TSG-4060-2

General Science 2

Québec

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INTRODUCTION

This course entitled *General Science 2* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve technological applications related to the functioning of the human body

In this course, adult learners will analyze and design technical objects and seek solutions to technological problems. They will acquire specific knowledge and techniques that will help them gain a better understanding of these types of objects and the factors at play in different technological problems involving graphical language, materials and engineering. They will also be able to evaluate the solutions proposed. This knowledge, combined with the knowledge acquired in their study of *The Material World*—in particular with respect to pure substances and mixtures—will enable them to study the relationships between the composition, uses and properties of different materials. As well, energy transformations will help adult learners better understand the use of various electrical functions. Similarly, they will be able to draw parallels between mechanical and electrical functions and how the musculoskeletal system works by associating their knowledge of mechanics and electricity with the knowledge acquired in their study of *The Living World*.

By the end of this course, in situations involving the study of a technological application in relation to the functioning of the human body, adult learners will be able to:

- ✓ analyze a technological application involving electrical or mechanical engineering
- ✓ justify the decision to use pure substances or different types of mixtures in the composition of the materials used to make a technical object
- ✓ use mechanical engineering to model the functioning of the musculoskeletal system
- ✓ analyze a characteristic of the musculoskeletal system
- ✓ produce a graphical representation of the simple parts of a technical object
- ✓ design a technical object using graphical language
- ✓ plan, with assistance, the steps for producing a working prototype comprising mechanical or electrical components
- ✓ follow, with assistance, a manufacturing process sheet for a prototype comprising mechanical or electrical components
- ✓ write a report on the testing of a prototype by following a basic framework

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications in context ▪ Analyzes an application from a scientific point of view ▪ Analyzes an application from a technological point of view ▪ Forms an opinion about the quality of an application	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to solve problems and study applications. The following are the steps in an investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the design process, the observation method from a technological point of view and modelling. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendices 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSG-4060-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC CONTENT

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Living World	
General concept: Musculoskeletal system The skeleton supports and protects the body. It plays an essential role in movement because of the muscles that act on it by contracting. Some bones are fused, while others are connected by joints, which provide a certain freedom of movement. Technological applications can sometimes help deal with musculoskeletal problems. For example, prostheses for hip or knee problems and wheelchairs, some of which are motorized, provide a better quality of life for people with disabilities or illnesses, or who have trouble getting around.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Function of the musculoskeletal system	• Identifies the main parts of the skeleton (head, thorax, spinal column, upper and lower limbs) • Explains the role of the musculoskeletal system (supports and protects the body, permits movement)
Types of joint movement	• Describes how joints work (linking bone to bone, mobility) • Describes types of joint movement (e.g. flexion, extension, abduction, adduction, rotation)

❖ The Material World

General concept: Organization of matter

Matter cycles between biotic (living) and abiotic (non-living) components of the environment. Indeed, whether it is inert or living, matter is made up of atoms that combine according to their affinities to form molecules of elements or more or less complex compounds. More often than not, matter in the environment and in the human body is a mixture of several types of molecules of elements and compounds. A pure substance can be identified by its characteristic properties. The properties of a mixture are different from those of its constituent parts, each of which retain their own characteristic properties.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Pure substance: compound, element Homogeneous and heterogeneous mixtures	• Defines a pure substance as a substance made up of a single type of atom or molecule • Distinguishes between elements (e.g. iron, carbon, sodium) and compounds (e.g. water, carbon dioxide, glucose) • Describes homogeneous and heterogeneous mixtures in different materials (e.g. steel, plastic, carbon fibre)

General concept: Transformation of energy

Energy occurs in a number of forms in the environment, but it always corresponds to the amount of work a system is likely to produce. Using the appropriate methods, it is possible to convert one form of energy into another.

When designing a new technology, it may be necessary to determine the types of energy that will be utilized and the best way of converting an available form of energy into another desired form of energy.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Forms of energy: electrical, chemical, thermal, mechanical, radiant	• Defines joule as the unit of measurement for energy • Describes different forms of energy (electrical, chemical, thermal, mechanical and radiant) • Identifies the forms of energy involved in a transformation of energy (e.g. light bulbs convert electrical energy into radiant and thermal energy, muscles convert chemical energy into mechanical and thermal energy)

❖ The Technological World

General concept: Graphical lines

Based on conventional geometrical representations, and inextricably linked to invention and innovation, technical drafting is a language that enables adult learners to clarify, refine and materialize their ideas.

The information in a technical drawing is usually associated with geometry, scales and different forms of representation. Orthogonal projections make it possible to create detail drawings and isometric representations, among other things. Some drawings also include information relating to industry standards in accordance with established rules of representation. Dimensioning provides the information about the real dimensions and position of each component of the object or system.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Basic lines	• Names basic lines in a drawing (visible contour, hidden contour, centre, extension, dimension lines) • Associates the basic lines in a drawing with the contours and details of a simple part
Scales	• Associates scales with their use (actual-size representation, reduction or enlargement of an object) • Chooses a simple scale for a drawing (e.g. 1:1, 1:2, 5:1)
Oblique projection	• Makes freehand sketches of simple objects using oblique projection
Orthogonal projections:	
– Multiview	• Interprets drawings representing parts in multiview orthogonal projection • Represents simple shapes in multiview orthogonal projection
– Isometric	• Interprets drawings representing parts in isometric projection
Standards and representations:	
– Diagrams	• Interprets technical diagrams and design plans
– Symbols	• Represents different types of motion related to the operation of an object using the appropriate symbols (rectilinear translation, rotation, helical)
Dimensioning	• Interprets technical drawings that include the dimensions

❖ The Technological World (cont.)

General concept: Mechanical engineering

The design or analysis of a technical object or technological system is based on fundamental concepts of mechanics and on processes specific to the field of engineering.

In mechanics, these concepts involve mechanical functions that can be either basic (linking, guiding, sealing, lubricating) or complex (transmission and transformation of motion). Common types of links and guiding controls as well as mechanisms that allow for rotational or translational motion or a speed change are studied.

Such technical knowledge makes it possible to justify the use of different shapes and materials, to apply or explain operating principles, and to use or suggest construction solutions.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Typical functions: linking, guiding, sealing and lubricating	• Associates a typical function with certain parts of a technical object
Typical mechanical links	• Describes the advantages and disadvantages of different types of links • Identifies the types of links used in a technical object (e.g. the two levers in a pair of pliers are connected by a pivoting link)
Function, components and use of motion transmission systems	• Identifies motion transmission systems in technical objects (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear)
Function, components and use of motion transformation systems	• Identifies motion transformation systems in technical objects (e.g. screw gear system, cam and roller, connecting rod and crank, rack and pinion)
Speed changes	• Identifies mechanisms that allow for speed changes in technical objects

General concept: Materials

To select an appropriate material, we must be familiar with its mechanical properties so that we have an accurate idea of the material's behaviour when it is used and subjected to constraints.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Mechanical properties	• Describes mechanical properties of different materials (e.g. hardness, ductility, elasticity, malleability, corrosion resistance) • Associates the use of different types of materials (metals, alloys, plastics and wood) with their mechanical properties
Constraints: tension, compression and torsion	• Describes the constraints to which different technical objects are subjected (e.g. the top of a beam is subjected to compression)

❖ The Technological World (cont.)

General concept: Electrical engineering

The design or analysis of a technical object or technological system is based on fundamental concepts of electricity and on processes specific to the field of engineering. The compulsory concepts are related to the different electrical components and their function (power supply, conduction, insulation, control and transformation of energy). Knowledge of their characteristics makes it possible to select and combine them appropriately.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Power supply	• Defines “power supply” as the function performed by any component that can generate electrical current • Identifies the component that ensures the power supply in an electrical circuit (e.g. cell, alternator, battery)
Conduction and insulation	• Defines “conduction” as the function performed by any component that can transmit electric current through a circuit • Distinguishes between electrical conductors and insulators in an electrical circuit
Control	• Defines “control” as the function performed by any component that allows electric current to flow through a circuit • Identifies the component that performs the control function in an electrical circuit (e.g. toggle switch, pushbutton switch)
Transformation of energy	• Defines the transformation of energy as the function performed by any component that can convert electrical energy into another form of energy • Identifies the component that transforms energy in an electrical circuit (e.g. heating element, motor, light bulb)

2. Techniques

The techniques presented here are grouped in three categories. Many of these techniques require the use of instruments and manual tools or machine tools. Safety and the use of safety equipment in the laboratory and workshop must be a constant concern for all those using such techniques.

In the Laboratory or Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Graphical language	
- Using scales	• Reduces or increases the dimensions of a technical object based on the scale
- Producing a graphic representation using instruments	• Uses instruments to produce a multiview orthogonal projection
Manufacturing	
- Safely using machines and tools	• Uses manual tools or machine tools safely (e.g. retractable utility knife, hammer, screwdriver, pliers, band saw, drill, sander)
- Assembling and disassembling	• Chooses and places the electrical components in sequence based on the circuit diagram • Connects the components using wires or connectors • Chooses the appropriate tools to assemble or disassemble a technical object
- Measuring and laying out	• Marks the materials to be shaped using a pencil or punch
- Making a part	• Makes a part using the appropriate techniques
Measurement	
- Using measuring instruments	• Uses measuring instruments appropriately (e.g. ruler, protractor, multimeter)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

Cultural References				
Technical objects, technological systems, processes and products	– Orthotic devices, prostheses, wheelchairs, etc. – Bicycle – Hand tools – Machines: agricultural machinery, diggers, machine tools – Systems: mechanical, electrical – Everyday objects: household appliances, locks, faucets, furniture, pumps			
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Technological World	Henry Bessemer John Boyd Dunlop Gustave Eiffel	Invention Québec Schools and faculties of Engineering Institut de recherche en électricité du Québec Centre de recherche industrielle du Québec	Plastics Home automation Space research Robotics Artificial limbs	World fairs Science-fiction film festivals
The Living World	Ambroise Paré	War amputees	Grafts and organ transplants	Paralympics Terry Fox's Marathon of Hope across Canada
The Material World	James Prescott Joule John Dalton	Science and technology museums Science clubs Faculties of Science and Engineering	Medical procedures using special materials	Nobel Prize Science fairs

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, involve technological applications, some of which are related to the functioning of the human body. These learning situations take into account general concepts from different areas. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a situation involving the musculoskeletal system and mechanical engineering, adult learners could model one or more types of joint movement in order to associate them with mechanical functions and explain or apply mechanical principles in order to design a prosthetic arm.

In a situation involving graphical language or electrical engineering, adult learners could be required to interpret a circuit diagram with a view to selecting the components needed to achieve the desired energy transformations. In the workshop, they could assemble components using the diagram and take readings of electrical parameters in order to ensure that their circuit is consistent with the specifications.

The musculoskeletal system, graphical language, mechanical engineering, electrical engineering, materials and the organization of matter could also be combined in a situation involving a defective or unsatisfactory technical object. Learners could analyze various comparable items with functions similar to that of the item in their project. By analyzing the item from a scientific point of view, they could determine whether the pure substances or mixtures used were an appropriate choice as a component of the materials.

In the learning situation described below, the main tasks help adult learners develop the second and third competencies. This situation therefore belongs to the *Expertise* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSG-4060-2. The example below reflects the educational aim of the broad area of learning *Health and Well-Being.*

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

ANKLE SUPPORT

An old ankle injury flares up every time you play hockey, so you want to protect your ankle by providing some sort of support. What would be best?

First, you must define the problem, select at least two types of supports, analyze them from a scientific and then a technological point of view and, finally, form an opinion.

Practically speaking, you must produce a design plan and a technical diagram for each type of support you are considering, provide a detailed account of your analyses and explain the scientific principles of the musculoskeletal system as they relate to the ankle. You might also take ergonomic and practical considerations into account.

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with an investigative process involving the technological design process and the observation of technological applications. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

Adult learners engaged in the process of solving a well-defined problem involving the design or modification of a technical object, which has electrical or mechanical components and is designed to support the musculoskeletal system, develop a representation of the need in question after reading and interpreting scientific and technological messages, some of which are contained in the specifications. They are guided in establishing a plan of action based on the chosen solution and use what they know about the characteristics of the musculoskeletal system, forms of energy, properties of materials, or the functions of mechanical or electrical components. They produce a sketch, interpret design plans or technical diagrams, and draw multiview orthogonal projections of one or more parts to be manufactured. They have access to help when carrying out their plan of action by producing a prototype in order to validate the feasibility of their solution and gain a better understanding of the constraints involved. Following a basic framework, they write a report on the testing of the prototype in which they suggest changes or provide justifications for their plan of action or solution in light of the need and constraints involved.

Adult learners studying a technological application that involves mechanical engineering or electrical engineering formulate questions related to the contextual elements presented, establish a connection with the musculoskeletal system, or compare the application and this system in terms of how they work. Using diagrams, concepts, laws, theories or models, they justify the use of materials and choice of electrical and mechanical components, or suggest any improvements in light of the problem that the application is designed to solve. Adult learners identify the substances, mixtures and properties associated with the materials and their uses, or emphasize the usefulness of converting electrical energy into other forms of energy.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

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