TSC-4063-2

Mechanization of Work

Path:

Applied Science and Technology

Environmental Science and Technology

Québec

TSC-4063-2 Mechanization of Work

INTRODUCTION

The course entitled *Mechanization of Work* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve a technological application in which a mechanism reflects a physical principle.

In this course, adult learners will analyze and design technical objects and seek solutions to technological problems. They will acquire more in-depth technological and technical knowledge, which will help them gain a better understanding of technical objects and the factors at play in different technological problems involving graphical language, materials, engineering and manufacturing. They will also be able to evaluate the solutions proposed. This knowledge, combined with the knowledge they will acquire in their study of *The Material World*, in particular with respect to force and motion, will help them understand the forces at play in the movement of two parts or when a speed change occurs in a motion transmission or transformation system. Similarly, they will learn about the forces exerted by fluids in the movement of a technical object.

By the end of this course, in situations involving a technological application in which a mechanism reflects a physical principle, adult learners will be able to:

- ✓ design a technical object or a technological system in which a mechanism reflects a physical principle
- ✓ analyze a technological application in which a mechanism reflects a physical principle
- ✓ discuss the choice of materials in a technological application
- ✓ draw the development of a simple shape in a technical object
- ✓ plan the steps involved in the production of a prototype containing mechanical parts requiring the use of manual tools or machine tools
- ✓ follow a manufacturing process sheet for a prototype including mechanical parts and requiring the use of manual tools or machine tools
- ✓ control the quality of the machined parts and the types of motion allowed by the links, using information contained in the detail drawings and an assembly drawing
- ✓ write a report on the production of a prototype including mechanical parts

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 the application	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

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

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

The most appropriate methods for this course are the technological design process, the observation method, documentary research, the experimental method and modelling. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendixes 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 TSC-4063-2 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 Technological World	
General concept: Graphical language Based on conventional geometrical representations and inextricably linked to invention and innovation, technical drafting is a language that enables adult learners to develop, refine and materialize their ideas. Some drawings include information about industry standards in accordance with the rules of representation.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Axonometric projection: exploded view (reading)	• Interprets exploded-view drawings
Multiview orthogonal projection: assembly drawing	• Interprets assembly drawings of simple technical objects
Functional dimensioning	• Defines “functional dimensioning” as the set of specific tolerances related to certain parts responsible for the smooth operation of an object (e.g. the distance between two axes is a determining factor in the operation of sprocket wheels in a gear assembly)

❖ The Technological World (cont.)

General concept: Graphical language (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Developments: prism, cylinder, pyramid, cone	• Associates the development of three-dimensional shapes with the construction of objects from sheet stock (e.g. cardboard boxes, metal air ducts) • Draws developments of simple solids (e.g. pyramid, cylinder, cube)
Standards and representations: diagrams and symbols	• Chooses the appropriate type of diagram for a given representation (e.g. uses a technical diagram to represent assembly solutions, a design plan to represent the operation of an object) • Represents different types of motion related to the operation of an object using the appropriate symbols (rectilinear translation, rotation, helical)

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.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Typical functions	• Explains the choice of a type of link in a technical object (e.g. using a screw makes it possible to attach and remove a battery case)
Guiding controls	• Explains the choice of a type of guiding control in a technical object (e.g. the slide guides a drawer and reduces friction)
Mechanical links	• Describes the characteristics of the links in a technical object (direct or indirect, rigid or flexible, removable or non-removable, partial or complete) • Determines the desirable characteristics of links in the design of a technical object • Judges the choice of assembly solutions in a technical object
Freedom of movement of a part	• Explains the purpose of limiting motion (degree of freedom) in a technical object (e.g. some hinges limit how far a cupboard door can open, preventing it from hitting the wall)
Adhesion and friction of parts	• Describes the advantages and disadvantages of the adhesion and friction of parts in a technical object
Construction and characteristics of motion transmission systems: friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear	• Explains the choice of motion transmission system in a technical object (e.g. using a gear assembly rather than friction gears to get better engine torque and avoid slipping)
Construction and characteristics of motion transformation systems: screw gear system, connecting rod, crank and slide, rack and pinion, cam and roller, eccentrics	• Explains the choice of motion transformation system in a technical object (e.g. most car jacks use a screw gear system rather than a rack-and-pinion system, because the force of the arm on the small crank provides more thrust and because, given that it is non-reversible, the system is safer) • Distinguishes between cams and eccentrics
Resisting torque, engine torque	• Explains speed changes in a technical object using the concepts of resisting torque and engine torque

❖ The Technological World (cont.)

General concept: Materials

The fact that it is possible to change the properties of matter is a powerful incentive for exploring and controlling its use. To use a material properly, we must be familiar with its functional characteristics and structure so that we can get an accurate idea of its behaviour when it is used.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Characteristics of mechanical properties	• Explains the choice of a material based on its properties (e.g. the malleability of aluminum makes it useful for making thin-walled containers)
Constraints: deflection, shearing	• Describes the constraints to which different technical objects are subject: deflection, shearing (e.g. a diving board is subject to deflection)
Types and properties:	
- plastics (thermosetting)	• Associates the use of plastics with their respective properties (e.g. Bakelite is used to mould electrical parts because it is a good electrical insulator)
- ceramics	• Associates the use of ceramics with their respective properties (e.g. ceramics are used in ovens because they are very hard, and heat and wear resistant)
- composites	• Associates the use of composites with their respective properties (e.g. carbon fibre is used for hockey sticks because of its hardness, resilience and lightness)
Heat treatments	• Defines heat treatments as a way of changing the properties of materials (e.g. quenching increases hardness but fragility as well)
Modification of properties: degradation, protection	• Describes different treatments to prevent the degradation of materials (e.g. metal plating, antirust treatments, painting)

General concept: Manufacturing

The concepts associated with manufacturing are important prerequisites. They serve as references for the use of different techniques.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Characteristics of laying out	• Associates laying out with saving materials, shaping techniques and the types of materials used
Machining:	
- characteristics of drilling, tapping, threading and bending	• Describes the characteristics of the tools needed to shape a material (e.g. the tip of a metal drill is conical, while that of a wood drill is double fluted)
Measurement and inspection:	
- direct measurement (vernier calipers)	• Explains the choice of the direct measuring instrument used (a vernier caliper is more precise than a ruler)

❖ The Technological World (cont.)

General concept: Manufacturing (cont.)

Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Measurement and inspection (cont.): - control, shape and position (plane, section, angle)	• Associates quality control techniques (indirect measurement) for materials and technical objects with the desired degree of precision (e.g. the shape of a musical instrument is validated using a three-dimensional digitizer to ensure the proper sound)

❖ The Material World

General concept: Force and motion

Matter in our environment is subject to different forces. Whether they are gravitational, electrical, magnetic or frictional, when these forces act on a body, they cause deformation and modify its state of motion.

Practically speaking, no mechanical system is subject to only one force. In general, several forces act simultaneously on a body. The result of these forces is a virtual force that produces the same dynamic effect as the forces acting simultaneously. When the resultant of the forces is nil, the body is in equilibrium. Everything is as if there were no forces acting on it. The state of movement of the body does not change: its speed remains constant (sometimes nil).

Adult learners will examine the effect of the force of gravity on a mass and learn to distinguish between mass and weight.

Note: *Cases in which the action of a force causes a change in direction of velocity will not be considered, nor will cases of uniform acceleration.*

Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Force	• Describes the effects produced by a force (change in the state of motion of a body, distortion of a body)
Types of forces	• Recognizes different types of forces in technical objects or technological systems (e.g. gravitational force in a chute, magnetic force exerted by an electromagnet)
Equilibrium of two forces	• Describes the conditions under which a body subjected to two forces can be in equilibrium
Relationship between constant speed, distance and time	• Qualitatively describes the relationship between speed, distance and time • Applies the mathematical relationship between constant speed, distance and time
Relationship between mass and weight	• Qualitatively describes the relationship between mass and weight • Applies the mathematical relationship between mass and weight

❖ The Material World (cont.)	
General concept: Fluids Human beings have demonstrated boundless ingenuity in the construction of floating and flying devices. Through research and experiments on prototypes, adult learners must learn to recognize the forces at work and examine their impact. They consider adjustments that might help control movement and ensure lift. **Note:** *These following principles will be studied qualitatively.*	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Archimedes' principle	• Describes the relationship between the weight of the water displaced by an immersed body and the upward acting force • Explains the buoyancy of a body in terms of Archimedes' principle
Pascal's law	• Recognizes technical objects or technological systems whose operation is based on Pascal's law (e.g. hydraulic and pneumatic systems)
Bernoulli's principle	• Describes the relationship between the velocity of a fluid and its pressure • Explains the concept of lift in terms of Bernoulli's principle

2. Techniques

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

In the Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Graphical language	
- Producing a graphic representation using instruments (development)	• Uses instruments to draw a development
- Drawing schematic diagrams	• Chooses the best view to describe a technical object • Indicates all the information needed to explain the operation or construction of an object
- Using vector graphic software	• Uses vector graphic software to draw different diagrams in two or three dimensions (e.g. drawing toolbar in Word)
Manufacturing	
- Safely using machines and tools	• Uses tools safely (e.g. retractable utility knife, hammer, screwdriver, pliers) • Uses machine tools safely (e.g. band saw, drill, sander)
- Machining	• Forms the part in accordance with the steps in the machining processes (e.g. stripping, splicing, soldering)
- Finishing	• Performs the necessary operations to finish a part (e.g. grinds, polishes, hammers or chisels metal parts)

In the Laboratory or Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Manufacturing (cont.)	
- Performing verification and control tasks	• Evaluates the dimensions of a part during and after construction using a ruler • Compares the real dimensions of a part with the specifications (e.g. draft, drawing, technical sheet) • Uses a template to verify the conformity of a part • Evaluates the dimensions of a part during and after construction using vernier calipers
- Making a part	• Makes a part using the appropriate techniques
Measurement	
- Using measuring instruments	• Uses measuring instruments appropriately (e.g. vernier caliper)
- Checking the reliability, accuracy and sensitivity of measuring instruments	• Takes the same measurement several times in order to verify the reliability of the instrument used • Carries out the necessary operations to ensure the accuracy of a measuring instrument (e.g. cleans and calibrates a balance, dries a graduated cylinder, conditions a pH meter) • Takes the sensitivity of a measuring instrument into account (e.g. uses a 25-mL graduated cylinder rather than a 100-mL cylinder to measure 18 mL of water)
- Interpreting measurement results (significant digits, measurement errors)	• Determines the margin of error attributable to a measuring instrument (e.g. the error in a measurement made using a graduated cylinder is provided by the manufacturer or corresponds to half of the smallest division on the scale) • Expresses a result with a number of significant figures that takes into account the errors related to the measure (e.g. a measurement between 10.3 and 10.4 cm, taken with a ruler graduated in millimetres, should be expressed as 10.35 cm or 103.5 mm)

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	– Agricultural machinery – Petroleum industry equipment: extraction, refining, distribution, use – Turbines – Electric power plants, wind turbines – Printing equipment – Automobile, hybrid vehicles, bicycle – Hot air balloons, zeppelins – Vessels: boat, submarine, air-cushion vehicle – Airplane – Manufactured goods in general – Instruments and devices: scale, clock – Tools: hand, electric, air, hydraulic – Machines: agricultural machinery, diggers, machine tools – Systems: mechanical, electrical, hydraulic, pneumatic, electronic – Everyday objects: household appliances, locks, faucets, furniture, pumps, skis, musical instruments, toys – Loom and sewing machine – Aerial tramway – Elevator – Escalator			
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Technological World	Leonardo da Vinci Joseph Brown and Lucian Sharp Le Corbusier Rudolph Diesel Henry Ford Frederick Winslow Taylor	Canadian Intellectual Property Office Canadian Patent Database Ordre des ingénieurs du Québec	Production line Interchangeability of parts Robotics Remote sensing Street lights Clothing Road network	Industrial Revolution Establishment of labour standards Globalization
The Material World	Archimedes Thomas Edison Blaise Pascal Orville and Wilbur Wright Sir Isaac Newton Albert Einstein	Faculties of Science and Engineering Museums of science and technology	Automobile industry Means of transportation Water purification systems	Breaking of the sound barrier Construction of dams Construction of wind farms

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, involve technological applications aimed at enhancing human strength and general concepts related to *The Material World* and *The Technological World*. 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 force, motion, fluids, materials, mechanical engineering and graphical language, adult learners could design an object taking into account the effects of corrosion, oxidation and wear on chosen materials. They could also point out forces in accordance with Pascal's law, verify the application of Archimedes' principle on a body, or analyze the mechanical engineering of a technological system in the workshop and produce the related technical drawing.

In a situation involving graphical language, force, motion and manufacturing, adult learners could try to solve a technological problem. In a technological design process, they could decide on the complex mechanical function to be used to transform lateral motion into rotational motion, then measure, lay out, shape, machine and inspect the necessary parts.

In the learning situation described below, the main tasks help adult learners develop the first and third competencies. This situation therefore belongs to the *Research* 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 TSC-4063-2. The example below reflects the educational aim of the broad area of learning *Career Planning and Entrepreneurship*.

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

FLYING MACHINE

You decide to participate in a contest to make a flying machine powered only by human force. To do so, you must design and build a machine that will be launched from a ramp eight metres above the surface of a lake. The rules are clear: no catapults, rubber bands or batteries. The airplane motor you bought at a yard sale would have been fantastic! But you must push, pull or pedal your machine to win. You are now designing your flying machine.

Follow the steps in a technological design process. Your flying machine must include technical drawings, technical diagrams and design plans, as well as a history of flying machines. You will build a prototype with the materials made available to you, then test and validate your solution. By explaining the relevant scientific principles, you must demonstrate how you will make sure your machine stays in the air long enough to win the contest.

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, the observation of technological applications, the experimental method, modelling or documentary research. 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 an open problem related to the design of a technical object or technological system develop a representation of the problem or need in question after reading and interpreting technical drawings, specifications or a manufacturing process sheet. They establish a plan of action based on the chosen solution, relying on their knowledge of force and motion or fluids, and combine materials or mechanical components. They produce design plans or technical diagrams and a development drawing of a simple shape, or determine the operations, manual tools or machine tools and the manufacturing techniques to be used as well as the machining characteristics to be taken into account. In the workshop or the machine shop, they develop a plan of action to construct a prototype, control the quality of the parts and their motion, and make the necessary adjustments. They present a complete and functional prototype in accordance with the need expressed and the constraints established. They explain the changes made to the plan of action or prototype.

Adult learners studying a technological application formulate questions pertaining to the contextual elements presented and identify the principles related to fluids of the types of motion or speed changes needed for the application to work properly. Using diagrams, concepts, laws or models, they explain the related issues and determine the forces involved or the degree of freedom of the parts and their effect. Using their scientific and technological knowledge, they assess the mechanical functions or materials used to make the movable parts of the application and, if applicable, suggest improvements.

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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