Uncertainty calculation
Archimedes' Principle

Part 1-Force or Weight Method (which uses $F_b = F_{bouyant} = F_{air} - F_{water}$)

While the measuring device is probably a triple beam balance with a resolution of $0.1g$ and an uncertainty of $\pm 0.05g$ (i.e., 1/2 of readability), other sources of error (e.g., string mass in particular when the string is wet) preclude using the uncertainty of balance. **Since the actual uncertainty is probably greater than uncertainty of balance, it is recommended that you use either the readability of balance (i.e., 0.1 g) or 0.5 g.** *You should explicitly note in your sample calculations which uncertainty you used.*

$$F_B \pm \delta F_B \Rightarrow F_{air} \pm \delta F_{air} - F_{water} \pm \delta F_{water} ,$$

where $\delta F_{air} = \delta F_{water} = \pm$__________$kg \times 9.8000 m/s^2 = \pm$____________$N$.

Add uncertainties (i.e., δF_{air} and δF_{water}) in quadrature to get δF_B.

Part 2- Displacement Method (You only have to **perform this calculation once** since all 3 objects will have the same uncertainty!)

Please note that in this part of the experiment you measured volume, which is converted to mass and then to force (i.e., weight of displaced water = buoyant force = $F_B = \rho_w g V_{disp}$).

We are using a graduated cylinder with 1 ml markings, the uncertainty (**because of the meniscus effect**) δV is 1 ml,

or $\pm \delta V = \pm 1 ml = \pm$_________$m^3$.

The displaced volume, V_{disp}, is given by the difference between the **final reading** and **initial reading** of the level of the water **and thus the uncertainty in volume,** δV_{disp} **is obtained by adding uncertainties (i.e.,** $\delta V_{initial}$ **and** δV_{final}**) in quadrature.**

If we assume uncertainties in density of water ρ_w and acceleration of gravity g are negligible we see

$$\delta F_B = \delta(\rho_w g V_{disp}) = \rho_w g \delta V_{disp}$$

Part 3-Buoyant Force Equation

In this part of the experiment buoyant force F_B is given by $F_B = \rho g V_{disp}$ where $V_{disp} = \pi r^2 h$ (since the cylindrical metal objects sink). **We shall assume the uncertainties in the acceleration of gravity g and density of water ρ are ignorable.** The uncertainty of buoyant force using the equation, F_{B_Eq}, is

$$\delta F_{B\_Eq} = \delta(\rho g V_{disp}) = \rho g \delta V_{disp} ,$$

where the fractional uncertainty in volume displaced is given by

$$\frac{\delta V_{disp}}{V_{disp}} = \sqrt{\left(\frac{\delta h}{h}\right)^2 + \left(2\frac{\delta r}{r}\right)^2} \quad , \quad \text{where}$$

δh = uncertainty of caliper or ruler (which ever was used) and
δr = uncertainty of caliper or ruler (which ever was used)