

Name:

Date:

Class:

Viscosity Activity Worksheet **Answers**

1. Describe the fluid you are working with using every day descriptive vocabulary. (For example: "I am looking at honey. It is yellow(ish) and clear(ish). It is pretty thick and moves slowly. It feels sticky.")

Answers to questions 1-6 will vary, depending on the fluids and equipment used.

2. Calculate the density of the fluid using these steps:

- Weigh the empty graduated cylinder. Record its mass in grams.

$$M_{\text{cylinder}} = \underline{\hspace{2cm}} \text{ [g]}$$

- Fill the cylinder with fluid, and record the volume in cm^3 . Note: $1 \text{ cm}^3 = 1 \text{ ml}$.

$$\text{Vol}_{\text{fluid}} = \underline{\hspace{2cm}} \text{ [cm}^3\text{]}$$

- Weigh the full graduated cylinder. Subtract the mass of the empty graduated cylinder and record the mass of the fluid.

$$M_{\text{fluid}} = \underline{\hspace{2cm}} \text{ [g]}$$

- The density of the fluid is the mass over the volume. Calculate the density of the fluid.

$$\rho_f = \frac{\text{Mass of Fluid [g]}}{\text{Volume of Fluid [cm}^3\text{]}}$$

$$\rho_f = \underline{\hspace{2cm}} \text{ [g/cm}^3\text{]}$$

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3. Measure the density of the sphere using these steps:

- Measure the radius of the sphere. Record as r [cm].

$$r_s = \text{_____} [\text{cm}]$$

- Calculate the volume of the sphere. Either use the equation:
$$Vol_s = \frac{4}{3}\pi r^3$$
or place the sphere in a graduated cylinder filled with water and record its displacement.

$$Vol_s = \text{_____} [\text{cm}^3]$$

- Weigh the sphere. Record its mass.

$$M_s = \text{_____} [\text{g}]$$

- Calculate the density of the sphere by dividing its mass by its volume.

$$\rho_s = \frac{\text{Mass of Sphere} [\text{g}]}{\text{Volume of Sphere} [\text{cm}^3]}$$

$$\rho_s = \text{_____} [\text{g/cm}^3]$$

4. Measure the terminal velocity of the sphere falling through the fluid using these steps:

- With your stopwatch ready, drop the ball into the fluid.

If the fluid is not very viscous, the ball will fall through it very fast, *so be ready!*

If the fluid is thick enough, then the ball will reach a constant speed.

This is the *terminal velocity*, the point at which the drag on the sphere by the fluid is equal to the force of gravity.

- Measure how fast the ball falls a distance. Record the distance, and the time.

$$\text{distance} = \text{_____} [\text{cm}]$$

$$\text{time} = \text{_____} [\text{s}]$$

- Calculate the velocity, which is the distance divided by the time.

$$V_s = \text{_____} [\text{cm/s}]$$

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5. Using this equation, derived from Stokes' law, calculate the viscosity of your fluid. Gravity is 981 cm/s^2 . Be very careful to show your units and how they cancel out. Your final answer should be in units of $[\text{g}/(\text{cm s})]$.

$$\mu = \left(\frac{2}{9}\right) * \frac{r^2 * g(\rho_s - \rho_f)}{V_s}$$

$\mu =$ _____ $[\text{g}/(\text{cm s})]$

6. Viscosities are usually recorded in $[\text{Pa s}]$. To convert from $[\text{g}/(\text{cm s})]$ to $[\text{Pa s}]$, simply divide by 10:

$$1 [\text{Pa S}] = 1 \left[\frac{\text{kg}}{\text{m s}} \right] = 1 \left[\frac{1000 \text{ g}}{100 \text{ cm s}} \right] = 10 \left[\frac{\text{g}}{\text{cm s}} \right]$$

$\mu =$ _____ $[\text{Pa s}]$

7. Using the internet, look up the viscosities of some common household fluids. Be sure to include units. Do any of the answers surprise you?

Fluid	Viscosity
Example: blood	3×10^{-3} to $4 \times 10^{-3} [\text{Pa S}]$
SAE 30 motor oil	0.25 to 0.5 $[\text{Pa S}]$
maple syrup	0.15 to 0.2 $[\text{Pa S}]$
milk	2×10^{-3} to $5 \times 10^{-3} [\text{Pa S}]$

Fluid	Viscosity
castor oil	0.25 to 0.5
ketchup	50 to 70 $[\text{Pa S}]$
shortening or lard	1,000 to 2,000 $[\text{Pa S}]$
honey	2 to 3 $[\text{Pa S}]$

Note: In searching the internet, you may find viscosities in a variety of units. Some may be in Poise $[\text{P}]$ or Centipoise $[\text{cP}]$. $1 [\text{cP}] = .001 [\text{Pa s}]$. The viscosity of water is $1 [\text{cP}]$. Other fluids may have viscosity in Stokes $[\text{St}]$, which is the ratio of the viscosity to the density of the fluid. To convert from Stokes, multiply it by the fluid's density, or find another source! *Hint:* Search for "dynamic viscosity."