COURSE: PHYSICS

(PHYSICS OF NATURE AROUND US)

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GENERAL INFORMATION

COURSE: PHYSICS

TYPE: FUNDAMENTAL (BASIC)

STATUS: OBLIGATORY (CREDIT/EXAMINATION)

AIMS:

- explanation of basic phenomena around us in the nature
- announcement of their potential application in control, electronics and information engineering (CEIE)

in relation to main idea of branch of Interdisciplinary Studies (IS)

THEMATIC SCOPE:

Analytical description of the basic natural phenomena around us in our the sourrounding on the base of main physical concepts and ideas

in compliance with program standards of the Polish Ministry of Science and Higher Education

GENERAL INFORMATION

FORMS

- **LECTURES:** 60 hours - semester II (30) and semester III (30)
  main physical concepts, ideas, models, laws, principles
- **CLASSES:** 30 hours - semester II (15) and semester III (15)
- **LABS:** 30 hours - semester III
  Lucyna GZĄDZIEL (Assoc.Prof.) and other members of IP CSE (?)

CREDIT/EXAMINATION

- **Semester II:**
  Credit for Classes: final colloqium combined with activity at Classes
  Credit for Lectures: colloqium on theoretical topics given at lectures
  Final grade: average of E+C (weighted) + participation in lectures
- **Semester III:**
  Credit for Classes: as above
  Credit for Labs: set of 12 experiments (details in III semester)
  Examination: theoretical topics given at lectures
  Final grade: average of E+C+L (weighted) + participation in lectures

INTRODUCTION

MOTIVATION (PRACTICAL ASPECTS)

Understanding of physical (natural) effects around us – base of general knowledge of engineering students in aspect for its potential application (!)

Most common physical effects we observe around us, which we have to understand – selected examples and basic questions:

- **why we feel effects of restrain/acceleration, and falling out of a turning car?**
- **why a parashut (rain droplets) do not free fall in the atmosphere?**
- **what is a cause and direction of air flow, and can we forecast a weather?**
- **what is a cause of the vibration (oscillation) of pendulum, string ..?**
- **why wave appears at surface of sea (lake) water ?**
- **why stone droping into a standing water generates a concentric wave?**
- **why milk run out from a pot during heating, and balloon rises in atmosphere?**
- **why water evaporates even at room temperature?**
- **why we have no hydrogen in Earth atmosphere?**
- **why atmospheric pressure decreases with increasing of height?**
- **why temperature in atmosphere decreases with increasing of height?**
- **why liquid creates droplets, and flows in a form of flux (stream)?**
- **why apple falls from a tree, but a Moon moves in orbit?**

INTRODUCTION

MOTIVATION (PRACTICAL ASPECTS)

Most common physical (nature) (effects) we observe around us, which we have to understand – subsequent examples and basic questions:

- why charge is always located at the surface of conductor (tube, sphere, etc)?
- when and why lighting, tunderbolt appear in the atmosphere?
- why magnetic needle „feels" magnetic field of Earth, and the flowing current?
- why during switch-on/off of heaters a flash appears?
- why color of sky around Sun is different during the sunrise and sunset?
- why light is refracted at media interface, but is diffracted on a slit?
- why sky is blue, when Sun light is green?
- why fruits have a specific color(s), wheras the clouds and milk are white?
- why we can see air motion at the surface of highway?
- when and why do we observe dust in the air?
- why light of car's lamps is scattered in the dust?
- when and why a rainbow appears on the sky?
- why do we observe an apparent position of stars during the Sun eclipse?
- why white stream appears when airplane starting from the airport?
- why during a sunny day a room interior from outside is not visible?
- why pinch of salt on blazing gas creates a yellow stream?
- and many others ?

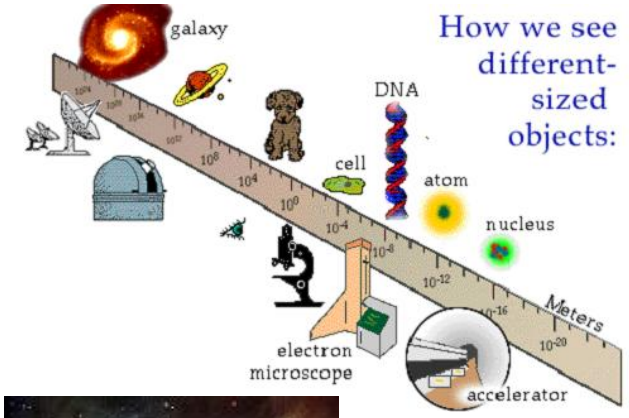
INTRODUCTION

MOTIVATION (GENERAL ASPECTS)

Scientific attempt to understanding of basic physical phenomenon - 95% of Universe remains with secret - what do we really understand ?!

PHYSICAL UNIVERSE – NATURE

physical world of matter: wide range of dimension, mass, time, density



- **35 orders of dimension(s):**
- **70 orders of mass (kg)**

electron (~10^{-30}) - Earth (~10^{24}) - Galaxy (~10^{40})

- **35 orders of time (s)**

pion (π) (~10^{-16}) - heartbeat (~1) - Earth (~10^{17})

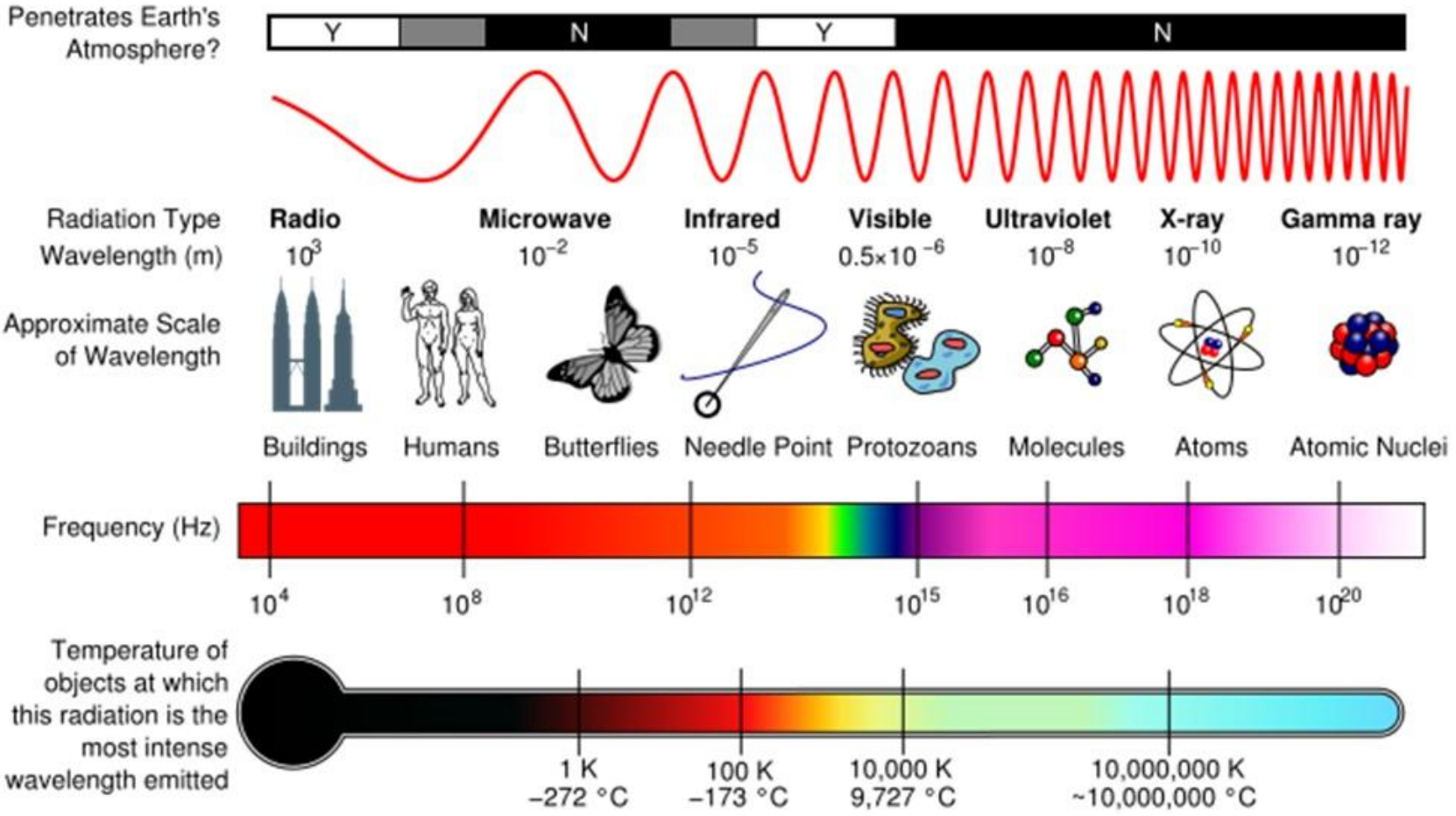
- **35 orders of density (1/ccm)**

interstellar matter (10^{5}) - Sun (~10^{20}) –
neutron stars/black holes (10^{40})

INTRODUCTION

PHYSICAL UNIVERSE – NATURE

physical world of matter: wide spectrum of electromagnetic radiation



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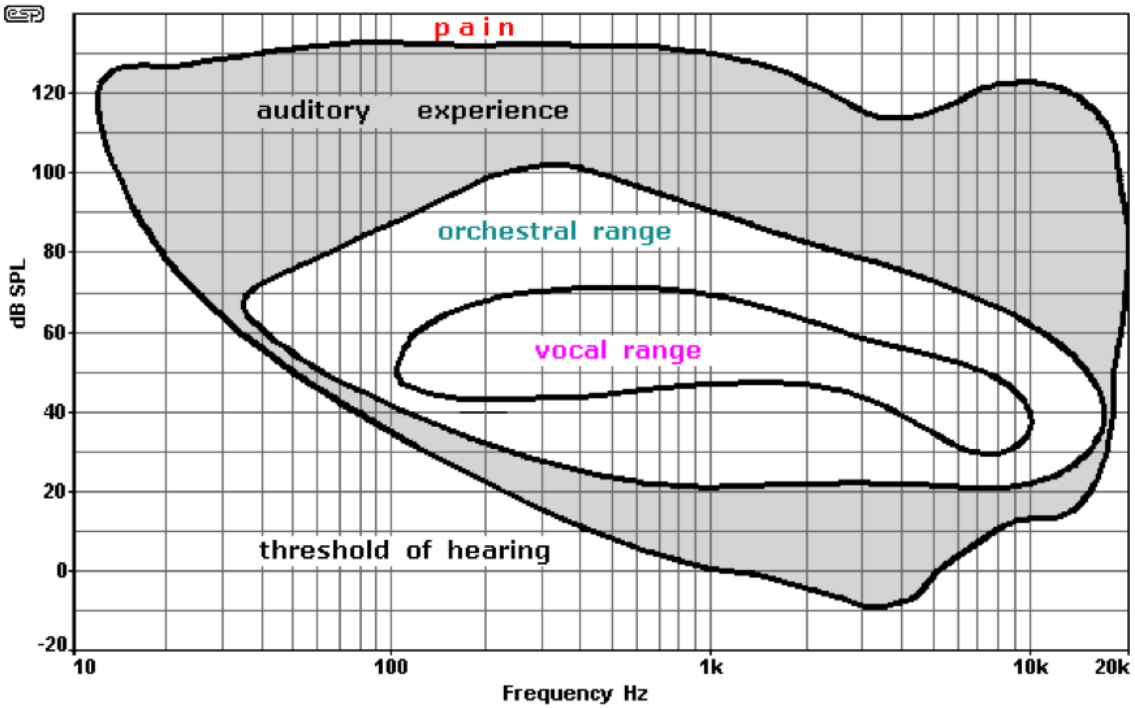
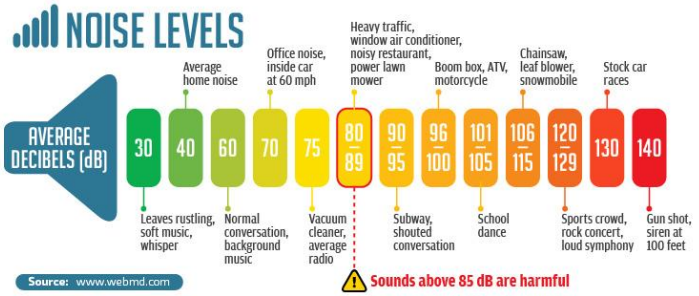
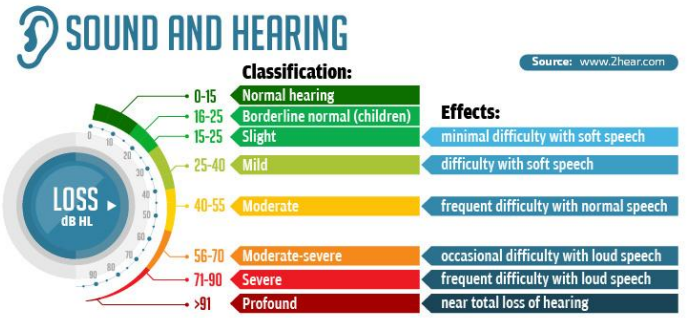
PHYSICAL UNIVERSE – NATURE

physical world of matter: wide spectrum of the acoustic – sound waves

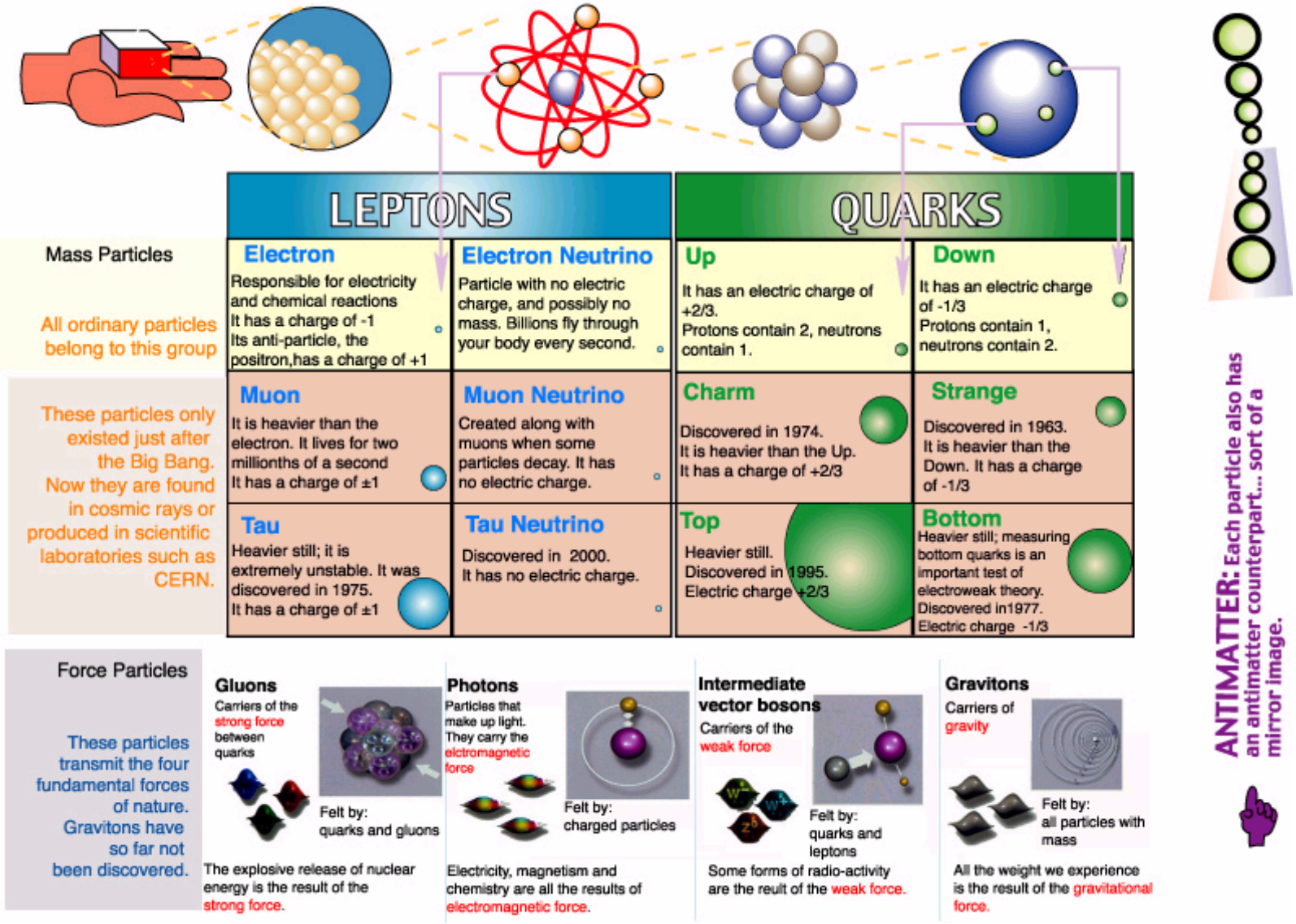






INTRODUCTION

FUNDAMENTAL PARTICLES IN UNIVERSE - CLASSIFICATION



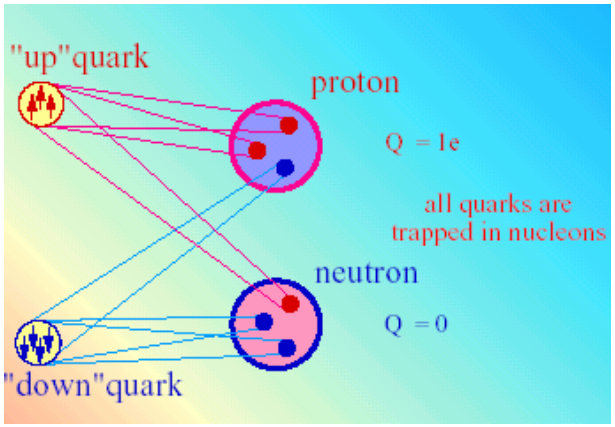
INTRODUCTION

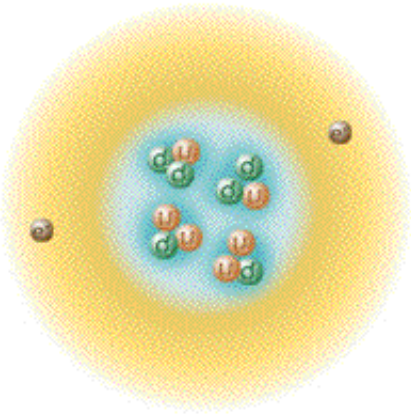
FUNDAMENTAL PARTICLES IN UNIVERSE - CLASSIFICATION

Smallest fundamental particles – quarks, their combination

Every mass particles = combination of selected quarks:

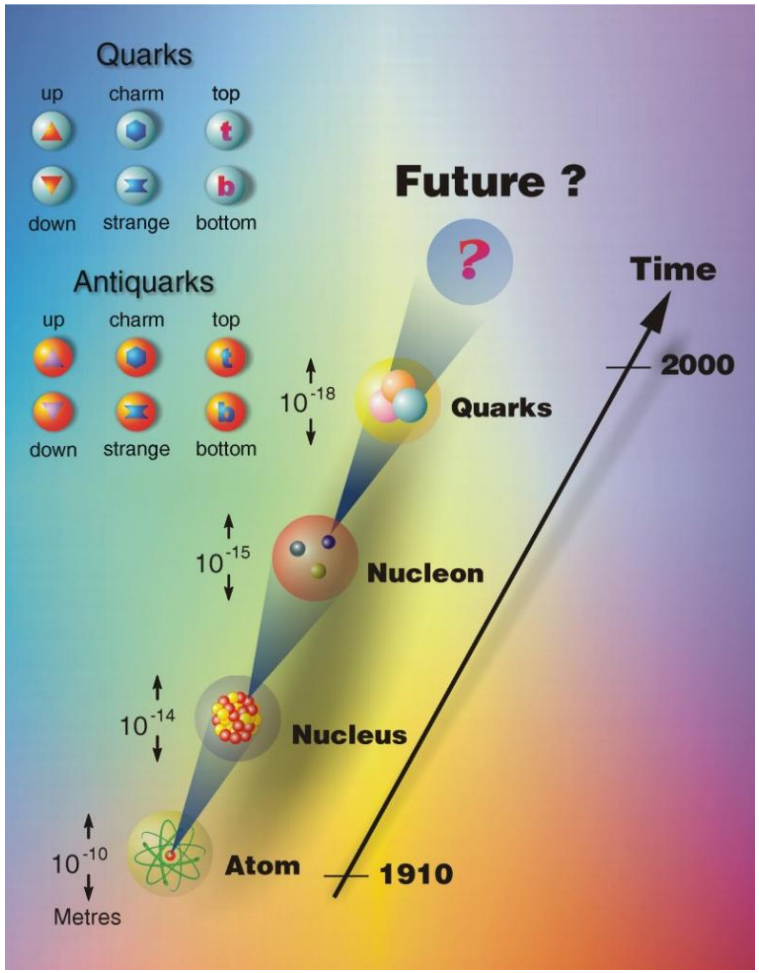
- **proton: triangle d-u-u**
- **neutron: triangle d-d-u**
- **deuteron: triangle d-u-u + triangle d-d-u**
- **tritium: proton + 2 neutrons: d-u-u+2(d-d-u)**





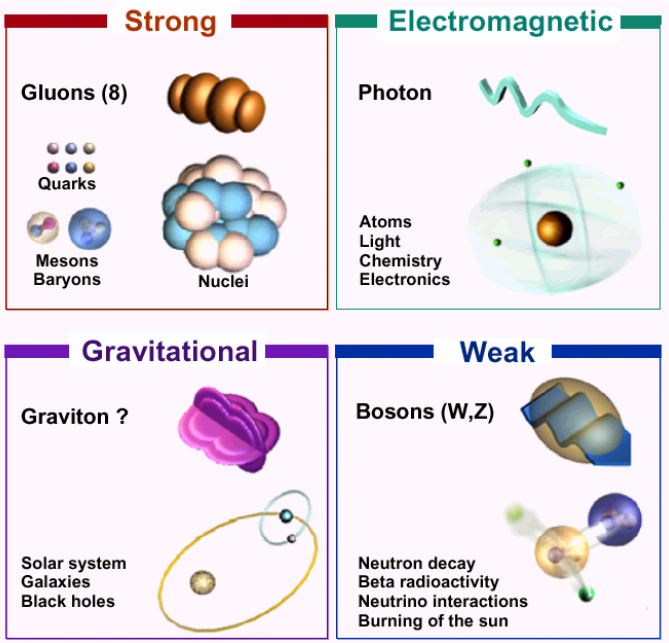
Particle's dimension:

- **quarks - 10^{-18} [m]**
- **nucleons (proton, neutron) - 10^{-14} [m]**
- **atoms - 10^{-10} [m]**



INTRODUCTION

FUNDAMENTAL PARTICLES – FUNDAMENTAL INTERACTIONS



Type	Particles	Relative intens.	Interaction time (s)	Range (m)
Strong	Quarks	1	10^{-24} - 10^{-22}	10^{-15}
Electro-magnetic	Charged	10^{-2}	10^{-20} - 10^{-16}	Very long
Weak	Leptons	10^{-5}	10^{-10} - 10^{-8}	10^{-18}
Gravitation	All	10^{-38}	1	infinite

Specific role f Higgs boson: joins fundamental interactions in Universe – Discovery: VII, 2012? (LHC) - reference mass of other particles

m ~ 10^{-25} kg

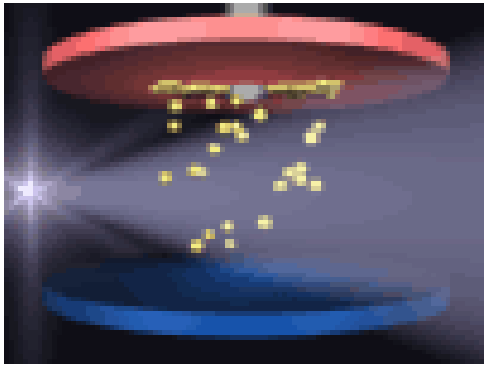
Without any doubts and controversions: only 4 stable elemental particles: electron (e), proton (p), neutrino, photon γ, and their anti-particles.

INTRODUCTION

EXPLORING OF NATURE - PHYSICAL KNOWLEDGE

- **PROCEDURE:**
  - experiments
  - simulations

  character: exact science

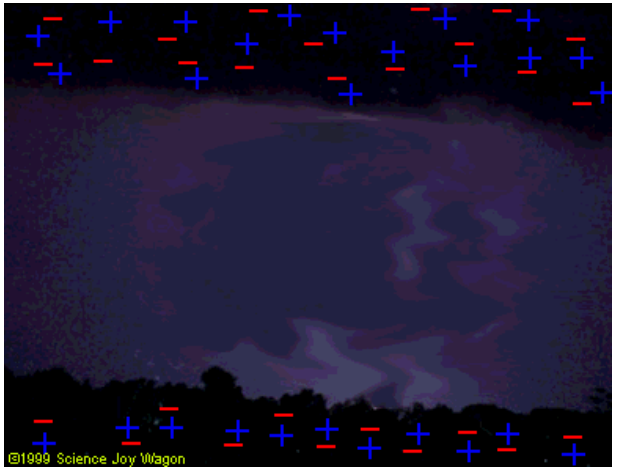


- **METHOD:**

  Physical parameters - quantitative mathematical relations - high precision and univocal - contrary to only descriptive humanistic and social sciences

- **APPROACH:**

  Storage of physical facts: 4 steps
  - observation (accident or record)
  - measurement (procedure)
  - data analysis - hypothesis - model - law
  - testing and prediction for further studies



- **KNOWLEDGE:**

  Well-ordered set of physical ideas on basis of physical facts

INTRODUCTION

EXPLORING OF NATURE - PHYSICAL KNOWLEDGE

- **MAIN IDEAS:**

  time space particle wave field force:
  exploration of physical knowledge
  - development of physical ideas

- **STRUCTURE:**

  single facts (phenomena) - laws and principles

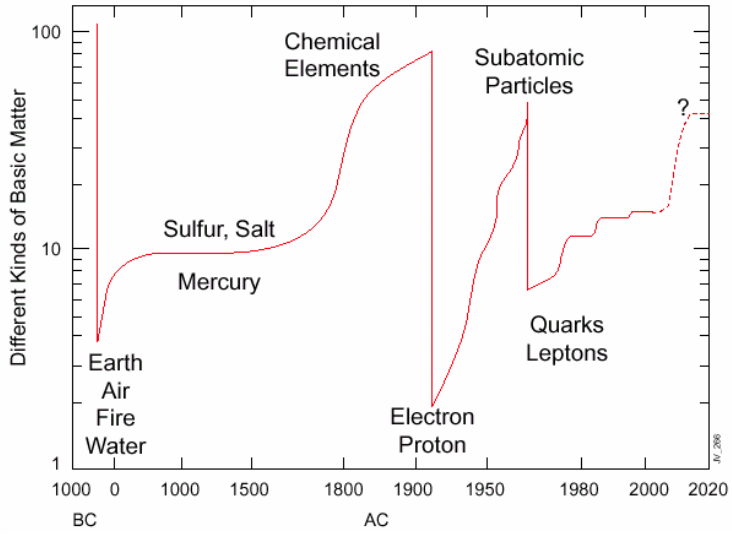
- **LAWS:**

  only approximated and open for new facts
  - extension of applicability

- **PRINCIPLES:**

  universal and invariable (in Universe)

old ancient idea: 4 basic elements



GENERAL CHARACTER OF PHYSICS:

„open" science - new facts (discovery)
- new mental horisons - flexible borders
of universe cognizability - cosmology

INTRODUCTION

IMPORTANCE OF PHYSICAL DEVELOPMENTS

- **FUNDAMENTAL:**
  extension of human knowledge on nature - valuation by NOBEL PRIZES
- **APPLIED: (main achievements - chosen examples)**

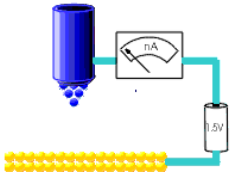
thermodynamics - **engine - transport**

- **energy power stations**

electromagnetism - **phone, radio, tv**

wave optics - **lightguides - optoelectronics - telecommunication**

quantum physics - **laser, maser, light sources**



atomic physics - **tunneling (probing) microscopy**

solid state physics - **materials - devices - systems**
microelectronics (S2, I sem.)

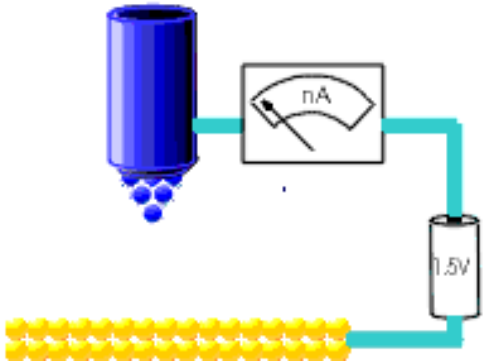
INTRODUCTION

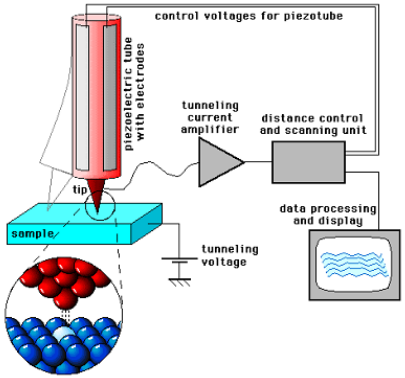
PHYSICAL DEVELOPMENTS FOR RESEARCH APPLICATION

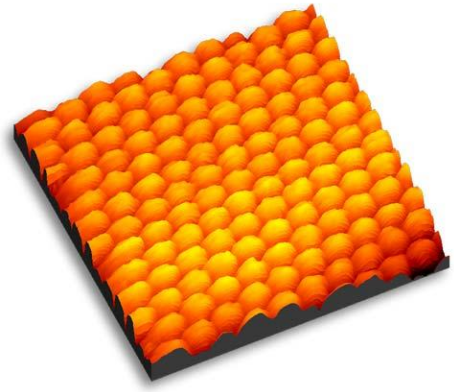
Example: tunneling effect(s)

Main application: scanning tuneling microscopy (STM) and related methods

Idea: Binning and Rohrer (IBM Zurich) – 1978; NP - 1986

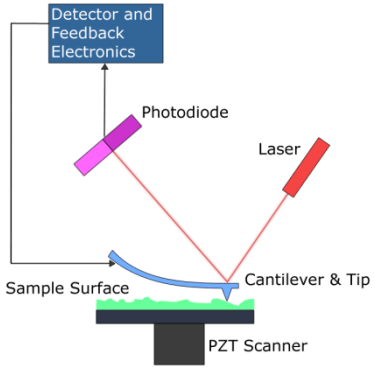


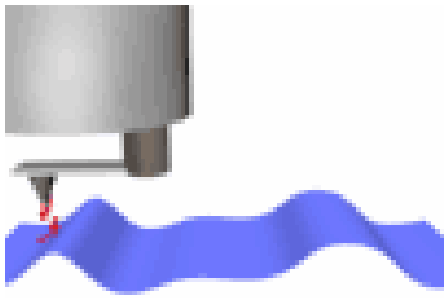


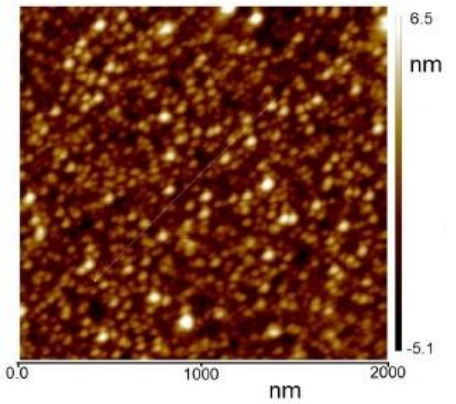


- **outstanding method of topographic analysis of surfaces in nm (atomic) scale**

Optical version of scanning microscopic methods - atomic force (AFM)







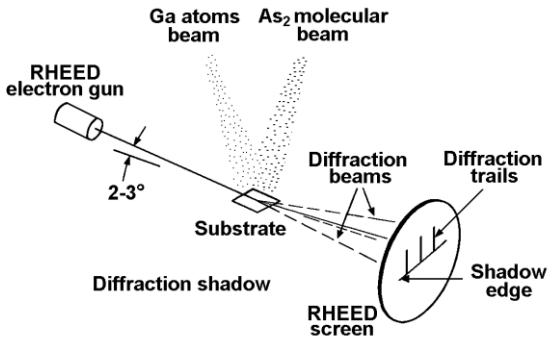
INTRODUCTION

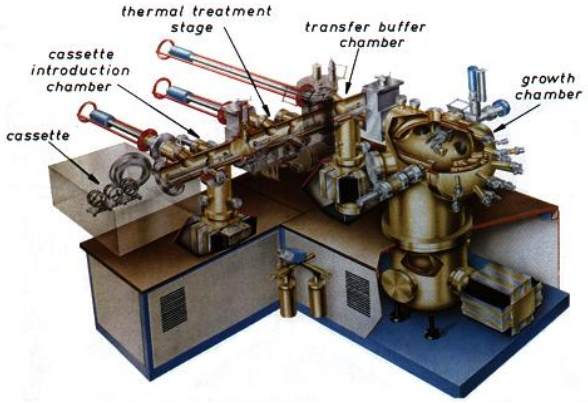
PHYSICAL DEVELOPMENTS FOR TECHNOLOGICAL APPLICATION

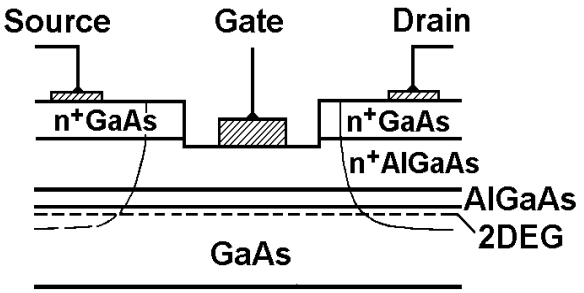
Example: nanotechnology of novel electronic materials/structures (nm scale)

IDEA: deposition of nanostructures by Molecular Beam Epitaxy (MBE) -Cho (1969)

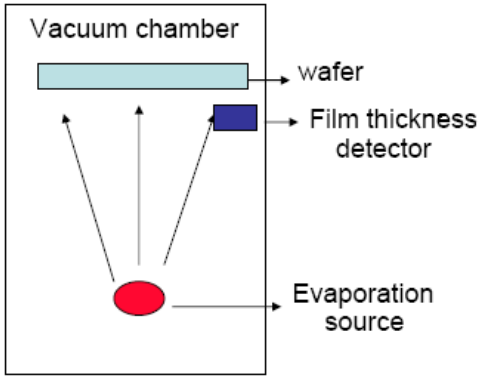
Processes controlled *in situ* by physical/chemical surface analytical methods !

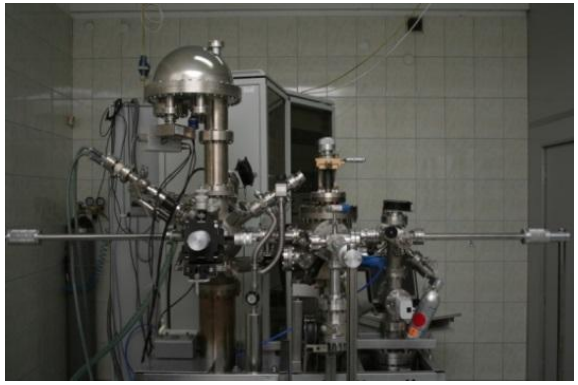


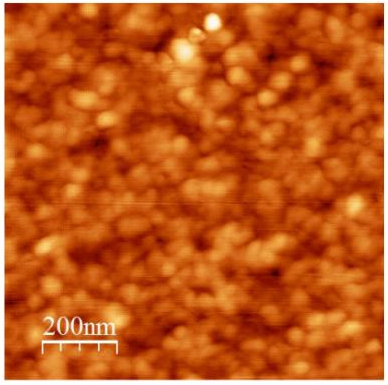


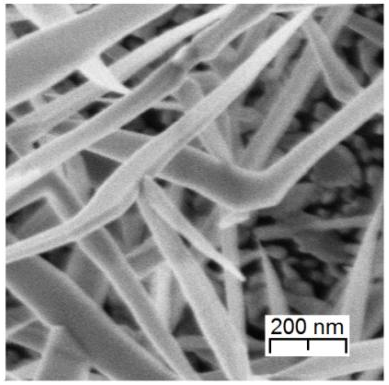


Nanomaterials of various dimensionality (nanowires, nanolayers – deposition methods







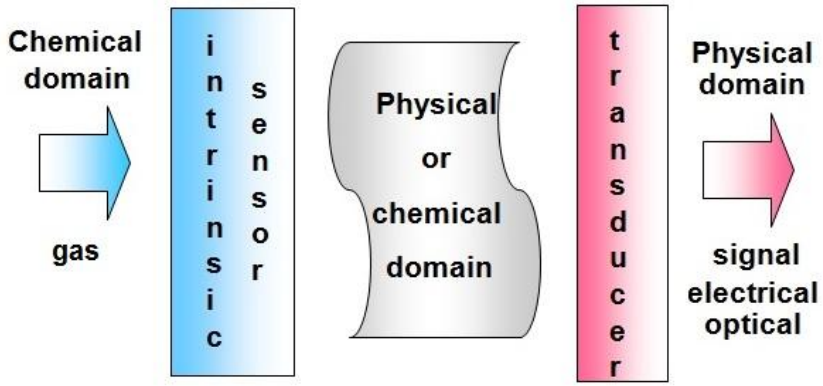


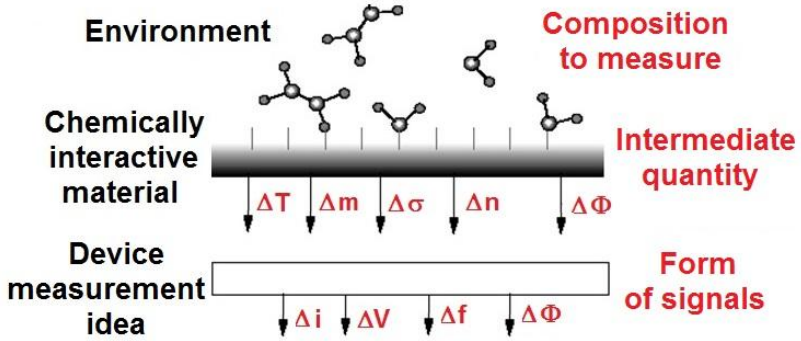
INTRODUCTION

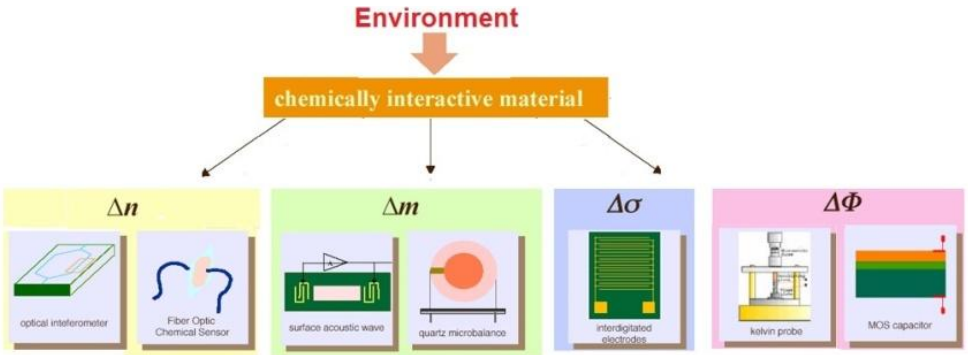
PHYSICAL DEVELOPMENTS FOR DEVICE APPLICATION

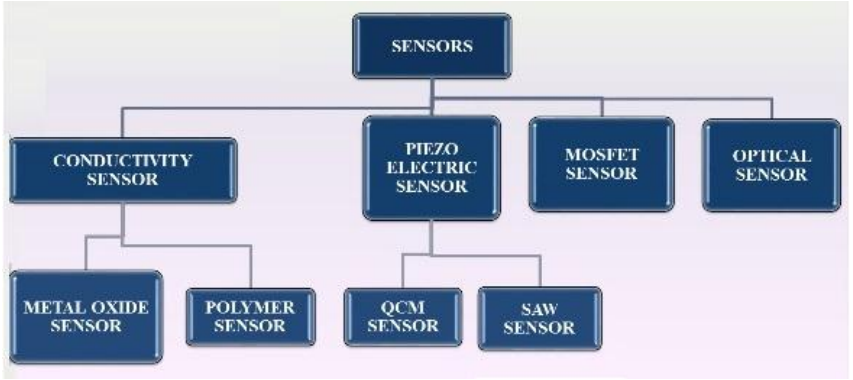
Example: chemical gas sensors - devices for environmental control

IDEA: measurement of toxic gas composition in environment by chosen physical and chemical effects in the form of various signals









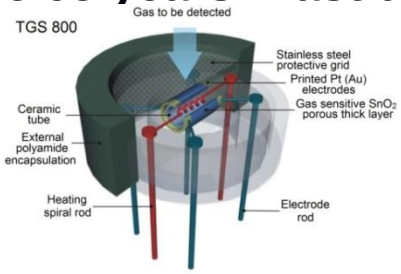
INTRODUCTION

PHYSICAL DEVELOPMENTS FOR DEVICE APPLICATION

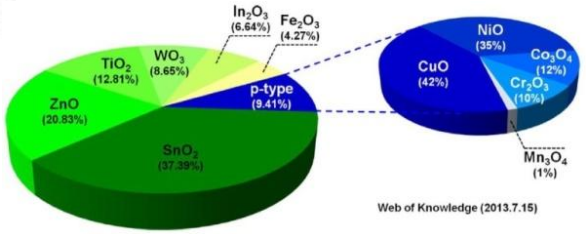
Example: most common gas sensors devices – conductometric MOX type

IDEA: Seyama (1962), Taguchi patent (1968) - FIGARO TGS first gas sensors

Since 65 years - fast development of various commercial MOX GS

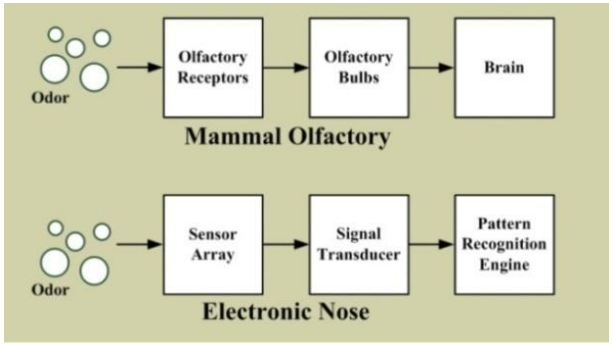


Heart of MOX gas sensors: various n and p-type conductive oxides (CO)



Last 50 years - MOX GS wide application –

Most spectacular device: artificial olfactory system - ELECTRONIC NOSE (EN) (Persaud, Gardner - 80.,) - poor anal.parameters in relation to human olfaction system (nose) - (Axel, Buck - 90.; Nobel Prize in medicine - 2004)



EN modern wide application: air and food quality monit.

Most spectacular system: CYRANO 320 EN - recogn. of cancer by breath analysis

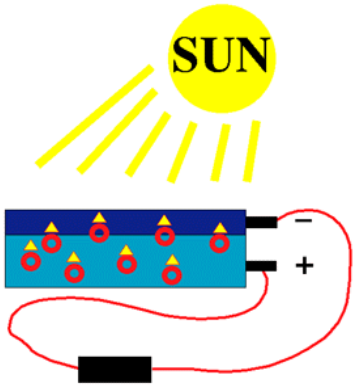
INTRODUCTION

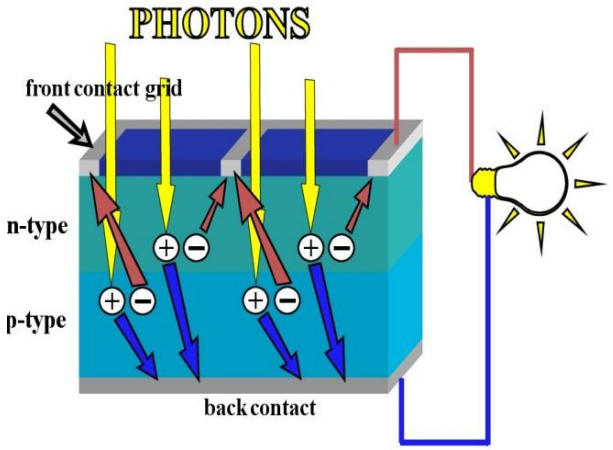
PHYSICAL DEVELOPMENTS FOR DEVICE APPLICATION

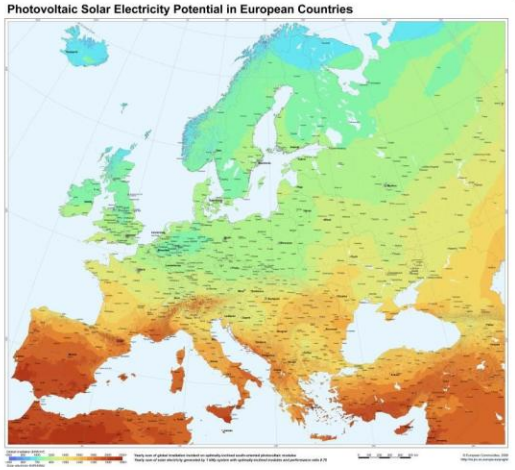
Example: photovoltaic devices as the renevable energy sources

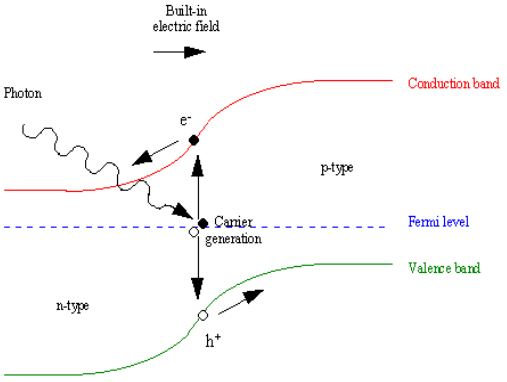
Idea: semiconductor heterostructures p-n: photocurrent generation

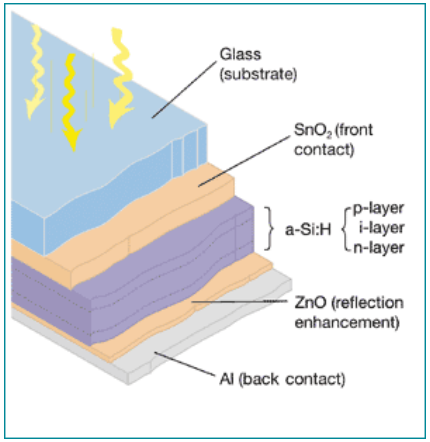
First solar battery - Chapin-Bell (1954); first solar panel – Sharp (1963)

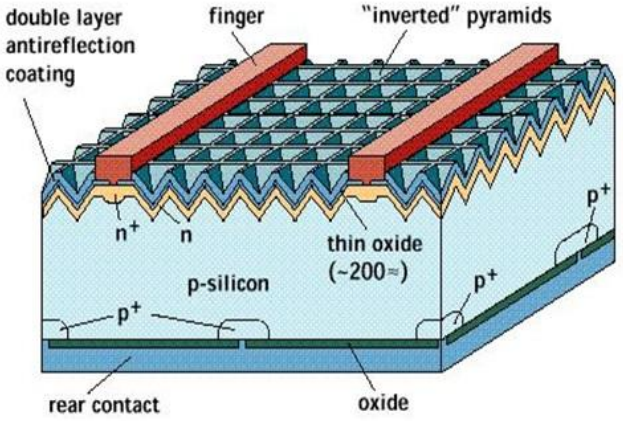












INTRODUCTION

PHYSICAL DEVELOPMENTS FOR DEVICE APPLICATION

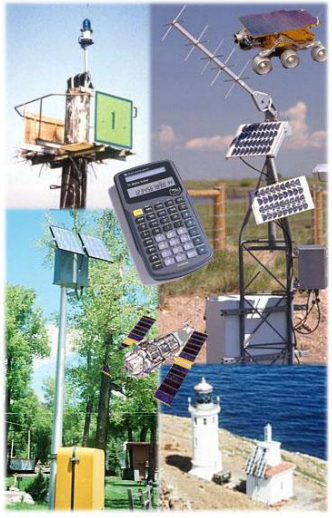
Example: photovoltaic devices as the renevable energy sources

ASSEMBLY SYSTEMS (at roof - our Faculty), free standing, follower)




AUTONOMIC VEHICLES
(cars, yachts, satelites, airplanes)


MOVABLE ELECTRONICS
(mobiles, calculators, crossing lights)



INTRODUCTION

PHYSICAL DEVELOPMENTS FOR DEVICE APPLICATION

Example: photovoltaic devices as the renevable energy sources

SOLAR ENERGY POWER STATIONS (solar farms - examples)

Waldpolenz Solar Park
Germany (40 MW)

Olmedilla Solar Park
Spain (60 MW)

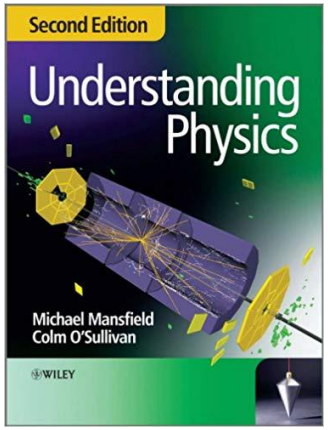
Wierzchosławice
Poland (1 MW)

Main limitations of solar systems as common renevable energy sources: high costs, limited Sun radiation in many places, available ground places

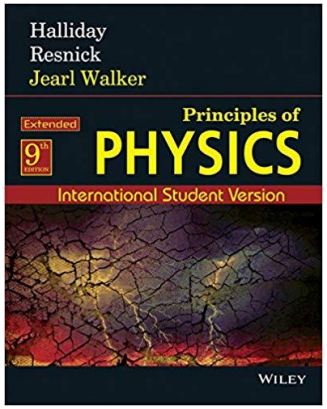
Europe: novel policy in some countries (Spain, Germany, etc.) related to climitatic danger problems – great challenge for all the World

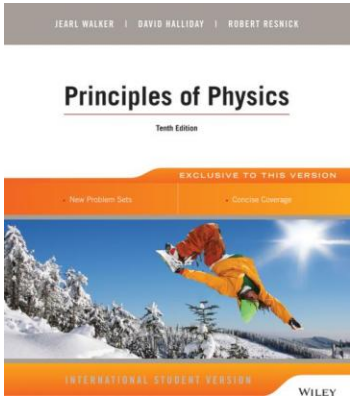
INTRODUCTION

BIBLIOGRAPHY - REFERENCES:



- **UNDERSTANDING PHYSICS**
  M. Mansfield, C.O'Sulivan
  Wiley, NY (several copies in SUT Library)





- **PRINCIPLES OF PHYSICS**
  Halliday, Resnick, Walker
  Wiley NY, USA
- **PRINCIPLES OF PHYSICS**
  Walker, Halliday, Resnick
  Wiley NY, USA

- **FUNDAMENTAL PHYSICS**
  J.Orear
  Mc Millian Publishing Co., NY, USA

Any any others Books and Textbooks on Physics (incl. Polish)

INTRODUCTION

OUTLINE OF TOPICS – SEMESTER 1

CLASSICAL MECHANICS

- Kinematics and dynamics of material point
- Conservation principles for material point
- Kinematic and dynamics of rigid body
- Concervation principles of rigi body

MECHANICAL VIBRATIONS (OSCILLATIONS)

- Kinematics and dynamics of various forms of vibrations

MECHANICAL WAVES

- Classification and characteristics of waves including sound waves

THERMAL EFFECTS INCLUDING GAS MECHANICS

- Temperature and phase transitions
- Gas properties including transiitions
- Kinetic theory of ideal gas
- Thermodynamics of gas systems

MECHANICS OF FLUIDS

- Static and dynamic characteristics of fluids