School of Informatics Course Proposal Form (version: May 2021)

Please see Page 2 for instructions on which parts of this form to complete, whom to consult with to avoid unnecessary effort, and where to send the completed form.

Proposer(s): Chris Lu, Mohsen Khadem & Barbara Webb **Date: 20/10/2021**

Cover page: Basic permanent course information

Unless otherwise noted, items in this section are entered into EUCLID and **cannot** be changed without creating an entirely new course.

Course Name	Introduction to Mobile Robotics
Is this an EPCC course?	_X_ No (default) *(If you don't know what EPCC is, this is the right choice.)* __ Yes *(If so, leave Course Acronym blank, to be filled in by ITO as EPCC/<number> for Theon and our Sortable List.)*
Course Acronym *(used only School-internally)*	MOB
SCQF Credit Level and Normal Year Taken	**Standard options for Informatics courses:** __ Level 8/Year 1 __ Level 8/Year 2 _X_ Level 10/Year 3 (also available in Year 4). *[In practice, most level 10 courses have many students in both UG3 and UG4. MSc students may take up to 20 credits at Level 10.]* __ Level 11/Year 4 (also available in Year 5 and MSc). *[These courses are listed as options in both UG and MSc DPTs.]* __ Level 11/PG (also available in Year 5). *[These courses are normally for MSc and UG5 students. They are not explicitly listed in UG4 DPTs, but UG4 students can take limited credits of them.]* __ Level 11/PG (only). *[These courses are not available to UG4 or UG5 students. Examples: CDT courses; CPD courses.]* **Other options. Please provide justification if using:** __ Level 9/Year 3 *[Deprecated except for compulsory UG3 courses. The course will not be available to other years.]* __ Level 10/Year 4 __ Other:
SCQF Credit Points	_X_ 10 __20 __40 __60 __80 __Other:
Delivery Location	_X_ Campus _X_ On-line Distance Learning
Course Type	_X_ Standard (default) __Dissertation __Online Distance Learning __Placement __Student Led Individually Created Course __Year Abroad
Marking Scheme	_X_ Standard (numerical) __Letter grade only __Pass/Fail *[Normally only for externally delivered courses]*

Guidance for remaining sections:

Before starting your proposal: please contact the DDoLT (Curriculum) informally before starting to complete this form, with at least the following information:

- Tentative course title, level, year, and number of credits
- Who the target audience is, and why the course is needed.

The DDoLT (Curriculum) or delegate will schedule a meeting with you to discuss your plans and whether a full course proposal makes sense. If so, you will be provided with further instructions.

Deadlines: New courses must be approved by the December BoS meeting to ensure allocation of teaching staff for the following academic year. Since it may require considerable discussion and iteration to prepare the proposal, you should **contact the DDoLT (Curriculum) as early as possible, ideally in spring or summer**, and you should **plan on submitting your full proposal by November.**

Submitting your proposal: When your proposal is complete, please submit to **iss-bos@inf.ed.ac.uk**.

Colour coding and item-by-item guidance:
Guidance is provided in italics for each item. Please also refer to the guidance for new course proposals at http://www.inf.ed.ac.uk/student-services/committees/board-of-studies/course-proposal-guidelines. Examples of previous course proposal submissions are available on the past meetings page http://web.inf.ed.ac.uk/infweb/admin/committees/bos/meetings-directory but note that the proposal form was updated in Apr 2021.

Sections in gold are for student view and are required before a course can be entered into DRPS.
Sections in orange are for School use but are still required for all courses (even those that have already been approved based on other documentation).
Section in gray are for consideration by the Board of Studies. They are normally required for all new course proposals but may be omitted in some cases, with permission (e.g., for invited proposals).

Glossary of terms:
(D)DoLT: (Deputy) Director of Learning and Teaching.
DRPS (The Degree Regulations and Programmes of Study): Provides the University's official listing and descriptions of courses, degree programmes, and the regulations that govern them; updated annually in April. Course information in DRPS is considered a contract with students.
DPT (Degree Programme Table): Lays out the course requirements for each year of a degree. All UoE degrees have a DPT in the DRPS.
Path: A system that students use to help choose courses and view options in their DPT. The information feeds through from DRPS but has a more student-friendly interface (e.g., by highlighting courses that are not running or where the student hasn't satisfied prerequisites).
SCQF (The Scottish Credit Qualifications Framework): Lays out the requirements for courses at different levels and with different numbers of credits.

1. Course overview and case for support

Except as noted, all fields are required and will go into the DRPS (course catalogue) entry for students. Important: Text in DRPS is effectively a contract with students, so should not include details that are likely to change from year to year.

Summary Description (for DRPS)

Provide a brief official description of the course, around 100 words. This should be student-friendly, as it is the part of the descriptor a student is most likely to read. If this course replaces another course, please say so in this summary.

A mobile robot is a machine controlled by software that use sensors and other technology to identify its surroundings and move around its environment. This course provides a general understanding of mobile robotics and related concepts, covering topics such as sensing perception, motion control, and planning. The emphasis is on algorithms, probabilistic reasoning, optimization, inference mechanisms, and behavior strategies, as opposed to electromechanical systems design. Practically useful tools and simulators for developing real robotic systems will also be covered in this course.

In the end of the course, students will develop skills in the analysis of predominant mobile robots, and independently build up a navigation system for a virtual self-driving car in simulation environments.

Contribution to curriculum; target audience and expected demand; consultation (for BoS only)

Why is this course needed and how does it relate to existing courses and degree programmes (including any prerequisite courses)?	**Need**: MOB (this proposed new course) is one of the core courses in the recently updated IPAB curriculum. MOB will replace Introduction to Robotics and Vision (IVR) to address the declining numbers and poor student satisfaction. The course aims to catch up on the rapid changes in intellectual landscape of robotics during the past decade. This course is also proposed to address the constant student complaints about IVR (see more in below). Other universities based in the UK (e.g., U of Cambridge, ICL), USA (e.g., MIT, CMU) and Canada (U of Toronto) has been teaching similar courses for a number of years. **Relationship to existing course**: **1. To its replacement**: MOB is aimed to replace the existing course Introduction of Vision and Robotics (IVR) to address the student complaints about IVR's overly wide topics and overly dense contents. Negative feedback of this course dominates for years, despite many modification efforts made by different course organizer involved. Realizing this is probably due to the problematic course structure on its own, we decide reconstruct it completely. The focus of MOB will placed on the robotics part only. The planned course lectures, coursework and difficulty will better match its 10 credits and the suggested load of 6-7h/week in total. **2.To other/later courses**: As for the relationship to other courses in the school, the newly designed practicals will em-

	phasize the training students the skills of using Robot Operating System (ROS), which is a key enabler for them to execute in the later SDP (System Design Project) course. The lack of proficiency in ROS is one of the major negative student feedback received in SDP and in our IPAB staff meeting we all agree such a lacking training can be relieved via MOB. Second, this new course can also pave the way for the later course 'Advanced Robotics' by providing general understanding of robotics and let the advanced course encompass more technical and deeper contents. 3.**To other programs/activities in the school**: As MOB teaches mobile robotics and heavily use self-driving car in lecture examples and coursework simulators (i.e. CARLA), we envision this course is also able to stimulate more and stronger students to join in the Edinburgh University Formula Student team.
What is the target audience, in terms of background and interests, and what is the expected demand (class size) for the course? *State what your estimate is based on: e.g. by referring to projects in an area, sizes of similar courses, employer demand, etc. A survey of students may be requested once the main descriptor information is ready.*	**Background:** The target audience are students with limited to no formal prior experience in robotics or mobile robotics. Enrolled students are assumed to have: Experience of AI knowledge and representation issues (equivalent to first and second year courses in Informatics); Enough school algebra and geometry (e.g., vectors, rotations, trigonometry etc.). Essential probability theory. Physics to understand Newton's Laws of Motion. They are also expected to be familiar with these mathematical methods: Bayes rule, Gaussian Distribution, Covariance matrices. Students should be comfortable with programming in using Python (or C++) and familiar with Linux systems that are heavily needed for the practical and coursework. **Class/course Size:** Based on the number of 120 enrolled students in IVR'21-22 (i.e., the predecessor course of MOB), and our plan to make MOB further available to the *Informatics MSc students* and to the E*ngineering School students (from whom constant enrollment queries were received),* our expected course size is expected to grow to 120-160.
Has this proposal been discussed with the DDoLT (Curriculum) or DoLT prior to BoS submission?	X Yes ___ No
Who else has been consulted?	Steve Tonneau

Proposals should typically be discussed with relevant colleagues, including the programme director (for MSc courses). Summarize their comments if needed.	Alex Li Subramanian Ramamoorthy and other IPAB colleagues in multiple IPAB staff meetings.

Course Description (for DRPS)

*This student-facing description should normally include **(a)** a more in-depth description of the learning aims, nature and context of the course, **(b)** a rough outline of the content, and **(c)** a description of how the course will be taught, and how students are expected to engage with it and to demonstrate their achievement of the learning outcomes.*
***Note:** Please keep this section general enough to avoid the need for yearly updates, and keep in mind that you should have only around 15 lecture hours of examinable material per 10pts of a course. (10pt courses may have 18-20 lecture hours, but the rest should be used for guest lectures, revision sessions, assignment feedforward/feedback, etc.)*

Delivery Method:

The course will be delivered through a combination of: (1) live lectures, (2) practical labs, (3) tutorials, and (4) an online discussion forum.

Content/Syllabus:

The exact set of methods and algorithms explored in the course will vary slightly from year to year, but will include many of the following topics:

- Introduction of Robotics: concept, use cases, and system architecture on sensing, perception & control. Ethical and privacy implication of robots (e.g., drones).
- Math refresher: basic operations of matrix, algebra, probability theory, derivatives
- Robot Motion Model: Coordinate transformations and Representation of Rotations; Forward kinematics
- Sensor Model and Measurement: Proprioceptive and exteroceptive models; a case study with cameras, lidar, radar, ultrasonic, inertia etc.
- Recursive State Estimation: Kalman filters, EKF, (Particle filters) etc.
- Localization & Tracking: Monte Carlo Localization, Ranging based Triangulation, Fingerprinting etc.
- Mapping: environment model, grid map, (structure from motion)
- Robot Operating System: basic principles, use cases, and examples
- SLAM: Framework & systems, loop closing, pose graph optimization
- Planning and Navigation: Obstacle avoidance, Path planning, receding horizon control
- Self-driving Car Simulator: Basic usage of CARLA in sensing and localization
- Basic Control Theory for Robotics: Open-loop and closed-loop control. Basic Idea on PID control

Assessment Weightings (for DRPS)

These should correspond approximately to the proportion of learning outcomes (below) that each component assesses. Note that assessed coursework is typically more time-consuming than exams for both students and staff. A typical course is based no more than 30% on coursework and doing so requires justification.

Written Exam __60___%
Practical Exam _____% (*for courses with programming exams)*
Coursework _40___%

Additional Information, Assessment (for DRPS)

State briefly for students what type of coursework to expect, including whether implementation is required. E.g., "Coursework will involve implementing some of the methods discussed" or "The coursework will assess students' analysis and proof skills. No implementation is required." More specific information can be useful, but please keep it high level and do not include details that are likely to change from year to year.

Coursework will involve comparing and evaluating the methods discussed in the course using the taught ROS and CARLA simulation software. Short written explanations along and discussion will also be evaluated as part of the coursework.

Non-assessed quizzes and example questions will also be utilized to help students better understand the course material. Feedback for the quizzes will be immediate, and feedback for example questions will be provided from the instructors or via peer discussion.

Learning Outcomes (MAXIMUM OF 5; for DRPS)

List the learning outcomes (LOs) of the course. These must be assessable (i.e., observable), so must specify what the student should be able to do concretely, not simply what they should "understand". Use concrete verbs that indicate (a) what type of assessment would be appropriate, and (b) what level of knowledge/thinking is expected (from recall to analysis to novel creation). ***Example verbs:*** *define, explain, implement, compare, justify. Assessments (described later) should be tied to the LOs.*

LOs should focus more on the types of thinking/skills developed than on the detailed course content, and should be appropriate to the level of the course: e.g., LOs at Level 11 should include more higher-level thinking skills than at Level 8. See how to write good learning outcomes and the descriptors of the SCQF Levels. Also, please consider including LOs related to ***social or ethical implications*** *or* ***meta-skills*** *as well as technically-focussed LOs.*

On completion of this course:

1) Students will be able to recall and explain the essential facts, concepts, principles and potential ethical concerns of mobile robotics and related concepts, demonstrated through written answers in examination conditions.

2) Students will be able to describe and evaluate the strengths and weaknesses of some specific sensor and motor hardware; and some specific software for sensory processing and perception, demonstrated through written answers.

3) Students will be able to employ useful software and tools (e.g. robot simulator, robotic operating system) to solve a core problem of mobile robots, and will show a working system via proof-of-concept simulation environments.

4) Students will, in writing a joint report, identify problem criteria and context, discuss design and development, test, analyse and evaluate the behaviour of typical mobile robots they have developed in simulation.

Graduate Attributes, Personal & Professional Skills (for DRPS)

Please list the generic transferrable skills that this course will develop, as aligned with the UoE's Graduate Attributes framework. Examples from the four skills categories in the framework include:

Research and enquiry: *problem-solving, critical/analytical thinking, handling ambiguity, knowledge integration*

Personal effectiveness: *leadership, planning and organizing, flexibility and change management, entrepreneurship*

Personal responsibility and autonomy: *ethics and social responsibility, independent learning, self-awareness and reflection, creativity, decision-making*

Communication: *interpersonal/teamwork skills; verbal, written, cross-cultural, or cross-disciplinary communication*

- Critical and analytical thinking: Apply critical and analytical thinking to real-world problems in the context of mobile robotics.
- Problem-solving skills: Develop their problem-solving skills so they can better create, identify, and evaluate options in order to solve other complex system problems in a similar spirit.
- Knowledge integration: The knowledge base obtained from multiple studied courses in the first and second years can be consolidated considering that (mobile) robotics and autonomous systems is a highly interdisciplinary subject across multiple areas.
- Leadership and teamwork skills: Course work in the form of small teams can cultivate the leadership and team spirits needed toward solving a complex system problem.
- Recognise and understand the ethical questions (e.g., privacy compromise due to drones) related to the application of mobile robotics as a concrete instance of embodied artificial intelligence.

2. Additional information on course design and resourcing (for BoS only, except where noted)

Breakdown of Learning and Teaching Activities (for DRPS)

Please fill in the number of timetabled hours per student for each type of activity. Do not include non-timetabled hours.

***A typical 10pt Informatics course** has:*

- *18-20 lecture slots (2/wk), but only ~15h should be examinable lectures, with the rest used for guest lectures, revision sessions, assignment feedforward/ feedback, etc. If unsure of plans, count these under 'lecture hours' but please explain tentative plans in the free text below.*
- *No more than 4-5 lab or tutorial hours. Please consider whether fewer can be used, e.g. by using some lecture hours for whole-class discussion/feedforward.*

***A typical 20pt course** has 30 lecture slots (3/wk) and no more than 8 lab/tutorial hours.*

Time-tabled Hours	Type
17	Lecture Hours
N/A	Dissertation Project Supervision Hours
4.5	Supervised Lab and Tutorials
2	Feedback/Feedforward hours
2	Summative assessment hours *[Normally 2h if using an exam; other-wise 0]*
1	Revision Session Hours

(Note for ISS: Remaining hours should be allocated to Directed and Undirected Learning Activities.)

Use of timetabled activities (not to be included in DRPS)

If labs or tutorials are planned, please describe their role in the course (e.g., as support for assessed coursework, review of exercises, discussion of ethical questions, etc). If a non-standard pattern or style of lectures is planned, please explain.

Overview:

Each week there will be two 1-hour live lectures. There will be four lab sessions in total spreading in four weeks, in addition to 2 discussion/feedforward sessions one before labs begin and one after labs end.

Live Lectures:

In total 20 hours of live lectures evenly spreading in 10 weeks. More specifically, *15* hours are examinable lectures covering the technical contents of this course and the ethical implications of mobile robots. *2* hours are discussion/feedforward analysis of the labs, *1* hour is used for assignment/coursework feedforward/feedback, *1* hour is used for guest lecture from EUFS team, and *1* hour is used for course revision.

Labs/Tutorials:

The labs provide students with the necessary skills and practical experience to attempt the assessed coursework. 4.5 hours total evenly spreading in 3 weeks in the middle point of the course progress.

Summative assessment and time spent on assignments (not to be included in DRPS)

Please describe your plans for summative assessment, in more detail than in the student-facing description: How many and what types of assessment are planned (oral presentation, report, programming, etc)? For each piece of assessment, please indicate ***(a)*** *which learning outcome(s) it assesses; and* ***(b)*** *how many hours students are expected to spend on it.*

Please minimize the time spent on summative assessments (for both students and markers) while robustly assessing the learning outcomes. See the School policy on Workload and Assessment, which places limits on the number of summative courseworks and time expectations: to ensure a 35-40h working week, we must limit time asked of students to ***6-7h/wk in total per 10 credits, including contact hours, self-study, and coursework.***

We will have one piece of summative coursework, worth 40% of the overall grade. This coursework will primarily assess Learning Outcome (LO) 1, 3 and 4, while the 2-hour exam will focus on LO 1 and 2. Students will be provided with different code skeletons in simulation environments and will be asked to (1) apply the learned technique to complete the code on top of the skeleton such that a set of functions of a virtual mobile robot can be enabled; (2) run a set of numerical experiments with the completed codes in simulation and apply the knowledge/concept covered in the course to validate and analyse the critically results (3) answer more open-ended questions related to the limitations of current solutions in the context of the experiment and propose better solutions (if any) in brief.

Submitted coursework reports will be provided by students in the form of a PDF document containing text, plots, and numerical outputs. The coursework will be provided to students two and a half weeks before the final submission deadline in (which will be in week 8/9). It is expected that it will take them on average 10 hours over two weeks, to complete the coursework. This work will be completed as a group in pairs .

Tentative plans for feedback/formative assessment (not to be included in DRPS)

Please describe your current plans for providing feedback to students: e.g. oral feedback during labs/tutorials, automarked solutions to in-lecture or online quizzes, peer feedback, etc. We also encourage submission of at least one piece of (individual or group) written work, with formative feedback emphasizing how students can improve.

Some useful guides for planning effective and efficient feedback:

- *Two short IAD web pages: Five basic principles for feedback and Tips for improving feedback*
- *EngagED in... assessment and feedback. This flyer from IAD discusses assessment **of**, **for**, and **as** learning, and includes examples of innovative approaches that could help both with scaling to large courses and with causing students to reflect on and become engaged with their own assessment.*
- *Considerable further reading is available at the University pages on Enhancing Feedback.*

We will utilize auto-marked multiple-choice online quizzes for technical topics in the course. These quizzes can be taken multiple times and will provide the student with instance feedback. They will be delivered using an online platform (e.g. via Learn).
In order to improve the transparency of the assessment, we will provide concrete examples of poor, mediocre, good and excellent answers to a non-assessed coursework. A large proportion for this non-assessed coursework will feature those questions whose answers can be open-ended or difficult to give students a sense about what a good solution 'looks' like. Furthermore, this will give students the opportunity to familiarize themselves with the format of the assessed coursework and the submission process. Feedback will be provided at the course level during a live class session for this non-assessed piece of work. Students will be permitted to work in small groups for this non-assessed coursework.
For the assessed coursework, detailed feedback will be provided via the marking rubric (e.g. from Gradescope).
In order to link feedback to following assignments, the final coursework and exams will have a certain amount of similar questions in assessed coursework, after applying numerical/complexity variations on them.
To give timely feedback, we will also provide with the opportunity to ask questions via an online forum (e.g. Piazza). They will be encouraged to provide peer-feedback, but the instructors and TA will also be available to answer questions.

Decolonisation and Inclusivity (not to be included in DRPS)

*What actions are you taking towards making your course inclusive for all students, in terms of both **content** and **delivery**? Please be as specific as possible. If you are not taking any action, please justify. See suggestions and guidance here.*

Content:

1. Mobile robotics technologies evolve a lot not only in developed countries but also in developing countries. In this sense, real examples or applications (e.g., drones and autonomous vehicles) in this vein will consider both the originating countries from both types.
2. As an introduction-level course, we now carefully change its content to friendly to students who have less experience and knowledge before taking it. In comparison to its replacement IVR which has long complained about its dense workload, this new course will not only reduce the lecture contents

and focus only on the robotics part, but also lowers the practical and coding barriers by providing code skeleton to bootstrap students.
3. We have reconsidered the terminology used in the course. Terms such as master-slave robots have been removed and replaced.
4. We have considered examples of influential work of underrepresented pioneers. For instance, in the introduction we have demonstrated the origin of automation and robotic mechanisms were in early Asia and Africa.

Delivery:

We will employ the "purpose, task, criteria" approach for the coursework, as that's been shown to have a high impact, especially for 1st generation university students. In the context of this new course, we will use a wide range of real-world examples of mobile robotics applications (e.g., autonomous vehicles, cleaning robots and drones) to lay down the course purpose relate the students to their life. We will then ask students to come up with other real-world application with their learnt knowledge and skills from the course (i.e., tasks). Concrete examples of assignment solutions and practical's will be given to make the criteria transparent as explained in earlier section about feedback.

Anticipated Resource Requirements

If tutorials are needed, how many students per tutors? (*Please provide your desired number, and the maximum feasible number.)*	**2** tutorials in total covering sample coding of practical related algorithms, numerical simulation. Given 25 students per tutorial group, this requires ~6 tutors x 4.5 hours
If labs are needed, how many students per demonstrator? (*Please provide your desired number, and the maximum feasible number.)*	**3** labs in total over the semester, each 2 hour long, with 25 students per lab, requiring ~6 demonstrators i.e. 6 demonstrators x 3 labs
Please estimate the number of hours required for marking, per student.	**3** markers x 15 hours for the assessed coursework **2** markers x 20 hours for the exam
If any other teaching support resource will be requested in order to **develop** or **maintain** the course, please provide an estimate of that here.	**1** TA for helping develop the coursework and online quiz with the CO. **1** TA for general tasks e.g. monitoring Piazza, ensuring the package versions in the labs are up-to-date, setting up Gradescope, etc.
Do you anticipate any difficulty recruiting enough teaching support? *(For example if the course is very large or very specialized.)*	NO
Does the course have any scaling limits due to available space or equipment?	n/a
If equipment is required, please state how it will be procured and maintained.	n/a
Does the course have any external funding? *(Typically only for CPD courses)*	n/a
Does the course need any special arrangements such as quotas, agreements with other schools, or registration arrangements? Does it have any	Not a must need, but it would be good to liaise with the Engineering school about this new course given its predecessor course IVR

atypical characteristics that may affect finance or student registration? Please specify if so.	constantly receives students requests from the Engineering school to enrol.

3. Further information for BoS consideration

A full proposal for a new course must include examples of exercises and assessment. Please provide these below, along with publicity information.

Course information and publicity

The course web page (typically the Learn landing page) will be linked from the Sortable Course List, and information such as timetables and assignment deadlines must be made available prior to the start of the academic year. Please specify here if any additional info/publicity is needed for your course, especially if it is aimed largely at non-SoI students.

It will be important to clearly communicate to prospective students what we expect in terms of prior knowledge, what the scope of the course is, and how it differs from and relates to other related courses (e.g., advanced robotics, computer vision and applied machine learning etc.).

Considering its predecessor course IVR constantly receives students requests from the Engineering school to enrol, it will be important that such non-SoI students are aware of the prerequisite requirements before attempting to take the course. Essentially most contents of this new course 3rd is friendly to the students from the Engineering school, apart from some topics (e.g., motion planning) require passing knowledge on discrete optimization (e.g., dynamic programming).

Sample tutorial/lab sheet questions

Provide a list of tutorial questions and answers and/or samples of lab sheets. These need not be fully fleshed out but should indicate what sort of exercises will be provided to help students learn the material.

Few sample tutorials with solutions can be found here. This tutorial covers the basic knowledge and usage examples of ROS, one of the predominant simulation software/middleware used in both academic and industrial robotics. This particular sample examines the LOs 3 and 4.

Sample assessment materials

*If the course is primarily assessed by **exam**, provide a sample exam question with model answers. The online list of past exam papers gives an idea of typical and alternative exam formats.*
*If the course is largely or primarily assessed by **coursework**, provide a sketch of a possible assignment with an estimate of effort against each sub-task and a description of marking criteria.*

This course is primarily assessed by exam. An sample exam question can be found here. This particular question examines LOs 1 and 2.

Any other relevant materials

Include anything else that is relevant, possibly in the form of links. If you do not want to specify a set of concrete readings for the official course descriptor, please list examples here.

n/a

4. Additional Course Details for DRPS

Except where otherwise noted, these fields are required for entry into EUCLID and will be visible to students in the DRPS entry.

Planned Academic Year of Delivery *(The first year you anticipate the course running, e.g. AY 2019-20)*	2022-2023
Keywords *Give a list of searchable keywords for the course.*	Mobile Robotics; Sensing and Perception; State Estimation; Localization and Mapping; Autonomous Vehicles
Course Organiser *(By default, the course proposer)*	Chris Lu
Intended Delivery Period	_X_ Semester1 ___Semester 2 ___Full Year ___Summer ___Other (please specify):
Timetable considerations/conflicts *For School use. Please specify any constraints to be considered (e.g. overlap of popular combinations, other specialism courses, external courses etc). Include whether the semester delivery is constrained or could be flexible.*	N.A.
Reading List/Learning Resources (for DRPS) *You are encouraged to create resource lists using LEGANTO*	Books that may be useful, but are not required: 1. Bongard, Josh. "Probabilistic robotics. Sebastian Thrun, Wolfram Burgard, and Dieter Fox. (2005, MIT Press.) 647 pages. 2. Ulrich Nehmzoe, Mobile Robotics: A Practical Introduction, 2nd Edition 3. Robin R. Murphy, Introduction to AI Robotics, MIT Press, 2000, ISBN: 0262133830
Feedback Information *Provide a high-level description of how and what type of feedback will be provided to students, for inclusion in DRPS.*	Three of the live lecture sessions will be devoted to discussing practical examples and exam-like questions. We will provide feedback on student answers at the course level. Feedback at the course level will also be provided for the assessed and non-assessed assignments/coursework. Piazza will be utilized for peer-feedback

Is this course available to visiting students?	_X_ Yes (default) ___No **If no, please provide a justification here:**
Required pre-requisite courses *Use sparingly: these are enforced in PATH and can only be waived by approval from the School's Curriculum Approval Officer. Note that cross-year required pre-requisites may prevent MSc students from registering; consider using recommended pre-requisites or "other requirements" instead.*	_X_ No ___Yes (please specify full course name(s) and code(s)):
Recommended pre-requisite courses	_X_ No ___Yes (please specify full course name(s) and code(s)):
Required co-requisite courses *Specify any courses that must be taken in parallel with the existing course. Note that this leads to a timetabling constraint that should be mentioned elsewhere in the proposal.*	_X_ No ___Yes (please specify full course name(s) and code(s)):
Prohibited Combinations *Specify any courses that may not be taken in combination with the proposed course].*	___No _X_ Yes (please specify full course name(s) and code(s)): Students MUST NOT also be taking advance robotics (code absent for now as that course proposal is also under review)
Other Requirements/Additional Information *This information is often used by MSc students and students from other Schools to see if they have appropriate background without having done our School's courses. So please avoid course titles, instead list specific knowledge and skills (such as mathematical concepts, programming ability or specific languages, etc).* *Also list any other constraints on registration, for example: "Only available to 4th Year Informatics students including those on joint degrees." or "This course is open to all Informatics students including those on joint degrees, and to students in the School of Mathematics. Other external students whose DPT does not list this course should seek permission from the course organiser."*	___No _X_ Yes (please specify): Enrolled students are assumed to have: • Experience of AI knowledge and representation issues (equivalent to first and second year courses in Informatics); • Enough school algebra and geometry (e.g., vectors, rotations, trigonometry etc.). • Essential probability theory. • Physics to understand Newton's Laws of Motion. They are also expected to be familiar with these mathematical methods: Bayes rule, Gaussian Distribution, Covariance matrices.

	In addition, students should be comfortable with programming in using Python (or C++) and familiar with Linux systems that are heavily needed for the practical and coursework.
Visiting Student Pre-requisites	_X_ Same as "other requirements" ___ Different than "other requirements" (please specify):

5. Placement in degree programme tables: for level 9-11 courses only (except EPCC)

This section is for consideration by the Board of Studies and will be used later by ITO to determine where the course will be added to existing degree programme tables.

Is this course restricted to students on a specific degree? *E.g., some courses are only available to students on a specific CDT or MSc.*	X No ___Yes (please specify and provide justification):
Is this course compulsory for students on any degree(s)?	X No ___Yes (please specify and provide justification):
Any issues for part-time students? *Normally, part-time students have access to the same courses as full-time students on the equivalent degree. If you anticipate any problems with this, please specify here.*	No issues anticipated as long as they are able to engage in all the necessary course activities.

For optional courses:
If this course is available but non-compulsory for students on various degrees (most courses), please fill in this section. The choices here determine where the course appears in degree programme tables (DPTs) and the 2-3 character tags are displayed in the Informatics sortable course list.

Should this course be tagged as 'ML' (machine learning foundations and methods)? *Courses with the ML tag are typically very high-demand and most degrees limit the number of ML credits. If your course might appeal to a similar audience but draw off students from these large courses, please select 'no' and choose one of the tags below.*	X No __Yes
If you chose 'no', please choose at least one of the following tags… *Ideally, select exactly one, unless there is a good argument for more than one. These three are used in various combinations for many of our degrees.*	X **FSS** (CS foundations, systems, and software) X **AIA** (artificial intelligence applications and paradigms) __**COG** (cognitive science: including HCI and NLP courses, but not most other AI courses. Please restrict to courses most relevant to natural cognition.)
…and also tick if any of the following tags or categories apply. *Do not tick any of these if you selected 'ML' already.*	__**SE** (software engineering: including courses that are highly relevant to SE degrees. All SE courses should also be FSS. This tag is mainly relevant for UG SE degrees.) __Databases and data management systems (used for Data Science MSc and MSc(R)) _Unstructured data and applications (used for Data Science MSc and MSc(R)) __Level 11 Security courses (used for Security MSc) __ATFC Optional courses (used for ATFC MSc)

If you are not sure which tags are most appropriate or have other questions about this section, please note any comments/issues here.	This new course does not fall into any of the above secondary tags.