This course is for people who are absolute beginners to Robotics and have no idea from where to start and what resources to take for reference. I have made this pdf for you, mostly the freshers in Engineering course. There are no prerequisites and you will be made to start from scratch. Before that we will understand Robotics in better way and then we will head towards the course.

Happy learning!

What is Robotics?

Robotics is a branch of engineering and technology that deals with the design, construction, operation, and application of robots. Robots are machines that can be programmed to perform tasks autonomously or semi-autonomously, typically in situations that are dangerous, repetitive, or tedious for humans. They are built to interact with the physical world and can be equipped with sensors, actuators, and computer systems to perceive their environment, make decisions, and carry out actions.

Robotics encompasses various subfields, including mechanical engineering, electrical engineering, computer science, and artificial intelligence. It combines knowledge from these disciplines to create robots that can perform a wide range of tasks, from industrial automation and manufacturing to healthcare, exploration, entertainment, and more.

Robots can be classified into different types based on their design and functionality, such as industrial robots used in manufacturing processes, humanoid robots that resemble humans in appearance and movement, mobile robots that navigate and operate in various environments, and specialized robots designed for specific tasks like surgical procedures or space exploration.

Advancements in robotics have led to significant technological developments in areas such as automation, artificial intelligence, machine learning, computer vision, and human-robot interaction. As robots become more capable and intelligent, they have the potential to revolutionize industries, improve efficiency, enhance productivity, assist humans in various tasks, and even explore new frontiers that are difficult for humans to reach.

Why is there a need of Robotics

There are several reasons why there is a need for robotics in various fields:

1. *Increased Efficiency*: Robots can perform tasks with high precision, speed, and consistency, which can significantly improve productivity and efficiency in industries such

as manufacturing and assembly lines. They can work non-stop without getting tired or requiring breaks, leading to increased output and reduced production time.

2. *Safety*: Robots can be deployed in hazardous environments where it may be dangerous or impractical for humans to work. For example, they can handle toxic chemicals, operate in extreme temperatures, or work in environments with high radiation levels. By replacing humans in these risky tasks, robotics helps prevent accidents, injuries, and exposure to harmful substances.

3. *Labor Shortages*: Many industries are facing challenges due to a shortage of skilled labor. Robotics can fill this gap by automating tasks that are difficult to staff or require specialized skills. By offloading repetitive or mundane tasks to robots, human workers can focus on more complex and creative aspects of their jobs.

4. *Precision and Quality*: Robots can execute tasks with a high level of precision, leading to improved product quality and consistency. They can perform tasks that require accurate measurements, alignments, or repetitive actions with minimal errors. This is particularly valuable in fields such as electronics manufacturing, where precision is crucial.

5. *Increased Productivity*: Robotics can increase overall productivity by allowing for continuous operation and reducing downtime. Robots can work 24/7, contributing to higher output levels and improved profitability for businesses.

6. *Exploration and Discovery*: Robots play a crucial role in exploring environments that are inaccessible or dangerous for humans. They have been used in space exploration, deep-sea exploration, and disaster response to gather data, perform tasks, and assist in rescue missions.

7. *Assistance and Support*: Robotics has the potential to assist humans in various domains. For example, in healthcare, robots can aid in surgeries, provide support for rehabilitation, or assist the elderly or individuals with disabilities in their daily activities. In education, robots can be used as interactive teaching tools to enhance learning experiences.

8. *Innovation and Advancements*: Robotics drives technological advancements and pushes the boundaries of what is possible. Through research and development in robotics, new technologies and techniques emerge, leading to breakthroughs in areas such as artificial intelligence, machine learning, computer vision, and human-robot interaction.

Overall, robotics offers numerous benefits, from improving efficiency and safety to enabling exploration and innovation. It has the potential to transform industries, enhance human capabilities, and shape the future of technology.

But why should I learn Robotics?

Having this question is totally understandable but, here is the read, Learning robotics can be a rewarding and beneficial endeavor for several reasons:

1. *Future Relevance*: Robotics is an emerging field with vast potential and increasing demand. By learning robotics, you acquire skills that are likely to be in high demand in the future. As automation and robotics continue to advance, there will be a growing need for individuals who can design, program, and maintain robots.

2. *Interdisciplinary Knowledge*: Robotics combines various disciplines such as mechanical engineering, electrical engineering, computer science, and artificial intelligence. By learning robotics, you gain a broad range of knowledge and skills that can be applied in diverse fields. This interdisciplinary approach enhances your problem-solving abilities and opens up opportunities in multiple industries.

3. *Problem-Solving and Creativity*: Robotics involves tackling complex problems and designing innovative solutions. It encourages critical thinking, creativity, and a systematic approach to problem-solving. By working on robotics projects, you develop skills in analyzing challenges, devising strategies, and implementing solutions, which are valuable in many areas of life and work.

4. *Hands-on Learning*: Robotics offers a hands-on learning experience that combines theory with practical application. Building and programming robots provide a tangible way to apply your knowledge and see real-world results. This hands-on approach fosters a deeper understanding of concepts and helps develop technical skills that are highly sought after by employers.

5. *Career Opportunities*: Learning robotics can open up a wide range of career opportunities. Industries such as manufacturing, automation, healthcare, agriculture, aerospace, and entertainment are increasingly utilizing robotics. By gaining expertise in robotics, you position yourself for careers in robot design, robot programming, research and development, automation engineering, and more.

6. *Innovation and Entrepreneurship*: Robotics fuels innovation and entrepreneurship. By understanding robotics, you can identify gaps and opportunities in various industries and develop innovative solutions to address them. This knowledge can empower you to start your own robotics-related ventures or contribute to cutting-edge research and development.

7. *Collaboration and Teamwork*: Robotics often involves working in teams, allowing you to develop collaboration and teamwork skills. Robotics projects require individuals with different expertise to come together and contribute their skills towards a common goal. Learning robotics gives you the opportunity to collaborate with others, exchange ideas, and work collectively to achieve objectives.

8. *Personal Growth and Lifelong Learning*: Learning robotics is not only about acquiring technical skills but also about personal growth. It challenges you to step out of your comfort zone, learn new concepts, and embrace continuous learning. It fosters a mindset of curiosity, adaptability, and resilience, which are essential in an ever-evolving technological landscape.

In summary, learning robotics offers future relevance, interdisciplinary knowledge, problem-solving abilities, hands-on learning, career opportunities, innovation potential, teamwork skills, and personal growth. Whether you are interested in pursuing a career in robotics or simply want to expand your horizons, learning robotics can be a rewarding and valuable endeavor.

Here is a TEDx video for further understanding:

[Maybe The Best Robot Demo Everr](#)

Let us now look at a brief history of robotics with the help of a YouTube video:

[A Brief History of Robotics](#)

Okay but what should I study as a beginner?

In a vast, syllabus to study includes various topics such as sensors, actuators, controller and control systems, electrical and mechanical systems, programming, kinematics and physics, simulation through gazebo or Webots, CAD designing and many things but in short, they can be categorized in three major parts that are:

Electrical and Electronics

Now, If we see, Electrical and Electronics are both vastly big topics on their own but we are not going on it yet. Firstly we should learn the difference between them, what exactly electrical and electronics mean? are they same? or are they different?.

Well, answer to this question is that the term Electrical deals with the flow of electrical power or charge, whereas electronics deals with the flow of electrons. There is only a minute difference between electrical and electronics, and both of them more or less deal with electricity. If there is the involvement of just electricity as energy, then that is called electrical. If there is a clear cut manipulation of electrical energy, then that is called electronics.

Electrical engineering deals with broader categories like signal processing, communication, electronics, electromagnetism, and much more. Electronic engineering is a microdomain that mostly deals with the design, processing and optimization of electronic devices. Now, a question might arise that do I need to learn both Electrical and Electronics both to master Robotics? Well, the answer can be both yes and no depending on far you want to go but since both the subjects are interrelated, the answer is yes almost every time.

Okay, but what should I study to learn Robotics?

There are many things to learn but we will start from the very basics to almost advanced topics. Yes, I have provided the links to courses in the pdf itself.

1. Basic Electronics:

Start by learning about basic electronic components such as resistors, capacitors, diodes, and transistors. Understand how they work and their various applications.

- Let's start from basics of electricity which you can start from this [Youtube video](#)
- Also this [playlist](#) explaining some basic electronics concepts with animations to have a good understanding of the components
- Here's also a [video guide](#) to how to start with electronics

2. Circuit Theory:

Study circuit analysis techniques, including Ohm's Law, Kirchhoff's Laws, and nodal analysis. Learn how to analyze and design basic circuits.

- Before these several laws, first learn about the electrical materials in this [video](#). If you are already aware of topics like magnetism, etc. you can skip this video.
- After this video, we will head to some [electrical tools](#) necessary while working on projects and hardware.
- Now we can move towards Circuit analysis to which, the best resource is Khan Academy's this [playlist](#)

3. Digital Electronics:

Familiarize yourself with digital logic gates, binary arithmetic, and Boolean algebra. Learn about digital circuits, such as multiplexers, decoders, and flip-flops.

- Assuming that you are now good to go with semiconductors and semiconductor devices, you can learn digital electronics concepts with this long [playlist](#)
- Digital Design by Morris Mano is the best to get understanding of the concepts of digital electronics and logic design.

4. Analog Electronics:

Includes, Rectifiers, Clipper circuits, Clamper circuits which are important in circuit designing point of view.

- **You skip the initial part of this [playlist](#) where the concept of Diode and VI characteristics is explained if you are confident that you already hold the conceptual things strongly.**

5. Microcontrollers and Microprocessors:

Gain knowledge about microcontrollers and microprocessors, which are the brains of many robots. Learn how to program them using languages like C or assembly language.

- **The most basic microcontroller that one should have knowledge of is the most famous 8051 Microcontroller and 8085 Microprocessor. Which you can learn from playlist of Bharat Acharya's [Microcontroller](#)and [Microprocessor](#) Although introduction is free but you might have to buy his course if you wish to learn more about these topics.**
- **The next thing you should learn is obviously the most famous open source microcontroller development board [Arduino](#) from this awesome [playlist](#) brought by Paul McWhorter, make sure to check his other playlists most importantly of Raspberry Pi and Robotics.**

4. Sensors and Actuators:

Understand different types of sensors used in robotics, such as proximity sensors, accelerometers, and encoders. Study actuators like motors, servos, and solenoids, which allow robots to move and interact with the environment.

- **Sensors as the name suggest senses various parameters around the environment such as temperature, humidity, etc. and sends the data to the microcontroller. Similarly, when you process the data and want a given task to be performed autonomously, that's where transducers get to work, learn more about them [here](#)**

These were some basic topics that everyone must know and now we will move to some advanced topics that will help you in your journey of learning Robotics

5. Power Electronics:

Learn about power electronics components, including power transistors, thyristors, and power diodes. Understand concepts like power conversion, voltage regulation, and motor control.

- **Power electronics is a branch of engineering that deals with the conversion and control of electrical power, using semiconductor devices like transistors and diodes. It enables efficient manipulation of electric energy for various applications such as motor drives, renewable energy systems, and voltage regulation.**

- Of course it's a long course but it will help you powering your robot and making it more efficient but this playlist is quite promising when you want to a good learning experience.

6. Analog and Digital Signal Processing:

Study the basics of analog and digital signal processing, including filtering, amplification, and modulation techniques. These concepts are essential for processing sensor data and controlling robot behavior.

- Before processing you must learn about signals and systems, and to learn S&S, there is no one else you should go to except Alan V. Oppenheim from this playlist
- Signal Processing is a vast topic, and analog and digital signal processing is a must learn to design various systems, learn this topics from this playlist

7. Control Systems:

Explore control theory and feedback control systems. Learn about PID (Proportional-Integral-Derivative) controllers, state-space representation, and system stability. These concepts are crucial for robot motion and manipulation.

- "Brian Douglas" (Control Systems Lectures): A comprehensive and easy-to-understand series covering various control theory topics has great playlist of videos explaining the topics in control systems.
- You can also prefer this book called "Modern Control Engineering" by Katsuhiko Ogata: widely used and easy to follow for beginners.

8. Communication Protocols:

Understand various communication protocols used in robotics, such as UART, I2C, SPI, and CAN bus. These protocols enable communication between different components in a robot system.

Refer to the playlists below to learn about basics and advanced of communication protocols.

- By Engineering Funda
- By Foolish Engineer
- Bonus topic: CAN Communication by AutosLearn

9. Power Supply and Energy Management:

Learn about power supply design, battery technologies, and energy management systems. Understand how to efficiently manage power resources in a robotic system.

- **Everything you need to know about powering Robots : [Video](#)**
- **Battery basics by [Robert Cowan](#)**
- **Power for you electronics and robotics projects: [Voltage Regulators and Converter](#)**

Apart from these topics you can learn ROS, Gazebo, MATLAB, Proteus, and many more software for excelling Robotics. Following topics you might know but still are regarded as very important when working specifically with electronics:

- [**How to use a Multimeter**](#)
- [**USB Ports, Cables, Types, & Connectors**](#)
- **Difference between wires and cables, types of wires and cables**
- **Soldering skills**

Remember, robotics is an interdisciplinary field, so it's also beneficial to study mechanical engineering concepts, kinematics, control algorithms, and computer programming. A strong foundation in electrical and electronic topics will help you better understand the inner workings of robots and enable you to design and build your own robotic systems.

Mechanical and Designing

Mechanics is vital in robotics as it provides the physical embodiment, movement, stability, and precision needed for robots to perform tasks. It influences energy efficiency, payload capacity, and safety, while enabling adaptability and integration with other disciplines. Essentially, mechanics forms the foundation on which robotic systems are built, ensuring their effectiveness and practical application in real-world scenarios.

You can start from various topics given below:

1. Kinematics:

Study of motion and positions of robot components, including joints and end-effectors, without considering forces or torques. It is the most basic thing you should be knowing before getting started into actual robotics. You might have learn this in High School but even if you haven't or wanna brush up the knowledge, you can learn it from this [playlist](#) by MIT

2. Dynamics:

Examination of forces, torques, and their effects on robot motion, essential for designing control systems. Before getting into dynamics, one should have hands on experience to use basic [measurement tools](#) which you can learn from here. Learn the basic and advanced of [Dynamics](#)

3. Mechanisms:

Learning about various types of robot mechanisms, such as parallel, serial, or articulated systems.

Mechanism are better to be generated from what you see around yourselves in machinery rather than some courses but you can go for these playlist from [NPTEL](#) or some examples from [Mohammed Sami](#) and some [basic mechanic principle](#) also explained in this [video](#)

4. Robot Design:

Acquiring skills in designing and analyzing robot structures for optimal performance and stability. Designing is an important aspect in Robotics, it helps you in deciding the perfect size, materials and mechanisms for you robot before actually manufacturing it. You can do it using various software like [AutoCAD](#), [AutoDesk Inventor](#), [SolidWorks](#) and many more.

5. End-effectors and Grippers:

Exploring different types of end-effectors and grippers for manipulation tasks.

End effectors and grippers are crucial components in robotics, as they serve as the "hands" of a robot, enabling it to interact with the environment and manipulate objects. Their importance lies in the following aspects:

1. *Object Manipulation*: End effectors and grippers allow robots to pick up, hold, move, and release objects with precision. This capability is vital for various applications, such as manufacturing, logistics, agriculture, and medical robotics.
2. *Versatility*: Different end effectors and gripper designs cater to specific tasks. By choosing the appropriate tool, a robot can perform a wide range of operations, from delicate handling of fragile objects to heavy-duty tasks.
3. *Automation*: End effectors and grippers enable robots to perform tasks autonomously, reducing the need for human intervention and enhancing efficiency in industrial processes.
4. *Adaptability*: Modular end effector designs and interchangeable grippers enable robots to switch between different tasks or handle various objects, making them

more adaptable to dynamic work environments.

5. *Precision and Safety*: Well-designed end effectors and grippers ensure accurate manipulation of objects, reducing the risk of damage and enhancing safety in human-robot collaborative settings.

- **Apart from this, you should be knowing different types of metals for chassis, [Gears](#), [Bearings](#), [Types of Motors](#), [Basics of Pneumatics](#) etc.**

Programming

Programming plays a crucial role in robotics, providing instructions for control, behavior, and task execution. It empowers robots to sense and perceive their environment, adapt, and learn autonomously, enhancing their performance over time. Through programming, robots can achieve autonomy and automation, making decisions and responding to changing conditions without constant human intervention. Safety and ethical considerations are also integrated into the programming process to ensure safe interactions with humans and the environment. Interdisciplinary collaboration fosters innovation, enabling real-world applications in diverse fields such as manufacturing, healthcare, agriculture, exploration, and disaster response. Programming is the fundamental bridge between physical hardware and intelligent functionality in robots, driving their practical use and advancement in today's world.

1. Arduino

This is not just about Arduino but all development boards, microcontroller or microprocessors. For robotics, you should be having a good catch on programming these board.

- **You can learn it again from famous YouTubes Paul McWhorter's [Arduino](#) series.**
- **Similarly you can learn [Raspberry-Pi](#), [STM32](#), [ESP32](#), etc.**

2. Programming Languages

Start by learning programming languages commonly used in robotics, such as Python, C/C++, and ROS (Robot Operating System) for more advanced applications.

- **Learn C from [Code With Harry](#) or [FreeCodeCamp](#)**
- **Learn C++ from [Code With Harry](#) or [FreeCodeCamp](#)**
- **Python course from [Mosh Hamdani](#)**

3. Robotics Frameworks and Libraries

Familiarize yourself with robotics frameworks and libraries like ROS, OpenCV (for computer vision), and Tensor Flow (for machine learning) to accelerate robot development.

- **Learn ROS from this amazing course by [The Construct](#)**
- **OpenCV from this playlist by [Tech with Tim](#)**
- **Machine Learning by [FreeCodeCamp](#)**
- **TensorFlow by [FreeCodeCamp](#)**

4. Sensor Integration

Learn to work with various sensors, such as cameras, ultrasonic sensors, LIDAR, and encoders, to perceive the robot's surroundings.

- **You can explore various YouTube channels, Discourse, and Subreddits but most preferably, reading datasheets help a lot to learn sensor integration with Arduino, Rpi, etc.**

5. Robot Localization and Mapping

Learn techniques for robot localization (knowing its position) and mapping the environment it operates in.

Learn Robotics localization and mapping from MATLAB Robotics tutorials on [Youtube](#) or their blogs.

6. Simulators

Work with robot simulators like Gazebo or MATLAB to test and validate your code in a virtual environment before deploying on real robots.

- **Gazebo Sim tutorials for [Gazebo](#)**
- **MATLAB On-ramp courses by [Mathworks Academy](#)**