While building HVAC systems are designed to operate at peak loads, this typically only occurs for a short period of time for the year, so designers and engineers will include the ability to vary the amount of heating or cooling that is provided at a given time in their designs to improve building energy efficiency. Be creative, consider all owner requirements, how they apply, and placement of equipment and ductwork, both supply and return, from a space.

**Abbreviations and Definitions:**

The abbreviations and definitions provided below will help you better navigate through the equations and design information provided:

|  |  |
| --- | --- |
| BTU | A British Thermal Unit is unit of heat defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. |
| BTU/H | A British Thermal Unit per hour. This is a rate of heat energy over time. HVAC systems are provided with a capacity to add or remove heat in BTU/H. |
| CFM | Cubic Feet Per Minute |
| CF | Window surface cooling factor. This is the rate of solar radiation through a transparent surface in BTU/H\*SF. |
| ΔT | This is the change in temperature between to surfaces. This could be the inside to outside temperature of the wall, etc. |
| Q | Heat transfer rate in BTU/H |
| RTU | Packaged air handling unit mounted on a roof, discharges conditioned air directly into the rooms below or through a duct system |
| Ton | The amount of cooling capacity in an air conditioning unit or system. One ton is equivalent to the amount of heat required to melt one ton of ice over a period of 24 hours. 1 ton equals 12,000 BTU/H |
| U-Factor | The rate at which a window, door, or skylight conducts non-solar heat flow. |
| VAV | HVAC system that controls the temperature within a space by varying the flow of heated or cooled supply air to the space |
| W | A Watt is a standard unit of power and is the equivalent of one joule per second.  |

**Design Resources**

Using the information below, determine the required air conditioning unit capacity. Refer to the table below listing unit dimensions and supply airflow rates for different capacities. Note that you might want to utilize more than one unit to meet the air conditioning needs. Your model should include the air conditioning unit(s) shown on the roof with the correct physical dimensions, as well as the ductwork necessary to distribute the supply and return air to each area.

**Available Air Conditioning Unit Schedule**

|  |  |  |  |
| --- | --- | --- | --- |
| **Model** | **Capacity****(Tons)** | **Airflow****(CFM)** | **Dimensions****Length x Width x Height** **(Feet)** |
| A-036 | 3 | 1,200 | 5 x 3 x 3 |
| B-048 | 4 | 1,600 | 6 x 3 x 3 |
| C-060 | 5 | 2,000 | 6 x 4 x3  |
| D-072 | 6 | 2,400 | 7 x 4 x 3 |
| E-090 | 7.5 | 3,000 | 9 x 5 x 4 |
| F-120 | 10 | 4,000 | 10 x 5 x 4 |
| G-150 | 12.5 | 5,000 | 12 x 5 x 4  |

**Ductwork Sizing Table**

|  |  |
| --- | --- |
| **Airflow Range****(CFM)** | **Size Options****width x height****(inches)** |
| 0 - 300 | 8x8 or 6x10 |
| 301 - 550 | 10x10 or 8x12 |
| 551 - 850 | 12x12 or 10x14 |
| 851 - 1,300 | 14x14 or 12x16 or 10x18 |
| 1,301 - 1,800 | 16x16 or 14x18 or 12x16 |
| 1,801 - 2,600 | 18x18 or 16x20 or 14x24 |
| 2,601 - 3,200 | 20x20 or 18x22 or 16x26 or 14x30 |
| 3,201 - 5,000 | 24x24 or 22x26 or 20x30 or 18x34 |

The heat gain sources needed for cooling equipment sizing are provided below.

**Lighting:**

Open/enclosed offices = 1.1 W/SF

Restroom = 0.9 W/SF

Conference Room = 1.3 W/SF

Storage = 0.5 W/SF

**Equipment:**

Computer = 135W

Monitor = 20W

Commercial Printer = 200W

Microwave = 400W

Refrigerator = 220 W

**People:**

200 BTU/H for office work

500 BTU/H for ping pong

**Insulation of surfaces:**

Walls = U-0.064 $\frac{BTU}{SF\*°F\*H}$

Roof = U-0.048$\frac{BTU}{SF\*°F\*H}$

Windows = U-0.45$\frac{BTU}{SF\*°F\*H}$

**Design weather conditions from ASHRAE:**

Atlanta, Georgia:

Design Conditions:

94°F outside in the summer

CFnorth = 7 $\frac{BTU}{H\*SF}$

CFeast = 26 $\frac{BTU}{H\*SF}$

CFsouth = 14 $\frac{BTU}{H\*SF}$

CFwest = 26 $\frac{BTU}{H\*SF}$

**Equations**

* Assume you need 0.045 cfm per peak BTU/H.
* Assume 550 cfm/ton when sizing the RTU.
* $Qwall=Awall\*U\*ΔT$
* $Qwindow temperature=Awindow\*U\*ΔT$
* $Qwindow solar=Awindow\*CF$
* $Qroof=Aroof\*U\*ΔT$

**Requirements**

* Teams must come up with a unique team name for use in replace of “ Engineering, Inc.”
* All work must be completed by students 13-18 years of age
* Model must be generated using SketchUp ([www.sketchup.com](http://www.sketchup.com))
* Model must be original and not a copy or recreation of any other work

**Submission**

The deadline for submissions is midnight eastern standard time December 31, 2022. The finished model should be downloaded as a .skp file and uploaded along with the student’s information and a brief narrative.

Submission shall include:

* Model to show walls, windows and doors as well as HVAC equipment and ductwork.
* Narrative to include description of the process used to develop the model. Narrative to be 2-4 pages in PDF format.
* Narrative to include appendix with backup calculations used for sizing of equipment.
* Narrative can include additional appendices at the discretion of the team which are not included in the page limit.

**Judging Criteria**

* Does the model meet the building owner’s requirements?
* Were any of the additional desires of the building owner addressed?
* What level of modeling skill is demonstrated?
* How creative are the solutions to the various challenges with the building design and layout?
* Does the model represent something that can be realistically constructed?

**Timeline**

* Competition opens: July 1, 2022
* Registration deadline: November 30, 2022
* Submission deadline: January 15 , 2023
* Winners announced on March 1, 2023 and awards to be send out shortly after

**Awards**

* 1st place: $1,000, a plaque, and recognition in Insights
* 2nd place: $500, a certificate, and recognition in Insights
* 3rd place: $300, a certificate, and recognition in Insights

The ASHRAE Student Activities Committee will evaluate all entries and select the winners. Awards will be sent to applicable Student Activities RVCs (Regional Vice Chairs) to be presented at their Regional CRC (Chapters Regional Conference) or Chapter meeting.