

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

Predmet:	MEHATRONSKI SISTEMI V LOGISTIKI
Course title:	MECHATRONICS SYSTEMS IN LOGISTICS

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
LOGISTIKA SISTEMOV 1. stopnja		1.	2.
SYSTEM LOGISTICS 1 <sup>st</sup> degree		1.	2.

Vrsta predmeta / Course type: OBVEZNI

Univerzitetna koda predmeta / University course code: UN

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15 e-P 45 a-P		5 e-V 15 a-V	10 LV		90	6

Nosilec predmeta / Lecturer: TONE LERHER

Jeziki / Languages: Predavanja / Lectures: SLOVENSKI / SLOVENE  
 Vaje / Tutorial: SLOVENSKI / SLOVENE

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: Ni pogojev. Prerequisites: No special conditions.

**Vsebina:**

- Modeli sil, aktivne (bremena) in pasivne (reakcijske) sile, moment dvojice sil, redukcija sil. Težišča teles. Trenje na ravni podlagi in na kolutih. Nosilci, paličja, mešani sistemi. Napetosti in deformacije, Hookov zakon.
- Hitrost in pospešek. Relativno gibanje. D'Alembertov princip. Izrek o gibanju masnega središča, gibalni in vrtilni količini ter mehanski energiji. Impulzivno gibanje in trk. Dinamika teles spremenljive mase.
- Eulerjeva gibalna enačba idealne kapljevine. Rotirajoča posoda. Laminarno in turbolentno pretakanje ter vrste izgub. Dimenzioniranje cevovodnih omrežij. Čas iztekanja kapljev pri spremenljivi gladini. Reakcija iztekajočega curka.
- Osnove, pomen in nastanek mehanskih nihanj. Osnovni elementi nihajočega sistema (masa, dušilka, vzmet). Zaporedna in vzporedna vezava vzmetnih elementov. Harmonično nihanje. Vsiljeno dušeno nihanje sistemov. Resonanca.
- Električna napetost in električni potencial. Kondenzator, kapacitivnost.
- Ohmov zakon, ohmska upornost. Kirchhoffova

**Content (Syllabus outline):**

- Force models, active (load) and passive (reaction) forces, moment of a force couple, force reduction. Centres of gravity of bodies. Friction on flat surface and discs. Beams, trusses, mixed systems. Stresses and deformations, Hook's Law.
- Velocity and acceleration. Relative motion. D'Alembert's Principle. Theorem on motion of mass centre, motion and rotation quantity and mechanical energy. Impulsive motion and collision. Dynamics of bodies with changeable mass.
- Euler equation for motion of an ideal liquid. Rotating vessel. Laminar and turbulent flow and different types of waste. Dimensioning pipeline networks. Time of liquid outflow if liquid level is changing. Reaction of outflowing jet.
- Basics, meaning and creations of mechanical oscillations. Basic elements of the oscillating systems (mass, dashpot, spring). Series and parallel connection of spring elements. Harmonic oscillation. Forced oscillation of damped systems. Resonance.
- Electric tension and electrical potentials. Capacitor, capacitance.

zakona, Joulov zakon.

- Magnetno polje premega tokovodnika. Magnetilna krivulja in histerezna zanka. Sila na tokovodnik v magnetnem polju. Induktivnost tuljave. Faradayev zakon elektromagnetne indukcije.
- Izmenični tokokrogi. Enofazni in večfazni sistemi. Električne meritve. Električni stroji in transformatorji. Električna oprema in naprave.
- Polprevodniki, polprevodniške diode, tranzistorji, tiristorji. Integrirana elektronska vezja. Analogni sistemi.
- Digitalni sistemi. Sekvenčna vezja. Družine logičnih vezij. Mikroprocesorji in programirana logična vezja. Senzorji in aktuatorji. Črna koda in RFID.

- Ohm's Law, ohm resistance. Kirchhoff's Laws, Joule's Law.
- Magnetic field of a linear conductor. Magnetic curve and hysteresis loop. Force on a conductor in a magnetic field. Coil inductivity. Faraday's Law of electromagnetic induction.
- Alternating current circuits. Single- and multi-phase systems. Electrical measurements. Electrical engines and transformers. Electrical equipment and devices.
- Semiconductors, semiconductor diodes, transistor. Integrated electronic circuits. Analogue systems.
- Digital systems. Sequential circuits. Families of logical circuits. Microprocessors and programmed logical circuits. Sensors and actuators. Bar code and RFID.

#### Temeljna literatura in viri / Readings:

E-gradivo predmeta.

Lerher, T. (2016) Mehatronski sistemi v logistiki. 1, Mehanika. Univerza v Mariboru, Fakulteta za logistiko.

Lerher, T., Potrč, I. (2017) Transportni sistemi v intralogistiki. Univerza v Mariboru, Fakulteta za logistiko.

Hibbeler, R.C. (2013) Mechanics of Materials, 9th edition, Pearson.

Hibbeler, R.C. (2010) Engineering Mechanics - Dynamics, 12th edition, Pearson.

Fischer, R., Linse, H. (2012) Elektrotechnik für Maschinenbauer: mit Elektronik, elektrischer Messtechnik, elektrischen Antrieben und Steuerungstechnik, 14 Auflage, Springer Vieweg.

Flegel, G., Birnstiel, K., Nerreter, W. (2009) Elektrotechnik für Maschinenbau und Mechatronik, 9 Auflage, Carl Hanser Verlag, München.

Heimann, B., Gerth, W., Popp, K. (2007) Mechatronik – Komponenten, Methoden, Biespielen, Fachbuchverlag Leipzig (Carl Hanser Verlag).

#### Cilji in kompetence:

Cilj predmeta je seznaniti študente s temeljnimi znanji s področja mehatronike. Prav tako je predmet namenjen pridobitvi praktičnih izkušenj na področju mehatronike.

#### Objectives and competences:

The goal of this course is to acquire basic knowledge from the field of mechatronics. As well as this course is aimed to gain practical experience in the field of mechatronics.

#### Predvideni študijski rezultati:

Razumevanje osnovnih zakonov mehanike in elektrotehnike bo omogočilo študentom reševanje praktičnih problemov stroke na področjih mehatronike, ki zajemajo statiko, trdnost, kinematiko, dinamiko, hidromehaniko, delovanje električnih strojev in naprav ter uporabe elektronskih vezij.

Po opravljenem izpitu iz tega predmeta bo študent sposoben izkazati znanje in razumevanje osnov mehatronskih in elektromehanskih sistemov in uporabo pridobljenega znanja v analizi teh sistemov.

#### Intended learning outcomes:

Understanding basic laws of mechanics and electrical engineering, which will enable students to solve practical professional problems in the fields of mechatronics, which covers statics, strength, kinematics, dynamics, hydromechanics, functioning of electrical engines and devices and the use of electronic circuits.

Upon passing the exam, students will be able to demonstrate knowledge and understanding the fundamentals of mechatronic and electromechanical systems. Thus, they will be able to use the acquired knowledge in the analysis of such systems.

#### Metode poučevanja in učenja:

Predavanja: pri predavanjih študent spozna teoretične vsebine predmeta. Del predavanj se izvaja na klasični način v predavalnici, del pa v obliki e-predavanj (e-predavanja se lahko izvajajo na videokonferenčni način ali s pomočjo posebej v ta namen didaktično pripravljenih e-gradiv v virtualnem elektronskem učnem okolju).

#### Learning and teaching methods:

Lectures: by lectures students understand the theoretical frameworks of the course. Part of the lecture course is in a classroom while the rest is in the form of e-learning (e-lectures may be given via video-conferencing or with the help of specially designed e-material in a virtual electronic learning environment).

Vaje: pri vajah študent utrdi teoretično znanje in spozna aplikativne možnosti mehatronskih sistemov v logistiki. Vaje se izvajajo na klasični način v predavalnici, v obliki laboratorijskih vaj ter v okviru elektronskega učnega okolja.

Tutorials: students enhance their theoretical knowledge and get familiar with the applied opportunities of mechatronics systems in logistics. Tutorials are performed on a classical way in a classroom, in the framework of the laboratory work and in the framework of the electronic learning environment.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
<ul style="list-style-type: none"> <li>• Opravljene obveznosti e-predavanj in e-vaj so pogoj za pristop k izpitu.</li> <li>• Pisni izpit</li> <li>• ustni izpit,</li> <li>• laboratorijske vaje.</li> </ul> <p>(za uspešno opravljen predmet je potrebno, da so vsi trije deli izpita ocenjeni več kot 50 %)</p>	<p>30 %</p> <p>50 %</p> <p>20 %</p>	<ul style="list-style-type: none"> <li>• Successful completion of e-lectures and e-tutorials is a prerequisite for entering the exam.</li> <li>• Written exam,</li> <li>• oral exam,</li> <li>• laboratory work.</li> </ul> <p>(to successfully pass the exam, all three parts of the exam needs to be evaluated above 50 % )</p>

Reference nosilca / Lecturer's references:

1. Lerher, T., Borovinšek, M., Ficko, M., Palčič, I. (2017). Parametric study of throughput performance in SBS/RS based on simulation. International journal of simulation modelling, Vol. 16, No. 1, 96-107, doi: [10.2507/IJSIMM16\(1\)8.372](https://doi.org/10.2507/IJSIMM16(1)8.372).
2. Lerher, T., Ekren, B. Y., Sari, Z., Rosi. B. (2016). Method for evaluating the throughput performance of shuttle based storage and retrieval systems. Technical Gazette, Vol. 23, No. 3, 715-723.
3. Lerher, T., Ekren, B. Y., Sari, Z., Rosi. B. (2015). Simulation Analysis of Shuttle Based Storage and Retrieval Systems. International Journal of Simulation Modelling, Vol. 14, No. 1, 48-59. doi: [10.2507/IJSIMM14\(1\)5.281](https://doi.org/10.2507/IJSIMM14(1)5.281).
4. LERHER, Tone, EDL, Milan, ROSI, Bojan. Energy efficiency model for the mini-load automated storage and retrieval systems. Int. j. adv. manuf. technol., August 2013, doi: [10.1007/s00170-013-5253-x](https://doi.org/10.1007/s00170-013-5253-x).
5. LERHER, Tone, ŠRAML, Matjaž, POTRČ, Iztok. Simulation analysis of mini-load multi-shuttle automated storage and retrieval systems. Int. j. adv. manuf. technol., 2011, vol. 54, no. 1/4, str. 337-348, doi: [10.1007/s00170-010-2916-8](https://doi.org/10.1007/s00170-010-2916-8).
6. LERHER, Tone, POTRČ, Iztok, ŠRAML, Matjaž, TOLLAZZI, Tomaž. Travel time models for automated warehouses with aisle transferring storage and retrieval machine. Eur. J. oper. res.. [Print ed.], Sep. 2010, vol. 205, iss. 3, str. 571-583, doi: [10.1016/j.ejor.2010.01.025](https://doi.org/10.1016/j.ejor.2010.01.025).
7. LERHER, Tone, ŠRAML, Matjaž, POTRČ, Iztok, TOLLAZZI, Tomaž. Travel time models for double-deep automated storage and retrieval systems. Int. J. Prod. Res., June 2010, vol. 48, no. 11, str. 3151-3172, doi: [10.1080/00207540902796008](https://doi.org/10.1080/00207540902796008).