Data Sheet 3 Group member names:

____________________ ____________________

____________________ ____________________

Mass of 750mL beaker: ________________________________grams

Amount of Karo and water in mixture: **Beaker ________ (A, B, C, D, or E)**

Karo ______________mL
Water ______________mL

Letter of Sphere: _______________ (V, W, X, Y, Z)

1. Measure the diameter of the sphere using the caliper (mm). Convert this to centimeters.

Diameter ______________cm
Radius ______________cm

2. Mass the beaker containing the Karo and water mixture: ______________g

3. Measure the distance between the beginning reference point and the ending reference point that were marked on the beaker: ______________cm

4. Record the time that the sphere takes to "fall" using the reference points. If the sphere bounces of the side of the beaker, rerun the trial. Remove each sphere using the spoon before running the next trial to ensure that the volume does not appear to be increasing.

Trial #	Time (seconds)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

5. Calculate the velocity for each of the ten trials. Velocity = distance/time.

Distance, cm (from step #3)	Time, s (from step #4)	Velocity cm/s

6. Average the ten velocities in step #5.

7. Calculate the density of the sphere.

   Density = mass/volume

   Mass of the sphere ____________g.
   (It may be necessary to mass a number of spheres and divide by total mass by the number of spheres to find the mass of one sphere.)

   Volume ____________ cm^3
   (Volume of a sphere is $\frac{4}{3} \times \pi \times r^3$)

   Density =

8. Calculate the density of the mixture.

   Mass of the mixture and the beaker ____________g
   Mass of the beaker ____________g

   Mass of the mixture ____________g
   (Subtract the mass of the beaker from the mass of the mixture and the beaker.)

   Volume ____________mL
   Record the amount of the mixture in the beaker.

   Density =

9. Calculate the viscosity of the Karo and water mixture. Viscosity is a measure of the resistance of a fluid, or how easily a fluid flows. A fluid with a high viscosity will move slowly, while a fluid with a low viscosity will flow quickly.

   Dynamic viscosity = $\eta = \frac{2(\Delta p)ga^2}{9v}$

Δp = difference in density between the sphere and the liquid (g/cm^3 or g/mL)
g = acceleration of gravity (convert to cm/s^2)
a = radius of the sphere (cm)
v = velocity of the sphere

The unit of dynamic viscosity is $\frac{g}{cm \cdot s}$.

Do you think the dynamic viscosity of Karo is higher or lower than the calculated viscosity? Why? How does the viscosity of water compare to the viscosity that was calculated?

Day 2

Based on the class results, which mixture had the highest viscosity? Why?

Tank #___: ____________mL Karo + ____________mL water

Length (cm)	Time (seconds)	Velocity (cm/s)

Average velocity: ____________cm/s

The Reynolds Number is a dimensionless number that is used to describe the smoothness of fluid flow. Reynolds Number is useful because it allows researchers or designers to use a model that is scaled down or up instead of the actual sized object. When scaling objects up or down, designers must consider the conditions of the object as well as the actual dimensions of the object. The Reynolds Number allows a researcher to simulate the forces on the object in a realistic manner using "dynamic similarity".

If an object is increased or decreased by a scale factor, the Reynolds Number must be calculated to create an accurate model.

For instance, a person swimming in a pool has a Reynolds Number of approximately 10^4. If a wind-up toy were used in an aquarium to model the man in the pool, the

Reynolds Number would have to be approximately 10^4. This may require changing the viscosity of the liquid in the aquarium.

In *Honey, We Shrunk Ourselves*, the coffee in the coffee cup that was shrunk would be very thick (near a solid) if the Reynolds Number was not considered.

When airplane designers test models, scaled versions of the wings and plane are used. In order for the real plane to fly similarly to the model, the designers must use the Reynolds Number on the model that real planes encounter in the air.

Measure the length of the wind-up toy: ________________cm

Calculate the Reynolds Number (Re).

1. Find the dynamic viscosity using the kinematic viscosity.

Kinematic viscosity = dynamic viscosity/density

Use the dynamic viscosity calculated in step #9 and the density calculated in step #8.

Kinematic viscosity = ________________cm^2/s

2. Using the velocity and length of the wind-up toy and the kinematic viscosity for the Karo + water mixture, calculate the Reynolds Number.

$$Re = \frac{\mu L}{v}$$

μ = velocity (cm/s)
L = length of the wind up-toy (cm)
v = kinematic viscosity (cm^2/s)

Notice, the units cancel and Re is dimensionless.