

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Geometrijske specifikacije proizvodov
Course title:	Geometric Product Specifications
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Konstruiranje (smer)	1. letnik	2. semester

Univerzitetna koda predmeta/University course code: 0566879

Koda učne enote na članici/UL Member course code: 6029-M

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		30			65	5

Nosilec predmeta/Lecturer: Robert Kunc, Samo Zupan

Vrsta predmeta/Course type: Obvezni strokovni predmet na smeri Konstruiranje, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Design Engineering, which is an elective specialised course in other fields of study.

Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: **Prerequisites:**

Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.	Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.
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Vsebina: **Content (Syllabus outline):**

1. Predavanje: Uvod in osnovne definicije - Definicija geometrijskih specifikacij proizvodov (GPS), vsebina predmeta in povezave	1. Lecture: Introduction and basic definitions - Definition of geometrical product specifications (GPS), course content and links.
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<ul style="list-style-type: none"> - Temeljna načela GPS po ISO in nekatere ključne razlike proti drugim standardom <p>2. Predavanje: GPS na virtualnih (3D) modelih in na tehničnih risbah (2D)</p> <ul style="list-style-type: none"> - Nivoji informacij GPS, matrika GPS - Sistem ISO standardov za GPS (opredelitev namena standardov po uporabniških nivojih) - Osnovne definicije GPS, terminologija - Nove definicije toleranc dolžinskih in kotnih mer (ISO 14405 – 14 novih definicij) <p>3. Predavanje: Geometrijsko dimenzioniranje in toleriranje (GDT)</p> <ul style="list-style-type: none"> - Predstavitev, definicije, načela in pravila - Razdelitev toleranc: velikostne (dolžinske in kotne) in konske (geometrijske), razlike, primerjava in pomanjkljivosti - Podrobne definicije geometrijskih toleranc (14) s posebnostmi <p>4. Predavanja: GDT – baze in bazni sistemi</p> <ul style="list-style-type: none"> - Kontrolirani ter referenčni geometrijski elementi - baze in bazne tarče - Kompleksne definicije in zapisi baz in baznih sistemov v 3D (virtualni modeli) in 2D prostoru (tehnične risbe) <p>5. Predavanje: Materialni pogoji GDT, pomen in uporaba</p> <ul style="list-style-type: none"> - Definicije: teoretično idealno stanje (TED in TEG), realno stanje, ovojnice, virtualna stanja, najslabša možna stanja... - Materialna stanja in pogoji pri GT: največja količina materiala (MMR), najmanjša količina materiala (LMR) in pogoj recipročnosti (RPR) - Tolerančne cone in pravila za kontrolo toleranc <p>6. Predavanje: GT – oblike, orientacije in teka</p> <ul style="list-style-type: none"> - Pomen in namen uporabe - Kompleksni primeri uporabe geometrijskih toleranc - Interpretacija zahtev GT in načini kontrole (metrološko in matematično) <p>7. Predavanje: GT – tolerance lege in tolerance profila</p> <ul style="list-style-type: none"> - Pomen in namen uporabe - Kompleksni primeri uporabe tolerance lege, bonus tolerance in bonus premika baze - Kompleksni primeri uporabe profilnih toleranc - Interpretacija zahtev GT in način kontrole <p>8. Predavanje: Statistične tolerance</p> <ul style="list-style-type: none"> - Statistične cenilke v GDT in osnove statistične kontrole (SPC) dimenzijske in geometrijske natančnosti - Definicije in pomen statističnih toleranc v moderni proizvodnji <p>9. Predavanje: Načini kontrole geometrijskih toleranc (GT)</p>	<ul style="list-style-type: none"> - Fundamental principles of GPS in accordance with ISO and key differences between ISO and other standards. <p>2. Lecture: GPS on virtual (3D) models and technical drawings (2D)</p> <ul style="list-style-type: none"> - GPS information levels, GPS matrix. - ISO standard system for GPS (identification of the purpose of different standards user levels). - Basic definitions of GPS, terminology. - New definitions of tolerances for linear and angular dimensions (ISO 14405 – 14 new definitions). <p>3. Lecture: Geometrical dimensioning and tolerancing (GDT)</p> <ul style="list-style-type: none"> - Presentation, definitions, principles and rules. - Tolerance types: size tolerances (linear and angular) and zone (geometrical) tolerances, differences, comparison and deficiencies. - Detailed definitions of geometrical tolerances (14) with specificities. <p>4. Lecture: GDT – datums and datum systems (i.e. references)</p> <ul style="list-style-type: none"> - Controlled and reference geometrical elements – datums and datum targets. - Complex definitions and notations of datums and datum systems in 3D (virtual models) and 2D space (technical drawings). <p>5. Lecture: Material conditions of GDT, meaning and use</p> <ul style="list-style-type: none"> - Definitions: theoretically ideal states (TED and TEG), true state, envelopes, virtual states, worst case state (i.e. condition) etc. - Material states and conditions using with GT: maximum material requirement (MMR), least material requirement (LMR) in reciprocity requirement (RPR). - Tolerance zones and rules for tolerance control. <p>6. Lecture: GT – form, orientation and runout tolerances</p> <ul style="list-style-type: none"> - Meaning and intended use. - Complex examples of using geometrical tolerances. - Interpretation of GT requirements and control method (metrological in mathematical). <p>7. Lecture: GT – position and profile tolerances</p> <ul style="list-style-type: none"> - Meaning and intended use. - Complex examples of using geometrical tolerances, bonus tolerance and datum shift. - Complex examples of using profile tolerances. - Interpretation of GT requirements and control method. <p>8. Lecture: Statistical tolerances</p> <ul style="list-style-type: none"> - Statistical estimators in GDT and basics of statistical
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<ul style="list-style-type: none"> - 2D in 3D tolerančne cone, integralni in matematično izvedeni geometrijski elementi - Metode ekstrakcije dejanske geometrije izdelkov po GPS standardih - Definicija in kontrola dimenzijskih in geometrijskih toleranc po načelu najslabšega možnega stanja in po statističnem načelu <p>10. Predavanje: Tolerančne analize (TA)</p> <ul style="list-style-type: none"> - Namen ter osnovne definicije TA, različne vrste TA - Linearne TA, definicije, metode, prednosti in pomanjkljivosti - Kompleksne (prostorske) TA - Programska orodja za TA, zmogljivosti in omejitve - TA po načelu najslabšega možnega stanja in po statističnih načelih <p>11. Predavanje: Stanje tehničnih površin in robov</p> <ul style="list-style-type: none"> - Profilne metode popisa stanja površin – hrapavost (R), valovitost (W) in primarni profil (P) - Ne-profilne metode definicij stanja površin in zapisa v TD - Stanje robov in posebnosti <p>12. Predavanje: Zapis GPS v 3D virtualne modele in prenos v tehnično dokumentacijo (2D)</p> <ul style="list-style-type: none"> - GPS definicije in simbolni zapisi (ISO, ASME...), prednosti, pomanjkljivosti, razlike - Posebnosti zapisa geometrijskih toleranc in referenc v 3D modele (nove definicije in pravila po ISO) - Programska oprema, zmogljivost, prednosti in pomanjkljivosti <p>13. Predavanje: Zapis (standardi) in programska oprema za prenos in branje prostorskih informacij GPS v proizvodnem procesu (lahki 3D formati)</p> <ul style="list-style-type: none"> - Standardizirani formati zapisa, namen, prednosti in pomanjkljivosti - Programska oprema, prednosti in pomanjkljivosti, primerjava <p>14. Predavanje: Sistemi vodenja tehnične dokumentacije</p> <ul style="list-style-type: none"> - PDM sistemi in programska oprema - PLM sistemi in programska oprema - ERP sistemi in programska oprema - Prenos informacij med sistemi, omejitve in pomanjkljivosti <p>15. Predavanje: Dokumentarni sistemi in standardi kakovosti, razno</p> <ul style="list-style-type: none"> - ISO 9001 - Tehnična dokumentacija v sistemih za trženje, spletni konfiguratorji proizvodov, itd. - Sklep 	<p>process control (SPC) of dimensional and geometrical accuracy.</p> <ul style="list-style-type: none"> - Definitions and meaning of statistical tolerances in modern production. <p>9. Lecture: Methods of geometrical tolerance (GT) control</p> <ul style="list-style-type: none"> - 2D and 3D tolerance zone, integral and mathematically derived geometrical elements. - Methods of product geometry extraction in accordance with GPS standards. - Definition and control of dimensional and geometrical tolerances according to “worst case” and statistical principle. <p>10. Lecture: Tolerance analyses (TA)</p> <ul style="list-style-type: none"> - Purpose and basic definitions of TA, types of TA. - Linear TA, definitions, methods, advantages and disadvantages. - Complex (spatial) TA. - Software tools for TA, efficiency and limitations. - TA according to “worst case” and statistical principle. <p>11. Lecture: State of technical surfaces and edges</p> <ul style="list-style-type: none"> - Profile methods of surface states definition – roughness (R), waviness (W) and primary profile (P). - Non-profile methods of surface state definitions on TD. - Edges states and specificities. <p>12. Lecture: Adding GPS in 3D virtual models and transmission into technical documentation (2D)</p> <ul style="list-style-type: none"> - GPS definitions and symbolic notations (ISO, ASME etc.), advantages, deficiencies, differences. - Specificities of adding geometrical tolerances and references into 3D models (new definitions and rules in accordance with ISO). - Software, efficiency, advantages and deficiencies. <p>13. Lecture: Standard symbolic notations and software for transmission and reading of spatial information of GPS in the production process (easy 3D formats)</p> <ul style="list-style-type: none"> - Standardized file formats, purpose, advantages and deficiencies. - Software, advantages and deficiencies, comparison. <p>14. Lecture: Systems of technical documentation management</p> <ul style="list-style-type: none"> - PDM systems and software. - PLM systems and software. - ERP systems and software. - Transmission of information between systems, limitations and deficiencies. <p>15. Lecture: Documentary systems, quality standards and miscellaneous</p>
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	- ISO 9001 - Technical documentation in marketing systems, online product configurators, etc. - Conclusion.
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Temeljna literatura in viri/Readings:

<p>Osnovna:</p> <ol style="list-style-type: none"> 1. ZUPAN, Samo, KUNC, Robert, ŽEROVNIK Andrej. Geometrijske specifikacije proizvodov (GPS); gradivo /univerzitetni učbenik v pripravi 2. ZUPAN, Samo, KUNC, Robert, ŽEROVNIK Andrej. Geometrijske tolerančne analize (GTA); gradivo/univerzitetni učbenik v pripravi 3. PREBIL, Ivan, ZUPAN, Samo. Tehnična dokumentacija. 2. izd. Ljubljana: Stri svetovanje, 2011. <p>Dodatna:</p> <ol style="list-style-type: none"> 1. ZUPAN, Samo, PREBIL, Ivan, NOVAK, Aleksander. Geometrijsko dimenzioniranje in toleriranje - GDT : tolerance oblike, lege in teka, Študijsko gradivo. Ljubljana: Fakulteta za strojništvo, CEMEK, 1999. 2. ZUPAN, Samo, PREBIL, Ivan, NOVAK, Aleksander. Skladi toleranc : tolerančna analiza, Študijsko gradivo. Ljubljana: Fakulteta za strojništvo, CEMEK, 1999. 	
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Cilji in kompetence:

Objectives and competences:

<p>Cilji:</p> <ol style="list-style-type: none"> 1. Pridobiti teoretično in praktično znanje s področja podrobnih geometrijskih specifikacije proizvodov (GPS) 2. Razumevanje načel in pravil standardiziranega sistema GDT in praktična uporaba 3. Razumevanje statističnih geometrijskih toleranc in statistične kontrole proizvodnih procesov ter praktična uporaba 4. Razumevanje in razvoj tolerančnih analiz (TA) ter praktična uporaba 5. Poznavanje in razvoj ter uporaba specializiranih programskih orodij (GDT, TA) 6. Poznavanje ključnih veljavnih standardov in načel ter pravil s področja GPS, GDT in TA, sistemov kakovosti in dokumentarnih sistemov <p>Kompetence:</p> <p>S2-MAG in P1-MAG, P2-MAG, P3-MAG, : Sposobnost poglobljenega razumevanja in uporabe načel in splošnih pravil GPS, načel in pravil geometrijske natančnosti in točnosti (GDT) in izvajanja tolerančnih analiz (TA).</p> <p>S6-MAG: Sposobnost uporabe informacijsko-komunikacijske tehnologije z upoštevanjem načel in pravil zahtev glede dimenzijske natančnosti na 3D modelih (MBD) in risbah</p> <p>S7-MAG in P3-MAG, P7-MAG: Usposobljenost za</p>	<p>Objectives:</p> <ol style="list-style-type: none"> 1. 1.Gaining theoretical and practical knowledge in the field of detailed geometrical product specifications (GPS). 2. Understanding principles and rules of standardized GDT system and practical use. 3. Understanding statistical geometrical tolerances and statistical control of production processes and practical use. 4. Understanding and developing tolerance analyses (TA) and practical use. 5. Understanding and development of specialised software tools (GDT, TA). 6. Understanding key applicable standards and principles and rules in the field of GPS, GDT and TA, quality systems and documentary systems. <p>Competences:</p> <p>S2-MAG and P1-MAG, P2-MAG, P3-MAG: In-depth understanding and use of principles and general rules of GPS, principles and rules of geometrical precision and accuracy (GDT) and tolerance analysis (TA) performance.</p> <p>S6-MAG: Ability to use information and communication technologies by taking account of the principles and rules of dimensional accuracy requirements in 3D models (MBD) and drawings.</p> <p>S7-MAG and P3-MAG, P7-MAG: Capacity to use</p>
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<p>uporabo standardiziranih pravil GPS za doseganje želene funkcionalnosti in sestavljenosti pri samostojnem reševanju tehničnih problemov v strojništvu.</p> <p>S8-MAG: Sposobnost iskanja virov, kritične presoje informacij, samostojnega nadgrajevanja pridobljenih znanj in poglobljanja znanja o strukturi in nivojih ISO in drugih standardov ter teoretičnih podlagah GPS, GDT in TA.</p>	<p>standardised GPS rules to achieve desired functionality and composability in solving technical problems in mechanical engineering.</p> <p>S8-MAG: Ability to find sources, critically evaluate information, upgrade gained knowledge on structure and levels of ISO and other standards and theoretical foundation of GPS, GDT and TA.</p>
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Predvideni študijski rezultati:

Intended learning outcomes:

<p>Znanja:</p> <p>Z2: Poglobljeno teoretično, metodološko in analitično znanje z elementi raziskovanja, ki je osnova za zelo zahtevno strokovno delo:</p> <ul style="list-style-type: none"> • Znajo interpretirati zahtevne tehnične risbe in 3D modele z dodanimi simboličnimi informacijami in znajo samostojno izdelati zahtevne tehnične risbe ter opremiti 3D modele s simboli in pridevki. • Poznajo in razumejo zahtevne koncepte in pravila toleriranja (GDT) in označevanja stanja površin in robov. • Razumejo in znajo uporabiti teoretična ozadja in metode za izvajanje linearnih geometrijskih tolerančnih analiz (TA) ter razumejo in znajo uporabiti programska orodja za zahtevne kompleksne prostorske tolerančne analize. • Razumejo vlogo in pomen zahtevnih pravil tehnične dokumentacije in pomen teh pravil za funkcionalnost. • Razumejo vlogo in pomen dokumentarnih sistemov, jih znajo pravilno zasnovati ter kreirati oziroma izbrati in uporabiti v tehnični praksi. <p>Spretnosti:</p> <p>S2.1: Obvladovanje zelo zahtevnih, kompleksnih delovnih procesov in metodoloških orodij na specializiranih področjih.</p> <ul style="list-style-type: none"> • Interpretacija in ustvarjanje/opremljanje zahtevnih 3D modelov in 2D tehničnih risb s potrebnimi simbolnimi GPS informacijami. <p>S2.2: Načrtovanje in vodenje delovnega procesa na podlagi ustvarjalnega reševanja problemov, povezanih s področjem izobraževanja in usposabljanja.</p> <ul style="list-style-type: none"> • Zasnova in uporaba sistemov za vodenje tehnične dokumentacije in prenos v druge sisteme. 	<p>Knowledge:</p> <p>Z2: In-depth theoretical, methodological and analytical knowledge with elements of research, which is the basis for demanding specialist work:</p> <ul style="list-style-type: none"> • Know how to interpret complex technical drawings and 3D models with added symbol information and produce complex technical drawings and complete 3D models with symbols and attributes. • Know and understand complex concepts and rules of tolerancing (GDT) and surface and edges states marking. • Understand and know how to use theoretical backgrounds and methods for conducting linear geometrical tolerance analyses (TA) and understand and know how to use software tools for complex spatial tolerance analyses. • Understand the role and meaning of complex rules of technical documentation and the importance of those rules for functionality. • Understand the role and meaning of documentary systems, know how to design them or select and use them in technical practice. <p>Skills:</p> <p>S2.1: Knowledge of very demanding, complex work processes and the methodological tools in specialised fields.</p> <ul style="list-style-type: none"> • Interpretation and creation/completion of complex 3D models and 2D technical drawings with necessary symbol GPS information. <p>S2.2: Planning and management of work process based on creative solving of problems connected to the field of education and training.</p> <ul style="list-style-type: none"> • Design and use of systems for management of technical documentation and transmission into other systems. • Introduction and use of applicable GPS standards
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<ul style="list-style-type: none"> Uvajanje in uporaba veljavnih standardov GPS v praksi. <p>S2.3: Sposobnost izvirnih dognanj/stvaritev in kritične refleksije.</p> <ul style="list-style-type: none"> Izvajanje linearnih in kompleksnih tolerančnih analiz ter možno ukrepanje na osnovi rezultatov. 	<p>in practice.</p> <p>S2.3: Ability to produce original findings/creations and critical reflexion.</p> <ul style="list-style-type: none"> Conducting linear and complex tolerance analyses and possible action based on the obtained results.
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Metode poučevanja in učenja:

Learning and teaching methods:

<p>P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.</p> <p>P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P4 Laboratorijske vaje z namensko uporabo računalniških programov za modeliranje in izdelavo tehničnih risb</p> <p>P8 Izdelava in predstavitev aplikativnih seminarskih/projektnih nalog.</p> <p>P12 Individualizirane lekcije in domače naloge v spletni učilnici.</p> <p>P14 Virtualne predstavitve.</p> <p>P15 Uporaba video vsebin kot priprava na predavanja in vaje.</p>	<p>P1 Auditory lectures with solving selected and typical theoretical and practically useful examples.</p> <p>P2 Presentation of subject matter based on the arranged and previously explained scheme.</p> <p>P4 Laboratory work with intended use of software for modelling and creation of technical drawings.</p> <p>P8 Creation and presentation of applicative seminar/project assignments.</p> <p>P12 Individual lessons and home assignments in virtual classroom.</p> <p>P14 Virtual presentations.</p> <p>P15 Use of video contents as presentation as preparation for lectures and tutorials.</p>
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Načini ocenjevanja:

Delež/Weight

Assessment:

Teoretični izpit (pisno/ustno)	50,00 %	Theory examination (written/oral)
Delo na laboratorijskih vajah (vključno z izdelki)	20,00 %	Practical examination in laboratory (written/oral)
Projektna naloga (pisno)	30,00 %	Project work (written)

Reference nosilca/Lecturer's references:

Robert Kunc

- TRAJKOVSKI, Jovan, AMBROŽ, Miha, KUNC, Robert. The importance of friction coefficient between vehicle tyres and concrete safety barrier to vehicle rollover - FE analysis study. *Strojniški vestnik*, ISSN 0039-2480, Dec. 2018, vol. 64, no. 12, str. 753-762, SI 106, ilustr. https://www.sv-jme.eu/?ns_articles_pdf=/ns_articles/files/ojs/5290/public/5290-30742-1-PB.pdf&id=6225, doi: 10.5545/sv-jme.2018.5290. [COBISS.SI-ID 16220699]
- TRAJKOVSKI, Jovan, KUNC, Robert, PREBIL, Ivan. Blast response of centrally and eccentrically loaded flat-, U-, and V-shaped armored plates : comparative study. *Shock waves*, ISSN 0938-1287, 2017, vol. 27, iss. 4, str. 583-591, ilustr., doi: 10.1007/s00193-016-0704-6. [COBISS.SI-ID 15164443]
- BIČEK, Matej, KUNC, Robert, ZUPAN, Samo. Mechanical impact on in-wheel motor's performance. *Journal of mechanics*, ISSN 1727-7191. [Print ed.], 2016, str. 1-12, ilustr. <https://www.cambridge.org/core/journals/journal-of-mechanics/article/div-classtitlemechanicalimpact-on-in-wheel-motorandaposs->

performancediv/A4D5DB17B7102D3897C02AAAC07A32A7, doi: 10.1017/jmech.2016.95. [COBISS.SI-ID 15295259]

4. PREBIL, Ivan, KUNC, Robert. Stahlleitplanken. V: BURG, Heinz (ur.), MOSER, Andreas (ur.). Handbuch Verkehrsunfallrekonstruktion : Unfallaufnahme, Fahrdynamik, Simulation, (Praxis), (ATZ-MTZ-Fachbuch). 2., aktualisierte Aufl. Wiesbaden: Vieweg + Teubner. 2009, str. 901-933, ilustr. [COBISS.SI-ID 11087387]

Samo Zupan

1. BIČEK, Matej, KUNC, Robert, ZUPAN, Samo. Mechanical impact on in-wheel motor's performance. Journal of mechanics, ISSN 1727-7191. [Print ed.], 2016, str. 1-12, ilustr. <https://www.cambridge.org/core/journals/journal-of-mechanics/article/div-classtitlemechanical-impact-on-in-wheel-motorandaposs-performancediv/A4D5DB17B7102D3897C02AAAC07A32A7>, doi: 10.1017/jmech.2016.95. [COBISS.SI-ID 15295259]
2. TUŠEK, Jaka, ZUPAN, Samo, ŠARLAH, Alen, PREBIL, Ivan, POREDOŠ, Alojz. Development of a rotary magnetic refrigerator. International journal of refrigeration, ISSN 0140-7007. [Print ed.], 2010, vol. 33, iss. 2, str. 294-300, ilustr., doi: 10.1016/j.ijrefrig.2009.11.003. [COBISS.SI-ID 11191067]
3. JOVANOVIĆ, Marko, ZUPAN, Samo, STARBEK, Marko, PREBIL, Ivan. Virtual approach to holonic control of the tyre-manufacturing system. Journal of manufacturing systems, ISSN 0278-6125, Jan. 2014, vol. 33, iss. 1, str. 116-128, ilustr., doi: 10.1016/j.jmsy.2013.07.005. [COBISS.SI-ID 13259035]
4. ZUPAN, Samo, NOVAK, Aleksander, PREBIL, Ivan. Konstrukcija magnetna hladilnika z vrtečim diskom MH SMM 2013 : poročilo. Ljubljana: Fakulteta za strojništvo, Katedra za modeliranje v tehniki in medicini, 2014. 23 f., 3 f. pril., graf. prikazi. [COBISS.SI-ID 13821979]
5. ZUPAN, Samo. Geometrijsko dimenzioniranje in toleriranje (GDT). Informator ZSIS : glasilo Zveze strojnih inženirjev Slovenije, ISSN 1408-9351, 2008, letn. 10, št. 27, str. 4-7. [COBISS.SI-ID 10732827]