SUPPORT DOCUMENT

Clarifications regarding the compulsory concepts on which the students may be tested in the Secondary IV ministerial examinations in Science and Technology (ST) and Applied Science and Technology (AST)

SCIENCE AND TECHNOLOGY	**555-410**
APPLIED SCIENCE AND TECHNOLOGY	**557-410**

Secondary IV

Direction de l'évaluation des apprentissages
2017-2018 school year

Éducation et Enseignement supérieur
Québec

INTRODUCTION

This document complements the Information Document on the uniform examinations for Science and Technology (ST) and Applied Science and Technology (AST). It was designed in conjunction with educators and science and technology specialists, and is based in part on materials produced by the Centre de développement pédagogique.

To help teachers administer the uniform examinations for ST and AST, the Ministère de l'Éducation et de l'Enseignement supérieur (MEES) has produced an Information Document every year since uniform exams were first administered for these courses in June 2012. From year to year, this document has included additional information and clarifications regarding the topics that may be covered in the exams and certain compulsory concepts in the curriculum. These additions have taken into account teachers' comments following each examination as well as observations resulting from the analysis of students' exam papers.

Over time, it became apparent that the appendices in the Information Document were not providing enough additional information regarding the compulsory concepts on which students may be tested in ministerial examinations.[1] It is to meet this need that MEES has now decided to produce a support document.

This document will provide more detailed definitions and information, as well as clarifications, diagrams, symbols and examples of combinations of concepts that may be used in evaluation. The ultimate goal of this exercise is to ensure fairness for all students and maximum consistency between the program content, teaching and learning methods and ministerial examinations.

Some of the descriptions of the concepts have been changed in this new version. These changes are listed on p. 4 for easy reference so that they can be compared with the previous version of the support document.

Teachers are invited to familiarize their students with the content of this support document and the different appendices in the Information Document.

1. As a result, this document contains no information on the italicized concepts in the Information Document, since evaluation in this regard is the responsibility of educational institutions.

List of Changes

EARTH AND SPACE

Biogeochemical cycles

Carbon cycle	tested in	ST	X	AST	

By way of example, this concept may be tested in conjunction with the following concepts: permafrost, greenhouse effect, energy resources, combustion, photosynthesis and respiration.

Lithosphere

Permafrost	tested in	ST	X	AST	

Increasing amounts of CO_2 and methane, soil instability (landslides), increasing amounts of vegetation and changing ecosystems may be regarded as direct consequences of melting permafrost.

By way of example, this concept may be tested in conjunction with the following concepts: greenhouse effect and carbon cycle.

Hydrosphere

Watershed/Catchment area	tested in	ST	X	AST	X

A watershed or catchment area is a territory bounded by crest lines surrounding a network of rivers and streams, which also includes groundwater and surface runoff. The term “upstream” refers to where the water is coming from in relation to a given position. The term “downstream” refers to where it is flowing in relation to this position.

Subwatersheds feed a watershed and function in the same way as the watershed.

Creating a reservoir or a navigation channel, irrigating and fertilizing soil, and draining or filling wetlands may be regarded as human activities that have an impact on a watershed.

Hydrosphere

Ocean circulation	tested in	ST	X	AST	
Glacier and pack ice	tested in	ST	X	AST	
Salinity	tested in	ST	X	AST	

The concepts of ocean circulation, glacier and pack ice, and salinity are interrelated.

Pack ice consists of brackish water, which is a mixture of fresh water and salt water, whose salinity is lower than that of the salt water in which it is formed.

When pack ice is formed, salt is discharged into the water, which increases the salinity (and density) of the water on which the pack ice floats and thus contributes to thermohaline circulation.

It should be noted that there is a difference between the terms “pack ice” and “ice floe.” Pack ice refers to large slabs of floating ice that are crowded together. An ice floe is a free-floating sheet of ice.

The disruption of thermohaline circulation, species displacement or extinction, the creation of new waterways, and the decrease in the albedo, or reflectivity, of the Earth’s surface may be regarded as examples of the impact of melting glaciers and pack ice. However, rising sea levels are the result of melting glaciers.

EARTH AND SPACE

Atmosphere

Greenhouse effect	tested in	ST	X	AST	

By way of example, this concept may be tested in conjunction with the following concepts: carbon cycle, permafrost, combustion, photosynthesis, respiration and energy resources. Diagrams may be used in testing this concept.

Atmosphere

Cyclone and anticyclone	tested in	ST		AST	X

Although other terms are used as synonyms in the literature, the terms “cyclone” and “anticyclone” are used in the ministerial examinations. The expressions “good weather” and “bad weather” should not be used to describe meteorological conditions, as the notion of good or bad weather is not the same for everyone. For example, a windy day may be good weather for a sailing buff but bad weather for a cyclist.

Space

Earth-moon system (gravitational effect)	tested in	ST		AST	X

With regard to tidal phenomena, the position of both the moon and the sun must be considered.

Lithosphere / Hydrosphere / Atmosphere / Space

Energy resources	tested in	ST	X	AST	X

Geothermal, wind, marine-current, river-related, tidal, solar and nuclear energy do not generate greenhouse gases when the resource in question is used. Even though greenhouse gases are generated in building, transporting and dismantling the facilities involved in the exploitation of the related resources, we consider that these resources produce little or no greenhouse gases.

The renewable or non-renewable nature of a resource may be tested in conjunction with other characteristics of energy resources.

Ministerial examinations may include questions on the advantages, disadvantages and impact of using different energy resources.

By way of example, in the Science and Technology course, this concept may be tested in conjunction with the concepts of carbon cycle and greenhouse effect.

Physical properties of solutions

Concentration (g/L, %, ppm)	tested in	ST	X	AST	

Although the majority of the solutions mentioned in the examinations are aqueous, solid homogeneous mixtures whose concentration is expressed in m/m may also be considered.

Physical properties of solutions

pH scale	tested in	ST	X	AST	

A colour chart of different acid-base indicators may be provided so that students can determine the pH of a solution. However, ministerial examinations will not include questions that involve interpreting the results of a mixture of indicators.

Students may be required to determine whether a solution is acidic, basic or neutral based on the molecular formula of the compound involved.

A strong acid and a weak acid (or a strong base and a weak base) may be distinguished according to their position on the pH scale. A strong acid cannot be regarded as a weak base, nor can a strong base be regarded as a weak acid. For example, a solution with a pH of 12 is regarded as a strong base, but will never be regarded as a weak acid in ministerial examinations.

The logarithmic nature of the pH scale can be used to compare the pH of two solutions. For example, a solution with a pH of 12.5 is 100 times more basic than a solution with a pH of 10.5.

When the pH of a solution is greater than 7, the terms “alkaline solution” or “basic solution” may be used.

The very nature of everyday substances may be used to determine whether they are acidic, basic or neutral.

By way of example, this concept may be tested in conjunction with the following concepts: acid-base neutralization reaction and electrical conductivity.

Physical properties of solutions

Ions	tested in	ST	X	AST	

The exact charge of a monatomic ion may be determined according to its position in the periodic table.

By way of example, this concept may be tested in conjunction with the following concepts: groups and periods in the periodic table, and electrical conductivity.

MATERIAL WORLD

Physical properties of solutions

Electrical conductivity	tested in	ST	X	AST	

A solution can conduct electricity if, and only if, mobile ions are formed when an electrolyte (or solute) is dissolved in water.

Students may be required to identify solutions that conduct an electric current based on the molecular formula of the compound involved.

The very nature of everyday substances may be used to determine their electrical conductivity.

By way of example, this concept may be tested in conjunction with the concepts of pH scale and ions.

Chemical changes

Combustion	tested in	ST	X	AST	X

The terms used with regard to the fire triangle are as follows: “oxidizing agent,” “fuel” and “ignition temperature.”

The ignition temperature is a characteristic property of a given substance. It is always the same but, in some cases, it may be more difficult to reach, for example, when wood is wet.

Ministerial examinations may include questions on the different types of combustion (rapid, spontaneous and slow).

By way of example, in the Science and Technology course, this concept may be tested in conjunction with the concepts of carbon cycle and greenhouse effect.

Chemical changes

Oxidation	tested in	ST		AST	X

Oxidation is a type of slow combustion.

Chemical changes

Photosynthesis and respiration	tested in	ST	X	AST	

By way of example, these concepts may be tested in conjunction with the concepts of carbon cycle and greenhouse effect.

Chemical changes

Acid-base neutralization reaction	tested in	ST	X	AST	

A colour chart of different indicators may be provided so that students can determine the pH of the solutions involved in an acid-base neutralization reaction.

Students may be required to recognize the molecular formula of an acid, a base or a salt consisting of one polyatomic ion (radical) (e.g. H_2SO_4, $Mg(OH)_2$, $CaCO_3$).

The neutralizing capacity of a strong acid compared with that of a weak acid (or of a strong base compared with that of a weak base) may be considered.

Students may be required to identify the neutralizing substance based on the molecular formula of the compound involved.

By way of example, this concept may be tested in conjunction with the following concepts: pH scale and balancing chemical equations.

Chemical changes

Balancing chemical equations	tested in	ST	X	AST	

Since balanced equations must be written in their simplest form, a correctly balanced equation must contain only the smallest possible natural number coefficients.

In Part B of the examination, students are not required to balance chemical equations involving molecules consisting of polyatomic ions. However, in Part A, they must be able to determine whether an equation involving molecules consisting of polyatomic ions is correctly balanced.

By way of example, this concept may be tested in conjunction with the concept of acid-base neutralization reaction.

Chemical changes

Law of conservation of mass	tested in	ST	X	AST	

It is neither necessary nor a good idea for students taking the Environmental Science and Technology option to use stoichiometry to verify the law of conservation of mass, because their answer could be slightly different from the expected answer.

MATERIAL WORLD

Organization of matter

Rutherford-Bohr atomic model	tested in	ST	X	AST	

It should not be considered a mistake if students include neutrons in the Rutherford-Bohr atomic model. In Part B of the examination, students are not required to draw the diagram of any element beyond the calcium atom (atomic number 20). However, in Part A, students must be able to recognize an atom that has an atomic number greater than 20 and that belongs to one of the four major groups in the periodic table (IA, IIA, VIIA and VIIIA).

By way of example, this concept may be tested in conjunction with the concept of groups and periods in the periodic table.

Organization of matter

Groups and periods in the periodic table	tested in	ST	X	AST	

Four groups may be identified by their name: alkali metals, alkaline earth metals, halogens and noble gases. The other groups may be identified by the name of the first element listed (e.g. carbon group).

Group numbers indicated in Arabic numerals (1 to 18) or as a combination of a Roman numeral followed by the letter A (IA to VIIIA) may also be used to identify groups.

Although other terms are used as synonyms in the literature, the term “noble gases” will be used to refer to Group VIIIA (or Group 18).

The study of the periodic table is not limited to the first 20 or 36 elements. Furthermore, students are not required to know the name associated with each element symbol.

By way of example, this concept may be tested in conjunction with the concepts of ion and the Rutherford-Bohr atomic model.

Electricity

Electrical charge	tested in	ST	X	AST	X

Students must deduce the behaviour (attraction or repulsion) of two charged objects that are close to each other without touching and that have electrical charges of opposite signs or like signs.

By way of example, this concept may be tested in conjunction with the concept of static electricity.

Electricity

Static electricity	tested in	ST	X	AST	X

The electrons transferred from one object to another can be determined based on a triboelectric series (electrostatic list) or a series of actions (conduction, friction).
Induction is the displacement of negative charges within a neutral object when it is close to a charged object.

By way of example, this concept may be tested in conjunction with the concept of electrical charge.

Electricity

Ohm's law	tested in	ST	X	AST	X

A mathematical relationship or a graph can be used to determine resistance, potential difference (voltage) and electric current intensity.

By way of example, this concept may be tested in conjunction with the following concepts: electrical functions, electrical circuits, energy efficiency or relationship between power and electrical energy.

Electricity

Electrical circuits	tested in	ST	X	AST	X

The position of the components whose function is to transform energy will determine the type of electrical circuit involved (series or parallel). Switches are not energy transformers; their position will determine the operating state of the circuit (open or closed) and not the type of circuit involved. When the switch is open, the current cannot flow.

A list of symbols used in ministerial examinations is found at the end of this document. Students must be able to recognize these symbols in a given circuit diagram. However, if they are asked to draw a circuit diagram, they will be given a list of symbols.

By way of example, this concept may be tested in conjunction with the following concepts: electrical functions and Ohm's law.

Electricity

Relationship between power and electrical energy	tested in	ST	X	AST	X

A mathematical relationship or a graph can be used to determine power, time and electrical energy.

The joule (J), the watt-hour (W•h or Wh) and the kilowatt hour (kW•h or kWh) are units of energy commonly used in electricity.

Without calculating the cost of using it, students must be able to determine whether an electrical appliance is more economical than another based on its energy consumption.

By way of example, this concept may be tested in conjunction with the concepts of energy efficiency and Ohm's law.

Electromagnetism

Forces of attraction and repulsion	tested in	ST	X	AST	X

This concept may be tested, but there are no additional clarifications in this regard.

MATERIAL WORLD

Electromagnetism

Magnetic field of a live wire	tested in	ST	X	AST	X
Magnetic field of a solenoid	tested in	ST		AST	X

The direction of the current should be determined according to the polarity of the terminals (+ and -), which is indicated on the source or the ends of the wires.

Students may be asked to determine the magnetic field based on a diagram of field lines.

Electromagnetism

Electromagnetic induction	tested in	ST		AST	X

This concept may be tested, but there are no additional clarifications in this regard.

Transformation of energy

Law of conservation of energy	tested in	ST	X	AST	X

Although other terms, such as “energy lost,” are used, the term “energy dissipated” is used in ministerial examinations to refer to the energy not converted into a useful form when an object is in operation in an open system (not isolated).

By way of example, this concept may be tested in conjunction with the concept of transformation of energy as an electrical function.

Transformation of energy

Energy efficiency	tested in	ST	X	AST	X

Energy efficiency is calculated as the ratio between the useful energy and the energy consumed, and it is expressed as a percentage (%).

By way of example, this concept may be tested in conjunction with the following concepts: relationship between power and electrical energy, and Ohm’s law.

Fluids

Archimedes’ principle	tested in	ST		AST	X

By way of example, this concept may be tested in conjunction with the following concepts: mass and weight, and types of forces.

Fluids

Pascal’s principle	tested in	ST		AST	X

The concept of pressure (P=F/A) may be applied to help students understand Pascal’s principle from both a qualitative and quantitative point of view. From a quantitative point of view, this should be done mathematically using simple proportions.

MATERIAL WORLD

Fluids

Bernoulli's principle	tested in	ST		AST	X

This principle applies to different fluids (air, water and other liquids), as is the case for Pascal's and Archimedes' principles. Examination questions regarding this principle will focus only on the change in speed and its effect on pressure.

Forces and motion

Forces	tested in	ST		AST	X

In ministerial examinations, a force is represented by a hollowed-out vector (⇨) and the symbol for motion is an ordinary arrow (⟶).

Forces and motion

Types of forces	tested in	ST		AST	X

Examination questions can focus on magnetic, gravitational and frictional forces. This concept may be tested in conjunction with the following concepts: mass and weight, and Archimedes' principle.

Forces and motion

Equilibrium of two forces	tested in	ST		AST	X

Examination questions involve objects whose equilibrium may be disrupted when they are subjected to forces. As a result, students could be required to determine the force that will maintain the equilibrium of a given object.

Forces and motion

Relationship between constant speed, distance and time	tested in	ST		AST	X

The formula $v = d/\Delta t$ applies to the calculation of both average speed and constant speed.

Forces and motion

Mass and weight	tested in	ST		AST	X

By way of example, this concept may be tested in conjunction with the following concepts: types of forces and Archimedes' principle.

TECHNOLOGICAL WORLD

Graphical language

Multiview orthogonal projection (general arrangement drawings)	tested in	ST		AST	X

Students may be required to interpret the general arrangement drawings of a technical object with few components and to draw the top, front and right-side views of this object.

Graphical language

Functional dimensioning	tested in	ST		AST	X

Functional dimensioning involves applying the concepts of dimensioning and tolerance.

Dimensioning

Dimensioning refers to the set of dimensions and tolerances that must be observed to manufacture and assemble an object, and ensure that it works properly.

Tolerance

Tolerance refers to the precision (permitted deviation) required for all the components of an object when it is manufactured. If necessary, this tolerance is indicated by a ± sign.

Functional dimensioning (or Specific tolerance)

Functional dimensioning refers to the deviation (interval) permitted in determining the dimensions of certain components so that an object will work properly. The minimum and maximum dimensions and the possible values of this interval must be considered.

The differences between the minimum and maximum dimensions are not always the same. For example, for a measurement of 32.5 mm, they can be expressed in four different ways:

$32.5^{+0.1}$ $32.5_{-0.2}$ $32.5^{+0.3}_{-0.1}$ 32.5 ± 1

It should be noted that when an object is manufactured, the components may have slightly different measurements, which explains the use of tolerances. There is often a permitted deviation between the measurements of each manufactured component.

Functional dimensioning of a component	3.5 mm ± 0.2
Minimum dimension	3.3 mm
Maximum dimension	3.7 mm
Interval Examples of possible intermediate values	From 3.3 mm to 3.7 mm 3.31 mm, 3.50 mm, 3.69 mm, etc.
Mathematical symbols, such as < (less than), > (greater than) and = (equal to) are used when determining the interval within which the measurement of a component may fall.	

Graphical language

Functional dimensioning (*cont.*)	tested in	ST		AST	X

The following expressions will be used to indicate whether or not, or to what extent, a technical object works.

Will always work: the minimum and maximum dimensions of the two components are such that they can always be assembled, while allowing for any required play. The object works as intended.

May not always work: it may not always be possible to assemble the components and even when it is possible, the technical object may not always work smoothly.
For example:

- an axle whose minimum diameter is too small (too much play between the components)
- an axle whose maximum diameter is the same as that of a hole (no play between the components)

Will never work: the components cannot be assembled so the object will not work.

Play is the space allowed between two components to ensure that they can move freely. Depending on the situation, there may or may not be any play between the components. In order to make this concept easier to understand, we will consider that an axle measuring 2.5 mm in Ø can be inserted, without any play, into a hole measuring 2.5 mm in Ø (regardless of the nature of the materials used to make the components).

Graphical language

Developments (prism, cylinder, pyramid, cone)	tested in	ST		AST	X

In ministerial examinations, developments can refer to materials folded into sheets, hollowed-out shapes or simple objects (without flaps).

In examination questions, the following representations are used:

- Contour line: ———————
- Bend line: – – – – – – – – – –

Graphical language

Standards and representations (diagrams, symbols)	tested in	ST		AST	X

In examination questions, the different types of motion required to make an object work can be presented in a design plan, an axonometric projection or an isometric projection. The following representations are used:

- Visible contour line (edge): ———————
- Hidden contour line (edge): – – – – – – – – – –
- Centre line: – · – · – · – · – · – ·
- Dimension line and extension line: |←————→|

In ministerial examinations, the thickness of the line is not evaluated, the construction lines are not shown and students are not required to indicate the dimensions.

Mechanical engineering

Adhesion and friction of parts	tested in	ST		AST	X

There is **adhesion** (static friction) between two surfaces in contact when they could slide over each other, but do not. There is **friction** (kinetic friction) when two surfaces in contact slide or move over each other.

Adhesion and friction may be affected by the following factors:

- The nature of the materials in contact
- The state of the surfaces in contact
- The presence or absence of a lubricant
- The perpendicular force exerted by one surface on another

In order to simplify evaluation in situations involving this concept, only one factor will vary in each situation. Clarifications regarding the first two factors are given below.

Nature of the materials in contact

A material is selected because of its nature (i.e. its properties), and it is shaped for a specific purpose. The nature of a material gives it specific properties.

State of the surfaces in contact

"State" refers to the surface of a material and the surface with which a material is in contact.

- The surface of a material must be considered, for example, in terms of its texture (smooth, textured) or granularity (the intrinsic properties of the material). For instance, friction wheels with an abrasive or rubbery surface will provide better adhesion. Material wear must also be considered because it modifies the surface.
- The surface with which a material is in contact must be considered in terms of its texture and granularity.

Note: In ministerial examinations, temperature and the dimensions of the surfaces in contact are not regarded as factors that affect adhesion and friction.

Temperature is significant only for certain materials. It is mistakenly assumed that temperature greatly affects adhesion. In reality, temperature has a negligible effect on the adhesion of certain polymers and rubbers, and none at all on the adhesion of materials such as steel.

Furthermore, the dimensions of the surfaces in contact increase adhesion only in the case of rubber. Rubber surfaces are a particular case in that adhesion is an intrinsic property of rubber: its adhesiveness makes it adhere firmly to surfaces.

Mechanical engineering

Characteristics of mechanical links	tested in	ST	X	AST	
Linking of mechanical parts **(degree of freedom of a part)**	tested in	ST		AST	X

Link

When two components are assembled, there is a link if, and only if, the assembled components perform a mechanical function that keeps the components together.

Flexible link

A link is flexible when there is a flexible linking component or flexible material to ensure that the components will return to their initial position if the object works properly.

It is wrong to say that the link between a tire and a wheel rim is a flexible link. It is a rigid link because there is no return movement involving these two components. In this case, the material is flexible, but not the link.

Partial link

A link is partial when the linked components must move in relation to one another for the object to work properly. A partial link may also involve a guiding control. For example, with regard to the ball launcher analyzed in the June 2015 examination, the link between the swing arm and the motor shaft is partial and the swing arm is rotationally guided by the motor shaft.

Removable and non-removable link

In the drawings of technical objects found in the ministerial examinations, the components or sets of components that remain assembled in all exploded view drawings are regarded as non-removable links (fixed links: glued, soldered).

Mechanical engineering

Linking of mechanical parts **(degree of freedom of a part) (*cont.*)**	tested in	ST		AST	X

Degree of freedom

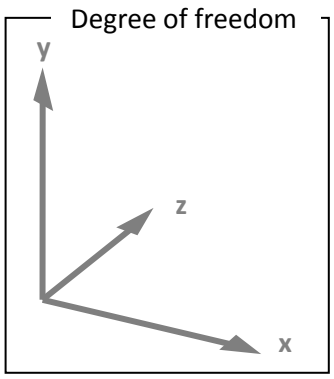
The reference axes (x, y and z) in the Cartesian plane are written as subscripts to the right of the letter that represents the type of freedom of movement.

- The letter T represents freedom of translational movement (T_x, T_y or T_z).
- The letter R represents freedom of rotational movement (R_x, R_y or R_z).

The object comes with a legend:

- *x* axis: left-right
- *y* axis: top-bottom
- *z* axis: front-back

For this concept, the following representation will always be used:

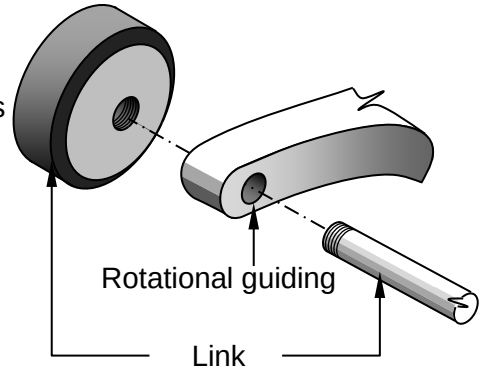


Mechanical engineering

Guiding controls	tested in	ST	X	AST	X

Guiding

Guiding is the function performed by a component that controls the motion of a moving component so that it follows a specific trajectory. Since a guiding control involves movement between the components, there can be no guiding control in a complete link.



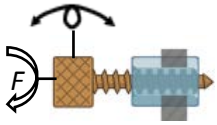
Direct-Rigid-Removable-Complete

Helical guiding

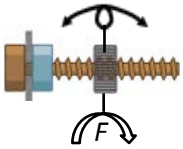
Helical guiding ensures the rectilinear motion of the moving component (the screw or the nut, as the case may be) while it rotates about the same axis.

These examples are taken from the Experimentation *section of the animation entitled* Mechanisms, *available at http://cdpsciencetechno.org/cdp/UserFiles/File/previews/mechanisms/.*

The following are two examples of helical guiding:



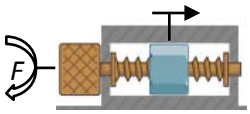
Screw gear system, type I
The screw (driver component) moves inside a fixed nut.



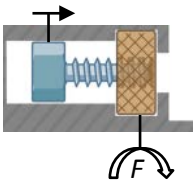
Screw gear system, type II
The nut (driver component) moves along a fixed screw.

The following are two examples of translational guiding that are not cases of helical guiding:

Screw gear system, type III



The screw (driver component) undergoes continuous rotational motion and the nut (driven component) undergoes continuous translational motion. This motion transformation system is an irreversible mechanism.



Screw gear system, type IV

The nut (driver component) undergoes continuous rotational motion and the screw (driven component) undergoes continuous translational motion. This motion transformation system is an irreversible mechanism.

TECHNOLOGICAL WORLD

Mechanical engineering

Construction and characteristics of motion transmission systems (friction gears, pulleys and belt, gear assembly, sprocket wheels and chain, wheel and worm gear)	tested in	ST	X	AST	X
Speed changes		ST	X	AST	X
Construction and characteristics of motion transformation systems (screw gear system, cams, connecting rods, cranks, slides and rotating slider-crank mechanisms, rack-and-pinion drive)		ST	X	AST	
Construction and characteristics of motion transformation systems (screw gear system, connecting rods, cranks, slides, cams, eccentrics and rotating slider-crank mechanisms, rack-and-pinion drive)		ST		AST	X

Motion transmission and transformation systems

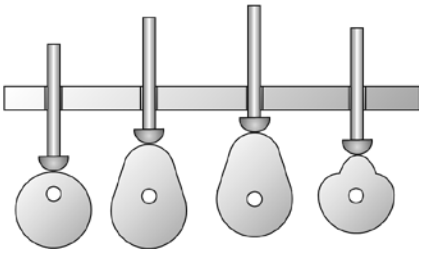
When explaining a mechanism, students must first correctly identify the type of system (motion transmission or transformation) and correctly name the mechanism involved. They must then indicate the movements, the characteristics as well as the advantages and disadvantages associated with its operation. Their explanation can also take into account the range of motion of the components.

The terms “driver component,” “intermediate component” and “driven component” must be used in explanations of mechanisms. Although other terms are used as synonyms in the literature, these are the terms used in the ministerial examinations.

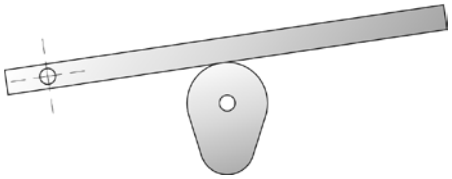
Cam

Cams are mechanical components that push another component so that it undergoes rotational or translational motion. Cams can be of different shapes (round, ovoid, curved, etc.) and, depending on their shape, their axes of rotation can be centred or eccentric.

Cam and follower in translational motion:



Cam and lever in rotational motion:



Speed changes

When explaining a speed change, students must do a simple calculation of the ratio between the driver component and the driven component. In a gear assembly involving several gears, the intermediate components do not interfere with any speed change.

TECHNOLOGICAL WORLD

Electrical engineering

Power supply	tested in	ST	X	AST	X

By way of example, this concept may be tested in conjunction with the following concepts: Ohm's law and electrical circuits.

Electrical engineering

Conduction, insulation and protection	tested in	ST	X	AST	X

This concept is covered in the Secondary IV ST curriculum. In AST, this concept is covered in Secondary III and may then be applied in Secondary IV to analyze technical objects and draw diagrams.

By way of example, this concept may be tested in conjunction with the following concepts: Ohm's law and electrical circuits.

Electrical engineering

Conduction, insulation and protection (resistance and colour code)	tested in	ST		AST	X

The following colour code is used to determine the value of electrical resistors. A resistor has four bands, the first three of which are used to determine the value.

COLOUR CODE USED TO DETERMINE THE VALUE OF ELECTRICAL RESISTORS

	Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White	Gold	Silver
Digit	0	1	2	3	4	5	6	7	8	9		
Multiplier	1	10	10^2	10^3	10^4	10^5	10^6					
Tolerance (%)	20										5	10

Electrical engineering

Control	tested in	ST	X	AST	X

This concept is covered in the Secondary IV ST curriculum. In AST, this concept and the various types of switches are covered in Secondary III and may then be applied in Secondary IV to analyze technical objects and draw diagrams.

By way of example, this concept may be tested in conjunction with the following concepts: Ohm's law and electrical circuits.

Electrical engineering

Transformation of energy (electricity and light, heat, vibration, magnetism)	tested in	ST	X	AST	X

By way of example, this concept may be tested in conjunction with the following concepts: Ohm's law, electrical circuits and the law of conservation of energy.

Electrical engineering

Other functions	tested in	ST		AST	X

This concept may be tested, but there are no additional clarifications in this regard.

TECHNOLOGICAL WORLD

Materials

Constraints tested in	ST	X	AST	X

Constraints are external forces (compression, deflection, shearing, tension and torsion) that are exerted on materials and that have a tendency to deform them. These types of deformation are not necessarily apparent.

In ministerial examinations, constraints are represented by hollowed-out vectors (⇨⇦), and the symbol for motion is an ordinary arrow (⟶).

These symbols may be used in a design plan or any other diagram.

Materials

Characteristics of mechanic properties tested in	ST	X	AST	X

Defining the mechanical property of a material used in an object involves observing the capacity of a component made of this material to withstand a constraint, a shock or an impact without breaking when the object is subjected to normal use.

The following are some definitions of the mechanical properties of materials:

- **Elasticity:** mechanical property that gives the material the capacity to lose its shape when subjected to a constraint and to return to its original shape when no longer subjected to that constraint.
- **Fragility:** mechanical property that gives the material the capacity to break without undergoing deformation when subjected to various constraints.
- **Hardness:** mechanical property that gives the material the capacity to resist scratches, indentation and deformation.
- **Resilience:** mechanical property that gives the material the capacity to resist <u>shocks</u> by undergoing deformation and to then return to its original shape.
- **Stiffness:** mechanical property that gives the material the capacity to retain its initial shape when subjected to various constraints.

Ductility and malleability are <u>shaping</u> properties usually associated with metals. These terms are not used to describe the components of a technical object that are made of these materials.

- **Ductility:** Capacity to be drawn into wires without breaking (e.g. the ductility of copper allows it to be drawn into wire).
- **Malleability:** Capacity to be flattened or bent without breaking (e.g. the malleability of aluminum allows it to be used to make foil).

Note that the mechanical property associated with a plastic plate subjected to deflection is elasticity and not malleability. This plastic plate is not considered malleable, since it was moulded or thermoformed rather than stretched out into a thin sheet by a rolling mill.

TECHNOLOGICAL WORLD

Materials

Types and properties	tested in	ST	X	AST	X

The following are some definitions of the properties of materials:

- **Chemical neutrality:** chemical property that describes a material that is not chemically active and that enables it to resist chemicals.
- **Corrosion resistance:** chemical property that describes a material that is able to resist the effects of corrosive substances (e.g. salts, chemicals).
- **Electrical conductivity:** physical property that enables a material to conduct an electric current.
- **Heat resistance:** physical property that enables a material to resist heat while retaining its mechanical properties.
- **Lightness:** physical property of a low-density material.
- **Thermal conductivity:** physical property that enables a material to transmit heat.

Properties of different types of materials

Note: Using a suggested vocabulary list, students must be able to associate materials with their specific properties.

Properties of Materials	Ceramics	Thermoplastics	Thermosetting Plastics
Electrical conductivity	low or none	none	none
Thermal conductivity	variable	low	variable
Hardness	very high	variable	high
Elasticity	none	high	variable
Chemical neutrality	high	high	variable
Stiffness	very high	variable	high
Heat resistance	very high	variable	high
Corrosion resistance	high	high	high
Resilience	low	high	high

Materials

Modifications of properties (degradation, protection)	tested in	ST	X	AST	X

The types of treatment used to prevent the degradation of materials pertain to all materials (plastics, metals, ceramics, wood). This may involve zinc coating (galvanization), anti-rust treatment, applying paint, varnish or a waterproof coating, or incorporating pigments or antioxidants.

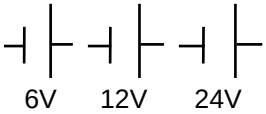
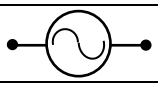
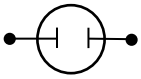
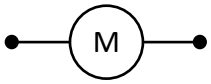
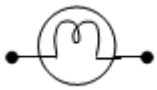
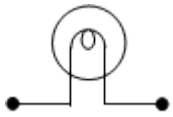
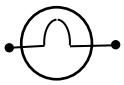
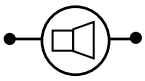
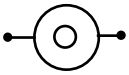
Manufacturing

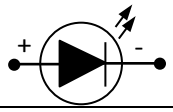
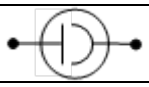
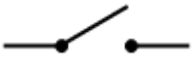
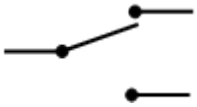
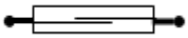
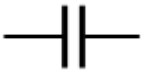
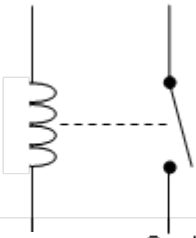
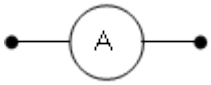
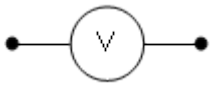
Manufacturing (characteristics of drilling, tapping, threading and bending)	tested in	ST		AST	X

This concept may be tested, but there are no additional clarifications in this regard.

TECHNOLOGICAL WORLD

Students must be able to recognize these symbols in a given circuit diagram. However, if they are asked to draw a circuit diagram, they will be given a list of symbols.

Battery *A 1.5-volt battery*	
Two batteries *If there are two batteries, this provides 3 volts.*	
More than two batteries *If there are more than two batteries, the voltage is indicated in the diagram.*	
Alternating current	
Electrical outlet *When analyzing a technical object that uses alternating current, only the symbol for the power source is used to represent the power supply. The transformer is not included in the circuit diagram.*	
Fuse	
Motor	
Resistor	
Light bulb *The symbol on the right is used to represent any type of indicator light in a technical object.*	  
Speaker OR alarm	
Audible warning device	
Heating element	

Light-emitting diode (AST only)	
Diode (AST only)	
Wire	
Photoelectric cell	
Push-button switch	
Rocker switch	
Double-throw switch (AST only)	
Magnetic switch	
Capacitor (AST only)	
Relay (AST only) *The symbol on the right is used to represent a relay consisting of a coil in a low-voltage circuit that activates the contact in a high-voltage circuit.*	
Ammeter	
Voltmeter	

GLOSSARY OF TERMS (ST)

Mechanical engineering						
Characteristics of a link			Types of motion and guiding controls			
Direct	or	Indirect	Translational	→	↔	←
Rigid	or	Flexible	Rotational	↷	↶↷	↶
Removable	or	Non-removable	Helical			
Complete	or	Partial				

Motion transformation mechanisms	Motion transmission mechanisms
Connecting rod and crank / Slider-crank	Sprocket wheel and chain
Cam and roller / Cam and follower	Pulley and belt
Rack and pinion	Gear assembly
Screw gear system	Wheel and worm gear
	Friction gear

Electrical engineering		
Electrical functions	Forms of energy	Types of circuits
Power supply	Chemical	Series
Control	Electrical	Parallel
Conduction	Mechanical (vibrational, magnetic and sound)	
Insulation	Radiant (light and solar)	
Protection	Thermal	
Transformation of energy		

Materials and Manufacturing	
Characteristics of mechanical properties	Types and properties of materials
Ductility	Electrical conductivity
Hardness	Thermal conductivity
Elasticity	Lightness
Fragility	Chemical neutrality
Malleability	Heat resistance
Resilience	Corrosion resistance
Stiffness	
Constraints	**Types of materials**
Shearing	Ceramics
Compression	Thermosetting plastics
Deflection	Thermoplastics
Traction	
Torsion	

GLOSSARY OF TERMS (AST)

Mechanical engineering

Factors affecting adhesion and friction	Characteristics of a link		
The nature of the materials in contact	Direct	or	Indirect
The state of the surfaces in contact	Rigid	or	Flexible
The presence or absence of a lubricant	Removable	or	Non-removable
The perpendicular force exerted by one surface on another	Complete	or	Partial

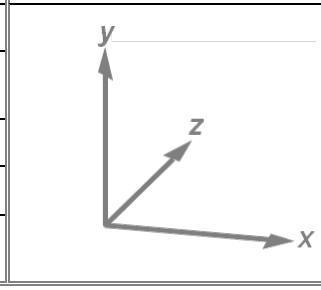
				Motion transformation mechanisms	Motion transmission mechanisms
Translational	→	↔	←	Connecting rod and crank / Slider-crank	Sprocket wheel and chain
Rotational	↷	↶↷	↶	Cam and roller / Cam and follower	Pulley and belt
Helical	↷	↶↷	↶	Rack and pinion	Gear assembly
				Screw gear system	Wheel and worm gear
					Friction gear

Electrical engineering

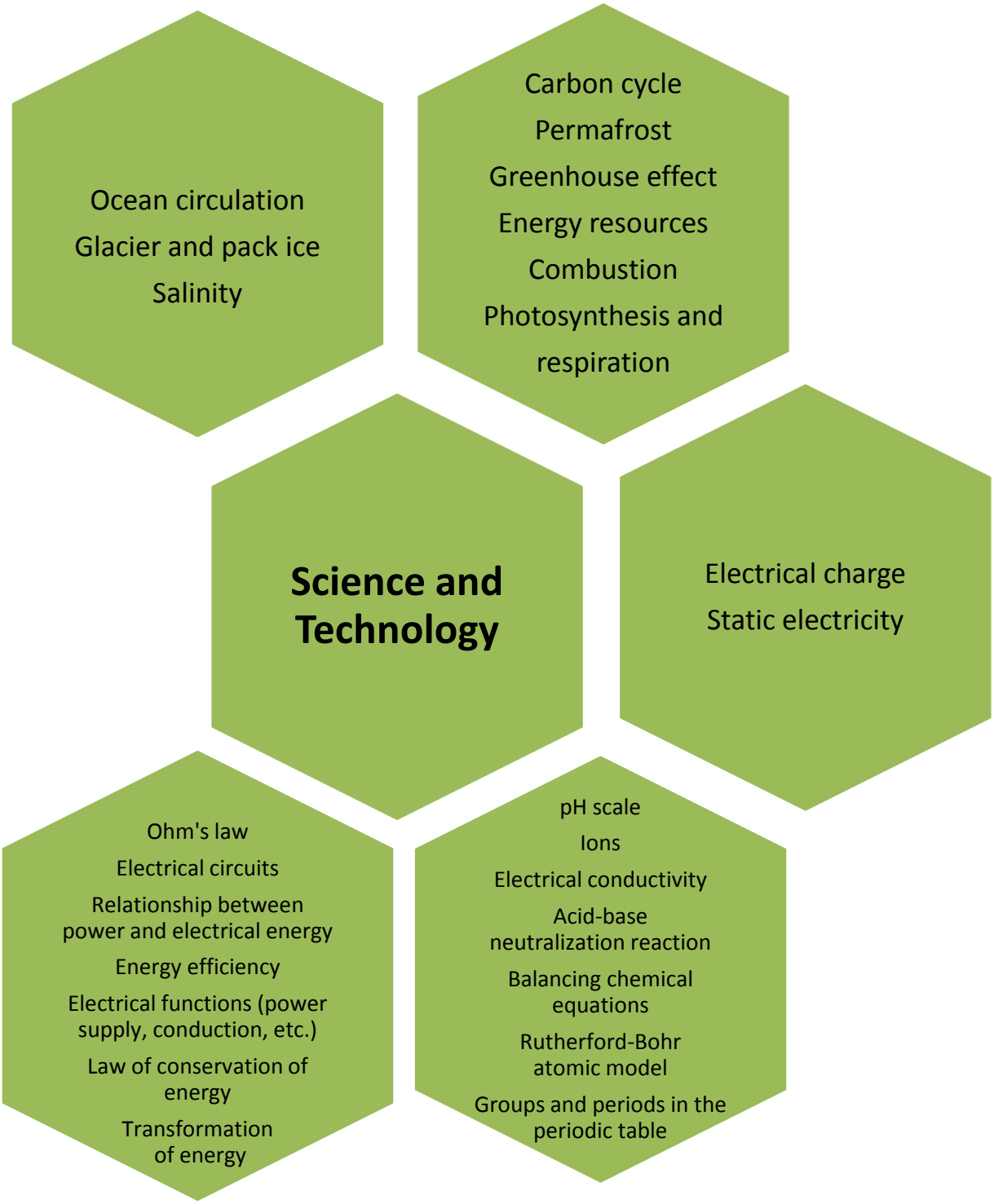
Electrical functions	Forms of energy	Types of circuits
Power supply	Chemical	Series
Control	Electrical	Parallel
Conduction	Mechanical (vibrational, magnetic and sound)	
Insulation	Radiant (light and solar)	
Protection	Thermal	
Transformation of energy		
Other functions		

Materials and Manufacturing

Characteristics of mechanical properties	Types and properties of materials	Manufacturing techniques
Hardness	Thermal conductivity	Threading
Elasticity	Lightness	Drilling
Fragility	Chemical neutrality	Bending
Malleability	Heat resistance	Tapping
Resilience	Corrosion resistance	
Stiffness		

Constraints	Degree of freedom of movement	Types of deformation	Types of materials
Shearing		Elastic	Ceramics
Compression		Plastic	Thermosetting plastics
Deflection		Fracture	Thermoplastics
Tension			
Torsion			

CONCEPTS THAT MAY BE TESTED TOGETHER IN MINISTERIAL EXAMINATIONS



CONCEPTS THAT MAY BE TESTED TOGETHER IN MINISTERIAL EXAMINATIONS