PROF. AHMAD T. SHAWAQFEH

PERSONAL

Date of Birth	: Oct. 10, 1966
Place of Birth	: Mafraq – JORDAN
Nationality	: Jordanian
Languages	: Arabic & English
Marital Status	: Married

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EDUCATION

1994 - 1997 **Clarkson University** **Potsdam, NY, USA**
Ph.D./Chemical Engineering
Thesis: "Fabrication and Characterization of Novel Anodic Alumina Membranes"

1990 - 1993 **Jordan University of Science & Technology** **Irbid, JORDAN**
M. Sc./Chemical Engineering
Thesis: "Solar Distillation of Ethanol-Water System in a Solar Still"

1985 - 1990 **Jordan University of Science & Technology** **Irbid, JORDAN**
B. S./Chemical Engineering
Project: "Theoretical and Experimental study for the dispersion in two-phase three dimensional spouted bed in a bubble column under slug flow regime"

HONORS & AWARDS RECEIVED

- B.S. and M.Sc.: Ranked the first and honored for excellent academic achievement, 1990, 1993.
- Royal award recipient for excellent academic achievement, Jordan, 1990.
- University and faculty of engineering honor board with 5 honorary awards for excellent academic achievements, Jordan, 1987-1990.
- Mutah University Scholarship for graduate study, USA, 1994-1997.

PROFESSIONAL EXPERIENCE

AL-BALQA' APPLIED UNIVERSITY **SALT, JORDAN**

2023-present ***Vice Dean for Academic Affairs, Faculty of Engineering Technology.***
July-Sept.-2024 ***IHead of Chemical Engineering Department, Faculty of Engineering Technology***
2015-Present ***Lecturer - Professor***

- Teaching chemical engineering undergraduate courses and laboratories as well as Supervising graduation projects.
- Preparing for the Establishment of graduate program in applied chemical processes and nanotechnology.
- Renovating and reconstructing undergraduate curriculum to match standard requirements.
- Building, reconstruction and renovating experimental infrastructure of undergraduate and graduate laboratories.
- Calibrating experimental setups for undergraduate laboratories.
- Conducting authentic research on hybrid techniques of industrial water treatment, energy auditing, conversion and storage, nanofluids, and industrial processes retrofitting.

2005–2006 ***Sabbatical Leave - Associate Professor***

- Laboratory infrastructure reform committee.
- Proposal for graduate program in chemical industries.

MUTAH UNIVERSITY **KARAK, JORDAN**

1997-2015 ***Lecturer - Professor***

- Teaching chemical engineering undergraduate courses and laboratories.
- Supervising graduation projects.
- Teaching industrial engineering management master program courses.
- Supervising master thesis at the industrial engineering management master program.

2010-2011 ***Faculty Representative at Mutah University Council***

2007-2008 ***Assistant Dean for Industrial Co-op and Students Affairs***

- Curricula reforms for new specialties.
- Establishment of new Bachelor program in Industrial Systems Engineering.

2004-2005 ***Director of HRH Prince Faisal Center for Dead Sea Studies***

- Executive manager and coordinator for bi-agreements with private industrial sector
- Sub-program manager for proposals and fund raising.
- Research activities follow-up and research outcome marketing.

2003-2004 ***Coordinator and sub-program manager - Faculty of Engineering***

- Tenders follow-ups
- Technical inspections of scientific supplies

1999-2000 & 2003-2004 ***Head of Chemical Engineering Department***

- Department curriculum reforms for new specialties.
- Establishment of new Bachelor program in Indstrial System Engineering.
- Establishment a new graduate program for chemical engineering.
- Faculty recruitments.

JORDAN UNIVERSITY OF SCIENCE & TECHNOLOGY **IRBID, JORDAN**

2011 – 2012 ***Sabbatical Leave - Professor***

1993 – 1994 ***Research Associate***

- Research studies on the distillation of ethanol-water system using solar energy.

1991 – 1993 ***Teaching Assistant***

- Preparing and supervising experiments for undergraduate laboratories.
- Assisting in graduate and undergraduate courses.

ILLINOISE INSTITUTE OF TECHNOLOGY **CHICAGO, IL, USA**

Summers of 2001 and 2002 ***Research Associate***

- Establishing fundamental research and building experimental infrastructure for conducting experimental research work on hydrogen storage in carbon nanotubes. Calibrating experimental analysis tools to characterize carbon nanotubes.
- Preparing, organizing and attending workshops on renewable energy.

CLARKSON UNIVERSITY **POTSDAM, NY, USA**

1994 – 1996 ***Research Assistant***

- Studying aluminum anodization and oxide films growth kinetics. The research was funded by the National Science Foundation (NSF).
- Supervising undergraduate projects on membranes manufacturing by anodization.

UNIVERSITY OF JORDAN **AMMAN, JORDAN**

1990 – 1991 ***Laboratory Supervisor***

– Preparing and supervising chemistry experiments for undergraduate laboratories.

ELITE HOTEL SUPPLIES INDUSTRIES LTD. **SAHAB, JORDAN**

Summer 2008 ***Faculty for Factory Program***

– Study and improvement of pigments stability in cosmetic products.

PETRA ENGINEERING INDUSTRIES CO. LTD. **MUWAQAR, JORDAN**

Summer 2007 ***Faculty for Factory Program***

– Industrial consultation on aspects improvements of electrostatic powder paint (EPP) processes.

ARAB POTASH COMPANY **KARAK, JORDAN**

Summer 1989 ***Operation Trainee***

SKILLS

- Hands on experience with HPLC, GC-MS, XRD, SEM & TEM techniques, spectrophotometric techniques (UV-VIS, UV-NIR, and FT-IR), Atomic Absorption spectroscopy, and Thermal Gravimetric Analysis.
- Experience with different mechanical, chemical, electrochemical polishing techniques, chemical vapor deposition techniques and electrostatic spray deposition. Skilled in data analysis and experimental design methods.
- Skilled in FORTRAN, MAPLE, MATHEMATICA, MATLAB, ASPEN PLUS, HYSYS, MS OFFICE. Op. Sys.: WINDOWS and LINUX

RESEARCH INTRESTS

– Fabrication technologies of thin films, membranes and carbon nanotubes and applications.
– Industrial wastes and contaminants treatment and recycling (solid, water and air): Advanced oxidation technologies, Biological treatment processes, membranes and ion exchange processes
– Energy conversion and storage (Solar & Hydrogen) + (Biodiesel & Oil Shale)
– Desalination Technologies (Thermal & Mechanical)

PUBLICATIONS

International Journal Papers

1. **Shawaqfeh, A.T.**, "Thermal leaching of heavy fuel from spent tires using simple solvents," *in preparation*, (2024)
2. **Shawaqfeh, A.T.**, "Kerogen separation by successive differential digestion of mineral matrix," *in preparation*, (2024)
3. **Shawaqfeh, A.T.**, "Ion-Exchange Novel Electrode for Electrochemical Removal of Metal Ions," *submitted to Desalination*, (2024).
4. Al-Jaber, H.I., M.H. Abu Zarga, M.A. Al-Qudah, **A.T. Shawaqfeh**, "Ceratoluteolin: A new flavonoid from Salvia *ceratophylla* from Jordan," *Arab. J. Chem.*, **16**(3), (2023). doi.org/10.1016/j.arabjc.2022.104511.
5. Suleiman, I.A., N.W. Assaf, **A.T. Shawaqfeh**, The surface energy phase diagrams of CO adsorption on the low index iridium surfaces and the morphology of iridium nanoparticles," *J. Cry. Gro.*, **593**. (2022). doi.org/10.1016/j.jcrysgro.2022.126774.

6. Assaf, N.W., I.A. Suleiman, **A.T. Shawaqfeh**, "An equilibrium ab initio atomistic thermodynamics investigation of hydrogen adsorption on the low index iridium surfaces and the morphology of iridium nanoparticles" *J. Phys. Chem. Solids*, **167**, (2022). doi.org/10.1016/j.jpcs.2022.110736.
7. Suleiman, I.A., **A.T. Shawaqfeh**, M. Stockenhuber, E.M. Kennedy, "Insights on the stability of the rocksalt cuprous chloride: An equilibrium ab initio atomistic thermodynamics study," *J. Physics and Chemistry of Solids*, **136**, (2020). doi.org/10.1016/j.jpcs.2019.109158.
8. Abu-Khader, M.M., **A.T. Shawaqfeh,** Z. Naddaf, J.P. Maity, P. Bhattacharya, "Radon in the groundwater in the Amman-Zarqa Basin and related environments in Jordan" *Ground water for sustainable development*, **7**, (2018). doi.org/10.1016/j.gsd.2018.03.009.
9. **Shawaqfeh, A.T.**, "Isobaric Vapor-Liquid Equilibrium For The Binary System Di-Isopropyle Ether +Isopropanol at 95 kPa," *Afinidad*, **67**(549), (2010).
10. **Shawaqfeh, A.T.**, "Removal of Pesticides from Water Using Anaerobic–Aerobic Biological Treatment," *Chinese Journal of Chemical Engineering*, **18**(4), (2010). doi:10.1016/S1004-9541(10)60274-1
11. **Shawaqfeh, A.T.**, F.A. Almomani, "Photocatalytic Treatment of Water Soluble Pesticide by Advanced Oxidation Technologies Using UV Light and Solar Energy," *Solar Energy*, **84**, (2010). doi:10.1016/j.solener.2010.03.020
12. Almomani, F.A., **A.T. Shawaqfeh**, H. Alzoubi, "Comparison between Different Treatment Alternatives for Removal of Pesticide from Water Solution," *Journal of Chemical Technology & Biotechnology*, **85**, (2010). doi:10.1002/jctb.2324
13. Almomani, F.A., M.S. Shawaqfeh, **A.T. Shawaqfeh**, M. Al-Shannag, "Impact of Fenton and Ozone on Oxidation of Wastewater Containing Nitroaromatic Compounds," *J. of Environmental Sciences*, **20**(5), (2008). doi:10.1016/S1001-0742(08)62112-9
14. Almomani, F.A., **A.T. Shawaqfeh**, "Combination of Advanced Oxidation Processes with Biological treatment: general review," *Mu'tah Lil-Buhuth wad-Dirasat-Natural and Applied Siences Series*, **22**(2), (2007).
15. Al-Otoom, A.Y., A.L. Khlaifat, **A.T. Shawaqfeh**, "Crystallization Technology for Reducing Water Permeability Into Concrete," *Industrial & Engineering Chemistry Research*, **46** (2007). doi:10.1021/ie070527l
16. Almomani, F.A., **A.T. Shawaqfeh**, M.S. Shawaqfeh, "Solar Wastewater Water Treatment Plant For Aqueous Solution of Pesticide," *Solar Energy*, **81**(10) (2007). doi:10.1016/j.solener.2007.01.007
17. Al-Qodah, Z.Q, **A.T. Shawaqfeh**, W. Lafi, "Two-Resistance Mass Transfer Model for The Adsorption of Pesticides Using Acid Treated Oil Shale Ash," *Adsorption*, **13**(1) (2007). doi:10.1007/s10450-007-9004-x
18. Al-Qodah, Z.Q, **A.T. Shawaqfeh**, W. Lafi, "Adsorption of Pesticides From Aqueous Solutions Using Oil Shale Ash," *Desalination*, **208** (2007). doi:10.1016/j.desal.2006.06.019
19. Al-Qodah, Z.Q, **A.T. Shawaqfeh**, W. Lafi, A.M. Khalil, "Batch Adsorption Models For Pesticides Using Acid Treated Oil Shale Ash," *WSEAS Transaction on Environment and Development*, **2**(1) (2006).
20. Al-Otoom A.Y., R.A. Shawabkeh, A.M. Al-Harahsheh, **A.T. Shawaqfeh**., "The chemistry of minerals obtained from the combustion of Jordanian oil shale," *Energy*, **30**(5) (2005). doi:10.1016/j.energy.2004.05.024
21. **Shawaqfeh, A.T.** T.M. Alkhamis, "Effect of artificial surface electric charge on laminar flow shear-induced single platelet loss," *Alexanderia Engineering Journal*, **43**(6) (2004), pp 757-764.
22. **Shawaqfeh, A.T.,** A.M Al-Harahsheh, "Solvation of jordanian oil shale using different organic solvents by continuous contact mixing," *Energy Sources*, **26**(14) (2004). doi:10.1080/00908310490442024
23. **Shawaqfeh, A.T.**, "Design and performance of continuous flow, perforated-basin double-slope solar

still," *Mu'tah Lil-Buhuth wad-Dirasat-Natural and Applied Siences Series*, **18**(4) (2003).

24. **Shawaqfeh, A.T.**, "Gas holdup and liquid axial dispersion under slug flow conditions in gas-liquid bubble columns," *Chem. Eng. Proc.*, **42** (2003). doi:10.1016/S0255-2701(02)00082-X
25. **Shawaqfeh, A.T.**, R.E. Baltus, "Fabrication and characterization of single layer and multi-layer anodic alumina membranes," *J. of Membrane Sci.*, **157** (1999). doi:10.1016/S0376-7388(98)00314-7
26. **Shawaqfeh, A.T.,** R.E. Baltus, "The growth kinetics and morphology of porous anodic alumina films formed using phosphoric acid," *J. Electrochem. Soc.*, **145** (1998). doi:10.1149/1.1838701
27. **Shawaqfeh, A.T.,** M.M. Farid, "Distillation of ethanol in a solar still: studies on heat and mass transfer," *Transactions of the ASME: Journal of solar energy engineering*, **117** (1995). doi:10.1115/1.2847809
28. **Shawaqfeh, A.T.,** M.M. Farid, "New development in the theory of heat and mass transfer in solar stills," *Solar Energy*, **55**(6) (1995). doi:10.1016/0038-092X(95)00069-4

Refreed Conference Papers

1. Almomani, F.A., **A.T. Shawaqfeh**, and M.S. Shawaqfeh, "Design of Solar Wastewater Water Treatment Plant for Waste Water Treatment," paper presented at *4th Internation Conference on Oxidation Technologies for Water Wastewater Treatment*, Goslar, Germany (2006).
2. Al-Qodah, Z.Q, **A.T. Shawaqfeh**, W. Lafi, and A.M. Khalil, "Kinetic and equilibrium modeling of pesticides adsorption using Oil Shale Ash," paper presented at the *2006 WSEAS International Conference (Energy and Environmental Systems and Water Resources, 06)*, Chalkida, Evia Island, Greece (2006).
3. Griffin, F., **A.T. Shawaqfeh**, and S. Al-Hallaj, "Fabrication and characterization of mono-dispersed catalytic metal films using electrostatic spray deposition", paper presented at the *203rd Meeting of The Electrochemical Society, Inc.*, Paris, France, (2003).
4. **Shawaqfeh, A.T.** and R.E. Baltus, "Fabrication and characterization of novel anodic alumina membranes," paper presented at *9th Annual Meeting of the North American Membrane Society*, Baltimore, Maryland (1997).
5. **Shawaqfeh, A.T.** and R.E. Baltus, "Fabrication of anodic oxidation alumina membranes," paper presented at *AIChE Annual Meeting*, Chicago, Illinois (1996).
6. Farid M.M. and **A.T. Shawaqfeh**, "Distillation of Ethanol in a Solar Still," poster paper presented at *43rd Canadian Chemical Engineering Conference*, Ottawa, Canada (1993).

Unpublished Technical Reports

1. **Shawaqfeh A.T.**, "Study and improvement of pigments stability in cosmetic products," *Elite Hotel Supplies Industries Ltd. Technical report submitted to Faculty For Factory program*, 6th round 2008, Amman Jordan.
2. **Shawaqfeh A.T.**, "Aspects improvements of electrostatic powder paint (EPP) processes," *Petra Engineering Industries Co. Ltd. Technical report submitted to Faculty For Factory program*, 5th round 2007, Amman Jordan.
3. **Shawaqfeh A.T**., Al Hallaj, S., and J. R. Selman, "Synthesis and characterization of carbon nanotubes for hydrogen storage," Center for Electrochemical Science and Engineering, *Illinois Institute of Technology*, Chicago, IL, USA, 2001.
4. **Shawaqfeh A.T**., Al Hallaj, S., and J. R. Selman, "The application of carbon nanotubes for hydrogen storage in small-scale appliances," Center for Electrochemical Science and Engineering, *Illinois Institute of Technology*, Chicago, IL, USA, 2002.

CONFERENCES AND WORSHOPS

1. 10th Jordan International Chemical Engineering Conference, October 21-23, 2024, Amman, JORDAN – Vice chair of organizing committee.
2. 9th Jordan International Chemical Engineering Conference, October 12-14, 2021, Amman, JORDAN – Organizing and Scientific committees' member.
3. 6th Jordan International Chemical Engineering Conference, March 12-14, 2012, Amman, JORDAN – Organizing and Scientific committee member
4. 4-Day training course on "Water Chemistry in RO & NF." Organized by MEDRC, April 19-22, 2009, Amman-JORDAN.
5. 3-Days Intensive Course on "Theory and Practice of SWRO Systems" Organized by MEDRC, Nov. 26-28, 2007, Amman-JORDAN.
6. 5th Jordan International Chemical Engineering Conference, Sept. 12-14, 2005, Amman, JORDAN – Organizing and Scientific committees' member.
7. "Relationship of Higher Education and Industry" Workshop, Yarmouk University, March 7, 2005, Irbid, JORDAN.
8. Troubleshooting Gas Chromatography & Star Workshop Training, Varian Ltd., July 12-15, 2004, London, United Kingdom.
9. International Engineering Conference (Mutah 2004), Mutah University, April 26-28, 2004, Mutah-Karak, JORDAN – Organizing and fund raising committees member.
10. 5-Days Intensive Course on "Membrane Technology in Drinking & Industrial Water Treatment, *Priciples, and Design & Applications*" Organized by Unesco-IHE & MEDRC, Oct. 12-16, 2003, Amman-JORDAN.
11. Chicago/Midwest Renewable Energy Workshop, Illinois Institute of Technology, June 24–25, 2002, Chicago, IL, USA.
12. Chicago/Midwest Renewable Energy Workshop, Illinois Institute of Technology, June 14–15, 2001, Chicago, IL, USA.
13. First International Chemical Engineering Conference (I), Sept. 2001, University of Jordan, Amman-JORDAN.
14. "Desalination Technologies: Future and Economical Trends" Workshop, Alexandria University, February 7–8, 2001, Alexandria, Egypt.
15. International Jordanian Chemical Engineering Conference (III), Sept. 27-29, 1999, Amman-JORDAN.
16. "The New Technologies Used to Separate Petroleum from Oil Shale" Workshop, Natural Resources Authority, Ministry of Energy and Mineral Resources, September 20–22, 1998, Amman, JORDAN.
17. International Jordanian Chemical Engineering Conference (I), Oct. 18-20, 1993, Amman-JORDAN.

PROPOSALS AND RESEARCH GRANTS

1. Numerical and Experimental Investigation of The Environmental Impact of The Dead Sea Level Fluctuation on The Eastern Part of Dead Sea (Fresh/Salt Water Interface Migration, Sinkholes Formation and Red Sea-Dead Sea Canal Effects) ***Higher Council for Science and Technology***, JORDAN, 2009. ($225,000).
2. Methods of Environmental Engineering: New strategies for water treatment (photocatalytic reactions, biological treatment, and combination of photocatalytic and biological), ***Higher Council for Science and Technology***, 2005. ($21,000).
3. Follow up grant for Japanese senior volunteers' activities at the chemical engineering department of Mutah University, ***Japan International Cooperation Agency (JICA)-Jordan Office***, JORDAN, 2004. ($28,000).

4. Synthesis and characterization of carbon nanotubes for hydrogen storage, ***Illinois Institute of Technology***, Department of Chemical and Environmental Engineering – Center for Electrochemical Science and Engineering, USA, 2002. ($100,000)
5. The application of carbon nanotubes for hydrogen storage in small-scale appliances, ***Illinois Institute of Technology***, Department of Chemical and Environmental Engineering – Center for Electrochemical Science and Engineering, USA, 2001. ($20,000)
6. Development of Chemical, Civil, and Mechanical Engineering Departments' Laboratories, ***International Bank***, JORDAN, 2001. ($2,800,000).
7. Establishment of HRH Prince Faisal Center for Dead Sea Studies, **International Bank**, JORDAN, 2000. ($420,000).

PROFESSIONAL MEMBERSHIPS

- Member of the Jordanian Engineers Association (JEA).
- Member of North American Membrane Society (NAMS).

COMMITTEES

- Member of the ***sectoral committee of "Engineering Sciences, Nanotechnology and Niotechnology" at the Scientific Research Support Fund (SRSF) for several rounds***.
- Department ***representative at the Faculty Council*** for several rounds.
- Academic advisor of students.
- Member of ***Curriculum Committee*** at the Chem. Eng. Dept. and the Faculty of Engineering.
- Member of ***Graduate Studies Committee*** at the Faculty of Engineering
- Member of ***Research Committee*** at the Faculty of Engineering.
- ***Graduation projects coordinator*** at the Faculty of Engineering.
- Member of several department and ***Faculty Promotions Committees***.
- Member of ***ABET Accreditation Committee*** at the Chemical Engineering Department.
- Member of several ***sub- committees at the Accreditation & Quality Assurance Commission for Higher Education Institutions***.
- Member of ***Quality Assurance Committee*** at the Chemical Engineering Department.
- Member of ***Strategic Planning Committee*** at Mutah University.
- Member of Chemical Engineering ***Courses Evaluation Committee*** at the Jordanian Engineers Association.
- Referee for the ***Graduation Projects Context*** at the JEA for several rounds. rounds.
- ***Supervisor and examiner of several MS Thesis'***
- Member of ***International Jordanian Chemical Engineering Conference organizing and scientific committee*** for several rounds.
- ***Referee for several engineering journal; local and international***.
- Member of ***General Engineering Qualifying Exam Committee***.
- Chairman and member of several ***Technical Bid Committees*** for preparing and setting up engineering laboratories at Mutah University and Al-Balqa Applied University.

REFERENCES

1. **Professor Mohammed M. Farid**, Department of Chemical and Materials Engineering, The University of Auckland, Private Bag 92019, Auckland 1142 New Zealand, E-mail: *m.farid@auckland.ac.nz*
2. **Professor Taha M. Alkhamis**, Mutah University, Chemical Engineering Department, Mutah B.O. Box 7, Karak 61710 Jordan, E-mail: *alkamis@mutah.edu.jo*.
3. **Professor Mousa K. Abu Arabi**, Department of Chemical Engineering, Jordan University of Science and Technology, P. O. Box 3030, Irbid 22110 Jordan, Email: *mousa@just.edu.jo*
4. **Dr. Said Al-Hallaj**, Chairman/CEO of *AllCell* Technologies, 2321 W. 41st St. Chicago, IL 60609 USA. E-mail: *salhallaj@allcelltech.com*.

COURSES TAUGHT (1997-2024)

	Course Name	Semesters		Course Name	Semesters
1	Industrial Physical Chemistry	1	2	Statics	1
3	Dynamics	1	4	Engineering Analysis	1
5	Programming Languages FORTRAN	3	6	Multivariate Calculus	3
7	Mathematical Analysis I	2	8	Mathematical Analysis II	2
9	Applied Mathematics in Chem. Eng.	8	10	Engineering Numerical Analysis	3
11	Principles of Chem. Eng. (I)	4	12	Principles of Chem. Eng.(II)	3
13	Fluid Mechanics	3	14	Fluid Mechanics Laboratory	5
15	Transport Phenomena I	5	16	Transport Phenomena II	5
17	Chem. Eng. Thermodynamics	2	18	Solution Thermodynamics	7
19	Thermodynamics Laboratory	4	20	Heat Transfer Laboratory	5
21	Momentum and Heat Transfer	5	22	Mass Transfer Operations	6
23	Particulate Solids	9	24	Particulate Solids Laboratory	9
25	Chemical Reaction Eng. (I)	3	26	Chemical Reaction Eng. (II)	3
27	Homogeneous Reaction Eng.	2	28	Heterogeneous Reaction Eng.	5
29	Reaction and Unit Operations Lab.	2	30	Modeling and Simulation	15
31	Unit Operations	2	32	Environmental Chemistry	1
33	Separation Processes	6	34	Separation Processes Laboratory	5
35	Process Dynamics & Control	35	36	Process Dynamics & Control Lab.	26
37	Process Synthesis, Design & Optimization	3	38	Chemical Process Industries	3
39	Industrial Wastewater Treatment	1	40	Solar Energy Technology	1
41	Renewable Energy	1	42	Desalination	2
43	Principles of Instrumental Analysis	2	44	Special Topics: Chromatography	3
45	Equipment Design	10	46	Plant Design	10
47	Industrial Safety	2	48	Graduation Project	>100
47	Industrial Safety Management (Grad.)	1	48	Advanced Operation Research (Grad.)	2
49	Modeling and simulation for discrete event systems. (Grad.)	2	50	Workplace Policies & Safe Procedures (Diploma)	1
51	Thermodynamics (Diploma)	1	52		