



Bundesinstitut für Berufsbildung (BIBB)

**Ausbildungsordnung und Rahmenlehrplan
für den Ausbildungsberuf
Mechatroniker/Mechatronikerin**

(Englische Übersetzung)

**Ordinance on Vocational Education and Training
in the Occupation of Mechatronics Fitter**

(English Version)

Bundesinstitut für Berufsbildung (BIBB)
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Ordinance
on Vocational Education and Training in the Occupation of Mechatronics Fitter
(Mechatroniker-Ausbildungsverordnung – MechatronikerAusbV) ^{*)}
promulgated on 21 July 2011

On the basis of § 4 Paragraph 1 of the Vocational Training Act in conjunction with § 5 of said Act, § 4 Paragraph 1 having been amended by Article 232, Clause 1 of the Ordinance dated 31 October 2006 (Federal Law Gazette I p. 2407), the Federal Ministry of Economics and Technology issues the following Ordinance in agreement with the Federal Ministry of Education and Research.

§ 1

State recognition of the training occupation

The training occupation of Mechatronics Fitter is accorded state recognition pursuant to § 4 Paragraph 1 of the Vocational Training Act.

§ 2

Duration of vocational education and training

Duration of training is three and a half years.

§ 3

Training profile, general training plan

(1) The skills, knowledge and competences (employability skills) listed in the general training plan (Annex) constitute the minimum object of the vocational education and training. Organisation of training which deviates from that contained within the general training plan is permitted in particular insofar as specific practical company characteristics necessitate such a deviation.

(2) Vocational education and training in the occupation of Mechatronics Fitter is structured in the following manner (training profile).

1. Vocational education and training, employment and collective wage agreement law
2. Structure and organisation of the company providing training
3. Health and safety at work
4. Environmental protection
5. Company and technical communication
6. Plan and control work processes, check and evaluate work results
7. Quality management
8. Check, mark off and label workpieces
9. Cut, separate and reform manually or by machine
10. Join

11. Install electrical sub-assemblies and components
12. Measure and test electrical values
13. Install and test hardware and software components
14. Build and test control systems
15. Programme mechatronic systems
16. Assemble sub-assemblies and components into machines and systems
17. Assemble and dismantle machinery, systems and plants; transport and secure
18. Test and adjust the functioning of mechatronic systems
19. Commission and operate mechatronic systems
20. Maintain mechatronic systems

§ 4

Implementation of vocational education and training

(1) The skills, knowledge and competences stated in the present Ordinance should be imparted in such a way so as to enable trainees to exercise a qualified occupational activity within the meaning of § 1 Paragraph 3 of the Vocational Training Act, this particularly to encompass the autonomous planning, execution and checking of work. Evidence of the competence described in No. (1) above is to be provided in the examinations pursuant to §§ 5 to 7.

(2) Trainers shall use the general training plan as the basis for the drawing up of a training plan for trainees.

(3) Trainees are to keep a written record of their training. They are to be afforded the opportunity to maintain this written record of training during training time. Trainees shall review the written record of training on a regular basis.

§ 5

Final examination

The final examination comprises Parts 1 and 2, which are held at separate times. The objective of the final examination is to ascertain whether candidates have acquired occupational employability skills. In the final examination, candidates should demonstrate mastery of the necessary occupational skills, possession of the required occupational knowledge competences and familiarity with the teaching material

^{*)} The present Statutory Ordinance constitutes a training regulation within the meaning of § 4 of the Vocational Training Act. The Skeleton Curriculum for Vocational Schools, published as Annex No. 168a to the Federal Gazette No. 168 of 9 September 1998, remains in force.

essential to the vocational education and training to be imparted via teaching at vocational school. The training regulation shall constitute the basis of the examination. Skills which have already constituted an object of examination in Part 1 of the final examination shall only be included in Part 2 of the final examination to the extent that such inclusion is necessary for the determination of the requisite occupational competence pursuant to § 38 of the Vocational Training Act.

§ 6

Part 1 of the final examination

(1) Part 1 of the final examination should take place before the end of the second year of training.

(2) Part 1 of the final examination encompasses such skills for the first three half years of training as are listed in the Annex and extends to include teaching material to be imparted at vocational school insofar as such teaching material is integral to the vocational education and training.

(3) Part 1 of the final examination comprises the examination area of "Working on a mechatronic sub-system".

(4) Candidates should demonstrate that they are in a position to:

1. evaluate technical documentation, determine technical parameters, plan and agree work processes, plan material and tool requirements;
2. wire up, connect and configure sub-assemblies and components, accord due consideration to compliance with safety rules, accident prevention regulations and environmental protection provisions;
3. evaluate the safety of mechatronic sub-systems, test mechanical and electrical protective measures;
4. analyse sub-systems, test functions, adjust and measure ratings and establish functionality;
5. hand over and explain systems; document the execution of the order, prepare technical documentation including test protocols.

(5) Candidates should carry out a work task which includes situational oral examination phases and written assignments.

(6) The examination time is 8 hours, whereby the situational oral examination phases should be of a total maximum duration of 10 minutes. The duration of the written assignments should be 90 minutes.

§ 7

Part 2 of the final examination

(1) Part 2 of the final examination encompasses such skills as are listed in the Annex and extends to include teaching material to be imparted at vocational school insofar as such teaching material is integral to the vocational education and training.

(2) Part 2 of the final examination comprises the following examination areas.

1. A work order
2. Work planning
3. Function analysis
4. Business and social studies

Due consideration should be accorded to vocational education and training, employment and collective wage agreement law; structure and organisation of the company providing training; health and safety at work; environmental protection, company and technical communication; planning and management of work processes; evaluation of work results; business processes and quality management.

(3) The following stipulations apply to the examination area of "Work order".

1. Candidates should demonstrate that they are in a position to:

- a) analyse work orders; obtain information from documentation, clarify technical and organisational interfaces, evaluate and select possible solutions in accordance with technical, economic and ecological considerations;
- b) plan and agree order processes, stipulate subtasks, draw up planning documentation, accord due consideration to work processes and areas of responsibility at the place of deployment;
- c) execute orders, test and document function and safety, comply with standards and specifications for the quality and safety of the systems; search systematically for causes of errors and defects;
- d) release and hand over systems; provide specialist information including in English; prepare acceptance protocols; document and evaluate work results and services; invoice for services; document system data and information.

2. The examination area should be based on the following activities: assembly or maintenance of a mechatronic system followed by subsequent commissioning in each case.

3. In order to demonstrate fulfilment of requirements in the examination area of "Work order", candidates should:

- a) execute a company order within 20 hours including provision of practical documentation and to take part in an order-related specialist oral examination of no more than 30 minutes' duration; the specialist oral examination should be conducted on the basis of the practically related documentation of the company order processed; the order-related specialist oral examination should act as a vehicle for evaluating relevant process skills with regard to the execution of the order under due consideration of the practically related documentation; prior to the execution of the company order the assignment including planned processing time should be presented to the Examination Board for approval; or
- b) prepare, execute and follow-up a practical work task in 14 hours, including documentation via task specific records, and to conduct a specialist oral examination of no more than 20 minutes' duration; the execution of the work task lasts 6 hours; observations of the way in which the task is executed, the task specific documentation and the specialist oral examination should act as a

vehicle for evaluating relevant process skills with regard to the execution of the work task.

The company providing training should select the examination option in accordance with 1 (3) above and should notify the candidate and the competent body of the selection at the same time as registration for the examination takes place.

(4) The following stipulations apply to the examination area of "Work planning".

1. Candidates should demonstrate that they are in a position to:

- a) conduct problem analyses;
- b) comply with technical rules in selecting the mechanical and electrical components, cabling, software, tools and equipment required for assembly and commissioning;
- c) adapt installation and assembly plans;
- d) plan the necessary stages of work according due consideration to health and safety at work and use standard software.

2. The examination area should be based on the preparation of a work plan for the assembly and commissioning of a mechatronic system in accordance with pre-stipulated requirements.
3. Candidates should perform the task in written form.
4. The examination time is 105 minutes.

(5) The following stipulations apply to the examination area of "Function analysis".

1. Candidates should demonstrate that they are in a position to:

- a) plan measures for maintenance or commissioning according due consideration to company processes;
- b) evaluate circuit documentation;
- c) interpret and alter programmes;
- d) identify and present functional correlations within a mechatronic system, mechanical and electrical values and sequences;
- e) align signals at interfaces functionally;
- f) select and deploy test procedures and diagnostic systems;
- g) localise causes of errors, check protective equipment and test electrical protective measures.

2. The examination area should be based on a description of the approach to be adopted towards preventative maintenance and the systematic identification of an error within a mechatronics system.
3. Candidates should perform the task in written form.
4. The examination time is 105 minutes.

(6) The following stipulations are in place in respect of the examination area of "Business and social studies".

1. Candidates should demonstrate that they are in a position to present and evaluate general business and societal correlations within the world of employment and work.
2. Candidates should process practically oriented tasks in written form.
3. The examination time is 60 minutes.

§ 8

Weighting and pass regulations

(1) The examination areas should be weighted as follows.

1. <u>Working on a mechatronic sub-system</u>	40 percent
2. <u>Work order</u>	30 percent
3. <u>Work planning</u>	12 percent
4. <u>Function analysis</u>	12 percent
5. <u>Business and social studies</u>	6 percent

(2) The final examination is deemed to have been passed if:

1. an overall result of at least "pass" is achieved in Part 1 and Part 2;
2. an overall result of at least "pass" is achieved in the examination area "Work order";
3. an overall result of at least "pass" is achieved in two of the examination areas pursuant to Paragraph 1 (5) above and
4. no mark of "fail" is recorded in any examination area in part 2.

(3) At the request of the candidate, an examination in the areas of "Work planning", "Function analysis" and "Business and social studies" for which a mark of worse than "pass" has been awarded should be supplemented by an oral examination of approximately 15 minutes if this may be decisive for the passing of the examination. In calculating the result for this examination area, the previous result and the result of the supplementary oral examination should be accorded weighting in the ratio of 2:1.

§ 9

Entry into force, ceasing to be in force

The present Ordinance enters into force on 1 August 2001. The Ordinance of 4 March 1998 (Federal Law Gazette I p. 408) in respect of vocational education and training in the occupation of Mechatronics Fitter ceases to be in force at this time.

Berlin, date:

The Federal Minister of Economics and Technology
per procuracionem

Annex
(to § 3 Paragraph 1 No.1)

General Training Plan
for Vocational Education and Training in the Occupation of Mechatronics Fitter

No.	Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year		
			1	2	3/4
1	VET, employment and collective wage agreement law (§ 3 Paragraph 2 No. 1)	<ul style="list-style-type: none"> a) Explain the significance of the training contract, in particular conclusion, duration and termination b) State mutual rights and responsibilities arising from the training contract c) State opportunities for advanced vocational training d) State essential parts of the training contract e) State essential provisions contained within the collective wage agreements applying to the company providing training 	to be imparted over the whole course of the training period		
2	Structure and organisation of the company providing training (§ 3 Paragraph 2 No. 2)	<ul style="list-style-type: none"> a) Explain structure and tasks of the company providing training b) Explain the basic functions of the company providing training, such as procurement, production, sales and administration c) State the relationships of the company providing training and its staff to organisations of trade and industry, professional bodies and trade unions d) Describe the basic principles, tasks and way of working of labour-management relations or staff representative organs within the company providing training 			
3	Health and safety at work (§ 3 Paragraph 2 No. 3)	<ul style="list-style-type: none"> a) Ascertain health and safety risk in the workplace and adopt measures for the avoidance of this b) Deploy occupationally related health and safety and accident prevention measures c) Describe behaviours when accidents occur and institute initial measures d) Deploy regulations for preventative fire protection; describe behaviours in the event of fire and initiate fire fighting measures 			
4	Environmental protection (§ 3 Paragraph 2 No. 4)	<p>Contribute to the avoidance of instances of environmental pollution caused by the company within the occupational sphere of influence, in particular</p> <ul style="list-style-type: none"> a) Explain possible instances of environmental pollution caused by the company providing training and its contribution to environmental protection using examples b) Deploy environmental protection regulations as these apply to the company providing training c) Take opportunities to use energy and materials in an environmentally friendly manner d) Avoid waste, make substances and materials available for disposal in an environmentally friendly manner 			

No.	Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year		
			1	2	3/4
5	Company and technical communication (§ 3 Paragraph 2 No. 5)	a) Procure and evaluate information b) Conduct discussions with line managers, colleagues and within the team in a manner appropriate to the situation, present facts and circumstances, use technical terminology in German and English c) Use opportunities to resolve conflicts d) Handle IT systems, in particular deploy software and connect and use peripheral devices e) Protect and secure data f) Prepare protocols and reports, use standard software	4*		
		g) Read and use partial, group and overall drawings h) Read and use circuit documentation on sub-assemblies and devices used in <u>fluidics</u> i) Read and use electrical, block, function, assembly and connection plans j) Prepare sketches and lists of parts	3*		
		k) Update technical plans of sub-assemblies, machines and plants l) Use technical regulations, operating instructions, work directives and other information including in English		3*	
		m) Use presentation techniques n) Explain products and work results on handover and provide initial instructions as to function o) Use company information and communication systems			3*
6	Plan and control work processes, check and evaluate work results (§ 3 Paragraph 2 No. 6)	a) Stipulate stages of work in accordance with functional, technical production and business criteria b) Stipulate and secure work processes in accordance with organisational and information criteria c) Plan work in a team, assign tasks d) Plan and set up the workplace e) Request and provide materials, tools and equipment in an order-related manner f) Prepare processing machines for the work process	5*		
		g) Make tools, machine tools, testing and measuring equipment and technical equipment ready for operational use, check and maintain such tools and equipment and initiate measures for the rectification of errors h) Monitor, evaluate and check own work and work done by others i) Document materials, spare parts, work time and technical checks		3*	
7	Quality management (§ 3 Paragraph 2 No. 7)	Observe standards and specifications for quality assurance of the products and secure quality in completing the order according due consideration to upstream and downstream divisions, in particular: a) Evaluate the quality assurance system and its effectiveness in conjunction with technical documentation, deploy procedures b) Select test methods and test equipment, ascertain and document utilisability of test equipment, use			5*

* To be imparted in connection with other training contents listed in the general training plan

No.	Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year		
			1	2	3/4
		inspection plans and company testing regulations c) Systematically seek causes of errors and quality defects, rectify and document such errors and defects d) Contribute to continuous improvement of work processes in own work area			
8	Check, mark off and label workpieces (§ 3 Paragraph 2 No. 8)	a) Select and handle measuring equipment for the measurement and checking of lengths, angles and areas b) Measure lengths, observe tolerances and check matching c) Check areas for evenness, angularity and precision of form and evaluate the quality of surface areas d) Monitor form of surface areas and characteristics of joining surfaces in accordance with technical requirements e) Mark off, punch and label workpieces f) Measure angles and check using angle gauges	3*		
9	Cut, separate and reform manually or by machine (§ 3 Paragraph 2 No. 9)	a) Saw sheet metals, boards and metal and plastic profiles as marked out b) File and chamfer areas and forms on workpieces flat, angled and parallel to measure c) Create and smooth drill holes d) Create internal and external screw threads e) Process workpieces by turning f) Process workpieces by milling g) Crop thin sheet metal and plastic boards h) Cold form and straighten sheet metals, pipes and profiles made of ferrous and non-ferrous metals	11		
10	Join (§ 3 Paragraph 2 No. 10)	a) Produce and secure screw fittings according due consideration to sequence of components and torque b) Dowel construction components c) Create soldered and adhesive connections d) Weld sheet metals, pipes and profiles	6		

* Im Zusammenhang mit anderen im Ausbildungsrahmenplan aufgeführten Ausbildungsinhalte zu vermitteln

No.	Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year		
			1	2	3/4
1	Install electrical sub-assemblies and components (§ 3 Paragraph 2 No. 11)	a) Assemble plug-in modules, housings and circuit unit combinations b) Select, install, wire up and label components for electrical auxiliary and circuit units c) Install and label components for open and closed loop control, measuring and checking d) Stipulate cabling routes in accordance with construction and on-site circumstances e) Select, prepare, lay and connect cables according due consideration to mechanical and electrical load, method of laying and purpose	8		
		f) Wire up sub-assemblies and devices using various methods according to documentation and templates g) Correct errors and document changes		5	
2	Measure and test electrical values (§ 3 Paragraph 2 No. 12)	a) Select measuring procedures and measuring devices, assess measurement errors and set up measuring equipment b) Measure voltage, current, resistance and output in the direct and alternating current circuit and calculate dependence c) Record, present and evaluate measurement series and response curves, especially of resistances dependent on voltage, temperature and light d) Measure and check analogue and digital signals, in particular signal time behaviour e) Check electrical parameters of sub-assemblies and components f) Build electrical circuits and check function	8		
3	Install and test hardware and software components (§ 3 Paragraph 2 No. 13)	a) Check hardware and software interfaces, compatibility of hardware components and system requirements for software b) Assemble and connect system components c) Configure hardware, install and adjust software		3	
		d) Install and configure networks and bus systems e) Check signals at interfaces, interpret protocols, test systems			4
		f) Carry out version changes of software g) Document changes in hardware and software			4
4	Build and test control systems (§ 3 Paragraph 2 No. 14)	a) Build and connect electrical and <u>fluidic</u> circuits b) Connect, check and adjust systems for the provision of electrical, pneumatic or hydraulic energy c) Measure and adjust pressure in <u>fluidic</u> systems	4		
		d) Analyse assignment, in particular sequences and reciprocal effect at interfaces of the system to be controlled e) Align control concepts and select control equipment f) Build electrical and fluidic circuits in accordance with pre-stipulated problem statements g) Install sensors, actuators and converters h) Check and adjust the interaction of connected functions, consider interfaces in localising errors			9
5	Programme mechatronic systems (§ 3 Paragraph 2 No. 15)	a) Evaluate control systems of different designs b) Enter and amend control programmes, prepare and use test programmes c) Prepare, enter and test application programmes for control systems		4	

No.	Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year			
			1	2	3/4	
		d) Monitor programme process in mechatronic systems, identify and rectify errors				4
6	Assemble sub-assemblies and components into machines and systems (§ 3 Paragraph 2 No. 16)	a) Identify sub-assemblies and components and check characteristics are error-free b) Carry out preliminary installations c) Install lubricating and cooling systems d) Install fluidic components, in particular cylinders and valves e) Prepare, lay and connect up pipes and hoses, check for leaks		6		
		f) Match sub-assemblies and components, adjust to the correct functionality and secure position g) Install floating and roller bearings and sub-assemblies with movable parts h) Install drives, gears and coupling systems i) Install and wire up circuit devices j) Install and wire up sub-assemblies for open and closed loop control, measuring and checking k) Install, adjust and connect sensors l) Check functions during the installation process				14
7	Assemble, dismantle, secure and transport machinery, systems and plants (§ 3 Paragraph 2 No. 17)	a) Assemble pipes, installation conduits and cable stages b) Create connections to pipeline systems for the purpose of supply and disposal, select and produce transitions c) Mount protective systems, shielding, cladding and insulation d) Select, fix and connect energy distribution and communication technology cables and equipment according due consideration to mechanical and electrical load and method of laying		6		
		e) Check the characteristics of the place of installation for fixing f) Adjust, fix and secure machines, devices and weight-carrying constructions to reference values g) Evaluate rooms with regard to their environmental conditions and the additional stipulations for rooms of a special kind h) Stipulate protective measures, carry out potential equalisation i) Evaluate and ladders, scaffolding and installation platforms in accordance with technical work and safety aspects j) Select and deploy lifting equipment, fittings and transport, secure and execute transport				12

No.	Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year		
			1	2	3/4
8	Test and adjust the functioning of mechatronic systems (§ 3 Paragraph 2 No. 18)	<ul style="list-style-type: none"> a) Select measuring and test procedures and diagnostic systems, check electrical values and signals at interfaces b) Connect signal processing sub-assemblies and check incoming and outgoing signals c) Check measuring equipment for the recording of sequences, pressure and temperature d) Test and adjust equipment for the identification of limit values, in particular switches and sensors 		4	
		<ul style="list-style-type: none"> e) Evaluate and adjust actuators in accordance with technical safety aspects f) Test open and closed loop control and monitoring systems, adjust control parameters g) Adjust target levels for relevant process values, in particular for sequences and pressure h) Systematically localise errors by according consideration to the interfaces of mechanical, <u>fluidic</u> and electrical sub-assemblies through visual checks, testing and measurement and with the assistance of monitoring systems and test programmes i) Test and adjust electrically and electronically operated drives j) Investigate the possible causes of malfunctions and errors, evaluate possibilities for the rectification of such malfunctions and errors and initiate repair k) Test and document individual and overall function 			12
9	Commission and operate mechatronic systems (§ 3 Paragraph 2 No. 19)	<ul style="list-style-type: none"> a) Check protection against direct touching b) Check effectiveness of protective measures, in particular fault current protective equipment, measure insulation, earthing and loop resistance c) Check the effectiveness of mechanical and electrical safety fixtures, in particular emergency off switches and alarm systems 		2	
		<ul style="list-style-type: none"> d) Test and commission auxiliary and control current circuits including the relevant signal and command transmitters for open and closed loop control and monitoring systems e) Check main circuits and gradually commission, measure operational values, adjust target values f) Commission <u>fluidic</u> equipment g) Check and adjust smoothness of running, quietness of running, revolution frequency, pressure, temperature and travelling distance, check for leaks h) Check and secure fixing, energy supply, lubrication, cooling and disposal i) Load and secure programmes and data, check and adjust programme process j) Check and commission signal transmission systems, in particular field buses k) Commission mechatronic systems, carry out function check l) Check protective measures for electromagnetic compatibility m) Identify system parameters at the time when commissioning takes place, compare with stipulated values and adjust n) Operate machines and systems, carry out test run with nominal and limit values 			14

No.	Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year		
			1	2	3/4
0	Maintain mechatronic systems (§ 3 Paragraph 2 No. 20)	<ul style="list-style-type: none"> a) Inspect mechatronic systems, check function of safety systems and protocol checks b) Maintain mechatronic systems in accordance with maintenance and repair plans, exchange parts subject to wear and tear as part of preventative maintenance c) Dismantle devices and sub-assemblies noting their function and label parts with regard to position and functional alignment d) Rectify malfunctions by conducting remedial procedures and exchanging parts and sub-assemblies e) Rectify software errors f) Compare system parameters with stipulated values and adjust g) Repair mechatronic systems according due consideration to company processes h) Adapt mechatronic systems to altered operational conditions i) Use diagnostic and maintenance systems 			13

Skeleton Curriculum for the Training Occupation of Mechatronics Fitter

(Resolution of the Standing Conference of the Ministers of Education and Cultural Affairs of 30 January 1998)

Part I Preliminary remarks

This skeleton curriculum for occupationally related teaching at a vocational school has been passed by the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK). The skeleton curriculum has been agreed in conjunction with the corresponding training regulations promulgated by the Federal Government (issued by the Federal Ministry of Economics and Technology or by the otherwise responsible ministry in agreement with the Federal Ministry for Education and Research). The procedure for reaching such agreement is governed by the "Joint Results Protocol of 30 May 1972". The skeleton curriculum takes the lower secondary school leaving certificate as its fundamental basis and describes minimum requirements.

In the case of allocated occupations, the skeleton curriculum is structured to include basic training extending across all occupational fields and specialist training for which such basic training forms the foundation.

The training regulations and the skeleton curriculum stipulating the objectives and contents of vocational education and training form the basis for the imparting of final qualifications in a recognised training occupation and of the qualification issued by the vocational school in conjunction with teaching in further subjects. This enables the creation of the essential prerequisites for qualified employment and entry into school based and vocational advanced and continuing training courses.

The skeleton curriculum does not contain any methodological stipulations in respect of teaching. Autonomous and responsible thoughts and actions constitute the overarching objective of training, and the preferred course of action is for delivery of these aims to take place via such forms of teaching in which they represent part of the overall methodological concept. In principle, any methodological approach adopted may contribute to the achievement of this objective. Methods which directly foster occupational competence are particularly suited to purpose and appropriate consideration should be accorded to these within the structuring of the teaching.

The federal states either adopt the skeleton curriculum directly or else implement it via their own curricula. In the latter case, the federal states ensure that coordination of the result stipulated in the skeleton curriculum in terms of structure of specialist content and time remains intact.

Part II Educational remit of the vocational school

Within the dual system of vocational education and training, the vocational school and the company providing training fulfil a joint educational remit.

In this process, the vocational school constitutes an independent learning venue. The vocational school cooperates with other VET participants as an equal partner. The task of the vocational school is to impart vocational and general educational content to pupils according particular consideration to VET requirements.

The aim of the vocational school is to provide basic and specialist vocational training and to extend general education previously acquired. Within this process, the vocational school pursues the objective of enabling pupils to carry out occupational tasks and be involved in shaping the world of work and of society whilst fulfilling their social and ecological responsibility. It is guided by the regulations contained within the educational laws of the federal states as these apply to such schools. Vocationally related teaching is also guided by the national vocational regulatory instruments in respect of each individual recognised training occupation:

- the Skeleton Curriculum issued by the Standing Conference of the Ministers of Education and Cultural Affairs (KMK);
- Training Regulations promulgated by the Federal Government in respect of in-company training;

Pursuant to the Framework Agreement on Vocational Schools (Resolution of the KMK of 15 March 1991), the aims of vocational schools are:

- to impart employability encompassing a combination of specialist competence and general skills of a human and social nature; to develop occupational flexibility enabling the changing requirements within the world of work to be met;
- to develop society including in respect of the convergence of Europe; to stimulate readiness to engage in advanced and continuing vocational training; to foster the ability and readiness to act in a responsible manner in the way in which pupils organise their own lives and act within public life.
-

In order to achieve these aims, a vocational school must:

- structure teaching in such a way so that it is aligned to the specific educational purpose of the task it pursues and emphasises an employment oriented approach;
- impart vocational skills and skills which extend across occupational fields whilst according due consideration to necessary vocational specialisation;
- guarantee differentiated and flexible educational provision in order to accord full consideration to varying degrees of ability and talent whilst also fulfilling the needs of the world of work and of society;
- provide extensive support for and promotion of opportunities for the disabled and the disadvantaged insofar as possible;
- indicate environmental threats and accident risks in conjunction with the exercise of an occupation and in connection with pupils' private lives and highlight means by which such threats and risks may be avoided or reduced.

In addition to this, the vocational school should, within the general teaching it conducts and to the greatest possible extent within occupationally related teaching, address core contemporary problems such as:

- work and unemployment,
- the peaceful co-existence of people, peoples and cultures in the world whilst maintaining a sense of cultural identity,

- the preservation of the natural basis of life and the guarantee of human rights.

The aims listed are aligned towards the development of employability skills. Employability skills within this context are defined as the readiness and ability of an individual person to conduct himself or herself in an appropriate, considered and individually and socially responsible manner in social, occupational and private situations.

Employability skills	develop within the dimensions of professional competence, human competence (personal competence) and social competence.
Professional competence	describes the readiness and ability to use specialist knowledge and ability as a basis to solve tasks and problems in a target oriented, appropriate, methodologically suitable and autonomous manner and to assess results.
Human competence	[Personal competence] describes the readiness and ability to act as an individual personality in clarifying, considering and assessing development opportunities, requirements and restrictions within the family, within an occupation and within public life, to evolve individual talents and to make and further develop life plans. It encompasses such personal qualities as autonomy, critical ability, confidence, reliability and a sense of responsibility and duty. It also particularly includes the development of considered values and self-determined loyalty to values.
Social competence	describes the readiness and ability to develop and live out social relationships, to detect and understand areas of affinity and conflict and to deal with and reach understanding with others in a rational and responsible manner. It also particularly includes the development of social responsibility and solidarity.
Methodological and learning competence	arise from a balanced development of these three dimensions.

Competence describes successful learning in respect of the individual learner and the equipping of him or her with the ability to act autonomously in private, occupational and social situations. In contrast to this, qualification is defined as successful learning in respect of usefulness of competences within the context of the demand for such competences in private, occupational and social situations (cf. German Education Council: Recommendations of the Educational Commission for the Reorganisation of Upper Secondary Education).

Part III Didactic principles

The objectives of vocational education and training require teaching to be conducted in accordance with educational methods aligned to the tasks of the vocational school and to enable young people to plan, execute and evaluate work related tasks within the scope of their occupational activity.

Learning at vocational school essentially takes place with reference to specific occupational actions, a variety of mental operations and theoretical understanding of the actions of others. This learning is primarily linked to reflecting on the execution of actions (action plan, process, results). The fact that occupational work is pervaded by this thought process creates the preconditions for learning at and from work. As far as the skeleton curriculum is concerned, this means that the description of aims and the choice of content take place in an occupationally related way.

Learning theory and didactic cognitions form the basis for the adoption of a pragmatic approach towards the structuring of employment oriented teaching in which the following points of reference apply.

- Situations which are usual for the execution of the occupation form the didactic points of reference (learning in order to be able to act).
 - Actions which trainees can perform themselves wherever possible or understand in theory constitute the starting point for learning (learning via acting).
 - Wherever possible, actions need to be autonomously planned, executed, checked, corrected where necessary and finally evaluated in writing by the learners themselves.
 - Actions should foster a holistic understanding of occupational reality, incorporating technical, safety, economic, legal, ecological and social aspects amongst others.
 - Actions need to be integrated into the experiences of the learners and be reflected upon with reference to their societal implications.
 - Actions should also include social processes such as declaration of interest or conflict resolution.
- Employment oriented teaching is a didactic concept bundling together specialist and action system structures and may be realised via a range of teaching methods.

Teaching provision at vocational schools is directed towards young people and adults who have different prior learning, cultural backgrounds and experiences gained from companies providing training. Vocational schools are only able to fulfil their educational remit if they accord due consideration to these differences and encourage pupils, including disadvantaged and particularly talented pupils, to develop in line with their individual potential.

Part IV Occupationally related preliminary remarks

The present Skeleton Curriculum for Vocational Education and Training in the Occupation of Mechatronics Fitter is coordinated with the Ordinance on Vocational Education and Training of 4 March 1998 (Federal Law Gazette, BGBl., I p. 408).¹

The principle vocational school curriculum content in the examination area of business and social studies is imparted on the basis of “Elements for teaching at vocational schools in the area of business and social studies for technical training occupations” (resolution of the KMK of 7 May 2008). The formulation of objectives and contents of the learning fields should be implemented in such a way so as to result in occupational competence. With regard to technological change, the contents stated in the skeleton curriculum are formulated in a functionally related manner. They should continue to undergo development in line with technological change.

In implementing the skeleton curriculum, methods which foster employability skills should be used. Mathematical, scientific and foreign language contents and economic, ecological and health and safety at work aspects should be imparted in an integrative manner.

The skeleton curriculum takes the following objectives as its starting point.

Pupils:

- work together with other people within the scope of their occupational activity and communicate with these people including in English;
- use technical regulations and provisions when working with mechatronics systems;
- accord due consideration to technical and business management values in carrying out basic calculations; use tables and formulae for this purpose;
- take ergonomic, economic, ecological and societal aspects into account when planning and executing work;
- minimise the negative impact of the work process on the environment by using appropriate materials, acting in a responsible manner and according due consideration to environmental regulations;
- ensure the smooth operation of plants and systems by complying with maintenance regulations; have an awareness of quality which enables them to adhere to quality standards and demonstrate cost-effective solutions;
- develop well-founded approaches for the identification of errors and rectification of malfunctions;
- use error diagnoses to derive conclusions for error rectification;
- use the computer as a work tool;
- Understand descriptions, operating instructions and other information typical to the occupation in German and English and can prepare such information for the customer in a comprehensible form.

¹ The promulgation of the Mechatronic Fitter Training Ordinance of 21 July 2011 (BGBl. I, p. 1516) on the occasion of the introduction of the examination form of “extended final examination” did not necessitate any amendments to the Skeleton Curriculum of the Standing Conference of the Ministers of Education and Cultural Affairs.

Part V Learning Fields

The contents of the skeleton curriculum are structured according to learning fields.

Summary of the Learning Fields for the Training Occupation of Mechatronics Fitter				
Learning fields		Suggested time allocation in hours		
		1 st year of training	2 nd year of training	3 rd and 4 th year of training
1	Analyse functional correlations in mechatronics systems	40		
2	Produce mechanical sub-systems	80		
3	Install electrical equipment according due consideration to technical safety aspects	100		
4	Investigate the energy and information flows in electrical, pneumatic and hydraulic sub-assemblies	60		
5	Communicate with the assistance of data processing systems	40		
6	Plan and organise work processes		40	
7	Realise simple mechatronics components		100	
8	Design and develop mechatronics systems		140	
10	Investigate the information flow in complex mechatronics systems			80
11	Plan assembly and disassembly			40
12	Commissioning, trouble shooting and repair			160
13	Preventative maintenance			80
14	Hand over mechatronics systems to customers			60
	Total	320	280	420

Learning field 1: 1st year of training**Analyse functional correlations in mechatronics systems****Suggested time allocation in hours: 40****Formulation of objectives**

Pupils use provisions and regulations in the investigation of technical plants. They work with technical documentation and use the statements contained within such documentation to arrive at a solution. They have mastery of procedures for the analysis and documentation of functional correlations and conduct discussions regarding possible ways of technical implementation within the team. They work with block diagrams and use such plans to recognise signal flow, material flow, energy flow and basic functionality. They recognise the opportunities for processing work results offered by data processing technology. The pupils have been made aware of the ecological and economic problems of these systems. They are conscious of the significance of the English language for technical communication.

Contents

- Requirements profiles of technical plants
- System parameters
- Block diagrams
- Signal, material and energy flows
- Significance of customer-specific requirements for technical realisation
- Significance and opportunities of data processing
- Documentation and presentation of work results
- Ecological and economic aspects

Learning field 2: 1st year of training**Produce mechanical sub-systems****Suggested time allocation in hours: 80****Formulation of objectives**

The pupils describe the structure, properties and areas of deployment of the materials and auxiliary materials used. They plan the cost-effective use of such materials and auxiliary materials and accord due consideration to environmental and health aspects. They read construction drawings and are able to sketch extracts from such drawings and include changes. They select the mechanical work procedures necessary for manufacture and evaluate the result of the production process. They use typical English language specialist terminology. They accord due consideration to regulations for health and safety at work in the preparation and execution of their work. They are able to organise work within a team.

Contents

- Individual and sub-assembly drawings, lists of parts
- Machine elements, matching and tolerances
- Installation plans, connection elements
- Basic technological principles of manual and machine cutting and reforming
- Production of mechanical connections in the form of frictional connections, form closure, material closure
- Company-specific operating and auxiliary materials
- Installation tools and auxiliary devices
- Storage appropriate to installation, safety aspects, health and safety at work
- Testing and measurement equipment, measurement errors
- Ecological and economic aspects

Learning field 3: 1st year of training**Install electrical equipment according due consideration to technical safety aspects****Suggested time allocation in hours: 100****Formulation of objectives**

The pupils are in possession of well-founded knowledge on the effect of electrical energy in straightforward technical processes. They are familiar with basic electrical circuits and are able to present such circuits and investigate the way in which they work. They apply their knowledge to the selection of electrical operating equipment. They carry out calculations for this purpose and use tables and formulae to solve the task. They are aware of the dangers which may arise for humans and technology as a result of the deployment of electrical energy. They master the measures used to protect humans and technical plants and apply the provisions. They select and deploy the necessary testing and measurement equipment. They integrate amendments into working documentation. They also source information from English language documentation.

Contents

- Electrical values, correlations between electrical values, ways of presenting and calculating electrical values
- Components in direct and alternating current circuits
- Electrical measurement procedures
- Selection of cables and wiring for transmission of energy and information
- Electrical networks
- Dangers of overload, short circuits, power surges
- Handling of tables and formulae
- Effect of electricity on the human body, safety rules, assistance measures in the event of accidents
- Measures against dangerous electrical shocks in accordance with the latest regulations
- Checking of electrical operating equipment
- Causes of overloads, interference voltage, effects and counter measures
- Electromagnetic compatibility

Learning field 4: 1st year of training**Investigate the energy and information flows in electrical, pneumatic and hydraulic sub-assemblies****Suggested time allocation in hours: 60****Formulation of objectives**

The pupils master basic control circuits. They read circuit diagrams, prepare sketches and integrate changes. They are familiar with the technical parameters for the operation of electrical, pneumatic and hydraulic sub-assemblies. They are aware of procedures for the generation of the necessary auxiliary energy. They apply basic measuring processes in a secure manner and are aware of the dangers of handling electrical, pneumatic and hydraulic systems. They understand English product descriptions and use the specialist English language terms which arise. They accord due consideration to health and safety at work and environmental protection provisions.

Contents

- Pneumatic and hydraulic values, correlations between pneumatic and hydraulic values, ways of presenting and calculating pneumatic and hydraulic values
- Supply units of electrotechnology, pneumatics and hydraulics
- Basic control circuits
- Technical documentation
- Signals and measurement values in control systems
- Dangers of handling electrical, pneumatic and hydraulic output sub-assemblies
- Economic aspects, health and safety at work and environmental protection, recycling

Learning field 5: 1st year of training**Communicate with the assistance of data processing systems****Suggested time allocation in hours: 40****Formulation of objectives**

The pupils describe the deployment of data processing systems and the alignment of such systems into business processes and the structures of networked systems and the resulting security requirements. They analyse work orders as well as obtaining operational information which they process and document using the software which is usually deployed within the branch. They are able to seek assistance in arriving at solutions from English language manuals.

Contents

- Operating systems
- Networked data processing systems
- Data protection and data security
- Use branch software to process information
- Control operational processes with the assistance of data processing
- Ergonomic aspects of computer workplaces

Learning field 6: 2nd year of training**Plan and organise work processes****Suggested time allocation in hours: 40****Formulation of objectives**

The pupils describe the company organisational structures and organise team work in accordance with functional, production and business criteria. They are familiar with the requirements regarding the serviceability of all technical equipment necessary for the work process and apply quality control procedures. They use the opportunities provided by data processing systems to plan the process and for the documentation of all necessary control and organisational steps. They accord due consideration to aspects of health protection and health and safety at work in preparing work. They use specialist English language terminology.

Contents

- Materials management and calculation
- Analysis of work processes
- Evaluation and documentation of results
- Ergonomics and preventative action against accidents
- Simple time and cost calculation
- Procedures for the representation of work processes
- Quality management

Learning field 7: 2nd year of training
Produce mechanical sub-systems

Suggested time allocation in hours: 100

Formulation of objectives

The pupils describe the structures of mechatronic sub-systems. They explain how sensors and converters work and adjust sensors. They are familiar with the possibilities for using electrical, pneumatic and hydraulic components to realise linear and rotational movements and apply knowledge of open and closed loop control systems to influence the route and direction of movement. They use signal investigations as a basis for testing the function of components and rectifying errors. They design basic circuits and describe the way such circuits work, including in English. They have a mastery of simple programming procedures.

Contents

- Control chain and open control loop, block diagrams
- Open and closed loop control system indicators
- Functionality of sensors and converters
- Signal behaviour of sensors and converters
- Programming of simple movement processes and control functions
- Design of circuits
- Graphical representations of open and closed loop control processes
- Measuring of signals
- Basic circuits and functionality of drives
- Representation of drive units and function plans

Learning field 8: 2nd year of training
Design and develop mechatronics systems

Suggested time allocation in hours: 140

Formulation of objectives

The pupils describe the structure and signal process of a mechatronic system comprising several components. They analyse the influence on the process procedure of changing operational conditions. They identify errors through signal investigations at interfaces and rectify the causes of such errors. They use technical procedures for the measurement of open and closed loop control processes and process and document the results obtained. They use their knowledge of open and closed loop control technology to influence the speed or revolution of movements. They are able to connect drive units, select different coupling systems between drive units and machines and deploy these systems in a targeted manner. They are aware of the causes and effects of overload situations. They determine the technical parameters of the necessary protective equipment and select such equipment. They integrate circuit alterations into the technical documentation. They are aware of sources of danger. They accord due consideration to health and safety at work and health protection provisions. They are able to describe technical open and closed loop control correlations and the functionality of selected drive units in English. They have a mastery of programming procedures.

Contents

- Operating indicators and response curves of drives
- Maximum values
- Functionality, selection and adjustment of protective equipment
- Open and closed loop control of drives
- Positioning processes, degrees of leeway
- Testing and measurement procedures for determination of position
- Gears, couplings
- Integration of alterations into existing documentation
- Programming of movement processes and control functions
- Computer simulation
- Identification of measurement values at interfaces

Learning field 9: 3rd year of training**Investigate the information flow in complex mechatronics systems****Suggested time allocation in hours: 80****Formulation of objectives**

The pupils are able to read circuit diagrams and use such diagrams as a basis for describing the information structure in systems. They present the connections between electrical, mechanical, pneumatic and hydraulic components. They have mastery of the technical measurement procedures for the investigation of information flows and are in a position to analyse signals and use such an analysis as the basis for drawing conclusions as to possible sources of error. They use diagnostic procedures involving application of data processing. They integrate amendments into working documentation. They are able to modify documentation including in English.

Contents

- Signal processes in systems
- Signal structures
- Bus systems
- Testing and measurement procedures
- Investigation at interfaces between system components
- Networking between sub-systems
- Hierarchies in networked systems
- Documentation of measurement results

Learning field 10: 3rd year of training**Plan assembly and disassembly****Suggested time allocation in hours: 40****Formulation of objectives**

The pupils have mastery of the planning and preparation for the assembly and disassembly of mechatronics systems. They explain the sequence of the work processes and are able to evaluate work results. They include aspects of health protection and health and safety at work in their considerations as early as the preparatory phase. They check assembly conditions at the installation site and take these into account. They plan the deployment of the equipment required. They organise work within a team. They are able to communicate in English when discussing assembly instructions.

Contents

- Company installation documentation
- Conditions for work at the installation site according due consideration to regulations
- Supply and disposal equipment for mechatronic systems
- Transportation, lifting equipment and installation tools
- Safety measures and checking of such measures
- Checks during assembly
- Form and positional tolerances
- Adjustment works
- Disposal and recycling for disassembly

Learning field 11: 3rd year of training
Commissioning, trouble shooting and repair

Suggested time allocation in hours: 160

Formulation of objectives

The pupils present the overall function and sub-function of a system including its protective equipment. They obtain information from technical documentation for this purpose. They explain the influence of components on the whole system and use interface investigations as a basis for testing the function of such components. They have mastery of the measurement procedures necessary for this purpose and use such procedures in a targeted manner. The pupils describe the procedures for the commissioning of mechatronic systems and stipulate the approach to be adopted for the commissioning of a whole system. They use the opportunities provided by diagnostic systems and interpret function and error protocols. They check the effectiveness of protective measures. They adjust sensors and actuators and check and adjust system parameters. Results are documented. They systematically localise errors and rectify malfunctions. They are able to communicate effectively in English.

Contents

- Block diagrams, effect and function plans of mechatronic systems
- Checking and adjustment of sensors and actuators
- System parameters
- BUS parameterisation
- Software installation
- Trouble shooting procedures in electrical, pneumatic and hydraulic systems
- Malfunction analysis
- Trouble shooting strategy, typical error causes
- Electrical and mechanical protective measures, protection regulations
- Electromagnetic compatibility
- Process visualisation, diagnostic systems, remote diagnosis
- Commissioning report, error documentation, repair protocol
- Quality assurance procedures
- Rectification of programming errors
- Taking customer requirements into account
- Influences of mechatronics systems on economic, ecological and social conditions

Learning field 12: 4th year of training
Preventative maintenance

Suggested time allocation in hours: 80

Formulation of objectives

The pupils describe influences on the operational reliability of technical systems and the necessity of preventative maintenance. They use maintenance plans and apply procedures to ascertain maintenance requirements. They are able to test, set and adjust safety equipment. They accord due consideration to health protection and health and safety at work during this process. They draw up error analyses and process the results statistically. Results of maintenance works are integrated into the documentation. Results are also processed in English.

Contents

- Contamination, fatigue, consumption, wear and tear and the effects of these
- System reliability
- Preparation and adaptation of maintenance plans
- Inspections
- Procedures for the checking of safety equipment
- Adjustment of system components to meet changed requirements
- Diagnostic procedures and maintenance systems
- Quality management
- Documentation

- Integration of alterations into technical documentation

Learning field 13: 4th year of training**Hand over mechatronics systems to customers****Suggested time allocation in hours: 60****Formulation of objectives**

The pupils prepare information on mechatronics systems in text and graphical form and present such information. They plan the plant induction of operating and service staff and conduct the induction training. They exchange information in English. They accord due consideration to the basic principles of structuring customer relations and to the marketing strategies of their company.

Contents

- Use of internal company communications systems
- Team work
- Communication
- Chairing discussions, presentation
- Customer/supplier relations
- Service instructions, operating instructions