Psychrometric properties of humid air: calculation procedures and interactive education in java supported web browser format

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Summary

In this study, a distance education and teaching courseware for psychrometry, namely Interactive Psychrometry Education (I-P-E) has been developed using Hyper Text Marked Language (HTML). In order to provide interaction, which has an important role in education, object-oriented programming language Java has been used. Since HTML and Java are platform-free languages, this program can be used in every kind of computer, which has a standard Internet browser.

In the study, procedures for calculating psychrometric properties are given in detail. Seven main properties of the psychrometrics, namely dry-bulb, wet-bulb and dew-point temperatures, atmospheric pressure, humidity ratio, relative humidity and enthalpy can be calculated in the program written in Java. According to the Gibbs Phase rule, in the humid air case, any three intensive properties will be sufficient to evaluate the remaining properties. Therefore the combination of three out of seven properties gives a total of 35 different sets. Java program has been developed and utilized to obtain the psychrometric properties of humid air in these sets. In addition to the Java program, in I-P-E, the psychrometry course text has been written in HTML. The equations and figures are prepared in suitable graphic format. The links and various information, and example problems have been also supplied in Java and text format. In example problems written in Java, parameters can be changed by the user within certain limits and in such a way, various results can be collected to analyze the affects of each parameter used. In addition to problems prepared, programs for unit conversion, thermophysical property calculation for water, air and some refrigerants are also presented in Java. I-P-E is not open to public but delivered in CDs to be used in off-line. Furthermore, a web site, namely http://www.devres.net/, is also employed to partially present I-P-E and to handle a part of Thermodynamic course's assignments, exam results, readings etc in web platform.

Introduction

In the 21st century, learning and teaching will be realized using the powers of electronic mediums, or in a better expression, bytes. Exchange of bytes between the teacher and the student by the means of electronic education is going to give its fruits by the production of a huge amount of informative data ever produced in the history of mankind. For instance, a weekday edition of The New York Times contains more information than the average person was likely to come across in a lifetime in seventeenth-century England (Wurman, 2000). The first author of this study bought his first personal computer in 1992, a 286 with 1 MB RAM and 40 MB harddisk and thought that how he could fill this huge amount of storage capacity since his previous computer was in the office with a "novel" 20 MB hard disk. From time to time, he is still using this "ancient" personal computer which has several up-grade operations during the time which became to 386DX30, for running "ancient" programs on his "ancient" data. Today he spells gigabytes of storage spaces. What happened in a decade and he needs, nearly, 250 times bigger storage capacity just for personal usage, and he is still using the computer like most of the people, as a word processor in most of his time. What happened in the last three centuries is that consumable information is being produced in the early hours of day and thrown, later on, in a dust bin until being bought a "recent" one in the next morning. Therefore, more data produced is not, in a point of view, as same as useful information which turns into applicable knowledge when someone needs it. Consequently, as Nobel laureate Herbert Simon stated, the meaning of "knowing has shifted from being able to remember -then you need more gigabytes- and repeat information to being able to find and use it -then you need faster processors and Internet connections (Simon, 1996; Bransford *et al.*, 1999).

In this study, an electronic courseware, namely I-P-E (Interactive Psychrometry Education) is being explained which has been developed for a part of Thermodynamics courses in Food Engineering Department of Istanbul Technical University. The educational trends are also discussed in the framework of interactive electronic education. As stated by Kent L. Norman, a key theme in e-education is navigation in the space of data, which will not be what you know, in contrary, to know where to find what you need to know, and to know how to collaborate with others (Norman, 1997).

Interactivity and Education

In Devres and Duran (2000), the new science of learning was discussed. In the following paragraphs, interactive education, which has an important role in this concept, is being examined.

Interactivity is a combination of the rate, richness, and relevance of the exchange of information between the student and the learning environment and the course materials. It takes either an explicit or implicit form. Explicit engagement involves the exchange of observable tokens such as words, messages, papers, etc. Implicit interactivity occurs when the student responds internally with unobservable tokens such as unspoken thoughts, agreement, or felt but unexpressed emotions. While implicit interactivity can involve true engagement, as educators point of view, they would like to draw out explicit interactivity (Norman, 1997). Therefore the potential of electronic media should be employed to enhance explicit interactivity in learning. In contrast, electronic media may cause (i) less concentration since there is no need to take notes (ii) less attendance since notes can be received by electronically, (iii) less co-operation and inspiration between "master" and "apprentice" (iv) less creative ideas since there is no/less brainstorming (v) fed up and lost in huge amounts of information. In consequence, e-education can be mitigated interactivity in those cases and should be paid attention and the power of human interaction never be neglected.

It is interesting to look at how the definition of education has changed over the years, Table 1. Three trends can be seen in these definitions. First, there is a shift in providers of education from parents and guardians to schools and finally to formal schooling in the 19^{th} century definition. Hundred fifty years later from this definition, aim of the education reflected to the second trend, which is a change in the content of education from dealing with personal and moral character to utilitarian skills. The third trend is a shift from the emphasis on understanding to training of skills. Although there is a tradition in education of emphasizing understanding over rote learning, it has been recently moved in the direction of skills-based training (Norman, 1997). Therefore, learning with understanding will be the goal of the education in the new century under the guide of interactions between human brains and bytes.

Table 1. The definitions of education (Norman, 1997).

EDUCATION: n. The bringing up, as of a child; instruction and discipline which is intended to enlighten the understanding, correct the temper, and form the manners and habits of youth, and fit them for usefulness in their future stations. To give children a good education in manners, arts and science, is important; to give them religious education is indispensable; and an immense responsibility rests on parents and guardians who neglect these duties. *EDUCATE:* vt. To bring up, as a child; to instruct; to inform and enlighten the understanding; to instill into the mind principles of arts, science, morals, religion and behavior. *To educate children well is one of the most important duties of parents and guardians. Source : the American Dictionary of the English Language, Noah Webster, 1828
EDUCATE: vt. To cultivate and discipline the mind and other faculties by teaching; send to school. Source: Webster's Encyclopedia of Dictionaries, 1978
EDUCATE: vt. To train or develop the knowledge, skill, mind, or character of, esp. by formal schooling or study; teach; instruct. Source: Webster's New World Dictionary, 1988.

As discussed above, in the early part of the twentieth century, education focused on the acquisition of literacy skills: simple reading, writing, and calculating. It was not the general rule for educational systems to train people to think and read critically, to express themselves clearly and persuasively, to solve complex problems in science and mathematics. Now, at the beginning of a new century, these aspects of high literacy are required of almost everyone in order to successfully negotiate the complexities of contemporary life. The skill demands for work have increased dramatically, as has the need for organizations and workers to change in response to competitive workplace pressures (Bransford et al., 1999). In this concept, educational institutions should have to change in order to stay competitive. They should find themselves a place on the new horizon of electronic education and command on new instructional technologies. However, development of the electronic education, is a time consuming process and who will be encouraged to prepare the courseware is a very difficult question to be answered (Devres and Duran, 2000). Faculty in higher education fall into two groups: (a) in principal researchers and (b) in principal teachers. Researchers tend not to be overly interested in instructional improvement. Teachers are, however, interested in teaching but not in technology. Neither group is particularly interested in cost/benefit arguments for instructional technology or enamored by multimedia glitz. However, the researchers are interested in gaining more time for research by making teaching more efficient; and the teachers are interested in teaching more and in greater detail (Norman, 1997). Enthusiasts for developing courseware should steal the time from their research or teaching time. In this respect, administrators in the educational institutions should support these enhancements in instruction techniques by means of increase in budget, incentives, promotions, grants and rewards etc. They should also provide necessary infrastructure for computers, electronic classrooms, net-works suitable to their bodies such as Local Area Network (LAN) or Wide Area Network (WAN). Norman advices to educational establishments to follow the steps stated below when they are on their way to electronic education (Norman, 1997), especially the last one is very radical and the author thinks it is better to change "young" as "young in mind" not "young in age":

1. Don’t push, don’t pull, let the current do its work.
2. Transition in small discrete steps rather than all at once.
3. Provide faculty support for course development.
4. Provide training with incentives.
5. Provide canned courses and turnkey systems.
6. Recognize and reward those who make the move.
7. Encourage early retirement for non-adopters and hire young enthusiasts.

Psychrometry and I-P-E

In the study of the processes of air conditioning, cold storage and drying, a knowledge of the psychrometric properties of the working fluid, i.e. humid air, is essential. In general, the psychrometric properties of a medium can be predicted either analytically by recourse to the laws for gases or by consulting specially prepared charts and tables. Using these charts, if the atmospheric pressure or altitude is known, it is easy to find the psychrometric properties using two other known properties. However, for instance during the designing of a cold store, in most cases its altitude is different from sea level. And yet, most of the charts available in the references are based on sea level properties. Therefore, finding psychrometric properties from zero-altitude charts can create errors. Although the best method for finding these properties is to calculate them analytically using the perfect gas relationships, in many situations, it is often neither convenient nor practical. A realistic solution for these problems is to employ a computer for the numerical solution of the relevant equations: the psychrometric properties being defined in the software (Devres, 1994).

There are seven main different properties in the psychrometric charts, namely, dry-bulb, wet-bulb and dew-point temperatures, atmospheric pressure, humidity ratio, relative humidity and enthalpy (Anon., 1981a; Devres, 1994). According to the Gibbs Phase Rule, there are four degrees of freedom for a system consisting of humid air, assuming it to be a mixture of nitrogen, oxygen, and water vapor. For all practical purposes the ratio of the masses of oxygen and nitrogen in air is constant, hence the degrees of freedom are reduced to three. Thus any three intensive properties will be sufficient to evaluate the remaining properties. Therefore the combination of three out of seven properties gives a total of 35 different sets. These are shown in Table 2. In this study, each set is used separately in an attempt to find solutions for the remaining unknown variables. In most cases analytical solutions were not found and numerical methods had to be employed (Devres, 1994).

For the determination of psychrometric properties, knowledge of the water-vapor saturation-pressure is essential. The equations for calculating saturation pressures for the temperature ranges -100°C to 200°C are given in Table 3. The solutions for the saturation vapor pressure as a function of temperatures were found with REGAN (Devres, 1989), using polynomial REGression ANalysis on data obtained from ASHRAE (Anon., 1981b). In some cases however, the saturation pressure was known allowing the temperature to be calculated from the data. In such cases, temperatures calculated using saturation pressures where derived from regression analysis are shown in Table 4 (Devres, 1994).

The definition of psychrometric properties can be given very easily where perfect gas relations are employed (Anon., 1981a). As a result, only equations (in total 28 equations) are given in Table 5. In every equation, in order to obtain the property given in the second column, the known properties given in the third column must be replaced in the equation given in the fourth column. The units of each property are shown in the last column (Devres, 1994).

Calculation procedures in step-by-step are shown in Table 6. With the following steps, it is easy to calculate the unknown properties. In most cases, however, numerical analyses must be employed for solution (Devres, 1994).

Table 2. Combination sets of seven psychrometric properties, each set comprising three properties (Devres, 1994)
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1	T	T*	T_D	2	T	T_D	P	3	T	P	W	4	T	W	ϕ	5	T	ϕ	h
6	T	T*	P	7	T	T_D	W	8	T	P	ϕ	9	T	W	h				
10	T	T*	W	11	T	T_D	ϕ	12	T	P	h								
13	T	T*	ϕ	14	T	T_D	h												
15	T	T*	h																

16	T*	T_D	P	17	T*	P	W	18	T*	W	ϕ	19	T*	ϕ	h
20	T*	T_D	W	21	T*	P	ϕ	22	T*	W	h				
23	T*	T_D	ϕ	24	T*	P	h								
25	T*	T_D	h												

26	T_D	P	W	27	T_D	W	ϕ	28	T_D	ϕ	h
29	T_D	P	ϕ	30	T_D	W	h				
31	T_D	P	h								

32	P	W	ϕ	33	P	ϕ	h
34	P	W	h				

35	W	ϕ	h

T	Dry-bulb temperature
T*	Wet-bulb temperature
T_D	Dew-point temperature
P	Pressure
W	Humidity ratio
ϕ	Relative humidity
h	Enthalpy

Table 3. Calculation of water-vapor saturation pressure which is dependent on the temperature within various temperature ranges (Devres, 1994).
$\alpha = A{\cdot}T^2 + B{\cdot}T + C + D{\cdot}T^{-1}$, T in K, $p_{ws} = 1000{\cdot}\exp(\alpha)$, p_{ws} in Pa

	Temperature (K)				
	$213.15 \le T < 273.15$	$273.15 \le T < 322.15$	$322.15 \le T < 373.15$	$373.15 \le T < 423.15$	$423.15 \le T < 473.15$
A	$-0.7297593707{\cdot}10^{-5}$	$+0.1255001965{\cdot}10^{-4}$	$+0.1246732157{\cdot}10^{-4}$	$+0.1204507646{\cdot}10^{-4}$	$+0.1069730183{\cdot}10^{-4}$
B	$+0.5397420727{\cdot}10^{-2}$	$-0.1923595289{\cdot}10^{-1}$	$-0.1915465806{\cdot}10^{-1}$	$-0.1866650553{\cdot}10^{-1}$	$-0.1698965754{\cdot}10^{-1}$
C	$+0.2069880620{\cdot}10^{+2}$	$+0.2705101899{\cdot}10^{+2}$	$+0.2702388315{\cdot}10^{+2}$	$+0.2683629403{\cdot}10^{+2}$	$+0.2614073298{\cdot}10^{+2}$
D	$-0.6042275128{\cdot}10^{+4}$	$-0.6344011577{\cdot}10^{+4}$	$-0.6340941639{\cdot}10^{+4}$	$-0.6316972063{\cdot}10^{+4}$	$-0.6220781230{\cdot}10^{+4}$

Table 4. Calculation of temperature which is dependent on water vapor saturation pressure within various pressure ranges (Devres, 1994).
$T = E{\cdot}\beta^4 + F{\cdot}\beta^3 + G{\cdot}\beta^2 + H{\cdot}\beta + K$, T in K, $\beta = \ln(p_{ws})$, p_{ws} in Pa

	Pressure (Pa)				
	$1 \le p < 611$	$611 \le p < 12350$	$12350 \le T < 101420$	$101420 \le T < 476207$	$476207 \le T < 1555099$
E	$+0.1004926534{\cdot}10^{-2}$	$+0.5031062503{\cdot}10^{-2}$	$+0.1209512517{\cdot}10^{-4}$	$+0.2467291016{\cdot}10^{-1}$	$+0.2748402484{\cdot}10^{-4}$
F	$+0.1392917633{\cdot}10^{-2}$	$-0.8826779380{\cdot}10^{-1}$	$-0.3545542105{\cdot}10^{+0}$	$-0.9367112883{\cdot}10^{+0}$	$-0.1068661307{\cdot}10^{+1}$
G	$+0.2815151574{\cdot}10^{+0}$	$+0.1243688446{\cdot}10^{+1}$	$+0.5020858479{\cdot}10^{+1}$	$+0.1514142334{\cdot}10^{+2}$	$+0.1742964962{\cdot}10^{+2}$
H	$+0.7311621119{\cdot}10^{+1}$	$+0.3388534296{\cdot}10^{+1}$	$-0.2050301050{\cdot}10^{+2}$	$-0.9882417501{\cdot}10^{+2}$	$-0.1161208532{\cdot}10^{+3}$
K	$+0.2125893734{\cdot}10^{+3}$	$+0.2150077993{\cdot}10^{+3}$	$+0.2718585432{\cdot}10^{+3}$	$+0.4995092948{\cdot}10^{+3}$	$+0.5472618120{\cdot}10^{+3}$

Table 5. Calculation of psychrometric properties (Devres, 1994).

Eq. No.	*To obtain*	*Knowns*	*Equation*	*Remarks*
1	p_{ws}	T	$\alpha = A \cdot T^2 + B \cdot T + C + D \cdot T^{-1}$	$p_{ws} = 1000 \cdot \exp(\alpha)$, T (K), p_{ws} (Pa)
2	T	p_{ws}	$T = E \cdot \beta^4 + F \cdot \beta^3 + G \cdot \beta^2 + H \cdot \beta + K$	$\beta = \ln(p_{ws})$, T (K), p_{ws} (Pa)
3	p_w	T_D	$\alpha = A \cdot T_D^2 + B \cdot T_D + C + D \cdot T_D^{-1}$	$p_w = 1000 \cdot \exp(\alpha)$, T_D (K), p_w (Pa)
4	T_D	p_w	$T_D = E \cdot \beta^4 + F \cdot \beta^3 + G \cdot \beta^2 + H \cdot \beta + K$	$\beta = \ln(p_w)$, T_D (K), p_w (Pa)
5	p_{ws}^*	T^*	$\alpha = A \cdot T^{*2} + B \cdot T^* + C + D \cdot T^{*-1}$	$p_{ws}^* = 1000 \cdot \exp(\alpha)$, T^* (K), p_{ws}^* (Pa)
6	h	T, W	$h = T + W \cdot (2501 + 1805 \cdot T)$	T (°C), h (kJ/kg)
7	T	h, W	$T = \dfrac{h - 2501 \cdot W}{1 + 1805 \cdot W}$	T (°C), h (kJ/kg)
8	W	h, T	$W = \dfrac{h - T}{2501 + 1805 \cdot T}$	T (°C), h (kJ/kg)
9	W	P, p_w	$W = 0.62198 \cdot \dfrac{p_w}{P - p_w}$	P (Pa), p_w (Pa)
10	P	p_w, W	$P = 0.62198 \cdot \dfrac{p_w}{W} + p_w$	P (Pa), p_w (Pa)
11	p_w	P, W	$p_w = \dfrac{P \cdot W}{W + 0.62198}$	P (Pa), p_w (Pa)
12	W_s	P, p_{ws}	$W_s = 0.62198 \cdot \dfrac{p_{ws}}{P - p_{ws}}$	P (Pa), p_{ws} (Pa)
13	P	p_{ws}, W_s	$P = 0.62198 \cdot \dfrac{p_{ws}}{W_s} + p_{ws}$	P (Pa), p_{ws} (Pa)
14	p_{ws}	P, W_s	$p_{ws} = 0.62198 \cdot \dfrac{P - W_s}{W_s + 0.62198}$	P (Pa), p_w (Pa)
15	W_s^*	P, p_{ws}^*	$W_s^* = 0.62198 \cdot \dfrac{p_{ws}^*}{P - p_{ws}^*}$	P (Pa), p_{ws}^* (Pa)
16	P	p_{ws}^*, W_s^*	$P = 0.62198 \cdot \dfrac{p_{ws}^*}{W_s^*} + p_{ws}^*$	P (Pa), p_{ws}^* (Pa)
17	p_{ws}^*	P, W_s^*	$p_{ws}^* = \dfrac{P \cdot W_s^*}{W_s^* + 0.62198}$	P (Pa), p_{ws}^* (Pa)
18	W_s^*	h, W, T^*	$W_s^* = \dfrac{h_s^* - h}{h_w^*} + W$	$h_s^* = T^* + (2501 + 1805 \cdot T^*) \cdot W_s^*$ $h_w^* = 4.186 \cdot T^*$; h, h_s^*, h_w^* (kJ/kg), T^* (°C)
19	W	W_s^*, h, T^*	$W = \dfrac{h - h_s^*}{h_w^*} + W_s^*$	$h_s^* = T^* + (2501 + 1805 \cdot T^*) \cdot W_s^*$ $h_w^* = 4.186 \cdot T^*$; h, h_s^*, h_w^* (kJ/kg), T^* (°C)
20	W	W_s^*, T, T^*	$W = \dfrac{(2501 - 2.381 \cdot T^*) \cdot W_s^* - (T - T^*)}{2501 + 1805 \cdot T - 4.186 \cdot T^*}$	T (°C), T^* (°C)
21	T^*	W_s^*, W, T	$T^* = \dfrac{2501 \cdot (W_s^* - W) - T \cdot (1 + 1805 \cdot W)}{2.381 \cdot W_s^* - 4.186 \cdot W - 1}$	T (°C), T^* (°C)
22	W_s^*	W, T, T^*	$W_s^* = \dfrac{(2501 + 1805 \cdot T - 2.381 \cdot T^*) \cdot W + (T - T^*)}{2501 - 2.381 \cdot T^*}$	T (°C), T^*(°C)
23	T	W_s^*, W, T^*	$T = \dfrac{(2501 - 2.381 \cdot T^*) \cdot W_S^* - (2501 - 4.186 \cdot T^*) \cdot W + T^*}{1 + 1805 \cdot W}$	T (°C), T^*(°C)
24	ϕ	p_w, p_{ws}	$\phi = p_w / p_{ws}$	p_w (Pa), p_{ws} (Pa)
25	p_w	ϕ, p_{ws}	$p_w = \phi \cdot p_{ws}$	p_w (Pa), p_{ws} (Pa)
26	p_{ws}	ϕ, p_w	$p_{ws} = p_w / \phi$	p_w (Pa), p_{ws} (Pa)
27	μ	W, W_s	$\mu = W / W_s$	
28	v	T, P, W	$v = R_a \cdot T \cdot (1 + 16078 \cdot W) / P \quad R_a = 287.055$ (J / kgK)	v (m³/kg), T (K), P (Pa)

Table 6. Recommended procedures for the calculation of psychrometric properties (Devres, 1994).

		Step 1	*Step 2*	*Step 3*	*Step 4*	*Step 5*	*Step 6*	*Step 7*	*Step 8*	*Step 9*
No	Knowns	*Equation(s) applied in each step*								
1	T, T^*, T_D	1	5	3	9,15,18	9	12	15	6	24
2	T, T_D, P	1	3	9	12	15,21	5	15	6	24
3	T, W, P	1	11	4	12	15, 21	5	15	6	24
4	T, W, ϕ	1	25	10	4	12	15, 21	5	15	6
5	T, ϕ, h	1	25	8	10	4	12	15, 21	5	15
6	T, T^*, P	1	5	15	20	12	11	4	6	24
7	T, T_D, W	1	3	10	12	15, 21	5	15	6	24
8	T, ϕ, P	1	25	9	12	4	15, 21	5	15	6
9	T, W, h	Unresolvable								
10	T, T^*, W	1	5	22	16	12	11	4	6	24
11	T, T_D, ϕ	Unresolvable								
12	T, h, P	1	8	11	4	12	15, 21	5	15	24
13	T, T^*, ϕ	1	25	4	5	9, 20	9	12	15	6
14	T, h, T_D	1	8	3	10	12	15, 21	5	15	24
15	T, T^*, h	1	8	5	22	16	11	4	12	24
16	T^*, T_D, P	3	5	15	9	23	1	12	6	24
17	T^*, P, W	11	4	5	15	23	1	12	6	24
18	T^*, W, ϕ	5	1, 10, 20, 25	1	10, 25	12	15	11	4	6
19	T^*, ϕ, h	5	8, 9, 15, 18, 25	Apply step 2	1	12	25	4	9	15
20	T^*, T_D, W	3	10	5	15	23	1	12	6	24
21	T^*, ϕ, P	5	15	9, 20, 25	1	12	9	25	4	6
22	T^*, W, h	5	7	1	22	16	11	4	12	24
23	T^*, T_D, ϕ	3	5	26	2	9, 15, 20	9	15	12	6
24	T^*, P, h	5	15	19	11	4	7	1	12	24
25	T^*, T_D, h	5	3	9, 15, 18	9	7	1	12	15	24
26	T_D, P, W	Unresolvable								
27	T_D, W, ϕ	3	26	2	10	12	15, 21	5	15	6
28	T_D, ϕ, h	3	26	2	8	10	12	15, 21	5	15
29	T_D, P, ϕ	3	26	2	9	12	15, 21	5	15	6
30	T_D, W, h	3	10	7	1	12	15, 21	5	15	24
31	T_D, P, h	3	9	7	1	12	15, 21	5	15	24
32	P, W, ϕ	11	4	26	2	12	15, 21	5	15	6
33	P, ϕ, h	6, 9, 25	1	12	25	4	9	15, 21	5	15
34	P, W, h	7	1	11	4	12	15, 21	5	15	24
35	W, ϕ, h	7	1	25	4	10	12	15, 21	5	15

Solve resulting equation using numerical analysis

Solve resulting quadratic equation

I-P-E (Interactive Psychrometry Education) is being developed to use as a courseware in part of Thermodynamics course in food engineering program of Istanbul Technical University. Following the development of I-HEAT-ED (Devres and Duran, 2000), same idea and approach were applied to psychrometry. In this courseware, psychrometry knowledge, psychrometry calculator which employs the data and procedures given in Tables 2-6, (Devres, 1994) and sample problems written in Java were compiled.

Programming

In the computer program, 32 out of the 35 combinations have been solved successfully. In combinations 9, 11 and 26 (see Table 6), the equations could not be solved. In each of these cases, two of the equations differed only by a numerical factor, effectively reducing the number of free parameters and not permitting non trivial solutions (Devres, 1994).

A computer program which uses equations given in Table 5 and procedures shown in Table 6, was developed in Java. Each equation encountered in the calculation procedures of thermodynamic properties of humid air was evaluated as functions or procedures in using Java programming language. In this framework, 58 procedures and functions were defined and edited by using Microsoft Visual J++ 1.0 as an editor and compiled under the use of SUN Microsystem's JDK 1.1.x (Java Development Kit). Since Java is an object-oriented programming language, the program was designed in separate files with an extension of "filename.class" in order to increase re-usage of the codes.

As likely explained in Devres and Duran (2000), in the preparation of I-P-E, the course texts were written with HTML (MS Front Page and Arachnophilia) by using previously prepared MS Word documents. The example problems were prepared with Java.

The problems in the courseware are being developed to fulfill the planned instruction technique during the instruction of psychrometry as follows:

1. Stating the problem.
2. Teaching/discussing/explaining the standard solution.
3. Offering individual exercises for practicing the standard solution.
4. Receiving all results calculated by students and checking them by the means of program.
5. Discussing the results and working/non-working alternatives.

Application of I-P-E

During the preparation of the texts of Psychrometry, in general, Engineering Thermodynamics (Çengel and Boles, 1994), ASHRAE (Anon., 1981a) and "Psychrometric properties of humid air: calculation procedures" (Devres, 1994) are used. The courseware is prepared in Turkish and English. Screen shots of I-P-E are shown in Figures 1-4. Figure 1 shows the main menu of I-P-E. A sample Turkish page in psychrometry is presented in Figure 2. Psychrometric properties calculator and a problem written in Java are given in Figures 3 and 4, respectively.

Results and Discussion

When humid air is used as a working fluid, it is essential to use reliable data for any necessary calculation. A good method to perform these calculations is the usage of computer software embodying the perfect gas properties. In this study, such software has been developed in Java and utilized to obtain the psychrometric properties of humid air. In addition to this program, a part of Thermodynamics which is compulsory in undergraduate food engineering program in Istanbul Technical University for four credits, the knowledge of psychrometry is presented both in Turkish and English and sample problems in Java are also supplied. The application of I-P-E in the Thermodynamic courses was found helpful to teach the psychrometry subject.

The legal and ethic concerns in electronic education are not defined yet (Devres and Duran, 2000). The intellectual property rights both in (i) the data being reproduced by way of scan, re-type, saved files in electronic medium as a part of e-education lecture text and (ii) the e-education text, itself, are the key elements in e-education developments (Basci Devres, 2000).

The creation of an effective courseware using Web-based technologies is a great deal of work (Devres and Duran, 2000). The industrial revolution did not occur over night nor can we expect that the computer revolution in education to realize in one semester (Norman, 1997). In the following years, whether we accept it or not, we will be involved in electronic education transition age with all changes thereto. Explorations of general principles for the design of effective learning environments and the architecture of the human/computer interface will be of concern to designers, who are us, of computer-based education systems. We are, also, as role models for our students whom are being educated in new instructional technologies and are going to develop better educational implementations using this knowledge. Therefore we have common responsibilities and mutual benefits to move in the direction of new technologies to fill the void and meet the challenge of electronic education.

Today is the time to re-discover “the America”!

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Notation

A	Constant defined in Table 3
B	Constant defined in Table 3
C	Constant defined in Table 3
D	Constant defined in Table 3
E	Constant defined in Table 4
F	Constant defined in Table 4
G	Constant defined in Table 4
h	Enthalpy of humid air (kJ/kg)
h_w*	Specific enthalpy of condensed water at the thermodynamic wet-bulb temperature and a pressure of 101 325 (Pa) (kJ/kg)
H	Constant defined in Table 4
K	Constant defined in Table 4
p_w	Partial pressure of water vapor in humid air (Pa)
p_{ws}	Pressure of saturated pure water (Pa)
P	Total pressure of humid air (Pa)
R_a	Gas constant for dry air (J/kg K)
T	Dry-bulb temperature (°C)
T*	Wet-bulb temperature (°C)
T_D	Dew-point temperature (°C)
v	Specific volume of humid air (m^3/kg)
W	Humidity ratio of humid air (kg/kg)
W_s	Humidity ratio of humid air at saturation (kg/kg)
W_s*	Humidity ratio of humid air at saturation at thermodynamic wet-bulb temperature (kg/kg)
α	Parameter defined in Table 3
β	Parameter defined in Table 4
ϕ	Relative humidity
μ	Degree of saturation

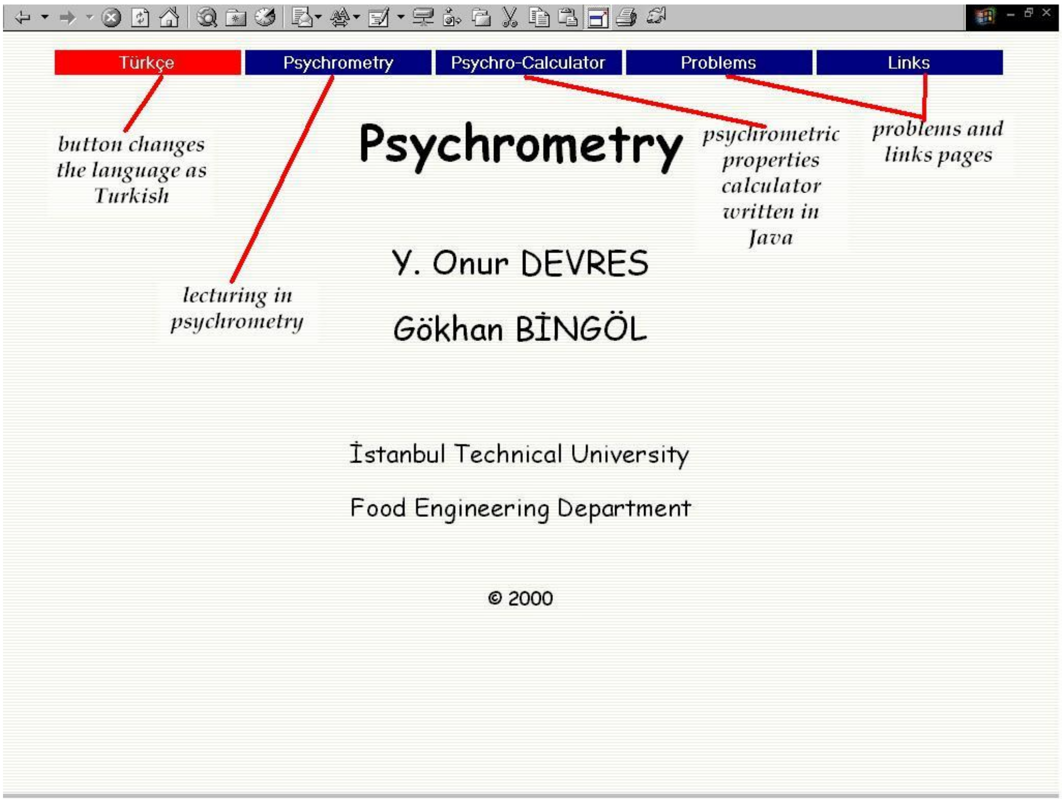

Figure 1. The main menu of I-P-E

Figure 2. Lecturing psychrometry in Turkish

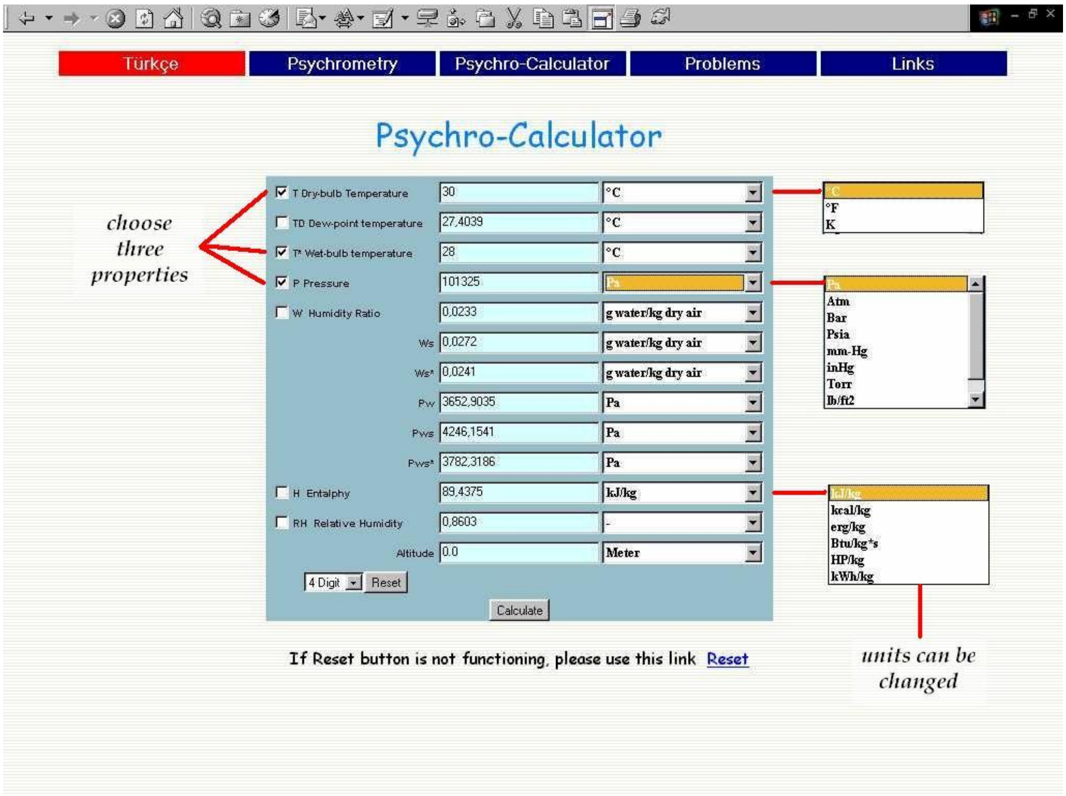

Figure 3. Sample page shows psychrometric properties calculator

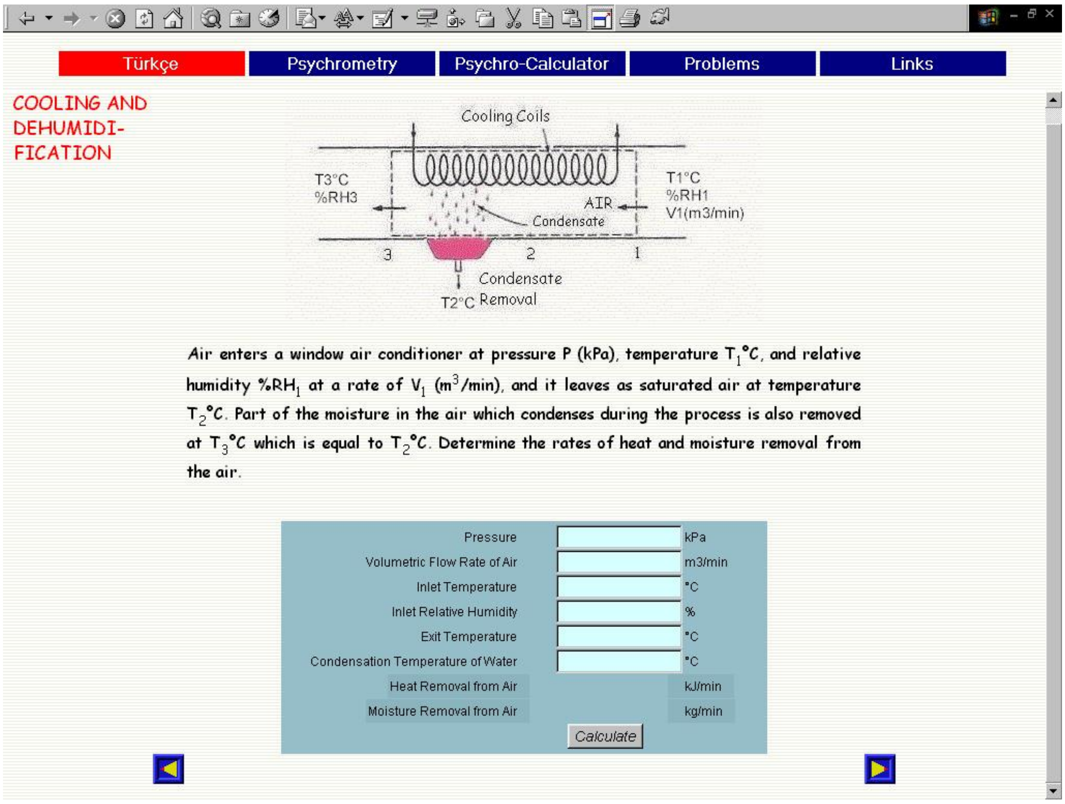

Figure 4. Sample page defines a problem