15. Curriculum 4.0 for incorporating Industry 4.0 tools in Higher Education

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Objectives
As an outcome of reading this chapter, the learner will gain knowledge on the following :
  ➢ New higher education degree programmes
  ➢ Courses and the corresponding syllabi relevant to Industry 4.0 in education to realise next ten years vision
  ➢ Guidelines for incorporating Industry 4.0 tools across various disciplines of Arts and Science Education
  ➢ Guidance for framing curriculum

15.1 Introduction
The fifth industrial revolution, Industry 5.0 is changing the world around us. Industry 5.0 is future, but already penetrating trend, of change processes directing towards closer cooperation between man and machine, and systematic prevention of waste and wasting including Industrial upcycling. There are two common themes in each phase of industrial evolution - 1. Speed and 2.Energy. From the starting itself, the race in technological revolution is always about achieving the speed by exploiting the energy sources. Speed from Mechanical Automation to Mass scale Cognitive Automation. Energy exploitation from Steam power to, now a days, nuclear power. Growing clamour about the Sustainability and environment will push Leaders towards looking for alternative means for achieving both 'Speed and Energy'. It is believed that New Innovations will be about Industrial transformation in the face of even faster and scalable production in a sustainable manner. Technology wise, evolution of 5G and Quantum Computing will play significant roles in achieving the speed factor along with Industrial innovations in Energy Production, Distribution, and Consumption.

The modern world is already moving on in the age of Industry 4.0, a term that stands for the fourth industrial revolution, which is characterized by automation of all kinds of processes, artificial intelligence (AI) in all spheres of life, robots, and endless possibilities that technology opens up. Education imparted should always align with the contemporary advancements of modern world. The problem of what knowledge to impart to make the students Industry 4.0 ready will be addressed in this chapter. The details of courses in this chapter can be used for framing the curriculum of higher education programmes. This chapter will be a great boon as a guide as it will guide the educationists to design courses and to use the materials given in this book for framing syllabi and curriculum, and for teaching and learning. By teaching the courses with the syllabi mentioned in this chapter, students will gain exposure to Industry 4.0 tools, case studies, applications of Industry 4.0 tools in various verticals. Also, it gives the fundamental knowledge on Industry 4.0 tools and their linkages with the higher education, Industries such as Insurance, Healthcare, agriculture through use cases and case studies.

15.2 Tools of Industry 4.0

Artificial Intelligence and Machine Learning, Automation and Robotics, Big Data, Internet of Things and Augmented Reality & Virtual Reality, Creativity are the tools of Industry 4.0. The fourth and fifth industrial revolutions are affecting the roles that Indian Universities and Colleges prepare students for, and educational institutions are ideally placed to help produce the workforce for this new world and the student experience to match it. It is necessary to align higher education with industry 4.0 and 5.0 through the education on the tools of Industry 4.0 and 5.0. It is also very essential to impart the skills that are necessary to develop the students to face the Volatile, Uncertain, Complex and Ambiguous (VUCA) world around us. Thus, awareness and practice on industry 4.0 and 5.0 tools, skill development to face VUCA world and technological advanced infrastructure become the keys for successful development of future pillars of our Globe. Linking Industry 4.0 and 5.0 with arts and science education is the need of the hour.

Today, the rate at which the transformation happening is very disruptive in nature and also exponential changes are being witnessed. We have already witnessed how many conventional business models and technologies got disrupted in the last few years. Technologies such as AI/ML/RL/AR/VR are mutating very fast. Industry 4.0 is getting fast forwarded due to some of these drivers. Educational institutions have to be way ahead of the requirement and prepare their students to meet the new challenges to be created by Industry 5.0. Currently, educational institutions are at crossroads and do not know how to interweave the Industry 4.0 tools into the arts, science, social science and teacher education programme in Universities. This chapter gives them a direction.

The administrators of the higher education system are looking for ways and means to align the education with the Industry 4.0 and Industry 5.0 to make their students understand the developments such as process automation, intelligent systems through artificial intelligence and big data, Internet of Things in the industrial sector. There is not enough literature on how to design the programmes and courses for the interdisciplinary nature i.e. process automation in healthcare, machine learning for economy and policy decision making, IoT in education, AI and IoT in insurance knowledge are to be imparted to the students, scholars and teaching community.

Big Data and Data Analytics

Big Data Analytics has gained attention after advent of social networking in 2010 and evolved as an important technology for analyzing huge volume of data. Data has tremendously increased in large volumes generated by business and individual users through social networking platforms accumulated as data silos in structured and unstructured format. Traditional computing environments faced the limitation in analyzing this complex huge volume of dataset and require high computational resources with huge investments. Big Data Analytics platforms provide solution by analyzing the huge data using commodity hardware without high investment. Google and Yahoo are the pioneer in devising the Big Data Processing Architecture HADOOP which overcome the limitation of traditional computing environment. Big Data Analytics is as well used as tool to gather understanding based on the patterns from the data silos which is used in various business domains to gain deep insights about their customers, the past operational data, augment the data warehouses. Big Data Analytics is used by e-commerce organizations as a marketing tool by identifying the customers' requirements based on click streams and recommend products. Big

Data Analytics using AI in Aviation industry has enormous insights as streaming data from various sources such as weather, aircraft engine data, flight data, customer data integrated provide insights on fuel efficiency, aircraft maintenance, cargo maintenance, ticket prediction.

Artificial Intelligence (AI)

Artificial Intelligence (AI) is a quite inevitable and essential technology in today's world. AI is everywhere and it plays a significant role in various aspects of life. AI can be seen as a part of robotic automation, self-driving cars, health-care & medical support, defence, online shopping and many other technologies. This course will make the readers to gain a systematic understanding of AI from the history and fundamentals to the future applications and tools. It also emphasizes on the challenges of AI, faced by the technology developers and practitioners. This course will serve as a great starting point for beginners to learn and understand AI irrespective of their diverse domains.

Automation

Automation is a buzzword in the technological arena, which leads to massive transformation in the manufacturing sector, with enabling technologies such as artificial intelligence, robotic processes, machine learning and data analytics. Automation reduces the workload of human by employing machines to perform repetitive, time-consuming and complex tasks. Nowadays, smart machines are capable of analysing and learning from the assigned tasks, expand their knowledge base and are even more capable of applying the acquired knowledge rationally in decision making, thereby reducing human intervention. The fundamental aspects to be identified by every industry before shifting to automation are, i) Potential areas of automation ii) Feasibility and scalability factors of automation and iii) Extent to which automation can be made in order to reap the benefits without much affecting the existing industrial ecosystem. Process automation can be adopted to any type of business, based on the organizational requirements, resource availability and constraints. Today, many enterprise solutions are readily available for automation which can provide high level of integration efficiency with minimal disruption to the existing organizational setup.

Robotic Process Automation

Robotic Process Automation (RPA) is used to design software robots that can automate the tasks of interacting with the digital systems (Javed et al., 2021). Examples of tasks that are performed by software robots include extraction of data from web pages, filling forms, preparing reports, managing files, interpretation of texts, chat and converse with customers, and decision making. These tasks can be categorized as repetitive and voluminous tasks as well as tasks which require critical thinking. The software robots are intended to carry out both categories of tasks and hence help in improving the productivity and efficiency in companies. There are a number of tools used for RPA and UiPath is one of the most popular tools.

Internet of Things (IoT)

Internet of Things (IoT) is a collection of physical objects with sensors, software & other technologies which have the capability to communicate with each other through internet. These objects include smartphones, computers, laptops, smart watches, cars, televisions, refrigerators and washing machines. The characteristics of these IoT devices are that they are based on different types of platforms. It is estimated by Statista Research Department that the number of IoT devices in the world will be approximately 75.44 billions by 2025 (Internet of Things, 2016). IoT is one of the key players to enhance the quality of manufacturing process and products in industries. The

usage of IoT for industries is known as Industrial Internet of Things (IIoT). With IIoT, machines have the capability to monitor themselves which in turn increases the efficiency. IIoT also helps in managing inventory, which in turn decreases the wastage and in ensuring that necessary goods are always available. IIoT will help in automatically understanding the consumer's interest and in making appropriate changes in the marketing strategies of retail stores.

The world has already moved to Industry 4.0. The students graduating from Higher Education institutions should be equipped with skills so that they can take up a career in this Industry 5.0. It is essential to integrate all the key technologies including artificial intelligence, augmented/ virtual reality, big data analytics, cloud computing, IoT and robotics in the curriculum of higher education. IoT can be integrated into the curriculum of higher education depending on the programmes that they have enrolled. All the graduates should be made aware of the basic concepts of IoT, so that they become aware of the IoT devices around them. The graduates who would take up active careers in Industry 5.0 should be given hands-on experience also so that they themselves can create and use IoT systems.

15.3 Learning

The three domains of learning according to Bloom's Taxonomy also known as KSA – Knowledge Skills Attitude (Kaur, H., 2019)are : (i)cognitive domain – it focuses on **k**nowledge, (ii) psychomotor domain – it focuses on **s**kills, and (iii) affective domain – it focuses on **a**ttitude. Cognitive domain focuses on knowledge and comprises of six sub-categories Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. The first three Knowledge, Comprehension, Application involves low order thinking skills and Analysis, Synthesis, and Evaluation involves high order thinking skills. The new version of learning is classified as Remembering, Understanding, Applying, Analysing, Evaluation, and Creating.

Psychomotor domain is also called kinaesthetic domain, it relates to natural, autonomic responses or reflexes. There are models of psychomotor domain. Perception set, Guided Response, Mechanism, and Complex Overt Response – to know what will be the result immediately after performance, Adaptation, and Origination.Affectivedomain was proposed by Krathwohl. It is concerned with feelings and emotions, which can be arranged as Receiving, Responding, Valuing, Organization, and Characterization.

The Levels of learning are classified as Listening, Reading, Reflecting, Assimilating and Implementing.

Lecture Listening

An oral presentation of the lesson by the teacher is known as Lecture, it is considered as the most ancient method of instruction. It is used for addressing larger groups and it is economic as more information can be provided to students in a short span of time. Students listen and learn through the flow of information given by the teachers (Kaur, H., 2019).

Demonstration Learning

Demonstration means explaining or showing students practically the working of any procedure or object. It is most commonly used in teaching different subjects where demonstration is needed

were it helps in boosting the interest of students which enhances understanding of the topic. Students remain more active while watching demonstrations (Kaur, H., 2019).

Heuristic Learning
This type of learning was proposed by Armstrong, the word which means 'to find' this makes students to learn curiously by discovery, instead of receiving information. Students should try to explore, explain, describe it gives purposeful experience, self-thinking, self-study, etc. The teacher gives a topic or problem to students and they have to find the solution using library, laboratory, online resources, seminars, workshops (Kaur, H., 2019).

Flipped Classroom
The modern concept, here teachers record their lectures and share them with students. So it is named as flipped classroom since 2007. Students can study video lectures and handouts at their own pace. There can be better discussions on assignments in the classroom (Kaur, H., 2019).

Kinaesthetic Learning
Hands on Learning or Tactile Learning, it more emphasis on physical activities, instead of lectures or demonstration. Students learn by experiences, role of playing, drama, sports, drawing, etc. It helps students in retaining what they have learnt so that students learn with greater interest and curiosity (Kaur, H., 2019).

Discussion
It acts as a better source of learning than lecturing or explaining, as discussion involves two way communication and lecture involves only one way communication. Discussions can enhance confidence of students if they are encouraged to speak. There is a tendency of high student participation in discussions. It also improves communication skills, critical thinking, creative thinking, etc. of students.

Team Teaching
In team teaching, not only one teacher plans the class activity, rather two or more teachers plan the activities, aids, evaluation strategies for the same set of students. It encourages friendship among teachers which will bring positivity in the learning environment. It is helpful for interdisciplinary approach on learning.

Open Learning
It is a form of learning in which there are no barriers of age, place, time, etc. Students can learn wherever and whenever they wish to. Learning is the responsibility of students, open learning is a student – centred approach learning. It is helpful for those students who cannot attend regular classes there is no restrictions on learning, it has greater flexibility.

Project / Activity-based Learning
It is also a part of many degree programmes. Students conduct research, carry our survey, and then present the findings of research in the form of a report. It helps students to learn and prepare the projects on their own.

Panel Discussion
The subject experts are invited for panel discussion where students will get to learn from experts in the field. By observing the discussion, students will learn how to communicate their ideas and viewpoints.

Brainstorming
It is marked by spontaneity, students have to share their opinion or idea about the topic. The views presented by the students during the session are not subject to criticism. It has greater scope for participation with large groups, such kind boosts creativity, confidence and innovation with learning happens from group.

Programmed Instruction
It addresses individual differences by providing immediate feedback to students on correct answers of the solved questions. Learning by doing principle is used in this type, such type of learning can also be used in the absence of the teacher.

Role Playing
Students are assigned with different roles and make aware of the different persons and their perspectives. It helps in sharpening the critical thinking, creative thinking, debating, negotiating, and reasoning ability of students. Such type can be used effectively to shape the attitude of students.

Simulation
It is also a form of role playing but it is based on experimental learning where students learn in an environment similar to real-life situations. It develops problem-solving abilities in students, this mainly focussed in skill development.

Computer Assisted Learning
With the use of technology, learning has become very much faster as compared to the traditional techniques. It makes learning active, efficient, easier, and convenient by the use of modern technology.

Game-based Learning
The learning is imparted with the use of games, use of games increases the student's participation and also boosts their interests. There are gaming applications for building vocabulary, practising typing and also great technologies like augmented reality offers game based platform for simulation learning to the students.

Seminar
It is also same as classroom interaction, in almost all educational institutes seminars are organized every year. It is a great source of information as the experts of a particular field present the topics, the information received is authentic, Students participating in seminar get to know about research activities and improve the presentation skills.

Tutorials
The student presents and the teacher supervised the presentation. It is followed by a question

session, where other students can ask queries; if the presenter is not able to resolve the queries, the teacher can help. It sharpens the communication skills of students.

Assignments
The classroom activity which helps in self-learning as it can be an extension of classroom learning. Students learn time management skills by working with deadlines. Students have flexibility in completing it at their own convenience but before the deadline.

Case Study
It is based on real-life situations are assigned to the students, defines actual situation usually involving a decision, a challenge, an opportunity, a problem, an issue or a controversy affecting a person. It boosts creativity, critical thinking, communication, interpersonal and time management skills in students. These bridge the gap between theory and practical, that is, students learn to apply theory to tackle real-life situations.

15.4 Digital Classroom & E-Learning Tools
The advent of information and communication technology has transformed traditional classroom into a digital classroom (Kaur, 2019). A digital classroom improves teaching and learning process by providing a conducive environment for interaction between teachers and students. Digital classrooms will play a crucial role in the forthcoming years in the teaching learning process of higher education. There are a number of tools used for e-learning (Ekaran, 2018). These tools help in creation & management of course content, content delivery, assessment of students, tracks the progress of course undertaken by students. The tools for e-learning include socrative, scratch, prezi, selfCAD, Quizlet, Google Classroom, Adobe Spark Video, Khan Academy, SeeSaw, Class Dojo, MOOCs, SWAYAM, SWAYAM PRABHA, CEC, ePathshala, NPTEL, ICT based Tools and Audio-Visual Aids.

Socrative
It is a cloud-based student response system, allowing teachers to immediately test student understanding by way of mini-quizzes, assigned to them on class laptops or tablets (Sammy Ekaran, 2018).

Scratch
Users can combine music, graphics, and photos to create interactive games, animations, and slideshows. All of their creations are shareable with others in a student's online community (Sammy Ekaran, 2018).

Prezi
It is a cloud-based presentation software used for creating, giving, and tracking beautiful interactive presentations. Prezi presentations are nothing like your traditional presentations; zooming in and out and moving side to side across one single, very attractive and modern canvas, focusing in on images and videos inputted by the user (Sammy Ekaran, 2018).

SelfCAD
It is free and a cloud-based 3D CAD software package for students. It is incredibly easy to use, yet

provides an authentic, 'real world' 3D design experience and also provide a database of already completed 3D printable designs, making thousands of 3D objects available for immediate 3D printing (Sammy Ekaran, 2018).

Quizlet

It provides a platform for students and teachers to create and share their own learning materials, including flashcards and diagrams, it also provides interactive game, and students must all contribute, stay focused and communicate well to win. (Sammy Ekaran, 2018).

Google Classroom

It is a powerful community based social tool for learning. It allows students to post questions and receive answers from their teachers and fellow students. Furthermore, teachers can post intriguing questions and lesson materials for review at home (Sammy Ekaran, 2018).

Adobe Spark Video

The application enables students to produce short, animated, narrated explainer videos. Students can easily add photos, video clips, icons, and voice, as well as professional-quality soundtracks and cinematic motion to their video creations. Video and vlog making is a great way to engage students creatively, and an 'out of the box' approach to class projects or reviewing learning materials (Sammy Ekaran, 2018).

Khan Academy

Lessons are presented by way of videos, interactive activities, and challenges. Learners also earn badges in line with their achievements and can save their progress to their own profile. Khan Academy is a great way to supplement your teaching, provide extra work to your gifted and talented students or help those who are struggling with certain content (Sammy Ekaran, 2018).

SeeSaw

It is an easy to use learning portfolio application, enabling students to document, showcase and reflect on what they are learning at school. Work can be made accessible to parents as well (Sammy Ekaran, 2018).

Class Dojo

It is a free classroom communication, community building, and behavior management application. A well-behaved student body is associated with better learning for everyone in the class as it minimizes distractions and improves student focus. Class Dojo enables teachers to not only track behavior and share this with parents, but also assign students tasks which build positive behavioral skills and traits (Sammy Ekaran, 2018).

MOOCs

Massive Open Online Courses (MOOCs) are online courses that available free of cost. Such courses are taught by prestigious Indian and foreign institutes on platforms such as MOT OCW, SWAYAM, edX, Udacity, Coursera. Anyone can enrol in a course of their choice whithout any restrictions of the qualification. Online courses comprise videos, course handouts, suggested readings and online tests.

SWAYAM
Study Webs of Active Learning for Young Aspiring Minds, is a MOOC based initiative by the Indian government, where courses from prestigious institutes are available online. Students can enrol in these courses free of cost.

SWAYAM PRABHA
It is a set of 32 DTH channels which telecast high-quality educational programmes using the GSAT-15 satellite. The website of SWAYAM PRABHA is maintained by INFLIBNET Centre. New content is telecast everyday foe at least four hours and it is then repeated five times in a days so that the students can learn at time of their convenience.

CEC
Consortium for Educational Communication was set up in 1993 by the UGC. It is an inter-university centre and the nodal agency to coordinate, guide and facilitate the production of educational content at the national level through its network. It streams both the live as well as recorded sessions available on YouTube. Students can interact with teachers through text mode, over the telephone or through videoconferencing.

ePathshala
It is a platform which supports a collection of wide range of educational e-resources including textbooks, audio, video, periodicals, and other materials. It can be used by teachers, researchers, educators, students.

NPTEL
National Programme on Technology Enhanced Learning a joint initiative by the IITs and IISc for improving the quality of teaching by providing online content which can be used by teachers and students. It helps to use courses to plan the classroom lectures.

ICT based tools
Online solutions like Google Classroom to share online contents with students, have discussions, receive assignments and conduct online tests.

Audio-Visual Aids
Recordings, Slides, Charts, Poster, Picture, Graphs, Maps, Mind maps, Diagram, Display Boards, Summary Cards, Projectors.

15.5 **New Degree Programmes and Courses**
In order to meet the challenges of aligning the education with industry 4.0, it becomes necessary to create specialized knowledge pools. Hence, undergraduate and post graduate programmes for digital transformation as given below become very essential. Table 15-1 shows the new undergraduate and postgraduate programmes in Industry 4.0 that can be offered in the higher education institutions. The programmes will offer specific courses related to the concepts and tools of Industry 4.0.

Table 15-1　New Degree Programmes in Industry 4.0

Undergraduate Programmes	Postgraduate Programmes
B.Sc. Data Analytics	M.Sc. Data Analytics
B.Sc Artificial Intelligence	M.Sc Artificial Intelligence
B.Sc. Cyber Security	M.Sc. Cyber Security
B.B.M. Learning Management	M.B.A. Learning Management
B.B.A. Learning Management	M.B.A. Industry 5.0
B.Com. Finance Analytics	M.Com. Finance Analytics
B.Com. Business Analytics	M.Com. Business Analytics

15.5.1 New Courses

It is necessary to introduce new courses for Industry 4.0 technologies as specified in Table 15-1. Industry 4.0 transforms all domains and sectors into Smart Factories through automation. Automation replace the repetitive tasks, which is boredom for the jobs aspirants but will not take away the opportunities but replace their skills as technology based. It is important to equip the learners with the basic operating technological skills required for Industry 4.0. All the technologies run the through the fuel of data which is an important components to drive the insights, solutions and challenges. The new courses for Industry 4.0 skills set are presented in table 15-2. A mapping of the digital transformation technology i.e Industry 4.0 components onto the various subject areas or departments of science, social science, humanities and arts has been done and is shown in table 15-2.

Table 15-2 Tools of Industry 4.0 as Courses in the Departments

Course	Departments where courses are to be introduced
Introduction to Industry 4.0	All Departments
Big Data and Data Analytics	Commerce, Social Science, Management, Social Work, Economics, Applied Maths, Women Studies, Bioinformatics, Environment Science, Biotechnology, Extension and Career Guidance, Physical Education, Human Genetics, Statistics, Maths, Psychology, Computer Science
Internet of Things (IoT)	Environment Science, Physics, Medical Physics, Nanotechnology, Electronics and Instrumentation, Computer Science
Augmented Reality	Chemistry, Textiles, Communication and Media Studies, Education Technology, Education, Computer Science
Artificial Intelligence	All Departments
Robotic Process Automation	All Departments

General Courses on Industry 4.0
- Introduction to Industry 4.0
- Advancements in Industry 4.0

Big Data and Data Analytics Courses
- Programming Essentials - Basics
- Data Management using SQL
- Introduction to SQL Programming
- R Programming for Social Science
- R Programming for Text Analytics
- Python Programming
- Big Data Analytics using SPARK
- Advanced Data Analytics using R
- Web scrapping using Python
- Data Visualization using R & Python
- Basics of Machine Learning
- Machine Learning Applications
- Statistics for Data Analytics and Machine Learning
- Data Analytics for Social Sciences
- Principles of Data Science
- Data Analytics for Health Care
- Machine Learning using Python
- Data Analytics for Education
- Behavioral Analytics using Sentiment Analysis
- Opinion Mining for Marketing
- Clinical Data Analytics
- Introduction to Data Integration Basics
- Sports Analytics
- Python Programming for Bio-Informatics
- Big Data Analytics Biological Databases
- Business Analytics
- Advanced Business Analytics using R

Artificial Intelligence Courses
- Artificial Intelligence
- Basics of Machine Learning
- Machine Learning Applications
- Artificial Intelligence using TensorFlow
- Python for Artificail Intelligence
- Natural Language Processing
- Speech Processing
- Reinforcement Learning
- AI in Healthcare

- AI in Finance and Economics
- AI in Automobile
- Knowledge Management
- Human Computer Interaction
- Bio-inspired computing
- Agent Based Computing
- Evolutionary Computing
- Deep Learning
- Fundamentals of Robotics : Actual Robots, Not soft bots, Similar to using Lego Mindstorms, EV3 core set

Robotic Process Automation (RPA) Courses
- Process Automation using UiPath
- Artificial Intelligence & Robotic Process Automation for Biological Sciences
- Robotic Process Automation
- Robotic Process Automation Design & Development
- Robotic Process Automation for Business

Internet of Things (IoT) Courses
- Basics of Electronics
- Introduction to the Internet of Things
- Arduino Platform and C Programming
- Raspberry Pi and Python Programming
- Developing Java Embedded Applications using Raspberry Pi
- Programming with Cloud IoT Plaforms
- Internet of Things: Sensing and Actuation from Devices
- Internet of Things Networks and Protocols
- Internet of Things and Smart Cities
- Internet of Things for Executives
- Cybersecurity and Internet of Things
- IoT in Healthcare
- Industrial IoT
- Big Data Analytics and Internet of Things

Creativity, Design Thinking and Problem Solving
- Design Thinking
- Creativity and Design Thinking for Problem Solving
- Human to Machine Interaction

15.6 Learning Path – Industry 4.0 Skill Sets – Scheme

Industry 4.0 has been adopted by almost all industries and is changing the skill set required by students for taking up jobs in the near future. It is very essential to equip students with the

knowledge of various Industry 4.0 tools. Various courses are designed by Bharathiar University for undergraduate and postgraduate programmes to incorporate the knowledge of Industry 4.0 tools such as artificial intelligence, big data, augmented reality, and internet of things among students. The scheme and syllabi of these courses are given in this section. T represents theory and P represents Practicals. Table 15-3 enumerates the courses that can be offered at the undergraduate level in the commerce and management streams. Table 15-4 enumerates the courses that can be offered at the postgraduate level in the commerce and management streams. Table 15–5 presents the courses that can be offered at the postgraduate level in the Social Science, Sociology, Social Work, Psychology and Women Studies streams.

15.6.1 UG – Commerce & Management
Table 15-3 Course for UG – Commerce and Management

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Introduction to Databases	4	T	1
3	Data Manipulation using SQL		P	2
4	Big Data Analytics		T	2
5	Data Analytics using R	4	P	3
6	Artificial Intelligence	4	T	3
ELECTIVES				
1	AI – Robotic Process Automation (UIPATH) – E	4	P	4
2	Advanced Data Analytics using R			
3	Sentiment Analysis			
4	Android Programming			

15.6.2 PG– Commerce & Management
Table 15-4 Course for PG – Commerce and Management

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Big Data Analytics	4	T	1
3	Programming Essentials for Data Analytics	4	P	2
4	Artificial Intelligence	4	T	2
5	Data Analytics using R	4	P	3
6	Robotic Process Automation (UIPATH)	4	P	3
7	Elective			
ELECTIVES				
1	Advanced Data Analytics using R	4	P	
2	Sentiment Analysis	4	P	

15.6.3 PG - Social Science, Sociology, Social Work, Psychology, Women Studies

Table 15-5 Course for PG – Social Science, Sociology, Social Work, Psychology and Women Studies

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Database Management Systems	4	T	1
3	Big Data Analytics	4	T	2
4	Data Manipulation using SQL	4	P	2
5	Artificial Intelligence	4	T	3
6	Data Analytics using R	4	P	3
7	Text Analytics	4	P	
8	Elective			
ELECTIVES				
1	Advanced Data Analytics using R (unstructured Data)	4	P	
2	Sentiment Analysis	4	P	
3	Robotic Process Automation (UIPATH)	4	P	

15.6.4 Linguistics, English

Table 15-6 shows the courses that can be offered in the Linguistics and English streams. Table 15-7 enumerates the courses that can be offered in Physics and Chemistry streams. Table 15 – 8 presents the courses that can be offered in the Life Sciences streams including Botany, Zoology and Textiles. Table 15 – 9 lists the courses that can be offered in the Biotechnology, Environmental Sciences, Human Genetics and Bio-Informatics streams. Table 15 – 10 enumerates the courses that can be offered in the Physical Education stream. Table 15 – 11 presents the courses that can be offered in the Mathematics, Applied Mathematics and Statistics streams. These courses will make the students aware of the digital transformations that are being made in their respective streams. They can also use the Industry 4.0 tools they have learnt to drive the changes of Industry 4.0.

Table 15-6 Courses – Linguistics and English

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Database Management Systems	4	T	1
3	Text Analytics	4	T	2
4	Artificial Intelligence	4	T	2
5	Elective			
ELECTIVES				
1	Sentiment Analysis	4	P	
2	Robotic Process Automation (UIPATH)	4	P	

15.6.5 Physics, Chemistry

Table 15-7 Courses – Physics and Chemistry

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Introduction to Data Science	4	T	1
3	Python Programming	4	P	2
4	Artificial Intelligence	4	T	2
5	Internet of Things	4	P	
6	Elective			
ELECTIVES				
1	Applied Machine Learning	4	P	
2	Robotic Process Automation (UIPATH)	4	P	

15.6.6 Life Sciences : Botany, Zoology, Textiles

Table 15-8 Courses – Life Sciences

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Introduction to Databases SQL Programming	4	P	1
3	Artificial Intelligence	4	T	2
4	Data Analytics using R	4	P	2
ELECTIVES				
1	Genomic Data Analytics using R Programming	4	P	3
2	Robotic Process Automation (UIPATH)	4	P	

For textiles, (in addition to the above)

3	Augmented Reality	4	P	

15.6.7 Biotechnology, Environmental Sciences, Human Genetics, Bio- Informatics,

Table 15-9 Courses - Biotechnology, Environmental Sciences, Human Genetics, Bio-Informatics

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Python Programming	4	T	1
3	Artificial Intelligence	4	P	2
4	Big Data Analytics	4	T	2
5	Genomic Data Analytics using R Programming	4	P	3
6	Internet of Things	4	T	3
7	Data Analytics using R	4	P	3
8	Programming Essentials for Data	4	P	2

	Analytics			
ELECTIVES				
1	Applied Machine Learning using Python	4	P	
2	IoT LAB	4	P	

15.6.8 Physical Education
Table 15-10 Courses – Physical Education

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Introduction to Data Analytics	4	T	1
2	Internet of Things	4	T	2
3	Data Analytics using R Programming	4	T	2
4	Artificial Intelligence	4	P	3
5	Elective			
ELECTIVES				
1	Sports Data Analytics using R (unstructured Data)	4	P	
2	IoT LAB	4	P	
3	Robotic Process Automation (UIPATH)	4	P	

15.6.9 Mathematics, Applied Mathematics, Statistics
Table 15-11 Courses - Mathematics, Applied Mathematics and Statistics

S.No	Subject	Credits	T/P	Semester
1	Industry 4.0	4	T	1 or 2
2	Python Programming	4	T	1
3	Artificial Intelligence	4	P	2
4	Big Data Analytics	4	T	2
5	Data Analytics using R Programming	4	P	3
8	Programming Essentials for Data Analytics	4	P	2
ELECTIVES				
1	Applied Machine Learning using Python	4	P	

15.7 Syllabi for New Courses - SYLLABI 4.0
Various courses that deal with Industry 4.0 tools are : Introduction to Industry 4.0, Advancements in Industry 4.0, Big Data Analytics, R Programming for Social Science, Data Analytics using R, Advanced Data Analysis using R, Python for Data Analytics, Artificial Intelligence, Robotic Process Automation, Robotic Process Automation Design & Development, Robotic Process

Automation for Business, Internet of Things, Critical Thinking, Design Thinking & Problem Solving, Quantum Computing, Cyber Security and Ethical Hacking and the syllabi for these courses are given in Annexure 1.

15.7.1 Introduction to Industry 4.0

Objectives
      At the end of completing this course, students will have knowledge on Industry 4.0, need for digital transformation and the following Industry 4.0 tools:
      1. Artificial Intelligence
      2. Big Data and Data Analytics
      3. Internet of Things

Syllabus

Unit I : Industry 4.0
Need – Reason for Adopting Industry 4.0 - Definition – Goals and Design Principles - Technologies of Industry 4.0 – Big Data – Artificial Intelligence (AI) – Industrial Internet of Things - Cyber Security – Cloud – Augmented Reality

Unit II : Artificial Intelligence
Artificial Intelligence : Artificial Intelligence (AI) – What & Why? - History of AI - Foundations of AI -The AI - Environment - Societal Influences of AI - Application Domains and Tools - Associated Technologies of AI - Future Prospects of AI - Challenges of AI

Unit III : Big Data and IoT
Big Data : Evolution - Data Evolution - Data : Terminologies - Big Data Definitions - Essential of Big Data in Industry 4.0 - Big Data Merits and Advantages - Big Data Components : Big Data Characteristics - Big Data Processing Frameworks - Big Data Applications - Big Data Tools - Big Data Domain Stack : Big Data in Data Science - Big Data in IoT - Big Data in Machine Learning - Big Data in Databases - Big Data Usecases : Big Data in Social Causes - Big Data for Industry -Big Data Roles and Skills -Big Data Roles - Learning Platforms; Internet of Things (IoT) : Introduction to IoT - Architecture of IoT - Technologies for IoT - Developing IoT Applications - Applications of IoT - Security in IoT

Unit IV : Applications and Tools of Industry 4.0
Applications of IoT – Manufacturing – Healthcare – Education – Aerospace and Defense – Agriculture – Transportationa and Logistics – Impact of Industry 4.0 on Society: Impact on Business, Government, People.   Tools for Artificial Intelligence, Big Data and Data Analytics, Virtual Reality, Augmented Reality, IoT, Robotics

Unit V : Jobs 2030
Industry 4.0 — Education 4.0 – Curriculum 4.0 – Faculty 4.0 – Skills required for Future - Tools for Education – Artificial Intelligence Jobs in 2030 – Jobs 2030 - Framework for aligning Education with Industry 4.0 – Framework for achieving next ten years vision – Challenges

Books
1. P. Kaliraj, T. Devi, Artificial Intelligence Theory, models and Applications, 2022, ISBN 9781032008097, CRC Press, Taylor & Francis Group
2. P. Kaliraj, T. Devi, Innovating with Augmented Reality : Applications in Education and Industry, 2022, ISBN 9781032008127, CRC Press, Taylor & Francis Group
3. P. Kaliraj, T. Devi, Big Data Applications in Industry 4.0, 2022, ISBN 9781032008110, CRC Press, Taylor & Francis Group

15.7.2 Advancements in Industry 4.0

(Choose any 5 Units out of the following)

Unit I : Machine Learning
Machine Learning - Introduction – Definition – Types of Machine Learning –Supervised, Unsupervised, Reinforcement Learning – Algorithms for Machine Learning – Problems solved by Machine Learning - Tools for Machine Learning - Applications areas of Machine Learning

Unit II : Robotic Process Automation (RPA)
Robotic Process Automation (RPA): Introduction to RPA – Need for automation – Programming constructs in RPA – Robots and Softbots – RPA architecture and process methodologies - Industries best suited for RPA - Risks & Challenges with RPA

Unit III : Cloud Computing
Cloud Computing : Need – Definition – Types of Cloud - Types of Services – SaaS, PaaS, Iaas

Unit IV : Cyber Security
Cyber Security : Cyber Crime and Information Security – Classification of Cyber Crimes - Types of Cyber Attacks - Cyber crime and Indian IT Act 2000 – Security Methods -

Unit V : Virtual Reality
Virtual Reality : Definition – Types of Head Mounted Displays – Tools for Virtual Reality – Applications of VR in Education, Industries - Difference between VR and AR –

Unit VI : Augmented Reality
Augmented Reality : Definition - Tools for Augmented Reality – Hololens - Advantages and Challenges of AR - Applications of AR in Education, Industries - Mixed Reality

BOOKS
1. P. Kaliraj, T. Devi, Industry 4.0 and Education: Transformative Technology and Applications, 2022, CRC Press, Taylor & Francis Group
2. P. Kaliraj, T. Devi, Artificial Intelligence Theory, models and Applications, 2022, ISBN 9781032008097, CRC Press, Taylor & Francis Group
3. P. Kaliraj, T. Devi, Innovating with Augmented Reality : Applications in Education and Industry, 2022, ISBN 9781032008127, CRC Press, Taylor & Francis Group

4. P. Kaliraj, T. Devi, Securing IoT in Industry 4.0 Applications with Blockchain, 2022, ISBN 9781032008103, CRC Press, Taylor & Francis Group
5. Uipath Inc., https://www.uipath.com/rpa/robotic-process-automation
6. Uipath Inc., https://www.uipath.com/rpa/academy

15.7.3 R Programming for Social Science

Unit I : Introduction R language
Understanding R features - Installing R and RStudio – Packages and Library – R Basic Data Types – R Data Formats - Basic Operators – R Objects: Vectors – List- Arrays - Matrix – Factors – DataFrame - R File Formats - Importing and Exporting Files: CSV File – JSON File – txt File – Command Line Vs. Scripts

Unit II :Data Wrangling
Data Understanding - Data Structure - Data Summarization - Viewing Data - Converting Objects - Generating Data: Regular Sequence – Random Sequence - Built-in Functions – Loop Structure: for - while – repeat – Loop Avoidance: ifelse –Switch - sapply() - lapply() - Pre-processing – omitting NA

Unit III : Data Manipulation
Slicing - Subscripts and Indices – Data Subset - Dplyr Package: Select Function - Filter Function - Mutate Function - Arrange Function - String Function: tolower() - toupper() - strsplit() – gsub() - grep()- regexpr()

Unit IV : Data Visualization
Introduction – Exploratory Data Analytics - MASS Package - Lattice Package – Datasets – Graphical Parameters - Histogram - Box Plot – Scatter Plot – Categorical Variable - Wordcloud - Bar Chart

Unit V : Reporting Tool
Analysing Gathering Information – Story Telling – R Markdown - R Markdown Framework - rmarkdown package – Knit for Embedded Code: knitr package - Convert File:HTML, PDF, MS Word - Markdown Formatted Text - ShinyApp - shiny package: Built Shiny app – Control Widgets – Customize Reactions – Reactive Expressions - Customize Appearance - Deploy Shiny app

Books
1. V. Bhuvaneswari, "Data Analytics with R Step by Step", Scitech Publisher, ISBN – 978-81- 929131-2-4, Edition 2016.
2. Roger D.Peng, "R Programming for Data Science", Lean Publishing, 2014.
3. Vignesh Prajapati, "Big Data Analytics with R and Hadoop", Packt Publishing, ISBN- 978-1-78216-328-2, 2013.
4. Sholom Weiss, et.al, "The Text Mining Handbook: Advanced Approaches in Analysing
5. Unstructured Data", Springer, Paperback 2010.
6. Emmanuel Paradis, "R for Beginners", 2005.

15.7.4 Artificial Intelligence & Robotic Process Automation for Biological Sciences

Objectives
  The objective of the course is
  1. To introduce Artificial Intelligence & machine learning for biology students
  2. To facilitate students to learn & apply AI tools for solving research issues in biology
  3. To understand the basics of robotic process automation
  4. To develop automated solutions for research problems in biology

Syllabus

Unit I : Artificial Intelligence (AI)
Introduction to AI – Fundamentals – Need for AI – Foundations of AI – AI environment – Application domains of AI – AI tools – Challenges and Future of AI.

Unit II : Machine learning (ML) and Deep learning (DL)
Fundamentals of ML and DL – ML algorithms to find associations across biological data, cellular image classification and identification of genetic variations. Artificial Intelligence in Biology research: AI in drug design – AI in Phylogeny – AI in next generation sequencing – AI in protein structure prediction – AI in protein folding analysis.

Unit III : Python programming
Introduction to Python language – Python, Machine learning and AI - Data types, variables and operators – Conditions and loops – Structure of a Python program – Packages and function – Writing simple python codes.

Unit IV : Robotic Process Automation (RPA)
Fundamentals of RPA – Programming basics from RPA perspective – Applying RPA – RPA development methodology – Architecture of RPA – RPA and emerging ecosystem.

Unit V : UiPath Studio
Introduction - Automation debugging – Automation library - Activities Packages – Basic automation tasks - Text and image automation – Data tables in RPA – Extracting data from data tables and pdf – Building simple Automation projects.

Reference Books:
1. P.Kaliraj, Devi Thirupathi, "Artificial Intelligence Theory, Models, and Applications", Auerbach Publications, CRC Press, Taylor and Francis group, 2021.
2. Ethem Alpaydin, "Introduction to Machine Learning", Third Edition, MIT Press, 2014.
3. Martin C. Brown, "Python: The Complete Reference", McGraw Hill Education, 2018.
4. https://www.uipath.com/landing/academic-studio-download
5. https://www.uipath.com/rpa/robotic-process-automation
6. https://www.uipath.com/rpa/academy

The perspectives of the AI Expert is as given below : Unit II of the above syllabus shall be redefined for every department, say, for botany, zoology, bio-technology, micro-biology, bio-informatics separately after discussing with the respective department experts who will have a vision for the next ten years. Unit IV & V RPA topics can be offered uniformly to all the departments except MBA, M.Com and related disciplines, as there is another course offered by UiPath Inc., Romania for Business managers, which could be adopted for the above disciplines. Rest of the units given in the syllabus can be made common.

15.8 Guidelines for framing new courses in Industry 4.0

Industry 4,0 tools cut across various domains such as healthcare, manufactuirng, agriculture, tourism, entertainment and agriculture. The guidelines for framing new courses are devised and the steps that are to be followed to invent or frame new courses in your discipline are as given below:

- Choose any of the Industry 4.0 and 5.0 tools. Say the tool is "T"
- Analyse how this tool will be useful in your discipline
- Choose the area in your discipline where this tool will be applicable. Say the area is "A"
- Search for the following :
    - Knowledge on tool "T"
    - Methods of applying the tool "T" in area "A"
    - Case Studies or Use Cases for the tool "T" in area "A"
    - Industries who are the fore runners in "T"
    - Industries who are the fore runners in "A"
    - User friendly Software tools for "T"
    - Recent developments in "T" + "A"

- Carry out the following :
    - Attend Good training programmes on "T"
    - Network with industrial experts with expertise on "T"
    - Network with Industries using "T" in area "A"
    - Tie up with research organisations or experts in "T"+"A"

- Frame the Syllabus for "T"+"A"   as given below:
    - Unit I on the area "A" of your discipline
    - Unit II on the "Introduction to the tool 'T'"
    - Unit III on the methods of applying the tool "T" in area "A"
    - Unit IV on "how to use the software tool for "T""
    - Unit V Case Studies or Use Cases for the tool "T" in area "A"

15.9 Skill Development

Critical Thinking, People Management, Emotional Intelligence, Critical Judgement, Negotiation, Cognitive Flexibility, Knowledge Production and Management are the various skillsets that are required to be possessed by the modern student. Education process needs to adopt each individual student to achieve 5 Cs: communication, collaboration, competence, creativity and critical thinking (Pinnamaneni, 2020).

The students should equip themselves with critical thinking, creativity and problem in order to

fetch jobs in Industry 4.0. These skills are essential for developing intelligent and creative solutions for various complex problems. The critical thinking and judgement are the skills which help the students to interpret things correctly and take proper decision in any workplace. Similarly, team work and collaboration also help in advancing the technological processes in a company. Cognitive science plays a crucial role in enabling the machines to think like humans. Knowledge management in Industry 4.0 is essential for proper machine and human interaction.

Design Thinking

Course Objectives
To impart knowledge on adopting principles of design thinking to bring innovations by transforming organisations culture and to solve complex problems which are difficult to decipher.
(1) The students to mainly understand on the core concepts of design thinking which includes
    (a) Empathy   (b) Brainstorming   (c) Prototyping   (d) Storytelling

UNIT 1: Definition and the perspective on Design Thinking Process
Introduction: Definition - The role of design thinking and designers – The modes of thinking - Design process (Double Diamond) - Design principles and other methods.

UNIT 2: Formation of Complexities and Building Strategy for Organizations
Challenges: A powerful way to use data (data collection) - Frame design and generate design - Thinking strategy to reframe the complexities with capability: Formation of the problem for the organizations - creation of design thinking strategy and capability (structure, culture, skills, process) - to reduce risk and enable performance.

UNIT 3: Problem Solving by Exploring Tools
Explore: Discover challenges - interpret through empathy study – Empathy study tools - perform risk assessment

UNIT 4: Idea Generation and Development of Concepts
Ideate: Generate ideas - shortlist a workable solution - perform risk assessment. Create: Develop prototypes of a big idea - get feedback - perform financial analysis of the solution and risk assessment

UNIT 5: Design Thinking setup within firm and Development Service
Evolve: Design thinking integration in organizations - Success factor and measure the solution. Design for effective services: Developed Product vs. Development services - service development - experience lifecycle.

Books for the Course
1. Vianna, M., Vianna, Y., K. Adler, I., Lucena, B. and Russo, B., 2012. Design Thinking Business Innovation. 1st ed. Rio de Janeiro: MJV Press, pp.1-85.
2. Ling, D., 2015. Complete Design Thinking Guide For Successful Professionals. 1st ed. Singapore: CreateSpace Independent Publishing Platform, pp.1-183.

15.10 Conclusions

The fourth industrial revolution, Industry 4.0 is changing the world around us. It is necessary to align higher education with industry 4.0 through the education on the tools of Industry 4.0. Introduction of various courses on Industry 4.0 tools would ensure upgradation of students' skills and their knowledge to match the newly created jobs of Industry 4.0. Bharathiar University has taken steps in imparting the knowledge of Industry 4.0 tools by introduction of various undergraduate and postgraduate programmes. This chapter provided an extensive review of various tools of Industry 4.0. It also provided the scheme and syllabi of various undergraduate and postgraduate programmes introduced by Bharathiar University to teach Industry 4.0 tools.

References
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2. Kaur, H., 2019. *Teaching & Research Aptitude*. 1st ed. Oxford University Press, pp.1.10 -1.22.
3. Javed A., Sundrani A., Malik N. and Prescott S. A., 'Robotic Process Automation using UiPath StudioX', Apress, 2021.
4. Internet of Things – number of connected devices worldwide 2015-2025, Statista Research Department, 27th Nov 2016 URL: https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/ , 28th April 2020.
5. P. Kaliraj, T. Devi, Artificial Intelligence Theory, models and Applications, 2022, ISBN 9781032008097, CRC Press, Taylor & Francis Group
6. P. Kaliraj, T. Devi, Innovating with Augmented Reality : Applications in Education and Industry, 2022, ISBN 9781032008127, CRC Press, Taylor & Francis Group
7. P. Kaliraj, T. Devi, Securing IoT in Industry 4.0 Applications with Blockchain, 2022, ISBN 9781032008103, CRC Press, Taylor & Francis Group

Appendix A

A. Syllabi for New Courses - SYLLABI 4.0

The syllabi for various courses that deal with Industry 4.0 tools are given in this section.

A.1 Big Data Analytics

Unit I : Introduction
Data – Information – Data Terminologies – Database – Data Mining – Data Warehouse – Data Evolution Roadmap – Big Data – Definition – Type of Data - Numeric – Categorical – Graphical – High Dimensional Data –– Data Classification – Hot Data – Cold Data – Warm Data – Thick Data – Thin Data - Classification of digital Data: Structured, Semi-Structured and Un-Structured- Data Sources - Time Series – Transactional Data – Biological Data – Spatial Data – Social Network Data –

Unit II : Data Science
 Data Science-A Discipline – Data Science vs Statistics, Data Science vs Mathematics, Data Science vs Programming Language, Data Science vs Database, Data Science vs Machine Learning. Data Analytics - – Relation: Data Science, Analytics, Big Data Analytics. Data Science Components: Data Engineering, Data Analytics-Methods and Algorithm, Data Visualization

Unit III : Big Data
Digital Data-an Imprint: Evolution of Big Data – What is Big Data – Sources of Big Data. Characteristics of Big Data 6Vs – Big Data Myths - Data Discovery-Traditional Approach, Big Data Technology: Big Data Technology Process – Big Data Exploration - Data Augmentation – Operational Analysis – 360 View of Customers – Security and Intelligence

Unit IV : Big Data Technology Potentials
AI – Machine Learning – Cloud Computing – Mobile Communication – IoT – Big Data in Industry 4.0- Big Data Platforms – HADOOP – SPARK – No SQL Databases - Types - Big Data Challenges

Unit V : Big Data Use Cases
Big Data Roles Data Scientist , Data Architect, Data Analyst – Skills – Case Study : Big Data – Customer Insights – Behavioural Analysis – Big Data Industry Applications - Marketing – Retails – Insurance – Risk and Security – Health care

BOOKS
1. V. Bhuvaneswari, T. Devi, "Big Data Analytics: Scitech Publisher , 2018
2. Han Hu, Yonggang Wen, Tat-Seng, Chua, Xuelong Li,"Toward Scalable Systems for Big Data Analytics: A Technology Tutorial", IEEE, 2014.
3. P. Kaliraj, T. Devi, Big Data Applications in Industry 4.0, 2022, ISBN 9781032008110, CRC Press, Taylor & Francis Group

A.2 Data Analytics using R

Unit I : Introduction Data Analytics
Data Analysis Vs Data Analytics – Data Analytics – Types - Data Analytics – Framework – Data Analytics – Tool - R language - Understanding R features - Installing R and RStudio – Packages and Library – Importing and Exporting Files: CSV File – JSON File – txt File –Excel File – Xml File - Command Line Vs. Scripts. - Data Pre-Processing – Missing Value – Omitting Null Values - Data Transformation – Data Selection – Data Integration –

Unit II : Understanding R features
Installing R and RStudio – Packages and Library – Importing and Exporting Files: CSV File – JSON File – txt File –Excel File – Xml File - Command Line Vs. Scripts Data Manipulation: Slicing - Subscripts and Indices – Data Subset - Dplyr Package: Select Function - Filter Function - Mutate Function - Arrange Function

Unit III : Data Summarization & Visualization
Mean – Median – Mode - Variablity Measures - Variance – Range - IQR – Standard Deviation – Sum of Squares –Identifying Outliers using IQR. Data Visualization – Introduction – Datasets – Exploratory Data Analytics – Univariate Analysis – Histogram - Bivariate Analysis - Box Plot – Multivariate Analysis - Scatter Plot - MASS Package - Categorical Variable –Bar Chart – Mosaic Plot

Unit IV : Reporting Tool
Analysing Gathering Information – Story Telling – R Markdown - R Markdown Framework - rmarkdown package – Knit for Embedded Code: knitr package - Convert File:HTML, PDF, MS Word - Markdown Formatted Text - ShinyApp - shiny package: Built Shiny app – Control Widgets – Customize Reactions – Reactive Expressions - Customize Appearance - Deploy Shiny app

Unit V : Data Analytics Case Studies
Marketing – Logistic Management – Insurance – Behavioural Analytics – Data Analytics on Diamond Dataset

BOOKS
1. V. Bhuvaneswari, "Data Analytics with R Step by Step", Scitech Publisher, ISBN – 978-81- 929131-2-4, Edition 2016.
2. Roger D.Peng, "R Programming for Data Science", Lean Publishing, 2014.
3. Vignesh Prajapati, "Big Data Analytics with R and Hadoop", Packt Publishing, ISBN-978-1-78216-328-2, 2013.
4. Sholom Weiss, et.al, "The Text Mining Handbook: Advanced Approaches in Analysing
5. Unstructured Data", Springer, Paperback 2010.
6. P. Kaliraj, T. Devi, Big Data Applications in Industry 4.0, 2022, ISBN 9781032008110, CRC Press, Taylor & Francis Group

A.3 Advanced Data Analysis using R

Unit I : Introduction
Data Analytics – Data Analysis Vs Data Analytics – Big Data Analytics – Data Formats – Data Characteristics – Big Data Platforms – Applications - Data Analytics Usecase: Data Analytics – Health care – Marketing -

Unit II : Descriptive Data Analytics
Data Visualization: Lattice Package –-Univariate Analysis: Histogram Features Mode - Skewness– Kurtosis – One Variable – Multiple Variable – Bivariate Analysis – Density Plot - Box Plot – Outlier Identification - Multivariate Analysis: Scatter Plot – Correlation – Cor() Function – Descriptive Analytics – Ships Dataset in MASS Package

Unit III : Regression Analysis
Linear Regression Analysis – Logistic Regression Analysis- Regression Analysis – Airqulaity Dataset - Clustering Approaches: k-means Clustering – Hierarchical Clustering – Clustering – Car Dataset

Unit IV : Text Pre-processing
Nature of Unstructured and Semi-structured text –Basic String Function: tolower() - toupper()- strsplit() – gsub() - grep()- regexpr() – Converting text to Document Standardization – tokenization – lemmatization – stemming - parsing text – n-gram – POS – Corpus Creation -   tm package - Text Visualization: Wordcloud – Wordcloud Package

Unit V : Inferential Analytics
Statistical Hypotheses - Parametric Test – non-parametric Test - Data Standardizing – Z score – negative Z Score - Chi-Square Test – Wilson's score interval

Unit VI : Dashboard & Reporting Tool
Analysing Gathering Information – Story Telling – R Markdown - R Markdown Framework - rmarkdown package – Markdown Formatted Text- Knit for Embedded Code: knitr package- Convert File: HTML, PDF, MS Word - Introduction Shiny Dashboard- shinydashboard package – Shiny – HTML –Structure: Header – Sidebar – Body – Layouts - Use cases – Social Analytics – Health Catalyst Prediction

BOOKS
1. V. Bhuvaneswari, "Data Analytics with R Step by Step", Scitech Publication, ISBN – 978-81- 929131-2-4, Edition 2016.
2. Roger D.Peng, "R Programming for Data Science", Lean Publishing, 2014.
3. Vignesh Prajapati, "Big Data Analytics with R and Hadoop", Packt Publishing, ISBN- 978-1-78216-328-2, 2013.
4. Sholom Weiss, et.al, "The Text Mining Handbook: Advanced Approaches in Analysing
5. Unstructured Data", Springer, Paperback 2010.
6. Emmanuel Paradis, "R for Beginners", 2005.
7. P. Kaliraj, T. Devi, Big Data Applications in Industry 4.0, 2022, ISBN 9781032008110, CRC Press, Taylor & Francis Group

A.4 Python for Data Analytics

Unit I : Python Introduction
History of Python – Python Features - Python Interpreter – Installation and Setup: Windows – Linux – macOS – Installing/Updating Python Packages - Essential Python Libraries - Basic Data Types – Python Built-in Functions – IDEs – Text Editors – IPython – Jupyter Notebook - Importing and Exporting Files: CSV File – JSON File – txt File - Excel File – Xml File – Delimited Formats.

Unit II : Data Structures
Introduction – NumPy Package - Python List: Introduction – Accessing values– List Manipulation – List Operations - Python Tuples: Creating Tuples - Operation in Tuples – Accessing and Functions in Tuples – Python Dictionary: Accessing – Functions in Dictionary – Functions – Namespaces - Indexing – Slicing – Matrices – Arrays Functions – Exception Handling - Global and Local Variables.

Unit III : Data Manipulation
Pandas Package –Series - Data Frame – Combining Data Frames –– Index Objects - Filtering – Renaming – Dealing with Outliers- Summarizing – Correlation – Covariance. Data Cleaning – Handling Missing Data – Data Transformation – String Manipulation – Regular Expressions – Data Wrangling – Reshape –Combine – Merge – Indexing.

Unit IV : Data Visualization
 matplotlib library – seaborn library – Configuration - Graphical Parameters – Plotting Function in Pandas: Line Plots – Bar Plots – Histograms - Density Plots– Scatter Plots - Facet Grids – Categorical Data.

Unit V : Advanced Interactive Plot
Introduction Plotly Library – Data Understanding - Preparing Variables – Visualization – Distribution: Histogram – Boxplot – Correlation: Scatter Plot – Heatmap – Ranking Plot: Barplot – Boxplot – Wordcloud.

BOOKS
1. Fred L. Drake, Guido Van Russom, "An Introduction to Python", Network Theory Limited.
2. Wesley J. Chun, "Core Python Programming", 2nd Edition, Pearson Education.
3. Magnus Lie Hetland, "Beginning Python: From Novice to Professional", 2nd Edition.
4. Mark Summerfield, "Programming in Python", Pearson Education.
5. Wes McKinney, "Python for Data Analysis", 2nd Edition, O'Reilly Media, Inc., ISBN: 9781491957653, 2017.
8. P. Kaliraj, T. Devi, Big Data Applications in Industry 4.0, 2022, ISBN 9781032008110, CRC Press, Taylor & Francis Group

Artificial Intelligence (AI)

A.5 Robotic Process Automation

Unit I : Introduction to Automation and RPA
 Basics of RPA - RPA Benefits - Processes that can be automated – Types of Robots.
Automation and RPA Concepts: Business models for implementing RPA – Centre of Excellence - Types and their applications – Building an RPA team - Approach for implementing RPA initiatives

Unit II : Understanding the Automation cycle
Automation stages and the role of a Business Manager - Guidelines for tracking the implementation success – Metrics /Parameters to be considered for gauging success- Choosing the right licensing option. Setting up the UiPath environment -– Introduction to UiPath - The User Interface - Keyboard Shortcuts - Automation Projects & Debugging - Managing Activities - Reusing Automation Library

Unit III : Basic Concepts of RPA
Recording & UI interaction - Data scraping & Screen scraping – Sequences, Variables and control flow - Selectors - Coding the Robot. Advanced Automation concepts: Image based automation - Keyboard based automation – Email automation - Information Retrieval - Advanced Citrix Automation challenges

Unit IV : Data persistence in RPA
Tables in RPA - Data Manipulation in excel - Extracting Data from PDF – Using anchors in PDF. Exceptional Handling: Debugging Tools - Strategies for solving issues - Catching errors. Orchestrator: Introduction - Tenants - Authentication - Users - Roles - Robots – Environments - Queues & Transactions – Schedules

Unit V : RPA projects
 Sales order entry Robot - Robot for transactions in Stock Market - MySQL Backup Robot - Email categorization Robot - Email Autoresponder Robot - Disk monitoring and clean-up Robot.

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1. https://www.uipath.com/landing/academic-studio-download
2. https://www.uipath.com/rpa/robotic-process-automation
3. https://www.uipath.com/rpa/academy

A.6 Robotic Process Automation Design & Development

Unit I : Robotic Process Automation (RPA)
Programming Basics - Data & Data Structures - Algorithms - Software Development Guidelines - Compilers - Frameworks and Languages - Information Sharing - File Types - Access Control. Basic RPA Concepts - Applying RPA - RPA vs Automation - Programming Constructs in RPA - RPA deployments. Advanced RPA Concepts - Standardization of processes - RPA Development - Robotic control flow architecture - RPA business case - Industries best suited for RPA - Risks & Challenges with RPA - RPA and emerging ecosystem

Unit II : UiPath Introduction
Installing UiPath Studio Academic Alliance edition - The User Interface - Keyboard Shortcuts - Automation Projects - Automation Debugging - Managing Activities Packages - Reusing Automation Library - Variables within Studio - Namespaces - Control Flow - Loops – Flowcharts. Data Manipulation techniques - Scalar variables, collections and Tables - Text Manipulation - Data manipulation - Gathering and Assembling Data

Unit III : Recording and Advanced UI Interaction
Basic and Desktop Recording - Web Recording - Screen Scraping - Data Scraping. Selectors - Defining and Assessing Selectors - Customization - Debugging - Dynamic Selectors - Partial Selectors - RPA Challenges. UiPath Advanced concepts and application - Image, Text and Data Tables Automation in Studio – Automating Citrix, PDF, and Email - Best Practices

Unit IV : Excel Data Tables & PDF
Data Tables in RPA - Data Manipulation in excel - Extracting Data from PDF - Anchors - Using anchors in PDF. Debugging and Exception handling - Debugging Tools - Strategies for solving issues - Catching errors. Project Organization - Best practices – Avoiding pitfalls - Invoke Activity

Unit V : UiPath Orchestrator - Tenants - Authentication - Users & Roles - Robots - Environments - Queues & Transactions – Schedules. Artificial Intelligence and Machine learning implementation in RPA - Digital Assistant - Future of RPA - Basic RPA Projects: Sales order entry Robot - Robot for transactions & Email categorization. Advanced Projects: Email Autoresponder Robot - Disk monitoring and clean-up Robot.

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1. https://www.uipath.com/landing/academic-studio-download
2. https://www.uipath.com/rpa/robotic-process-automation
3. https://www.uipath.com/rpa/academy

A.7 Robotic Process Automation for Business

Unit I : Introduction to RPA
Overview of RPA - Benefits of RPA in a business environment - Industries & domains fit for RPA - Identification of process for automation - Types of Robots - Ethics of RPA & Best Practices -

Automation and RPA Concepts - Different business models for implementing RPA - Centre of Excellence – Types and their applications - Building an RPA team - Approach for implementing RPA initiatives.

Unit II : Role of a Business Manager in Automation initiatives
Skills required by a Business Manager for successful automation - The importance of a Business Manager in automation - Analyzing different business processes - Process Mapping frameworks - Role of a Business Manager in successful implementation – Part 1 - Understanding the Automation cycle – First 3 automation stages and activities performed by different people.

Unit III : Evaluating the Automation Implementation:
Detailed description of last 3 stages and activities performed by different people - Role of a Business Manager in successful completion – Part 2 - Activities to be performed post-implementation - Guidelines for tracking the implementation success - Metrics/Parameters to be considered for gauging success - Choosing the right licensing option - Sending emails - Publishing and Running Workflows.

Unit IV : Ability to process information through scopes/systems
Understand the skill of information processing and its use in business - Leveraging automation - Creating a Robot - New Processes. Establish causality by variable behaviour - Understand the skill of drawing inference or establishing causality by tracking the behaviour of a variable as it varies across time/referenced variable - Leveraging automation for this skill - Robot & new process creation.

Unit V : Inference from snapshots of curated terms – Omni-source data curation - Multi-source trend tracking - Understand the skill of drawing inference from the behaviour of curated terms by taking snapshots across systems in reference to time/variable(s) - Leveraging automation for this skill – Robot creation and new process creation for this skill.

REFERENCE LINKS

1. https://www.uipath.com/landing/academic-studio-download
2. https://www.uipath.com/rpa/robotic-process-automation
3. https://www.uipath.com/rpa/academy

A.8 Internet of Things

Unit I : Introduction to IoT
Evolution of IoT – Definition & Characteristics of IoT - Architecture of IoT – Technologies for IoT – Developing IoT Applications – Applications of IoT – Industrial IoT – Security in IoT

Unit II : Basic Electronics for IoT
Electric Charge, Resistance, Current and Voltage – Binary Calculations – Logic Chips – Microcontrollers – Multipurpose Computers – Electronic Signals – A/D and D/A Conversion – Pulse Width Modulation

Unit III : Programming Fundamentals with C using Arduino IDE
Installing and Setting up the Arduino IDE – Basic Syntax – Data Types/ Variables/ Constant – Operators – Conditional Statements and Loops – Using Arduino C Library Functions for Serial, delay and other invoking Functions – Strings and Mathematics Library Functions

Unit IV : Sensors and Actuators
Analog and Digital Sensors – Interfacing temperature sensor, ultrasound sensor and infrared (IR) sensor with Arduino – Interfacing LED and Buzzer with Arduino

Unit V : Sending Sensor Data Over Internet
Introduction to ESP8266 NODEMCU WiFi Module – Programming NODEMCU using Arduino IDE – Using WiFi and NODEMCU to transmit data from temperature sensor to Open Source IoT cloud platform (ThingSpeak)

BOOKS
1. Arshdeep Bahga, Vijay Madisetti, 'Internet of Things: A Hands-On Approach', 2014. ISBN: 978-0996025515
2. Boris Adryan, Dominik Obermaier, Paul Fremantle, 'The Technical Foundations of IoT', Artech Houser Publishers, 2017.
3. Michael Margolis, 'Arduino Cookbook', O'Reilly, 2011
4. Michael Margolis, 'Arduino Cookbook', O'Reilly, 2011
5. Marco Schwartz, 'Internet of Things with ESP8266', Packt Publishing, 2016.
6. Dhivya Bala, 'ESP8266: Step by Step Tutorial for ESP8266 IoT, Arduino NODEMCU Dev Kit', 2018
7. P. Kaliraj, T. Devi, Securing IoT in Industry 4.0 Applications with Blockchain, 2022, ISBN 978-1032008103, CRC Press, Taylor & Francis Group

Reference Links
1. Introduction to IoT Part I – Lecture 1 - https://nptel.ac.in/courses/106/105/106105166/
2. Introduction to IoTs Part I & Part II –Lectures 1 & 2 https://nptel.ac.in/courses/108108098/
3. Introduction to IoT – Lecture 1 - https://ocw.cs.pub.ro/courses/iot/courses/01
4. Electronics for Internet of Things – Lecture II - https://ocw.cs.pub.ro/courses/iot/courses/02
5. Introduction to Arduino – I – Lecture 22 - https://nptel.ac.in/courses/106105166/
6. Introduction to Arduino – II – Lecture 23 - https://nptel.ac.in/courses/106105166/
7. Integration of Sensors and Actuators with Arduino – I – Lecture 24 - https://nptel.ac.in/courses/106105166/
8. Integration of Sensors and Actuators with Arduino – II – Lecture 25 - https://nptel.ac.in/courses/106105166/
9. https://www.youtube.com/watch?v=-nuBmJBvdog

A.9 Critical Thinking, Design Thinking and Problem Solving

Syllabus

Unit I : Critical Thinking
Definition, Conclusions and Decisions, Beliefs and Claims, Evidence – finding, evaluation, Inferences, Facts – opinion, probable truth, probably false, Venn diagram. Applied critical thinking: Inference, Explanation, Evidence, Credibility, Two Case Studies, critical thinking and science, critical evaluation, self assessment

Unit II : Applied critical thinking
Introduction, Need of Design Thinking, problem to question - design thinking process, Traditional Problem Solving versus Design Thinking, phases of Design Thinking, problem exploration, Stake holder assessment, design thinking for manufacturers, smart Idea to implementation

Unit III : Design Thinking
Thinking to confidence, fear management, duty Vs passion, Team management, Tools for Design Thinking, prototype design, Relevance of Design and Design Thinking in engineering, human centered design, case study : apply design thinking in problem

Unit IV : Problem solving
Problem definition, problem solving methods, selecting and using information, data processing, solution methods, solving problems by searching, recognizing patterns, spatial reasoning, necessity and suffiency, choosing and using models, making choices and decisions

Unit V : Reasoning
Deductive and hypothetical reasoning, computational problem solving; generating, implementing, and evaluating solutions, interpersonal problem solving. Advanced problem solving : Combining skills – using imagination, Developing models, Carrying out investigations, Data analysis and inference. Graphical methods of solution, Probability, tree diagrams and decision trees

Books
    1. John Butterworth and Geoff Thwaites, Thinking skills : Critical Thinking and Problem Solving, Cambridge University Press, 2013
    2. H. S. Fogler and S. E. LeBlanc, Strategies for Creative Problem Solving, 2nd edition, Pearson, Upper Saddle River, NJ, 2008
    3. A. Whimbey and J. Lochhead, Problem Solving & Comprehension, 6th edition, Lawrence Erlbaum, Mahwah, NJ, 1999
    4. M. Levine, Effective Problem Solving, 2nd edition, Prentice Hall, Upper Saddle River, NJ, 1994
    5. Michael Baker , The Basic of Critical Thinking, :The Critical Thinking Co press , 2015
    6. David Kelley and Tom Kelley, Creative Confidence, 2013

Reference Links

1. www.swyam.gov.in
2. www.nptel.ac.in
3. www.videolectures.net
4. www.ideou.com
5. www.creativeconfidence.com
6. www.ted.com/talks/tim_brown_urges/designers_to_think_big
7. www.ideo.com/work
8. www.designkit.org

A.10 Quantum Computing

Unit I : Introduction to Quantum Computing, Linear operators and spectral decomposition

Unit II :   Operator functions and tensor products Postulates of quantum mechanics

Unit III :   Computation, quantum and classical Deutsch-Jozsa, Fourier transform and phase estimation

Unit IV : Factor Simon's algorithm, factorization

Unit V : Search Grover search, Query complexity

Books
1. Quantum Computation and Quantum Information, M A Nielsen and I L Chuang.
2. An Introduction to Quantum Computing, P Kaye, R Laflamme and M Mosca.
3. Linear Algebra and its Applications, G. Strang.
4. Matrix Analysis, Bhatia.

A.11 Cyber Security

Objectives
    The objective of the course is to impart knowledge to make the students
    1. To understand the fundamental functioning of Cyber security
    2. To understand the different protective mechanism in varied Cyber space

Syllabus

Unit I : History of Internet
Overview of Cyber Security – The Security Environment – Threats: Cyber Crime, Warfare, terrorism and Espionage. vulnerabilities: vulnerabilities in software, System administration, Network Architectures, Open Access Data, Weak Authentication

Unit II : Cyber space
Web browsing and browser security – Email security, firewall in browsers, security certificate –

basic security for HTTP applications and services. Password security – guidelines to choose a password – two steps authentication – WiFi security. Securing social media – social media secure networking – smart phone security – Android, IoS

Unit III :
Cyber Intrusion, Abuse of Privileges, Unauthorized Access, Malware infection, Intrusion detection and Prevention Techniques: Network based and host based, Anti-Malware software. Cyber Security Regulations – Government and Private organizations in Cyberspace – Cyber Security Standards – National Cyber Security Policy 2013

Unit IV : Introduction to Cryptography
Classifications of Cryptography: Symmetric key and Asymmetric key Cryptography, Applications of Cryptography. Firewalls- Types of Firewalls, VPN Security Security Protocols: - Application Layer security - PGP and S/MIME, ransport Layer security – SSL and TLS, Network Layer Security -IPSec

Unit V : Introduction to Cyber Forensics
Preliminary Investigations procedure and methods, Conducting disk-based analysis, Tracing Internet access, Tracing memory. Recovering from Information Loss – Destroying Sensitive Information – CCleaner for Windows – Defensive Programming – Emerging Cyber Security Threats

Books

1. Michael E Whitman and Herbert J Mattord, "Principles of Information Security", 4th Edition,Vikas Publishing House, 2011.
2. Atul Kahate, "Cryptography and Network Security", McGraw Hill, 2013.
3. William Stallings, "Cryptography and Network Security Principles and Practices",7th Edition, Pearson, 2017.
4. Man Young Rhee, "Internet Security: Cryptographic Principles", Wiley Publications, 2003.
5. Nelson, Phillips, Enfinger, Steuart, "Computer Forensics and Investigations", Cengage Learning, India Edition, 2008.
6. P. Kaliraj, T. Devi, Securing IoT in Industry 4.0 Applications with Blockchain, 2022, ISBN 978-1032008103, CRC Press, Taylor & Francis Group.

A.12 Ethical Hacking

Objectives
    Through this course students will be enabled
    1. To learn various hacking techniques and attacks
    2. To know how to protect data assets against attacks from the Internet
    3. To evaluate where information networks are most vulnerable

Syllabus

Unit I : Introduction To Ethical Hacking
Hacker and Cracker. Fundamentals of Computer Fraud - Footprinting and scanning – Malware

Threats: Viruses and Worms, Trojans, Spyware, Malware Counter measures. Ethical and Legality

Unit II : Security testing
Introduction To Penetration Testing: Virtualization, VirtualBox, Vulnerable Machines, Target Machines and Beast Machine. Anonymous Hacking: Tor browser – Proxychains – Proxy Server – VPN – MAC Address

Unit III : Web Attacks
Web Server Hacking – Application Hacking – Database Hacking. Wireless Technologies – Mobile Security and Attacks – Wireless LANs. Firewalls, Honeypots

Unit IV : Introduction to Information Gathering
Types, Tools, Methods, and Frameworks – DNS Footprinting – Email Footprinting. Vulnerability Scanning and Analysis: Network Vulnerability Scanning – Mobile Application Vulnerability Scanning

Unit V : Password Cracking Techniques
Importance of Using Password - Hashes and encoders – BruteForce Attacks – Dictionary Based Attacks – Cracking Online Services – SSH, FTP. Physical Security, Social Engineering – Cloud Computing – Session Hijacking – Cryptography
BOOKS
1. Lakshay Eshan, "Ethical Hacking: A Beginners Guide to Learning the World of Ethical Hacking", Shockwave Publishing, 2018.
2. Michael T.Simpson "Hands-On Ethical Hacking and Network Defense", 2 Edition, by Cengage Learning.
3. Arnold Robbins, Elbert Hannab and Linda Lamb, "Learning the vi and vim Editors" 7th Edition O"Reilly, 2008.
4. P. Kaliraj, T. Devi, Securing IoT   in Industry 4.0 Applications with Blockchain, 2022, ISBN 978-1032008103, CRC Press, Taylor & Francis Group.

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