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NEW SHORT STORIES AS A WAY OF TEACHING CHEMICAL ENGINEERING

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ABSTRACT

One of the strategies to teach undergraduate Chemical Engineering is to solve problems that have been posted as short stories. The authors have presented articles in-several journals with stories proposed for teaching[6,7,8]. In this article the authors present two new short stories.

KEYWORDS: ***Fluid Engineering, terminal velocity, Stokes equation, Psychometric chart , Air conditioning.***

1.0-INTRODUCTION

Chemical Engineering is a discipline widely practiced and taught all over the world. Instructors, teachers or professors, in charge of teaching the knowledge, are required to learn the basic elements and to transmit such knowledge, using numerous pedagogical techniques to motivate the learning. In this article as previously performed, the authors present two short stories that serves as a basis for the resolution of a problem, those stories happens in the desert and are related to fluid flow, the movement of solid particles and air conditioning.

2.0 CASE STUDIES

2.1–Simoom

A few days ago, our professor in Fluids Engineering told us that years ago he had visited Morocco. He traveled to Marrakech, a city located on the edge of the Sahara desert. One of the many excursions offered to tourists was to travel by camel through the desert dunes.

Dr. Hernandez did not waste the opportunity and the next day he was riding a camel through that huge desert. As he strolled along the dunes, the guide explained the teacher that warm winds could often appear in the desert, lifting the sand and that a whole caravan could be burried in minutes. That wind -the guide said- got the name of Simoom.

Dr. Hernandez intrigued, by this explanation , took some grains of sand, that according to him would have an average diameter of 2 mm, and dropped them. The air, at that time, was only 35 degrees Celsius and the atmospheric pressure was 700 mm, as reported through his smartphone.

Then the teacher wondered what should the minimum velocity of air be to begin lifting the sand, if its density was about 3000 kg/m^3.

I already solved that problem, he told us, now it's up to you to calculate that speed, so start calculating. You can use books, notepads, smartphones, laptops and tablets, whatever you want or have in hand.

After examining the problem, I realized that actually what we had to calculate was the so-called terminal velocity (u_t), whose value is given by the

Stokes equation, that we had seen by chance the day before[3,4,5] . This equation reads as follows:

$$u_t = \sqrt{\frac{4(\rho_s - \rho) g D_p}{3 C_D \rho}} \qquad (1)$$

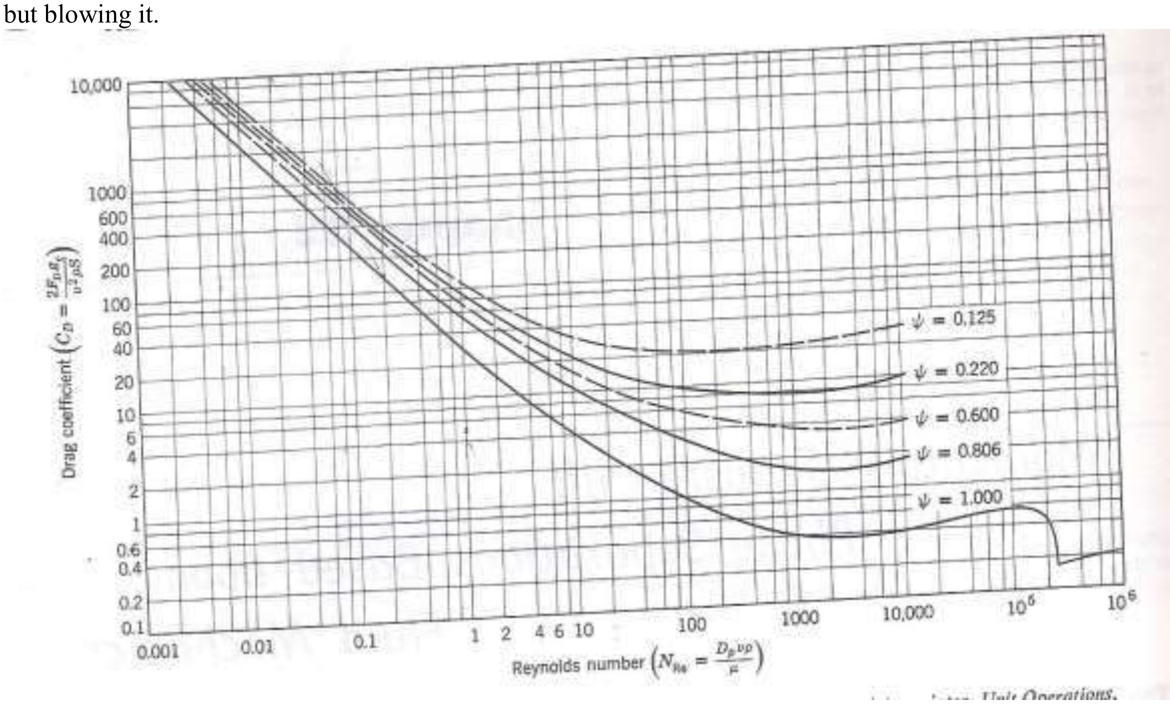
In this equation there are terms such as the particle $\square_p$ and fluid $\square\square$ (air in our case) densities. D_p is the particle diameter, g is the gravity force and C_d is the drag coefficient. Maybe, you have seen a vacuum cleaner in a store suspending a ball in the air. Of course the vaccum cleaner is no sucking air but blowing it.

One of the terms in Eq. 1 is the drag coefficient. The parameter——C_D depends on the Reynolds number and on the particle sphericity.(How close to the sphere is the particle).

If we take the sphericity of the sand as of 1 , then the Reynolds can be -obtained.

Viscosity = 0.0185 cps, density = 1.0717 kg/m^3

And from Graph 1. we can obtain the value of C_D.

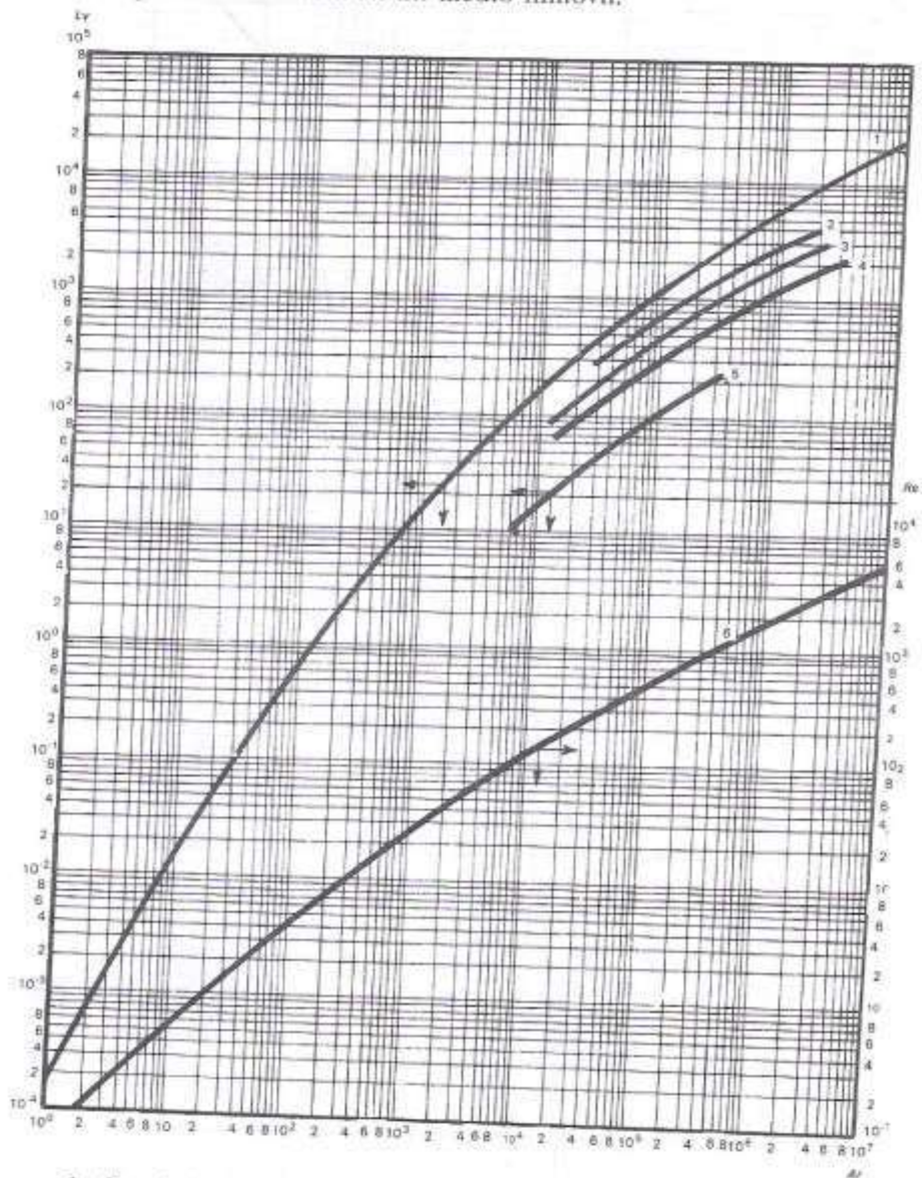


Graph 1. Drag coefficient vs Reynolds number.[4]

Trying to use Graph presents a problem because the wind speed is not known. Therefore, to solve the problem we should proceed by trial and error. That is, assume a Re, obtain Cd from this graph, insert the value into Eq. 1 to obtain ut. Use this value to calculate Re and if is equal to the assumed one, then that is the correct answer. If not, assume a different Re, continue until $Re_{assumed}$ = Re from Graph 1. The literature says that when the Reynolds' number is bigger than 1000 there is turbulent flow[9] and C_D is 0.4. But we do not know the value of the Reynolds.

Checking the course notes, I found that the teacher had told us that this problem could be solved without a trial and error approach, using a different graph,[5] using the correlation of Arquimedes number against the Reynolds number for several shape particles, as depicted in Graph 2.

Apéndice LVI. Los *Re* y *Ly* en función de *Ar* para la sedimentación de una partícula unitaria en un medio inmóvil.



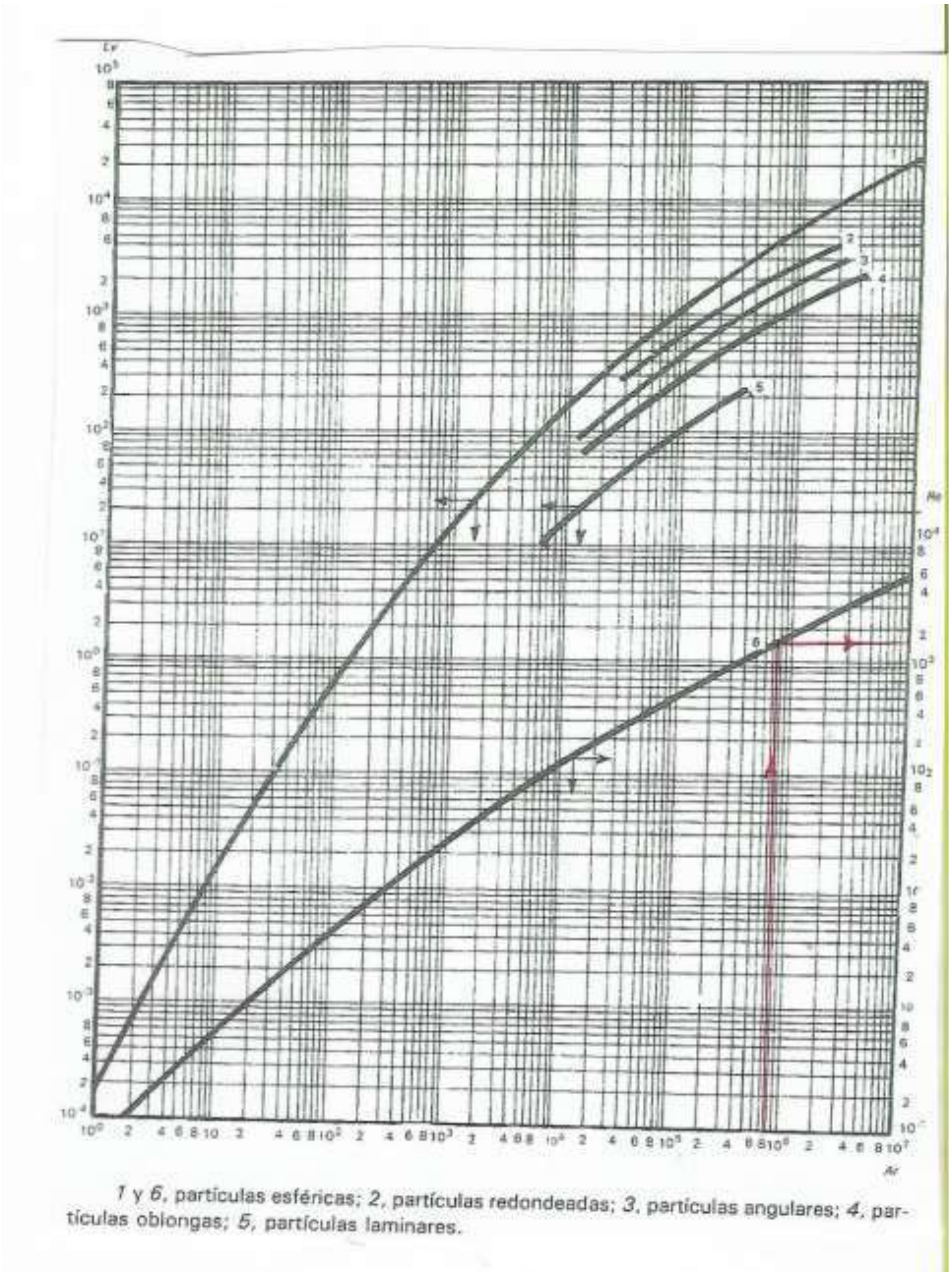
1 y *6*, partículas esféricas; *2*, partículas redondeadas; *3*, partículas angulares; *4*, partículas oblongas; *5*, partículas laminares.

Graph 2.- Arquimedes' Number vs. Reynolds' number.

Archimedes ' number (Ar) is, as shown in Eq. 2.

$$Ar = \frac{g(\rho_s - \rho)\rho \quad D_p^3}{\mu^2} \qquad (2)$$

All the parameters needed for Eq. 2 are known except air's viscositry (μ) whose value is 0.0185 cps for the temperature proposes . Placing the available data in that equation 2 Archimedes ' number can be calculated and its value is Ar = 737238.



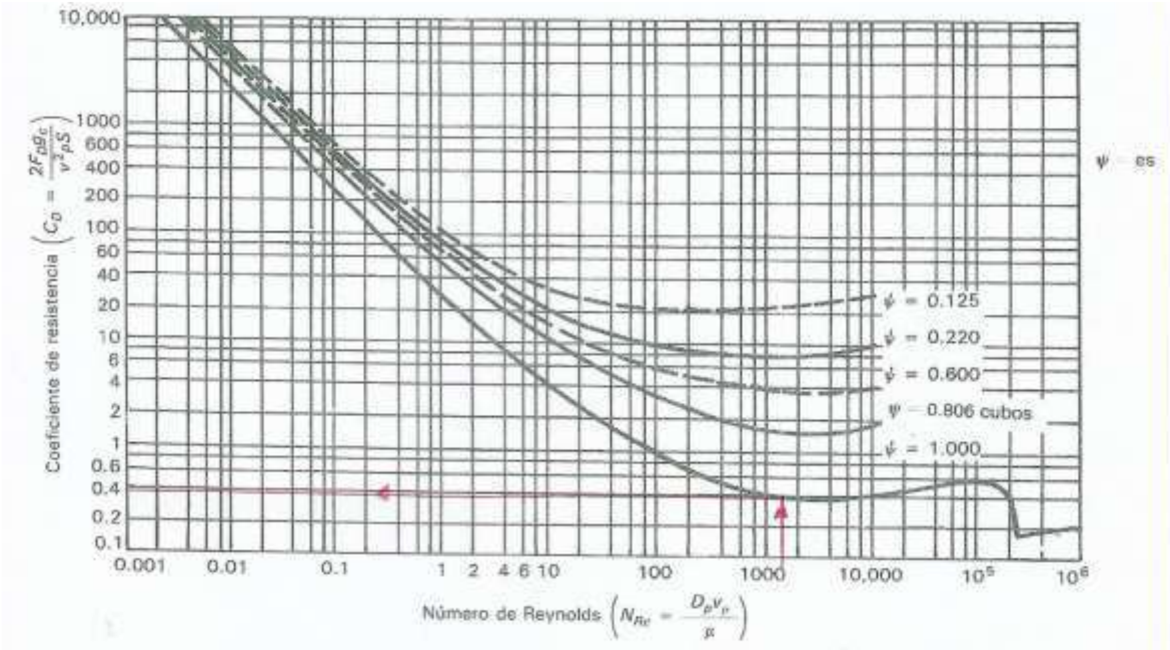
Graph 3.- Reynolds number vs. Archimedes' number . Path to locate the Reynold´number.

Therefore, using graph 3, the Reynolds : is Re = 1500

For this value, the corresponding value for the terminal velocity was:

Ut = 12.346 m/s

Thus, the problem was resolved. Of course the result can be verified by placing the obtained Re in graph 1 of Cd vs Reynold and thus obtain the drag coefficient value .



Graf. 4. Path to locate the drag coefficient.

Cd = 0.4

With it the terminal velocity of the sand was 13.53 m/s

Which is quite close to what was obtained, so the terminal velocity could be put as an average of those values or about 13 m/s . Then the velocity of air needed to lift the desert sand was only 13 m/s or 45 km/h and if this is the case is more worthwhile for the professor to hasten to return before the dreaded Simoom of the desert could be presented.

2.2.- Second story . In the Sonora desert.

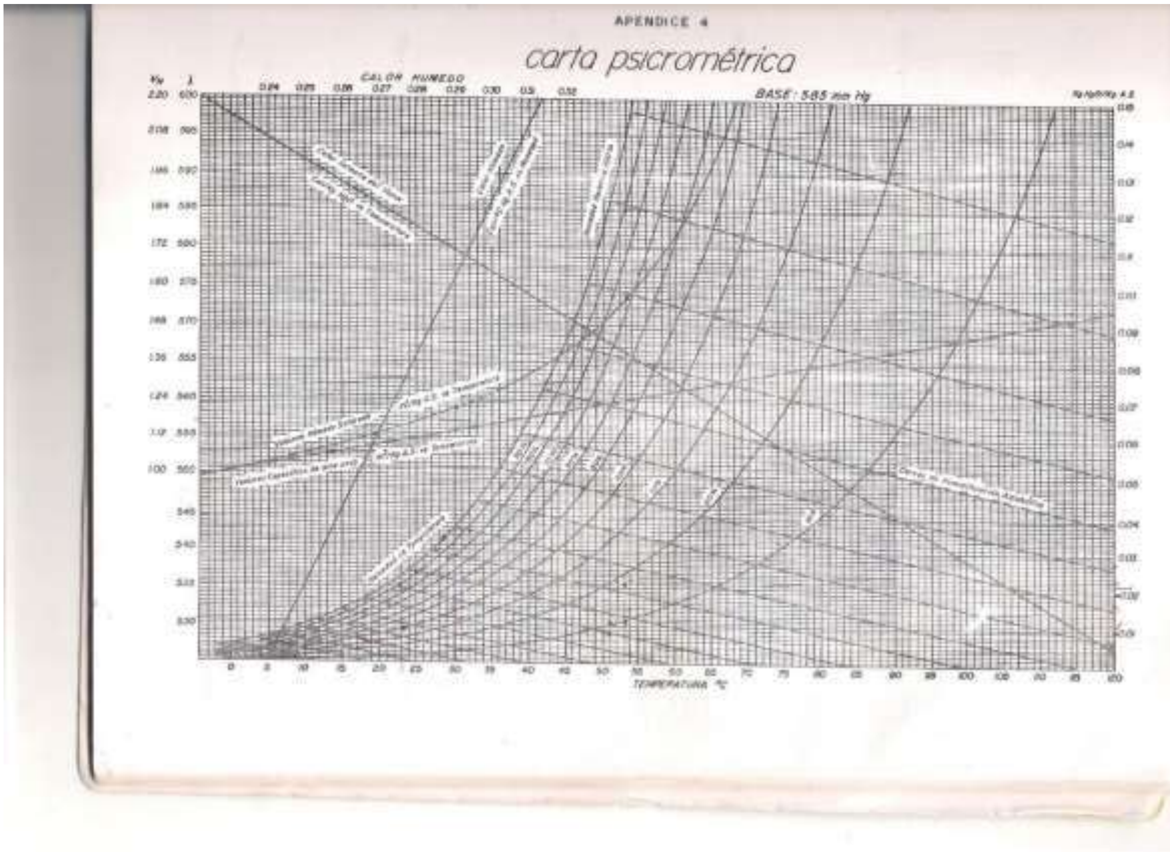
Professor Martinez and his nephew Hector walking through the Sonoran desert, got separated from the expedition due to carelessness. In the middle of the desert, heated by the sun rays they drank the little water contained in their canteens. So harassed by thirst and fatigue, they decided to take refuge near some rocks to protect themselves from direct sunlight. The nephew tried to communicate with the rest of the expedition members explaining the situation. Thanks to the communication devices, the rest of the group was able to locate them. However, they were told that they could not be picked up until the next day. Therefore, meanwhile they had to take care of themselves. Thus, the professor and Hector had to protect themselves and try to spend, in the best possible way, the night without straying much from the place where they were, avoiding risks.

The main problem was thirst, because the water in the canteens was over. The restless professor always carried with him a clock, equipped with a psychometric sensor, which besides giving the time, provided temperature data, humid bulb temperature, dew temperature, absolute humidity, relative humidity, pressure, etc. After consulting his watch he found that the temperature was 45 °C in the shade and a relative humidity of 20%. The nephew consulting his phone found that it was predicted a low temperature of 10 ° C during the night.

We are saved! , the professor said. - We're not running out of water. But why did he say this?

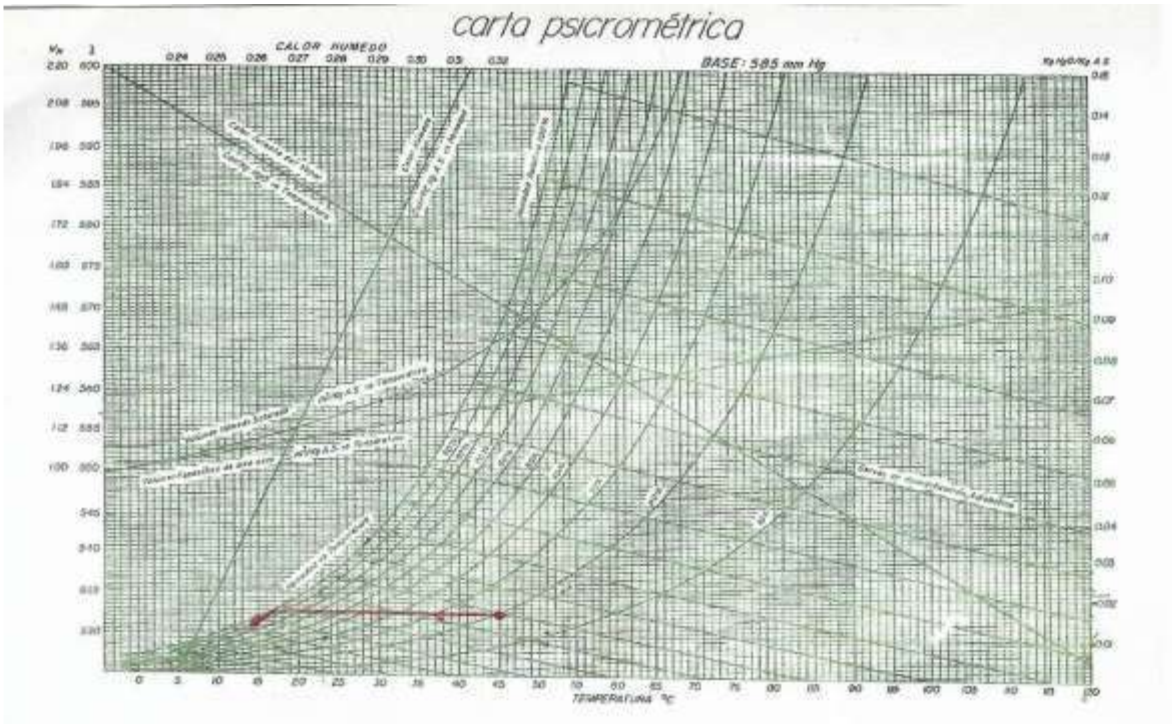
3.1.- PSYCHOMETRY.

According to the data obtained by the teacher and consulting the psychometric (shown in Graph 5) chart it can be obtained the absolute humidity according to the psychometric chart and the value was of 0.012 kg/kg.



Graph 5.-Psychometric chart at 760 mm Hg.

However, if the air is cooled at constant pressure down to 10 °C, it is found that below18 °C the air will saturate, then the excess moisture will condense until reaching10 °C because saturated air has a humidity of 0.008 kg/kg (Graph 6 This difference in humidity would produce rain or be deposited as dew, so they should only wait and collect the condensed water in their canteens, in addition to sending SOS signals with the nephew's phone.



Graph 6. Passage of air when it cools.

4.-CONCLUSIONS

The problems posed in the form of short stories can motivate students to use terms that seem abstract in problem solving. In this article the authors presented two stories, one related to the movement of solid particles and the other akin to psychometry used extensively in air conditioning, environmental engineering, and drying.

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