

# Observing Viscosity With EM

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### Abstract

Viscosity is a physical property of all fluids . It can be defined as the internal friction of a fluid to motion of flow. The proposed paper introduces a model in which Viscosity of a substance is measured by using Empirical Modelling. EM is the study of artefacts which are based on variables, observables and dependencies . It centers on the concept of observation,dependency etc. The proposed paper discusses the viscosity of a liquid using Empirical tools such as tkeden. The model has been made for teaching purposes to show the variation in viscosity of a liquid with variation in the temperature,density,mass etc.

Please note that proposed weighting for the model is 50%-50%

## 1 Introduction

**Today's era is the era of technology. Computer technology is growing very fast. Empirical modelling is one of the tools used by computer technology. Empirical Modelling is a structure of tools and principals which are used to apply on different kinds of computer based models .Empirical modelling is a study of artefacts using computer technology in order to help humans to interact with computers. Empirical Modelling can be understood by following three terms:**

(a) Practice: As EM is based on man-made models(artefacts) ,it takes observables, dependencies into account . Here, the practice word implies to the et in daily routine :

(b) Principals : Principals are set of rules that are used to observe the experiences such as studying various laws of nature using EM construals .

(c ) Philosophy : The entire study of EM becomes a philosophy when it gives new ideas . It recognizes the knowledge that is a outcome of a stream of thought and meanings as associated with relationships that are directly apprehended in personal experience . In this way , it can embrace various aspects of computing that admit no satisfactory treatment through formal language and theory alone[1].

### 1.1 Tools used in EM:

As Empirical modelling is the study of any kind of computer modelling based on observations and dependencies instead of using various mathematically explained relationships. Therefore, it is based on various means .These means are known as tools .

TKEDEN in the main tool used in empirical modelling .tkeden is a programming language that uses definitions, some conventional features. Here conventional features mean loops, control statements etc. It is also called definitive language. It helps to define the variables , procedures,definitions in a working environment. Eden has a number statements which are similar to C language. Cadence is the another tool used in empirical modelling . Its environment is centred on DOSTE interpreter. DOSTE is a kind of operative system .

There are a number of key features of EM that make it highly suited for application to educational technology, and which clearly distinguish it from other approaches to software development and use. Firstly, in an EM environment, the artefact or model being viewed, explored or created is 'alive' (live in terms of being running) and all parts of the artefact are constantly open to observation and change. Secondly, the artefact or model is composed of a set of definitions which express dependency (a definition specifies an object, value or thing as deriving from the properties/values of other objects, values or things). These two features taken together form the underlying concepts of a spreadsheet environment: a spreadsheet is always 'live', open to observation and modification (there is no concept of 'compiling and running'), and it is composed of values and definitions (in cells) that rely upon dependencies (between cells)[2]

### 1.2 Viscosity in terms of EM:

Empirical is the study of computer modelling in order to understand any phenomena based on dependencies, a set of rules. The proposed paper introduces a model based on a natural phenomena that is called Viscosity . Viscosity can be defined as the internal

resistance to the flow of the fluid. In other words , viscosity is thickness. Low viscosity refers to high flow and vice versa. As water is thin , it has low viscosity whereas oil/honey is thick , so it has high viscosity and low flow. Viscosity is a very important phenomena in daily life.

This paper ,discusses about the nature of liquid at different stages . As viscosity is a property of a fluid , it varies with some factors such as temperature, density . The tool EDEN has been used to show the viscosity of a fluid. The term viscosity is further studied by following factors:

(1)Dynamic viscosity : this is the resistance of fluid to its flow against the solid object and called normal viscosity.

(2) Kinematic viscosity: It measures the resistive flow of fluid under the effect of gravity.

Viscosity is being measured in pascal second(pa s).  
Th1 pascal second=10 poise=1,000millipascal second

1 centipoise =1 millipascal second [3]

## 2 Dependencies :

### (a) Exponential model

$$\mu(T) = \mu_0 \exp(-bT)_{[4]}$$

where T is temperature and  $\mu_0$  and  $b$  are coefficients. This expression can be used to evaluate viscosity of a liquid. The experiments show that as the temperature increases ,the viscosity of a liquid decreases. Because, as the temperature in increased , the average speed molecules in the liquid increases, therefore, force on molecules decreases ,therefore fluidity increases and viscosity decreases.

From daily life experience, honey becomes less thick as it is heated up . As the temperature is increased, the honey becomes less thick because of decrease in viscosity.

From the above expression , it is clear that viscosity of a liquid varies with temperature. The value for the coefficients can be determined and hence, viscosity of the liquid can be measured using Eden programming .

On the contrary , viscosity increases as the temperature decreases. This is because of increment in the frequency of intermolecular collisions at high temperatures. Since most of the time the molecules in a gas are flying freely through the void, anything that increases the number of times one molecule is in contact with another will decrease the ability of the molecules as a whole to engage in the coordinated movement. The more these molecules collide with one another, the more disorganized their motion becomes .[5]

Following a table shows the viscosities of different liquids and gases at different temperatures:[6]

Gases,Liquids	Temperature (T) in degree centigrades	Viscosity in pascal seconds
Air	15	17.9
Hydrogen	0	8.42
Water	20	1
Water	40	0.65
Oil,Vegetable,Soya bean	20	69
Oil,Vegetable,Soya bean	40	26
Honey	20	10
Glycerin	20	1420
Glycerin	40	280

The above given table shows the different viscosity- is at different temperatures. But , it was difficult to show this variation in viscosities through the proposed model. Because it is difficult to introduce liquids as dependencies .

### (b) Density Model:

The proposed model has been conducted with the spheres falling in a liquid . Therefore, the following dependencies are being used.[7]

The mathematical expression describing the viscous drag force on a sphere

$$R = 6\pi \eta r v$$

The formula for the buoyant force on a sphere is

$$B = \rho_{\text{fluid}} g V_{\text{displaced}}$$

The formula for weight

$$W = mg = \rho_{\text{object}} g V_{\text{object}}$$

combine all these things together for a sphere falling in a fluid. Weight goes down, buoyancy goes up, drag goes up. After awhile, the sphere will fall with constant velocity. When it does this all the forces cancel. When a sphere is falling through a fluid it is completely submerged.

$$B + R = W$$

$$\rho_{\text{fluid}} g V + 6\pi \eta r v = \rho_{\text{object}} g V$$

$$6\pi \eta r v = (\rho_{\text{object}} - \rho_{\text{fluid}}) g V$$

$$6\pi \eta r v = \Delta \rho g \frac{4}{3} \pi r^3$$

$$\eta = \frac{2 \Delta \rho g r^2}{9 v}$$

Here, ' $\Delta\rho$ ' is the difference between the density of the sphere and density of liquid. ' $g$ ' is acceleration due to gravity ' $r$ ' be the radius of the sphere. ' $v$ ' is velocity of the sphere which is determined by  $d/t$  where  $d$  is the distance by which sphere falls in the liquid and  $t$  is the time what it takes to fall

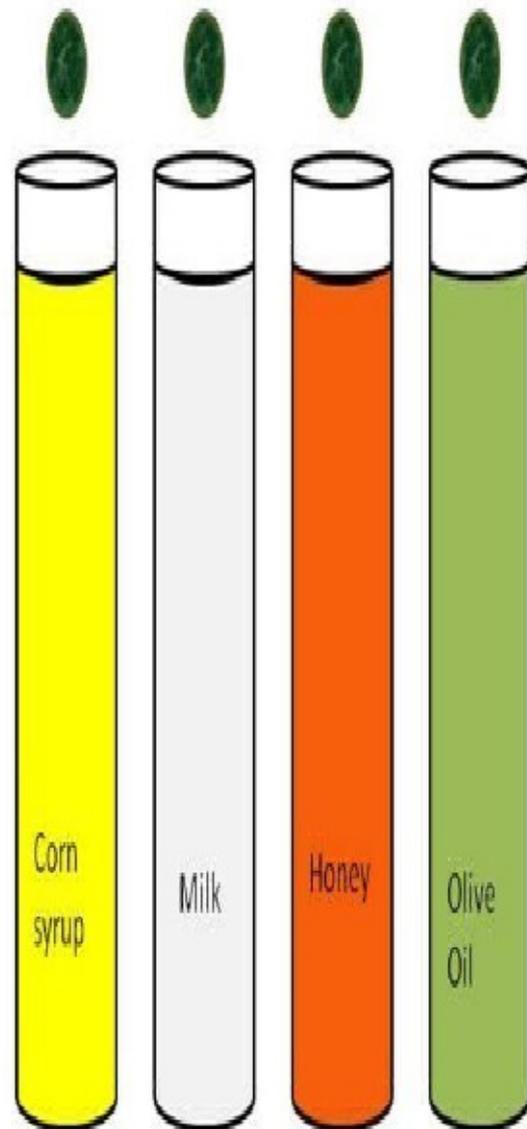
Drop a sphere into a liquid. If size and density of the sphere and the density of the liquid, are known then viscosity of the liquid can be determined. [8]

The above mentioned formula is being used to measure viscosity of a liquid. From the formula, it

is clear the viscosity of a liquid depends upon various factors such as density of the liquid, density of sphere, velocity of the sphere. In the model, the

density of the liquid, radius, mass of the sphere are being used as inputs. Here, liquid, density are being as dependencies. According to the formula, if densities of the liquid and sphere are known, we can determine the viscosity of the liquid. In the model, radius, mass of the sphere and density of the liquid has been used as variables by using Eden.

The model has been made for teaching purposes. This model helps to show a viscosity changes with the different volumes and their densities. During the model a few of the problems have been experience if the the density difference between the liquid and the sphere is high, the sphere will float on the surface.



The Experiment can be done with different type of liquids. Therefore, type of liquid is a dependency itself .

### **3 Importance Of EM :**

Empirical Modelling is the study of artefacts based on observations , dependencies and construals. .The importance of EM lies in its definitive scripts which are used to solve the problems using observables,dependencies rather than described in the mathematical relationships. The tools such as Eden and Cadence are designed to generate artefacts in this era of computer technology. It is efficient to create models in EM .

#### ACKNOWLEDGMENT:

Iam highly thankful to Mr.Meurig Beynon who helped a lot in the model. In addition , online resources were very helpful too.

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