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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Kinematika in dinamika robotov | | | | | | | | | | | | | | |
| **Course title:** | | | Robot Kinematics and Dynamics | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Podiplomski magistrski študijski program druge stopnje Elektrotehnika | | | | | Robotika | | | | | | | | 1 | | 1 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Robotics | | | | | | | | 1 | | 1 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Obvezni-strokovni / Compulsory professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64297 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** | **-** | | | **30** | | | **-** | | | | **-** | | | **75** | |  | **6** |
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| **Nosilec predmeta / Lecturer:** | | | | | Marko Munih | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | **S**  **slovenski, angleški / Slovene, English** | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | **slovenski, angleški / Slovene, English** | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik. | | | | | | | | |  | Enrolment in the year of the course. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Homogone transformacije diferencialnih premikov (odvod transformacije, diferencialna translacija in rotacija, transformacija diferencialnih premikov med koordinatnimi sistemi); Jacobijeva matrika za manipulator (izračun, geometrijska in analitična, inverzna, singularnost, redundantnost, psevdoinverzna J matrika); Statika (ekvivalentni momenti sklepa, transformacija sil in momentov, dualnost kinematike in statike, togost); Generiranje trajektorije (interpolacije, absolutni, inkrementalni interpolator, kubični polinom in polinomi višjega reda, linearni segmenti s paraboličnimi nastavki, vmesne točke, trajektorija podana v zunanjih koordinatah). Lagrangeova dinamika togega manipulatorja (izračun kinetične in potencialne energije, enačba gibanja); Pomembne lastnosti dinamičnega modela (poševno simetrična matrika N, linearnost, zapis v zunanjih koordinatah); Newton-Euler dinamika (izpeljava ravnotežnih enačb, izračun kinematičnih veličin); Primeri. | | | | | | | |  | | Homogenious transformations of diferential movements (transformation derivative, differential translation and rotation, transformation of differential movements between coordinate systems); Jacobian matrix for manipulator (calculation, geometry and analytical, inverse, singularity, redundancy, J pseudoinverse ); Statics (equvivalent joint torques, transformation of forces and moments, kinematics and statics duality, stiffness); Trajectory generation (interpolation, absolute, incremental interpolator, cubic and higher order polynomials, linear segments with parabolic ends, intermediate points, trajectory defined in external coordinates); Lagrange dynamics of rigid manipulator (calculation of kinetic and potential energy, movement equations); Important properties of dynamic model (Skew-symmetry of matrix N, linearity, notation in external coordinates); Newton-Euler formulation (equilibriaum equations, calculation of kinematic quantities); Examples. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| 1. M. Munih: Diferencialna kinematika, statika in generiranje trajektorije, Založba FE in FRI, 2005. 2. M. Munih: Dinamika in vodenje robotov, Založba FE in FRI, 2005. 3. L. Sciavico, B. Siciliano: Modeling and Control of Robot Manipulators, The McGraw – Hill Companies, Inc., New York, 2000. 4. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, S. Thrun: Principles of robot motion, MIT Press, 2005. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| (a) Spoznati teoretične osnove diferencialne kinematike, statike, Lagrange in Newton-Euler dinamike.  (b) Preveriti medsebojen vpliv veličin z omenjenih področij na realnih mehanizmih v laboratoriju.  (c) Dolgoročno: razumevanje podanih relacij in njihova uporaba | |  | | (a) Spoznati teoretične osnove diferencialne kinematike, statike, Lagrange in Newton-Euler dinamike.  (b) Preveriti medsebojen vpliv veličin z omenjenih področij na realnih mehanizmih v laboratoriju.  (c) Dolgoročno: razumevanje podanih relacij in njihova uporaba | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Samostojnost pri uporabi relacij diferencialne kinematike in statike. Sposobnost zapisa preprostejših sistemov samostojno ter bolj kompleksnih sistemov gibanja s pomočjo ustreznih računalniških orodij.  Uporaba relacij diferencialne kinematike, statike in dinamike v robotiki, robotskem vidu, navideznih okoljih.  Izbira ustreznega zapisa, modela in opisa pri reševanju zadanega praktičnega problema.  Uporaba pridobljenega znanja znotraj drugih elektro in tudi drugih področjih tehnike. Uporaba na področjih računalniške grafike, navidezne resničnosti, multimedije, tudi npr. rehabilitacijska robotika.  Reševanje konkretnega primera, sodelovanje v delovni skupini. | | |  | Independence when using tools of differential kinematics and statics. Ability to lay out simple systems individually and more complex systems of movement by using suitable computer tools.  Use of tools of differential kinematics and statics in robotics, robot vision and virtual reality environments.  Selection of adequate notation, model and description for solving practical problems.  Use of knowledge obtained also in other fields of electrical engineering and other fields of engineering. Use in the fields of computer graphics, virtual reality, multimedia, also e.g. rehabilitation robotics.  The students are solving practical problems, they obtain skills of group cooperation. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja, laboratorijsko delo v manjših skupinah. Praktične vaje potekajo na večjem številu sodobnih industrijskih in drugih robotov. Študenti imajo na voljo skripta z zgoščeno vsebino predmeta. Vabljeni so gostujoči predavatelji iz slovenske industrije. | | |  | Lectures, laboratory practice in smaller groups. In practical exercises are used larger number of modern industrial and other robots. Students have available lecture notes with condensed content of the subject. Invited are guest lectures from Slovenian industry. | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Pisni/ustni izpit: od 6 do 10 pozitivno, od 1 do 5 negativno  Pisno poročilo ob koncu praktičnih laboratorijskih vaj.  Zahtevana je obvezna prisotnost pri praktičnih vajah. Študent pripravi poročila za posamezne opravljene projekte. Pisni izpit obsega naloge in vprašanja iz obravnavane snovi.  Prispevki k oceni:   * laboratorijske vaje * izpit | 50%  50% | | | | Witten/oral exam: from 6 to 10 positive, from 1 to 5 negative.  Written report at the end of project period is required. Presence is obligatory during practical exercises. Student prepares report for each project. The written exam contains cases and questions in the fields of course.  Contributions to the final grade:   * laboratory exercises * exam |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. BAJD, Tadej, MIHELJ, Matjaž, MUNIH, Marko. Introduction to robotics, Springer, 2013. 2. BAJD, Tadej, MIHELJ, Matjaž, LENARČIČ, Jadran, STANOVNIK, Aleš, MUNIH, Marko. Robotics, Springer, 2010. 3. REJC, Jure, KOVAČIČ, Franc, TRPIN, Anton, TURK, Igor, ŠTRUS, Miran, REJC, Danilo, OBID, Pavle, MUNIH, Marko. The mechanical assembly dimensional measurements with the automated visual inspection system. Expert syst. appl. 2011, vol. 38, no. 8, str. 10665-10675. 4. ČINKELJ, Justin, KAMNIK, Roman, ČEPON, Peter, MIHELJ, Matjaž, MUNIH, Marko. Closed-loop control of hydraulic telescopic handler. Autom. constr. 2010, vol. 19, no. 7, str. 954-963. 5. AMBROŽIČ, Luka, GORŠIČ, Maja, GEEROMS, Joost, FLYNN, Louis, LOVA, Molino, KAMNIK, Roman, MUNIH, Marko, VITIELLO, Nicola. Cyberlegs : a user-oriented robotic transfemoral prosthesis with whole-body awareness control. IEEE robotics & automation magazine, 2014, vol. 21, no. 4, str. 82-93. | | | | | |