



# ROS FOR ROBOT ARM SPECIALIZATION

*ONLINE COURSE - ILT*

Develop a deep understanding of ROS & acquire the skillset to support you in a building and manipulating a whole system for a robot arm.

71 hours of ILT - sessions

18 hours of TA - sessions

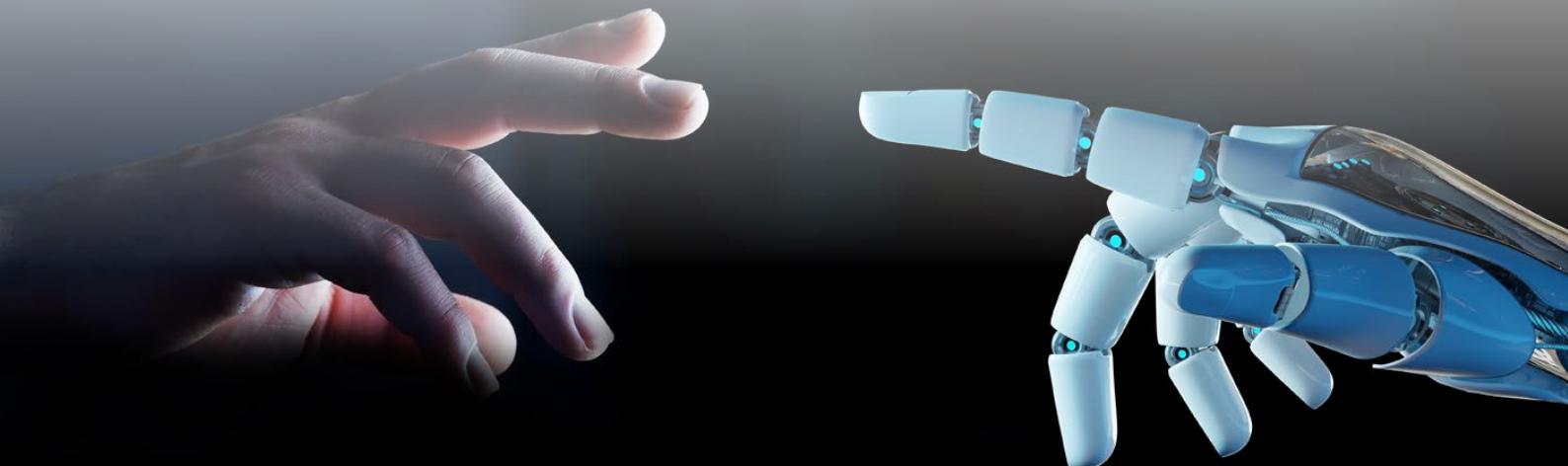
24 hours of self-paced

FREE access to DataCamp courses

*GET IN TOUCH*

# OVERVIEW

Widespread Robo-tech development across the world calls for professionals who are well-prepared and qualified in using ROS to navigate all of the complexities of the Robotics industry. Phi Science in collaboration with top-notched experts and academics brings you the most trendy and commonly used software as well as frameworks that penetrate this industry nowadays and future. Speaking of the fast growth in the robotics market, ROS becomes a standard that any robotic and embedded systems engineer must learn. Therefore, throughout your 18 week learning journey, you'll explore this industry, and consider its impact on the (industrial robotics, and automation) applications, operations, stakeholders, and teams' synergies. As the content and deliverables of this specialization are rooted in problem-based learning, in which you'll be exposed to real-world obstacles during your live, and mentor-led classes will support you in learning by practicing to gain the key skills and a pragmatic experience by engaging in actual use cases, hands-on tasks, and your capstone project.



## Graduates of this specialization will be able to walk away with:

- Hands-on experience in ROS
- Understanding of Mathematical concepts which being utilized for robotics in terms of positioning and the geometric equations.
- Understanding of motion planning and trajectory generation.
- Testing in real-time systems.
- Understanding of sensing and perception.
- Knowing how to integrate a simple Robot decision-making algorithm



# CAREER OUTLOOK & JOB MARKET

Communication isn't just a key for humans! It's vital to speak the same language between human and machine, robot and machine control. This is the key role of ROS!

ROS is meant to be an operating system for robots. In the same way as operating systems for PCs, servers, or standalone devices, ROS is a full OS for service robotics.

## Why ROS?

### 1- one of the top-ranked in Robot software companies

According to a survey study was conducted by StartUS, the selection was made from databases of 181 robotics software companies, ROS was ranked among the top 5 most common software and the first popular OS in middleware. ROS is known for its utility in building a whole robotic system with multiple components or looking to coordinate multiple robots.



55% of the world's robot companies will be including a ROS package **by 2024**



+2500 systems are operated by ROS (ResearchGate)



+9M ROS package are being downloaded on **monthly basis** (ResearchGate)

### 2-Well-controlled environments

Major automation industries are heading to use ROS in their manufactories, such a case: the auto-guided vehicles (AVGs) to avoid the unexpected risks might happen. Hence, they might need to develop their customized ROS package, and since ROS is an open resource it gives users full access to the source code. Therefore, developers not only have access to the code, but they can also edit it within the licensing agreement.

#### Top companies use ROS (Designnews)



Locus robotics



TurtleBot



Universal robots



Yaskawa Motoman

### 3-Saving time and budget

ROS brings the sense of optimism everywhere. Systems that were still prohibitively expensive just 10 years ago can today be bought online much more cheaply because of the ROS community as well as its standardized software interfaces.

**Roboticians with ROS proficiency earn an average total compensation according to their years of experience (PayScale):**



## Challenges beginners might face in their baby steps with ROS

### 2.1 Knowledgeable with programming

Learning ROS is challenging. To understand OS you have to realize the concepts of what operating system does, how it works, and how applications use OS to provide the target services. This clearly requires you to put a good effort into learning C++, python, Ubuntu, and some further commands.

### 2.2 Have good mathematical skills

To be able to use ROS you must have a good understanding of mathematics, linear algebra, and calculus. Since using it in almost cases, mainly in MoveIt for path planning.

### 2.3 Technical problems while setting up the platform on the computer

## How does Phi support your learning journey and help you break down these obstacles?

Well, to maximize your learning outcomes you firstly have to start enhancing your skills in programming as well as linear algebra in mathematics. This is why we designed this specialization to build the initially required skills to easily learn ROS. Even though, usually, students who come from engineering backgrounds, as well as the information technologies, are the most expected to pass this course successfully and take 4 months to come up with actual results.

Gaining hands-on learning is the best way to develop your practical skills in ROS. Also, you will be exposed to a problem-solving learning approach to have a comprehensive learning experience. By the end of this specialization, you will come out with a full project portfolio that supports your next steps in applying for entry-level careers which ask for ROS proficiency.

# SYLLABUS

Build and refine your knowledge of ROS fundamentals and practices as you work through the weekly modules of this online specialization.

## PHASE I: INITIAL COURSES

28 CREDITS

### COURSE 1: PROGRAMMING FOR ROBOTICS - PREREQUISITE COURSE

11 HRS - ILT

Gain the prerequisite skillset in Python, C++ and Linux commands. You will have free access to the DataCamp platform to advance your self-paced learning as well as to attend a live-tutoring session with your instructor.

#### OUTCOMES:

- Coding in a neat way.
- Solving robot positioning problems using coding.

#### SCHEDULE:



**Lecturing days:** lectures are supposed to be conducted on **Wednesday** on weekly basis **over the month**.



**Lecturing times:** teaching hours will be conducted afternoon - due to the difference between time zones, in the period of **4:00 Pm - 9:00 Pm (KSA)** on a time average of **2 -3h per session**.

#### WEEK 1

3 HRS - ILT

#### The Python language essentials and simple codes in python

- DataCamp Content
- Week 1 hands-on assignment

#### WEEK 2

2 HRS - ILT

#### C++ compiler & simple codes in C++

- DataCamp Content
- Week 1 hands-on assignment

#### WEEK 3

2 HRS - ILT

#### Examples on 2D coordinates

- DataCamp Content
- Week 1 hands-on assignment

#### WEEK 4

2 HRS - ILT

#### Examples on 3D coordinates

- DataCamp Content
- Week 1 hands-on assignment

#### WEEK 5

2 HRS - ILT

#### Recap

- DataCamp Content

### COURSE 2: MATHEMATICS FOR ROBOTICS - PREREQUISITE COURSE

9 HRS - ILT

Understanding basics of linear algebra. This course will be covering the topics of multiplication of Points 2D/3D, vectors, and matrices, homogeneous coordinates, formulating with respect to problems.

#### OUTCOMES:

- Understanding 2D/3D geometry equations.
- Describing position/orientation in 2D/3D with respect to another defined position.

## SCHEDULE:



**Lecturing days:** lectures are supposed to be conducted on **Saturday** on weekly basis over the month.



**Lecturing times:** teaching hours will be conducted in the mornings - due to the difference between time zones, in the period of **10:00 Am - 2:00 Pm (KSA)** on a time average of **2 -3h per session**.

### WEEK 1

3 HRS - ILT

Points as a vector in 2D /3D space

- Weekly Assignment:
- Self-Paced Content

### WEEK 2

2 HRS - ILT

Matrices multiplication

- Weekly Assignment:
- Self-Paced Content

### WEEK 3

2 HRS - ILT

Other ways of presenting points in space

- Weekly Assignment:
- Self-Paced Content

### WEEK 4

2 HRS - ILT

Recap

- Self-Paced Content

## PHASE II: CORE COURSES

**70 CREDITS**

### COURSE 1: ROS ESSENTIALS

21 HRS - ILT

This course will let you know and absorb key concepts of ROS. Throughout this month, you will get a total understanding of ROS basics theoretically and practically.

## OUTCOMES:

- Students will be able to create a ROS environment.
- Create new packages.
- Run examples from tutorials.
- Use debugging commands.



**Lecturing days:** lectures are supposed to be conducted on **Saturday and Wednesday** on weekly basis throughout the month.

## SCHEDULE:



**Lecturing times:** teaching hours will be conducted in the mornings - due to the difference between time zones, in the period of **10:00 Am - 2:00 Pm (KSA)** on a time average of **4h per Saturday's session, 4:00 Pm - 8:00 Pm (KSA)** on a time average of **1-2 h per Wednesday's session**.

### WEEK 1

4HRS - ILT

What is ROS /ROS in industry / Alternatives  
Setting up environment

- Weekly Recap Session
- Weekly Assignment
- Self-Paced Content

### WEEK 2

4HRS - ILT

ROS package  
ROS Topics

- Weekly Recap Session
- Weekly Assignment
- Self-Paced Content

### WEEK 3

4HRS - ILT

ROS Services  
ROS Messages  
Rviz (Simulator)

- Weekly Recap Session
- Weekly Assignment
- Self-Paced Content

### WEEK 4

4HRS - ILT

URDF, Xacro  
Gazebo (Simulator)  
Examples  
Preparing codes from phase 1 to be used with ROS

- Self-Paced Content

## COURSE 2: FWD/INV KINEMATICS

16 HRS - ILT

This course will let you know and absorb key practices on Kinematics in Gazebo.

### OUTCOMES:

- Students will be able to simulate (2 - 6)DOF robots.
- To insert a 3D model of a new robot in Simulation.
- To Use the simulator to imagine the working space.
- To Calculate Inv kinematics.



**Lecturing days:** lectures are supposed to be conducted on **Saturday and Wednesday** on weekly basis throughout the month

### SCHEDULE:



**Lecturing times:** teaching hours will be conducted in the mornings - due to the difference between time zones, in the period of **10:00 Am - 2:00 Pm (KSA)** on a time average of **4h per Saturday's session, 4:00 Pm - 8:00 Pm (KSA)** on a time average of **1-2h per Wednesday's session.**

#### WEEK 1

4HRS - ILT

##### Simulating 2 DOF Robot in rviz

- Weekly Recap Session
- Weekly Assignment
- Self-Paced Content

#### WEEK 2

4HRS - ILT

##### Simulating 3 DOF Robot in rviz

- Weekly Recap Session
- Weekly Assignment
- Self-Paced Content

#### WEEK 3

4HRS - ILT

##### Simulating industrial Robots Introduction to Moveit

- Weekly Recap Session
- Self-Paced Content

## COURSE 3: PATH PLANNING

22 HRS - ILT

Throughout this course, you will understand the problem of path planning and approaches to solve it as well as optimization in path planning.

### OUTCOMES:

- By the end of this phase students will be able to program an Arm robot to hold and move objects to a useful task and to plan its path using different planning algorithms.



**Lecturing days:** lectures are supposed to be conducted on **Saturday and Wednesday** on weekly basis throughout the month.

### SCHEDULE:



**Lecturing times:** teaching hours will be conducted in the mornings - due to the difference between time zones, in the period of **10:00 Am - 2:00 Pm (KSA)** on a time average of **4h per Saturday's session, 4:00 Pm - 8:00 Pm (KSA)** on a time average of **1-2h per Wednesday's session.**

#### WEEK 1

4HRS - ILT

##### Why Moveit ? Simple Move in Move it

- Weekly Recap Session
- Weekly Assignment
- Self-Paced Content

#### WEEK 2

4HRS - ILT

##### Gazebo and Moveit Simple gripping example

- Weekly Recap Session
- Weekly Assignment
- Self-Paced Content

#### WEEK 3

4HRS - ILT

##### Pick and place Difference between paths

- Weekly Recap Session
- Self-Paced Content

#### WEEK 4

4HRS - ILT

##### Optimized Path Differences between ROS1 and ROS2.

- Weekly Recap Session
- Self-Paced Content

## BUILD A REAL-WORLD PROJECT

10 HRS - ILT

Learn and apply! As a complementary part of this specialization, and under the supervision of your instructor, you have to finish building a real-world project to get graduated. In order to leverage the theoretical and practical knowledge, you gain from the courses, you have to reach and pass the last milestone of this specialization which is the graduate project. In which, you will be using Python, C++, and ROS to finalize a simulation for the prototype.

### OUTCOMES:

- Hands-on experience on a robot arm that does a useful task in reality.

### WEEK 8

- Team formation and project selection

### WEEK 9

- Literature review

### WEEK 15,14,13,12

- Design and implementation

### WEEK 16,17

- Documentation
- Presentation & Graduation Day

### TOPICS:

- A Robotic arm moves a cube from A to B
- A Robotic arm organize cubes in a box
- A Robotic arm tries to throw a cube in a bin.

# PROGRAM REWARDS



## Mentorship session

Graduates who successfully did it to the finish line will have the opportunity to attend Peer-to-Peer sessions, to get career advice based on their progress and evaluation along with the specialization. Besides all that, they will be supported in building their LinkedIn profiles to appear with a professional look. Moreover, they might get endorsed to pursue a certain position in the field. Your instructors will be also part of your connections network, this will let you build great potential & bring you superior opportunities.



## Well recognized portfolio

You will prepare a portfolio that will give you the opportunity to show your potential employers what you can actually do. In this portfolio, you can include the final project that you have worked on during the cohort.



## Your Certificates

- **Certificate of Completion**

Earn your completion certificate, and get your recognition of your newly developed skills. Assessment is continuous and based on a series of practical evaluations completed online on Phi's LMS & completed a comprehensive application of a real-world project. In order to be issued with a Phi certificate of completion, you'll need to meet the requirements outlined in this course guide brochure. The brochure will be made available to you as soon as you begin the course.

Your certificate will be issued in your legal name and sent to you upon successful completion of the course, as per the stipulated requirements.

- **Certificate of Recognition**

To get an honorable mention on a certificate, you should come up with a total grade in both the project and practical evaluation that exceed %85.

- **Recommendation Letter**

You can earn such a letter signed by your instructor once complete your final project.

# JOIN & LEARN WITH THE BEST



PROGRAM LEAD AND ADVISOR

## Anis Koubaa

DIRECTOR OF THE RESEARCH AND INITIATIVES CENTER AT PRINCE SULTAN UNIVERSITY,  
FULL PROFESSOR | DRONE EXPERT | CLOUD ROBOTICS | ARTIFICIAL INTELLIGENCE

Anis koubaa is a professor in computer science, and leader of the robotics and iot research lab, at prince sultan university. He is also an r&d consultant at gaitech robotics in china and a senior researcher at cister/inesc tec and isep-ipp, porto, portugal. He is also the author of six books with springer on robots, sensor networks, and robot operating systems (ros). Anis is also nominated in the carrier-based top %2 scientists list made by stanford university



INSTRUCTOR

## Amr Halawa

SPACEPLANE R&D ENGINEER | PH.D. | AEROSPACE ENGINEERING

Amr is currently working as a research & development engineer on a spaceplane development project at PD Aerospace in Japan. Amr holds a Ph.D. in Aerospace & Wind Energy from Kyushu University, Japan, and has over 10 years of work experience in both academia and industry in applied aerodynamics and CFD as well as a strong knowledge of various engineering tools and programming languages.



INSTRUCTOR

## Nuri Benbarka

COMPUTER VISION AND MACHINE LEARNING RESEARCHER  
PH.D. CANDIDATE, UNIVERSITY OF TÜBINGEN-WÜRTTEMBERG

Nuri is a final-year Ph.D. student in computer vision and mobile robotics. During his study he published papers in high-ranked conferences like IROS and WACV, also won the NuScenes object tracking challenge of 2021.

Nuri was a lecturer at the University of Tripoli in which he taught robotics and programming courses.



INSTRUCTOR

## Ayham Alharbat

ROBOTICS RESEARCHER - SAXION UNIVERSITY OF APPLIED SCIENCES

Ayham is currently working as a researcher and lecturer in the Mechatronics Research Group at Saxion University of Applied Sciences - the Netherlands. His areas of expertise are Dynamic Systems Modeling, Simulation, Predictive Control, Physical Interaction Control, Aerial Robotics, and Embedded Control Systems.



INSTRUCTOR

## Mohammad Shannak

EMBEDDED SYSTEMS | UNIVERSITY OF FREIBURG - GERMANY

Mohammad Shannak is a robotics engineer. He's currently doing his master's in Embedded Systems at the University of Freiburg, Germany. He works at the Hahn Schickard Research Institute in the automation field, and he's a researcher at the university's robotics laboratory in the field of self-driving cars.

# FREQUENTLY ASKED QUESTIONS

## 1- What is ROS?

ROS is considered to be an open resource platform intended to help researchers, developers & roboticists build and re-use code between multi-robotics applications.

It can be used not only in the laboratory but in the commercial and services industries

Robot Operating systems, which is a standard for robotics software development, can be used on any robot. Whatever is the programming for mobile robots, robotic arms, drones, boats, machines, all can be on ROS. Every time you start a new application, it becomes easier, and then you don't need to re-learn it. You can also easily switch to an existing ROS project developed by another hand and not be lost.

## 2-Should I learn ROS?

Yes, you should do that! Basically, if you're striving to get involved in the design, manufacturing, and Robot-tech market, you should be knowledgeable with the market advances and latest trends since ROS is becoming an essential component not only a trend, the growing need for robotics engineer who has the skills in using ROS should lead you to learn it. Well, as many ROS learners said, the learning curve to pick up robotics from scratch is far steeper, in other words, by learning ROS you're advancing your career and adding significant value to the industry by speeding up development on the future projects that wouldn't be delivered on time without ROS.

## 3-Who use ROS?

ROS is being adopted into some of the key players in the robotics market like fetch and ABB. The majority of enterprises are either using it as it can be accessible by anyone or a fork of ROS in some form. Till the moment, use-cases are still growing tremendously!

ROS is used across numerous industries from agriculture to medical devices, now it's spreading to include all kinds of automation and software-defined dynamic use-cases. In the GCC, many Startups and companies are launching that use ROS as a key tool in their frameworks.

#### **4-Who is this course suitable for?**

Learning ROS is not that easy, yet it's doable. You can do it by self-paced learning, there's a huge amount of tutorials and videos available on search engines. Meanwhile, it might take a long time to achieve the desired outcomes yet no practical experience might be done nor a mentor tracking. This course will help you achieve your goals if you're having a basis in engineering or computer science. You're expected to have at least the basic knowledge of mathematics and mainly in programming. Need help to determine whether this course is right for you? Contact us.

#### **5-How many hours should I expect to spend on self-studying and following up?**

10h - 12h the expected number of hours that normal students might spend in their self-learning and studying as well as doing their weekly assignment.

#### **6-Can I skip a certain course?**

Not exactly, you can only waive courses in the initial phase (prerequisites kit). We recommend you to apply and join these foundational courses, to learn basic components before digging deep into the advanced level since the whole curriculum is designed following the synoptic methodology. You can waive these courses upon your responsibility if your submitted documents met our criteria.

#### **7-Is this program accredited?**

This specialization program is non-academia-recognized. Our Bioinformatics professional training kit is designed and developed in collaboration with the industrial leads in the field, learning outcomes and the curriculum are articulated to meet market-based and in-demand skillset in such vacancies globally and regionally. Once completed the program, you will be qualified to apply for entry-level jobs in the field.

#### **8-Does Phi Science offer financial aid or discounts?**

As part of paying back to our society, Phi is glad to provide up to 2 full scholarships for any of its specializations. Please submit your application form. Moreover, you can get your early-bird registration discount when enrolling in any of the announced programs 2 weeks at least before the kick-off day.



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