# General Information:

Name of Course: Energy systems 2. (Heat and Humidity)

Course Code: MSE046ANEM

Semester: 5th

Number of Credits: 3

Allotment of Hours per Week: 1 Lectures and 2 Practical Lessons /Week

Evaluation: colloquium

Prerequisites: Building Constructions Studio 1.

Responsible lecturer: László FÜLÖP PhD, professor emeritus

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## General Subject Description

Thermal conductivity, Heat transfer coefficient, Multidimensional heat flow, thermal bridges, Non-steady state heat transfer, Heat storage capacity, Psychometry, Solar radiation, Shadow chart, Energy balance of windows, Energy in buildings basics.

## Learning Outcomes

## Get to know the thermal basics, requirements, regulations, regulations and EU directives of building physics and building energy.

## Subject content

Basic forms of heat transfer, thermal transmittance coefficient, layer boundary temperatures. Multidimensional heat flows, thermal bridges. Linear heat transfer coefficient and resulting heat transfer coefficient. Heat flow of surfaces in contact with the ground. Radiant thermal balance of glazed structures. Properties of wet air. Moisture uptake of porous materials, sorption isotherm. Surface condensation, capillary condensation, mold growth. Room humidity balance. Evaporative diffusion in steady state and non-steady state cases. Moisture content of the structures, filling time. Ecliptic diagram, insolation and shading. Unsteady processes in time: heat storage mass, damping, delay. Energy requirements for buildings, building energy standards, regulations. The basics of energy in buildings. To control the risk of summer overheating. Thermal comfort basics.

## Examination and evaluation system

*In all cases.* *Annex 5 of the Statutes of the University of Pécs, the* ***Code of Studies and Examinations (CSE) of the University of Pécs*** *shall prevail. https://english.mik.pte.hu/codes-and-regulations*

Attending is required all classes, and will impact the grade (max. 10%). Unexcused absences will adversely affect the grade, and in case of absence from more than 15% of the total number of lesson (it is max. 2 lesson) will be grounds for failing the class. To be in class at the beginning time and stay until the scheduled end of the lesson is required, tardiness of more than 20 minutes will be counted as an absence. In the case of an illness or family emergency, the student must present a valid excuse, such as a doctor's note.

All homework must be prepared and submitted within the deadline set by the lecturer. Late submission results in point reduction.

Course signature: attending classes, all homework submitted and accepted.

Mid-term test: calculations. The required level: at least 50%

Final test (exam): theory questions, formulas, diagrams. The required level: at least 50%

Grading will follow the course structure with the following weights:

Average calculated by the homework, mid-term test and final test as follow:

Homework: 20%

Mid-term test: 40%

Final test: 40%

Total: 100%

Grading Scale:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Numeric Grade: | 5 | 4 | 3 | 2 | 1 |
| Explanation: | A, excellent | B, good | C, average | D, satisfactory | F, Fail |
| Evaluation in points: | 85%-100% | 71%-84% | 60%-70% | 50%-59% | 0-49% |

## Readings and Reference Materials

**Required:**

* + EN 832:2002 standard
	+ EN ISO 6946:2007 (Thermal conductance resistance and Heat transfer coefficient)
	+ EN ISO 13789:2000 (Thermal behavior of buildings)
	+ EN ISO 13790 (Thermal performance of buildings)
	+ EN ISO 10211-1:1998 (Heat flux at thermal bridges and surface temperatures)
	+ EN ISO 14683:2003 (Thermal bridges, linear heat transfer coefficients)
	+ EN 12207:2001 (Air tightness of doors and windows)
	+ Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings.
	+ Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast) Nearly zero energy building (nZEB)
	+ Directive 2018/844 EU: Revised EPBD (19. June 2018)

**More:**

* + Gudni A. Jóhannesson, Building Physics, TERC Kft. • Budapest, 2013
	+ Victor and Aladar Olgyay: Solar Control and Shading Devices – February 21, 1977 nd Bioclimatic Approach to Architecture, Design with Climate: Bioclimatic Approach to Architectural Regionalism, 1963
	+ Carl-Eric Hagentoft (Author), Introduction to Building Physics – January 1, 2001

## Methodology

Presentations illustrated by projection. The material of the lectures and handouts are to be sent via the Neptun system.

Practice solving numerical examples and consulting on homework assignments.

The course is based on through collaboration, participation and discussions trough lessons. This is an interaction between Students and Faculty; used the teaching methods like ‘Problem-based learning’ and ‘learning-by-doing’. The communication and work should be reflect a respect for fellow students and their desire to work. (You will need: ruler scale, sketchbook, pencils, pens, rulers, callipers, pocket calculator.)

## Students with Special Needs

Students with a disability and needs to request special accommodations, please, notify the Deans Office. Proper documentation of disability will be required. All attempts to provide an equal learning environment for all will be made.

# Detailed requirements and schedule of the Course

## Schedule

(Excluding the semester break)

|  |  |  |
| --- | --- | --- |
|   | **LECTURE** | **PRACTICE** |
| Week 1 | Introduction, main tasks and aims | Main fields of heat and humidity technologies in architecture |
| Week 2 | Comfort standards, Design criteria for the indoor environment | Energy certificate of buildings. Consistency, wetting issues |
| Week 3 | Thermal balance, Steady state air-to-air conductanceThermal conductivityRadiant heat exchangeThermal transmittance through a multi-layer structureHeat transfer coefficient | Convective heat transfer coefficientsU-value calculations |
| Week 4 | Multidimensional heat transfer, thermal bridges. Insulated structural thermal bridges. Linear thermal transmittance coefficient.Thermal bridge standards. | Homework supervisionLinear thermal transmittance coefficient of reinforced concrete beams, ribs  |
| Week 5 | Point thermal transmittance Timber structuresResultant heat transfer coefficient | Homework supervisionSteel rods through the thermal insulation Timber structures average U-value |
| Week 6 | Heat transfer via groundSlab-on-ground floor, ways of thermal insulationLinear thermal transmittance coefficient of ground contact floor and wall | Homework supervisionRelated calculation examples |
| Week 7 | Non steady state heat transferHeat storage capacityThermal massDaily heat storage cycleTemperature fluctuation in the structure by location and timeAttenuation, time lag (summer case)Thermal mass of a room / building, classification by thermal massEffect of the thermal mass (capacity) | Homework supervisionThermal mass calculations |
| Week 8 | Consistency, humidity issuesTemperature profile within a structureFrost zone within a structure | Homework supervisionTemperature profile calculation, seeking for the frost zone  |
| Week 10 | Humid Air, Water vapour in air, vapour pressure, diffusion, gas mixture. Saturation and relative humidityMollier h-x diagramCarrier Psychrometric ChartInside temperature of the surfaceMoisture storage function of porous materials. Capillary condensation. | Homework supervisionFinding condensation temperature in Mollier h-x diagramCalculation of the U-value related to condensation and capillary condensation temperature. |
| Week 11 | Moisture penetration, vapour diffusion. Acceptable moisture content. Vapour transfer fluxAnalysing the partial pressure diagramNon-steady state analysis. Calculation of the vapour subsidence timeConvective moisture transport | Homework supervisionCalculation of vapour transfer flux and pressure distribution across the structure. Drawing of the partial pressure diagram |
| Week 12 | Solar radiationStereographic ecliptic diagram | Homework supervisionDrawing the shadow mask for a facade |
| Week 13 | Energy balance in buildingsEnergy loss and energy gain In the heating season. Transmission and ventilation heat losses. Power and energy. Energy balance of windows | Homework supervisionRelated calculations |
| Week 14 | Heat transfer coefficient of windowsLow emissivity surface coatingsShading, smart glazing | Homework supervisionRelated calculations |
| Week 15 | Summary | Summary |

László FÜLÖP PhD

responsible lecturer

Pécs, 01.10. 2019