Budapesti Műszaki és Gazdaságtudományi Egyetem
Gépészmérnöki Kar

ÚTMUTATÓ

a Mechanical Engineering Modelling mérnöki mesterszak (MSc)
2009/2010. őszi félévében beiratkozott hallgatói részére

Szakfelelős:
Dr. Stépán Gábor
dékán, egyetemi tanár, akadémikus

Összeállította:
Dr. Szekrényes András
egyetemi adjunktus

Budapest, 2009. szeptember

Tartalomjegyzék

Előszó

A Budapesti Műszaki és Gazdaságtudományi Egyetem Gépészmérnöki Karán 1871 óta folyik mérnökképzés.

A Kar 2005-ben indította el négy szakon az Európai Felsőoktatási Térségben egységesített BSc (Bachelor of Science) alapdiplomás képzést. E négy szak: a gépészmérnöki szak, az energetikai mérnök szak, a mechatronikai mérnöki szak és az ipari termék- és formatervező mérnök szak. A képzés valamennyi szakon hétszemeszteres.

A mérnöki mesterszakra nemcsak a BME-n végzett alapdiplomás (BSc) mérnökök jöhetnek, hanem az ország bármely felsőoktatási intézményében végzett gépészmérnöki, mechatronikai mérnöki, közlekedésmérnöki BSc diplomával rendelkezők is. A felvételi feltételeket úgy alakítottuk ki, hogy más mérnöki, továbbá fizikus, matematikus, informatikus alapképzési diplomával rendelkezők is bekapcsolódhatnak a mesterképzésbe néhány kiegészítő feltétel teljesítése mellett.

Remélem és hiszem, hogy a képzés során olyan mérnökké válnak, akik mindenben eleget tesznek Pattantyús Á. Géza néhai műegyetemi professzor által megfogalmazott elvárásoknak:

„A mérnöki hivatás felelősségteljes gyakorlásához az alapos szaktudáson felül széles látókörre, erkölcsi értékkel párosult jellemerőre és felelősségtudatra van szükség.”

Mindnyájuknak jó egészséget, elegendő akaraterőt és tanulmányi sikereket kíván

Dr. Stépán Gábor
dékán

1. A Mechanical Engineering Modelling képzésről és a gépészmérnöki pályáról

A hazai gépipar és gépgyártás évek óta az ország gazdasági növekedésének többszörösét meghaladó fejlődést mutat, amelynek meghatározó tényezője az export jelentős bővülése: az ország exportjának meghatározó részét a gépipar adja.

A klasszikus okleveles gépészmérnökképzés mindig is indított olyan szakokat, szakirányokat, amelyek kifejezetten kutató-fejlesztő tevékenységre készítettek fel, törekedtek a legfrissebb elméleti, kísérleti és számítástechnikai ismeretek közvetlen alkalmazására a gépészmérnökök néhány olyan szakterületén, ahol a matematika egyes fejezetei mellett a természettudományos alapismeretek közül a szilárd testek és folyadékok mechanikája, a termodinamika, az informatika, vagy akár az elektromosságtan kiemelt és elmélyült ismeretére volt szükség.

Az 1990-es években, az ipar szerkezet- és tulajdonosváltása közben érezhetően csökkent a tervező, fejlesztő, és különösen a kutató gépészmérnöki munkakörök aránya, miközben nőtt az üzemeltetésben, karbantartásban illetve a műszaki kereskedelemben, szoftverfejlesztésben alkalmazott gépészmérnökök száma. Már az 1990-es években is voltak azonban jelei annak, hogy nyugat-európai cégek telepítenek hazánkba tervező, fejlesztő részlegeket, illetve alkalmazzák fiatal mérnökeinket időlegesen ilyen munkakörökben nyugaton, majd hazaküldve őket hazánkban is alakítanak kisebb innovációs részlegeket, intézeteket. Ezek az egységek váratlanul nagy igényt mutatnak például gépészmérnöki modellezéshez jól értő, fejlesztési munkákban a bonyolult szoftver rendszereket jól alkalmazni tudó, azok elméleti alapjait mélyen értő gépészmérnökökre, ráadásul mind a napi munkavégzésben, mind pedig az információk megszerzésében alapvető követelmény a velük elsősorban angol nyelven való szakmai kommunikáció.

A Gazdaság- és Vállalkozáselemző Intézet 2008-ban készített felmérése szerint a BME Gépészmérnöki Kara a legnagyobb presztízzsel rendelkező műszaki felsőoktatási intézmény ma Magyarországon [http://www.gvi.hu/data/research/diploma_2008_jelentes_200810928.pdf]. A BME Gépészmérnöki diplomáinak jó nemzetközi elismertségét mutatja diplomásaink ideiglenes vagy állandó bekapcsolódása a nemzetközi munkaerőpiacba, hogy hazánk nemzetközi integrálódásával párhuzamosan egyre több nyugat-európai és amerikai hallgató tanul nálunk részképzésen angol nyelven, magyar rokoni kapcsolatokkal rendelkezők esetében gyakran meg is szerzik a gépészmérnöki diplomát a BME-n. Számos hallgatónk van a világ minden tájáról, és ő az érdeklődés a szomszédos országok magyar anyanyelvű lakossága részéről. A képzés tehát mind interdiszciplináris jellege, mind pedig angol oktatási nyelve miatt összességében kitűnő lehetőséget ad arra, hogy abba időszakonként, hosszabb-rövidebb időre bekapcsolódjanak más országokból idelátogató kiváló vendégprofesszorok, továbbá cserehallgatóként részképzésen hazánk iránt érdeklődő, itt hosszabb-rövidebb tanulmányokat folytatni kívánó külföldi hallgatók.

2. A kétciklusú képzésről

Az utóbbi időben egyre többet hallunk az egységes „európai felsőoktatási térség” kialakításáról. Ezt a “Bolognai Nyilatkozat”-ban leírtak alapján kívánják megvalósítani, amelyhez szükséges folyamatokat, átalakításokat a bolognai folyamatként említik. E nyilatkozatban lefektetett célok egyike az ún. többciklusú képzés bevezetése, amelynek segítségével kívánják a különböző felsőoktatási intézményekben szerzett diplomákat összehasonlítani, elfogadni.

Hazánk is csatlakozott ehhez a folyamathoz. A műszaki felsőoktatásban többségében már 2005-től bevezetésre került a kétciklusú képzés. Ez alapvetően eltér attól a gyakorlattól, amelyet a korábbi főiskolai és egyetemi képzés jelentett. Ez idáig a középfokú végzettséget szerzett hallgatónak döntenie kellett, hogy felsőfokú tanulmányait az elsősorban gyakorlati képzést szolgáló főiskolán, vagy az inkább mélyebb elméleti ismereteket nyújtó egyetemen folytatja.

Az új képzés egyik lényeges jellemzője, hogy az első ciklus végén (alapdiploma, BSc, baccaleureus) hét szemeszternyi tanulás (210 kredit gyűjtése után a hallgató olyan gyakorlati ismereteket is elsajátít, amely lehetővé teszi számára az iparban való elhelyezkedést – azaz rendelkezik a munkába álláshoz szükséges tanúsítvánnyal. Azok számára viszont, akik további ismereteket kívánnak szerezni valamelyik speciális szakterületen, elegendő elméleti alapot ad, hogy további tanulmányaikat is sikeresen végezhessék. E második ciklus végén mester (MSc, Magister) végzettséget szerezhetnek további négy félévnyi tanulás (120 kredit megszerzése) után. A legjobbaknak lehetőségük van tanulmányaik folytatására a doktori képzésben (PhD fokozatot szerezhetnek), amely további hat féléves tanulmányt (180 kredit megszerzése, a doktori záróvizsgák letétele és a disszertáció megvédése) jelent.

Jóllehet az alapdiploma jogilag független attól, hogy melyik intézményben szerezte meg valaki, de – mint ahogy a világ bármely részén, úgy Magyarországon is – mivel a különböző intézmények oktatási színvonala eltérő, így nem mindegy a továbbtanulni szándékozók számára az intézmény megválasztása. Azok a hallgatók, akik alapdiplomájukat (első ciklus) egyetemen szerzik meg, olyan speciális ismereteket is elsajátítanak, amelyek birtokában nagyobb sikerrel végezhetik majd tanulmányaikat a második ciklus során. Természetesen – ez az első ciklus jellegéből is következik – egyúttal olyan gyakorlati ismeretekhez is hozzájutnak, amelyek birtokában a továbbtanulni nem szándékozók az iparban sikerrel elhelyezkedhetnek.

A BME Gépészmérnöki Kara az alapdiplomás képzés tananyagának kialakítása során is arra törekedett, hogy a képzést sikeresen teljesítő hallgatók tudása az egyetem tradícióinak megfelelően magas színvonalú, korszerű, európai mércével mérve is versenyképes legyen.

2005-től a Gépészmérnöki Kar áttért a kétciklusú képzésre. Az első ciklus tanulmányai során a hallgatók a mintatanterv szerint hét szemeszter alatt 210 kredit értékű tanulmányokat folytatnak, és szakdolgozat készítése, valamint sikeres záróvizsga után alapdiplomát (BSc fokozat) szerezhetnek, amennyiben középfokú C-típusú nyelvvizsgával rendelkeznek.

Az alapképzés befejezését követően – azok, akik megfelelő tanulmányi eredményeket értek el – folytathatják tanulmányaikat a mesterképzés keretében államilag finanszírozott vagy térítéses képzés formájában.

Az új kétciklusú képzés sikeres teljesítése más szemléletet kíván. Egy-két szemeszter tanulmányi eredményei és az időközben kialakult vagy átalakult érdeklődés alapján célszerű életpályát tervezni és ehhez igazodó döntéseket hozni. Ilyenek pl. az alapképzés során a szakirány megválasztása, ill. annak eldöntése, hogy az első ciklus elvégzése után a hallgató folytatni kívánja-e

tanulmányait vagy az ipari, mérnöki gyakorlatot választja.

A tanulmányi munka mennyiségének mérése

A mesterdiploma megszerzéséhez a négy szemeszterből álló tanulmányok során 120 kreditpont összegyűjtése szükséges. Ez szemeszterenként átlagosan 30 kreditpontot megszerzését jelenti.

A kreditpontok megszerzésének feltétele a tárgyak követelményeinek teljesítése.

A tanulmányi munka minősítése

A tantárgyakból szerzett érdemjegyek mellett a tanulmányi munka minősítésére szolgál a súlyozott tanulmányi átlag:

$$K = \frac{\sum (\text{érdemjegy} \times \text{kreditpont})}{\sum \text{kreditpont}}.$$

Az ösztöndíj index azt mutatja, hogy az adott félévben mennyiségileg és minőségileg hogyan teljesített a hallgató egy elvárt optimális szinthez képest:

$$\text{ösztöndíj index} = \frac{\sum (\text{megszerzett kreditpont} \times \text{osztályzat})}{30}.$$

A képletből látható, hogy a mintatantervben előírt 30 kreditponttal osztanak, vagyis ha kicsivel több kreditet vesz fel a hallgató, akkor az ösztöndíj index is jobb lehet, ha kevesebbet, akkor az ösztöndíj index biztosan nem lesz abban a félévben 5.0. A számításánál csak a teljesített tantárgyakat kell figyelembe venni.

A görgetett tanulmányi átlagot ugyanúgy kell kiszámítani, mint a súlyozott átlagot. A különbség annyi, hogy az aktuális félév helyett az addigi összes félévre vonatkozó tanulmányi eredmény alapján kell kiszámítani az átlagot.

A kreditrendszerrel kapcsolatos szabályozások

A mesterképzésbe történő becsatlakozás feltétele – megfelelő felvételi eredmény mellett – az, hogy a hallgató az alapdiplomás képzése során bizonyos ismeretekkel rendelkezzen. Mivel a gépészeti modellezés mesterszakra különböző alapszakokról jöhetnek hallgatók, lehetnek olyanok, akik ezeket a „bemeneti feltételeket” csak részben teljesítik. Részükre ún. „felvezető/különbözeti” tárgyakat írunk elő. A kreditrendszer rugalmassága miatt ezeket a tantárgyakat a mesterképzés tárgyai mellett vagy külön félévben lehet felvenni. A „felvezető/különbözeti” tárgyakat a tanulmányok megkezdését követő két félévben kell teljesíteni.

A mesterképzés keretében a tantervben előírt tantárgyakból 120 kreditpontot kell megszerezni. A kreditrendszer keretében lehetőség van arra, hogy minden hallgató a neki megfelelő ütemben és különböző tanulmányi úton jusson el a mesterdiplomához.

A kreditrendszer a tantárgyak felvételében rugalmasságot biztosít. A mesterképzés keretében csak javasolt előtanulmányt írunk elő, melyet a tárgy könnyebb teljesítése érdekében célszerű követni.

A mesterképzés tantervében 33 kreditpont értékű diplomatervezés szerepel, melyet két félévre megosztva lehet elkészíteni (Major Project és Final Project). Kötelező előtanulmányi követelmény, hogy a Major Project tantárgy akkor vehető csak fel, ha a mintatanterv szerinti tantárgyakból legalább 54 kredit értékűt teljesítettek, valamint a gépészmérnökitől különböző BSc szakról érkezett hallgatók részére előírt „felvezető/különbözeti" tantárgyakat maradéktalanul teljesítették.

A mesterképzésben résztvevő hallgató a tanterv tantárgyainak valamint a kritérium tárgyak teljesítése után, az abszolutórium (végbizonyítvány) birtokában tehet záróvizsgát. Oklevél kiállítására a sikeres záróvizsga és a nyelvvizsga követelmények igazolása után kerül sor.

A nyelvi követelményeket a 15/2006.IV.3 OM rendelet szabályozza, mely szerint a mesterfokozat megszerzéséhez államilag elismert legalább középfokú C-típusú nyelvvizsga letétele vagy azzal egyenértékű érettségi bizonyítvány, illetve oklevél szükséges bármely olyan élő idegen nyelvből, amelyen az adott szakmának tudományos szakirodalma van.

Azon hallgatók részére, akik nem teljesítették a szak követelményeinek megfelelő szakmai gyakorlatot, a képzés ideje alatt összefüggő szakmai gyakorlaton kell résztvenni. A szakmai gyakorlat időtartama legalább 4 hét, amelyet a felsőoktatási intézmény tanterve határoz meg.

A tanulmányokkal kapcsolatos részletes szabályozást a Tanulmányi és Vizsgaszabályzat (BME TVSZ) tartalmazza. A hallgatókra vonatkozó fizetési kötelezettségeket és juttatásokat a Térítési és Juttatási Szabályzat (BME TJSZ) rögzíti.

3. Az oktatási tevékenységben résztvevő karok és szervezeti egységek

Az oktatási egység valamely tudományterület művelésére és oktatására létrejött szakmai szervezet, amely általában tanszék, ritkábban intézet. A képzésben az alábbi oktatási egységek működnek közre:

Kar	kód	Tanszék	Cím
GE		**Gépészmérnöki Kar**	
GE	EN	Energetikai Gépek és Rendszerek Tanszék	D ép. III. em.
GE	FO	Mechatronika, Optika és Gépészeti Informatika Tanszék (további régebbi tanszéki kódok: MI)	E ép. III. em. D ép. IV. em.
GE	GT	Gyártástudomány és -technológia Tanszék	E ép. II. em.
GE	GE	Gép- és Terméktervezés Tanszék (további régebbi tanszéki kód: TT)	K ép. mfsz. 79 Mg ép. I. em.
GE	VG	Hidrodinamikai Rendszerek Tanszék	D ép. III. em.
GE	MM	Műszaki Mechanika Tanszék	MM ép. I. em.
GE	MT	Anyagtudomány és Technológia Tanszék	MT ép. fszt.
GE	ÁT	Áramlástan Tanszék	AE ép.
GT		**Gazdaság- és Társadalomtudományi Kar**	
		Üzleti Tudományok Intézet:	
GT	20	Menedzsment és Vállalatgazdaságtan Tanszék	T ép. IV. em.
TE		**Természettudományi Kar**	
		Matematika Intézet:	
TE	90	Differenciálegyenletek Tanszék	H ép. IV. em.
		Fizikai Intézet:	
TE	12	Atomfizika Tanszék	F ép. III. lh. mfsz.
VI		**Villamosmérnöki és Informatikai Kar**	
VI	AU	Automatizálási és Alkalmazott Informatikai Tanszék	V2 ép. IV. em.

4. A tantárgyak kódrendszere

A tantárgyak az Útmutató következő fejezeteiben, az alábbi formában jelennek meg. A magyarázat kedvéért példaként vegyük az alábbi tárgyat:

COUPLED PROBLEMS IN MECHANICS
BMEGEMMMW07

Contact hours: 1+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Kovács Ádám, associate prof.

Topics:
Diffusion problems: thermomechanical, chemomechanical, hygromechanical fields. Coupled piezo-electromechanical equations. Fluid-structure interaction. Smart structures, micro-electromechanical systems. Contact stresses in deformable bodies. Finite element modelling. Mesh coupling. Partitioned analysis. Case studies.

Recommended literature:

1. Zienkiewicz, O.C.; Taylor, R.L., Finite Element Method (5th Edition) Volume 1 - The Basis, Elsevier, 2000.
2. Hearn, E.J., Mechanics of Materials, Volume 2 - The Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials (3rd Edition), Elsevier, 1997.

Minden tantárgynak van egy azonosító kódja, esetünkben ez:

BME	GE	MM	MW	07
egyetem	kar	tanszék	M - mesterképzés, W - Mech. Eng. Mod.	2 karakteres kód

A kód első hét karaktere tartalmazza a BME, a Gépészmérnöki Kar és a tanszék kódját. A kar tanszékeinek nevét, címét és kódját a 3 fejezet táblázata tartalmazza. A következő két karakter a mesterképzésre (M) illetve a Mechanical Engineering Modelling mesterszakra (W) vonatkozik. A kód utolsó két karaktere a tanszéki tárgyak megkülönböztetésére szolgál. A 2. és 3. sorban kiegészítő információk olvashatók. A 2. sorban:

- *a kontakt órák száma (Contact hours)*, utána pedig azok megoszlása: az első az előadás, a második a gyakorlat a harmadik pedig a laboratóriumi gyakorlat;
- *a tantárgy kreditpont értéke (Credits)*, melyeket a tantárgyi követelmények teljesítésével kell megszerezni (a példában „3” kredit szerepel);
- *a félév végi osztályzat jellege (Requirement)*, amely lehet vizsgajegy (examination) vagy félévközi munkával megszerezhető jegy (practical mark);
- *a tantárgyfelelős(ök) (Responsible) neve.* Figyelem: nem feltétlenül azonos a tárgy előadójával.
- Ezt követi a tantárgy tartalmát tömören összefoglaló néhány soros annotáció, majd a tárgyhoz ajánlott szakirodalom.

5. Mechanical Engineering Modelling mérnöki mesterszak tanterve

A tantervben előforduló rövidítések magyarázata a következő:

lect – lecture
sem - seminar (classroom practice)
lab - laboratory practice
cr – credits
p/e/s - practical mark/exam/signature

Beginning of the term: spring				Mechanical Engineering Modelling	Beginning of the term: fall			
1. Semester (spring)	2. Semester (fall)	3. Semester (spring)	4. Semester (fall)		1. Semester (fall)	2. Semester (spring)	3. Semester (fall)	4. Semester (spting)
lect / sem / lab / cr / p/e/s				**Subjects**	lect / sem / lab / cr / p/e/s			
				Basic Subjects				
4/2/0/8/e				Differential Equations and Numerical Methods		4/2/0/8/e		
	3/1/0/4/e			Laser Physics	3/1/0/4/e			
3/0/0/4/e				Analytical Mechanics		3/0/0/4/e		
3/0/0/4/e				Advanced Fluid Mechanics		3/0/0/4/e		
2/1/0/4/e				Advanced Thermodynamics		2/1/0/4/e		
	2/0/1/4/e			Electronics	2/0/1/4/e			
	2/1/0/4/e			Advanced Control and Informatics	2/1/0/4/e			
				Special Compulsory Subjects				
	2/1/0/4/e			Machine Desing and Production Technology	2/1/0/4/e			
	3/0/1/5/p			Major Compulsory Subject I	3/0/1/5/p			
2/1/0/5/p				Major Compulsory Subject II		2/1/0/5/p		
		0/0/11/14/s		Major Project				0/0/11/14/s
				Special Subjects				
		1/0/2/3/e		Major Elective Subject I				1/0/2/3/e
			1/0/1/3/e	Major Elective Subject II			1/0/1/3/e	
			1/1/0/3/p	Major Elective Subject III			1/1/0/3/p	
3/0/1/5/p				Minor Compulsory Subject I		3/0/1/5/p		
	2/1/0/5/p			Minor Compulsory Subject II	2/1/0/5/p			
		1/0/1/3/e		Minor Elective Subject I				1/0/1/3/e
		2/0/0/3/p		Minor Elective Subject II				2/0/0/3/p
			0/0/15/19/s	Final Project			0/0/15/19/s	
				Subjects in Economics				
	3/0/0/5/p			Management	3/0/0/5/p			
		3/0/0/5/p		Marketing				3/0/0/5/p
				Elective Subjects				
		1/1/0/3/p	1/0/1/3/p	Further Elective Subjects			1/0/1/3/p	1/1/0/3/p
				Criterion				
				Industrial Practice				
				Total				
30	31	31	28	Total credit points	31	30	28	31
17/4/1/22	17/4/2/23	8/0/15/23	3/2/16/21	Total contact hours	17/4/2/23	17/4/1/22	3/2/16/21	8/0/15/23
4	4	2	1	Number of Exams	4	4	1	2

6. A Mechanical Engineering Modelling mérnöki mesterszak lehetséges moduljai

A BME Mechanical Engineering Modelling mérnöki mesterszakán hat lehetséges modul közül kettőt (major és minor) kell választani. Ez azonban egy kínálati lista, nem jelenti azt, hogy minden modul minden évben elindul. A modulokat 6 fő jelentkező létszám alatt nem lehet indítani. Ezért fontos, hogy a hallgató a képzés elindulásakor eldöntse, hogy mely modulokon kíván továbbtanulni. Ezek szerint azt, hogy a képzésben melyik modulok fognak elindulni, maga a hallgatóság dönti el. Azok számára, akik olyan modult neveztek meg, amely elégséges jelentkezőszám miatt nem indítható, az a lehetőség marad, hogy átjelentkezzenek az induló modulokra, vagy megvárják, amíg egy következő szemeszterben elegendő számú jelentkezővel a kívánt modul elindul.

6.1 Fluid Mechanics modul

Beginning of the term: spring				Fluid Mechanics	Beginning of the term: fall			
1. Semester (spring)	2. Semester (fall)	3. Semester (spring)	4. Semester (fall)		1. Semester (fall)	2. Semester (spring)	3. Semester (fall)	4. Semester (spting)
lect / sem / lab / cr / p/e/s				**Subjects**	lect / sem / lab / cr / p/e/s			
				Basic Subjects				
3/0/0/4/e				Advanced Fluid Mechanics		3/0/0/4/e		
				Special subjects / Major or Minor Compulsory Subjects				
	2/2/0/5/p			Computational Fluid Dynamics	2/2/0/5/p			
2/1/1/5/p				Flow Measurements		2/1/1/5/p		
		0/0/11/14/s		Major Project				0/0/11/14/s
				Special subjects / Major or Minor Elective Subjects				
		1/1/0/3/ p		Large-Eddy Simulation in Mechanical Engineering				1/1/0/3/p
		2/0/0/3/p		Fluid Technical Process Modelling				2/0/0/3/p
		1/1/0/3/p		Multiphase and Reactive Flow Modelling				1/1/0/3/p
		2/0/0/3/p		Unsteady Flows in Pipe Networks				2/0/0/3/p
		2/0/0/3/p		Measurement Techniques and Signal Processing				2/0/0/3/p
			2/0/1/3/p	Building Aerodynamics			2/0/1/3/p	
			2/0/0/3/p	Aerodynamics and its Application for Vehicles			2/0/0/3/p	
			2/0/0/3/p	Advanced Technical Acoustics and Measurement Techniques			2/0/0/3/p	
			2/0/0/3/p	Hemodynamics			2/0/0/3/p	
			2/0/0/3/p	Flow Stability			2/0/0/3/p	
			2/0/0/3/p	Theoretical Acoustics			2/0/0/3/p	
			0/0/15/19/s	Final project			0/0/15/19/s	

6.2 Solid Mechanics modul

Beginning of the term: spring				Solid Mechanics	Beginning of the term: fall			
1. Semester (spring)	2. Semester (fall)	3. Semester (spring)	4. Semester (fall)		1. Semester (fall)	2. Semester (spring)	3. Semester (fall)	4. Semester (spting)
lect / sem / lab / cr / p/e/s				**Subjects**	lect / sem / lab / cr / p/e/s			
				Basic Subjects				
3/0/0/4/e				Analytical Mechanics		3/0/0/4/e		
				Special subjects / Major or Minor Compulsory Subjects				
2/0/2/5/p				Finite Element Analysis		2/0/2/5/p		
	2/1/0/5/p			Continuum Mechanics	2/1/0/5/p			
		0/0/11/14/s		Major Project				0/0/11/14/s
				Special subjects / Major or Minor Elective Subjects				
		1/1/0/3/p		Elasticity and Plasticity				1/1/0/3/p
		1/1/0/3/e		Nonlinear Vibrations				1/1/0/3/e
		1/0/1/3/p		Coupled Problems in Mechanics				1/0/1/3/p
			1/1/0/3/p	Mechanisms			1/1/0/3/p	
			1/1/0/3/e	Beam Structures			1/1/0/3/e	
			1/0/1/3/p	Experimental Methods in Solid Mechanics			1/0/1/3/p	
			0/0/15/19/s	Final project			0/0/15/19/s	

6.3 Thermal Engineering modul

Beginning of the term: spring				Themal Engineering	Beginning of the term: fall			
1. Semester (spring)	2. Semester (fall)	3. Semester (spring)	4. Semester (fall)		1. Semester (fall)	2. Semester (spring)	3. Semester (fall)	4. Semester (spting)
lect / sem / lab / cr / p/e/s				**Subjects**	lect / sem / lab / cr / p/e/s			
				Basic Subjects				
2/1/0/4/e				Advanced Thermodynamics		2/1/0/4/e		
				Special subjects / Major or Minor Compulsory Subjects				
	2/1/1/5/p			Combustion Technology	2/1/1/5/p			
1/0/3/5/p				Measurements in Thermal Engineering		1/0/3/5/p		
		0/0/11/14/s		Major Project				0/0/11/14/s
				Special subjects / Major or Minor Elective Subjects				
		2/1/0/3/e		Energy Conversion Processes and its Equipment				2/1/0/3/e
		1/0/2/3/p		Simulation of Energy Engineering Systems				1/0/2/3/p
		2/0/1/3/p		Thermal Physics				2/0/1/3/p
			2/0/1/3/p	Thermo-Mechanics			2/0/1/3/p	
			2/1/0/3/p	Steam and Gas Turbines			2/1/0/3/p	
			2/1/0/3/e	Thermo-Hydraulics			2/1/0/3/e	
			0/0/15/19/s	Final project			0/0/15/19/s	

6.4 Design and Technology modul

Beginning of the term: spring				Design and Technology	Beginning of the term: fall			
1. Semester (spring)	2. Semester (fall)	3. Semester (spring)	4. Semester (fall)		1. Semester (fall)	2. Semester (spring)	3. Semester (fall)	4. Semester (spting)
lect / sem / lab / cr / p/e/s				**Subjects**	lect / sem / lab / cr / p/e/s			
				Special subjects / Major or Minor Compulsory Subjects				
	2/1/0/4/e			Machine Design and Production Technology	2/1/0/4/e			
	2/0/1/5/p			Product Modelling	2/0/1/5/p			
1/0/3/5/p				Advanced Manufacturing		1/0/3/5/p		
		0/0/11/14/s		Major Project				0/0/11/14/s
				Special subjects / Major or Minor Elective Subjects				
		1/0/2/4/p		CAD Technology				1/0/2/4/p
		2/0/0/3/e		Materials Science				2/0/0/3/e
		1/0/2/4/p		Structural Analysis				1/0/2/4/p
			1/1/0/3/p	Process Planning			1/1/0/3/p	
			1/1/0/3/p	NC Machine Tools			1/1/0/3/p	
			2/0/0/3/e	Fatigue and Fracture			2/0/0/3/e	
			0/0/15/19/s	Final project			0/0/15/19/s	

6.5 Industrial Electronics modul

Beginning of the term: spring				Industrial Electronics	Beginning of the term: fall			
1. Semester (spring)	2. Semester (fall)	3. Semester (spring)	4. Semester (fall)		1. Semester (fall)	2. Semester (spring)	3. Semester (fall)	4. Semester (spting)
lect / sem / lab / cr / p/e/s				**Subjects**	lect / sem / lab / cr / p/e/s			
				Basic Subjects				
	2/0/1/4/e			Electronics	2/0/1/4/e			
				Special subjects / Major or Minor Compulsory Subjects				
	2/0/1/5/p			Power Electronics	2/0/1/5/p			
2/0/1/5/p				Motion Control		2/0/1/5/p		
				Special subjects / Major or Minor Elective Subjects				
		1/0/2/3/p		Analog Electronics				1/0/2/3/p
		1/0/2/3/p		Digital Electronics				1/0/2/3/p
		1/0/2/3/p		Real Time Systems				1/0/2/3/p
			1/0/1/3/p	Programmable Digital Devices			1/0/1/3/p	
			1/0/1/3/p	Industrial Vision Systems			1/0/1/3/p	
			1/0/1/3/p	Web Based Laboratory			1/0/1/3/p	
			1/0/1/3/p	Industrial Embedded Systems			1/0/1/3/p	

6.6 Robotics modul

Beginning of the term: spring				Robotics	Beginning of the term: fall			
1. Semester (spring)	2. Semester (fall)	3. Semester (spring)	4. Semester (fall)		1. Semester (fall)	2. Semester (spring)	3. Semester (fall)	4. Semester (spting)
lect / sem / lab / cr / p/e/s				**Subjects**	lect / sem / lab / cr / p/e/s			
				Basic subjects				
	2/1/0/4/e			Advanced Control and Informatics	2/1/0/4/e			
				Special subjects / Major or Minor Compulsory Subjects				
	2/0/1/5/p			Robot Constructions	2/0/1/5/p			
2/1/0/5/p				Robot Control		2/1/0/5/p		
		0/0/11/14/s		Major Project				0/0/11/14/s
				Special subjects / Major or Minor Elective Subjects				
		3/0/0/3/e		Production Planning and Control				3/0/0/3/e
		2/0/1/3/p		Software Technologies				2/0/1/3/p
		1/1/0/3/e		Artificial Neural Networks and Hybrid Systems				1/1/0/3/e
		1/0/2/3/p		Robot Programming				1/0/2/3/p
			2/0/0/3/p	Simulation of CNC Machines and Robots			2/0/0/3/p	
			1/1/1/3/p	Assembly			1/1/1/3/p	
			1/1/0/3/p	Special Robots and Robot Applications			1/1/0/3/p	
			1/1/0/3/p	Microelectronics in Control			1/1/0/3/p	
			0/0/15/19/s	Final project			0/0/15/19/s	

7. Záróvizsgatárgyak

A záróvizsga tárgyait a major és minor modulok tárgyaiból kell összeállítani. Erre három lehetőség van:

1. Lehetőség (összesen 17 kp):
    - Major Compulsory Subject I, 5 kp
    - Major Compulsory Subject II, 5 kp
    - Basic Subject, 4kp
    - Major Elective Subjects, 3 kp

2. Lehetőség (összesen 15 kp):
    - Major Compulsory Subject I, 5 kp
    - Major Compulsory Subject II, 5 kp
    - Minor Compulsory Subject, 5 kp

3. Lehetőség:
    - A záróvizsgára mindenki válasszon legalább 15 kreditpontnyi tárgyat.
    - A záróvizsgatárgyak között nem lehet a Differential Equations and Numerical Methods es a Laser Physics.
    - A 15 kreditpontból legalább 10 kredipont a major szakirányból kell, hogy legyen.

8. A Mechanical Engineering Modelling mérnöki mesterszak tantárgyainak ismertetése

8.1 Basic Subjects

DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS
BMETE90MX46

Contact hours: 4+2+0 **Credits:** 8 **Requirement:** examination
Responsible: Dr. Garay Barna, professor

Further lecturer(s): Dr. Bálint Péter, associate prof., Dr. Moson Péter, associate prof., Dr. Gyurkovics Éva, associate prof.

Topics:
Ordinary differential equations. Well-posedness of initial value problems. Various types of stability. Stability of equilibria by linearization and Liapunov functions. Phase space analysis near equilibria and periodic orbits. The loss of stability in parametrized families of equations. Explicit/implicit Euler and Runge-Kutta methods. Comparing exact and approximate dynamics, error estimate between exact and approximate solutions. Retarded equations.
Partial differential equations. The standard initial and boundary value problems of mathematical physics. Separation of variables. Fourier series as coordinate representation in Hilbert space. The method of finite differences for the heat equation: error estimate and the maximum principle.

Recommended literature:

1. Farkas M., Kotsis D., Mile K., Matematika VIII. Differenciálegyenletek (Mathematics VIII, Differential Equations), Műegyetemi Kiadó, Budapest, 1998.
2. Hirsch, M.W., Smale, S., Devaney, R.L., Differential equations, dynamical systems, and an introduction to chaos, Academic Press, New York, 2004.
3. Iserles, A., A first course in the numerical analysis of differential equations, Cambridge University Press, Cambridge, 1996.

LASER PHYSICS
BMETE12MX00

Contact hours: 3+1+0 **Credits:** 4 **Requirement:** examination
Responsible: Dr. Lőrincz Emőke, associate prof.

Further lecturer(s): Dr. Richter Péter, professor

Topics:
Theory of laser oscillation, characteristics of laser light, laser applications. Interaction of photons with atoms, line-broadening mechanisms, coherent amplification, optical resonator, conditions of continous wave and transient laser oscillation. Properties of laser beams: monochromacity, coherence, directionality, brightness. Laser types: solid-state, semiconductor, gas, fluid (dye) and miscellaneous. Laser applications: industrial, medical, communication, measurement technique.

Recommended literature:

1. Saleh B. E. A, Teich M. C.: Fundamentals of Photonics, John Wiley & Sons, Inc. 1991.
2. Svelto O.: Principles of Lasers, Springer, 1998.

3. LIA Handbook of Laser Materials Processing, ed. in chief John F. Ready, Laser Institute of America, 2001

ANALYTICAL MECHANICS

BMEGEMMMW01

Contact hours: 3+0+0 **Credits:** 4 **Requirement:** examination
Responsible: Dr. Stépán Gábor, professor

Topics:

Classification of mechanical systems of assemble of particles and rigid bodies. Classifications of constraints, geometric and kinematic constraints. Virtual velocity, virtual power and general force. Lagrangian equations of the second kind. Examples. Approximations of the natural frequencies of continua. Longitudinal, torsional and bending vibrations of beams, standing wave and travelling wave solutions. Strings. Vibrations of rotors, critical speed of shafts, Campbell diagram.

Recommended literature:

1. Gantmacher, F.: Lectures in analytical mechanics, Mir Publishers, Moscow, 1975.
2. Hand-Finch, Analytical Mechanics, Cambridge Univ. Press, 2004.

ADVANCED FLUID MECHANICS

BMEGEÁTMW01

Contact hours: 3+0+0 **Credits:** 4 **Requirement:** examination
Responsible: Dr. Kristóf Gergely, associate prof.

Topics:

Main objective of the subject is to understand the physical phenomena occurring in various flow categories of technical relevance and to gain practical knowledge in analyzing flow phenomena. Detailed thematic description of the subject: Overview of the fundaments of fluid mechanics. Vorticity transport equation. Potential flows, solution methods based on analytical solutions. Percolation, Darcy flow. Wells. Boundary layers. Similarity solutions for laminar and turbulent boundary layers. Overview of computational fluid dynamics (CFD). Turbulence models. Fundaments of gas dynamics. Wave phenomena. Izentropic flow, Prandtl-Meyer expansion, moving expansion waves. Normal shock waves, oblique shock waves, wave reflection. Jets. Open surface flows, channel flows. Pipe networks. Transient flow in pipelines. Atmospheric flows.

Recommended literature:

1. lecture handouts
2. Lamb, H.: Hydrodynamics, 1932.
3. Schlichting, H.: Boundary Layer Theory, 1955.
4. Shapiro A.H: The Dynamics and Thermodynamics of Compressible Fluid Flow, 1953.
5. Streeter, V.L. & Wylie, E.B: Fluid Mechanics, McGraw-Hill, 1975.
6. Ferziger, J.H. & Peric, M.: Computational Methods for Fluid Dynamics, Springer, ISBN 3-540-42074-6, 2002.

ADVANCED THERMODYNAMICS

BMEGEENMWAT

Contact hours: 2+1+0 **Credits:** 4 **Requirement:** examination
Responsible: Dr. Gróf Gyula, associate prof.
Further lecturer(s): Dr. Ván Péter, senior research fellow

Topics:

General model structure of thermodynamics. Equation of state (gases, liquids and solids). Laws of thermodynamics. System of body and environment, heat, work, reservoirs, extended systems. Irreversible processes, availability, exergy analysis, entropy generation minimization. Multi component phase equilibrium. Reaction equilibrium. Basics of non equilibrium thermodynamics. Second law. Linear laws. Onsager reciprocity. Local equilibrium. Heat conduction, diffusion, cross effects. Rheology. Poynting-Thomson body.

Recommended literature:

1. Bejan: Advanced Engineering Thermodynamics, J. Wiley & Sons, 2006
2. Honig: Thermodynamics, Academic Press San Diego, 1999

ELECTRONICS

BMEVIAUM001

Contact hours: 2+0+1 **Credits:** 4 **Requirement:** examination
Responsible: Dr. Rakos Balázs, assistant prof.

Further lecturer(s): Dr. Glöckner György, assistant prof.

Topics:

Electronic components: Diode, Zener diode, Transistors (bipolar and field effect transistors), Common-emmiter characteristics.
Discrete circuits: Emitter-follower circuit, Amplification, Impedance matching, Series connection of amplifier stages, Feedback.
Integrated circuits: Operational amplifier, Mathematical operations, Wave shape generation, Function generation, Filters, Power supply.

Recommended literature:

1. Charles Fraster and John Milne: Integrated Electrical and Electronics Engineering for Mechanical Engineers, McGraw-Hill Book Company, London, 1994.
2. Animated Lecture notes in electronics form: http://elektro.get.bme.hu/
3. James W. Nilsson: Electric Circuits, Addison-Wesley Company, Massachusets 1990.
4. J. Millman, A. Grabel: Microelectronics, 1987.
5. I. Nagy, J. Megyeri: Analog elektronika (Analog Electronics), Tankönyvkiadó, Budapest, 1992, J4-1081/10

ADVANCED CONTROL AND INFORMATICS

BMEGEMIMW01

Contact hours: 2+1+0 **Credits:** 4 **Requirement:** examination
Responsible: Dr. Aradi Petra, associate prof.

Further lecturer(s): Dr. Lipovszki György, associate prof.

Topics:

The aim of subject to introduce the construction of advanced computer controlled systems and main control algorithms. Introducing the sampling theory – conditions and limitations. Feature and application of Z transformation. Modelling of systems using sampled discrete transfer function and sampled state space equations. Introducing the most important analytical methods of discrete time systems. Showing design methods creating control systems with the next methods: the pole-placement with tracking and regulation objectives, the minimum-variance control, the moving-average control, the dead-beat control, the mean-level control, and linear-quadratic-gaussian (LQG) control designs.

Recommended literature:

1. Sokszorosított fejezetek Kovács Jenő (szerk.): *Számítógépes irányításelmélet* c. műből, amely oktatási segédanyag az University Oulu digitális irányítástechnikai oktatásában. (Chapters from the lecture note: Kovács Jenő, *Computer Control Theory*, University of Oulu)

MACHINE DESIGN AND PRODUCTION TECHNOLOGY (Special Compulsory Subject)

BMEGEGEMW01

Contact hours: 2+1+0 **Credits:** 4 **Requirement:** examination
Responsible: Dr. Váradi Károly, professor

Further lecturer(s): Dr. Mátyási Gyula, associate prof.

Topics:

Machine design: Design principles and methods. Requirements. Modern design techniques. Structural behavior and modeling. Design of frame structures. Polymer and composite components. Load transfer between engineering components. Structural optimization (object function, design variables, constrains, shape and size optimization).
Production: Machine-tools and equipment, devices and fixtures, kinematics, machining principles, production procedures and processes, production volume, batches and series. Manufacturability and tooling criteria, preliminary conditions and production analysis, methods of sequencing operations, production planning and scheduling. Production management (TQC and JIT), automated production; cellular manufacturing, machining centres and robots. Product data and technical document management (PDM, TDM), engineering changes and production workflow management (CE, ECM).

Recommended literature:

1. Grabowski, H.: Universal design theory, Shaker Verlag, Aachen, 1998.
2. Ullman, D.G.: The mechanical design process, McGraw Hill, 1997.
3. Dym, C.L.: Engineering design, Cambridge University Press, 1994.
4. Kalpakjian, Schmid: Manufacturing Engineering and Technology, Prentice-Hall Inc. Publ. 2001, ISBN 0-201-36131-0

8.2 A Fluid Mechanics modul tantárgyai

Special subjects / Major or Minor Compulsory Subjects

COMPUTATIONAL FLUID DYNAMICS
BMEGEÁTMW02

Contact hours: 2+2+0 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Kristóf Gergely, associate prof.

Further lecturer(s): Lohász Máté Márton, assistant prof.

Topics:
Main objective of the subject is providing sufficient theoretical background and practical knowledge for professional CFD engineers. Detailed thematic description of the subject: Derivation of differentiation and integration schemes; accuracy and stability. Approximation of surface integrals, divergence and gradient terms in finite volume method. Numerical fluxes, upwinding schemes. Solution methods for the pressure-velocity coupling: psi-omega method, pressure correction methods. Solution of linear systems of algebraic equations with special respect to the iterative Poisson solvers. Characteristics of the governing equations of compressible fluid flows. Method of characteristics. Finite volume method with explicit time marching scheme for compressible fluid flows. Numerical mesh: quality requirements and advanced meshing techniques. Main characteristics of the turbulence. Length scales. Overview of turbulent models: Reynolds-averaged models, transport equation of turbulent kinetic energy, two-equation models. Analyses of the sources of errors and uncertainties. Error estimation. Simulation exercises in computer laboratory.

Recommended literature:

1. lecture handouts
2. Ferziger, J.H. & Peric, M.: Computational Methods for Fluid Dynamics, ISBN 3-540-42074-6, Springer-Verlag, Berlin, 2002.

FLOW MEASUREMENTS
BMEGEÁTMW03

Contact hours: 2+1+1 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Vad János, associate prof.

Further lecturer(s): Suda Jenő Miklós, assistant prof., Balczó Márton, research assistant.

Topics:
Main objective of the subject is getting acquainted with the measurement principles, application areas, advantages and limitations of various flow measuring techniques applied in industrial practice as well as in research&development related laboratory activities. Detailed thematic description of the subject: Practical / industrial aspects of flow measurements. Measurement of temporal mean pressures: static, total, dynamic. Probes and methods. Manometers. Pressure-based measurement of velocity magnitude and direction. Anemometers, thermal probes. Measurement of unsteady pressures. Temperature measurements. Hot wire anemometry. Laser optical flow diagnostics: Laser Doppler Anemometry (LDA), Phase Doppler Anemometry (PDA), Particle Image Velocimetry (PIV). Flow visualization. Flow rate measurements with use of contraction elements and deduced from velocity data. Comparison. Flowmeters: ultrasonic, MHD, capacitive cross-correlation technique, Coriolis, vortex, rotameter, turbine, volumetric. Industrial case studies.

Collaboration of measurement technique and computational simulation. Laboratory exercise.

Recommended literature:

1. Vad, J. (2008), *Advanced flow measurements.* Műegyetemi Kiadó, 45085. ISBN 978 963 420 951 5.

MAJOR PROJECT IN FLUID MECHANICS

BMEGEÁTMWD1

Contact hours: 0+0+11 **Credits:** 14 **Requirement:** signature
Responsible: Dr. Vad János, associate prof.

Topics:

The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader and advisors. Each student's project is guided by the project leader and depending on the problem -if applicable- by advisor(s). They form the so-called evaluation team.
Detailed thematic description of the subject: Several experimental and/or numerical (CFD) major project proposals will be announced by the project leaders on the registration week or before. The major project proposals are defined as being complex problems for the 3rd semester and also can be continued in course of the Final Project (BMEGEÁTMWD2) in the 4th semester, hence resulting in the Master Thesis of the student.
In course of the Major Project one single student or group of max. 2 students will work on one selected challenging problem of fluid mechanics.
1st evaluation team meeting on the 4th week: 1st project presentation by the student
2nd evaluation team meeting on the 8th week: 2nd project presentation by the student
3rd evaluation team meeting on the 13th week: 3rd major project presentation by the student
On the 14th week: submission of the major Project Report in printed and electronic (CD/DVD) format.
Evaluation team members assess the students work, presentations & report.

Recommended literature:

1. Preliminary literature survey is essential part of the project start, but reference literature will be provided by the project leader / advisors, too.

Special subjects / Major or Minor Elective Subjects

LARGE-EDDY SIMULATION IN MECHANICAL ENGINEERING

BMEGEÁTMW05

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Kristóf Gergely, associate prof.

Further lecturer(s): Lohász Máté Márton, assistant prof.

Topics:

The main objective of the subject is to get familiar with the concept of Large-Eddy Simulation and its widely used techniques. A secondary objective is to gain knowledge about post-processing techniques specially suited for instantaneous and steady 3D flow data. Applications from turbulent heat transfer and noise production will be shown.
Detailed thematic description of the subject: Motivations why to use Large-Eddy Simulation (LES). Filtering of the incompressible Navier-Stokes equations, basic filter properties. Numerical

requirements of the simulation. Subgrid scale modelling approaches. Interacting error dynamics. Practical aspect of the simulation (domain time and mesh requirements). Special LES boundary conditions: inlet turbulence generation. Hybrid and zonal LES/RANS approaches. Postprocessing of LES results: flow topology description, vortex detection methods. Case studies: internal cooling channel, flow around an airfoil, near field of a jet.

Recommended literature:

1. Lesieur, M.; Métais, O. & Comte, P. Large-Eddy Simulations of Turbulence Cambridge University Press, 2005
2. Pope, S.B. Turbulent Flows, Cambridge University Press, 2000
3. Sagaut, P. Large Eddy Simulation for incompressible Flows. An Introduction Springer, 2002
4. Geurts, B.J. Elements of direct and large-eddy simulation R.T. Edwards, Inc., 2003

FLUID TECHNICAL PROCESS MODELLING

BMEGEÁTMW06

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Vad János, associate prof.

Further lecturer(s):-

Topics:

The main objective of the subject is to get acquainted with various industrial fields, with special regard to ones based on fluid mechanical processes. Obtainment of skill in recognition and solution of industry-related problems, on the basis of real case studies.
Detailed thematic description of the subject: Case studies from various fields of industry regarding problem solution related to fluid flow technology. Outline of the technological process, problem setting. Practical aspects of problem setting. Error analysis. Field work: on-site measurements and additional studies. Simulation case studies. Interactive solution of industry-related diagnostic problems. Proposals for elimination of the problem and their justification. Future remarks.

Recommended literature:

1. Vad, J. (2008), Advanced flow measurements. Miegyetemi Kiadó, 45085. ISBN 978 963 420 951 5.

MULTIPHASE AND REACTIVE FLOW MODELLING

BMEGEÁTMW07

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Szabó K. Gábor, research fellow

Further lecturer(s):-

Topics:

The main objective of the subject is to understand the physical phenomena occurring in fluid systems with more than one chemical components or more than one phases. Familiarization with special measurement techniques used in such systems. Outlining the concepts of possible theoretical models and numerical modelling, understanding limitations due to restricted range of validity and computational resources. Detailed studying of models used in some typical engineering applications.
Detailed thematic description of the subject: Physical phenomena, major concepts, definitions and modelling strategies. Lagrangian vs. Eulerian description. Equilibrium vs. non-equilibrium models.

Dimensionless numbers. Modelling free surface and fluid-fluid interfaces. Bubble growth and collapse. Gravity and capillary waves. Dispersed particle transport. Flow regimes and model options. Sedimentation and fall-out. Flow regimes in vertical, horizontal and inclined pipes. Closure relations. Advanced two-phase flow instrumentation. Phase change and heat transfer in single-component systems: boiling, cavitation, condensation. Related heat transport problems and industrial applications. Phase interactions: particle agglomeration and break-up. Modelling chemical reactions: flames, combustion models, atmospheric reactions. Computational Multi-Fluid Mechanics (CMFD): general methods and limitations, usage of general purpose computational fluid dynamics codes, design of specialized target software. Applications in power generation, hydrocarbon and chemical industry.

Recommended literature:

1. Lecture notes downloadable from the Department's Internet site.
2. C. Crowe, M. Sommerfield, and Yutaka Tsuji. Multiphase Flows with Droplets and Particles. CRC Press, 1998.
3. D. Gidaspow. Multiphase Flow and Fluidization. Academic Press, Boston, 1994.
4. Further literature will be provided on the course website.

UNSTEADY FLOWS IN PIPE NETWORKS

BMEGEVGMW02

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Halász Gábor, professor

Topics:

Structure of piping systems. Description of steady flow as initial condition for computing transient operation. Derivation of the basic equation system for 1D unsteady flow in pipe sections. Solution methods: method of characteristics, implicit methods. Boundary condition treatment. Modelling gas release and cavitation. Open channel flow modelling. Possibilities to protect the system from dangerous pressure surges, check valves, air chambers. Electrodynamic analogy, the impedance method.

Recommended literature:

1. Wylie, E.B. – Streeter, V.L.: Fluid transients in systems, McGraw-Hill, 1993
2. Fox, R.W. – McDonald, A.T.:Introduction to Fluid Mechanics, John Wiley & Sons, 1994

MEASUREMENT TECHNIQUES AND SIGNAL PROCESSING

BMEGEMIMW07

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Lipovszki György associate professor

Further lecturers: Dr. Pandula Zoltán, assistant professor

Topics:

Signals and systems in the time and frequency domains. Mathematical methods in signal processing. Methods of digital data acquisition and signal processing.
Measurement errors and probability. Signal to noise ratio improvement. Analogue signal filtering and processing. Filtering and processing of digital signals.
Noisy periodic signals, stochastic signals, amplitude density function, cross- and autocorrelation. Statistical methods of signal processing: non-parametric and parametric statistical tests.

Recommended literature:

1. Sydenham, P. H.: Handbook of Measurement Science, Vol. 1 and 2., J. Wiley 1982.
2. J. S. Bendat – A.G. Piersol: Random Data (Analysis and Measurement Procedures) John Wiley &Sons Inc. 2000.

BUILDING AERODYNAMICS

BMEGEÁTMW08

Contact hours: 2+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Lajos Tamás, professor

Further lecturer(s):

Topics:

The main objective of the subject is to extend the knowledge of students in Aerodynamics in general and in Building Aerodynamics and transport of pollutant in particular as well as to contribute to development of skills of students in practical use of theoretical knowledge.
Detailed thematic description of the subject: Structure and properties of atmospheric boundary layer, characteristics of wind. Bluff-body aerodynamics: boundary layer separation, characteristics of separated flows, vortices, their effects on the flow description of complex 3-dimensional flow fields. Arising and characterisation of wind forces. Wind and structure interaction, aero-elasticity. Building aerodynamics (buildings, chimney and towers). Bridge aerodynamics. Computational wind engineering. Wind codes and standards: fundamentals and philosophy (ASCE and EUROCODE). Wind loading estimates based on wind tunnel measurements, numerical simulation and standards. Dispersion of pollutants in urban environment, effect of buildings on dispersion. Relationship between wind effects and ventilation of halls and rooms in building. Wind tunnel and CFD case studies.

Recommended literature:

1. Simiu, E and Scanlan, RH.: Wind Effects on Structures: Fundamentals and Applications to Design, Wiley-Interscience, 1996 (third edition)
2. Lawson, T.: Building Aerodynamics, ISBN 1-86094-187-7, Imperial College Press, 2001
3. Lajos T.: Az áramlástan alapjai (2009) ISBN 9789630663823

AERODYNAMICS AND ITS APPLICATION FOR VEHICLES

BMEGEÁTMW09

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Régert Tamás, assistant prof.

Further lecturer(s): Dr. Lajos Tamás, professor

Topics:

The main objective of the subject is to extend the knowledge of students in Aerodynamics in general and in Vehicle Aerodynamics in particular as well as to contribute to development of skills of students in practical use of theoretical knowledge.
Detailed thematic description of the subject: Streamlined body aerodynamics: theory of airfoils, streamlined bodies of revolution, streamlined bodies of finite extension. Compressibility effects, flows with variable air density. Impact of aerodynamics on aircrafts at subsonic and supersonic speeds. Bluff body aerodynamics: boundary layer separation, characteristics of separated flows, vortices, their effects on the flow and their detection techniques, description of complex 3-

dimensional flow fields. Principles of aerodynamic design and optimization of passenger car bodies, trucks and buses. Basics of flow control: control techniques without flow separation (turbulators, boundary layer blow down and suction), and with flow separation (high lift devices, vortex generators, winglets). STOL aircraft, delta wing aircraft, Formula 1 race car aerodynamics.

Recommended literature:

1. A.M. Keuthe, C-Y Chow: Foundations of Aerodynamics. John Wiley & Sons, Inc. 1998. ISBN 0-471-12919-4
2. W. H. Hucho: Aerodynamik des Automobils. Springer-Verlag, 1999. ISBN: 3-540-62160-1
3. T. Lajos: Az áramlástan alapjai (2009) ISBN: 9789630663823
4. Web page: www.aerodyn.org
5. Web page: http://www.aeromech.usyd.edu.au/aero/aerodyn.html

ADVANCED TECHNICAL ACOUSTICS AND MEASUREMENT TECHNIQUES

BMEGEÁTMW10

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Vad János, associate prof.

Further lecturer(s): Dr. Koscsó Gábor, assistant prof.

Topics:

The main objective of the subject is to extend the knowledge in technical acoustics and measurement techniques with the help of presentation of acoustic design and measurement methods, common in the engineering practise.
Detailed thematic description of the subject: The ray theory, sound propagation in non-homogeneous media. Sound propagation in duct and higher order modes. Spherical waves, and the point monopole, dipole and quadrupole sound sources. The flow generated sound, Lighthill's acoustic analogy and the inhomogeneous wave equation. Attenuation of sound waves. Acoustic measurements, microphones, analysers, calibrators, intensity measurement, anechoic and reverberating chambers.

Recommended literature:

1. A.P.Dowling, J.E.Foowcs Williams: Sound and Sources of Sound, Ellis Horwood Limited, 1983, ISBN 0-85312-400-0
2. Leo L. Beranek: Noise and Vibration Control, Institute of Noise Control Engineering,1988,ISBN 0-9622072-0-9

HEMODYNAMICS

BMEGEVGMW06

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Pandula Zoltán, assistant professor

Topics:

Fluid mechanical and structural questions of the arterial system. Models and methods for the description of blood flow in blood vessels (fluid mechanical and mechanical equations), numerical solution of the equations. Major invasive and non-invasive methods of blood flow and blood pressure measurements, methods for numerical modelling of blood pressure. Characteristic physiological quantities and their influence in hemodynamics.

Recommended literature:

1. Nichols, W. W., O'Rourke, M. F. (2005): McDonald's Blood flow in arteries, (Oxford University Press), ISBN 0 340 80941 8
2. Streeter, V. L., Wylie, E. B.(1967): Hydraulic Transients, (McGraw-Hill Book Company)

FLOW STABILITY

BMEGEVGMW07

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Paál György, associate professor

Topics:

Mechanisms of instability, basic concepts of stability theory, Kelvin-Helmholz instability. Basics of linear stability for continuous and discrete systems with examples; stability of discretization techniques (explicit and implicit Euler technique, Runge-Kutta schemes) and linear stability analysis of surge in turbomachines. The Hopf bifurcation theorem with application to turbomachinery. Galerkin projection and its applications. Lorenz equations; derivation (Rayleigh-Bénard convection), linear and nonlinear stability, interpretation of the bifurcation diagram. Loss of stability of parallel inviscid and viscous flows. Instability of duct flow, jet flow, boundary layer. Thermal and centrifugal instability. Uniform asymptotic approximations.

Recommended literature:

1. P. G. Drazin: Introduction to Hydrodynamic Stability. Cambridge University Press, 2002
2. P. G. Drazin, W. H. Reid: Hydrodynamic Stability. Cambridge University Press, 2004
3. J. Guckenheimer, P. Holmes: Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields. Applied Mathematical Sciences, Vol. 42, Springer-Verlag, New York, 1983, ISBN 0-3879-0819-6

THEORETICAL ACOUSTICS

BMEGEVGMW08

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Paál György, associate professor

Topics:

Lighthill's theory. Green functions, jet noise. Effect of rigid walls,.the Ffowcs-Williams - Hawkings equation. Effect of flows on sound propagation, the Philips and the Lilley equation.
Vibrating string, membrane and plate. Sound radiation from planes, cylinders and spheres. Sound waves in ducts, higher modes, dissipation, flexible wall. Diffraction of sound waves.

Recommended literature:

1. P. M. Morse and K. U. Ingard: Theoretical Acoustics, McGrow-Hill, New York, 1976
2. M. E. Goldstein: Aeroacoustics. McGrow-Hill, New York, 1976

FINAL PROJECT IN FLUID MECHANICS

BMEGEÁTMWD2

Contact hours: 0+0+15 **Credits:** 19 **Requirement:** signature
Responsible: Dr. Vad János, associate prof.

Further lecturer(s):

Topics:

The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader and advisors. Each student's project is guided by the project leader and depending on the problem -if applicable- by advisor(s). They form the so-called evaluation team.
Detailed thematic description of the subject: Several experimental and/or numerical (CFD) final project proposals will be announced by the project leaders on the registration week or before. The final project proposals are defined as being complex problems of fluid mechanics, that's solving started in the 3rd semester in course of the Major Project (BMEGEÁTMWD1) and is to be continued in course of this Final Project (BMEGEÁTMWD2) in the 4th semester, hence resulting in the Master Thesis of the student. In course of the Final Project one single student will work on the selected challenging problem of fluid mechanics.
1st evaluation team meeting: on the 4th week: 1st project presentation by the student
2nd evaluation team meeting: on the 8th week: 2nd project presentation by the student
3rd evaluation team meeting: on the 13th week: 3rd final project presentation by the student
On the 14th week: submission of the final Project Report (ie. the Master Thesis) in printed and electronic (CD/DVD) format.
Evaluation team members assess the students work, presentations & report.

Recommended literature:

1. Preliminary literature survey is essential part of the project start, but reference literature will be provided by the project leader / advisors, too.

8.3 A Solid Mechanics modul tantárgyai

Special subjects / Major or Minor Compulsory Subjects

FINITE ELEMENT ANALYSIS

BMEGEMMMW02

Contact hours: 2+0+2 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Vörös Gábor, associate prof.

Further lecturer(s): Dr. Szekrényes András, assistant prof.

Topics:

Discretization of linear boundary value problems. Finite elements in equilibrium problems of 2d and 3d elasticity. Effects of FE mesh. Errors in FEA. Adaptive methods. Finite elements in frequency analysis for elastic structures. Transient dynamic analysis by FEM. Finite element modelling of contact problems and elastic buckling.

Recommended literature:

1. Ross, C.T.F.: Finite Element Methods in Engineering Science. Ellis Horwood, 1990.
2. Ross, C.T.F.: Finite Element Programs for Structural Vibrations. Springer, 1991.
3. Felippa, C.A.: Introduction to Finite Element Methods. Interneten keresztül is elérhető oktatási anyag PDF formátumban a Müncheni Műszaki Egyetem, Computational Mechanics MSc kurzusán: http://www.st.bv.tum.de/index.html?2/content/teaching/fem1/fem1.html

CONTINUUM MECHANICS
BMEGEMMMW03

Contact hours: 2+1+0 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Szabó László, professor

Topics:
Historical overview. Mathematical background (Cartesian tensors, properties and representations, invariants, tensor fields, derivatives of tensors, integral theorems). Kinematics. Bodies and configurations. Lagrangian and Eulerian description of a continuum. Deformation gradient. Deformation of arc, surface and volume elements. Deformation and strain tensors. Polar decomposition: stretch and rotation tensors. Displacement, infinitesimal strain and rotation. Material time derivative. Rates of deformation: stretching and spin tensors. Conservation of mass, continuity equation. Concept of force. Cauchy's theorem on the existence of stress. First and second Piola-Kirchhoff stress tensors. Linear momentum principle. Equation of motion. Angular momentum principle. Balance of energy: concepts on stress power, rate of work, internal energy. First and second law of thermodynamics. Clausius-Duhem inequality. Dissipation function. Constitutive theory. Principles of determinism and local action. Material frame indifference and objectivity. Constitutive equations of elasticity, viscoelasticity, plasticity and fluid mechanics.
Recommended literature:

1. Malvern, L. E., Introduction to the Mechanics of a Continuous Medium, Prentice Hall, 1969.
2. Holzapfel, G., Nonlinear Solids Mechanics. A Continuum Approach for Engineering. John Wiley & Sons, New York, 2000.
3. Béda, Gy., Kozák, I., Verhás, J., Continuum Mechanics, Akadémiai Könyvkiadó, Budapest, 1998.

MAJOR PROJECT IN SOLID MECHANICS
BMEGEMMMWD1

Contact hours: 0+0+11 **Credits:** 14 **Requirement:** signature
Responsible: Dr. Kovács Ádám, associate prof.

Topics:
In course of the Project one student or group of 2 students will work on one selected challenging problem of mechanical engineering. Several experimental and/or numerical project proposals will be announced by the project leaders. The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader. At the end of each semester a written Project Report is to be submitted and the summary and findings of the investigations on the selected problem is to be presented as Project Presentation.

Recommended literature: It depends on the topic of the project.

Special subjects / Major or Minor Elective Subjects

ELASTICITY AND PLASTICITY
BMEGEMMMW05

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Szabó László, professor

Topics:

Elasticity: Covers vector and tensor analysis, indicial notation. Displacements and small strains. Compatibility of strain. Theory of stress. Principle stresses. Generalized Hooke's law. Strain energy function. Isotropy and anisotropy. Equilibrium equations. Problems in plane stress and plane strain. Airy stress function. Torsion of prismatic bars. Thick-walled tube, rotating disk. Principle of virtual work. Rayleigh-Ritz methods. Introduction to the finite element method. Truss and beam elements. *Plasticity:* Reviews stress and strain deviators, invariants and distortional energy. Principal and octahedral stresses and strains. Tresca and von Mises yield criteria. Yield surface and Haigh-Westergaard stress space. Lode's stress parameters. Subsequent yield surface. Prandtl-Reuss relations. Work and strain hardening. Isotropic and kinematic hardening rules. Incremental and deformation theories. Time-dependent deformations: visco-elasticity, elasto-viscoplasticity and creep. Simple truss. Bending of straight beams. Thick-walled tube. Plasticity equations in finite element methods. Stress updating algorithms and consistent tangent modulus.

Recommended literature:

1. Khan, A. S., Huang, S., Continuum Theory of Plasticity, John Wiley & Sons, New York, 1995.
2. Malvern, L. E., Introduction to the Mechanics of a Continuous Medium, Prentice Hall, 1969.
3. Chen, W. F., Han, D. J., Plasticity for Structural Engineers, Springer-Verlag, Berlin, 1988.
4. Simo, J.C., Hughes, T. R. J., Computational Inelasticity, Springer-Verlag, New York, 1997.

NONLINEAR VIBRATIONS

BMEGEMMMW06

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Stépán Gábor, professor

Topics:

Phase plane analysis of single degree-of-freedom nonlinear systems. Construction of trajectories and their analysis in case of conservative nonlinear systems. The effect of nonlinear damping. Harmonic excitation of nonlinear mechanical systems, resonance in nonlinear systems. Self-excited vibrations. Liénard and Bendixson criteria for limit cycles. Hopf bifurcations. Chaotic oscillations.

Recommended literature:

1. Ludvig Gy., Gépek dinamikája (Dynamics of Machines), Műszaki Könykiadó, Budapest, 1989.
2. Rand R., Topics in Nonlinear Dynamics with Computer Algebra, Gordon and Breach, 1994.
3. Lesser M., The Analysis of Complex Nonlinear Mechanical Systems, World Scientific, 1996.

COUPLED PROBLEMS IN MECHANICS

BMEGEMMMW07

Contact hours: 1+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Kovács Ádám, associate prof.

Topics:

Diffusion problems: thermomechanical, chemomechanical, hygromechanical fields. Coupled piezo-electromechanical equations. Fluid-structure interaction. Smart structures, micro-electromechanical systems. Contact stresses in deformable bodies. Finite element modelling. Mesh coupling.

Partitioned analysis. Case studies.

Recommended literature:

1. Zienkiewicz, O.C.; Taylor, R.L., Finite Element Method (5th Edition) Volume 1 - The Basis, Elsevier, 2000.
2. Hearn, E.J., Mechanics of Materials, Volume 2 - The Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials (3rd Edition), Elsevier, 1997.

MECHANISMS

BMEGEMMMW08

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Bende Margit, assistant prof.

Topics:

Structural analysis of kinematical chains: degrees of freedom, groups, six-bar chains, equivalent chains. Straight-line guide. Four-bar linkage. Planar motion: relative centers of zero velocity, transmission, theorem of Kennedy. Curvature theory: fixed and moving centrodes, envelopes, inflexion circle, return circle, centre of curvature, theorem of Euler-Savary, theorem of Bobillier. Acceleration field. Cams and gears.

Recommended literature:

1. Sandor, G.N., Erdman, A.G.: Advanced Mechanism Design: Analysis and Synthesis. Prentice Hall, 1984.

BEAM STRUCTURES

BMEGEMMMW09

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Vörös Gábor, associate prof.

Topics:

Torsion and shear of thin walled beams, calculation of warping-sector area function, shear center, shear flow. Constrained torsion of prismatic beams. Stability problems of beam structures, bending and flexural-bending buckling. Application of numerical methods based on the Trefftz principle. Dynamic problems, application of modal decomposition method. Example: seismic excitation.

Recommended literature:

1. Ludvig Gy., Gépek dinamikája (Dynamics of Meachines), Műszaki Könykiadó, Budapest, 1989.
2. Ponomarjov, SZ. D., Szilárdsági számítások a gépészetben (Strength Calculations in Engineering), Műszaki Könykiadó, Budapest, 1964.

EXPERIMENTAL METHODS IN SOLID MECHANICS

BMEGEMMMW10

Contact hours: 1+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Szekrényes András, assistant prof.

Further lecturers: Dr. Szabó Zsolt, associate prof, Dr. Thamm Frigyes, associate prof., Takács Dénes, research assistant , Gáspár Tibor, engineer, Wohlfart Richárd, engineer

Topics:
Strain measuring methods (theory and practice: strain gauges, static and dynamic strain bridges, evaluation methods). Moiré-method, holographic interferometry, thermoelastic analisys, Experimental methods in the fracture mechanics of composites. Self-excited vibrations of wheels. Dynamic measurements of wheels. Measuring methods, equipments and evaluations for vibration analysis. Modal analysis.

Recommended literature:

1. Dr. Thamm Frigyes: Szilárd testek mechanikájának kisérleti módszerei (Experimental Methods in Solid Mechanics), Műegyetemi kiadó, J 10016
2. Human Vibration, Brüel&Kjaer kiadvány.
3. Thamm-Ludvig-Huszár-Szántó: A szilárdságtan kísérleti módszerei (Experimental Methods in Strength of Materials), Műszaki könyvkiadó, Budapest, 1968.

FINAL PROJECT IN SOLID MECHANICS
BMEGEMMMWD2

Contact hours: 0+0+15 **Credits:** 19 **Requirement:** signature
Responsible: Dr. Kovács Ádám, associate prof.

Topics:
The aim of the subject of is to demonstrate the ability of the student to solve high level, practical engineering problems, based on acquired knowledge in the fields of mechanical engineering. The projects have to be prepared by the students under the guidance of supervisors. The Final Projects include tasks in design, simulations, laboratory tests, manufacturing as well as controlling, interfacing and software tasks. The expected result is mostly a Final Report prepared according to written formal requirements. During the Final Exam, the results have to be explained in an oral presentation.

Recommended literature: It depends on the topic of the project.

8.4 A Thermal Engineering modul tantárgyai

Special subjects / Major or Minor Compulsory Subjects

COMBUSTION TECHNOLOGY
BMEGEENMWCT

Contact hours: 2+1+1 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Penninger Antal, professor

Further lecturer(s): Lezsovits Ferenc, assistant lect.

Topics:
Types of fuels, ultimate/proximate analysis, fuel technology, analysis methods and results, excess air factor, calorific value, stoichiometric calculation, practical analysis of combustion products. Physical parameters of combustion, reaction types, flame velocity, combustion aerodynamics; premixed and diffusion flames, atomization, pulverization, different types of burners. Fuel technology: properties of various solid, liquid and gaseous fuels. Equipment constructions. Modelling methods and techniques in combustion.

Laboratory: Flame velocity. Flame demonstrations. Emission measurement.

Recommended literature:

1. Warnatz, Jürgen: Combustion: Physical and chemical fundamentals, modeling and simulation, experiments, pollutant, Springer, 1999.
2. Kuo, Kenneth, Kuan-yun: Principles of combustion, Wiley, 2005.

MEASUREMENTS IN THERMAL ENGINEERING

BMEGEENMWM1

Contact hours: 1+0+3 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Bereczky Ákos, associate prof.

Further lecturer(s): Dr. Gróf Gyula, associate prof., Lezsovits Ferenc, assistant lect., Dr. Sztankó Krisztián, assistant prof.

Topics:

Measurement methods and techniques of thermal processes. System - model - measurement - evaluation. State of the art data acquisition methods, systems and signal transducers. Operational and service measurements, engine diagnostics, performance characteristic. Stability and vibrations tests. Evaluation methods in data processing. Questions of safety, availability and reliability. Application of LabView graphical programming environment.

Recommended literature:

1. Lipták, G. Béla: Instrument engineers' handbook, CRC Press, 2003-2006 (Vol. 1: Process measurement and analysis, Vol. 2: Process control and optimization)
2. The measurement and automation, National Instruments Catalogue 2004.

MAJOR PROJECT IN THERMAL ENGINEERING

BMEGEENMWD1

Contact hours: 0+0+11 **Credits:** 14 **Requirement:** signature
Responsible: Dr. Bereczky Ákos, associate prof.

Topics:

In course of the Project one student or group of 2 students will work on one selected challenging problem of mechanical engineering. Several experimental and/or numerical project proposals will be announced by the project leaders. The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader. At the end of each semester a written Project Report is to be submitted and the summary and findings of the investigations on the selected problem is to be presented as Project Presentation.

Recommended literature: It depends on the topic of the project.

Special subjects / Major or Minor Elective Subjects

ENERGY CONVERSION PROCESSES AND ITS EQUIPMENT

BMEGEENMWEE

Contact hours: 2+1+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Penninger Antal, professor

Further lecturer(s): Dr. Lezsovits Ferenc, assistant prof., Dr. Bereczky Ákos, associate prof.

Topics:
Energy sources, demands and utilizations. Power generation. Steam cycles (superheating, reheating, regeneration, combined). Boilers and steam generators. Nuclear power stations. Combined heat and power generation. Internal combustion engines. Centralized - distributed power generation. Calculation of energy balance, software's for system planning and modelling. Environment protection.

Recommended literature:

1. Kehlhofer, Rolf: Combined-cycle gas and steam turbine power plants, Fairmont Pr. 1991.
2. Büki: Energetika (Energy management), Műegyetemi kiadó. 1997.

SIMULATION OF ENERGY ENGINEERING SYSTEMS
BMEGEENMWSE

Contact hours: 1+0+2 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Czinder Jenő, assistant prof.

Topics:
Methods of determination the dynamic models. Type of equation groups. Linear – nonlinear, distributed – concentrated parameters. Application of Matlab/Simulink interactive programming language. Case studies: simple and complex energy conversion processes. Student projects: dynamic modelling and simulation experiment.

Recommended literature:

1. Zeigler, Phillip: Theory of modelling and simulation, Academic Press, 2000.
2. http://www.mathworks.com/

THERMAL PHYSICS
BMEGEENMWTP

Contact hours: 2+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Gróf Gyula, associate prof.

Topics:
Physical backgrounds. Mechanism and models of heat conduction in solids. Non homogeneous materials. Determination methods and techniques of thermophysical properties. (Solution of inverse problem of heat conduction.) Steady state and transient methods.

Recommended literature:

1. Maglic: Compendium of thermophysical property measurement methods, Plenum, 1984.
2. Ozisik: Inverse Heat Transfer (Fundamentals and applications), Taylor&Francis, 2000

THERMO-MECHANICS
BMEGEMMMWTM

Contact hours: 2+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Kovács Ádám, associate prof.

Topics:
Temperature dependence of material properties. Governing equations of coupled thermal and

mechanical fields. Thermal boundary conditions. Thermal stresses in beams, plane problems, plates, thick-walled tubes and rotating disks. Instationary heat conduction, transient thermal stresses. Numerical thermal stress analysis. Heat conductance and capacitance matrices. Computer simulation of thermal stresses.

Recommended literature:

1. Boley, B.A, Weiner, J.H.: Theory of thermal stresses. Wiley, 1960.
2. Zienkiewicz, O.C., Taylor, R.L.: The Finite Element Method. Volume 1. The Basis, Butterworth, Heinemann, 2000.

STEAM AND GAS TURBINES

BMEGEENMWTU

Contact hours: 2+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Penninger Antal, professor

Further lecturer(s): Dr. Sztankó Krisztián, assistant prof.

Topics:

Classification of turbines. Flow in nozzle. Historical notes. Principal elements. Axial flow turbines: impulse stage, reaction stage, velocity compounded stage. Losses, design considerations. Calculation of nozzles and stage parameters, power and torque. Efficiency, characteristic curves. Gas turbine cycles (inter-cooling, reheating, aircraft engines etc.). Compressors, combustion chambers, turbines, co-operation of elements. Efficiency and losses. Constructions.

Laboratory: Steam- and gas turbine demonstration and measurement.

Recommended literature:

1. P. Slyakhin: Steam turbines: Theory and design, University Press of Pacific 2005.
2. Saravanamuttoo, Rogers, Cohen: Gas turbine theory, Prentice Hall, 2001.
3. Kostyuk, Frolov: Steam and gas turbine, MIR, Moscow

THERMO-HYDRAULICS

BMEGETEMWTH

Contact hours: 2+1+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Aszódi Attila, associate prof.

Topics:

Heat generation and removal in different type of nuclear reactors. General differential equation of heat conduction. Material properties of UO2. Equations of hydraulic systems. Convective heat transfer. Thermal instabilities. Natural convection. Boiling heat transfer. Boiling curve, boiling crisis. Condensation. Two phase flow patterns, flow maps. Temperature distribution in the fuel. Thermohydraulics of the coolant subchannels. Design limits of nuclear fuel. Computer codes in thermohydraulics. Fundamentals of reactor safety, the role of human factor. Design Basis Accidents. Beyond Design Basis Accidents. Relevant nuclear accidents (e.g. TMI-2, Chernobyl).

Recommended literature:

1. N. E. Todreas, M. S. Kazimi: Nuclear Systems I; Thermal hydraulic fundamentals, 1990.
2. L. S. Tong, J. Weisman: Thermal Analysis of Pressurized Water Reactors, ANS, 1996.
3. Manuscript of the lectures

FINAL PROJECT IN THERMAL ENGINEERING
BMEGEENMWD2

Contact hours: 0+0+15 **Credits:** 19 **Requirement:** signature
Responsible: Dr. Lezsovits Ferenc, assistant prof.

Topics:
The aim of the subject of is to demonstrate the ability of the student to solve high level, practical engineering problems, based on acquired knowledge in the fields of mechanical engineering. The projects have to be prepared by the students under the guidance of supervisors. The Final Projects include tasks in design, simulations, laboratory tests, manufacturing as well as controlling, interfacing and software tasks. The expected result is mostly a Final Report prepared according to written formal requirements. During the Final Exam, the results have to be explained in an oral presentation.

Recommended literature: It depends on the topic of the project.

8.5 A Design and Technology modul tantárgyai

Special subjects / Major or Minor Compulsory Subjects

PRODUCT MODELLING
BMEGEGEMW02

Contact hours: 2+0+1 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Váradi Károly, professor

Further lecturer(s): Dr. Renner Gábor, associate prof.

Topics:
The process of product modeling. Traditional and concurrent design. Product lifecycle management. Integrated product development. Conceptual design. Geometric models. Assembly models. Presentation techniques. Simulation models (Finite element analysis. Kinematic simulation. Behavior simulation). Optimization (object function, shape and size optimization(. Application models. Virtual prototyping. Rapid prototyping. Product costing models.

Recommended literature:

1. Horváth I., et al: Advanced Design Support, Delft University of Technology, 2005.
2. Stoll, H.W.: Product design methods and practices, Marcel Dekker, Inc., 1999.

ADVANCED MANUFACTURING
BMEGEGTMW01

Contact hours: 1+0+3 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Mátyási Gyula, associate prof.

Topics:
Mechanics of metal cutting. Machinability, advanced tool materials, coatings and tool wear. New generation of cutting tools and tool holders. Dry machinig. HSM-High speed machining. Machining of hard materials. Micro and nano technology. Reverse Engineering. Rapid Prototyping. Methods for machinig for different parts, dies and moulds. CAD/CAM and CNC structures. Monitoring of

manufacturing. In-Process measuring methods in manufacturing.

Recommended literature:

1. George Schneider: Cutting tool application, Prentice Hall Inc.:http://www.prenthall.com/
2. Kalpakjian, Schmid: Manufacturing Engineering and Technology, Prentice-Hall Inc.Publ. 2001, ISBN 0-201-36131-0
3. Manufacturing, B. Benhabib, Marcel Dekker Inc., 2003, ISBN 0-8247-4273-7

MAJOR PROJECT IN DESIGN AND TECHNOLOGY

BMEGEGEMWD1

Contact hours: 0+0+11 **Credits:** 14 **Requirement:** signature
Responsible: Dr. Váradi Károly, professor

Topics:

In course of the Project one student or group of 2 students will work on one selected challenging problem of mechanical engineering. Several experimental and/or numerical project proposals will be announced by the project leaders. The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader. At the end of each semester a written Project Report is to be submitted and the summary and findings of the investigations on the selected problem is to be presented as Project Presentation.

Recommended literature: It depends on the topic of the project.

Special subjects / Major or Minor Elective Subjects

CAD TECHNOLOGY

BMEGEGEMW04

Contact hours: 1+0+2 **Credits:** 4 **Requirement:** practical mark
Responsible: Dr. Renner Gábor, associate prof.

Further lecturer(s): Gombor Balázs, assistant lect.

Topics:

CAD tools and methods in machine design. Concurrent design. Product modeling. Surface and solid models. Parametric design. Feature based design. Integrated approach. Kinematic simulation. Conceptual design. Product data management. Product lifecycle management. Distributed design approach. Virtual prototyping. Rapid prototyping.

Recommended literature:

1. Lee, K.: Principles of CAD/CAM/CAE systems, Addision-Wesley, 1999.
2. Horváth, I., et al: Advanced Design Support, Delft University of Technology, 2005.

MATERIALS SCIENCE

BMEGEMTMW01

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Mészáros István, associate prof.

Topics:

Structure of crystalline solids. Imperfections in crystals. Mechanical properties of alloys.

Dislocations and strengthening mechanisms. Deterioration mechanisms of engineering materials. Phase diagrams. Phase transformations. Material characterization. Non-destructive evaluation techniques. Electrical properties of metals, alloys and semicinductiors. Superconductivity. Magnetic properties. Soft and hard magnetic materials.

Recommended literature:

1. W.D. Callister: Materials Science and Engineering (John Wiely and Sons, ISBN: 0-471-32013-7)
2. R.A. Flinn, P.K. Trojan: Engineering Materials and their Applications (Houghton-Mifflin Pub. Company, ISBN: 0-395-35660-1)

STRUCTURAL ANALYSIS

BMEGEGEMW05

Contact hours: 1+0+2 **Credits:** 4 **Requirement:** practical mark
Responsible: Gombor Balázs, assistant lect.

Further lecturer(s): Dr. Goda Tibor, associate prof.

Topics:

Structural analysis and machine design. Fundamentals of FEM. Basic element types of professional FE systems. Preparing FE models (symmetry conditions, mesh structure, boundary conditions, loading models and material properties). Material and geometric nonlinearity. Time-dependent behaviour. Steady state and transient heat transfer. Integrated CAD-FEM systems. Structure optimization.

Recommended literature:

1. Knight, C.E.: The Finite Element Method in Mechanical Design, PWS-KENT Publishing Company, 1993.
2. Cook, R.D.: Finite Element Modeling for Stress Analysis, John Wiley & Sons, Inc. 1995.
3. Soares, C.A.M.: Computer Aided Optimal Design: Structural and Mechanical Systems, Springer-Verlag, 1987.

PROCESS PLANNING

BMEGEGTMW02

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Mátyási Gyula, associate prof.

Topics:

Manufacturing errors, methods of prevention and elimination; surfaces of positioning, manufacturing allowances, preproduct design and selection. Manufacturing planning, machine tools and equipment, manufacturing processes and procedures, operations, electro-chemical (ecm, edm) and thermal processes, survey of surface technology. Type and Group Technology, basics of automation; cellular manufacturing, tooling criteria. Parameter planning, operation element plans, basics of primary and secondary optimisations. Adaptation, principles of NC technology; NC programming. Quality and statistical process control (SPC). Principals of computer aided manufacturing (CAM).

Recommended literature:

1. George Schneider: Cutting tool application, Prentice Hall Inc.:http://www.prenhall.com/

2. Kalpakjian, Schmid: Manufacturing Engineering and Technology, Prentice-Hall Inc.Publ. 2001, ISBN 0-201-36131-0

NC MACHINE TOOLS

BMEGEGTMW03

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Németh István, expert, Dr. Arz Gusztáv, senior research fellow

Topics:

Fundamentals of the kinematics of machine tools and the NC technology. Machine elements and structural building blocks. Lathes and turning centres. Milling machines and machining centres. Parallel kinematics machine tools. Integration of machine tools into production systems. Synthesis, analysis and optimisation of configuration alternatives. Dynamic modelling techniques. Mechatronic modelling, analysis and simulations. Controllers. Control loops, velocity control, position control. Positioning systems. Interpolators, algorithms, software and hardware solutions.

Recommended literature:

1. Geoffrey Boothroyd, Winston A. Knight: Fundamentals of Machining and Machine Tools, Marcel Dekker, 1989.
2. Serope Kalpakjian, Steven R. Schmid: Manufacturing Engineering and Technology, Prentice Hall, 2001.
3. Y. Altintas: Manufacturing Automation, Cambridge University Press, 2000.
4. B. Benhabib: Manufacturing, Marcel Dekker, 2003.
5. Horváth Mátyás, Markos Sándor (szerk.): Gépgyártástechnológia (Machine Design Technology), Műegyetemi Kiadó.

FATIGUE AND FRACTURE

BMEGEMTMW02

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Ginsztler János, professor

Topics:

Cyclic loading. High cycle fatigue. S-N curve. Fatigue limit. Low cycle fatigue. Manson -Coffin relation. Neuber theory. Linear elastic fracture mechanics. Energy concept. Stress field near the crack tip. Stress intensity factor. Fracture toughness. Fracture mechanical design. Non linear fracture mechanics. Crack opening displacement. J-integral. Stable crack growth. Testing techniques. Design philosophy in nonlinear fracture mechanics. Environment assested cracking. Case studies.

Recommended literature:

1. Blumenauer-Pusch, Műszaki Törésmechanika (Applied Fracture Mechanics) Műszaki Könykiadó, Budapest, 1987.
2. Richard W. Hertzberg, Deformation and fracture mechanics of engineering materials, John Wiley & Sons,1989.
3. T.L Anderson, Fracture mechanics, CRC Press,1994.

FINAL PROJECT IN DESIGN AND TECHNOLOGY
BMEGEGEMWD2

Contact hours: 0+0+15 **Credits:** 19 **Requirement:** signature
Responsible: Dr. Váradi Károly, professor

Topics:
The aim of the subject of is to demonstrate the ability of the student to solve high level, practical engineering problems, based on acquired knowledge in the fields of mechanical engineering. The projects have to be prepared by the students under the guidance of supervisors. The Final Projects include tasks in design, simulations, laboratory tests, manufacturing as well as controlling, interfacing and software tasks. The expected result is mostly a Final Report prepared according to written formal requirements. During the Final Exam, the results have to be explained in an oral presentation.

Recommended literature: It depends on the topic of the project.

8.6 Az Industrial Electronics modul tantárgyai

Special subjects / Major or Minor Compulsory Subjects

POWER ELECTRONICS
BMEVIAUM002

Contact hours: 2+0+1 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Járdán R. Kálmán, senior research fellow

Topics:
Components. Transients. Analytical methods of calculation. Computer simulation software. Rectification, single and multiphase systems. Topologies. Various loads, unidirectional, and bidirectional power flow. Electromagnetic Compatibility (EMC). DC/DC converters. Resonant, quasi-resonant circuits. Single and three phase AC/AC conversion. Cycloconverters. Matrix converters

Recommended literature:

1. Mohan/Undeland/Robbins: Power Electronics. John Wiley, 1995.
2. Járdán, R.K.: Power Electronics & Motion Control I. Lecture Notes. 2002., http://elektro.get.bme.hu/
3. R. Resnick, D. Halliday: Physics. Part. II. John-Wiley&Sons, 4. ed., 1992
4. Nagy, I. (mk): Elektrotechnika Előadás segédlet (Electronics Lecture Notes). 10. fej. (Chapter 10) Teljesítményelektronika (Power Electronics). Műegyetemi Kiadó, 3. kiad. 1987.

MOTION CONTROL
BMEVIAUM003

Contact hours: 2+0+1 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Korondi Péter, associate prof.

Topics:
Classification of rotating electric machines: AC machines, Induction motors Servo motors, PM DC

motors, Brushless motors, Switched Reluctant Motors, Stepper motors.
Controlled electric drives: Cascade control of PM servo motors (current, speed and position control loops), Torque control, Electrically commutated servo drives, Variable frequency induction motor drives, Field oriented control.
Internet based tests of electric drives: Microprocessor and DSP controlled electric drives.

Recommended literature:

1. Lecture notes in electrical form: http://elektro.get.bme.hu/
2. Mohamed El-Sharkawi: Fundamental of Electric Drives, Thomson-Engineering, 2000.

Special subjects / Major or Minor Elective Subjects

ANALOG ELECTRONICS
BMEVIAUM004

Contact hours: 1+0+2 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Sütő Zoltán, assistant prof.

Further lecturer(s): Zabán Károly, engineer

Topics:
The role of analogue electronics in complex systems: filtering, amplifying, transforming signals. Actuators. Semiconductors: basic principles, diodes, transistors. Special devices. Varicap. Integrated circuits. Characteristics and applications. Amplifiers: single and multistage transistor amplifiers, analysis and design. Feedback: gain and impedances. Application of operational amplifiers. Power amplifiers. Analogue transducer, PID controller. Filters. The analogue switch. Sample & hold, A/D and D/A converter, analogue multiplexer, demultiplexer. Simulation of analogue circuits

Recommended literature:

1. M. N. Horenstein: Microelectronics Circuits and Devices, Prentice Hall, 1990, ISBN 0-13-583170-9
2. A.S. Sedra, K.C. Smith: Microelectronics Circuits, Saunders College Publishing, Third Edition, 1991, ISBN 0-03-051648-X
3. J. Whitaker, B. Raton: The Electronics Handbook, CRC Press, Beaverton, 1996.
4. J. Millman, A. Grabel: Microelectronics, 1987.
5. I. Nagy, J. Megyeri: Analog electronika, Tankönyvkiadó, Budapest, 1992, J4-1081/10

DIGITAL ELECTRONICS
BMEVIAUM005

Contact hours: 1+0+2 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Rakos Balázs, assistant professor

Further lecturer(s): dr. Glöckner György, assistant prof.

Topics:
Introduction, number systems, Boolean and switching algebra. Codes, BCD and alphanumeric codes. Redundant coding for error detection and correction. Minterms, maxterms, logic functions. Combinational networks. Elementary and complex combinational circuits. Reduction of

combinational networks, dynamic behaviour (hazards). Sequential networks (Introduction, description and representation). Asynchronous and synchronous sequential networks. Elementary sequential networks. Systematic design of synchronous sequential networks. Complex sequential networks. Electrical properties of digital circuits. IC fabrication technology. Integrated circuit logics (bipolar, MOS, CMOS). Interfacing. Application specific ICs (ASICs). Programmable circuits. Methods of digital control. Laboratory activities and problem solving activities.

Recommended literature:

1. Millman, J.-Grabel, A.: Microelectronics, McGraw-Hill, 1987
2. D.I. Porat, A. Barna: Introduction to Digital Techniques, John Wiley&Son, Second Edition, 1987, ISBN 0-471-09187-1
3. M. Bolton: Digital System Design with Programmable Logic, Addison-Wesley Publishing Company, Massachusetts 1990.
4. G. Franklin, D. Powell, M. Workman: Digital Control of Dynamic Systems, 1990.
5. R. Sandige: Modern Digital Design, 1990.

REAL TIME SYSTEMS

BMEVIAUM006

Contact hours: 1+0+2 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Sütő Zoltán, assistant prof.
Further lecturer(s): Dr. Kis Péter, assistant prof.

Topics:

Introduction to real-time systems; System decomposition and scheduling techniques; Programming language and operating systems support; Formal specification, analysis, and verification techniques; Embedded programming techniques; Sensor Input/Actuator Output; Power-aware computing (dynamic voltage/frequency scaling, shutdown techniques); Real-time rule-based expert systems; Fault detection, fault recovery, and reliability issues; Time-critical distributed systems and communication networks.

Recommended literature:

1. Alain Burns, Andy Wellings,*Real Time Systems and Programming Languages: Ada 95, Real-Time Java and Real-Time C/POSIX (3rd Edition)* Addison Wesley; 3 edition (April 5, 2001)
2. Rick Grehan, Robert Moote, Ingo Cyliax, *Real-Time Programming : A Guide to 32-bit Embedded Development*, Addison-Wesley Professional; Bk&CD Rom edition (December 9, 1998)
3. Jean J. Labrosse *MicroC OS II: The Real Time Kernel (With CD-ROM)*
4. Albert M. K. Cheng: *Required textbook: Real-Time Systems: Scheduling, Analysis, and Verification,*

PROGRAMMABLE DIGITAL DEVICES

BMEVIAUM007

Contact hours: 1+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Sütő Zoltán, assistant prof.
Further lecturer(s): Dr. Glöckner György, assistant prof., Zabán Károly, engineer

Topics:

Application specific ICS (ASICs), essentials, classification, comparison, application. Programmable logic devices (principle, categories, types, programmability, comparison). CPLDs and FPGAs in detail. Programmability, development methods. Applications. Storage elements: semiconductor memories (principle of storage, classification, features) Non-volatile and Read/write memories (principle of storage, properties, programming methods, applications). Microprocessors and microcontrollers (basics, operation, architecture, application). Programmable interface elements (functions, architecture, operation, programming, usage).

Recommended literature:

1. Bob Zeidman - Introduction to CPLD and FPGA Design (www.fpga-guide.com)
2. Z. Navabi (Kluwer, 2005) - Digital Design and Implementation with Field Programmable Devices, Chapter 4
3. ASICs... the book (HTML) - http://iroi.seu.edu.cn/books/asics/ASICs.htm#anchor749424
4. Chapters of 'Millman, J.-Grabel, A.: Microelectronics, McGraw-Hill, 1987'
5. Chapters of Douglas V. Hall: Microprocessors and interfacing, Mc Graw-Hill, 1992
6. Wakerly J. F.: Digital Design, Principles and Practices; Prentice Hall 2006; ISBN 0-13-186389-4
7. Meyer-Baese, Uwe , Digital Signal Processing with Field Programmable Gate Arrays Springer ISBN-10: 3-540-21119-5

INDUSTRIAL VISION SYSTEMS

BMEVIAUM008

Contact hours: 1+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Hamar János, associate prof.

Further lecturer(s): Dr. Sütő Zoltán, assistant prof.

Topics:

Sensors, Optics & Lighting; Simple color models (RGB, HLS, CMYK, CNS, CIE) camera calibration, filters, Fundamental techniques in Computer Graphics Coordinate systems in 2D and 3D CG, homogeneous coordinates, affine transformations, Fourier transformation, viewing transformations, frame to window mapping, line and polygon clipping. Stereo vision, Graphic Communication, Basic rendering - Point Operations; Neighborhood Operations Intelligent Vision - Imaging Techniques; Sample Problems & Review.

Recommended literature:

1. Hill S.,F.: Computer Graphics Using Open GL, Prentice Hall Computer Science Team
2. Alexander Hornberg (Editor) Handbook of Machine Vision, ISBN 3-527-40584-4

WEB-BASED LABORATORY

BMEVIAUM009

Contact hours: 1+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Hamar János, associate prof.

Further lecturer(s): Dr. Sütő Zoltán, assistant prof.

Topics:

Remote supervising and measurement. Features of SCADA (Supervisory Control and Data Acquisition) systems, architectures, requirements. Facilities offered by the Web, problems and security issues. Intelligent measuring instruments. Communication protocols. Software meters. Web application architectures, Web services, Java-based web systems, Human-machine interface. Development tools.

Recommended literature:

1. Timothy Lethbridge: Object-oriented Software Engineering: Practical Software Development Using Uml And Java, Mcgraw-Hill College; 2nd edition, 2004, ISBN-10: 0077109082, ISBN-13: 978-0077109080
2. Bruce Eckel: Thinking in Java (4th Edition), Prentice Hall PTR; 4th edition, 2006, ISBN-10: 0131872486, ISBN-13: 978-0131872486
3. Marty Hall: Core Servlets und Java Server Pages, Markt+Technik Verlag 2005, ISBN-10: 3827269547, ISBN-13: 978-3827269546
4. The Java Tutorial - A practical guide for programmers and the J2EE Tutorial on-line documents at http://java.sun.com/learning/tutorial/index.html
5. Ko C. C.: Creating Web-Based Laboratories, Springer, 2004.
6. Bailey D, Wright E.: Practical SCADA for Industry, Elsevier, 2003.

INDUSTRIAL EMBEDDED SYSTEMS

BMEVIAUM010

Contact hours: 1+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Rakos Balázs, assistant prof.

Further lecturer(s): Dr. Kis Péter, assistant prof.

Topics:

Hardware/software systems and codesign: Architecture selection, microcontroller selection, IDE selection, operating system considerations, programming selection and costs.
Models of computation for embedded systems, Partitioning, scheduling, and communication, Embedded device that uses the following communication protocols: Bluetooth, IrDA (Infrared Data Association), and WiFi, ASI and Profibus. Simulation, synthesis, and verification, Hardware/software implementation, Performance analysis and optimization.

Recommended literature:

1. Alain Burns, Andy Wellings,*Real Time Systems and Programming Languages: Ada 95, Real-Time Java and Real-Time C/POSIX (3rd Edition),* Addison Wesley; 3 edition (April 5, 2001)
2. Rick Grehan, Robert Moote, Ingo Cyliax, *Real-Time Programming : A Guide to 32-bitEmbedded Development,* Addison-Wesley Professional; Bk&CD Rom edition (December 9, 1998)
3. Jean J. Labrosse, *MicroC OS II: The Real Time Kernel (With CD-ROM)*
4. Karim Yaghmour,*Building Embedded Linux Systems,* O'Reilly Media, Inc.; 1 edition (April 22, 2003)
5. http://www.linuxdevices.com/

8.7 A Robotics modul tantárgyai

Special subjects / Major or Minor Compulsory Subjects

ROBOT CONSTRUCTIONS

BMEGEGTMW04

Contact hours: 2+0+1 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Németh István, expert

Topics:

Review of robot arm structures and the rules of motions and motion simulations. The actuators as robot arm components: electromagnetic actuators (AC/DC drives), fluid power actuators, non-conventional actuators. The structure of micro robots. Sensory functions, sensors. Grasping theory and grippers. Analysis of units and components. Design and simulation of a selected robot arm unit, a gripper unit, as well as the selection of the relevant sensors.
Laboratory tests, control parameter setting on existing robot arms and grippers.

Recommended literature:

3. Actuators, (Ed.: H. Janocha), Springer Verlag, 2004, ISBN 3-540-61564-4
4. Y.Altintas, Manufacturing Automation, Cambridge University Press, 2000, ISBN 0-521-65973-6
5. B. Benhabib, Manufacturing, Marcel Dekker Inc., 2003, ISBN 0-8247-4273-7
6. Assistenzroboter, FIPA Workshop F 112 Dez.2004, Stuttgart.
7. Robot grippers (Eds: D.T. Pham, W.B. Heginbotham), IFS Publ. Ltd.-Springer Verlag, 1986, ISBN 0-948507-03-9
8. Downloads recommended from: http://www.manuf.bme.hu/

ROBOT CONTROL

BMEGEGTMW09

Contact hours: 2+1+0 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Monostori László, professor

Further lecturer(s): Dr. Kemény Zsolt, research fellow

Topics:

The course is an introduction to the basics and fundamental problems of robot modelling and control. The curriculum focuses mainly on the most common robot class in industrial use, i.e. rigid, open-chain robots, dealing with their modelling and control on the usual three levels of kinematics, differential kinematics and dynamics. Furthermore, the course gives an outlook on the properties of other robot classes (e.g., mobile robots), conditions and typical problems of practical application, and strives to provide advice concerning acquisition of further knowledge and solving problems not covered by the curriculum.
Completing the course contributes to the students learning to solve practical robotics-related modelling, planning and control problems on their own, using exact methods, while keeping up with today's quickly evolving technical knowledge.
Prerequisites: Required knowledge are the basics of control engineering, as well as a few selected areas of mechanical engineering. It is recommended to complete the mathematical curriculum

prescribed for the first 4 semesters, especially with respect to the basics of linear algebra (matrix operations)

Recommended literature:

1. Lantos Béla: Robotok irányítása (Robot Control), Akadémiai Kiadó, Budapest, 1991, ISBN 963-05-6217-0
2. Mark W. Spong, M. Vidyasagar: Robot Dynamics and Control, John Wiley and Sons, 1989, ISBN 047161243X
3. Carlos Canudas de Wit, Bruno Siciliano, Georges Bastin (eds.): Theory of Robot Control, Springer-Verlag London, 1996, ISBN 3-540-76054-7

MAJOR PROJECT IN ROBOTICS

BMEGEGTMWD1

Contact hours: 0+0+11 **Credits:** 14 **Requirement:** signature
Responsible: Dr. Mátyási Gyula, associate prof.

Topics:

In course of the Project one student or group of 2 students will work on one selected challenging problem of mechanical engineering. Several experimental and/or numerical project proposals will be announced by the project leaders. The aim of the course is to develop and enhance the capability for complex problem solving of the students under advisory management of their project leader. At the end of each semester a written Project Report is to be submitted and the summary and findings of the investigations on the selected problem is to be presented as Project Presentation.

Recommended literature: It depends on the topic of the project.

Special subjects / Major or Minor Elective Subjects

PRODUCTION PLANNING AND CONTROL

BMEGEGTMW10

Contact hours: 3+0+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Monostori László, professor

Further lecturer(s): Dr. Váncza József, associate prof.

Topics:

The aim of subject to introduce the basic problem of the production management planing and control, the nominations, connections and methods. The topics dealing with warehouse management, for short and long time period the production and capacity planning, short time scheduling and analyzing methods of production management systems. The students became familiar with classical methods - they applied in the production management systems nowadays - and they have a view about the results of future trends. Primary importance given for the modelling and abilities of analyzing. We close a bigger series of the performance with a demonstration so the students can get a real view about the limits and development trends of production planning.

Recommended literature:

1. Hopp, W.J.; Spearman, M.L, Factory physics, Foundations of manufacturing management, Irwin, 1996.
2. Sokszorosított fejezetek az Erdélyi Ferenc (szerk.): *A technológia menedzsment informatikai*

eszközei; Információrendszerek. I-II. rész. c. műből. OMFB megbízásából, a PHARE TDQM-HU-9305.01-1383.sz. projekt keretében készített tananyag Miskolc, 1997. április.

3. A tárgy előadóinak honlapjáról (http://www.sztaki.hu/~vancza) elérhető segédanyagok és az ott felsorolt irodalom (Complementary notes available at:http://www.sztaki.hu/~vancza).

SOFTWARE TECHNOLOGIES

BMEGEMIMW03

Contact hours: 2+0+1 **Credits:** 3 **Requirement:** practical mark
Responsible: dr. Tamás Péter

Topics:

Compararison of the traditional and component based program technologies. Principles of object based programming. Component based technologies. Theoretical bacjground and practical aspects of software modelling. The Internet as a resource. Development of Java applet. Construction and elements of Net Framework. .Net applications, ASP.NET applications. The ADO.Net. Distributed systems. Cliend serving applications. Programming in Java and C# (based on Java).

Recommended literature:

1. Kuzmina Jekatyerina, dr. Tamás Péter, Tóth Bertalan: Programozzunk Java nyelven (előkészületben) (Programming in Java)
2. Kuzmina Jekatyerina, dr. Tamás Péter, Tóth Bertalan: Programozzunk C# nyelven (előkészületben) (Programming in C#)

ARTIFICIAL NEURAL NETWORKS AND HYBRID SYSTEMS

BMEGEGTMW11

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** examination
Responsible: Dr. Monostori László, professor

Topics:

Symbolic and subsymbolic forms of knowledge representation and processing. Basics of pattern recognition, discriminant functions, preprocessing, feature extraction and selection, learning algorithms and their classifications, the Bayes decision algorithm. Concept of artificial networks, multilayer perceptrons, the back-propagation learning algorithm. Further models of ANNs and their applications. Handling of uncertainty, basics of fuzzyness, fuzzy control, fuzzy expert systems. Neuro-fuzzy approaches. Genetic algorithms.

Recommended literature:

1. Haykin, S., Neural networks, A comprehensive foundation, 2nd edition, Prentice Hall, 1999.
2. Lin and R., Neural Fuzzy Systems: A Neuro-Fuzzy Synergism to Intelligent Systems, Prentice Hall, 1996.
3. Horváth G., Neurális hálózatok és alkalmazásaik (Neural Networks and Applications), Műegyetemi Kiadó, Budapest, 1998.
4. Lecture Notes by the lecturer

ROBOT PROGRAMMING

BMEGEGTMW06

Contact hours: 1+0+2 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Mátyási Gyula, associate prof.

Further lecturer(s): Dr. Szalay Tibor, associate prof.

Topics:

Hardware and software architectures of robot controller. Robot coordinate systems, robot kinematics, transformation between coordinate systems, interpolation modes, path planning. Robot programming methods, teach-in, numerical codes, high level program languages. Main structure of a robot language, commands, parameters, variables, input/output controlling, program organizing solutions. Programming of sensors and actuators of the robot.

Recommended literature:

1. J. Somló, B.Lantos, P.T. Cat : Advanced Robot Control Akadémiai Kiadó, 1997, ISBN 963-05-7350-4

SIMULATION OF CNC MACHINES AND ROBOTS

BMEGEGTMW12

Contact hours: 2+0+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr Erdős Gábor, research fellow

Topics:

Overview of simulation programs. Mathematical principals (homogenious transformation matrices, graphs, Jacobi matrix). Modelling of mechanical systems (modelling of low level kinematical pairs, kinematical graphs). Modelling of machines with open kinematic chain (industrial robots). Solution of inverse kinematical problem (symbolically and numerically). Modelling of kinematical systems (calculation of velocity and acceleration functions). Simulation of traditional CNC machines. Structured reading and process of input files (lex/yascc type browsers). Calibration of simulation models (origos, setting of extremities). Usage of simulation (exercise of coincidence, problems of interpolation, choosing of solution branch, positioning of objects). Mechanical modelling based on graph structures (generating independent constrain functions). Simulation of parallel robots. Simulation of material selection.

Recommended literature:

1. Horváth, Markos: Gépgyártástechnológia (Machine Production Technology),Műegyetem Kiadó
2. LinkageDesigner User Guide
3. Edward, J. Haug, Computer Aided Kinematics and Dynamics of Mechanical Systems, Allyn and Bacon, 1989.

ASSEMBLY

BMEGEGTMW07

Contact hours: 1+1+1 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Szalay Tibor, associate prof.

Topics:

Assembly (objects); definitions of assembly; units and items, object oriented assembly tree and documents;

Assembly (process); assembly procedures, operations, methods and organisation structures; process oriented assembly tree and documents;
Automation: Initiating, financial and social analysis of automation, specific and universal equipments, organizing and scheduling of the process;
Design for assembly
Quality control (object oriented view of quality assurance); probability functions and distributions, dimensional chains and analysis; calculation of resulting error and tolerance based on full and partial changeability;
Quality control (process oriented view): sensors and monitoring, control and statistical process control.

Recommended literature:

1. Boór Ferenc., Assembly (lecture note) http://www.manuf.bme.hu/
2. Lotter, Manufacturing Assembly Handbook, FESTO Blue Digest on Automation.

SPECIAL ROBOTS AND ROBOT APPLICATIONS

BMEGEGTMW08

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Arz Gusztáv, senior research fellow

Topics:

Review of robot applications excluding the industrial robot applications. Personal, office, rehabilitation, surgery, house keeping, toy, construction, transport, agriculture, sea/deepwater, space, defence, civil protection robots. User and system requirements. Analysis of units and components. Design and simulation of a selected service robot application including a mobile unit, an arm unit, a gripper unit, as well as perception sensors.
Laboratory tests, control parameter setting on existing medical, civil protection, and cleaning robots.

Recommended literature:

1. S. Kalpakjian, S.R. Schmid, Manufacturing Engineering and Technology, Fourth edition, Prentice Hall, 2001, ISBN 0-201-36131-0
2. Y. Altintas, Manufacturing Automation, Cambridge University Press, 2000, ISBN 0- 521-65973-6
3. B. Benhabib, Manufacturing, Marcel Dekker Inc., 2003, ISBN 0-8247-4273-7
4. Assistenzroboter, FIPA Workshop F 112 Dez.2004 Stuttgart
5. Downloads recommended from: http://www.manuf.bme.hu/

MICROELECTRONICS IN CONTROL

BMEGEMIMW06

Contact hours: 1+1+0 **Credits:** 3 **Requirement:** practical mark
Responsible: Dr. Aradi Petra, associate prof.

Topics:

Basics of control systems. Microelectronic devices in control engineering tasks. Building blocks, architecture and programming of microprocessor systems, development tools. Microcontrollers. Embedded systems. Programmable logic controllers (PLCs). Interfacing computers and other devices to real-world processes. RF and mobile devices. Mobile robotic applications.

Recommended literature:

1. Available at the ftp-site of the department:http://www.rit.bme.hu/ftp/pub/oktatas/

FINAL PROJECT IN ROBOTICS
BMEGEGTMWD2

Contact hours: 0+0+15 **Credits:** 19 **Requirement:** signature
Responsible: Dr. Mátyási Gyula, associate prof.

Topics:
The aim of the subject of is to demonstrate the ability of the student to solve high level, practical engineering problems, based on acquired knowledge in the fields of mechanical engineering. The projects have to be prepared by the students under the guidance of supervisors. The Final Projects include tasks in design, simulations, laboratory tests, manufacturing as well as controlling, interfacing and software tasks. The expected result is mostly a Final Report prepared according to written formal requirements. During the Final Exam, the results have to be explained in an oral presentation.

Recommended literature: It depends on the topic of the project.

8.8 Subjects in Economics

MANAGEMENT
BMEGT20MW02

Contact hours: 3+0+0 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Gyökér Irén, associate prof.

Further lecturer(s): Finna Henrietta, assistant lect., Dr. Szabó Balázs, assistant prof.

Topics:
The objectives of the course are that the students know the duties of management and the attributes of the manager job with the current formed perception in different ages. Over the set targets the students will understand the characteristic of human behaviour, the behaviour of managers and their employee, the team properties in the labour-environment and the corporations how develop their functional rules. The applicable (for previous) management methods and their expected effects on the members of corporation and their capacities are presented in the course of the discussed themes.

Recommended literature:

1. Robert Vecchio, Organizational Behavior: Core Concepts, Dryden Press, 2005.
2. Debra L. Nelson and James Campbell Quick, Organizational Behavior: Foundations, Reality and Challenges, Thomson South-Western, 2005.
3. Donnelly, J.H., Gibson, J.L., Ivancevich, J.M., Fundamentals of Management, Irwin, USA, 1995.

MARKETING
BMEGT20MW01

Contact hours: 3+0+0 **Credits:** 5 **Requirement:** practical mark
Responsible: Dr. Szalkai Zsuzsanna, associate prof.

Topics:

Marketing in the 21st century. Strategic marketing planning. The modern marketing information system. Consumer markets and buyer behavior. Business markets and business buyer behavior. Competitive strategies. Market segmentation, targeting, and positioning. Product strategy and new-product development. Managing services. Designing pricing strategies. Marketing channels. Integrated marketing communication.

Recommended literature:

1. Kotler, Ph., Armstrong, G., Saunders, J., V., Wong (2002): Principles of Marketing. Prentice Hall
2. Kotler, Ph. (2000): Marketing Management. Prentice Hall
3. Vágási M. (szerk.) (2007): Marketing-stratégia és menedzsment (Marketing Strategy and Management). Alinea Kiadó