Lab 8 Formal Report Format/Checklist:

Header: (5 points) 5/5
- ✓ Names
- ✓ Date
- ✓ Lab #

Abstract: (20 points): 20/20

Remember it is a summary, not an introduction. The abstract should not say anything that is not stated elsewhere in the report.

In the abstract answer the questions in paragraph form:
- ✓ What was your percent difference in Part 1? Which value was larger, V_{ball} or V_{water}?4/4
- ✓ What was you percent difference in Part 2? Which value was larger, F_B or $F_{g\ water}$?4/4
- ✓ What was your percent error for Part 3? Which value was larger the expected value or your experimental value for water density?4/4
- ✓ What was your percent error for Part 4? Which value was larger the expected value or your experimental value for isopropyl alcohol density?4/4
- ✓ Briefly state a couple prominent errors/uncertainties you encountered in the experiment that might explain these discrepancies but do not elaborate here, you will do that in the discussion. These should be the errors/uncertainties that caused the most error/uncertainty (largest discrepancy between expected and experimental values) or the errors/uncertainties that effected the most measurements (most repeated errors/uncertainties). 4/4

Introduction: (5 points): 5/5

Summarize the physics theories explored by this lab: briefly summarize Archimedes Principle. The easiest way to do this by reviewing the introduction on the lab instructions and summarizing it in your own words. Here are a couple questions to guide you:
- ✓ What is the volume relationship between an object and the fluid displaced by the object? *An object displaces the same volume of fluid as there is volume of the object submerged in the fluid.* 2.5/2.5
- ✓ What is buoyancy force and how does it relate to the above concept? *Buoyancy force is the upward force exerted by the fluid on an object and is equal to the weight of the fluid displaced by the object times gravity.*2.5/2.5

Methods: (20 points): 20/20

Describe what you did without plagiarizing the instructions and with enough detail that a knowledgeable person could figure it out. No bullet points.
- ✓ Summarize the methods for Part 1 and mention: 5/5
  - How you used calipers to find diameter then used $\frac{4}{3}\pi r^3$ to calculate V_{ball}
  - How you found V_{water} experimentally
  - How you calculated % Difference Part 1 = $\frac{|V\ ball - V\ water|}{Average\ of\ V\ ball\ and\ V\ water} * 100$
- ✓ Summarize the methods for Part 2 and mention: 5/5
  - $F_B = W_{in\ air} - W_{in\ water}$
  - $m_{water} = m_{with\ water} - m_{without\ water}$
  - $F_{g\ water} = m_{water} * 9.8\ m/s^2$
  - How you calculated % Difference Part 2 = $\frac{|F_{g\ water} - F_B|}{Average\ of\ F_{g\ water}\ and\ F_B} * 100$

✓ Summarize the methods for Parts 3 and 4 and mention: 10/10
- You recorded the weight of the wood block in air for F_g
- You recorded the force exerted on the force sensor, F_T, as you lowered the block to each d, depth ***(in meters!)***
- You found buoyancy force, F_B, exerted on the block by the displaced water using:
  - $F_B = F_g - F_T$
- You graphed F_B *vs d* for which the slope was $\frac{F_B}{d}$, knowing that $F_B = \rho_{fluid} * V_{displaced} * g = \rho_{fluid} * A_{cross-sectional} * d * g$ so the slope, $\frac{F_B}{d}$, was equal to $\rho_{fluid} * A_{cross\ sectional} * g$. You then measured the cross-sectional area of the block using calipers (for a cylindrical block A = πr^2 for a rectangular block A = *l* * *w*, ***remember this should be in meters!***) and divided the slope by the cross-sectional area in meters and gravity to find ρ_{fluid} for water in part 3 and isopropyl alcohol in part 4 such that $\rho_{fluid} = \frac{slope\ of\ F_B\ vs\ d}{A_{cross-sectional} * g}$.
- $\%\ Error = \frac{|Theoretical - Experimental|}{Theoretical} * 100$

Results: (25 points): 25/25

✓ Table 1 (for part 1)-labeled and captioned with units 3/3

Table 1: Volume of a metal ball calculated by measuring the diameter (V_{ball}) and measured by collecting the volume of water displaced by ball (V_{water}).

Ball diameter (cm)	3.811
V_{ball} (cm^3)	29.0
V_{water} (ml)	29.0
% Difference	0

✓ Table 2 (for part2)- labeled and captioned with units 4/4

Table 2: Buoyancy force computed by differencing weight of ball in air and weight of ball in water (F_B) and by calculating the weight of the water displaced by the ball in Part 1 ($F_{g\ water}$).

$W_{in\ air}$ (N)	$W_{in\ water}$ (N)	F_B (N)	$m_{without\ water}$ (g)	$m_{with\ water}$ (g)	m_{water} (kg)	$F_{g\ water}$ (N)	% Difference
2.39	2.12	0.27	40.64	69.13	28.49	0.27	0

✓ Table 3a (for water)-labeled and captioned with units 3/3

Table 3a: Depth, weight of block in air, force of tension on force sensor, and buoyancy force for a wooden block submerged in water.

depth (m)	F_g (N)	F_T (N)	F_B (N)
0	1.2	1.2	0
0.01	1.2	0.96	0.24
0.02	1.2	0.84	0.36
0.03	1.2	0.68	0.52
0.04	1.2	0.44	0.76

0.05	1.2	0.32	0.88
0.06	1.2	0.265	0.935
0.07	1.2	0.135	1.065

✓ Table 3b (for water)- labeled and captioned with units 3/3

- Note: Expected $\rho_{water} = 1000\ kg/m^3$

Table 3b: Slope of Figure 1, experimental density of water calculated from slope of Figure 1, theoretical density of water, and % error of experimental density of water and theoretical density of water.

Slope of F_B vs d for Water (N/m)	15.155
Density of water (kg/m^3)	941.19
Expected density of water (kg/m^3)	1000
% Error	5.90%

✓ Table 4a (identical to table 3 but for alcohol)-labeled and captioned with units 3/3

Table 4a: Depth, weight of block in air, force of tension on force sensor, and buoyancy force for a wooden block submerged in isopropyl alcohol.

depth (m)	F_g (N)	F_T (N)	F_B (N)
0	1.21	1.21	0
0.01	1.21	0.985	0.225
0.02	1.21	0.88	0.33
0.03	1.21	0.72	0.49
0.04	1.21	0.645	0.565
0.05	1.21	0.53	0.68
0.06	1.21	0.395	0.815
0.07	1.21	0.24	0.97
0.08	1.21	0.08	1.13

✓ Table 4b (identical to table 4 but for alcohol)- labeled and captioned with units 3/3

- Note: Expected $\rho_{isopropyl\ alcohol} = 786\ kg/m^3$

Table 4b: Slope of Figure 2, experimental density of isopropyl alcohol calculated from slope of Figure 2, theoretical density of isopropyl alcohol, and % error of experimental density of isopropyl alcohol and theoretical density of isopropyl alcohol.

Slope of F_B vs d for Water (N/m)	13.192
Density of water (kg/m^3)	819.28
Expected density of water (kg/m^3)	786
% Error	4.20%

- ✓ Graph 1 3/3
  - labeled and captioned
  - axes have titles and units
  - graph is titled (F_B vs d for Water)
  - Trendline is displayed on graph

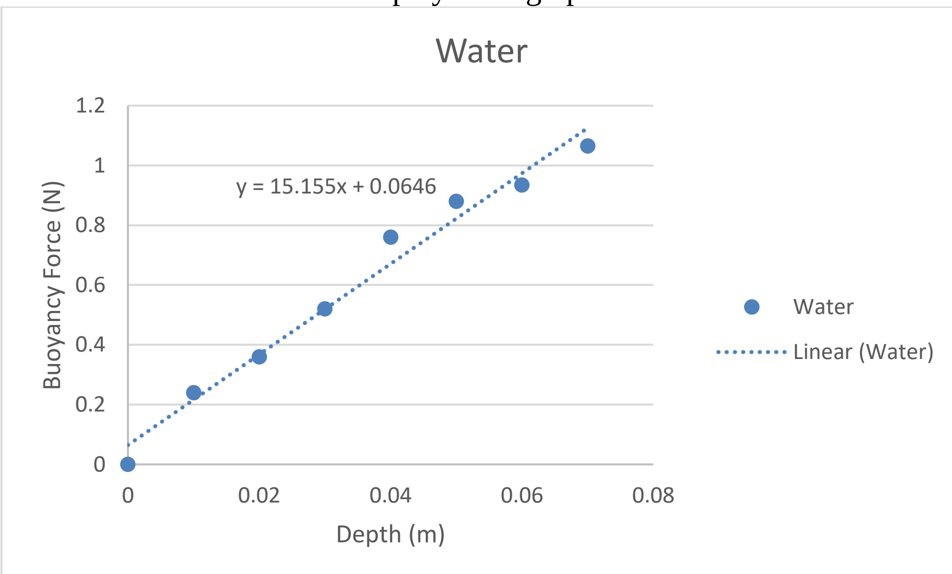

Figure 1: Graph of F_B vs d for water.

- ✓ Graph 2 3/3
  - labeled and captioned
  - axes have titles and units
  - graph is titled (F_B vs d for Isopropyl Alcohol)
  - Trendline is displayed on graph

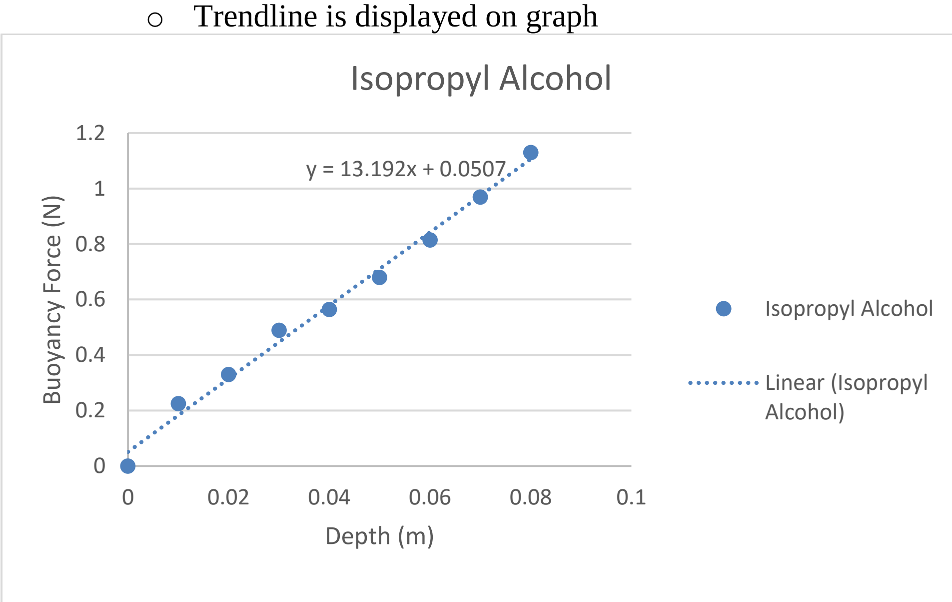

Figure 2: Graph of F_B vs d for isopropyl alcohol.

Discussion: (20 points): 20/20
This is the most important part of the formal report. This is where you explain your results.

- ✓ What was your percent difference in Part 1? Which value was larger? V_{ball} or V_{water}? Why do you think this was the case (possible uncertainties/experimental errors)? Your stated errors should follow logically and be both descriptive and specific. 5/5
  - *State which is larger V_{ball} or V_{water}*
  - *State % difference*
  - *V_{water} is larger than V_{ball}: Perhaps your fingers and the eye bolt were slightly submerged causing extra water to flow into your graduated cylinder and that resulted in an inflated collected volume of water. Perhaps the problem was not with the water collection at all, perhaps the diameter you got from the calipers wasn't the diameter. Perhaps the cross-section wasn't at the exactly the center of the sphere so you measured the diameter not of the "great circle" but a lesser circle. A smaller diameter than the actual diameter would make the volume of your sphere (V_{ball}) smaller.*
  - *V_{water} is smaller than V_{ball}: Maybe there were air bubbles trapped in the spout or the container wasn't filled enough so the spout was empty in the case of a much larger V_{ball} than V_{water}. Perhaps you were conservative and held part of the ball out of the water so it was never fully submerged.*
- ✓ What was your percent difference in Part 2? Which value was larger? F_B or $F_{g\ water}$? Why do you think this was the case (possible uncertainties/experimental errors)? Your stated errors should follow logically and be both descriptive and specific. 5/5
  - *State which is larger F_B or $F_{g\ water}$*
  - *State % difference*
  - *F_B smaller than F_{gwater}: If you did not tare your force sensor as instructed F_B is going to be smaller than it should be but other reasons F_B could be smaller if you did tare would be submerging more than just the ball (submerging eye bolt) while the ball was hanging from the force sensor or perhaps the outside of your graduated cylinder was wet when you weighed $m_{with\ water}$ (weight was heavier than a graduated cylinder with a dry outside) and then you shook off some of the external water when you weighed $m_{without\ water}$ (weight of graduated cylinder is lighter than it was now that some of the external water is gone) so m_{water} is falsely inflated.*
  - *F_B larger than F_{gwater}: If $F_{g\ water}$ was smaller, perhaps the reasons from Part 1 that led to a smaller volume of water to be collected are to blame (air bubbles in spout or ball not fully submerged) or perhaps the opposite happened with your graduated cylinder. Perhaps your graduated cylinder was pretty dry on the outside but you just dumped out your water instead of shaking it out to effectively dry the inside so now you have a falsely smaller value for m_{water} because the $m_{without\ water}$ is inflated by water remaining inside the graduated cylinder.*
- ✓ What was your percent error for Part 3? Which value was larger the expected value or your experimental value for water density? Why do you think this was the case (possible uncertainties/experimental errors)? Your stated errors should follow logically and be both descriptive and specific. 5/5
  - *State which is larger theoretical or experimental*
  - *State % error*
  - *State Reasoning:*
    - *If experimental ρ_{water} is larger: There could be impurities dissolved in the water that increase the density of the water, F_B was larger than it should have been, depth was smaller than it should have been, or the cross-sectional area that you measured was smaller than it should have been.*
      - *F_B larger than it should have been: block submerged more than a full centimeter deeper each time but an interval of 1cm was recorded each*

time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid.

- *Depth smaller than it should have been: block submerged less than a full centimeter deeper each time but an interval of 1cm was recorded each time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid.*
- *$A_{cross\text{-}section}$ was smaller than it should have been: maybe when it was wet you were able to sink the calipers into the wood when taking the measurement. For a cylindrical block, not measuring exactly at the center would also decrease the radius and thus the cross-sectional area.*

▪ *If experimental ρ_{water} is smaller: There could be impurities dissolved in the water that are less dense than water, F_B was smaller than it should have been, depth was larger than it should have been, or the cross-sectional area that you measured was larger than it should have been.*

- *F_B smaller than it should have been: block submerged less than a full centimeter deeper each time but an interval of 1cm was recorded each time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid.*
- *Depth larger than it should have been: block submerged more than a full centimeter deeper each time but an interval of 1cm was recorded each time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid.*
- *$A_{cross\text{-}section}$ was larger than it should have been: maybe when it was wet it swelled and you were gentle with calipers being sure to not allow them to sink into the wood at all when taking the measurement or perhaps you took the measurements of a rectangular block on a slight diagonal rather than straight across.*

✓ What was your percent error for Part 4? Which value was larger the expected value or your experimental value for isopropyl alcohol density? Why do you think this was the case (possible uncertainties/experimental errors)? Your stated errors should follow logically and be both descriptive and specific. 5/5

✓

- *State which is larger theoretical or experimental*
- *State % error*
- *State Reasoning:*

▪ *If experimental $\rho_{alcohol}$ is larger: There could be impurities dissolved in the alcohol that increase the density of the alcohol or your slope was inflated because F_B was larger than it should have been or depth was smaller than it should have been.*

- *F_B larger than it should have been: block submerged more than a full centimeter deeper each time but an interval of 1cm was recorded each time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid.*
- *Depth smaller than it should have been: block submerged less than a full centimeter deeper each time but an interval of 1cm was recorded each time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid. Maybe you had a hard time seeing the lines with respect to the level of the fluid.*

        - *$A_{cross\text{-}section}$ was smaller than it should have been: maybe when it was wet you were able to sink the calipers into the wood when taking the measurement. For a cylindrical block, not measuring exactly at the center would also decrease the radius and thus the cross-sectional area.*
    - *If experimental $\rho_{alcohol}$ is smaller*: There could be impurities dissolved in the alcohol that are less dense than the alcohol, F_B was smaller than it should have been, depth was larger than it should have been, or the cross-sectional area that you measured was larger than it should have been.*
    - **Not very likely!*
        - *F_B smaller than it should have been: block submerged less than a full centimeter deeper each time but an interval of 1cm was recorded each time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid.*
        - *Depth larger than it should have been: block submerged more than a full centimeter deeper each time but an interval of 1cm was recorded each time anyway. Maybe you had a hard time seeing the lines with respect to the level of the fluid.*
        - *$A_{cross\text{-}section}$ was larger than it should have been: maybe when it was wet it swelled and you were gentle with calipers being sure to not allow them to sink into the wood at all when taking the measurement or perhaps you took the measurements of a rectangular block on a slight diagonal rather than straight across.*

Conclusion: (5 points): 5/5
A sentence or two that summarizes the scientific results (not the skills gained). For example, you might compare the results of your data analysis with the expected values to say whether your results support or appear to contradict the theory. The theories we test are well-established, so if the theory is contradicted, you should mention how the errors may have brought about these differences.

If you had small % differences (and most of you did), it is safe to say that your results reflected the assertion made by Archimedes Principle, that buoyancy force is equal to the mass of a fluid displaced by an object. If you had high % differences (over 25%) you probably were not taring after each measurement and were overall careless in the execution of the experiment.

PDF Format