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STUDY OF THE PHYSICS TEACHING AND RESEARCH IN THE TECHNICAL UNIVERSITIES

Erik BODEGOM[1], Dan-Alexandru IORDACHE[2]

Rezumat. *Pornind de la constatarea evoluţiei Fizicii (reieşind din principalele rezultate obţinute în cadrul premiilor Nobel pentru Fizică), această lucrare studiază posibilităţile de: a) optimizare a alegerii temelor de bază ale Fizicii predate în Universităţile tehnice, b) efectuare a unor cercetări ştiinţifice de valoare în cadrul celor mai bune Universităţi naţionale (BNU) care n-au obţinut premii Nobel pentru Fizică, c) obţinere a unor rezultate complementare utile (raportate la rezultatele obţinute în cadrul "curentului de bază" al Fizicii) prin studiile ştiinţifice BNU ale unor teme pentru care s-au acordat premii Nobel, d) îmbunătăţire a tehnologiilor didactice, pentru mai buna pregătire în domeniul Fizicii a viitorilor ingineri.*

Abstract. *Starting from the Physics evolution (as described by the main results obtained in frame of the Physics Nobel prizes), this work studies the possibilities: a) to optimise the choice of the basic Physics topics taught in frame of technical Universities, b) of valuable scientific research accomplished in frame of the best Universities (BNU) that didn't obtained Physics Nobel prizes, c) of obtainment of some useful complementary results (relative to the basic results obtained by the Physics mainstream) of the BNU scientific studies accomplished in the frame of some scientific fields with awarded Physics Nobel prizes, d) of improvement of the didactic technologies, for a better Physics training of the future engineers.*

Key words: Physics evolution, Main results obtained by the works awarded with Physics Nobel prizes, Evolution on decades and countries of the number of awarded Physics Nobel prizes, Improvement of didactic technologies

1. Introduction

The important Physics applications in technical sciences, biology, medicine, etc. are very well known. Despite of these well-known facts, there is a tendency in the technical academic education to reduce at minimum the Physics teaching and knowledge of students, of the undergraduate cycle, especially. E.g. the academic requirements of the speciality organisations SEFI and CESAER of the European Union [1] for the undergraduate studies (3 years) of all technical faculties stop after the statement "Explain the principles of electric and magnetic fields and apply the basic laws of electric circuits", with the unique additional element "Explain the basic principles of quantum theory". This trend is not a new one: see

[1]Prof., Physics Department, Portland State University, United States of America.
[2]Prof., Physics Chair II, University "Politehnica" of Bucharest, Romania.

e.g. the speech of Henry Augustus Rowland, first president of the American Physical Society, at the APS meeting from Columbia University (1899), who underlined the very weak resonance of majority people to the most results of the "pure sciences". In practice, only between the 1940-1960 years, corresponding to the: a) 2^{nd} World War, b) beginning of transistors use and to the: c) building of the first nuclear reactors intended to the obtainment of additional electrical power, the Physics had a rather large "audience" in the technical world, during the last century.

That is why this work will examine in detail the Physics evolution in the last century, as well as its connection to the technical and medical applications.

2. Study of the Physics evolution in the last century and of possibilities to optimize the choice of basic Physics topics taught in frame of technical Universities

Taking into account the remarkable importance of the Nature sciences studies, the corresponding number of published works is huge: approx. 654,000 scientific works published in international journals in 2000, and even more published scientific works in the domestic reviews (e.g. only in China there were published approx. 181,000 scientific works in the Chinese scientific reviews) and – correspondingly – the number of yearly published abstracts of these scientific works is also huge: approx. 180,000 Physics abstracts/year, approx. 105,000 Electrical & Electronics abstracts/year, approx. 100,000 Computer & Control abstracts/year, etc.

For this reason, the number of recognised scientific fields is also extremely large; e.g. according to the *Physics Abstracts* classification a (sub)domain of Physics is given by a combination of 4 digits and a letter, therefore it seems to exist approximately 200,000 sub-domains of Physics! Between the Physics and the technical sciences there is a strong connection, and for this reason the *Physics Abstracts* review became a part of the INSPEC database, co-ordinated by the IEE (Institute of Electrical Engineers) organisation. According to the INSPEC classification [2] there are 61 main fields of Physics, 37 main fields of the Electrical and Electronic Engineering, 23 main fields of Computer and Control sciences, 9 main fields of the Manufacturing and Production engineering, and other 5 main fields of the Information Technology (IT).

Due to the huge number of the scientific and technical domains (even of the main domains) and of the published scientific and/or technical works, the teaching of the basic elements of Physics requires the selection of the most important results, namely of those elements that were generally recognised for their particular importance. Though we cannot affirm that any scientific results awarded by Nobel prizes is more important than any other results that didn't obtain a Nobel prize, we consider that all most important scientific (and even technical) results were recognised by Nobel prizes. That is why, we will use the brief analysis of the results recognised by Nobel prizes in order to point out: a) the strong connection between Physics, Chemistry and the Technical Sciences, b) the evolution of the Physics development in the last century. We will mention the previous work referring to the statistical study of the Physics Nobel prizes (but only up to 1990) [3], as well as our main sources used for a complete statistical study for the whole interval 1901-2005 [3]-[8].

The main fields of the research works awarded by Physics Nobel prizes, as well as the evolution of these main fields along the decades of the interval 1901-2005, were studied in the frame of our treatise [8] (vol. 1, pp. 25-26). Other statistical data referring to the: (i) the evolution on decades and countries of the awarded Physics Nobel prizes, (ii) classification of Universities and scientific research institutions depending on the number of graduate titles (Bachelor, Master and/or Doctors) and the number of activity years accomplished by the Physics Nobel laureates in frame of these institutions, (iii) the physics contribution to a student's education in various countries and schools, etc were synthesised in our works [9], while the main results obtained by the Physics Nobel laureates with Engineering studies and/or studies in Technical Universities are presented by the enclosed Table 1.

It was found that the main topics corresponding to the awarded Physics Nobel prizes (PNP) can be classified as it follows:

a) *topics recognised as important for technical applications by practically all engineers*: Thermodynamics (2 awarded PNP) and Electromagnetism & electromagnetic waves (5 awarded PNP) = totally 7 PNP (all awarded up to 1919), representing approximately 6.31% from the 111 main Physics topics corresponding to the awarded Physics Nobel prizes,

b) *important Physics topics for the understanding of the work of practically all modern technical devices:* Optics (11 awarded PNP), Quantum Physics (8 PNP), Condensed Matter Physics (19 PNP) = totally 38 PNP (awarded between 1902 and 2005), representing about 34.23% from the 110 main Physics topics corresponding to awarded PNP,

c) *important Physics topics for the understanding of the work of the modern devices specific to certain technical specialties:* Spectroscopy (9 PNP), Atomic and Molecular Physics (11 PNP), Nuclear Physics (11 PNP), Plasma Physics (2 PNP) = totally 33 PNP (awarded between 1902 and 2001), representing about 29.73% of all main Physics topics awarded with PNP,

d) *important Physics topics for future, but that are not presently used in technical applications:* Elementary Particles & Fundamental Interactions (27 PNP), Astrophysics and Cosmology (6 PNP) = totally 33 PNP, representing also 29.73% of all main PNP topics.

As it concerns the opinions of the technical Universities leaderships relative to the usefulness of the Physics elements teaching in the undergraduate cycle, it seems that there are now 3 main opinions:

(i) *the necessity to ensure unique Physics textbooks for scientists and engineers (involving the topics on Elementary particles & Fundamental interactions, Astrophysics and Cosmology)*: specific mainly to the American [10] and the UK Universities [11], etc.

(ii) *the necessity to ensure the teaching in the undergraduate cycle of the Physics knowledge corresponding to the topics of the above a) and b) items, and – depending on the specific technical speciality – also of some notions belonging to the above item c)*: technical academic education feature in France, Italy, Israel, etc.

(iii) *the restriction of the taught Physics elements in the undergraduate cycle only to the elements belonging to the above item a), with very few additional elements concerning the principles of the Quantum Physics:* opinion of some European organisations [1], etc.

Of course, it is not very easy to decide what between these education politics is the best one, but it seems that the most important question remains: are the undergraduate alumni – under-specialised engineers, or under-educated ones?

3. Study of the valuable scientific results obtained by the BNU technical Universities in frame of some new Physics topics

From the analysis of Table 5 of works [9], it results that a total Worldwide number of 180 Universities contributed to the scientific preparation and activity years of the PNP laureates between 1901-2005. It appears a second question for this work: What can be the contribution to the mainstream of Physics of some of best national Universities (BNU), that are not (at least, now) involved in the above list of 180 Universities?

Because from Table 5 [9], it results also that many of the best classified Universities had (and have) strong research institutions involved in their structure, or they co-operate strongly with such institutions[3], it seems that the contributions at the Physics mainstream of BNU could consist in: 1) results obtained in co-operation with some strong local research institutions[4], 2) results obtained in some

[3] See the recent ascension of the University of Colorado, at Boulder, that was completely missing in 2000 in the list of the Universities with contributions to the scientific preparation and activity years of some PNP laureates, and it arrived this year (2005) – due to the strong cooperation with the National Institute for Standards and Technology (NIST) and the Joint Institute for Laboratory Astrophysics (JILA) [both from Boulder] - in the top (as the 24th from a total of 180 classified Universities, Table 5 [9]) of the Worldwide best Universities from the PNP point of view criterion.

[4] A very efficient cooperation corresponds to the participation of some BNU professors to the activity in frame of research groups led by Physics Nobel prize laureates [e.g., prof. Ion M.

"new" Physics topics area, not yet awarded with PNP[5], 3) published works corresponding to important results obtained in frame of BNU, located in the field of already awarded PNP: (i) before the PNP award, (ii) after the PNP award, but completing the previously found and recognised results.

In order to avoid some "repetitions", the scientific activities of some professors of BNU Universities, already mentioned in certain reference sources (e.g. [7]), will not be cited again in frame of this work.

Referring to the first type - corresponding to the above item a) - of Physics mainstream works (published in international ISI reviews), we have to mention the already existing such co-operation, as those between (e.g.) the Physics Departments of: (i) Politecnico di Torino (Italy) and the National Institute for Electrical Engineering "Galileo Ferraris" (Turin), (ii) University "Politehnica" from Bucharest and the National Institute for Atomic Physics (IFA, Măgurele-Bucharest), etc.

As examples of the second type, we can cite the studies in frame of: a) Biophysics, accomplished at: (i) PSU (referring mainly to the dynamics of Ca^{++} channels [14]), (ii) University of Kent at Canterbury (in the field of Applied (Medical) Optics [15]), (iii) Politecnico di Torino, in frame of Non-destructive Testing & Examinations and of Theoretical Biology [16], also in frame of the study of Cancer Growth [17], etc)], b) Cryogenics and Microphysics [18], c) Computational Physics [19], [20], Advanced Laser Technologies [21] and: d) Non-conventional Energy Sources [22], both at University "Politehnica" from Bucharest (UPB), etc.

4. Possibilities of obtainment of useful complementary results and of convergence of the BNU studies accomplished in frame of some scientific fields with awarded Physics Nobel prizes

A rather well-known example (at least in Romania) of the above 3rd type is that of the UPB alumni – Alexandru Proca (1897-1955), who predicted [independently of the first prediction done in 1935 by the Japanese professor Hideki Yukawa (1907-

Popescu (UPB) [12] participated in the interval 1963-1964 to the scientific activities in frame of the Hertzian Laboratory of École Normale Supérieure (Paris), directed by Prof. Alfred Kastler (PNP laureate in 1966)].

[5]The physicists (professors and researchers) from the technical Universities, especially, have to avoid the wrong orientations pointed out by paper [13]: "You cannot deny that Physics is central for the development of society, but unfortunately far too more physicists possess an arrogant and spoiled attitude where they expect that the surrounding world, in deep respect for the importance of Physics, will rush forward and overwhelm them with large grants. Instead we see that this arrogance causes the grants to go to subjects other than Physics".

1981), Nobel prize for Physics in 1949] also the mesons existence, obtaining[6] additionally (referring to Prof. Yukawa's works) also their evolution equations (see also [23]).

Other possible analysed objects of this study could refer to the UPB Physics researches in the fields of Liquid Crystals [24] (Physics Nobel prize awarded in 1991 to Professor Pierre Gilles de Gennes, 1991) and even of Complexity features in Physics of Materials (study of power laws, limit laws, fractal scaling, etc [25]), in field of the PNP awarded in 1977 to Professor Philip Warren Anderson. It is possible to affirm that the studies accomplished by such BNU converge (usually, considerably less quick and incomplete, but obtaining some complementary results) to the most important results obtained by the mainstream research.

4. Possibilities of improvement of the didactic technologies intended to a better Physics training and understanding

From beginning, *we have to underline also that – besides their important support offered to the scientific research from the Physics Departments of different Universities – some important research institutions are also directly implied in the scientific training of the Physics professors and in the Physics education of students*. E.g.: a) the Abdus Salam International Center for Theoretical Physics (ICTP) from Trieste, Italy, has very important contributions (by means of its Training and Research in Italian (TRIL) Program [26]) to the scientific research preparation of many Physics professors in several extremely important modern Physics topics (Physics of Condensed Matter, Physics and Energy, Physics and Technology, Earth and Environmental Sciences, Space Physics, Physics of the Living State, Topics at the Interface with Chemistry, Engineering, Biology, Instrumentation for Nuclear and Subnuclear physics, etc), b) the Institute of Physics of the Polish Academy of Sciences (and the much regretted Prof. Waldemar Gorzkowski, mainly) had an extremely important role in the building and continuous growth of the most important Physics competitions for high-school students: the International Physics Olympiads [begun in 1967, now at the 35th edition (Salamanca, Spain) in 2005] [27] and the "First Step to Nobel Prize in Physics" international contest for scientific works of these (high-school) students (begun in 1992/1993, and continued yearly without interruption) [28]. These national and international competitions succeed to ensure (for a limited number from the best high-school students) a very good preparation, with remarkable results during their future training in frame of scientific or technical Universities.

[6] A. Proca: a) "Sur les équations fondamentales des particules élémentaires", *C.R. Acad. Sci. Paris* **202**, 1490 (1936); b) "Théorie non relativiste des particules à spin entier", *J. Phys. Radium* **9**, 61 (1938).

As it concerns the possibilities of improvement of the Physics teaching in the technical Universities, we consider as necessary the careful study both of the qualitative possibilities, as well as of the quantitative aspects.
So, many recent studies (e.g. [29]) stress out the necessity to: a) minimize the cognitive load by limiting the amount of material presented (see also [30]), b) have a clear organizational structure of the presentation, c) link new material to ideas that the audience knows, d) avoid unfamiliar technical terminology, e) point out frequently the applications of the taught notions in the work of usual systems, f) use new educational technology (clickers, peer instruction technique [31], etc).

Conclusions

We consider as necessary to pay attention to the rather numerous applications of some recent results of the scientific research (many of them recognized by Physics Nobel prizes awards) in the technical sciences and technologies. That is why, we believe as useful also the detailed examinations by the international organizations (as SEFI, CESAER, etc) for the academic education of engineers, not only of the minimal requirements for each didactic discipline, but mainly of the optimum (in strong relation with the other Curriculum disciplines) requirements, in order to ensure a right equilibrium between the technical abilities of the future (undergraduate) engineer and his possibilities to really understand the physical phenomena that underlie the normal functioning (operation) of technical devices and installations.

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Tab. 1. Main features of scientific activities of the Physics Nobel Prizes laureates with Engineering studies (and/or studies in Technical Universities)

Nr.	**Laureate name&award year of Physics Nobel prize**	**Level of the Engineering studies**	**Main accomplishments**
1: 1st	Röntgen, Wilhelm Conrad, 1901	Eng., Eidgenösische Technische Hochschule, Zürich, 1868	X rays discovery (Würzburg, 1895)
2: 4th	Becquerel, Antoine Henry, 1903	Eng. (1877), Dr. Eng. (1888), École des Ponts et chaussées, Paris	Natural radioactivity (Paris, 1896)
3: 10th	Michelson, Albert Abraham, 1907	Alumni of the Navy Academy of USA, Maryland, 1873	Michelson's interferometer & Michelson - Morley experiment, 1887
4: 16th	Dalén, Nils Gustaf, 1912	Eng.: Chalmers Tekniska Högskola, Göteborg, 1896 & ETH Zürich, 1 year	Automatic regulators and Gas Accumulators for lighthouses & buoys
5: 24th	Guillaume, Charles-Édouard, 1920	PhD Eng.: Eidgenösische Tech-nische Hochschule, Zürich, 1883	Metrology materials: invar, elinvar,etc, 1899
6: 25th	Einstein, Albert, 1921	Eng., Eidgenösische Technische Hochschule, Zürich, 1900	Theories of: relativity & gravitation, photoelectric effect, stimulated emission, Einstein - de Haas exp., Bose - Einstein statistics
7: 39th	Dirac, Paul Adrien Maurice, 1933	BSc Electrical Engineering, University of Bristol, 1921	New productive forms of the atomic theory 1928, 1930 (with E. Schrödinger)
8: 40th	Chadwick, Sir James, 1935	Postuniv.: Physikalisch-Tech-nische Reichanstalt, Berlin, 1914	Experimental discovery of neutron, 1932
8: 41st	Anderson, Carl David,1936	B. Sc. (1927) & PhD (1930): Caltech, California, USA	Experimental discoveries of positron, 1932 & lepton μ, 1937
10: 55th	Cockroft, Sir John Douglas, 1951	M. Sc. Technology: University of Manchester, 1922	Artificial Transmutation of Atomic Nuclei, 1932
11: 62nd	Lamb, Willis Eugene jr., 1955	B. Sc. Chemistry: Univ. of California at Berkeley, 1934	Fine structure of H spectrum, 1947
12: 63rd	Kusch, Polycarp, 1955	B. Eng.: Case Institute of Technology, Ohio	Accurate determination of $\mu_{electron}$, 1948
13: 64th	Shockley, William Bradford, 1956	Eng.: Caltech, 1932; PhD Eng.: MIT, Cambridge, Mass., 1936	Design (with phys. John Bardeen and W. H. Brat-tain) of **transistor**, 1948
14: 74th	Glaser, Donald Arthur, 1960	B. Eng.: Case Inst. Technology, Ohio, 1946; PhD Eng.: Caltech, 1950	Invention of the chamber with bubbles, 1952

15: 76th	Mössbauer, Rudolf Ludwig, 1961	B. Eng. (1952), M. Eng. (1955), Dr. Eng. (1958): Technische Hochschule, München, Germany	Mössbauer effect, 1958
16: 78th	Wigner, Eugene Paul, 1963	Eng. Chem.(1924), Dr. Eng.(1925), Technische Hochschule, Berlin	Theory of atomic nucleus and elementary particles (1931→)
17: 81st	Townes, Charles Hard, 1964	Dr. Eng.: Caltech, 1939	NH_3 maser, 1954 (experimental part)
18: 86th	Feynman, Richard Philips, 1965	B. Eng.: Massachusetts Institute of Technology, Cambridge, Mass., 1939	Quantum electrodynamics (1947→)
19: 90th	Gell-Mann, Murray, 1969	Dr. Eng.: MIT, Cambridge, Mass., 1951	Classification of elementary particles and fundamental interactions
20: 93rd	Gabor, Dennis, 1971	B. & Dr. Eng.: Technische Hochschule, Berlin-Charlottenb., 1927	Invention of holography, 1948
21: 96th	Schrieffer, John Robert, 1972	B. Eng.: MIT, Cambridge, Mass., 1939	BCS theory of super-conductivity, 1957
22: 97th	Giaever, Ivar, 1973	B. Eng.: Norway Inst. Technol., 1952; Dr. Eng.: Rensselaer Polytechnic Inst., New York, 1964	Experimental discovery of tunneling in semi- & superconductors, 1960
23: 104	Rainwater, Leo James, 1975	B. Eng.: Caltech, 1939	Combined nuclear model, 1950
24: 105	Richter, Burton, 1976	B. Eng. (1952), Dr. Eng. (1956): MIT, Cambridge, Mass., USA	Discovery of ψ/J particle→ charm quark
25: 110	Kapitza, Piotr Leonidovich, 1978	B. Eng.: Polytechnic Institute Sankt-Petersburg, 1918	Liquid He super-fluidity, 1938 & thermonuclear plasma (Tokamak), 1970
26: 112	Wilson, Robert Woodrom, 1978	Dr. Eng.: Caltech, 1962	Discovery of cosmic microwave background radiation, 1978
27: 117	Fitch, Val Longsdon, 1980	B. Eng.: Univ. Mc Gill, Montreal, Quebec, Canada	Violation of fundamental symmetries principles in neutral K mesons disintegration, 1964
28: 120	Siegbahn, Kai Manne Boerge, 1981	Dr. Eng.: Royal Technological Institute, Stockholm, Sweden, 1944	Development of the high-resolution electronic spectroscopy, 1957
29: 121	Wilson, Kenneth Geddes, 1982	Dr.: Caltech, 1961	Theory of critical pheno-mena in connection with phase transitions, 1971
30: 123	Fowler, William Alfred, 1983	Phys. Eng.: Ohio State University, 1933; PhD: Caltech, 1936	Formation of the chemical elements in Universe by star explosions, 1957

31: 125	Van der Meer, Simon, 1984	Phys. Eng.: University of Technology, Delft, 1952	Discovery of W & Z bosons – agents of weak interactions, 1983
32: 126	Klitzing, Klaus von, 1985	Phys. Diplomat: Technical University Braunschweig, 1969	Discovery of the quantum Hall effect, 1969
33: 127	Ruska, Ernst, 1986	Eng.: Technische Hochschule, Berlin, 1931	Electronic Microscope, 1931 … 1937
34: 129	Rohrer, Heinrich, 1986	Eng. (1955) and Dr. Eng. (1960): Eidgenösische Technische Hochschule (ETH), Zürich	Design (with phys. Gerd Binnig) of the scanning tunneling microscope, 1981
35: 131	Bednorz, Johannes Georg, 1987	Dr. Eng.: ETH, Zürich, 1982	Ceramic Superconductors with high critical temperature, 1986
36: 132	Müller, Karl Alexander, 1987	M. Eng. (1952), Dr. Eng. (1958): ETH, Zürich	Ceramic Superconductors with high critical temperature, 1986
37: 137	Paul, Wolfgang, 1989	M. Sci. (1937) and PhD (1939): Technische Hochschule, Berlin	Development of the ion trap technique, 1954
38: 139	Kendall, Henry Way, 1990	PhD: Massachusetts Institute of Technology (MIT), 1955	Development of the quark model, 1968
39: 142	Charpak, Georges, 1992	Eng.: École des Mines, Paris, 1948	Invention and development of particle detectors, in particular the multi-wire proportional chamber, 1968
40: 147	Reines, Frederick, 1995	M. Eng.: Stevens Institute of Technology, N. J., 1939	Detection of the (electronic) neutrino, 1956
41: 148	Perl, Martin Lewis, 1995	Chem. Eng.: Brooklyn Polytechnic Institute, New York, 1948	Discovery of the tau lepton, 1975
42: 150	Osheroff, Douglas D., 1996	B. Sc.: Caltech, 1967	Discovery of super-fluidity in helium-3, 1971
43: 151	Richardson, Robert C., 1996	B. Physics & Electr. Eng.: Virginia Polytechnic Institute, 1960	Discovery of super-fluidity in helium-3, 1971
44: 154	Phillips, William D., 1997	PhD: Massachusetts Institute of Technology, Cambridge, US, 1976	Development of methods to cool and trap atoms with laser light, 1988
45: 155	Laughlin, Robert B., 1998	PhD: Massachusetts Institute of Technology, Cambridge, US, 1979	Theory of the fractional quantum Hall effect, 1983
46: 160	Alferov, I. Zhores, 2000	Electr. Eng.: Leningrad Electro-technical Institute, 1952 &PhD in technology, Ioffe Phys. Techn. Inst. Leningrad, 1961	Development (with phys. H. Kroemer) of semiconductor hetero-structures used in high-speed and opto-electronics

47: 162	Kilby, Jack S., 2000	Electr. Eng.: University of Illinois, 1947; M. Electr. Eng.: University of Wisconsin, 1950	Invention of the **integrated circuits**, 1958 (TI, Dallas)
48: 163	Cornell, Eric A., 2001	PhD (Physics): Massachusetts Institute of Technology, 1990	Achievement of Bose-Ein-stein condensation in dilute gases of alkali atoms, 1995
49: 164	Ketterle, Wolfgang, 2001	MS: Technical University München, 1982	Achievement of Bose-Ein-stein condensation in dilute gases of alkali atoms, 1995
50: 165	Wieman, Carl E., 2001	B.Sc.: Massachusetts Institute of Technology (MIT), 1973	Achievement of Bose-Ein-stein condensation in dilute gases of alkali atoms, 1995
51: 166	Davis, Raymond jr., 2002	Chem. BSc (1938), Phys. Chem. PhD (1942): Univ. of Maryland	Contributions to astro-physics & detection of cosmic neutrinos, 1971
52: 176	Hall, John L., 2005	BSc (1956), MS (1958), PhD (1961): Carneggie Institute of Technology, Pittsburgh, PA, US	Development of the laser-based precision spectro-metry & optical frequency comb. technique, 1972..84

Average percentages of the Physics Nobel Prize laureates who had Engineering studies,

or who studied in some Technical Universities, on decades

23.1% (1901-1909), 10% (1910-1919), 16.7% (1920-1929), 27.3% (1930-1939), 0% (1940-1949), 20% (1950-1959), 35.3% (1960-1969), 28% (1970-1979), 50% (1980-1989), 36.4% (1990-1999), 38.9% (2000-2005), and:

29.3% = the general (average) percentage for the whole interval 1901-2005

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