# XYZ College

Fluid Mechanics

**Drag Measurement on a Sphere**

**BEng (Hons) Mechanical Engineering**

## Aim and Objective

The aim of this activity is to gather experimental data and utilize available data to create a graphical correlation to determine the drag coefficient of a sphere at a given Reynolds number value.

- Recognize the various factors affecting an object's drag as it moves through a fluid.
- Establish assumptions and be aware of how they affect the reliability of outcomes.
- Compile experimental data using predetermined procedures.
- Conduct data analysis, manipulation, and correlation.
- Analyse, describe, and present experimental results in a concise and clear way.
- Make a recommendation for enhancing the experiment's methodology and data collection approach.

## Background theory

Many engineers have worked hard over the years to gain a thorough knowledge of drag forces, and the following empirical statement was developed and widely used:

$$F_D = \frac{1}{2} C_D p \mu^2 A$$

Here, $F_D$ = drag force, $C_D$ = drag coefficient, U = Fluid velocity, P = Fluid density, A = Projected area of the sphere ($\pi d^2/4$) And, $\frac{1}{2} p \mu^2$ =stagnation Pressure.

## Equipment

1. The wind tunnels
   It makes use of a low speed GUNT wind tunnel provided by GUNT Technologies, Germany. The tunnel may be relocated because it is mounted on castors and is intended for use by students.

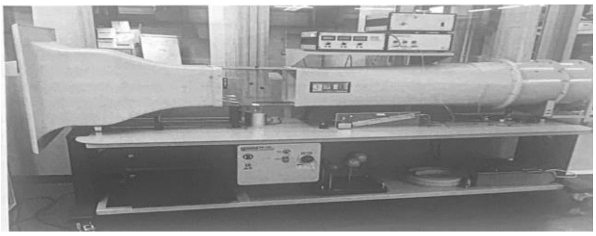

*Figure 1: GUNT Technology wind tunnel*

Air velocity measurement

In wind tunnel work, it is common practice to measure air velocity directly using tools like a pitot static tube. In order to monitor the difference in air pressure between a suitable segment of the tunnel and the atmosphere outside the tunnel, it is also typical to install an inclined tube manometer. As the wind speed rises, this discrepancy widens. This area of the GUNT wind tunnel is where four tapping locations are connected by plastic tubing at the point of the contraction's throat and by one tube to the manometer's lower end. For this tunnel, a manometer with an inclined tube has been installed. The tube's scale has been calibrated, and velocity data are collected straight from it.

Measurement of the drag force

As seen in Figure 2, the Gunt-Technology wind tunnel has a load cell. The load has the ability to gauge the pitching moment, lift force, and drag forces. In this experiment, the only factor that matters is drag. The cell load is interfaced to a display so that it can be read and to a computer so that it can be recorded. A maximum force of 4N may be measured by the load cell.

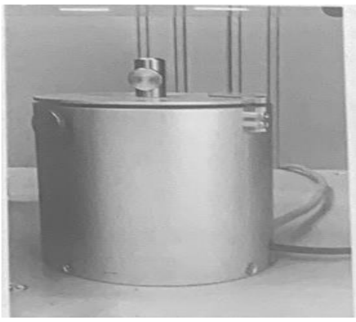

*Figure 2: load cell for measurement of drag*

2. The spheres
   The workshop produced five spheres that were completed to a satisfactory level of smoothness. They are constructed of polyethylene. To prevent surface damage, the spheres should be handled carefully. Each sphere includes a threaded aluminium insert that can be put into the carrier and is supported by a 6mm rod that can be installed on the load cell.

## Experimental Procedure

1. The tunnel's working part was opened, gently attach a sphere to the load cell, and then seal it.
2. Make sure the velocity was zero on the inclined manometer and the computer interface, and zero the load on the digital display.
3. The air velocity was increased to a desired value as indicated by the inclined manometer and the drag was recorded by clicking on the "+" sign. The force was recorded in Newtons.
4. Repeat step 3 until the sphere was able to collect enough data. The changes of the drag force with the velocity are displayed graphically on the computer.
5. Steps 2 to 4 were repeated for all the spheres.
6. The diameter of each sphere was measured using a vernier.
7. The barometric pressure and ambient temperature were measured in the lab.

## Results and data analysis

*Table 1: Observed and Calculated data*

| | $u[m/s]$ | $\frac{F_D}{\frac{1}{2}\rho u^2 A}$ | $\frac{\rho u D}{\mu}$ | $B_r$ |
|---|---|---|---|---|
| **Gold/Yellow** | 0 | 0 | 0 | 0.017154 |
| | 4 | 0.984717 | 14077.3 | 0.017154 |
| | 8.1 | 0.960553 | 28506.53 | 0.017154 |
| | 12.2 | 0.952696 | 42935.76 | 0.017154 |
| | 16.2 | 0.930536 | 57013.06 | 0.017154 |
| | 20.1 | 0.955445 | 70738.43 | 0.017154 |
| | 24.1 | 0.949436 | 84815.73 | 0.017154 |
| | 28.6 | 0.943834 | 100652.7 | 0.017154 |
| **Green** | 0 | 0 | 0 | 0.038596 |
| | 4.2 | 0.992409 | 22171.75 | 0.038596 |
| | 8 | 0.656478 | 42231.9 | 0.038596 |
| | 12 | 0.632164 | 63347.85 | 0.038596 |
| | 16.1 | 0.634841 | 84991.7 | 0.038596 |
| | 20 | 0.630219 | 105579.7 | 0.038596 |

| | | | | |
|---|---|---|---|---|
| | 24.1 | 0.614873 | 127223.6 | 0.038596 |
| | 27.9 | 0.607218 | 166921.6 | 0.038596 |
| **Purple** | 0 | 0 | 0 | 0.049575 |
| | 4.2 | 0.772636 | 22171.75 | 0.049575 |
| | 8.1 | 0.664743 | 42759.8 | 0.049575 |
| | 8.1 | 0.664743 | 42759.8 | 0.049575 |
| | 11.9 | 0.673718 | 62819.95 | 0.049575 |
| | 15.9 | 0.646935 | 83935.9 | 0.049575 |
| | 20 | 0.626948 | 105579.7 | 0.049575 |
| | 24 | 0.605747 | 126695.7 | 0.049575 |
| | 28.5 | 0.577221 | 150451.1 | 0.049575 |
| **Orange** | 0 | 0 | 0 | 0.068615 |
| | 4.2 | 0.781522 | 29562.33 | 0.068615 |
| | 7.9 | 0.599572 | 55605.33 | 0.068615 |
| | 12 | 0.588095 | 84463.8 | 0.068615 |
| | 16.1 | 0.585033 | 113322.3 | 0.068615 |
| | 20.1 | 0.584966 | 141476.9 | 0.068615 |
| | 24 | 0.570999 | 168927.6 | 0.068615 |
| | 28.2 | 0.557219 | 198489.9 | 0.068615 |
| **Baby Blue** | 0 | 0 | 0 | 0.107211 |
| | 4.6 | 0.655237 | 32377.79 | 0.107211 |
| | 8.2 | 0.618597 | 57716.93 | 0.107211 |
| | 12 | 0.595207 | 84463.8 | 0.107211 |
| | 12 | 0.612713 | 84463.8 | 0.107211 |
| | 16.1 | 0.568926 | 113322.3 | 0.107211 |
| | 20.1 | 0.458613 | 141476.9 | 0.107211 |
| | 20.1 | 0.458613 | 141476.9 | 0.107211 |
| | 23.9 | 0.39719 | 168223.7 | 0.107211 |
| | 28.2 | 0.404169 | 198489.9 | 0.107211 |

*Sample Calculations: -*

1. Gold/ yellow
   i.

$$\frac{F_D}{\frac{1}{2}\rho u^2 A} = \frac{0.02}{\frac{1}{2} * 1.293 * 4^2 * \frac{\pi}{4} * 0.05^2} = 0.984717$$

   ii.

$$B_r = \frac{\pi d^2}{4A_t} = \frac{\pi * 0.05^2}{4 * (0.292 * .392)} = 0.01754$$

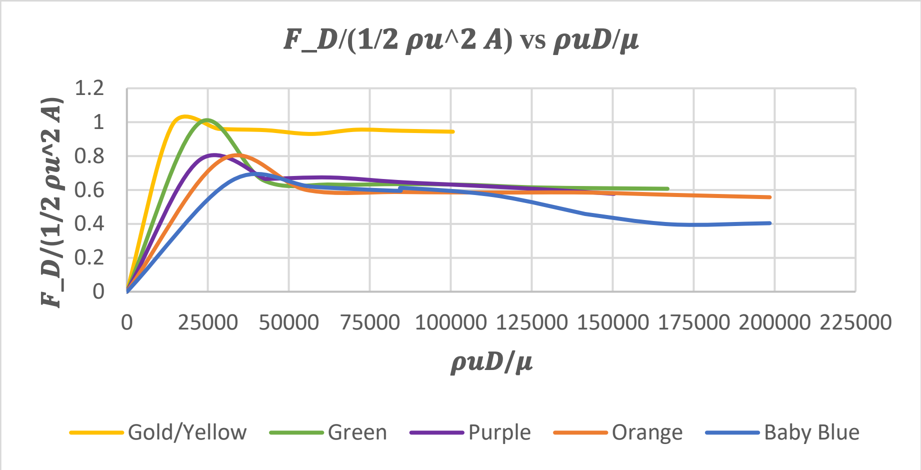


*Figure 3:* $\frac{F_D}{\frac{1}{2}\rho u^2 A}$ $vs \frac{\rho u D}{\mu}$

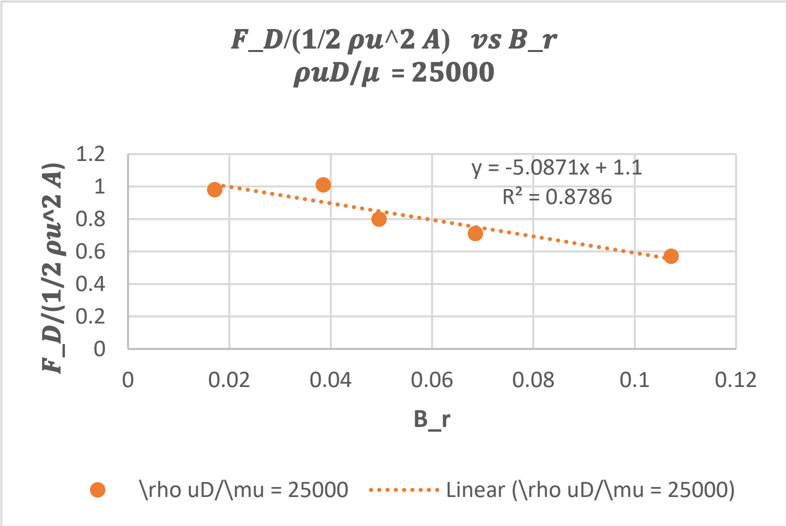


*Figure 4:* $\frac{F_D}{\frac{1}{2}\rho u^2 A}$ $vs\ B_r at \frac{\rho u D}{\mu} = 25000$

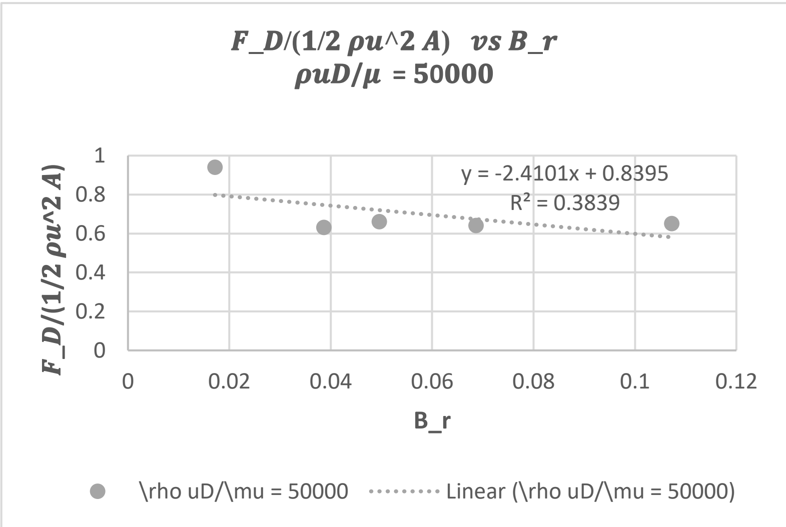

*Figure 5:* $\frac{F_D}{\frac{1}{2}\rho u^2 A}$ *vs* $B_r$ *at* $\frac{\rho u D}{\mu} = 37500$

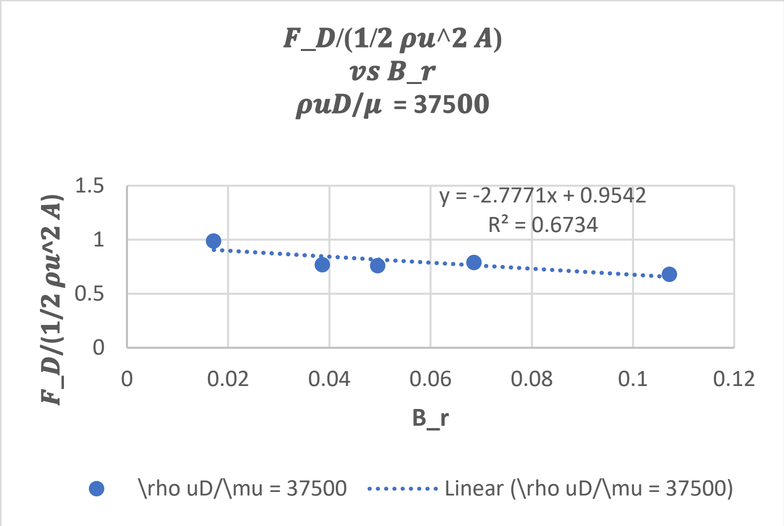


*Figure 6:* $\frac{F_D}{\frac{1}{2}\rho u^2 A}$ *vs* $B_r$ *at* $\frac{\rho u D}{\mu} = 50000$

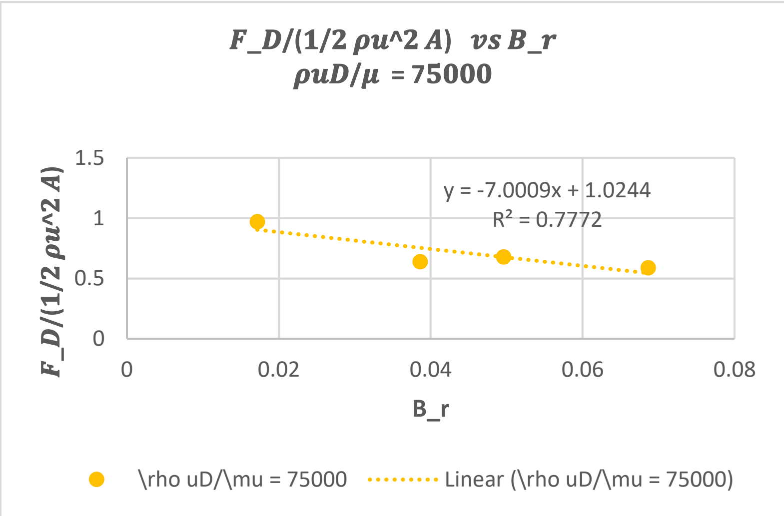


*Figure 7:* $\frac{F_D}{\frac{1}{2}\rho u^2 A}$ *vs* $B_r$ *at* $\frac{\rho u D}{\mu} = 75000$

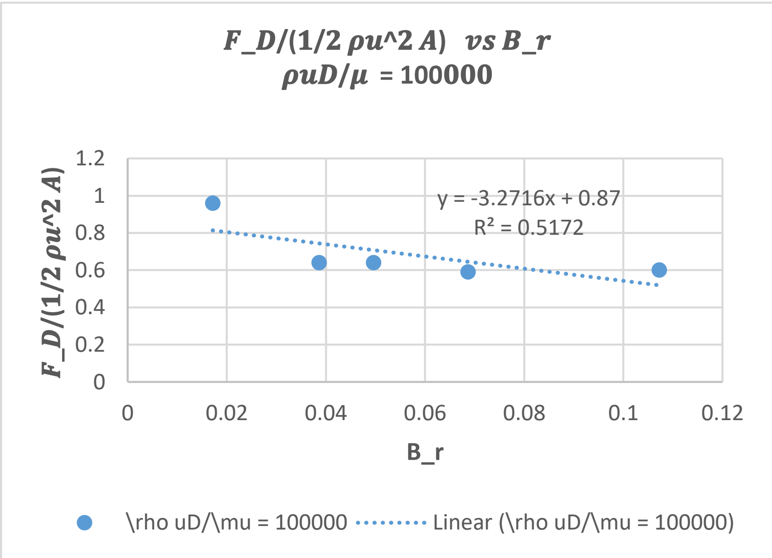

*Figure 8:* $\frac{F_D}{\frac{1}{2}\rho u^2 A}$ $vs\ B_r\ at\ \frac{\rho u D}{\mu} = 100000$

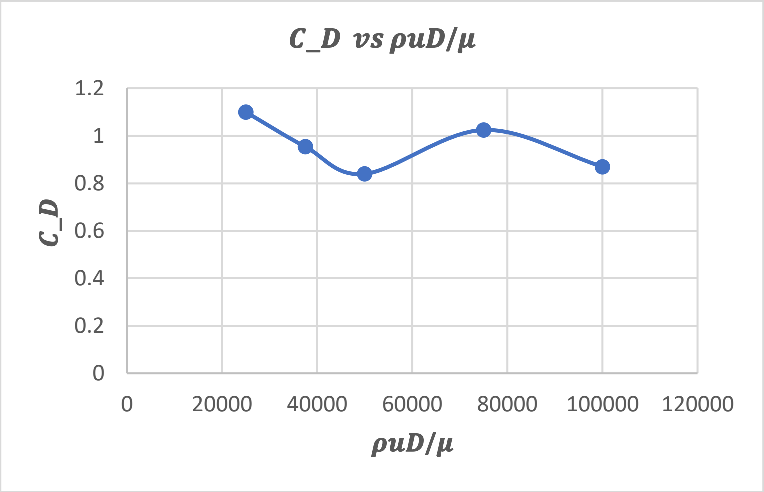


*Figure 9:* $C_D\ \ vs \frac{\rho u D}{\mu}$

## Discussion

Drag coefficient depends upon the $\frac{\rho u d}{\mu}, \frac{\epsilon}{d}$ $and$ $\frac{\pi d^2}{4A_t}$ but an assumption was made that drag coefficient depends upon the $\frac{\rho u d}{\mu}$ $and$ $\frac{\pi d^2}{4A_t}$. Mechanical smooth surface of the spheres was used to analysis with this assumption. Smooth surface of the spheres validated this assumption and gave approximately accurate result. Experiment procedure of this experiment is reliable at small variations of experiment condition. Graph 9 shows the graphical correlation between drag coefficient of sphere and Reynolds no. It is used to obtain the drag coefficient of sphere at a given value of Reynolds number.

## Conclusion

This experiment's major goal was to collect experimental data and use the available data to build a graphical correlation that would show how much drag a sphere would experience at a certain Reynolds number. The experiment's objective was successfully accomplished by establishing a connection between the sphere's drag coefficient and Reynolds number. During the experiment, there were both measurement and human errors.

## Recommendations

The diameter of the spheres must be precisely measured in order to prevent mistake in the experiment's results. It should be handled gently to prevent harm to the spheres' smooth surface.

## References

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