Simulations of Respiratory Droplet Spray

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Introduction

As we experience the COVID-19 pandemic, restrictions have been implemented for the protection of society. New guidelines such as social distancing and face masks have been introduced to slow the spread of the virus. It is important to determine the effectiveness of these protocols.

First, the goal of this project is to determine the dispersion pattern of droplets, resulting from breathing, talking, coughing, and sneezing and whether the recommended social distance of 2 meters is adequate. Secondly, this project will determine the effectiveness of face masks to minimize the spreading of infectious particles.

Experimental Design

My project consisted of:
1. Creating a computational domain representative of the social distancing guidelines
2. Devise a mesh and determine the size required for grid independence
3. Simulate experimental cases to verify validity of mesh and geometry created
4. Run simulations to produce results for the unmasked cases
5. Run simulations for mask cases to determine the mass flux (and social distance) reduction

	Reynolds Number	Velocity (m/s)
Breathing	700	1
Talking	3500	5
Coughing	7000	10
Sneezing	14000	20

Results

The plots depict the decrease of velocity in particles, demonstrated by the transition from red to blue
X-axis: distance from inlet in the axial direction (2 meters)
Y-axis: distance from inlet in radial direction (0.5 meters)
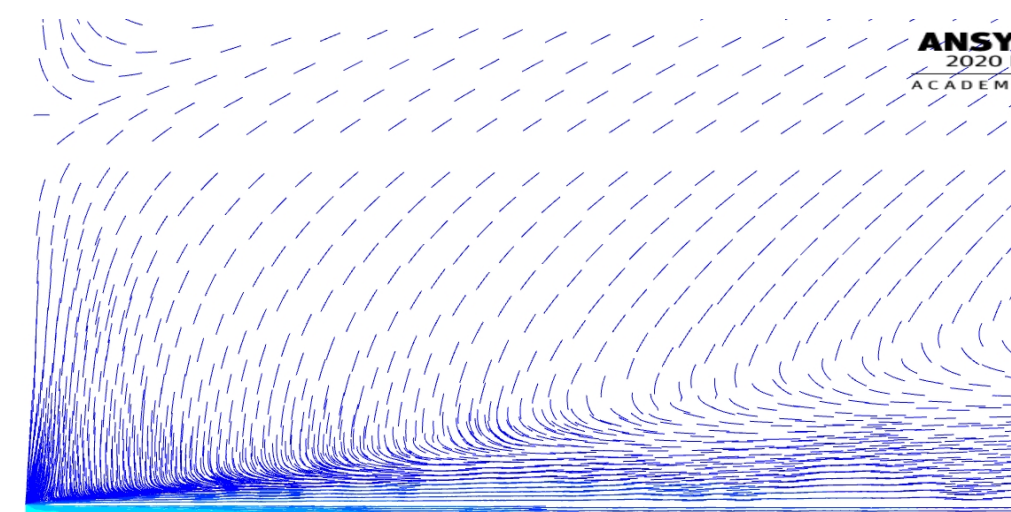
Velocity Magnitude

2.00e+01
1.80e+01
1.60e+01
1.40e+01
1.20e+01
1.00e+01
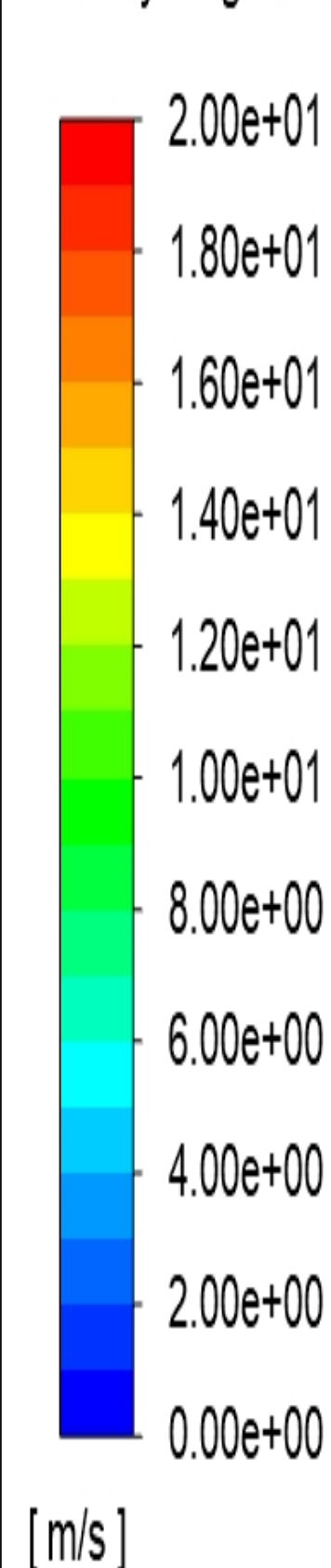8.00e+00
6.00e+00
4.00e+00
2.00e+00
0.00e+00
[m/s]

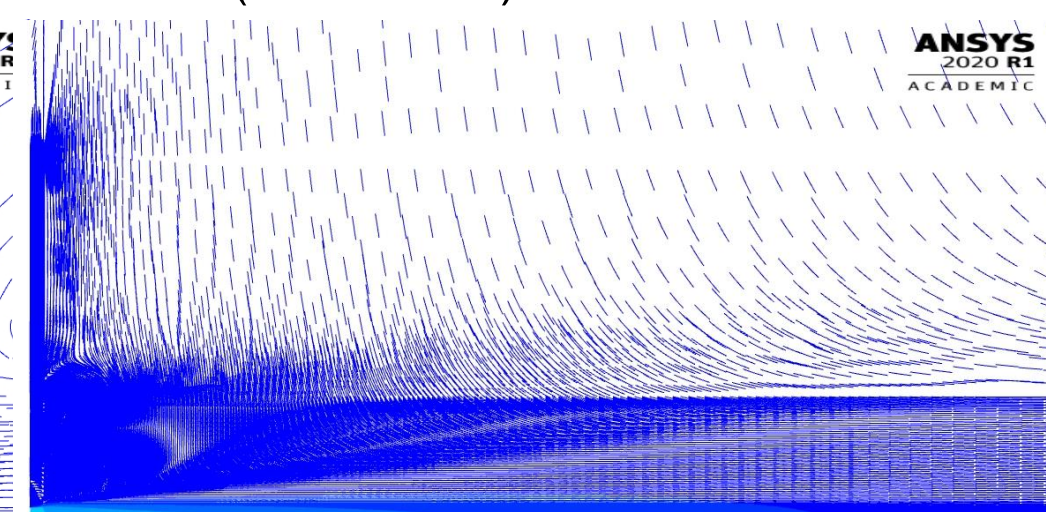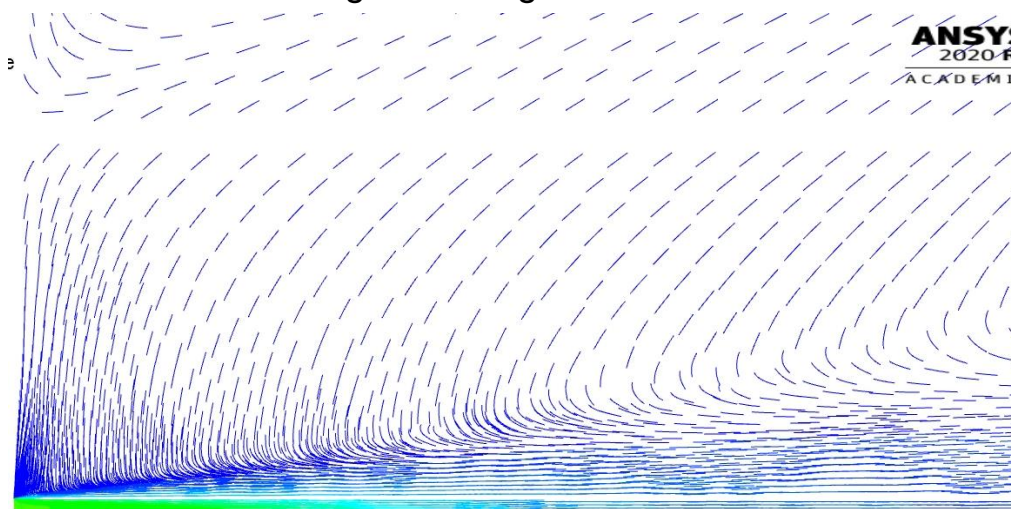Fig 1: Talking without a mask

Fig 2: Talking with a mask

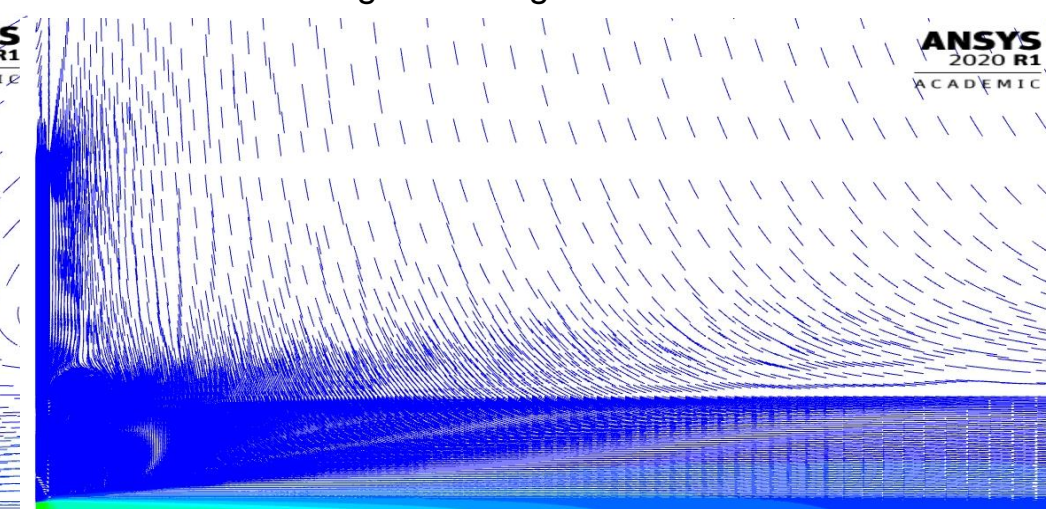Fig 3: Coughing without a mask

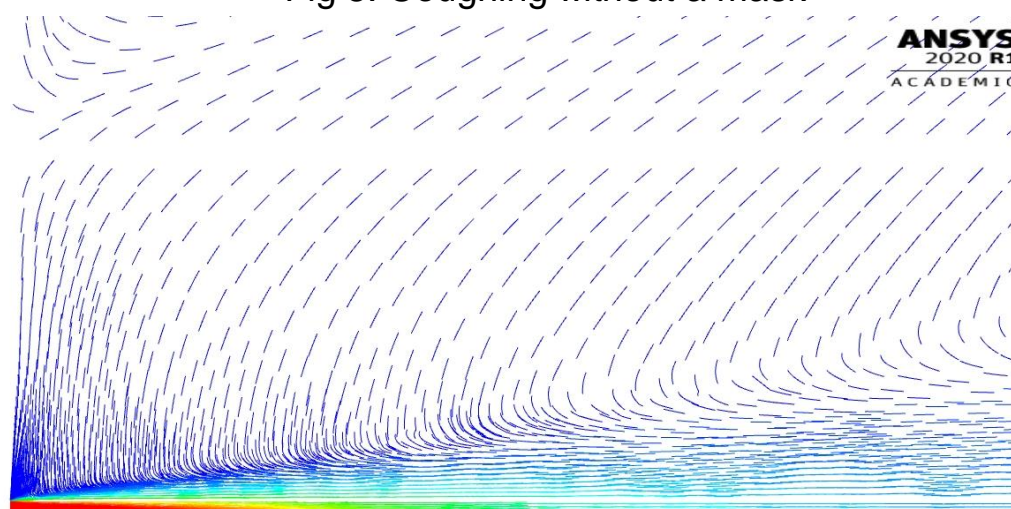Fig 4: Coughing with a mask

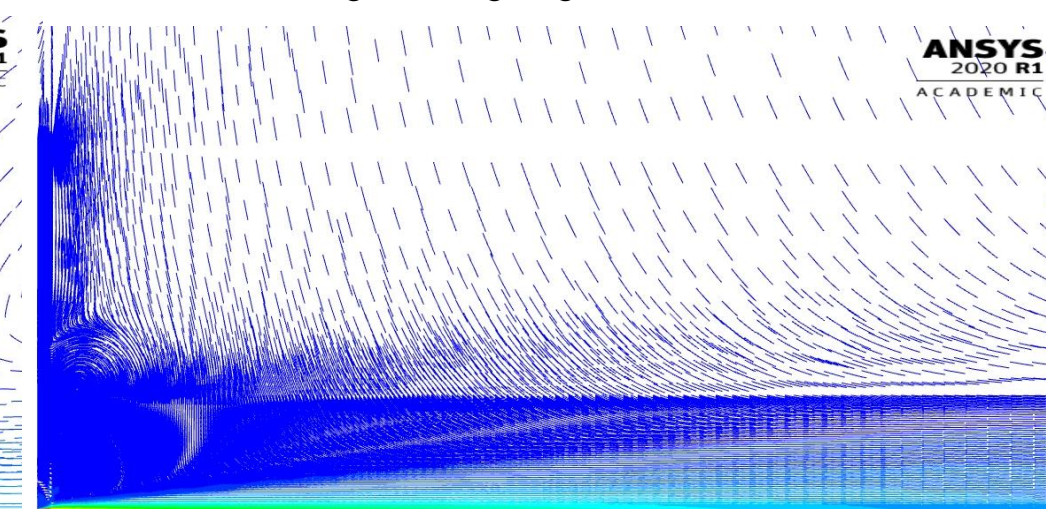Fig 5: Sneezing without a mask

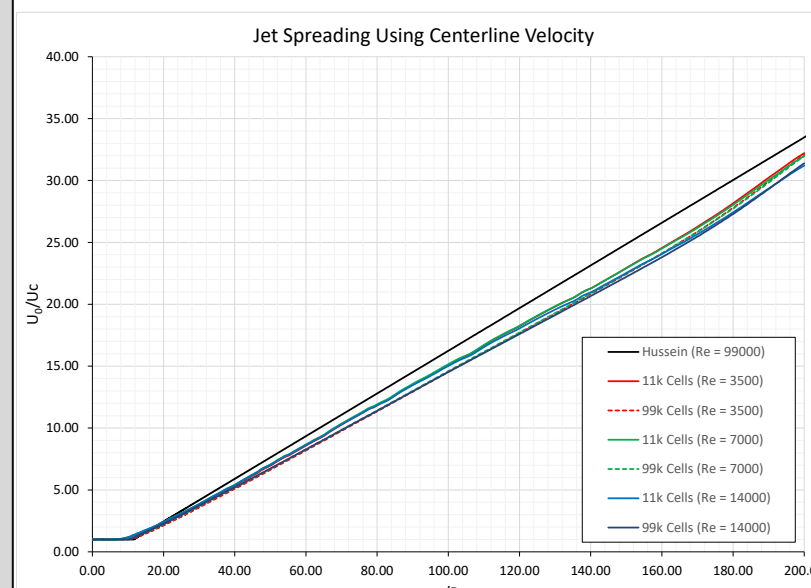Fig 6: Sneezing with a mask

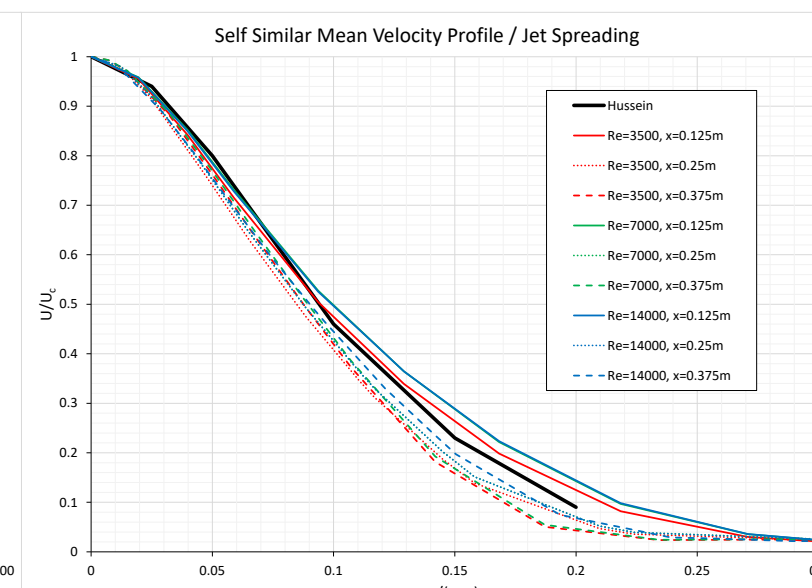Fig 7: Graph demonstrating grid independence and jet spreading

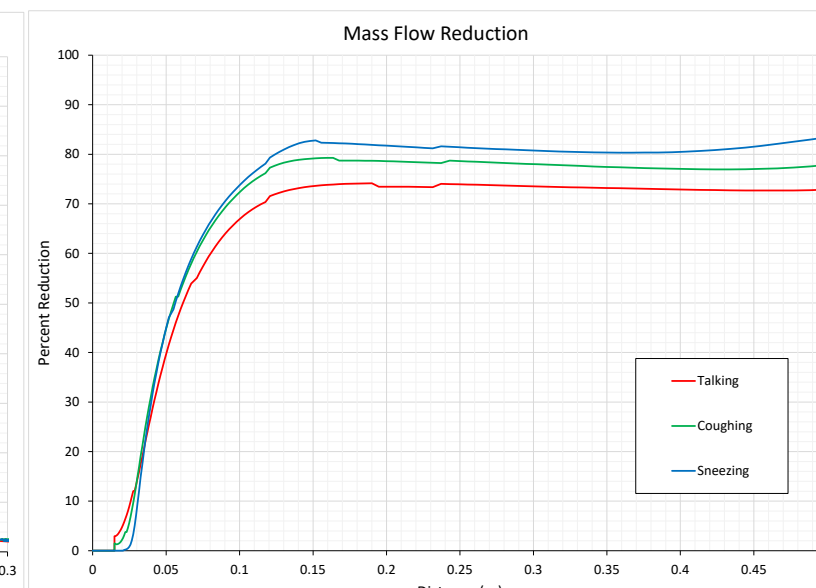Fig 8: Graph demonstrating jet spreading and self similarity

Fig 9: Effectiveness of mask in reducing flow and spread of droplets

Conclusions

From this project, I concluded:
- Breathing is a laminar flow and does not produce a high velocity compared to other methods of exhalation
- Different turbulence models, such as k-epsilon or k-omega, determine the precision of data
- Jet spreading does not depend on the mesh created
- The use of masks significantly reduces the velocity of particles emanating from the mouth by 75-80%.
- The great decrease in the velocity of particles causes air resistance to increase in importance, furthering the decrease in velocity of the particles
- Two meters is an adequate distance to minimize the spread of particles

Further Research

If I were to continue this project, I would consider more conditions, such as inside/outside, temperature, and humidity. By taking these factors into consideration, my research would produce more realistic data and results.

Acknowledgements

Hussein, H. J., Capp, S. P., & George, W. K. (1994). Velocity measurements in a high-Reynolds-number, momentum-conserving, axisymmetric, turbulent jet. *Journal of Fluid Mechanics, 258*, 31-75.