Agnel Charities'

Padre Conceicao College of Engineering , Verna

Department of Mechanical Engineering

# Consortium of Students of Mechanical Engineering (COSME)

Presents

# ECHO '21

# ROBOMATION

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# ECHO

(2020 – 2021)

# *Robomation*

# INSTITUTE PROFILE

On June 9, 1957 when the Ashram was inaugurated at Bandra, Mumbai, Our Founder, **Fr. Conceicao Rodrigues** spelt out his dream. “***Our principle aim will be to promote our rich heritage***“, he said. As the first Indian Missionary Society, we have strived to serve our fellow citizens while nurturing this dream. The Ashram has branches all over India and is immersed in the development of modern Indian society at every level.

The Agnel Ashram in Goa spreading over 25 acres of verdant, hilly slopes, at Verna, was the fulfillment of a long felt need of providing technical education facilities for the youth of Goa. Within a span of two decades, the project has made considerable progress, thanks to the generous support from the Government, friends and well wishers.

Padre Conceição College of Engineering (PCCE) is an engineering college in Verna, Goa, India, established in 1997. The college is affiliated to Goa University, Taleigao, Goa, and the programmes are approved by All India Council for Technical Education (AICTE), New Delhi. The college is a part of Agnel Technical Education Complex, Verna, Goa. PCCE has 4 Bachelor disciplines: Mechanical Engineering, Computer Engineering, Electronics and Telecommunication Engineering and Information Technology and Masters in Information Technology

# Institute Vision

**" To establish a sustainable engineering ecosystem"**

To strive towards excellence in Technical Education and Research by facilitating students with modern technology, interdisciplinary approach and problem solving ability to meet the needs of the industry, society and nation at large.

# Institute Mission

- To continuously improve students' educational outcomes through effective teaching learning methodology.
- To provide students and faculty with advanced technology and excellent scholastic ambience for research.
- To provide opportunities for holistic development of students with a focus on self-learning, ethics, leadership, and entrepreneurship skills.
- To strengthen the network with alumni and industries.

# Mechanical Engineering Department Vision:

To empower the students to serve the society and nation, by imparting value based education through contemporary infrastructure, excellence in education and research, in the realm of Mechanical Engineering

# Mechanical Engineering Department Mission:

- To provide an effective and appropriate pedagogy to instill critical and proactive thinking in mechanical engineering students and empower them to make cogent contributions to the society.
- To endow the students with ethical values, professional and entrepreneurial skills and make them competitive at the national as well as global level.
- To develop alliances with Research & Development organizations, industries and alumni for excellence in teaching, research and consultancy.

## Program Educational Objectives (PEO):

***Within a few years of graduating, the Mechanical Engineering graduates will:***

**PEO 1**: Have successful careers in industry, academia and entrepreneurship in various fields of mechanical engineering and allied disciplines.

**PEO 2**: Have professional, ethical, leadership qualities, and proactively address a variety of technical and societal problems.

**PEO 3**: Retain intellectual curiosity and disseminate knowledge through lifelong learning, to tackle the rapidly evolving challenges of the modern world.

**PEO 4**: Contribute effectively towards the advancement of industry, society and nation through research and development.

## Program Specific Outcomes(PSO):

***At the end of this program the student will be able to:***

- Apply the knowledge of design, industrial, manufacturing, thermal engineering and multidisciplinary perspectives to address the needs of Mechanical Engineering systems.
- Develop and implement solutions for products and services with the help of engineering tools.

# HOD'S MESSAGE

'Vipattya Vikramah' is all I can say is the learning we take back from this year gone by. It was through these difficulty times on can comes to witness the creation and the creator. Many have lost people close in their life. We must indeed stand in solidarity with all our citizens and the world at large.

But I am happy to note that it did not deter the spirit of our students to learn and contribute towards making this issue of ECHO'21 a success. We are to be aware that we couldn't have the Annual Cultural function Mithya this year due to the prevailing conditions. The online classes have also made both faculty and students both to come and interface with technology ever more than before I suppose, and rightly moving with spirit I would like to congratulate the staff and students who have strenuously taken up the duty of bringing forth this year's departmental magazine in spite of all the hurdles. The theme Robomation is indeed a wonderful topic and something where each of us is the field of mechanical engineering must keep ourselves updated as it encompasses across manufacturing to health-care if I may say, thus benefitting society at large.

I congratulate Prof. Flasio Colaco – the COSME faculty in charge, and his team of other colleagues who have worked towards bringing forth this issue of ECHO'21. I wish everyone good health and happiness.

**- Dr. Geethalakshmi K.**

# CO-ORDINATOR'S MESSAGE

The Consortium of Mechanical Engineering (COSME) , had to really have a rough course this year with the council not in place this year due to the current Pandemic situation , it was indeed a tough year but all I can say this issue is out due to the resilient attribute of some of our students who came out to help, be it in sending articles online or in editing .With no much activities carried out this year , we can all say we have indeed learned and unlearned a lot.

In today's ever evolving times Mechanical Engineering has been integrated with electronics and coding to bring out the very dynamic field having both robotics and automation as a next level approach whose application range from manufacturing and beyond.

The magazine shall also have a short report on the online Techyon'20 event we had for the institute. It was indeed a pleasure to see participants take part.

- Prof. Flasio Colaco

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# ABOUT COSME

**CONSORTIUM OF MECHANICAL ENGINEERS** popularly called as COSME is a collegiate organization which relates the activities under Mechanical Engineering Department. COSME is among the most active student bodies in the institute which actively takes part in the TECHYON event and works under the banner of TURBULENCE thus gathering and forming students from the department of mechanical engineering leading to a more holistic approach in the undergraduate years. Mentored by experienced faculty members of the Mechanical Engineering department, students take upon many initiatives that prepare them to face the challenges of the future. COSME aims to create opportunities for the students to enhance their knowledge about the latest developments in the technological world by organizing various events.

**Functions of COSME:**

- Promoting the interests of students in various technical areas pertaining to mechanical engineering.

- To promote interaction between academia and industry by organizing industrial visits, special lectures and intellectual talks.

- Interacting with other technical societies, within and outside the institute to promote flow of knowledge and interest.

- To allow students to learn and focus on the cutting-edge technology by presenting it to the students in interesting manner through seminars and workshop

# Robotics

*Ajinkya Chavan , Mech -VI*

## Introduction

**Robotics** is an interdisciplinary branch of computer science and engineering. Robotics involves design, construction, operation, and use of robots. The goal of robotics is to design machines that can help and assist humans. Robotics integrates fields of mechanical engineering, electrical engineering, information engineering, mechatronics, electronics, bioengineering, computer engineering, control engineering, software engineering, mathematics, etc.

Robotics develops machines that can substitute for humans and replicate human actions. Robots can be used in many situations for many purposes, but today many are used in dangerous environments (including inspection of radioactive materials, bomb detection and deactivation), manufacturing processes, or where humans cannot survive (e.g. in space, underwater, in high heat, and clean up and containment of hazardous materials and radiation). Robots can take on any form, but some are made to resemble humans in appearance. This is claimed to help in the acceptance of robots in certain replicative behaviors which are usually performed by people. Such robots attempt to replicate walking, lifting, speech, cognition, or any other human activity. Many of today's robots are inspired by nature, contributing to the field of bio-inspired robotics.

## Etymology

The word *robotics* was derived from the word *robot*, which was introduced to the public by Czech writer Karel Čapek in his play *R.U.R. (Rossum's Universal Robots)*, which was published in 1920. The word *robot* comes from the Slavic word *robota*, which means work/job. The play begins in a factory that makes artificial people called *robots*, creatures who can be mistaken for humans – very similar to the modern ideas of androids. Karel Čapek himself did not coin the word. He wrote a short letter in reference to an etymology in the *Oxford English Dictionary* in which he named his brother Josef Čapek as its actual originator.

According to the *Oxford English Dictionary*, the word *robotics* was first used in print by Isaac Asimov, in his science fiction short story *"Liar!"*, published in May 1941 in *Astounding Science Fiction*. Asimov was unaware that he was coining the term; since the science and technology of electrical devices is *electronics*, he assumed *robotics* already referred to the science and technology of robots. In some of Asimov's other works, he states that the first use of the word *robotics* was in his short story *Runaround* (Astounding Science Fiction, March 1942), where he introduced his concept of The Three Laws of Robotics. However, the original publication of "Liar!" predates that of "Runaround" by ten months, so the former is generally cited as the word's origin.

## Applications

As more and more robots are designed for specific tasks, this method of classification becomes more relevant. For example, many robots are designed for assembly work, which may not be readily adaptable for other applications. They are termed as "assembly robots". For seam welding, some suppliers provide complete welding systems with the robot i.e. the welding equipment along with other material handling facilities like turntables, etc. as an integrated unit. Such an integrated robotic system is called a "welding robot" even though its discrete manipulator unit could be adapted to a variety of tasks. Some robots are specifically designed for heavy load manipulation, and are labeled as "heavy-duty robots".

Current and potential applications include:

- Military robots.
- Industrial robots. Robots are increasingly used in manufacturing (since the 1960s). According to the Robotic Industries Association US data, in 2016 automotive industry was the main customer of industrial robots with 52% of total sales.[31] In the auto industry, they can amount for more than half of the "labor". There are even "lights off" factories such as an IBM keyboard manufacturing factory in Texas that was fully automated as early as 2003.
- Cobots (collaborative robots).
- Construction robots.
- robotic exoskeleton.
- Agricultural robots (AgRobots). The use of robots in agriculture is closely linked to the concept of AI-assisted precision agriculture and drone usage. 1996-1998 research also proved that robots can perform a herding task.
- Medical robots of various types (such as da Vinci Surgical System and Hospi).
- Kitchen automation. Commercial examples of kitchen automation are Flippy (burgers), Zume Pizza (pizza), Cafe X (coffee), Makr Shakr (cocktails), Frobot (frozen yogurts) and Sally (salads). Home examples are Rotimatic (flatbreads baking) and Boris (dishwasher loading).
- Robot combat for sport – hobby or sport event where two or more robots fight in an arena to disable each other. This has developed from a hobby in the 1990s to several TV series worldwide.

## Components

*Fig. Insight Lander with Solar Panel*

**Power source**

Power supply and Energy storage The *InSight* lander with solar panels deployed in a clean room. At present, mostly (lead–acid) batteries are used as a power source. Many different types of batteries can be used as a power source for robots.

They range from lead–acid batteries, which are safe and have relatively long shelf lives but are rather heavy compared to silver–cadmium batteries that are much smaller in volume and are currently much more expensive. Designing a battery-powered robot needs to take into account factors such as safety, cycle lifetime and weight. Generators, often some type of internal combustion engine, can also be

**Actuation**

*Fig. Robotic Leg powered by Air muscles*

Actuators are the "muscles" of a robot, the parts which convert stored energy into movement. By far the most popular actuators are electric motors that rotate a wheel or gear, and linear actuators that control industrial robots in factories. There are some recent advances in alternative types of actuators, powered by electricity, chemicals, or compressed air.

**Vision**

Computer vision is the science and technology of machines that see.

Computer vision systems rely on image sensors which detect electromagnetic radiation which is typically in the form of either visible light or infra-red light. The sensors are designed using solid-state physics. The process by which light propagates and reflects off surfaces is explained using optics. Sophisticated image sensors even require quantum mechanics to provide a complete understanding of the image formation process. Robots can also be equipped with multiple vision sensors to be better able to compute the sense of depth in the environment. Like human eyes, robots' "eyes" must also be able to focus on a particular area of interest, and also adjust to variations in light intensities.

There is a subfield within computer vision where artificial systems are designed to mimic the processing and behavior of biological system, at different levels of complexity. Also, some of the learning-based methods developed within computer vision have their background in biology.

### Mechanical grippers

*Fig. Industrial Robot operating in a Foundry*

Fingers can, for example, be made of a chain with a metal wire run through it. Hands that resemble and work more like a human hand include the Shadow Hand and the Robonaut hand. Hands that are of a mid-level complexity include the Delft hand. Mechanical grippers can come in various types, including friction and encompassing jaws. Friction jaws use all the force of the gripper to hold the object in place using friction. Encompassing jaws cradle the object in place, using less friction.

One of the most common types of end-effectors are "grippers". In its simplest manifestation, it consists of just two fingers that can open and close to pick up and let go of a range of small objects.

### Swimming (Piscine)

*Fig Robotic Fish*

Therefore, many researchers studying underwater robots would like to copy this type of locomotion. Notable examples are the Essex University Computer Science Robotic Fish G9, and the Robot Tuna built by the Institute of Field Robotics, to analyze and mathematically model thun uniform motion. The Aqua Penguin, designed and built by Festo of Germany, copies the streamlined shape and propulsion by front "flippers" of penguins. Festo have also built the Aqua Ray and Aqua Jelly, which emulate the locomotion of manta ray, and jellyfish, respectively.

In 2014 *iSplash*-II was developed by PhD student Richard James Clapham and Prof. Huosheng Hu at Essex University. It was the first robotic fish capable of outperforming real carang iform fish in terms of average maximum velocity (measured in body lengths/ second) and endurance, the duration that top speed is maintained. This build attained swimming speeds of 11.6BL/s (i.e. 3.7 m/s). The first build, *iSplash*-I (2014) was the first robotic platform to apply a full-body length carangiform swimming motion which was found to increase swimming speed by 27% over the traditional approach of a posterior confined waveform.

**Speech recognition**

Interpreting the continuous flow of sounds great strides have been made in the field since Davis, Biddulph, and Balashek designed the first "voice input system" which recognized "ten digits spoken by a single user with 100% accuracy" in 1952. Currently, the best systems can recognize continuous, natural speech, up to 160 words per minute, with an accuracy of 95%. With the help of artificial intelligence, machines nowadays can use people's voice to identify their emotions such as satisfied or angry.

**Control**

*Fig. Puppet Magnus with Complicated Control Systems*

The mechanical structure of a robot must be controlled to perform tasks. The control of a robot involves three distinct phases – perception, processing, and action (robotic paradigms).coming from a human, in real time, is a difficult task for a computer, mostly because of the great

Sensors give information about the environment or the robot itself (e.g. the position of its joints or its end effector). This information is then processed to be stored or transmitted and to calculate the appropriate signals to the actuators (motors), which move the mechanical structure to achieve the required co-ordinated motion or force actions.

The processing phase can range in complexity. At a reactive level, it may translate raw sensor information directly into actuator commands (e.g. firing motor power electronic gates based directly upon encoder feedback signals to achieve the required torque/velocity of the shaft). Sensor fusion and internal models may first be used to estimate parameters of interest (e.g. the position of the robot's gripper) from noisy sensor data. An immediate task (such as moving the gripper in a certain direction until an object is detected with a proximity sensor) is sometimes inferred from these estimates. Techniques from control theory are generally used to convert the higher-level tasks into individual commands that drive the actuators, most often using kinematic and dynamic models of the mechanical structure.

At longer time scales or with more sophisticated tasks, the robot may need to build and reason with a "cognitive" model. Cognitive models try to represent the robot, the world, and how the two interact. Pattern recognition and computer vision can be used to track objects. Mapping techniques can be used to build maps of the world.

# Automation

*Gojay Helekar, Mech VI*

**Automation** describes a wide range of technologies that reduce human intervention in processes. Human intervention is reduced by predetermining decision criteria, sub-process relationships, and related actions — and embodying those predeterminations in machines. Automation, includes the use of various equipment and control systems such as machinery, processes in factories, boilers, and heat-treating ovens, switching on telephone networks, steering, and stabilization of ships, aircraft, and other applications and vehicles with reduced human intervention.[4] Automation covers applications ranging from a household thermostat controlling a boiler, to a large industrial control system with tens of thousands of input measurements and output control signals. Automation has also found space in the banking sector. In control complexity, it can range from simple on-off control to multi-variable high-level algorithms. In the simplest type of an automatic control loop, a controller compares a measured value of a process with a desired set value and processes the resulting error signal to change some input to the process, in such a way that the process stays at its set point despite disturbances. This closed-loop control is an application of negative feedback to a system. The mathematical basis of control theory was begun in the 18th century and advanced rapidly in the 20th.

Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices, and computers, usually in combination. Complicated systems, such as modern factories, airplanes, and ships typically use all these combined techniques. The benefit of automation includes labor savings, reducing waste, savings in electricity costs, savings in material costs, and improvements to quality, accuracy, and precision. The World Bank's World Development Report 2019 shows evidence that the new industries and jobs in the technology sector outweigh the economic effects of workers being displaced by automation. Job losses and downward mobility blamed on Automation has been cited as one of many factors in the resurgence of nationalist, protectionist and populist politics in the US, UK and France, among other countries since the 2010s. The term *automation*, inspired by the earlier word *automatic* (coming from *automaton*), was not widely used before 1947, when Ford established an automation department. It was during this time that industry was rapidly adopting feedback controllers, which were introduced in the 1930s.

**Open-loop and closed-loop (feedback) control**

Fundamentally, there are two types of control loops: open-loop controller, and closed-loop control. In open-loop control, the control action from the controller is independent of the "process output" (or "controlled process variable"). A good example of this is a central heating boiler controlled only by a timer, so that heat is applied for a constant time, regardless of the temperature of the building. (The control action is switching the boiler off and on. The process output is building temperature).

In closed-loop control, the control action from the controller is dependent on the process output. In the case of the boiler analogy, this would include a temperature sensor to monitor the building temperature, and thereby feed a signal back to the controller to ensure it maintains the building at the temperature set on the thermostat. A closed-loop controller, therefore, has a feedback loop that ensures the controller exerts a control action to give a process output equal to the "Reference input" or "set point". For this reason, closed-loop controllers are also called feedback controllers.

The definition of a closed-loop control system according to the British Standard Institution is 'a control system possessing monitoring feedback, the deviation signal formed as a result of this feedback being used to control the action of a final control element in such a way as to tend to reduce the deviation to zero.'

Likewise, a *Feedback Control System* is a system that tends to maintain a prescribed relationship of one system variable to another by comparing functions of these variables and using the difference as a means of control. The advanced type of automation that revolutionized manufacturing, aircraft, communications, and other industries, is feedback control, which is usually *continuous* and involves taking measurements using a sensor and making calculated adjustments to keep the measured variable within a set range. The theoretical basis of closed-loop automation is control theory.

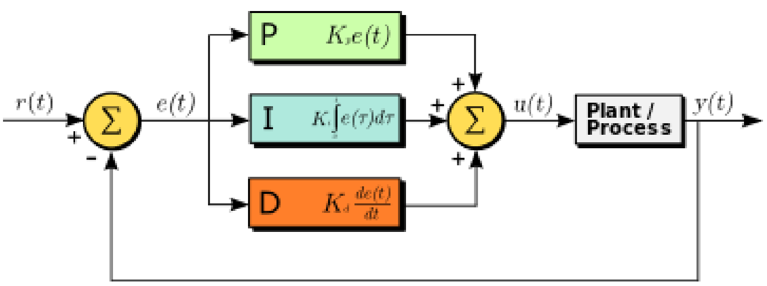
## Control actions

### Discrete control (on/off)

One of the simplest types of control is *on-off* control. An example is a thermostat used on household appliances which either open or close an electrical contact. (Thermostats were originally developed as true feedback-control mechanisms rather than the on-off common household appliance thermostat.)

Sequence control, in which a programmed sequence of *discrete* operations is performed, often based on system logic that involves system states. An elevator control system is an example of sequence control.

### PID controller




*A block diagram of a PID controller in a feedback loop, r(t) is the desired process value or "set point", and y(t) is the measured process value.*

A proportional–integral–derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems.

In a PID loop, the controller continuously calculates an *error value* as the difference between a desired set point and a measured process variable and applies a correction based on proportional, integral, and derivative terms, respectively (sometimes denoted *P*, *I*, and *D*) which give their name to the controller type.

The theoretical understanding and application date from the 1920s, and they are implemented in nearly all analog control systems; originally in mechanical controllers, and then using discrete electronics and latterly in industrial process computers.

**Sequential control and logical sequence or system state control**

Sequential control may be either to a fixed sequence or to a logical one that will perform different actions depending on various system states. An example of an adjustable but otherwise fixed sequence is a timer on a lawn sprinkler.

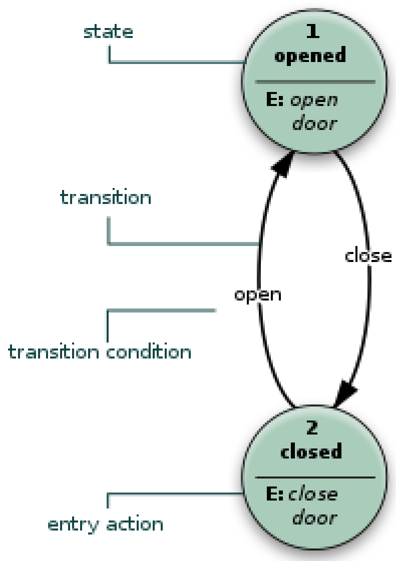
States refer to the various conditions that can occur in a use or sequence scenario of the system. An example is an elevator, which uses logic based on the system state to perform certain actions in response to its state and operator input. For example, if the operator presses the floor n button, the system will respond depending on whether the elevator is stopped or moving, going up or down, or if the door is open or closed, and other conditions.

Early development of sequential control was relay logic, by which electrical relays engage electrical contacts which either start or interrupt power to a device. Relays were first used in telegraph networks before being developed for controlling other devices, such as when starting and stopping industrial-sized electric motors or opening and closing solenoid valves. Using relays for control purposes allowed event-driven control, where actions could be triggered out of sequence, in response to external events. These were more flexible in their response than the rigid single-sequence cam timers. More complicated examples involved maintaining safe sequences for devices such as swing bridge controls, where a lock bolt needed to be disengaged before the bridge could be moved, and the lock bolt could not be released until the safety gates had already been closed.

The total number of relays and cam timers can number into the hundreds or even thousands in some factories. Early programming techniques and languages were needed to make such systems manageable, one of the first being ladder logic, where diagrams of the interconnected relays resembled the rungs of a ladder.

Special computers called programmable logic controllers were later designed to replace these collections of hardware with a single, more easily re-programmed unit.

In a typical hard wired motor start and stop circuit (called a *control circuit*) a motor is started by pushing a "Start" or "Run" button that activates a pair of electrical relays. The "lock-in" relay locks in contacts that keep the control circuit energized when the push-button is released. (The start button is a normally open contact and the stop button is normally closed contact.) Another relay energizes a switch that powers the device that throws the motor starter switch (three sets of contacts for three-phase industrial power) in the main power circuit. Large motors use high voltage and experience high in-rush current, making speed important in making and breaking contact. This can be dangerous for personnel and property with manual switches. The "lock-in" contacts in the start circuit and the main power contacts for the motor are held engaged by their respective electromagnets until a "stop" or "off" button is pressed, which de-energizes the lock in relay.




*This state diagram shows how UML can be used for designing a door system that can only be opened and closed*

Commonly interlocks are added to a control circuit. Suppose that the motor in the example is powering machinery that has a critical need for lubrication. In this case, an interlock could be added to ensure that the oil pump is running before the motor starts. Timers, limit switches, and electric eyes are other common elements in control circuits.

Solenoid valves are widely used on compressed air or hydraulic fluid for powering actuators on mechanical components. While motors are used to supply continuous rotary motion, actuators are typically a better choice for intermittently creating a limited range of movement for a mechanical component, such as moving various mechanical arms, opening or closing valves, raising heavy press-rolls, applying pressure to presses.

### Computer control

Computers can perform both sequential control and feedback control, and typically a single computer will do both in an industrial application. Programmable logic controllers (PLCs) are a type of special-purpose microprocessor that replaced many hardware components such as timers and drum sequencers used in relay logic type systems. General-purpose process control computers have increasingly replaced stand-alone controllers, with a single computer able to perform the operations of hundreds of controllers. Process control computers can process data from a network of PLCs, instruments, and controllers to implement typical (such as PID) control of many individual variables or, in some cases, to implement complex control algorithms using multiple inputs and mathematical manipulations. They can also analyze data and create real-time graphical displays for operators and run reports for operators, engineers, and management.

Control of an automated teller machine (ATM) is an example of an interactive process in which a computer will perform a logic derived response to a user selection based on information retrieved from a networked database. The ATM process has similarities with other online transaction processes. The different logical responses are called *scenarios*. Such processes are typically designed with the aid of use cases and flowcharts, which guide the writing of the software code. The earliest feedback control mechanism was the water clock invented by Greek engineer Ctesibius (285–222 BC).

## History

### Industrial Revolution in Western Europe

*Steam engines promoted automation through the need to control engine speed and power.*

The introduction of prime movers, or self-driven machines advanced grain mills, furnaces, boilers, and the steam engine created a new requirement for automatic control systems including temperature regulators (invented in 1624; see Cornelius Drebbel), pressure regulators (1681), float regulators (1700) and speed control devices. Another control mechanism was used to tent the sails of windmills. It was patented by Edmund Lee in 1745. Also in 1745, Jacques de Vaucanson invented the first automated loom. Around 1800, Joseph Marie Jacquard created a punch-card system to program looms.

In 1771 Richard Arkwright invented the first fully automated spinning mill driven by water power, known at the time as the water frame. An automatic flour mill was developed by Oliver Evans in 1785, making it the first completely automated industrial process.

*A flyball governor is an early example of a feedback control system. An increase in speed would make the counterweights move outward, sliding a linkage that tended to close the valve supplying steam, and so slowing the engine.*

A centrifugal governor was used by a Mr. Bunce of England in 1784 as part of a model steam crane. The centrifugal governor was adopted by James Watt for use on a steam engine in 1788 after Watt's partner Boulton saw one at a flour mill Boulton & Watt were building. The governor could not actually hold a set speed; the engine would assume a new constant speed in response to load changes. The governor was able to handle smaller variations such as those caused by fluctuating heat load to the boiler. Also, there was a tendency for oscillation whenever there was a speed change. As a consequence, engines equipped with this governor were not suitable for operations requiring constant speed, such as cotton spinning.

Several improvements to the governor, plus improvements to valve cut-off timing on the steam engine, made the engine suitable for most industrial uses before the end of the 19th century. Advances in the steam engine stayed well ahead of science, both thermodynamics and control theory. The governor received relatively little scientific attention until James Clerk Maxwell published a paper that established the beginning of a theoretical basis for understanding control theory.

**20th century**

Relay logic was introduced with factory electrification, which underwent rapid adaption from 1900 through the 1920s. Central electric power stations were also undergoing rapid growth and the operation of new high-pressure boilers, steam turbines and electrical substations created a large demand for instruments and controls. Central control rooms became common in the 1920s, but as late as the early 1930s, most process controls were on-off. Operators typically monitored charts drawn by recorders that plotted data from instruments. To make corrections, operators manually opened or closed valves or turned switches on or off.

Control rooms also used color-coded lights to send signals to workers in the plant to manually make certain changes.

The development of the electronic amplifier during the 1920s, which was important for long-distance telephony, required a higher signal-to-noise ratio, which was solved by negative feedback noise cancellation. This and other telephony applications contributed to the control theory. In the 1940s and 1950s, German mathematician Irmgard Flügge-Lotz developed the theory of discontinuous automatic controls, which found military applications during the Second World War to fire control systems and aircraft navigation systems.

Controllers, which were able to make calculated changes in response to deviations from a set point rather than on-off control, began being introduced in the 1930s. Controllers allowed manufacturing to continue showing productivity gains to offset the declining influence of factory electrification.

Factory productivity was greatly increased by electrification in the 1920s. U.S. manufacturing productivity growth fell from 5.2%/yr 1919–29 to 2.76%/yr 1929–41. Alexander Field notes that spending on non-medical instruments increased significantly from 1929 to 1933 and remained strong thereafter.

The First and Second World Wars saw major advancements in the field of mass communication and signal processing. Other key advances in automatic controls include differential equations, stability theory and system theory (1938), frequency domain analysis (1940), ship control (1950), and stochastic analysis (1941).

Starting in 1958, various systems based on solid-state digital logic modules for hard-wired programmed logic controllers (the predecessors of programmable logic controllers (PLC)) emerged to replace electro-mechanical relay logic in industrial control systems for process control and automation, including early Telefunken/AEG Logistat, Siemens Simatic, Philips/Mullard/Valvo [de] Norbit, BBC Sigmatronic, ACEC Logacec, Akkord [de] Estacord, Krone Mibakron, Bistat, Datapac, Norlog, SSR, or Procontic systems.

In 1959 Texaco's Port Arthur Refinery became the first chemical plant to use digital control. Conversion of factories to digital control began to spread rapidly in the 1970s as the price of computer hardware fell.

**Significant applications**

The automatic telephone switchboard was introduced in 1892 along with dial telephones. By 1929, 31.9% of the Bell system was automatic. Automatic telephone switching originally used vacuum tube amplifiers and electro-mechanical switches, which consumed a large amount of electricity. Call volume eventually grew so fast that it was feared the telephone system would consume all electricity production, prompting Bell Labs to begin research on the transistor.

The logic performed by telephone switching relays was the inspiration for the digital computer. The first commercially successful glass bottle blowing machine was an automatic model introduced in 1905.The machine, operated by a two-man crew working 12-hour shifts, could produce 17,280 bottles in 24 hours, compared to 2,880 bottles made by a crew of six men and boys working in a shop for a day. The cost of making bottles by machine was 10 to 12 cents per gross compared to $1.80 per gross by the manual glassblowers and helpers.

Sectional electric drives were developed using control theory. Sectional electric drives are used on different sections of a machine where a precise differential must be maintained between the sections. In steel rolling, the metal elongates as it passes through pairs of rollers, which must run at successively faster speeds. In paper making the paper, the sheet shrinks as it passes around steam heated drying arranged in groups, which must run at successively slower speeds. The first application of a sectional electric drive was on a paper machine in 1919. One of the most important developments in the steel industry during the 20th century was continuous wide strip rolling, developed by Armco in 1928.

*Automated pharmacology production*

Before automation, many chemicals were made in batches. In 1930, with the widespread use of instruments and the emerging use of controllers, the founder of Dow Chemical Co. was advocating continuous production.

Self-acting machine tools that displaced hand dexterity so they could be operated by boys and unskilled laborers were developed by James Nasmyth in the 1840s. Machine tools were automated with Numerical control (NC) using punched paper tape in the 1950s. This soon evolved into computerized numerical control (CNC).

Some of the larger processes include electrical power generation, oil refining, chemicals, steel mills, plastics, cement plants, fertilizer plants, pulp and paper mills, automobile and truck assembly, aircraft production, glass manufacturing, natural gas separation plants, food and beverage processing, canning and bottling and manufacture of various kinds of parts. Robots are especially useful in hazardous applications like automobile spray painting. Robots are also used to assemble electronic circuit boards. Automotive welding is done with robots and automatic welders are used in applications like pipelines.

### Space/computer age

With the advent of the space age in 1957, controls design, particularly in the United States, turned away from the frequency-domain techniques of classical control theory and backed into the differential equation techniques of the late 19th century, which were couched in the time domain. During the 1940s and 1950s, German mathematician Irmgard Flugge-Lotz developed the theory of discontinuous automatic control, which became widely used in hysteresis control systems such as navigation systems, fire-control systems, and electronics. Through Flugge-Lotz and others, the modern era saw time-domain design for nonlinear systems (1961), navigation (1960), optimal control and estimation theory (1962), nonlinear control theory (1969), digital control and filtering theory (1974), and the personal computer (1983).

### Advantages, disadvantages, and limitations

Perhaps the most cited advantage of automation in industry is that it is associated with faster production and cheaper labor costs. Another benefit could be that it replaces hard, physical, or monotonous work. Additionally, tasks that take place in hazardous environments or that are otherwise beyond human capabilities can be done by machines, as machines can operate even under extreme temperatures or in atmospheres that are radioactive or toxic. They can also be maintained with simple quality checks. However, at the time being, not all tasks can be automated, and some tasks are more expensive to automate than others. Initial costs of installing the machinery in factory settings are high, and failure to maintain a system could result in the loss of the product itself.

Moreover, some studies seem to indicate that industrial automation could impose ill effects beyond operational concerns, including worker displacement due to systemic loss of employment and compounded environmental damage; however, these findings are both convoluted and controversial in nature, and could potentially be circumvented.

The main advantages of automation are:

- Increased throughput or productivity
- Improved quality
- Increased predictability
- Improved robustness (consistency), of processes or product
- Increased consistency of output
- Reduced direct human labor costs and expenses
- Reduced cycle time
- Increased accuracy
- Relieving humans of monotonously repetitive work
- Required work in development, deployment, maintenance, and operation of automated processes — often

structured as “jobs”
- Increased human freedom to do other things

Automation primarily describes machines replacing human action, but it is also loosely associated with mechanization, machines replacing human labor. Coupled with mechanization, extending human capabilities in terms of size, strength, speed, endurance, visual range & acuity, hearing frequency & precision, electromagnetic sensing & effecting, etc., advantages include:

- Relieving humans of dangerous work stresses and occupational injuries (e.g., fewer strained backs from lifting heavy objects)
- Removing humans from dangerous environments (e.g. fire, space, volcanoes, nuclear facilities, underwater, etc.)

The main disadvantages of automation are:

- High initial cost
- Faster production without human intervention can mean faster unchecked production of defects where automated processes are defective.
- Scaled-up capacities can mean scaled-up problems when systems fail — releasing dangerous toxins, forces, energies, etc., at scaled-up rates.
- Human adaptiveness is often poorly understood by automation initiators. It is often difficult to anticipate every contingency and develop fully preplanned automated responses for every situation. The discoveries inherent in automating processes can require unanticipated iterations to resolve, causing unanticipated costs and delays.

**Paradox of automation**

The paradox of automation says that the more efficient the automated system, the more crucial the human contribution of the operators. Humans are less involved, but their involvement becomes more critical. Lisanne Bainbridge, a cognitive psychologist, identified these issues notably in her widely cited paper "Ironies of Automation." If an automated system has an error, it will multiply that error until it is fixed or shut down. This is where human operators come in. A fatal example of this was Air France Flight 447, where a failure of automation put the pilots into a manual situation they were not prepared for.

Limitations

- Current technology is unable to automate all the desired tasks.
- Many operations using automation have large amounts of invested capital and produce high volumes of product, making malfunctions extremely costly and potentially hazardous. Therefore, some personnel is needed to ensure that the entire system functions properly and that safety and product quality are maintained.
- As a process becomes increasingly automated, there is less and less labor to be saved or quality improvement

to be gained. This is an example of both diminishing returns and the logistic function.

- As more and more processes become automated, there are fewer remaining non-automated processes. This is an example of the exhaustion of opportunities. New technological paradigms may, however, set new limits that surpass the previous limits.

## Current limitations

Many roles for humans in industrial processes presently lie beyond the scope of automation. Human-level pattern recognition, language comprehension, and language production ability are well beyond the capabilities of modern mechanical and computer systems (but see Watson computer). Tasks requiring subjective assessment or synthesis of complex sensory data, such as scents and sounds, as well as high-level tasks such as strategic planning, currently require human expertise. In many cases, the use of humans is more cost-effective than mechanical approaches even where the automation of industrial tasks is possible. Overcoming these obstacles is a theorized path to post-scarcity economics.

## Societal impact and unemployment

Increased automation often causes workers to feel anxious about losing their jobs as technology renders their skills or experience unnecessary. Early in the Industrial Revolution, when inventions like the steam engine were making some job categories expendable, workers forcefully resisted these changes. Luddites, for instance, were English textile workers who protested the introduction of weaving machines by destroying them. More recently, some residents of Chandler, Arizona, have slashed tires and pelted rocks at driver-less cars, in protest over the cars' perceived threat to human safety and job prospects.

The relative anxiety about automation reflected in opinion polls seems to correlate closely with the strength of organized labor in that region or nation. For example, while a study by the Pew Research Center indicated that 72% of Americans are worried about increasing automation in the workplace, 80% of Swedes see automation and artificial intelligence as a good thing, due to the country's still-powerful unions and a more robust national safety net.

In the United States, 47% of all current jobs have the potential to be fully automated by 2033, according to the research of experts Carl Benedikt Frey and Michael Osborne. Furthermore, wages and educational attainment appear to be strongly negatively correlated with an occupation's risk of being automated. Even highly skilled professional jobs like a lawyer, doctor, engineer, journalist are at risk of automation.

Prospects are particularly bleak for occupations that do not presently require a university degree, such as truck driving. Even in high-tech corridors like Silicon Valley, concern is spreading about a future in which a sizable percentage of adults have little chance of sustaining gainful employment. "In *The Second Machine Age*, Erik Brynjolfsson and Andrew McAfee argue that "...there's never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate." As the example of Sweden suggests, however, the transition to a more automated future need not inspire panic, if there is sufficient political will to promote the retraining of workers whose positions are being rendered obsolete.

According to a 2020 study in the *Journal of Political Economy*, automation has robust negative effects on employment and wages: "One more robot per thousand workers reduces the employment-to-population ratio by 0.2 percentage points and wages by 0.42%."

Research by Carl Benedikt Frey and Michael Osborne of the Oxford Martin School argued that employees engaged in "tasks following well-defined procedures that can easily be performed by sophisticated algorithms" are at risk of displacement, and 47% of jobs in the US were at risk. The study, released as a working paper in 2013 and published in 2017, predicted that automation would put low-paid physical occupations most at risk, by surveying a group of colleagues on their opinions. However, according to a study published in *McKinsey Quarterly* in 2015 the impact of computerization in most cases is not the replacement of employees but automation of portions of the tasks they perform.The methodology of the McKinsey study has been heavily criticized for being intransparent and relying on subjective assessments. The methodology of Frey and Osborne has been subjected to criticism, as lacking evidence, historical awareness, or credible methodology. In addition the OECD, found that across the 21 OECD countries, 9% of jobs are automatable.

The Obama administration has pointed out that every 3 months "about 6 percent of jobs in the economy are destroyed by shrinking or closing businesses, while a slightly larger percentage of jobs are added." A recent MIT economics study of automation in the United States from 1990 to 2007 found that there may be a negative impact on employment and wages when robots are introduced to an industry. When one robot is added per one thousand workers, the employment to population ratio decreases between 0.18 and 0.34 percentages and wages are reduced by 0.25–0.5 percentage points. During the time period studied, the US did not have many robots in the economy which restricts the impact of automation. However, automation is expected to triple (conservative estimate) or quadruple (a generous estimate) leading these numbers to become substantially higher.

Based on a formula by Gilles Saint-Paul, an economist at Toulouse 1 University, the demand for unskilled human capital declines at a slower rate than the demand for skilled human capital increases. In the long run and for society as a whole it has led to cheaper products, lower average work hours, and new industries forming (i.e., robotics industries, computer industries, design industries). These new industries provide many high salary skill-based jobs to the economy. By 2030, between 3 and 14 percent of the global workforce will be forced to switch job categories due to automation eliminating jobs in an entire sector. While the number of jobs lost to automation is often offset by jobs gained from technological advances, the same type of job loss is not the same one replaced and that leading to increasing unemployment in the lower-middle class. This occurs largely in the US and developed countries where technological advances contribute to higher demand for highly skilled labor but demand for middle-wage labor continues to fall. Economists call this trend "income polarization" where unskilled labor wages are driven down and skilled labor is driven up and it is predicted to continue in developed economies.

Unemployment is becoming a problem in the United States due to the exponential growth rate of automation and technology. According to Kim, Kim, and Lee (2017:1), "seminal study by Frey and Osborne in 2013 predicted that 47% of the 702 examined occupations in the United States faced a high risk of decreased employment rate within the next 10–25 years as a result of computerization." As many jobs are becoming obsolete, which is causing job displacement, one possible solution would be for the government to assist with a universal basic income (UBI) program. UBI would be a guaranteed, non-taxed income of around 1000 dollars per month, paid to all U.S. citizens over the age of 21. UBI would help those who are displaced take on jobs that pay less money and still afford to get by. It would also give those that are employed with jobs that are likely to be replaced by automation and technology extra money to spend on education and training on new demanding employment skills. UBI, however, should be seen as a short-term solution as it doesn't fully address the issue of income inequality which will be exacerbated by job displacement.

**Lights-out manufacturing**

Lights-out manufacturing is a production system with no human workers, to eliminate labor costs.

Lights out manufacturing grew in popularity in the U.S. when General Motors in 1982 implemented humans "hands-off" manufacturing to "replace risk-averse bureaucracy with automation and robots". However, the factory never reached full "lights out" status.

The expansion of lights out manufacturing requires:

- Reliability of equipment
- Long-term mechanic capabilities
- Planned preventive maintenance
- Commitment from the staff

**Health and environment**

The costs of automation to the environment are different depending on the technology, product or engine automated. There are automated engines that consume more energy resources from the Earth in comparison with previous engines and vice versa. Hazardous operations, such as oil refining, the manufacturing of industrial chemicals, and all forms of metal working, were always early contenders for automation.

The automation of vehicles could prove to have a substantial impact on the environment, although the nature of this impact could be beneficial or harmful depending on several factors. Because automated vehicles are much less likely to get into accidents compared to human-driven vehicles, some precautions built into current models (such as anti-lock brakes or laminated glass) would not be required for self-driving versions. Removing these safety features would also significantly reduce the weight of the vehicle, thus increasing fuel economy and reducing emissions per mile. Self-driving vehicles are also more precise concerning acceleration and breaking, and this could contribute to reduced emissions. Self-driving cars could also potentially utilize fuel-efficient features such as route mapping that can calculate and take the most efficient routes. Despite this potential to reduce emissions, some researchers theorize that an increase in the production of self-driving cars could lead to a boom of vehicle ownership and use. This boom could potentially negate any environmental benefits of self-driving cars if a large enough number of people begin driving personal vehicles more frequently.

Automation of homes and home appliances is also thought to impact the environment, but the benefits of these features are also questioned. A study of energy consumption of automated homes in Finland showed that smart homes could reduce energy consumption by monitoring levels of consumption in different areas of the home and adjusting consumption to reduce energy leaks (e.g. automatically reducing consumption during the nighttime when activity is low). This study, along with others, indicated that the smart home's ability to monitor and adjust consumption levels would reduce unnecessary energy usage. However, new research suggests that smart homes might not be as efficient as non-automated homes. A more recent study has indicated that, while monitoring and adjusting consumption levels does decrease unnecessary energy use, this process requires monitoring systems that also consume a significant amount of energy. This study suggested that the energy required to run these systems is so much so that it negates any benefits of the systems themselves, resulting in little to no ecological benefit.

**Automation tools**

Engineers can now have numerical control over automated devices. The result has been a rapidly expanding range of applications and human activities. Computer-aided technologies (or CAx) now serve as the basis for mathematical and organizational tools used to create complex systems. Notable examples of CAx include

Computer-aided design (CAD software) and Computer-aided manufacturing (CAM software). The improved design, analysis, and manufacture of products enabled by CAx has been beneficial for industry.[81]

Information technology, together with industrial machinery and processes, can assist in the design, implementation, and monitoring of control systems. One example of an industrial control system is a programmable logic controller (PLC). PLCs are specialized hardened computers which are frequently used to synchronize the flow of inputs from (physical) sensors and events with the flow of outputs to actuators and events.[82]


*An automated online assistant on a website, with an avatar for enhanced human–computer interaction.*

Human-machine interfaces (HMI) or computer human interfaces (CHI), formerly known as *man-machine interfaces*, are usually employed to communicate with PLCs and other computers. Service personnel who monitor and control through HMIs can be called by different names. In the industrial process and manufacturing environments, they are called operators or something similar. In boiler houses and central utility departments, they are called *stationary engineers*.

Different types of automation tools exist:

- ANN – Artificial Neural Network
- DCS – Distributed Control System
- HMI – Human Machine Interface
- RPA – Robotic Process Automation
- SCADA – Supervisory Control and Data Acquisition
- PLC – Programmable Logic Controller
- Instrumentation
- Motion control
- Robotics

Host simulation software (HSS) is a commonly used testing tool that is used to test the equipment software. HSS is used to test equipment performance concerning factory automation standards (timeouts, response time, processing time).

### Cognitive automation

Cognitive automation, as a subset of artificial intelligence, is an emerging genus of automation enabled by cognitive computing. Its primary concern is the automation of clerical tasks and workflows that consist of structuring unstructured data. Cognitive automation relies on multiple disciplines: natural language processing, real-time computing, machine learning algorithms, big data analytics, and evidence-based learning.

According to Deloitte, cognitive automation enables the replication of human tasks and judgment "at rapid speeds and considerable scale." Such tasks include:

- Document redaction
- Data extraction and document synthesis / reporting
- Contract management
- Natural language search
- Customer, employee, and stakeholder onboarding
- Manual activities and verifications
- Follow-up and email communications

### Recent and emerging applications

Automated power production

Technologies like solar panels, wind turbines, and other renewable energy sources—together with smart grids, micro-grids, battery storage—can automate power production.

Retail

Many supermarkets and even smaller stores are rapidly introducing Self-checkout systems reducing the need for employing checkout workers. In the United States of America (USA), the retail industry employs 15.9 million people as of 2017 (around 1 in 9 Americans in the workforce). Globally, an estimated 192 million workers could be affected by automation according to research by Eurasia Group.

Online shopping could be considered a form of automated retail as the payment and checkout are through an automated Online transaction processing system, with the share of online retail accounting jumping from 5.1% in 2011 to 8.3% in 2016. However, two-thirds of books, music, and films are now purchased online. In addition, automation and online shopping could reduce demands for shopping malls, and retail property, which in the USA is currently estimated to account for 31% of all commercial property or around 7 billion square feet (650 million square metres). Amazon has gained much of the growth in recent years for online shopping, accounting for half of the growth in online retail in 2016. Other forms of automation can also be an integral part of online shopping, for example, the deployment of automated warehouse robotics such as that applied by Amazon using Kiva Systems.

**Food and drink**

*KUKA industrial robots being used at a bakery for food production*

The food retail industry has started to apply automation to the ordering process; McDonald's has introduced touch screen ordering and payment systems in many of its restaurants, reducing the need for as many cashier employees. The University of Texas at Austin has introduced fully automated cafe retail locations. Some Cafes and restaurants have utilized mobile and tablet "apps" to make the ordering process more efficient by customers ordering and paying on their device. Some restaurants have automated food delivery to tables of customers using a Conveyor belt system. The use of robots is sometimes employed to replace waiting staff.

**Mining**

Automated mining involves the removal of human labor from the mining process. The mining industry is currently in the transition towards automation. Currently, it can still require a large amount of human capital, particularly in the third world where labor costs are low so there is less incentive for increasing efficiency through automation.

**Video surveillance**

The Defense Advanced Research Projects Agency (DARPA) started the research and development of automated visual surveillance and monitoring (VSAM) program, between 1997 and 1999, and airborne video surveillance (AVS) programs, from 1998 to 2002. Currently, there is a major effort underway in the vision community to develop a fully-automated tracking surveillance system. Automated video surveillance monitors people and vehicles in real-time within a busy environment. Existing automated surveillance systems are based on the environment they are primarily designed to observe, i.e., indoor, outdoor or airborne, the number of sensors that the automated system can handle and the mobility of sensors, i.e., stationary camera vs. mobile camera. The purpose of a surveillance system is to record properties and trajectories of objects in a given area, generate warnings or notify the designated authorities in case of occurrence of particular events.

### Highway systems

As demands for safety and mobility have grown and technological possibilities have multiplied, interest in automation has grown. Full automation commonly defined as requiring no control or very limited control by the driver; such automation would be accomplished through a combination of sensor, computer, and communications systems in vehicles and along the roadway. Fully automated driving would, in theory, allow closer vehicle spacing and higher speeds, which could enhance traffic capacity in places where additional road building is physically impossible, politically unacceptable, or prohibitively expensive. Automated controls also might enhance road safety by reducing the opportunity for driver error, which causes a large share of motor vehicle crashes. Other potential benefits include improved air quality (as a result of more-efficient traffic flows), increased fuel economy, and spin-off technologies generated during research and development related to automated highway systems.

### Waste management

*Play media Automated side loader operation*

Automated waste collection trucks prevent the need for as many workers as well as easing the level of labor required to provide the service.

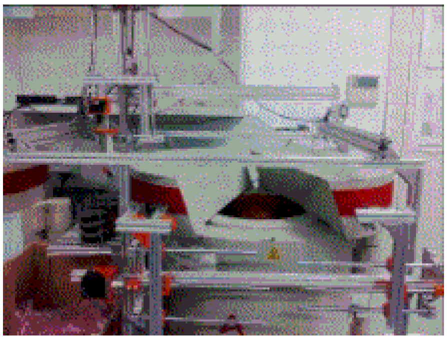
### Business process

Business process automation (BPA) is the technology-enabled automation of complex business processes.[98] It can help to streamline a business for simplicity, achieve digital transformation, increase service quality, improve service delivery or contain costs. BPA consists of integrating applications, restructuring labor resources and using software applications throughout the organization. Robotic process automation (RPA; or RPAAI for self-guided RPA 2.0) is an emerging field within BPA and uses artificial intelligence. BPAs can be implemented in a number of business areas including marketing, sales and workflow.

**Home**

Home automation (also called **domotics**) designates an emerging practice of increased automation of household appliances and features in residential dwellings, particularly through electronic means that allow for things impracticable, overly expensive or simply not possible in recent past decades. The rise in the usage of home automation solutions has taken a turn reflecting the increased dependency of people on such automation solutions. However, the increased comfort that gets added through these automation solutions is remarkable.

**Laboratory**



*Automated laboratory instrument*

Automation is essential for many scientific and clinical applications. Therefore, automation has been extensively employed in laboratories. From as early as 1980 fully automated laboratories have already been working. But,automation has not become widespread in laboratories due to its high cost. This may change with the ability of integrating low-cost devices with standard laboratory equipment e.g Auto samplers

**Logistics automation**

Logistics automation is the application of computer software or automated machinery to improve the efficiency of logistics operations. Typically this refers to operations within a warehouse or distribution center, with broader tasks undertaken by supply chain engineering and enterprise resource planning systems.

**Industrial automation**

Industrial automation deals primarily with the automation of manufacturing, quality control, and material handling processes. General-purpose controllers for industrial processes include programmable logic controllers, stand-alone I/O modules, and computers. Industrial automation is to replace the human action and manual command-response activities with the use of mechanized equipment and logical programming commands. One trend is increased use of machine vision to provide automatic inspection and robot guidance functions, another is a continuing increase in the use of robots.

**Industrial Automation and Industry 4.0**

The rise of industrial automation is directly tied to the "Fourth Industrial Revolution", which is better known now as Industry 4.0. Originating from Germany, Industry 4.0 encompasses numerous devices, concepts, and machines, as well as the advancement of the industrial internet of things (IIoT). An "Internet of Things is a seamless integration of diverse physical objects in the Internet through a virtual representation." The revolutionary advancements have drawn attention to t of automation in a new light and shown ways to increase productivity and efficiency. Industry 4.0 works with the IIoT and software/hardware to connect in a way that (through communication technologies) add enhancements and improve manufacturing processes. It opens up a manufacturing platform that is more reliable, consistent, and efficient than before. Implementation of systems such as SCADA is an example of software that takes place in Industrial Automation today. SCADA is a supervisory data collection software, just one of the many used in Industrial Automation. Industry 4.0 vastly covers many areas in manufacturing and will continue to do so as time goes on.

**Industrial robotics**

*Automated milling machines*

Industrial robotics is a sub-branch in industrial automation that aids in various manufacturing processes. Such manufacturing processes include machining, welding, painting, assembling and material handling to name a few. Industrial robots use various mechanical, electrical as well as software systems to allow for high precision, accuracy and speed that far exceed any human performance. The birth of industrial robots came shortly after World War II as the United States saw the need for a quicker way to produce industrial and consumer goods. Servos, digital logic and solid-state electronics allowed engineers to build better and faster systems and over time these systems were improved and revised to the point where a single robot is capable of running 24 hours a day with little or no maintenance. In 1997, there were 700,000 industrial robots in use, the number has risen to 1.8M in 2017 In recent years, artificial intelligence (AI) with robotics is also used in creating an automatic labeling solution, using robotic arms as the automatic label applicator, and AI for learning and detecting the products to be labelled.

**Programmable Logic Controllers**

Industrial automation incorporates programmable logic controllers in the manufacturing process. Programmable logic controllers (PLCs) use a processing system which allows for variation of controls of inputs and outputs using simple programming. PLCs make use of programmable memory, storing instructions and functions like logic, sequencing, timing, counting, etc. Using a logic-based language, a PLC can receive a variety of inputs and return a variety of logical outputs, the input devices being sensors and output devices being motors, valves, etc. PLCs are similar to computers, however, while computers are optimized for calculations, PLCs are optimized for control tasks and use in industrial environments. They are built so that only basic logic-based programming knowledge is needed and to handle vibrations, high temperatures, humidity, and noise. The greatest advantage PLCs offer is their flexibility. With the same basic controllers, a PLC can operate a range of different control systems. PLCs make it unnecessary to rewire a system to change the control system. This flexibility leads to a cost-effective system for complex and varied control systems.

PLCs can range from small "building brick" devices with tens of I/O in a housing integral with the processor, to large rack-mounted modular devices with a count of thousands of I/O, and which are often networked to other PLC and SCADA systems.

They can be designed for multiple arrangements of digital and analog inputs and outputs (I/O), extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory.

It was from the automotive industry in the USA that the PLC was born. Before the PLC, control, sequencing, and safety interlock logic for manufacturing automobiles was mainly composed of relays, cam timers, drum sequencers, and dedicated closed-loop controllers. Since these could number in the hundreds or even thousands, the process for updating such facilities for the yearly model change-over was very time-consuming and expensive, as electricians needed to rewire the relays to change operational characteristics.

When digital computers became available, being general-purpose programmable devices, they were soon applied to control sequential and combinatorial logic in industrial processes. However, these early computers required specialist programmers and stringent operating environmental control for temperature, cleanliness, and power quality. To meet these challenges this the PLC was developed with several key attributes. It would tolerate the shop-floor environment, it would support discrete (bit-form) input and output in an easily extensible manner, it would not require years of training to use, and it would permit its operation to be monitored. Since many industrial processes have timescales easily addressed by millisecond response times, modern (fast, small, reliable) electronics greatly facilitate building reliable controllers, and performance could be traded off for reliability.

## Agent-assisted automation

Agent-assisted automation refers to automation used by call center agents to handle customer inquiries. The key benefit of agent-assisted automation is compliance and error-proofing. Agents are sometimes not fully trained or they forget or ignore key steps in the process. The use of automation ensures that what is supposed to happen on the call actually does, every time. There are two basic types: desktop automation and automated voice solutions.

**Desktop automation** refers to software programming that makes it easier for the call center agent to work across multiple desktop tools. The automation would take the information entered into one tool and populate it across the others so it did not have to be entered more than once, for example.

**Automated voice solutions** allow the agents to remain on the line while disclosures and other important information is provided to customers in the form of pre-recorded audio files. Specialized applications of these automated voice solutions enable the agents to process credit cards without ever seeing or hearing the credit card numbers or CVV codes.

# STUDENT ACHIEVEMENTS

## TECHNICAL

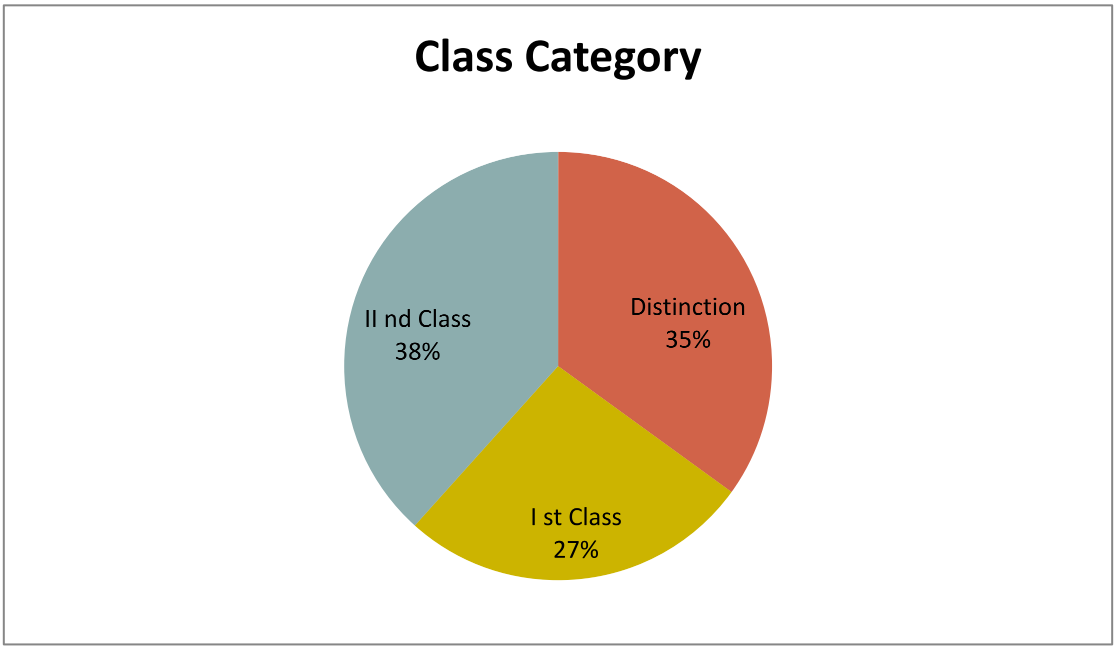
**[2020 - 2021]**

The Below mentioned are a few of Our Mechanical Students who had outstanding performance at various intra and inter state events :

| S.No. | Date | Participant | Event and Venue | Award |
|---|---|---|---|---|
| 1 | 02-09-2021 to 04-09-2021 | Royce Rego | National Level Combat Robot design and Development. SLIET Punjab. | Outside state |
| 2 | 02-09-2021 to 04-09-2021 | Ohan Rebello | National Level Combat Robot design and Development. SLIET Punjab. | Outside state |
| 3 | 02-09-2021 to 04-09-2021 | Kael Farnandes | National Level Combat Robot design and Development. SLIET Punjab. | Outside state |
| 4 | 02-09-2021 to 04-09-2021 | Raj Latkar | National Level Combat Robot design and Development. SLIET Punjab. | Outside state |

## August ' 2020 Examinations

60 Students from the 2016- 2020 Batch , answered the B.E – Mechanical ( Semester VIII ) Examination. All who appeared for the exam successfully passed out as graduate mechanical engineers.




| Toppers in Semester VIII | |
|---|---|
| **Rank** | **Name** |
| 1 | KANKONKAR PRANYUD |
| 2 | KUBAL NIKHIL KISHORE |
| 3 | DSILVA NAHIL IAN FLORES |
| | |
| **Toppers in Semester VI** | |
| **Rank** | **Name** |
| 1 | DE SOUZA BRANDON BENEDICTO |
| 2 | PONTES KEVIN NICHOLAS |
| 3 | GADKARI NARENDRA CHANDRAKANT |
| | |
| **Toppers in Semester IV ( Jun'20 )** | |
| **Rank** | **Name** |
| 1 | RODRIGUES DENVER BOSCO |
| 2 | REGO ROYCE RONY |
| 3 | REGE AKHILESH UPENDRA |

## Jan' 2021 Examinations

| Toppers in Semester VII | |
|---|---|
| **Rank** | **Name** |
| 1 | LOBO EMMANUEL AMOL MARIANO |
| 2 | GADKARI NARENDRA CHANDRAKANT |
| 3 | PAI KAKODE SATYESH PRASHANT |
| | |
| **Toppers in Semester V** | |
| **Rank** | **Name** |
| 1 | REGO ROYCE RONY |
| 2 | REBELLO OHAN |
| 3 | RODRIGUES DENVER BOSCO |
| | |
| **Toppers in Semester III** | |
| **Rank** | **Name** |
| 1 | VED UMEXA POROBO |
| 2 | MAHENDRA CHANDRASHEKHAR HIRVE |
| 3 | ARYAN VINOD KUNDAIKAR |

# A Report

**<u>TECHYON '20 - (ONLINE)</u>**

*Submitted by –Prof. Gaurak Phaldessai, Cultural Incharge (Mech. Dept)*

Techyon is an inter college technical event held annually at PCCE. The word Techyon was derived from Tachyon which is a hypothetical particle with speed more than the speed of the light. It hosts various technical events across all the departments. Many colleges from various parts of Goa participate in this event. TECHYON 2020 was held on 5$^{th}$ and 6$^{th}$ of November. Our sponsor for the Contraption was INHALE.

Inaugural function of TECHYON was held on 5$^{th}$ November at 10.00 am using Microsoft Teams platform. The Chief Guest for the function was **Mr. Vincent Toscano, Co-founder and managing partner of Uzoorba Technologies LLP.**. Other dignitaries present were **Rev. Fr. Anthony Castello**, Director, ATEC, **Dr. Mahesh Parappagoudar**, Principal of PCCE, **Dr. Stephen Barreto**, Registrar, PCCE and **Dr. Niyan Marchon, Head, RDCC**. Mr. Toscano in his address stressed on the importance of such events in molding a student's professional attitude and teamwork. He also compelled students to think why they have chosen engineering as a career and what they should be doing. He also congratulated the team for successfully organizing the event and declared TECHYON 2020 OPEN.

Mechanical department hosted events like Contraption, Paper Presentation, Mechanism building and Solidwars. All the events were held virtually. In contraption, students had to record video explaining about their mechanism and various steps involved. In contraption, an input triggers several steps down the line and finally gives the output.


*Mechanism Building – Photograph submitted by student sent ONLINE*

Paper presentation is a project display competition wherein students explain about their projects related to engineering and society and also answer questions put by the judges. Students are taught about various basic mechanisms which they see in everyday life in their curriculum. Students fabricated models of these mechanisms and demonstrated them in the Mechanism building competition. Around 6 entries were there for mechanism building competition. Solidwars is a modeling competition where students compete with one another to develop a 3D model of the geometry given to them in a given period of time. They had to record their steps while modeling. Softwares like Solidworks, ANSYS, Fusion 360, etc were used for this competition.


*Fig . Steering Wheel Mechanism(L) & Peltier Effect(R) demonstrated by students (ONLINE)*

# ISHRAE COLLEGIATE CHAPTER [2020 - 2021]

***XV$^{TH}$ ISHRAE STUDENTS CWC INSTALLED AT PCCE***

Padre Conceicao College of Engineering (PCCE) had the Installation of the Chapter Working Committee (CWC) 2020-21 for the Indian Society of Heating Refrigerating and Air conditioning Engineers (ISHRAE) Student Chapter, PCCE on virtual meeting platform in light of the ongoing pandemic, on 28 August 2020.

The team headed by **Assistant Professor Mohnish Borker** were the first in Goa to take this initiative and have the online installation of the CWC. PCCE management provided full moral support for the installation of the Chapter Working Committee. Mr. Santosh Tajave of Greenberry Design was the Chief Guest of the installation ceremony. Also present were the guest of honours Mr. Devanand Patekar; President, ISHRAE Goa Chapter, Mr. Shankar Sapaliga; West Zone Activities Chair ISHRAE, Mr. Brian Soares; Students Activity Chair ISHRAE Goa and The Head of Department Dr. Geetalakshmi K. Mr. Patekar commended the efforts of the college for conducting the first virtual installation ceremony in Goa and enlightened the students on the benefits of joining a professional society. He also highlighted the importance of such societies towards “Aatmanirbhar Bharat”. Mr. Shankar Sapaliga, provided valuable insight on the activities and programmes conducted by ISHRAE to help engineering students sharpen and develop their professional and soft skills which conducts various online seminars, competitions and webinars. Mr. Santosh Tajave, inspired the students to follow their passion and always thrive for innovation, new ideas and continue learning.

PCCE has always been in the forefront for conducting student related programmes through ISHRAE. One great initiative taken before lockdown was a student awareness program named “Atmabodh”, wherein students visited local schools making them aware of global warming and importance of HVAC.

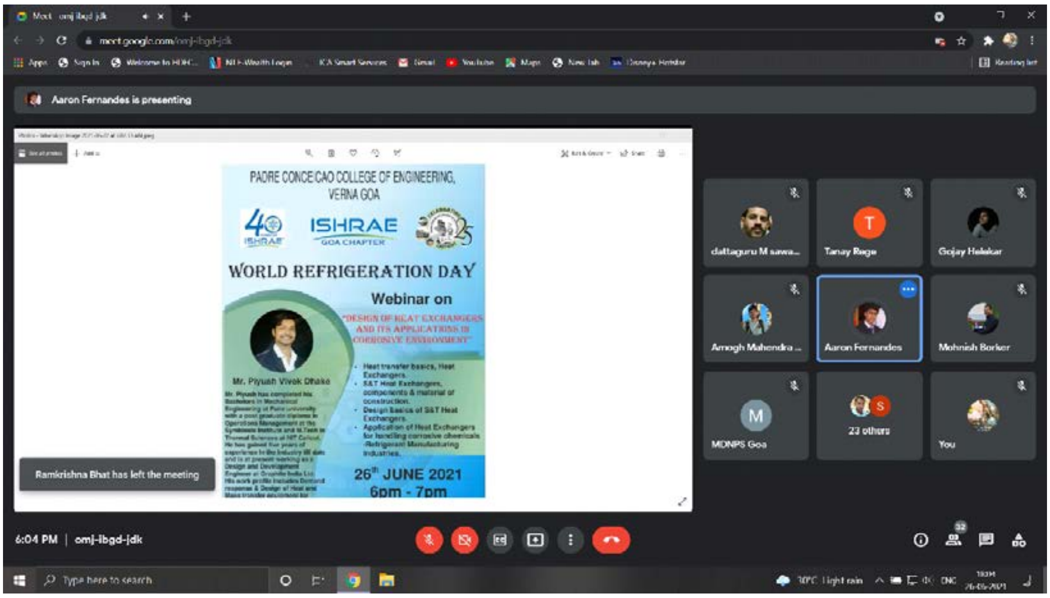

Mohnish Borker is presenting
Prajakta Palekar
and 22 more
18:48
You
ISHRAE
MAKE IN INDIA
Being Personally Driven by PM Shri Narendra Modi
meet.google.com is sharing your screen
Stop sharing
Hide
Devanand Patekar
Mohnish Borker
Aditya Shetti
Brian Soares
Aditya Bhattacharjee
Santosh Tajave
Yash Chopdekar
Emmanuel Lobo
Verian Anthony D'co...

# ISHRAE
# Activities Report
## [2020 – 2021]

❖ **WORLD REFRIGERATION DAY WEBINAR**

*Theme: "Design of heat Exchangers and its applications in corrosive environment"*, Date: 26th June, 2021

On the occasion of World Refrigeration Day, the PCCE student's chapter of ISHRAE organized an informative seminar about Heat Exchangers wherein Mr. Piyush Dhake was the distinguished speaker.

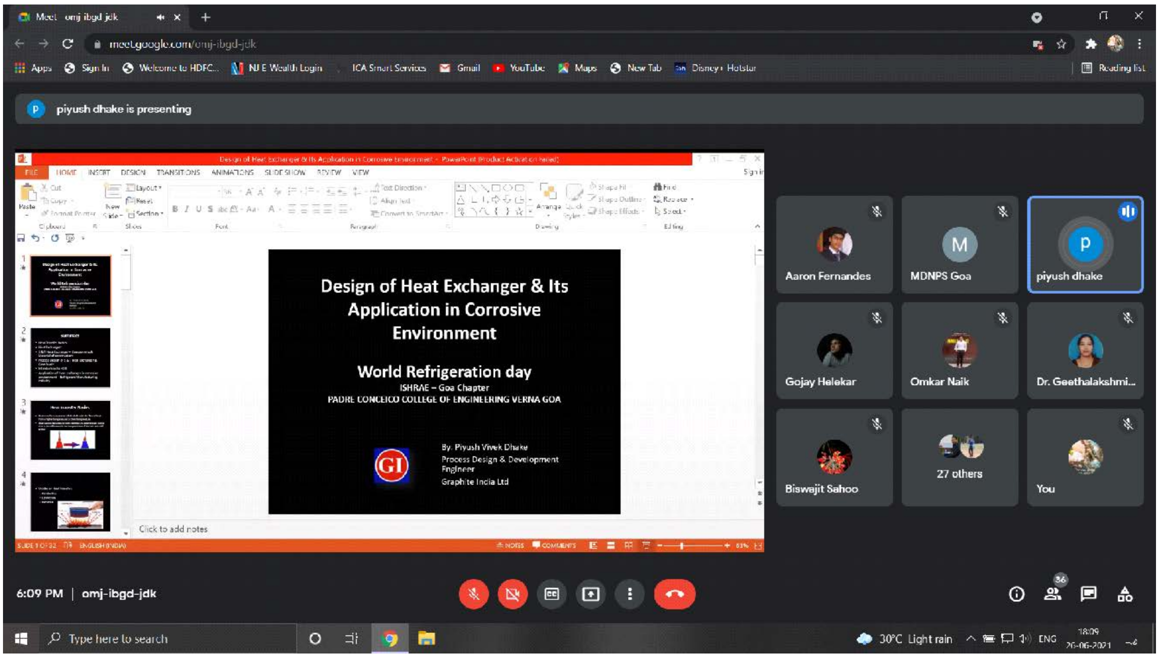



The seminar began with a small introduction by the host for the day, Mr. Aaron Fernandes. It was followed by the national Anthem and a brief introduction to ISHRAE, its presence in Goa and its goals, by Mr Mohnish Borker.

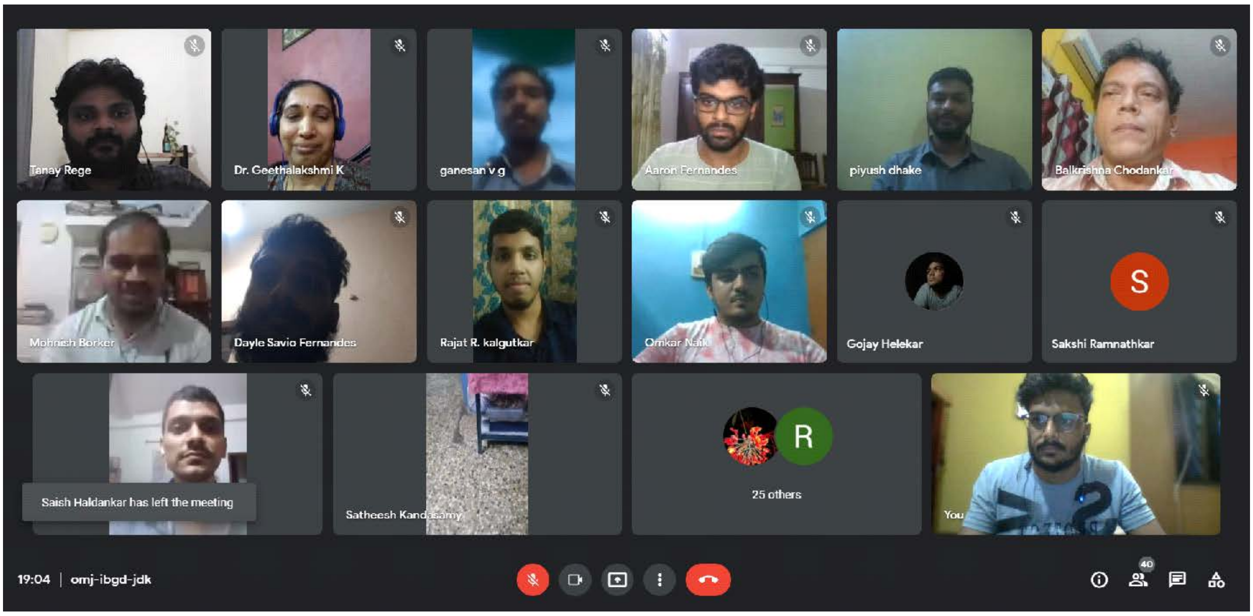
The seminar had the following objectives:

1. Heat Exchanger Basics
2. Heat exchangers
3. S & T Heat Exchangers
4. Process Design of S & T Heat Exchanger and case study
5. Intro to HTRI
6. Applications of corrosive exchangers in corrosive environment

The session was very informative as it started with the basics of heat exchangers and then took charge to explain the design procedure considering the customers' demands. A brief overview about the software used in designing was given by the speaker and the use of graphite was highlighted.



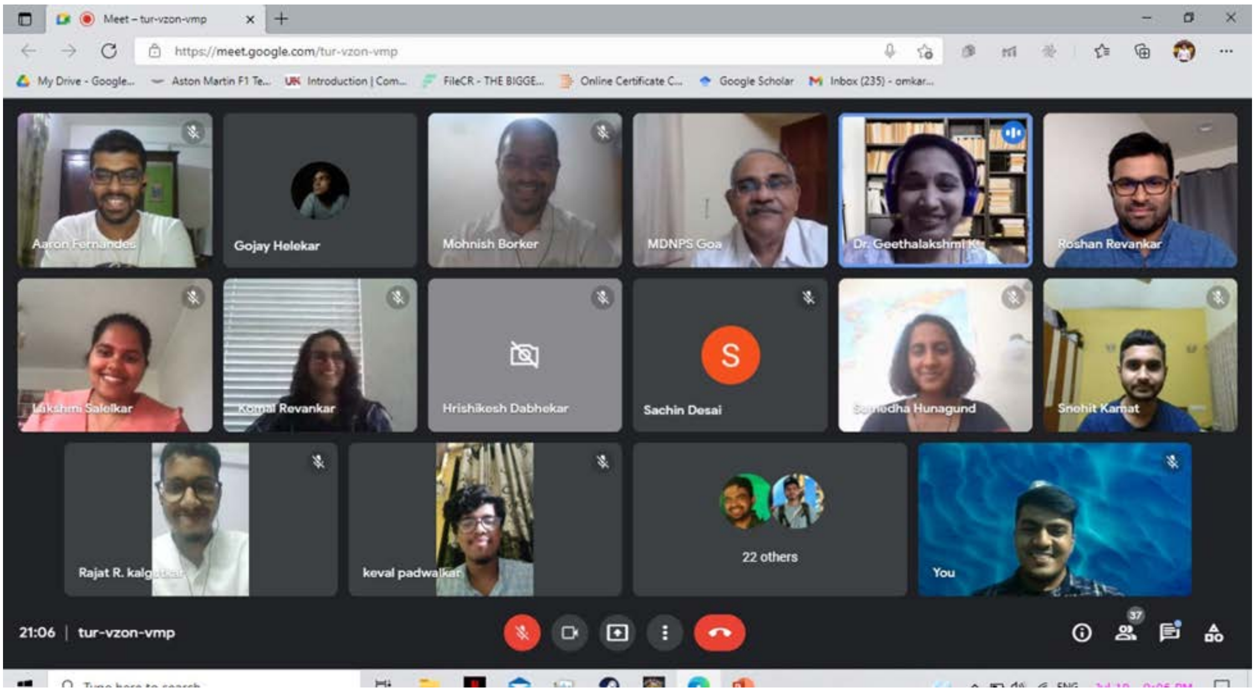

Lastly the speaker discussed about different applications in corrosive environments helping the design of the Heat exchangers. The Rest of the seminar was accommodated with a Q&A session where many informative questions and great answers were exchanged between the students and the speaker. After which all the other guests shared their opinions about the seminar and had some inspiring words to say to the students. The seminar was finally concluded with a Vote of Thanks by Omkar Naik and a group picture taken together.



## ❖ PACERS GAZALI

*“A student’s day program to promote ISHRAE membership”*, Date: 11th July, 2021

Pacers ‘Ghazali’ was an event organized by the student members of the ISHRAE Goa chapter under the supervision of their coordinator Mr. Monish Borker, held on July 10th. The event invited past ISHRAE presidents and student members to speak about their experiences and how ISHRAE has helped them in them in their career. Student members of ISHRAE were treated to the experiences of members all the way to the founding members of the ISHRAE Goa chapter. Past presidents like Roshan Revankar (USA), Sanket Pai (Australia), Komal Revankar (USA), Lakshmi Salelkar (Sweeden), Misburn Fernandes (UK) were amongst the ones joining from outside the country. Notable guest such as Rev. Fr. Agnelo Gomes, president of Goa chapter Prof. Sunil Shetye and founding member Mr. Milind Sardesai, along with many others. Each of them shared their experiences with the student members and the nuances of working with them.




The event started with an introduction from student member followed by the national anthem. Dr. Geetalakshmi then shared a few words with the members and also introduced the new Director Rev. Fr Agnelo Gomes, who also had a few words to say. After a small address by Goa chapter president Sunil Shetye, each past presidents and members of shared their experiences and whatever they had learned being apart of ISHRAE. After which, Student president Omkar Naik presented the various activities conducted over the years. Details for the upcoming event ‘Tapas’ were later discussed by Rajat Kalgutkar. New members were enlightened about the activities and achievements of ISHRAE by Youth chair Snehit Kamat and how it can help them in their career. Finally, founding member Milind Sardessai gave his concluding remarks on the meeting and how great was his experience was with the ISHRAE Goa chapter was so far and ended with a concluding note by Monish Borker.

❖ **TAPAS 2021**

"Annual Technical event with lecture series", *Date*: 16th & 17th July, 2021

The ISHRAE students chapter of PCCE held its annual technical event **TAPAS 2021** this year on 16th and 17th of July 2021. Going by the need for sustainable development and the current energy crisis, TAPAS 2021 was focussed at inculcating the knowledge of Renewable technology among aspiring engineering and diploma students. The theme for this year was **"Renewables: the future energy of India"**. A series of lectures were organised by eminent industry professionals and academia.

**Lecture 1: Solar: A Leader in Sustainable Energy**

**Speakers: Mr Narayan Shanbhag and Mr Sanket Pai Angle**

***Founders, JN Solar Power LLP, Goa***

The first lecture was held during the 'TAPAS 2021 Lecture Series' on 16th July 2021, at 11:00 am and was titled 'Make Hay While The Sun Shines'. With its eminent speakers. At the beginning of the session


Mr Sanket briefed the participants about the basic need of renewable sources of energy in today's world, and what role does solar energy play between them. This was followed by a short presentation on Solar Panel, where he discussed various topics such as Photovoltaic effect, what are the types of Solar Photovoltaic (PV) systems, what are ON & OFF grid solar PV, Hybrid solar PV system.

Later, Mr Narayan Shanbhag presented on solar water heaters and emphasised on the types of collectors. He then discussed the importance of solar power generation in Goa and which areas are more likely to have tremendous benefits from them. And then briefed on their own company and what they had accomplished.

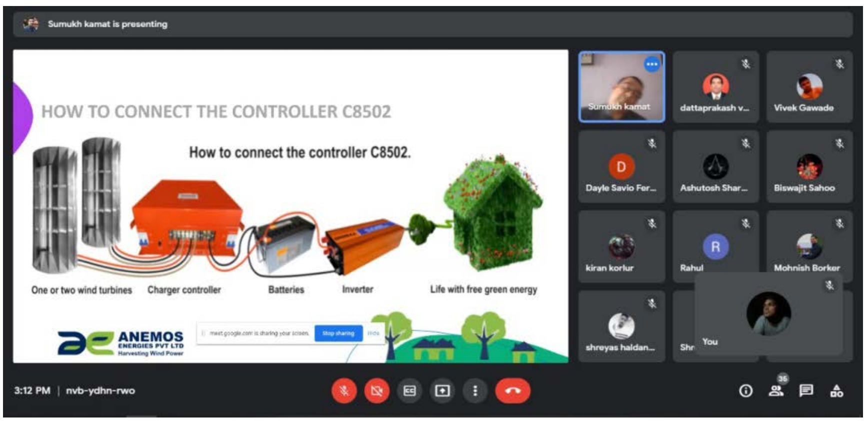
## Lecture 2: Wind Energy Opportunities in India

**Speaker: Mr Sumukh Kamat**

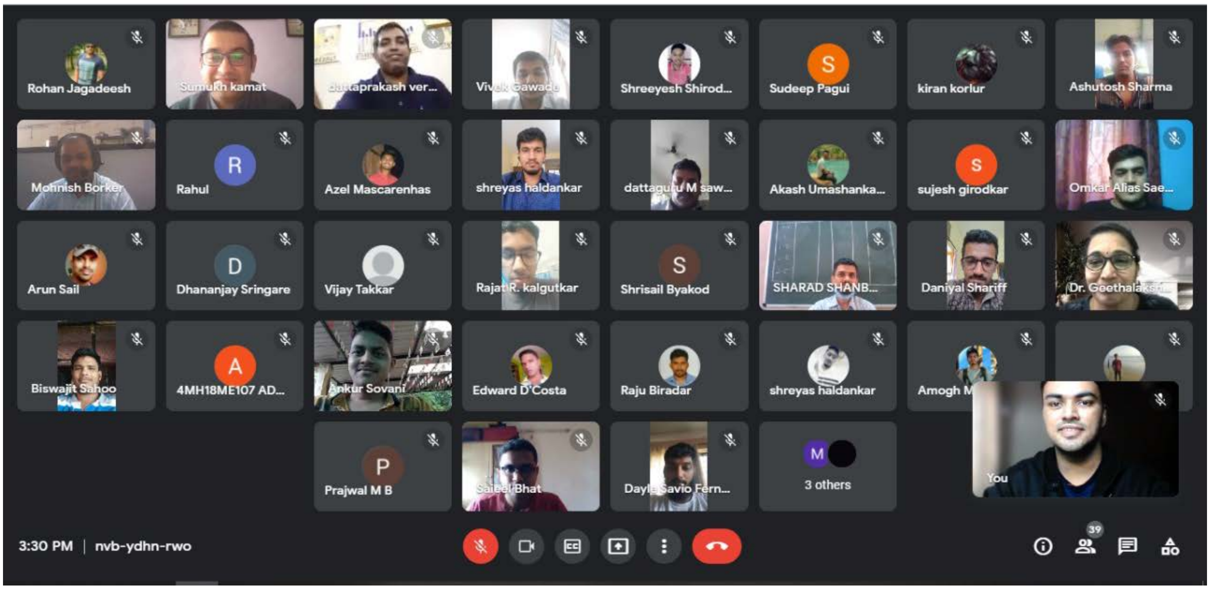
***Vice President—Operations, Anemos Energies Pvt Ltd, Goa***

This session kick started at 2:30 pm on 16th July 2021 by Mr. Sumukh Kamat who has worked in companies like Unilever, Siemens Healtineer etc and also been a General Manager of design and


innovation at Kineco Composite for 17+ years. And currently is a Vice President of Anemos Energies Pvt Ltd. Mr Sumukh Kamat's presentation was focused on Wind Energy Opportunities in India and a glimpse at Vertical Axis Wind Turbine (VAWT). In this topic he discussed on how India is growing towards the production of renewable energy by displaying the statistical data of power production by wind energy in India. He also discussed Horizontal Axis Wind Turbine (HAWT) and Vertical Axis Wind Turbine (VAWT), highlighting their advantages and disadvantages, explaining the one suits best based on the location and climatic condition.



And lastly while ending the presentation he briefed on a major project on VAWT under construction by his company.



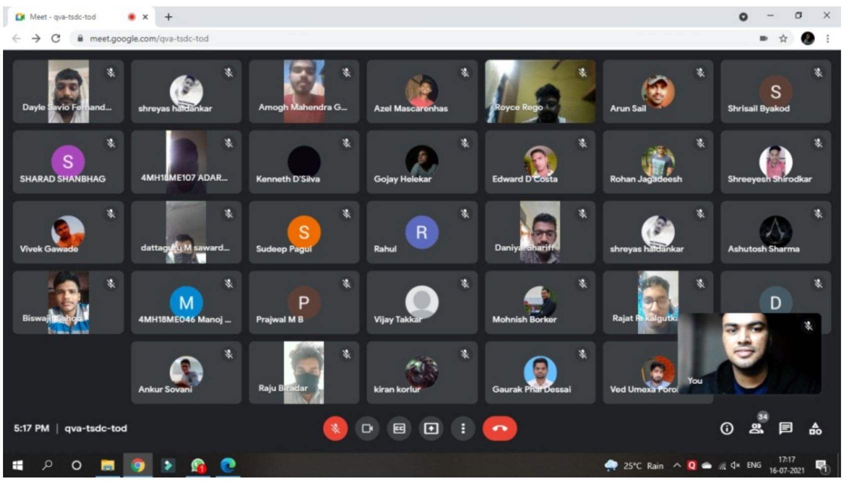

## Lecture 3: Biofuels to Bioenergy

**Speaker: Dr. Luv Kumar Kaushik**

***Post-Doctoral Scholar, IIT Guwahati***

The third lecture was held on 16th July 2021, at 4:30pm. The speaker of the lecture was Dr.Lav Kumar Kaushik. The purpose of "Biofuels to Bioenergy" was to make students aware about the importance of biofuels used as an alternate or supplemental fuels for internal combustion engines.

The seminar started by the speaker, Dr. Lav Kumar Kaushik by talking dynamically about the Bioenergy and how it has been used. In the presentation the major topics covered were; Biomass to Bioenergy, Advantages and Disadvantages of biomass energy, Comparison with Fossil fuels, Bioenergy crops, Agricultural and forestry residues, Direct Combustion, Biological gasification(aerobic and anaerobic digestion), Electricity from Biomass, Energy Return Over Energy Invested(EROEI), Different types of Biofuels and so on. A lot of information was covered while talking about Biofuels and Bioenergy.



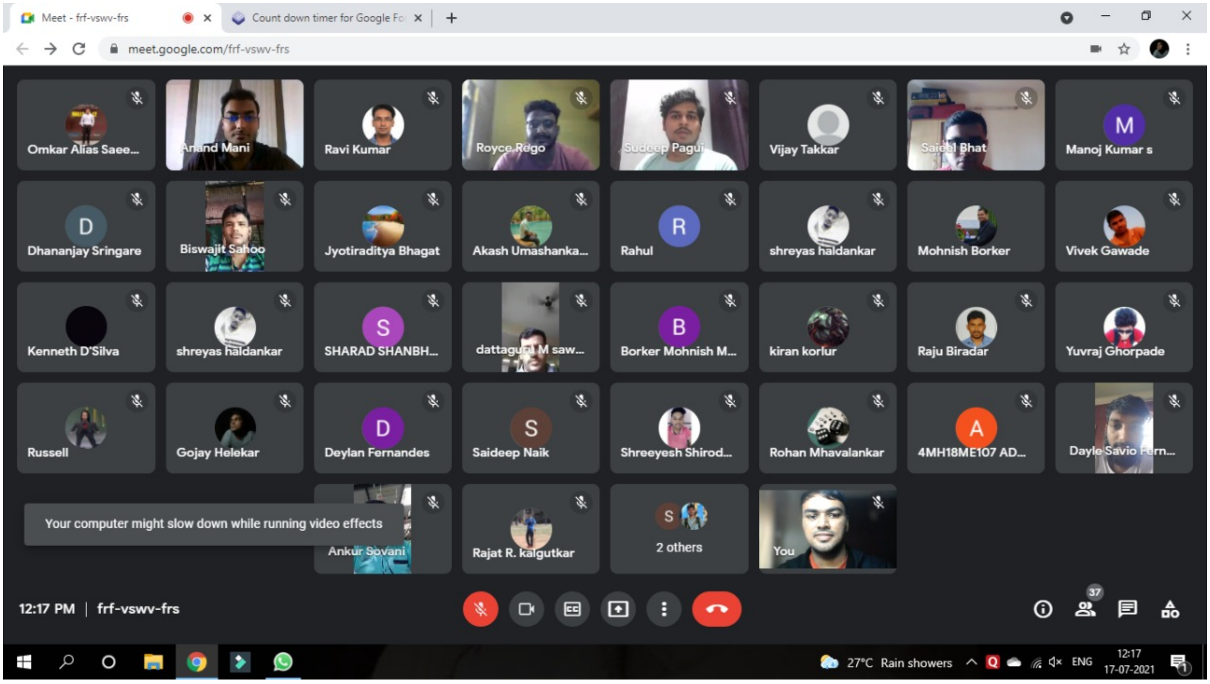
## Lecture 4:  Ocean thermal energy conversion powered desalination plant

**Speaker: Mr. Anand Mani**

***Project scientist, National institute of Ocean Technology, Chennai***

The speaker for the final lecture was Mr. Anand Mani. It was held on 17th July 2021, at 11:00 am with a motive to make students aware about the use of 'ocean thermal energy' as an alternate source of energy for producing electricity instead of using fossil fuels or nuclear energy.

Mr Anand Mani, presently working as a project scientist at National institute of Ocean Technology, Chennai. The speaker started his lecture by explaining the process and functioning of the OTEC power plant, he also presented and explained various cycles. He explained the process of desalination with the help of illustration and spoke about the merits and demerits of OTEC. He stressed that OTEC power plant is beneficial to deal with the low boiling point fluid, which could be dangerous if it escaped into the environment.




Moving on to the criticism he informed that the pressurized chamber needs to have zero leaks in order for the chamber to be able to evaporate the water, so it takes a lot of maintenance. Overall it was an amazing lecture by Mr. Anand Mani wherein he enlightened the young mind with lot of information which they were not aware about.

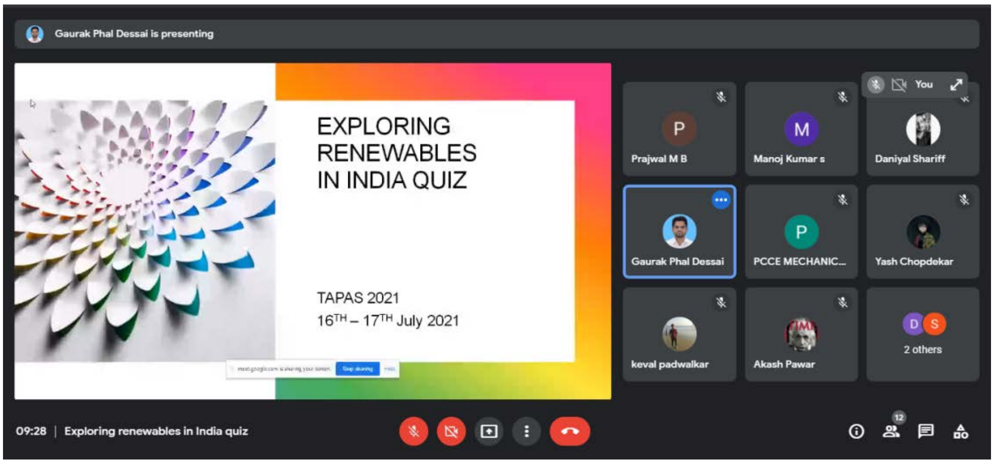
The lecture series concluded with the vote of thanks by Prof. Mohnish Borker. In the end there was assessment quiz related to the individual lecture and was shared with the attendees. There were a number of responses with positive feedback from the participants.

## QUIZ

*Theme: "Exploring Renewables in India"*, Date: 16th & 17th July, 2021

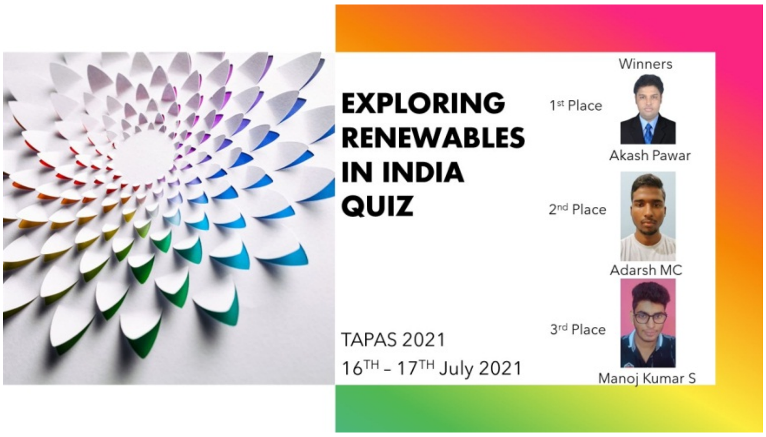
Padre Conceicao College of Engineering (PCCE) in association with ISHRAE hosted a Quiz competition as a part of it's annual event TAPAS 2021 organized by ISHRAE PCCE Student Chapter, on a virtual meeting platform, on 16th and 17th July 2021. Students from all over India participated in this event.

The topic of the quiz was "Exploring Renewables in India". The quiz had tremendous participation of 56 students from engineering colleges from all over the country. Of these participants, 10 qualified the Qualifying round on 16th July 2021, which was held in online mode. The qualifying students battled for glory in the Live rounds on 17th July 2021 which was held on a virtual meeting platform. The live rounds commenced at 09:30 am. The role of the Quizmaster was taken by Professor Gaurak Phaldessai, Assistant Professor at PCCE.




The live round consisted of 3 sub rounds namely MCQ round, Visual round and Rapid-fire round. The motive of this Quiz was to make the students aware of the developments of our country in the field of Renewable Energy.

The 1st place was bagged by Mr. Akash Pawar of Don Bosco College of Engineering, Goa and the 2nd and 3rd places were bagged by Mr. Adarsh MC and Mr. Manoj Kumar S of Maharaja Institute of Technology, Mysore respectively. The Live round concluded with a Vote of Thanks by Faculty Co-ordinator, Professor Mohnish Borker.

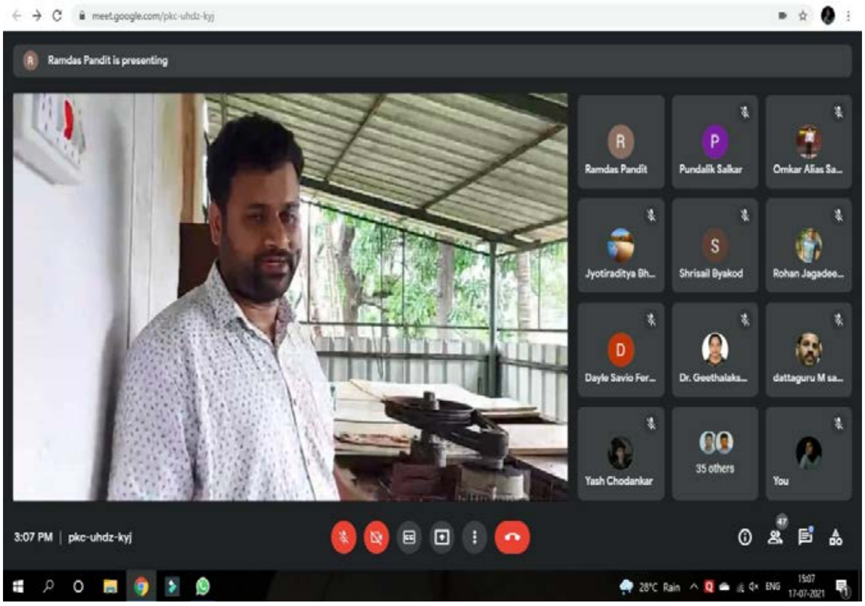


## VIRTUAL VISIT

*Venue: Gajanan Ice Works,* Date: 17th July, 2021

A virtual visit to Gajanan Ice Works Khandepar, Ponda-Goa was conducted on 17th July, 2021, by Mr Ramdas Pandit, Assistant professor at Padre Conceicao College of Engineering Verna-Goa at 2:30 pm.

The virtual meet started with the introduced to the manufacturing process of Ice, its uses and its demand in the market by Mr. Ramdas Pandit. He explained the various parts of machines such as compressor, Condenser, Receiver, Expansion Valve, Evaporator, Refrigeration and Accumulator and Crusher Machine. They produce three types of ice such as Block Ice, Tube Ice, and Flake Ice.




After the presentation Mr. Ramdas gave the students a view of the plant displaying 2 different types of crushers used, the power meter system, the evaporator system with the brine solution and the packaging of the ice in the trays. Business ideas, failure and success strategy was also explained. The Ice plant continuously require electricity and ample of water. Hence, the water flow system was well explained by Mr. Ramdas.

# FACULTY ACHIEVEMENTS
## [2020 – 2021]

- Dr. Joe Kurian Successfully Completed his Phd. on 15th of January '2021 and was conferred with a Doctorate in Organization Behavior by Goa University.

*Journal Publications /Book Chapter*

| Sr.No | Name of the Authors | Title of the Paper | Name of the Journal |
|---|---|---|---|
| 1. | Dr.Mahesh B. Parappagoudar. | Engine Performance and Exhaust Emission of Garcinia Gummi-Gutta based Biodiesel-Diesel-Ethanol Blends | SN Applied Sciences |
| | | Analysis and optimisation of transesterification parameters for high-yield GarciniaGummi-Gutta biodiesel using RSM and TLBO | Australian Journal of Mechanical Engineering |
| 2. | Mr.Gaurak Phaldessai, | Basic Numerical Analysis on the GNVR Shape for an Airship | International Research Journal of Engineering and Technology (IRJET) |
| | | Fabrication and Analysis of cooling jacket incorporated with phase change material | International Journal of Latest Trends in Engineering and Technology |
| 3. | Mr.Flasio Colaco | Design Illustration of a Combat Robot | International Journal of Innovative Research (IJIRSET) |

*Conference Publications*

| | | | |
|---|---|---|---|
| 1 | Mr.Gaurak Phaldessai, | Thermal analysis of solar air heater by using pebbles as an absorber material | National Conference on “Materials, Mechanics and Modelling” (NCMMM2020) on 29 and 30 August 2020 organised by Dept. of Mechanical Engineering, National Institute of Technology, Jamshedpur |
| 2 | Mr. Saeesh Verenkar, Mr.Flasio Colaco | Investigating the impact of Covid-19 Pandemic on online-teaching learning in Goa | World conference on education, education in the 21st century a blended perspective, GVM’s Dada vaidya college, Ponda, Goa |
| 3 | Mr. SaeeshVerenkar, Mr. Pushparaj Pingulkar | Characterisation of Banana/Sisal Fibre reinforced polymer Composite | National E-Conference on “Progresses and Research in Mechanical Engineering (PRIME-2020)”on 31st July, 2020 organized by Department of Mechanical Engineering, SDM College of Engineering & Technology, Dharwad. |

# Participation at Workshops / Seminars & Courses Completed

| SR.NO | NAME OF FACULTY | DATE | FDP / Training Activities / STTPs | ORGANISED BY |
|---|---|---|---|---|
| 1 | Dr. Joe Kurian | June-July 2021 | Introduction to Self-Determination Theory: An approach to motivation, development and wellness | University of Rochester, @ Coursera |
| | | February to March 2021 | Introduction to Psychology | Yale University @coursera |
| | Mr. Joe Kurian | 29.06.2020 to 04.07.2020 | Mentor Training Programme | AICTE, New Delhi |
| | | 03.08.2020 to 07.08.2020 | Training of Trainers | NITTR, Goa |
| 2 | Mr. Saeesh Verenkar | 17th July 2020 | WEBINAR ON New product | HiTECH |
| 3 | Mr. Prasad Pawar | 03.08.2020 to 07.08.2020 | Training of Trainers for teachers educators | NITTR, Goa |
| 4 | Mr. Pushparaj Pingulkar | 27th - 31st July 2020 | FDP on Recent Trends in Industry 4.0 Technologies | Department of Computer Engineering, DBCE, Fatorda, Goa |
| | | 25/01/2021to 6/2/21 | Faculty development program in Entrepreneurship | CIBA-Verna, Department of Science & Technology and Goa State Council for Science and Technology |

| | | | | |
|---|---|---|---|---|
| 5 | Mr. Mohnish Borker | 12th to 16th October 2020 | A Beginner's Perspective on Electric Vehicle | Department of Mechanical Engineering, Pimpri Chinchwad College of Engineering - Pune |
| | | 28th October to 10th November 2020 | Energy Simulation and CFD analysis in buildings | Department of Mechanical Engineering, Easwari Engineering College, Chennai |
| | | 21st to 25th June 2021 | Recent trends in Refrigeration and Air conditioning | Department of Mechanical engineering, ADCET - Ashta |
| | | 5th to 16th July 2021 | Sustainable Energy Systems | Asian Universities Alliance (AUA)/ IITB |
| | | 17th July 2021 | Certificate workshop on Climate action during London Climate Action week 2021<br><br>a)Game theory in climate cooperation<br><br>b)Economics of environmental policy | Envipol, London Climate Action |
| | | 26th to 30th July 2021 | Recent Trends in HVAC&R | Mechanical Engineering Department, Walchand Institute of Technology, Solapur |
| | | 26th July – 6th August 2021 | International (Carbon capture, utilization and storage) CCUS Virtual Course | Institut Teknologi Bandung (ITB) - Indonesia and The IEA Greenhouse Gas R&D Programme (IEAGHG) |

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|---|---|---|---|---|
| | | 7th to 11th December 2021 | Hydrogen, Ethanol and Natural gas as an Alternative and Sustainable Fuel for Transportation | Department of Mechanical Engineering Vishwakarma Institute of Information Technology (VIIT), Pune |
| | | 26th to 30th July 2021 | Recent Trends in HVAC&R | Mechanical Engineering Department, Walchand Institute of Technology, Solapur |
| 6 | Mr. Flasio Colaco | 25th to 27th February 2021 | workshop on Basics of Computational Fluid Dynamics using OpenFOAM | The Teaching Learning Centre, ICT at IIT Bombay |
| | | 21st to 25th September 2020 | Multi-Scale Computational Fluid Dynamics: Fundamentals and Applications | The Department of Mechanical Engineering, Dr. B. R. Ambedkar National Institute of Technology Jalandhar, Punjab |
| | | September to October 2020 | Learning to Teach Online | University of New South Whales, Sydney (Coursera) |
| | | September 2020 | All about Scientific Publishing – Trends, Nuances, Tool, Ethics | Springer Nature |

# FACULTY PROFILE

| | |
|---|---|
| **Dr. Mahesh Parappagoudar** | **Phd – ( IIT – Kharagpur) –** Mechanical Engineering<br>Professor & Principal (Industry Exp.– 2 Years, Teaching Exp.– 27Years)<br>Area of Interest – Manufacturing science, Soft computing |
| **Dr. Joe Kurian** | **Phd – ( Goa University) –** Organization Behavior<br>**M.Tech ( IIT-Madras) –** Maintenance Engg. & Management.<br>Professor ( Industry exp. – 5 Years, Teaching Exp.– 21 Years)<br>Area of Interest – Mechanical vibrations, Industrial automation , Six sigma management |
| **Dr. Geethalaxmi K.** | **Phd (NIT, Surathkal) –** Containerless Extrusion<br>Professor ( Teaching Exp. – 21 Years)<br>Area of Interest – Polymer composites, Nano-structured materials |
| **Prof. Saeesh Verenkar** | **M.Tech (SRM University) –** Computer Aided Design<br>Assistant Professor (Industry Exp - 01 Year, Teaching Exp. – 07 Years)<br>Area of Interest – FEM, Mechanical vibrations, Composites |
| **Prof. Dattaprakash Vernekar** | **M.Tech (V.J.T.I, Mumbai University) –** Automobile Engg.<br>Assistant Professor (Industry Exp - 01 Year, Teaching Exp. – 06 Years)<br>Area of Research – I.C engines, Energy conversion |
| **Prof. Marvin Fernandes** | **M.E (Mumbai University) –** Machine Design<br>Assistant Professor (Industry Exp - 01 Year, Teaching Exp. – 06 Years)<br>Area of Interest – Engg. Mechanics, Hydraulic machinery |
| **Prof. Prasad Pawar** | **M.Tech (M.G.University, Kerala) –** Thermal Power Engg.<br>Assistant Professor (Teaching Exp. – 3.5 Years)<br>Area of Interest – Fluid mechanics, Heat transfer |
| **Prof. Pushparaj Pingulkar** | **M.Tech (N.I.E, VTU) –** Machine Design<br>Assistant Professor (Industry Exp. – 2 Years, Teaching Exp. – 04 Years)<br>Area of Interest – Kinematics, Dynamics of Machinery, FEA |
| **Prof. Mohnish Borker** | **M.Tech (NIT, Calicut) –** Energy Engg. & Management<br>Assistant Professor (Teaching Exp. – 04 Years)<br>Area of Interest –Thermodynamics, Renewable Energy |
| **Prof. Ramdas Pandit** | **M.Tech (VIT, Bangalore)** – CAD-CAM<br>Assistant Professor (Industry Exp. – 04 Years ; Teaching Exp–04 Years)<br>Area of Interest – FEA, Vibrations, SCM |

| | |
|---|---|
| **Prof. Gaurak Phaldessai** | **M.Tech (NIT, Jamshedphur) –** Thermal Engineering<br>Assistant Professor (Industry -01 Year, Teaching – 3.5 Years)<br>Area of Interest –Thermal Engg., CFD, Phase change material, Solar technology |
| **Prof. Flasio Coalco** | **M.Tech** (Manipal University) - Thermal Science and Energy Systems<br>Industry:1 Year 5 Months Teaching:5 Years<br>Areas of Interest: Thermal design, Solar technology, Engine research, LCA, Engineering Graphics. |
| **Prof. Pratik Sawardekar** | **M.E (Goa University) –** Industrial Engineering<br>Assistant Professor (Industry - 02 Years, Teaching – 05 Years)<br>Area of Interest – Multi-Criterion Decision Making, Optimization Techniques |
| **Prof. Pundalik Salkar** | **M.E (Goa University) –** Industrial Engineering<br>**LLM (Goa University) -** Criminal Law<br>Assistant Professor (Teaching - 03 Years)<br>Area of Interest – Machine Design, Manufacturing Technology, Workstation Design. |