International OBE Symposium

Incorporating Complex Problem Solving (CPS) and Complex Engineering Activities (CEA) in an Engineering Program

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Going Through Board of Accreditation for Engineering and Technical Education (BAETE)

Curriculum and Teaching-Learning Processes 4.6

The curriculum should satisfy the relevant program-specific criteria described in Section 6.

The breadth and depth of the curriculum and the teaching-learning activities should be appropriate for solving complex engineering problems in the relevant discipline. The curriculum should contain an adequate number of courses on mathematics, physical science, humanities and non-engineering subjects. The teaching-learning processes and activities selected for each course should be effective and appropriate for achieving the outcomes. Student participation and learning should be enhanced. Hands-on activities in the lab should be an integral part of teaching and learning. The program should include adequate activities in the lab.

The program should demonstrate the culmination of program outcomes (POs) at the level of solving complex engineering problems, preferably through a final-year design project or capstone project extending over a period of one year.

10 criteria

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4.8 Program Outcomes and Assessment

Program Outcomes (POs) or graduate attributes are narrower statements that describe what students are expected to know and be able to do by the time of graduation. These statements relate to the knowledge, skills and attitudes acquired by students while progressing through the program. The program must demonstrate that by the time of graduation, students have achieved an acceptable minimum level of certain knowledge, skills and behavioral traits. The BAETE specifically requires that students acquire the following graduate attributes:

(a) Engineering knowledge: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in K1 to K4 respectively to the solution of complex engineering problems.

(b) Problem analysis: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences. (K1 to K4)

(g) Environment and sustainability: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts. (K7)

(h) Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. (K7)

(i) Individual work and teamwork: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

(j) Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

(k) Project management and finance: Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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- “In addition to incorporating the above-listed POs (graduate attributes), the educational institution may include additional outcomes in its learning programs. An engineering program that aims to attain the above-mentioned POs should ensure that its curriculum encompasses all the attributes of the Knowledge Profile (K1 – K8) as presented in Table 4.1 and as included in the PO statements. The ranges of **Complex Problem Solving** (P1 – P7) and **Complex Engineering Activities** (A1 – A5) that should be addressed in the program are given in Tables 4.2 and 4.3, respectively.”

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Table 4.1: Knowledge Profile

	Attribute
K1	A systematic, theory-based understanding of the natural sciences applicable to the discipline
K2	Conceptually based mathematics, numerical analysis, statistics and the formal aspects of computer and information science to support analysis and modeling applicable to the discipline
K3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
K4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
K5	Knowledge that supports engineering design in a practice area
K6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
K7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the engineer's professional responsibility to public safety; the impacts of engineering activity; economic, social, cultural, environmental and sustainability
K8	Engagement with selected knowledge in the research literature of the discipline

Table 4.2: Range of Complex Engineering Problem Solving

Attribute	**Complex Engineering Problems** have characteristic P1 and some or all of P2 to P7:
Depth of knowledge required	P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8 which allows a fundamentals-based, first principles analytical approach
Range of conflicting requirements	P2: Involve wide-ranging or conflicting technical, engineering and other issues
Depth of analysis required	P3: Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models
Familiarity of issues	P4: Involve infrequently encountered issues
Extent of applicable codes	P5: Are outside problems encompassed by standards and codes of practice for professional engineering
Extent of stakeholder involvement and conflicting requirements	P6: Involve diverse groups of stakeholders with widely varying needs
Interdependence	P7: Are high level problems including many component parts or sub-problems

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- “The program should describe the process involved in defining and refining the POs. The correlation between the course outcomes (COs) and POs should be demonstrated through the mapping of COs onto POs. The way in which each attribute of the Knowledge Profile (K1 – K8) is addressed in the curriculum should be demonstrated through mapping. The program should also demonstrate how each attribute of the Range of Complex Engineering Problems (P1 – P7) and Complex Engineering Activities (A1 – A5) is incorporated in the teaching, learning and assessment.”

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Table 4.3: Range of Complex Engineering Activities

Attribute	**Complex activities** means (engineering) activities or projects that have some or all of the following characteristics:
Range of resources	A1: Involve the use of diverse resources (and for this purpose resources include people, money, equipment, materials, information and technologies)
Level of interaction	A2: Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues
Innovation	A3: Involve creative use of engineering principles and research-based knowledge in novel ways
Consequences for society and the environment	A4: Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
Familiarity	A5: Can extend beyond previous experiences by applying principles-based approaches

Review of POs

Program Outcomes	Category
PO1	Engineering Knowledge
PO2	Problem Analysis
PO3	Design/Dev of Solution
PO4	Investigation
PO5	Modern Tool usage
PO6	The Engineer and Society
PO7	Environment and sustainability
PO8	Ethics and Professionalism
PO9	Individual Leadership/Teamwork
PO10	Communication
PO11	Project Management and Finance
PO12	Lifelong learning

Knowledge Profile *(Curriculum)*

Theory-based natural **sciences**	WK1
Conceptually-based **mathematics**	WK2
Theory-based **engineering** fundamentals	WK3
Forefront **specialist** knowledge for practice	WK4
Engineering **design**	WK5
Engineering **practice** (technology)	WK6
Engineering in **society**	WK7
Research literature	WK8

Example of an Accreditation Concern

At the moment from detailed documented evidence and interviews with IHL's stakeholders, the Panel concluded that the 'CODE XXXX Introductory Economics for Engineering' course now lacks important engineering components such as knowledge for industry-scale plant design, procurement, plant management, cash flow, depreciation and bank loan assessment. Panel also noted that this **existing course is not strong in 'Engineering Economics'** and **is presently not incorporated in the 3rd Year (Semester V and VI)** which would be of great help to further strengthen the students' confidence on engineering economics knowledge when carrying out the IHL's Capstone Integrated Design Project (IDP) in the final year. **The CODE XXXX course is presently not being taught by an experienced industry-centred academic or Professional Engineer (PEng).** IHL is committed to further strengthening the 'Complex Problem Solving' and 'Complex Engineering Activities' components into their existing Materials Engineering curriculum to accommodate the new expectations of the revised XXXX Engineering manual XXXX 2012 Complex problem solving and engineering activities for this programme can be further enhanced/increased for this programme.

How does complexity relate to curriculum

+ General Subjects
+ Industrial Placement
+ Core & Specialist (Engineering) Subjects – *Complex Problem Solving*
+ Elective Subjects – *Complex Problem Solving*
+ Design Project – *Complex Engineering Activities*
+ Final Year Project – *Complex Problem Solving*

Sample CO to PO

Course Code	Course	PO 1 Engineering Knowledge	PO 2 Problem Analysis	PO 3 Design/ Development of Solutions	PO 4 Investigation	PO 5 Modern Tool Usage	PO 6 The Engineer and Society (Safety/health)	PO 7 Environment and Sustainability	PO 8 Ethics	PO 9 Communication	PO 10 Individual and Team Work	PO 11 Life Long Learning	PO 12 Project Management and Finance
KKKM1513	Materials Science	X	X		X								
KKKM1914	Engineering Design Graphics	X		X		X				X			
KKKM1024	Computer Programming	X	X			X							
KKKM1324	Introduction to Electrical Engineering	X	X	X		X				X	X		
KKKM1344	Engineering Mechanics I	X	X		X								
KKKM2013	Mechanical and Electrical Engineering Tools	X				X	X	X				X	
KKKM2114	Thermodynamics I	X	X							X	X		
KKKM2314	Measurement and Instrumentation	X	X		X					X	X		
KKKM2513	Engineering Materials	X	X		X	X				X	X		
KKKM2124	Fluid Mechanics I	X	X							X	X		
KKKM2324	Engineering Mechanics II	X	X	X						X	X		
KKKM2344	Mechanic of Materials	X	X	X						X	X		
KKKM2724	Manufacturing Processes	X	X		X					X	X		
KKKM3014	Numerical Methods	X	X			X				X			
KKKM3114	Thermodynamics II	X	X	X	X			X		X			
KKKM3314	System Dynamics and Simulations	X	X	X		X				X	X		
KKKM3934	Design of Machine Components	X	X	X	X					X	X		
KKKM3124	Fluid Mechanics II	X	X	X	X	X				X	X		
KKKM3144	Heat Transfer	X	X		X					X	X		
KKKM3364	Electrical Machines and Power	X	X	X						X			

Sample CO and PO Scores

Tajuk Kursus/Kursus Setara	Taraf Kursus	Pensyarah	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	CO9	CO10	CO11	CO12	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Professionalisme Kejuruteraan dan Alam Bina II	WF	Dr. Abu Bakar Sulong	100%	100%	98%	96%	95%													100%	98%	96%				
Pengaturcaraan Komputer	WJ	En. Azli Ariffin / En. Mohamad Hanif Md Saad	93%	96%	98%										93%	96%	-	-	98%	-	-	-	-	-	-	-
Pengenalan Kejuruteraan Elektrik	WJ	En. Mohamad Hanif Md Saad	83%	46%	24%	34%	100%								64%	34%	-	-	24%	-	-	-	100%			
Mekanik Kejuruteraan I	WJ	En. Zulkhairi Zainol Abidin / Prof Dr. Mohd Zaidi Omar	61%	57%	57%										61%	57%	-	57%								
Mekanik Kejuruteraan II	WJ	PM Dr. Mohd Zaki Nuawi	73%	73%	60%	82%	100%	-	-	-	-	-	-	-	73%	73%	60%	-	-	-	-	-	100%	82%	-	-
Mekanik Bahan	WJ	PM. Dr. Nordin Jamaluddin / En. Mohammad Rasidi Rasani	72%	72%	66%	100%	100%	100%	-	-	-	-	-	-	72%	72%	66%	100%	-	-	-	-	100%	100%	-	-
Proses Pembuatan	WJ	Prof. Dr. Andanastuti Muchtar	81%	31%	69%	22%	53%	0%	100%	100%					66%	22%	-	-	69%	-	-	-	100%	100%		
Mekanik Bendalir I	WJ	En. Mohammad Rasidi Rasani / PM Dr Rozli Zulkifli	54%	48%	58%	66%	100%	76%	100%	100%			-	-	54%	82%	-	-	-	-	-	-	100%	100%	-	-
Mekanik Bendalir II	WJ	Prof. Ir. Dr. Shahrir Abdullah / En. Mohammad Rasidi Rasani	38%	13%	2%	23%	35%	48%	98%	98%					35%	29%	15%	-	6%	-	-	-	96%	96%	-	-
Pemindahan Haba	WJ	PM Dr Rozli Zulkifli	98%	100%	100%	98%	100%	100%							98%	100%	-	98%	-	-	-	-	100%	100%	-	-
Mesin dan Elektronik Kuasa	WJ	Dr. Sallehuddin Mohd Haris / En Zulkhairi Zainol Abidin	89%	87%	87%	75%	100%					-	-	-	89%	87%	75%	-	-	-	-	-	100%			
Kejuruteraan Kawalan	WJ	Prof Dr-Ing. Nik Abdullah Nik Mohamed / Dr. Sallehuddin Mohd	78%	54%	78%	95%	100%	100%	100%						66%	78%	-	95%	100%	-	-	-	100%	100%		
Rekabentuk Sistem	WJ	Prof. Ja'afar Sahari / PM Dr. Dzuraidah Abd. Wahab	83%	98%	88%	93%	100%								-	-	88%	-	83%	-	93%	-	100%	98%	-	-
Pengurusan Projek	WJ	Ir. Dr. Zambri Harun	100%	100%	94%	100%	97%	100%	100%						94%	100%	100%	97%	100%	100%	-	100%				
Projek Ilmiah 2	Elektif	Prof. Dato' Dr. Kamaruzzaman Sopian / En. Zulkhairi Zainol Abidin	89%	72%	92%	67%	72%	86%	97%	97%					86%	86%	86%	86%	86%	86%	97%	86%				
Projek I	WJ	Dr. Syarif Junaidi	100%	100%	94%	100%	97%	100%	100%						94%	100%	100%	97%	100%	100%	-	100%				
Projek I	WJ	PM. Dr. Jaharah Abd Ghani	89%	72%	92%	67%	72%	86%	97%	97%					86%	86%	86%	86%	86%	86%	97%	86%				
Dinamik Bendalir Komputeran	Elektif	Dr. Wan Faizal Wan Mahmood / Prof. Dr Ir. Shahrir Abdullah	100%	61%	94%	100%	100%	100%	100%		-	-	-	-	100%	100%	94%	94%	100%	-	-	-	100%	100%	-	-
Integriti Struktur			100%	78%	100%	100%	100%								100%	100%	-	78%	100%	-	-	-	100%	100%		
Kaedah Unsur Terhingga	Elektif	PM Dr. Zainuddin Sajuri / Prof. Dr. Ahmad Kamal Ariffin	94%	89%	39%	89%	78%	89%			-	-	-	-	94%	100%	-	-	39%	-	-	-	89%	-	-	-
Dinamik Kejuruteraan	Elektif	En. Azli Ariffin	88%	100%	100%	100%	100%				-	-	-	-	94%	88%	-	100%	100%	-	-	-	100%	100%	-	-
Kakisan	Elektif	PM Dr. Syarif Junaidi	100%	100%	100%						-	-	-	-	100%	100%	-	-	-	-	100%	-	-	-	-	-
Tribologi	Elektif	PM Dr. Mariyam Jameelah Ghazali	100%	100%	100%	100%	100%	-	-	-	-	-	-	-	100%	100%	-	100%	-	-	-	-	100%	100%	-	-

Now, how do you map CPS and CEA

Programme Outcomes (PO)

* Engineering Problem Solving (**WP/SP/DP**)

* Engineering Activities (**EA/TA/NA**)

Knowledge Profile (K)

PO1 Engineering Knowledge (**K1-4**)

PO2 Problem Analysis (**K1-4**)

PO3 Design (**K5**)

PO4 Investigation (**K8** - except Dublin)

PO5 Modern Tools (**K6**)

PO6 Engineers & Society (**K7**)

PO7 Environment & Sustainability (**K7**)

PO8 Ethics (**K7**)

PO9 Teamwork

PO10 Communication

PO11 Project Management & Finance

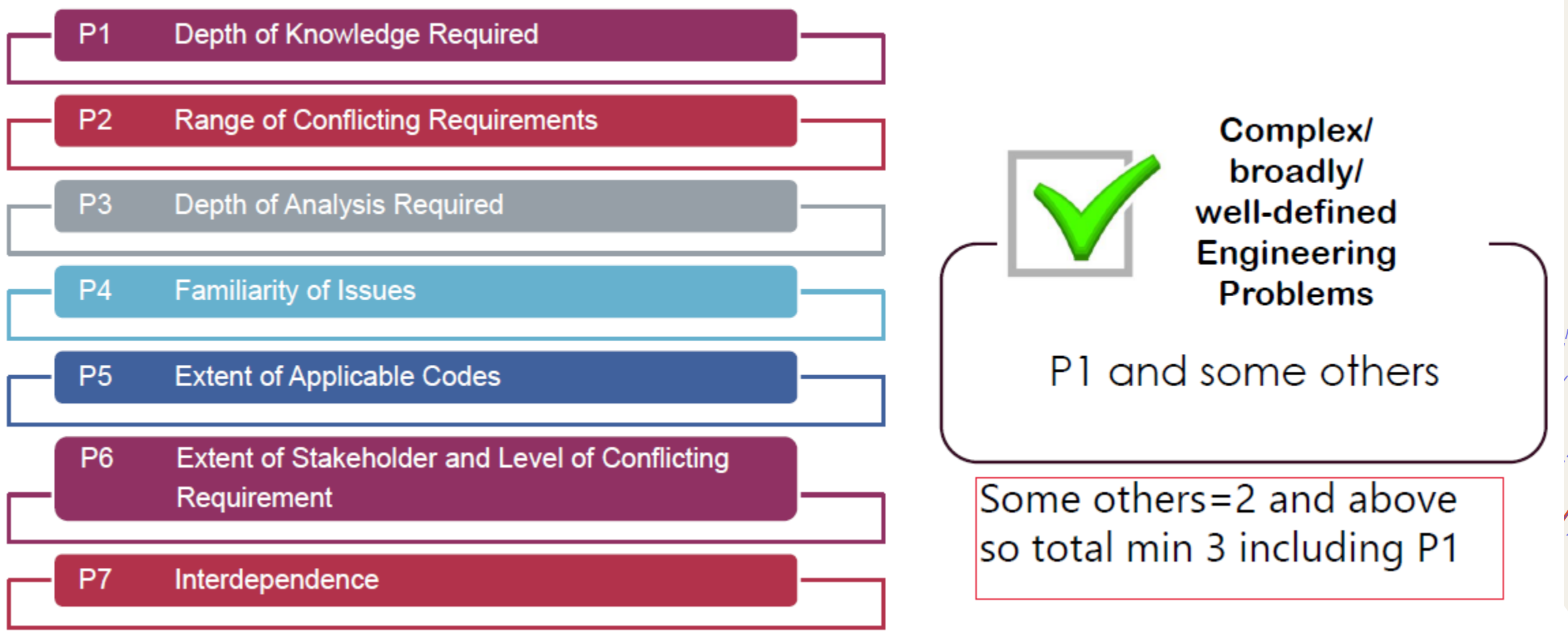
PO12 Lifelong Learning

Analysis of problems & synthesis of solutions

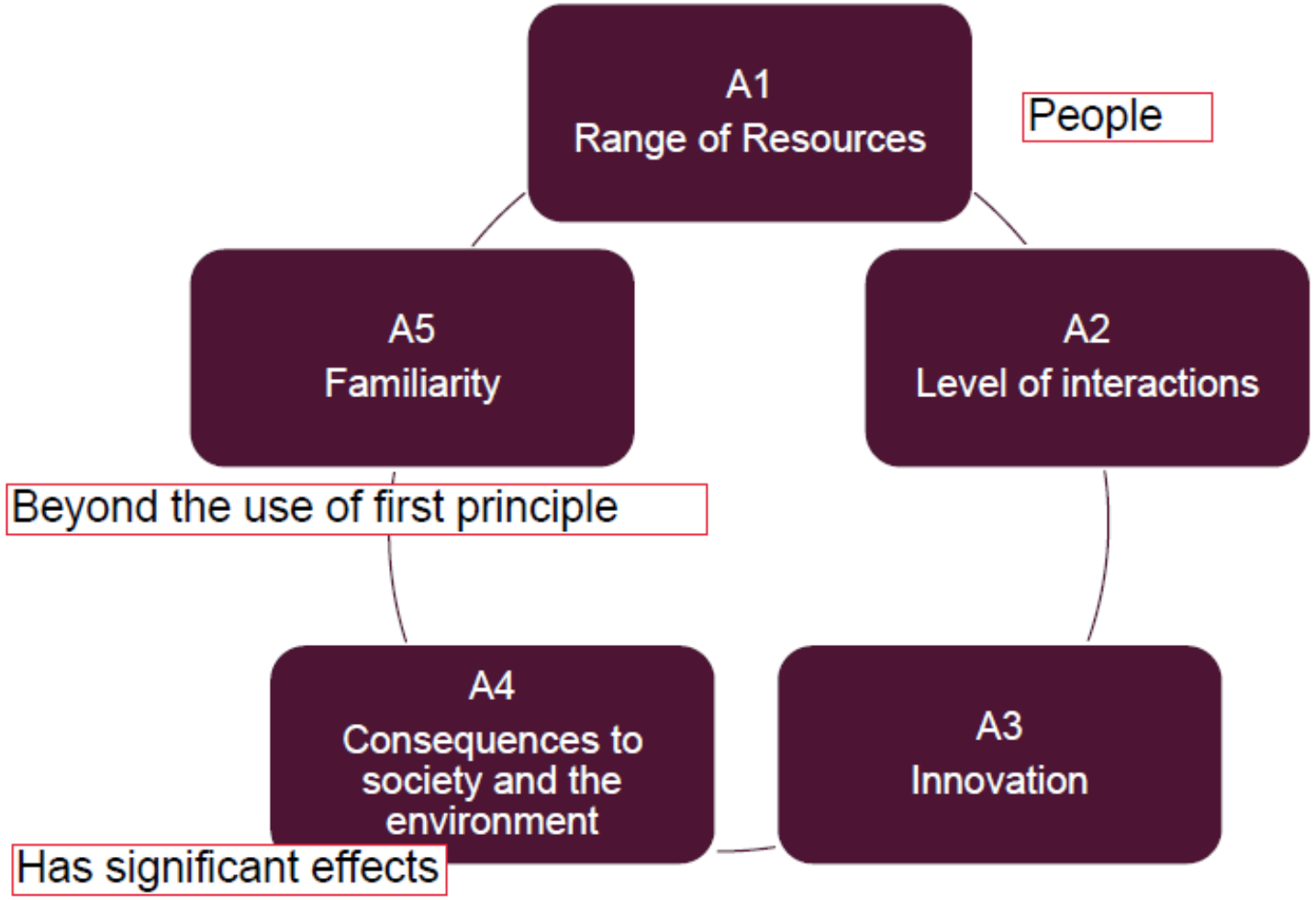
Responsibilities

Required in workplace

EAC Malaysia: The Attributes Complex/ Broadly/Well Defined Engineering Problems



EAC Malaysia: The Attributes of Complex/ Broadly/Well Defined Activities - Activities/ Projects



Complex/broadly/ well-defined Engineering Activities

Some or all of A1 to A5

Use of eng. principle and at the same time has research aspect

Example: Capstone / Integrated Design Project - Standard EAC 2020

- Involve complex engineering problems and design systems, components or processes integrating (culminating) core areas and meeting specified needs.
- Appropriate consideration for public health and safety, cultural, societal, project management, economy, and environmental considerations where appropriate.
- The IDPs are multifaceted assignment that serves as a culminating academic and intellectual experience for students, typically towards the end of an academic programme or learning-pathway experience.
- Involve students working in group.
- To deliver and assess many relevant POs through the Integrated project.

Sample: CO-PO Mapping

	Projek IDP Kej. Awam						Projek IDP Kej. EE				Projek IDP Kej. Kimia												Projek IDP Kej. Mekanikal					
	CO1	CO2	CO3	CO4	CO5	CO6	CO1	CO2	CO3	CO4	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	CO9	CO10	CO11	CO12	CO1	CO2	CO3	CO4	CO5	CO6
PO1											X																	
PO2												X																
PO3		X	X				X						X										X					
PO4														X														
PO5								X							X									X				
PO6				X					X							X									X			
PO7	X																X											
PO8																		X								X		
PO9					X														X								X	
PO10						X														X								X
PO11										X											X							
PO12																						X						

Sample: CO – CPS / CEA Mapping

Programme Outcome (PO) relationship with Complex Problem Solving (CPS) and Complex Engineering Activities (CEA)

Codes	Courses	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
KKKM2012	Integrated Project I			CPS1 CPS3 CPS4	CPS1 CPS3 CPS4					CEA2 CEA4			
KKKM3012	Integrated Project II			CPS1 CPS3 CPS4	CPS1 CPS3 CPS4			CPS1 CPS3 CPS4					
KKKM3223	Fluid Dynamics					CEA1 CEA6							
KKKM4953	Engineering Design and Manufacturing I	CPS1 CPS2 CPS4		CPS1 CPS3 CPS4		CEA3 CEA4	CPS3 CPS5						
KKKM4963	Engineering Design and Manufacturing II		CPS1 CPS3 CPS4	CPS1 CPS3 CPS4	CPS1 CPS3 CPS4					CEA2 CEA4			
KKKM4064	Research Project II		CPS1 CPS3 CPS4		CPS1 CPS3 CPS4					CEA2 CEA4			

Rubric! Without rubric, it is as good as never implemented

JABATAN KEJURUTERAAN MEKANIK & PEMBUATAN
BORANG PEMARKAHAN LAPORAN TESIS PROJEK ILMIAH II
(PEMERIKSA)

Nama Pelajar		Pemeriksa	
No. Pendaftaran		Tanda tangan	
Tajuk		Tarikh	

Agihan markah Projek Ilmiah II: (**Penyelia**: laporan (35%) + buku log (5%)) + (**Pemeriksa**: laporan (25%) + peperiksaan lisan (15%) + Ringkasan Eksekutif (10%))

Skala 0 -1 – Lemah 2 – Sederhana 3 – Memuaskan 4 – Baik 5 – Cemerlang

Bil.	Bahagian	0-1	2	3	4	5	Markah mengikut skala (0-5)	Pemberat	Markah Penuh
1	Abstrak (PO3,PO4, PO5, PO11) CPS3, CPS4	Tiada , atau tidak berkaitan dengan topik projek	• Tujuan • Bahan dan kaedah	• Tujuan • Bahan dan kaedah • Keputusan/hujah penting	• Tujuan • Bahan dan kaedah • Keputusan/hujah penting • Kesimpulan	• Kewajaran kajian • Tujuan • Bahan dan kaedah • Keputusan/hujah penting • Kesimpulan		2	
2	Pengenalan (PO1, PO2, PO5)	Tiada , atau tidak berkaitan dengan topik projek	Tidak berupaya menyatakan • latar belakang permasalahan • kepentingan • objektif • skop	Kurang berupaya menyatakan • latar belakang permasalahan • kepentingan • objektif • skop	Berupaya menyatakan • latar belakang permasalahan • kepentingan • objektif • skop	Berupaya menyatakan dengan jelas dan tersusun • latar belakang permasalahan • kepentingan dan hubungannya dengan isu • objektif • skop		3	
3	Kajian perpustakaan (PO3) CPS3, CPS4	Tiada , atau tidak berkaitan dengan topik projek	Pengumpulan maklumat merujuk kepada 10 rujukan	Pengumpulan maklumat merujuk kepada 10-30 rujukan	Pengumpulan maklumat merujuk kepada 30-40 rujukan	Pengumpulan maklumat merujuk kepada lebih daripda 40 rujukan		2	
4	Metodologi (PO1,PO6)	Tiada , atau tidak	Ada tapi tidak difahami	Ada tapi, Tidak teratur dan jelas	Memadai • perincian kaedah	Lengkap dan teratur • perincian kaedah		3	

IDP PROJECT

- Mechanical Engineering Programme

Code & name of course:

1) KKKM4953 Engineering Deign & Manufacturing I
2) KKKM4963 Engineering Deign & Manufacturing II

Status : Programme (Compulsory)

Semester offered : Semester 7 & 8

PO : KKKM4953 (6 PO), KKKM4964 (6 PO)

CO: 3,5,6,8,9,10,12

Lecturers: Prof. Ir. Dr. Shahrum Abdullah, Ir. Dr. Zambri Harun, Prof. Dr. Norhamidi Bn Muhamad, Prof. Dr. Mohd. Zaidi Omar, Prof. Dr. Dzuraidah Abd.Wahab, Dr. Wan Fathul Hakim Wan Zamri, Dr. Abdul Hadi Azman

Project Brief

- Design a **complex Mechanical system**
- Innovative and useful to **solve real-world problems**
- Themes: Sustainable Development Goals (**SDG**), Industry 4.0
- **Culminating and integrative** of all the core mechanical topics that the students have studied in year 1-3, for example:
  - Kinematic & dynamics analysis
  - Fluid mechanics
  - Energy & combustion
  - Mechanical system

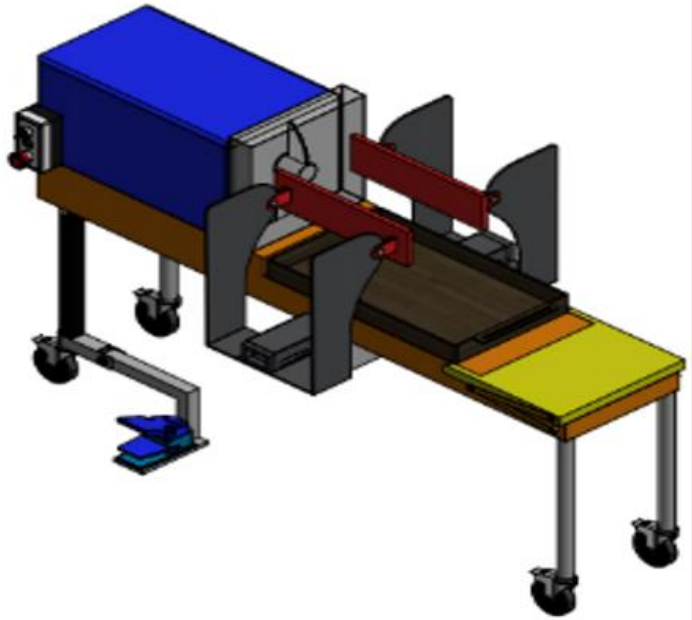
IDP Project

-Mechanical Engineering Programme

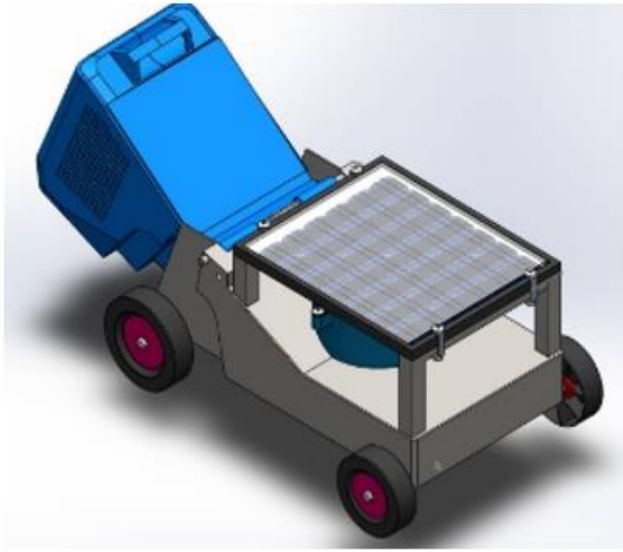
Sample Projects

Industrial Dust Collector

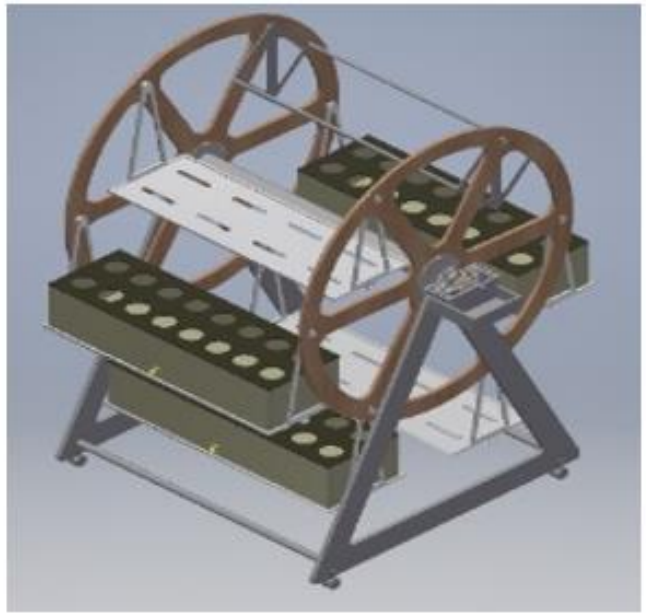
Industrial Jackfruit Cutting Machine



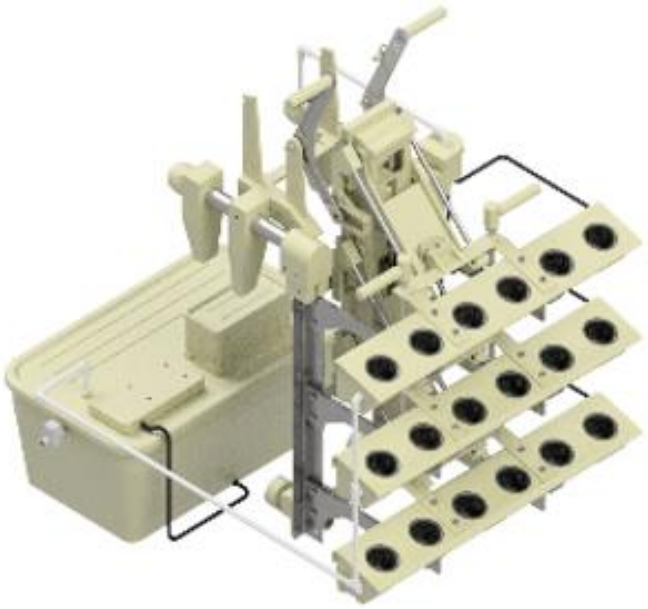
Automated Solar Lawn Mower



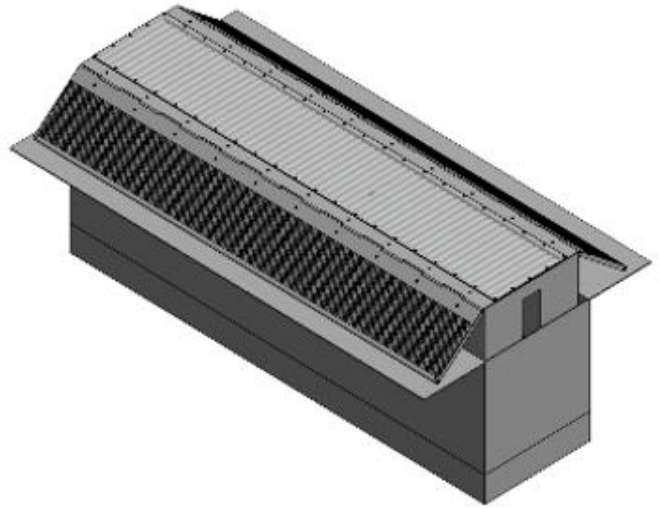
Vertical Farming



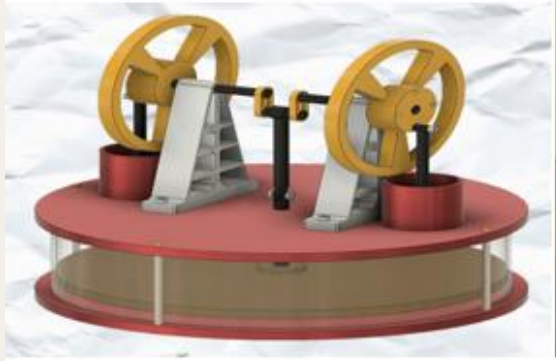
Smart Home Gardening



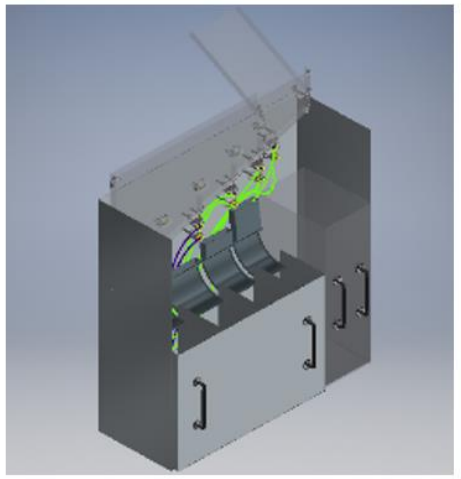
Speed Breaker Power Generator



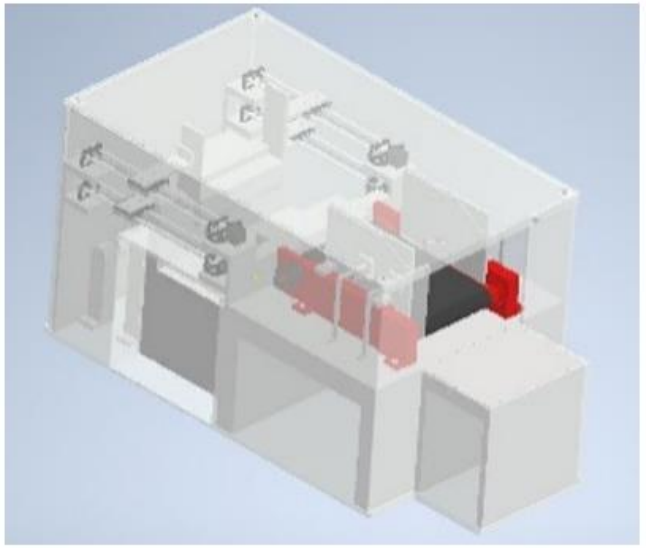
Sterling Engine: Another alternative for renewable energy



Automated Dish Sorter



Automated parcel wrapping machine



Prototypes

Elevated Wheelchair

Lake trash collector

Hybrid Brake Calliper

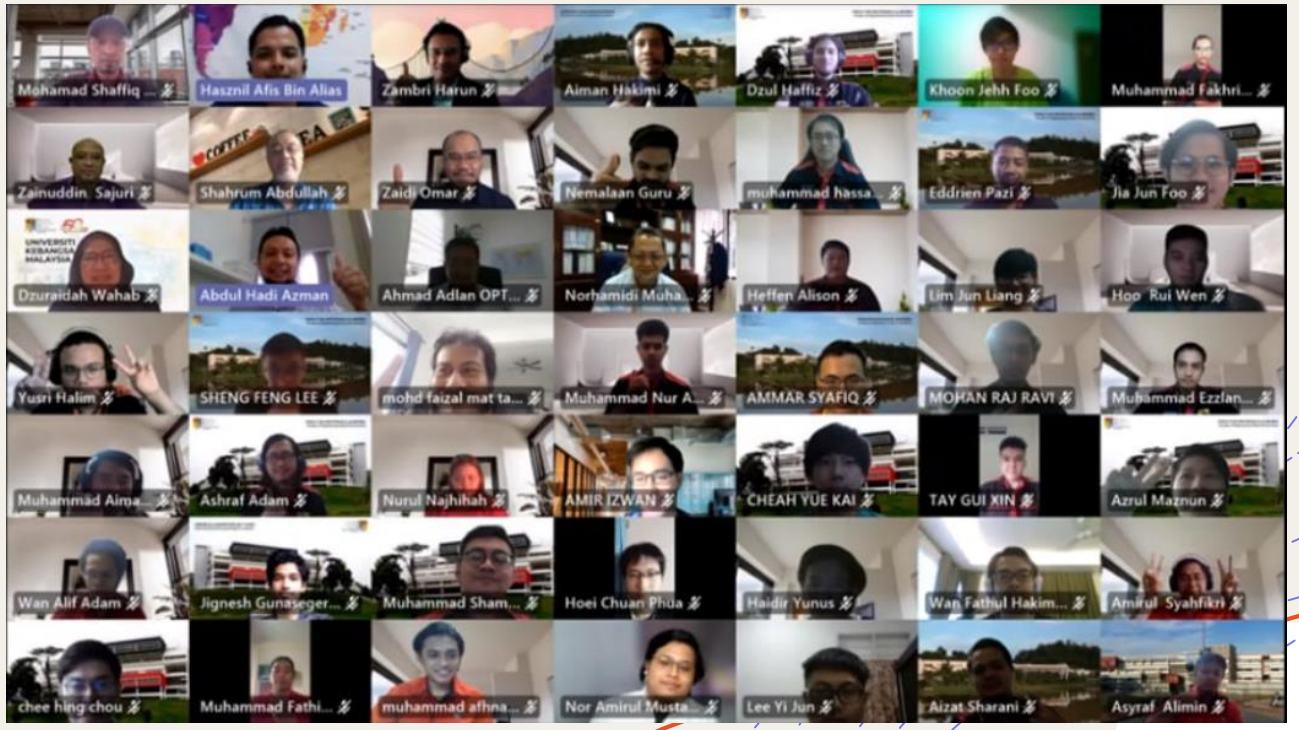
Presentation: Mechanical Engineering Design and Manufacturing Colloquium 2021

External evaluators (Alumni):

Mr. Hasznil Afis Alias, Senior Design Engineer, PROTON

Mr. Mohamad Shaffiq Bin Rozak, Head Of M&E Production, Air Selangor.

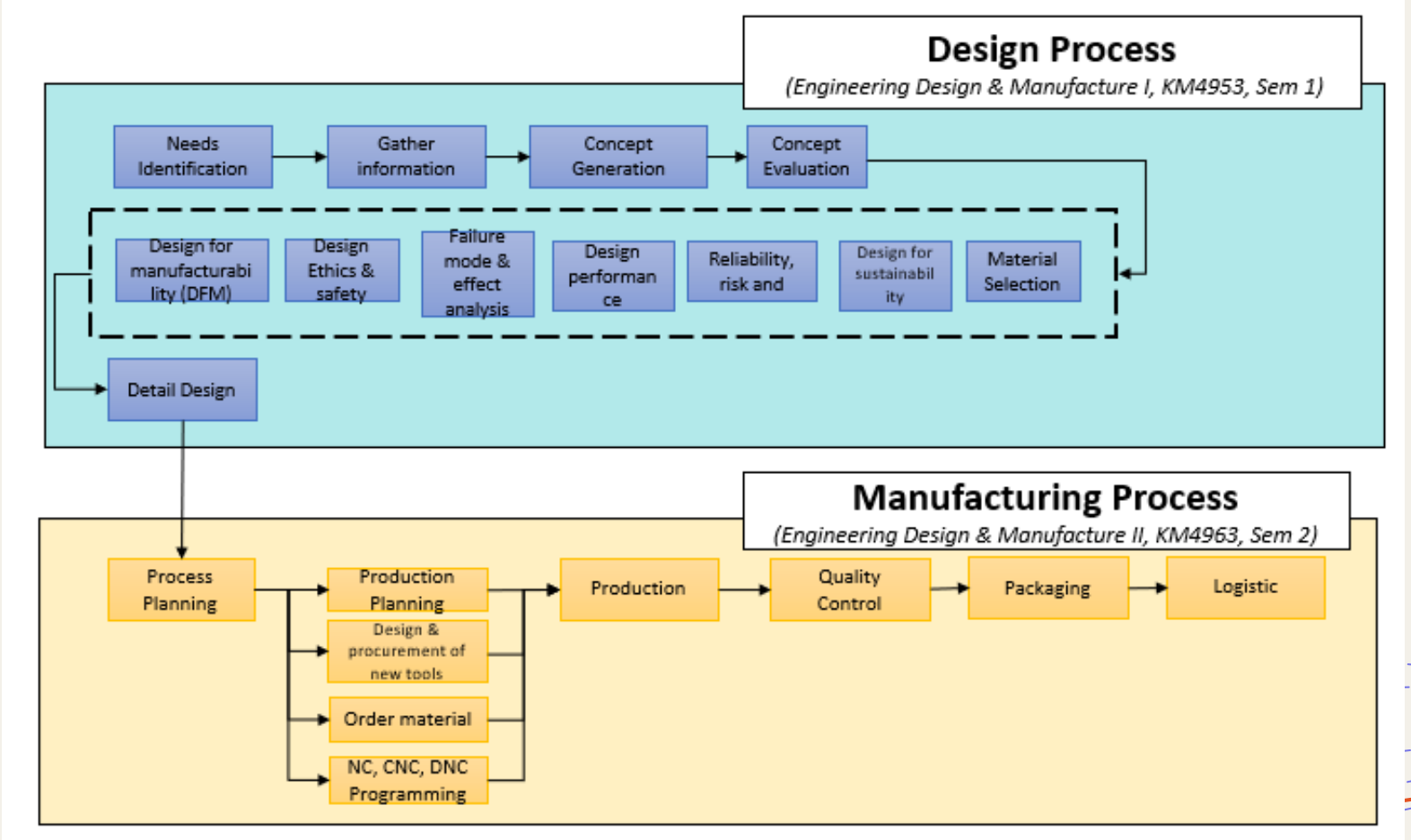
Mr. Ahmad Adlan Bin Ahmad Damanhuri, Managing Director, Optimac Megaworks (M) Sdn Bhd



IDP PROJECT

- Mechanical Engineering Programme

Implementation



Thanks