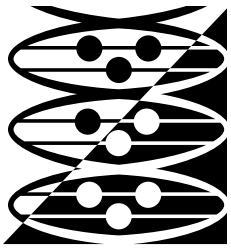

APPLICATIONS OF PHYSICS 11 AND 12

Integrated Resource Package 2007

BRITISH COLUMBIA
The Best Place on Earth

IRP 173

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This Integrated Resource Package (IRP) provides information teachers will require in order to implement Applications of Physics 11 and 12. This document supersedes the *Applications of Physics 11 and 12 Integrated Resource Package 1996*.

The information contained in this document is also available on the Internet at www.bced.gov.bc.ca/irp/

The following paragraphs provide brief descriptions of the components of the IRP.

INTRODUCTION

The Introduction provides general information about Applications of Physics 11 and 12, including special features and requirements.

Included in this section are

- a rationale for teaching Applications of Physics 11 and 12 in BC schools
- information about graduation program requirements and provincial examinations
- goals for Applications of Physics 11 and 12
- information about the revision process that led to the publication of this document
- descriptions of the curriculum organizers—groupings for Prescribed Learning Outcomes that share a common focus
- suggested time frame for each course
- a graphic overview of the curriculum content from K to 10.

CONSIDERATIONS FOR PROGRAM DELIVERY

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners.

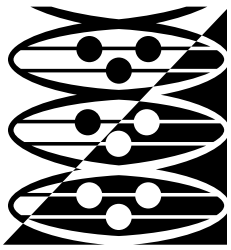
PRESCRIBED LEARNING OUTCOMES

This section contains the *Prescribed Learning Outcomes.* Prescribed Learning Outcomes are the legally required content standards for the provincial education system. They define the required attitudes, skills, and knowledge for each subject. The Prescribed Learning Outcomes are statements of what students are expected to know and be able to do by the end of the course.

STUDENT ACHIEVEMENT

This section of the IRP contains information about classroom assessment and measuring student achievement, including sets of specific achievement indicators for each Prescribed Learning Outcome. Achievement indicators are statements that describe what students are able to do in order to demonstrate that they fully meet the expectations set out by the Prescribed Learning Outcomes. Achievement indicators are not mandatory; they are provided to assist teachers in assessing how well their students achieve the Prescribed Learning Outcomes.

Also included in this section are key elements—descriptions of content that help determine the intended depth and breadth of Prescribed Learning Outcomes.



INTRODUCTION

Applications of Physics 11 and 12

This Integrated Resource Package (IRP) sets out the provincially prescribed curriculum for Applications of Physics 11 and 12. The development of this IRP has been guided by the principles of learning:

- Learning requires the active participation of the student.
- People learn in a variety of ways and at different rates.
- Learning is both an individual and a group process.

In addition to these three principles, this document recognizes that British Columbia's schools include students of varied backgrounds, interests, abilities, and needs. Wherever appropriate for this curriculum, ways to meet these needs and to ensure equity and access for all learners have been integrated as much as possible into the Prescribed Learning Outcomes, achievement indicators, and assessment activities.

RATIONALE

The Applications of Physics 11 and 12 curriculum is relevant to a wide range of human concerns and achievements. The concepts of physics have a profound effect on the way we think about our universe, our societies, our interactions with the environment, and ourselves. Technological change, which stems from the application of science concepts, is often accompanied by extensive social change.

By placing physics concepts in the context of technology and its role in society, the Applications of Physics 11 and 12 curriculum helps students develop knowledge and skills that they can apply directly in further studies and careers in the sciences, technologies, and trades. By using, designing, and constructing a variety of devices, students develop the knowledge, skills, and attitudes that enable them to adapt to and take advantage of technological change.

The pedagogical approach in Applications of Physics 11 and 12 focuses on hands-on problem-solving methods suited to the interests and abilities of a wide range of students. Students learn basic concepts of physics as they participate in activities including labs and close examinations of commonly used technologies. They develop their knowledge further by designing and constructing various devices for use in classroom activities. To enhance their learning, they visit local workplaces and use local expertise to help them solve problems relevant to themselves, their school, and their community.

In keeping with this rationale, the Applications of Physics 11 and 12 curriculum seeks to

- introduce to students the nature, scope, skills, methods, and relevance of the concepts of physics and how they are applied in everyday life
- maintain the intellectual integrity of the discipline of physics as it is applied in technologies
- provide an introductory course suitable to the interests and abilities of a wide range of students (Applications of Physics 11)
- provide a rigorous follow-up course suitable for students who have a particular career interest in a technology or trade or who plan to continue their education (Applications of Physics 12).

REQUIREMENTS AND GRADUATION CREDITS

Applications of Physics 11 and 12 are designated as four-credit courses, and must be reported as such to the Ministry of Education for transcript purposes. Letter grades and percentages must be reported for these courses. It is not possible to obtain partial credit for these courses.

The course code for Applications of Physics 11 is PHA 11. The course code for Applications of Physics 12 is PHA 12. These courses are also available in French (Applications de la physique 11, course code PHAF 11; Applications de la physique 12; course code PHAF 12).

GRADUATION PROGRAM EXAMINATION

Because the instructional approach for Applications of Physics 11 and Applications of Physics 12 is intended to be experiential in nature, there is no Graduation Program examination for either course.

GOALS FOR APPLICATIONS OF PHYSICS 11 and 12

The over-riding goals for Applications of Physics 11 and 12 are represented in the Prescribed Learning Outcomes for Applications of Physics 11 and 12 in each curriculum organizer.

CURRICULUM ORGANIZERS

A curriculum organizer consists of a set of Prescribed Learning Outcomes that share a common focus. The Prescribed Learning Outcomes for Applications of Physics 11 are grouped under the following curriculum organizers:

- Mechanical Systems
- Fluid Systems
- Thermal Systems
- Electrical Systems

The Prescribed Learning Outcomes for Applications of Physics 12 are grouped under the following curriculum organizers:

- Transformers
- Momentum
- Transducers
- Waves & Vibrations
- Electricity and Magnetism

Note that these organizers are for the purposes of identifying Prescribed Learning Outcomes; they are not intended to suggest a linear delivery of course material.

LEARNING RESOURCES

For the current list of recommended learning resources, please check the Learning Resources website: www.bced.gov.bc.ca/irp_resources/lr/resource/gradcoll.htm

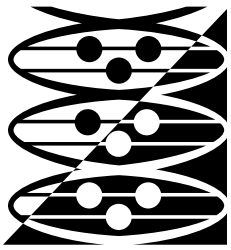
The Grade Collection charts list the recommended learning resources by media format, showing links to the curriculum organizers and suborganizers. The charts are followed by an annotated bibliography. Teachers should check with suppliers for complete and up-to-date ordering information.

Ministry policy concerning Learning Resources can be found on the ministry's policy website: www.bced.gov.bc.ca/policy/policies/

SUGGESTED TIME FRAME

Provincial curricula are developed in accordance with the amount of instructional time recommended by the Ministry of Education for each subject area. Teachers may choose to combine various curricula to enable students to integrate ideas and make meaningful connections.

Applications of Physics 11 and Applications of Physics 12 can both be used to satisfy graduation requirements. Each is designed as a four-credit course with an estimated 90 to 110 hours of instructional content. This estimate is provided as a suggestion only; when delivering the prescribed curriculum, teachers may adjust the instructional time as necessary.



CONSIDERATIONS FOR PROGRAM DELIVERY

Applications of Physics 11 and 12

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners. Included in this section is information about:

- Alternative Delivery policy
- addressing local contexts
- involving parents and guardians
- course requirements respecting beliefs
- safety considerations
- confidentiality
- inclusion, equity, and accessibility
- working with the school and community
- working with the Aboriginal community
- information and communications technology
- copyright

ALTERNATIVE DELIVERY POLICY

The Alternative Delivery policy does not apply to the Applications of Physics 11 and 12 curriculum.

The Alternative Delivery policy outlines how students, and their parents or guardians, in consultation with their local school authority, may choose means other than instruction by a teacher within the regular classroom setting for addressing Prescribed Learning Outcomes contained in the Health curriculum organizer of the following curriculum documents:

- Health and Career Education K to 7, and Personal Planning K to 7 Personal Development curriculum organizer (until September 2008)
- Health and Career Education 8 and 9
- Planning 10

The policy recognizes the family as the primary educator in the development of children's attitudes, standards, and values, but the policy still requires that all Prescribed Learning Outcomes be addressed and assessed in the agreed-upon alternative manner of delivery.

It is important to note the significance of the term "alternative delivery" as it relates to the Alternative Delivery policy. The policy does not permit schools to omit addressing or assessing any of the Prescribed Learning Outcomes within the health and career education curriculum. Neither does it allow students to be excused from meeting any Prescribed Learning Outcomes related to health. It is expected that students who arrange for alternative delivery will address the health-related Prescribed Learning Outcomes and will be able to demonstrate their understanding of these Prescribed Learning Outcomes.

For more information about policy relating to alternative delivery, refer to www.bced.gov.bc.ca/policy/

ADDRESSING LOCAL CONTEXTS

There is some flexibility in the Applications of Physics 11 and 12 curriculum, providing opportunities for individual teacher and student choice in the selection of topics to meet Prescribed Learning Outcomes. This flexibility enables educators to plan their programs by using topics and examples that are relevant to their local context and to the particular interests of their students. When selecting topics it may be appropriate to incorporate student input.

INVOLVING PARENTS AND GUARDIANS

The family is the primary educator in the development of students' attitudes and values. The school plays a supportive role by focussing on the Prescribed Learning Outcomes in the Applications of Physics 11 and 12 curriculum. Parents and guardians can support, enrich, and extend the curriculum at home.

It is highly recommended that schools inform parents and guardians about the Applications of Physics 11 and 12 curriculum, and teachers (along with school and district administrators) may choose to do so by

- informing parents/guardiansand students of the Prescribed Learning Outcomes for the subject by sending home class letters, providing an overview during parent-teacher interviews, etc.

- responding to parent and guardian requests to discuss course unit plans, learning resources, etc.

COURSE REQUIREMENTS RESPECTING BELIEFS

For many students and teachers, the study of some science concepts may lead to issues and questions that go beyond the immediate scope of curriculum (e.g., science is used to meet many industrial requirements, but industrial decision makers must consider factors other than scientific feasibility before adopting a particular process). The technological application of science in areas such as genetic engineering, human reproduction, and medical technology raises questions of ethics and values. Because these social questions arise, in part, from capabilities that science makes possible, they should be addressed. It must be made clear to students, however, that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions objectively and with sensitivity.

Reconciling scientific discoveries (for example, in age dating) and religious faith poses a particular challenge for some students. While respecting the personal beliefs of students, teachers should be careful to distinguish between knowledge based on the application of scientific methods, and religious teachings and associated beliefs such as creationism, theory of divine creation, or intelligent design theory.

SAFETY CONSIDERATIONS

Science education is an activity-based process that provides an exciting method of teaching and learning. However, experiments and demonstrations may involve inherent risks for both the teacher and the student.

Safety guidelines must be discussed with students. These safety guidelines must support and encourage the investigative approach generally and laboratory instruction specifically, while at the same time promoting safety in the classroom and laboratory. Encouraging a positive safety attitude is a responsibility shared among the board, school administrators, teachers, and students in every school district. The co-operation of all these groups helps develop a strong safety consciousness both inside and outside our schools.

Field work and field trips require special vigilance with respect to traffic and road safety, safe practices in study areas and when obtaining samples, and an awareness of changes in weather.

Another important aspect of in-school safety is the Workplace Hazardous Materials Information Systems (WHMIS). Through labelling, material safety data sheets, and education and training, WHMIS is designed to ensure that those using hazardous materials have sufficient information to handle them safely. Each school district should have an individual trained in WHMIS who can work with teachers to establish safe, well-ventilated classroom and laboratory working conditions.

To assist teachers in providing a safe science-learning environment, the Ministry of Education publishes the *Science Safety Resource Manual*, which has been distributed to every school.

> The *Science Safety Resource Manual* is available online at www.bced.gov.bc.ca/irp/resdocs/scisafety.htm

CONFIDENTIALITY

The *Freedom of Information and Protection of Privacy Act* (FOIPPA) applies to students, to school district employees, and to all curricula. Teachers, administrators, and district staff should consider the following:

- Be aware of district and school guidelines regarding the provisions of FOIPPA and how it applies to all subjects, including Applications of Physics 11 and 12.
- Do not use students' Personal Education Numbers (PEN) on any assignments that students wish to keep confidential.

- Ensure students are aware that if they disclose personal information that indicates they are at risk for harm, then that information cannot be kept confidential.
- Inform students of their rights under FOIPPA, especially the right to have access to their own personal information in their school records. Inform parents of their rights to access their children's school records.
- Minimize the type and amount of personal information collected, and ensure that it is used only for purposes that relate directly to the reason for which it is collected.
- Inform students that they will be the only ones recording personal information about themselves unless they, or their parents, have consented to teachers collecting that information from other people (including parents).
- Provide students and their parents with the reason(s) they are being asked to provide personal information in the context of the Applications of Physics 11 and 12 curriculum.
- Inform students and their parents that they can ask the school to correct or annotate any of the personal information held by the school, in accordance with Section 29 of FOIPPA.
- Ensure students are aware that their parents may have access to the schoolwork they create only insofar as it pertains to students' progress.
- Ensure that any information used in assessing students' progress is up-to-date, accurate, and complete.

For more information about confidentiality, refer to www.mser.gov.bc.ca/FOI_POP/index.htm

INCLUSION, EQUITY, AND ACCESSIBILITY FOR ALL LEARNERS

British Columbia's schools include students of varied backgrounds, interests, and abilities. The Kindergarten to grade 12 school system focusses on meeting the needs of all students. When selecting specific topics, activities, and resources to support the implementation of Applications of Physics 11 and 12, teachers are encouraged to ensure that these choices support inclusion, equity, and accessibility for all students. In particular, teachers should ensure that classroom instruction, assessment, and resources reflect sensitivity to diversity and incorporate positive role portrayals, relevant issues, and themes such as inclusion, respect, and acceptance.

Government policy supports the principles of integration and inclusion of students who have English as a second language and of students with special needs. Most of the Prescribed Learning Outcomes and suggested achievement indicators in this IRP can be met by all students, including those with special needs and/orESL needs. Some strategies may require adaptations to ensure that those with special and/orESL needs can successfully achieve the Prescribed Learning Outcomes. Where necessary, modifications can be made to the Prescribed Learning Outcomes for students with Individual Education Plans.

For more information about resources and support for students with special needs, refer to www.bced.gov.bc.ca/specialed/

For more information about resources and support for ESL students, refer to www.bced.gov.bc.ca/esl/

WORKING WITH THE SCHOOL AND COMMUNITY

This curriculum addresses a wide range of skills and understandings that students are developing in other areas of their lives. It is important to recognize that learning related to this curriculum extends beyond the science classroom.

School and district-wide programs support and extend learning in Applications of Physics 11 and 12. Community organizations may also support the curriculum with locally developed learning resources, guest speakers, workshops, and field studies. Teachers may wish to draw on the expertise of these community organizations and members.

WORKING WITH THE ABORIGINAL COMMUNITY

The Ministry of Education is dedicated to ensuring that the cultures and contributions of Aboriginal peoples in BC are reflected in all provincial curricula. To address these topics in the classroom in a way that is accurate and that respectfully reflects Aboriginal concepts of teaching and learning, teachers are strongly encouraged to seek the advice and support of local Aboriginal communities. As Aboriginal communities are diverse in terms of language, culture, and available resources, each community will have its own unique protocol to gain support for integration of local knowledge and expertise. To begin discussion of possible instructional and assessment activities, teachers should first contact Aboriginal education co-ordinators, teachers, support workers, and counsellors in their district who will be able to facilitate the identification of local resources and contacts such as elders, chiefs, tribal or band councils, Aboriginal cultural centres, Aboriginal Friendship Centres, and Mé tis or Inuit organizations.

In addition, teachers may wish to consult the various Ministry of Education publications available, including the "Planning Your Program" section of the resource, *Shared Learnings.* This resource was developed to help all teachers provide students with knowledge of, and opportunities to share experiences with, Aboriginal peoples in BC.

For more information about these documents, consult the Aboriginal Education web site: www.bced.gov.bc.ca/abed/welcome.htm

INFORMATION AND COMMUNICATIONS TECHNOLOGY

The study of information and communications technology is increasingly important in our society. Students need to be able to acquire and analyse information,reason and communicate, make informed decisions, and understand and use information and communications technology for a variety of purposes. Development of these skills is important for students in their education, their future careers, and their everyday lives.

Literacy in the area of information and communications technology can be defined as the ability to obtain and share knowledge through investigation, study, instruction, or transmission of information by means of media technology. Becoming literate in this area involves finding, gathering, assessing, and communicating information using electronic means, as well as developing the knowledge and skills to use and solve problems effectively with the technology. Literacy also involves a critical examination and understanding of the ethical and social issues related to the use of information and communications technology. When planning for instruction and assessment in Applications of Physics 11 and 12, teachers should provide opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society.

COPYRIGHT AND RESPONSIBILITY

Copyright is the legal protection of literary, dramatic, artistic, and musical works; sound recordings; performances; and communications signals. Copyright provides creators with the legal right to be paid for their work and the right to say how their work is to be used. There are some exceptions in the law (i.e., specific things permitted) for schools but these are very limited, such as copying for private study or research. The copyright law determines how resources can be used in the classroom and by students at home.

In order to respect copyright it is necessary to understand the law. It is unlawful to do the following, unless permission has been given by a copyright owner:

- photocopy copyrighted material to avoid purchasing the original resource for any reason
- photocopy or perform copyrighted material beyond a very small part—in some cases the

copyright law considers it "fair" to copy whole works, such as an article in a journal or a photograph, for purposes of research and private study, criticism, and review

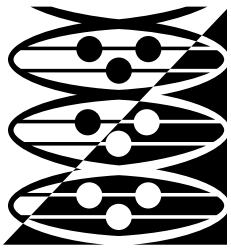
- show videotaped television or radio programs to students in the classroom unless these are cleared for copyright for educational use (there are exceptions such as for news and news commentary taped within one year of broadcast that by law have record-keeping requirements—see the web site at the end of this section for more details)
- photocopy print music, workbooks, instructional materials, instruction manuals, teacher guides, and commercially available tests and examinations
- show videotapes at schools that are not cleared for public performance
- perform music or do performances of copyrighted material for entertainment (i.e., for purposes other than a specific educational objective)
- copy work from the Internet without an express message that the work can be copied

Permission from or on behalf of the copyright owner must be given in writing. Permission may also be given to copy or use all or some portion of copyrighted work through a licence or agreement.

Many creators, publishers, and producers have formed groups or "collectives" to negotiate royalty payments and copying conditions for educational institutions. It is important to know what licences are in place and how these affect the activities schools are involved in. Some licences may also have royalty payments that are determined by the quantity of photocopying or the length of performances. In these cases, it is important to assess the educational value and merits of copying or performing certain works to protect the school's financial exposure (i.e., only copy or use that portion that is absolutely necessary to meet an educational objective).

It is important for education professionals, parents, and students to respect the value of original thinking and the importance of not plagiarizing the work of others. The works of others should not be used without their permission.

For more information about copyright, refer to www.cmec.ca/copyright/indexe.stm



PRESCRIBED LEARNING OUTCOMES

Applications of Physics 11 and 12

Prescribed Learning Outcomes are content standards for the provincial education system; they are the prescribed curriculum. Clearly stated and expressed in measurable and observable terms, Prescribed Learning Outcomes set out the required attitudes, skills, and knowledge—what students are expected to know and be able to do—by the end of the subject and grade.

Schools have the responsibility to ensure that all Prescribed Learning Outcomes in this curriculum are met; however, schools have flexibility in determining how delivery of the curriculum can best take place.

It is expected that student achievement will vary in relation to the Prescribed Learning Outcomes. Evaluation, reporting, and student placement with respect to these outcomes are dependent on the professional judgment and experience of teachers, guided by provincial policy.

Prescribed Learning Outcomes for Applications of Physics 11 and 12 are presented by grade and by curriculum organizer and suborganizer, and are coded alphanumerically for ease of reference; however, this arrangement is not intended to imply a required instructional sequence.

Wording of Prescribed Learning Outcomes

All Prescribed Learning Outcomes complete the stem, "It is expected that students will …."

When used in a Prescribed Learning Outcome, the word "including" indicates that any ensuing item **must be addressed**. Lists of items introduced by the word "including" represent a set of minimum requirements associated with the general requirement set out by the outcome. The lists are not necessarily exhaustive, however, and teachers may choose to address additional items that also fall under the general requirement set out by the outcome.

Conversely, the abbreviation "e.g.," (for example) in a Prescribed Learning Outcome indicates that the ensuing items are provided for illustrative purposes or clarification, and are **not requirements that must be addressed**. Presented in parentheses, the list of items introduced by "e.g.," is neither exhaustive nor prescriptive, nor is it put forward in any special order of importance or priority. Teachers are free to substitute items of their own choosing that they feel best address the intent of the Prescribed Learning Outcome.

Domains of Learning

Prescribed Learning Outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective. The following definitions of the three domains are based on Bloom's taxonomy.

The **cognitive domain** deals with the recall or recognition of knowledge and the development of intellectual abilities. The cognitive domain can be further specified as including three cognitive levels: knowledge, understanding and application, and higher mental processes. These levels are determined by the verb used in the Prescribed Learning Outcome, and illustrate how student learning develops over time.

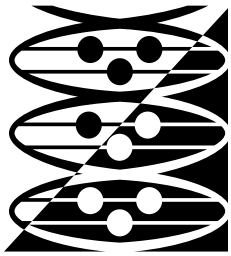
- *Knowledge* includes those behaviours that emphasize the recognition or recall of ideas, material, or phenomena.
- *Understanding and application* represents a comprehension of the literal message contained in a communication, and the ability to apply an appropriate theory, principle, idea, or method to a new situation.
- *Higher mental processes* include analysis, synthesis, and evaluation. The higher mental processes level subsumes both the knowledge and the understanding and application levels.

The **affective domain** concerns attitudes, beliefs, and the spectrum of values and value systems.

The **psychomotor domain** includes those aspects of learning associated with movement and skill demonstration, and integrates the cognitive and

affective consequences with physical performances.

Domains of learning and cognitive levels also form the basis of the Assessment Overview Tables provided for each grade in the Classroom Assessment Model. In addition, domains of learning and, particularly, cognitive levels, inform the design and development of the Graduation Program examination for many grade 12 subjects.



PRESCRIBED LEARNING OUTCOMES

By Grade

GRADE 11

It is expected that students will:

MECHANICAL SYSTEMS

Mechanical Systems (Force)

A1 explain the importance of force direction and magnitude
A2 demonstrate understanding of elastic force
A3 describe the relationship between force, lever arm, and torque

Mechanical Systems (Rate)

A4 analyse motion with constant velocity (uniform motion)
A5 analyse motion with constant acceleration (non-uniform motion)
A6 explain acceleration that occurs as a result of unbalanced force (Newton's second law of motion)
A7 explain the basic difference between linear and rotational motion

Mechanical Systems (Energy)

A8 solve common problems involving work, force, and distance
A9 analyse the nature and transformation of energy in a mechanical system
A10 analyse the efficiency of a mechanical system
A11 demonstrate understanding of power as it relates to mechanical systems

Mechanical Systems (Resistance)

A12 analyse causes and effects of resistive forces in a mechanical system

FLUID SYSTEMS

Fluid Systems (Pressure)

B1 explain characteristics of fluids
B2 demonstrate understanding of the relationship between pressure, force, and area
B3 compare hydraulics and pneumatics
B4 explain buoyancy and fluid displacement (Archimedes' principle)

Fluid Systems (Rate)

B5 explain the significance of rate with respect to fluid systems

Fluid Systems (Energy)

B6 demonstrate understanding of how the energy stored in fluid systems can be controlled and used
B7 analyse the efficiency of a fluid system
B8 demonstrate understanding of power as it relates to fluid systems

Fluid Systems (Resistance)

B9 analyse resistive forces in a fluid system

THERMAL SYSTEMS

Thermal Systems (Temperature)

C1 explain the significance of temperature and temperature differences in thermal systems
C2 analyse various methods of measuring temperature and temperature difference

Thermal Systems (Energy)

C3 analyse the transfer of thermal energy
C4 analyse change of state in a thermal system
C5 demonstrate understanding of power as it relates to thermal systems

Thermal Systems (Rate and Resistance)

C6 explain the relationship between thermal resistance, temperature difference, and rate of heat flow in a thermal system

C7 analyse the relationship between the transfer of thermal energy and the physical attributes of the material through which it is transferred

ELECTRICAL SYSTEMS

Electrical Systems (Fundamentals)

D1 apply basic principles of safety when working with electricity
D2 apply basic terms, concepts, and skills related to electrical systems
D3 determine resistance in electrical systems

Electrical Systems (Circuits)

D4 analyse DC circuits
D5 analyse AC circuits
D6 analyse electric devices with respect to function and efficiency
D7 compare electrical systems with fluid systems, mechanical systems, and thermal systems

GRADE 12

It is expected that students will:

TRANSFORMERS

A1 demonstrate the conversion of force and distance within a mechanical system
A2 demonstrate the changes of force and linear displacement within a fluid system
A3 demonstrate changes of voltage and current within an electrical system
A4 evaluate transfers of energy from one form to another

MOMENTUM

B1 analyse the relationship between impulse and linear momentum
B2 analyse collisions in two dimensions using the concepts of
- conservation of momentum
- conservation of energy

B3 analyse angular momentum and factors affecting it
B4 explain the law of conservation of momentum as it relates to
- angular momentum
- fluid momentum

TRANSDUCERS

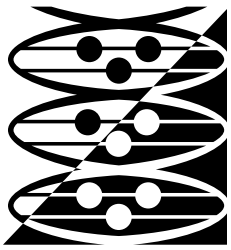
C1 evaluate the application and functioning of mechanical transducers
C2 evaluate the application and functioning of fluid transducers
C3 explain the application of thermal transducers and how they work
C4 evaluate the application and functioning of electrical transducers

WAVES AND VIBRATIONS

D1 analyse waves with reference to their properties and using the universal wave equation
D2 analyse wave interactions and their applications
D3 explain the effects of vibrations in various systems

ELECTRICITY AND MAGNETISM

E1 apply basic principles of safety when working with electricity
E2 demonstrate principles of electromagnetic induction
E3 demonstrate the principles involved in electrical circuits
E4 analyse the operation and applications of motors, alternators, and generators
E5 explain the role and operation of capacitors



STUDENT ACHIEVEMENT

Applications of Physics 11 and 12

This section of the IRP contains information about classroom assessment and student achievement, including specific achievement indicators to assist teachers in assessing student achievement in relation to each Prescribed Learning Outcome. Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of Prescribed Learning Outcomes.

CLASSROOM ASSESSMENT AND EVALUATION

Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment evidence can be collected using a wide variety of methods, such as

- observation
- student self-assessments and peer assessments
- quizzes and tests (written, oral, practical)
- samples of student work
- projects
- oral and written reports
- journals and learning logs
- performance reviews
- portfolio assessments.

Student performance is based on the information collected through assessment activities. Teachers use their insight, knowledge about learning, and experience with students, along with the specific criteria they establish, to make judgments about student performance in relation to Prescribed Learning Outcomes.

There are three major types of assessment that can be used in conjunction with each other to support student achievement.

- Assessment **for** learning is assessment for purposes of greater learning achievement.
- Assessment **as** learning is assessment as a process of developing and supporting students' active participation in their own learning.
- Assessment **of** learning is assessment for purposes of providing evidence of achievement for reporting.

Assessment for Learning

Classroom assessment for learning provides ways to engage and encourage students to become involved in their own day-to-day assessment—to acquire the skills of thoughtful self-assessment and to promote their own achievement.

This type of assessment serves to answer the following questions

- What do students need to learn to be successful?
- What does the evidence of this learning look like?

Assessment for learning is criterion-referenced, in which a student's achievement is compared to established criteria rather than to the performance of other students. Criteria are based on Prescribed Learning Outcomes, as well as on suggested achievement indicators or other learning expectations.

Students benefit most when assessment feedback is provided on a regular, ongoing basis. When assessment is seen as an opportunity to promote learning rather than as a final judgment, it shows students their strengths and suggests how they can develop further. Students can use this information to redirect their efforts, make plans, communicate with others (e.g., peers, teachers, parents) about their growth, and set future learning goals.

Assessment for learning also provides an opportunity for teachers to review what their students are learning and what areas need further attention. This information can be used to inform teaching and create a direct link between assessment and instruction. Using assessment as a way of obtaining feedback on instruction supports student achievement by informing teacher planning and classroom practice.

Assessment as Learning

Assessment as learning actively involves students in their own learning processes. With support and guidance from their teacher, students take responsibility for their own learning, constructing

meaning for themselves. Through a process of continuous self-assessment, students develop the ability to take stock of what they have already learned, determine what they have not yet learned, and decide how they can best improve their own achievement.

Although assessment as learning is student-driven, teachers can play a key role in facilitating how this assessment takes place. By providing regular opportunities for reflection and self-assessment, teachers can help students develop, practise, and become comfortable with critical analysis of their own learning.

Assessment of Learning

Assessment of learning can be addressed through summative assessment, including large-scale assessments and teacher assessments. These summative assessments can occur at the end of the year or at periodic stages in the instructional process.

Large-scale assessments, such as Foundation Skills Assessment (FSA) and Graduation Program exams, gather information on student performance throughout the province and provide information for the development and revision of curriculum. These assessments are used to make judgments about students' achievement in relation to provincial and national standards. The large-scale provincial assessment for Applications of Physics 11 and 12 is the graduation program examination for Science 10, worth 20% of the final course mark. This exam is a requirement for all students taking Science 10.

Assessment of learning is also used to inform formal reporting of student achievement.

For Ministry of Education reporting policy, refer to www.bced.gov.bc.ca/policy/policies/student_reporting.htm

Assessment *for* Learning	Assessment *as* Learning	Assessment *of* Learning
Formative assessment *ongoing in the classroom* • teacher assessment, student self-assessment, and/or student peer assessment • criterion-referenced—criteria based on Prescribed Learning Outcomes identified in the provincial curriculum, reflecting performance in relation to a specific learning task • involves both teacher and student in a process of continual reflection and review about progress • teachers adjust their plans and engage in corrective teaching in response to formative assessment	Formative assessment *ongoing in the classroom* • self-assessment • provides students with information on their own achievement and prompts them to consider how they can continue to improve their learning • student-determined criteria based on previous learning and personal learning goals • students use assessment information to make adaptations to their learning process and to develop new understandings	Summative assessment *occurs at end of year or at key stages* • teacher assessment • may be either criterion-referenced (based on Prescribed Learning Outcomes) or norm-referenced (comparing student achievement to that of others) • information on student performance can be shared with parents/guardians, school and district staff, and other education professionals (e.g., for the purposes of curriculum development) • used to make judgments about students' performance in relation to provincial standards

For more information about assessment for, as, and of learning, refer to the following resource developed by the Western and Northern Canadian Protocol (WNCP): *Rethinking Assessment with Purpose in Mind.*

This resource is available online at www.wncp.ca

Criterion-Referenced Assessment and Evaluation

In criterion-referenced evaluation, a student's performance is compared to established criteria rather than to the performance of other students. Evaluation in relation to prescribed curriculum requires that criteria be established based on the Prescribed Learning Outcomes.

Criteria are the basis for evaluating student progress. They identify, in specific terms, the critical aspects of a performance or a product that indicate how well the student is meeting the Prescribed Learning Outcomes. For example, weighted criteria, rating scales, or scoring guides (reference sets) are ways that student performance can be evaluated using criteria.

Wherever possible, students should be involved in setting the assessment criteria. This helps students develop an understanding of what high-quality work or performance looks like.

Criterion-referenced assessment and evaluation may involve these steps:

Step 1	Identify the Prescribed Learning Outcomes and suggested achievement indicators (as articulated in this IRP) that will be used as the basis for assessment.
Step 2	Establish criteria. When appropriate, involve students in establishing criteria.
Step 3	Plan learning activities that will help students gain the attitudes, skills, or knowledge outlined in the criteria.
Step 4	Prior to the learning activity, inform students of the criteria against which their work will be evaluated.
Step 5	Provide examples of the desired levels of performance.
Step 6	Conduct the learning activities.
Step 7	Use appropriate assessment instruments (e.g., rating scale, checklist, scoring guide) and methods (e.g., observation, collection, self-assessment) based on the particular assignment and student.
Step 8	Review the assessment data and evaluate each student's level of performance or quality of work in relation to criteria.
Step 9	Where appropriate, provide feedback and/or a letter grade to indicate how well the criteria are met.
Step 10	Communicate the results of the assessment and evaluation to students and parents/guardians.

KEY ELEMENTS

Key elements provide an overview of content in each curriculum organizer and suborganizer. They can be used to determine the expected depth and breadth of the Prescribed Learning Outcomes.

ACHIEVEMENT INDICATORS

To support teachers in assessing provincially prescribed curricula, this IRP includes sets of achievement indicators in relation to each Prescribed Learning Outcome.

Achievement indicators, taken together as a set, define the specific level of attitudes demonstrated, skills applied, or knowledge acquired by the student in relation to a corresponding Prescribed Learning Outcome. They describe what evidence a teacher might look for to determine whether or not the student has fully met the intent of the Prescribed Learning Outcome. Each achievement indicator defines only one aspect of the corresponding Prescribed Learning Outcome. It should be noted that the achievement indicators are designed to be considered as an entire set when determining whether students have fully met the Prescribed Learning Outcome.

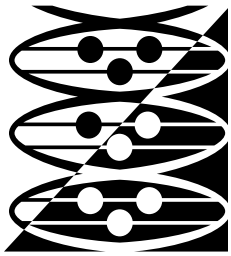
In some cases, achievement indicators may also include suggestions as to the type of task that would provide evidence of having met the Prescribed Learning Outcome (e.g., a constructed response such as a list, comparison, analysis, or chart; a product created and presented such as a report, drama presentation, poster, letter, or model; a particular skill demonstrated such as interpreting graphs).

Achievement indicators support assessment *for* learning, assessment *as* learning, and assessment *of* learning. They provide teachers and parents with tools that can be used to reflect on what students are learning. They also provide students with a means of self-assessment and ways of defining how they can improve their own achievement.

Achievement indicators are not mandatory; they are suggestions only, provided to assist teachers in assessing how well their students achieve the Prescribed Learning Outcomes. Achievement indicators may be useful to provincial examination development teams and inform the development of exam items. However, examination questions, item formats, exemplars, rubrics, or scoring guides will not necessarily be limited to the achievement indicators as outlined in the Integrated Resource Packages.

> Specifications for provincial examinations are available online at www.bced.gov.bc.ca/exams/specs/

The following pages contain the suggested achievement indicators corresponding to each Prescribed Learning Outcome for the Applications of Physics 11 and 12 curriculum. The achievement indicators are arranged by curriculum organizer and suborganizer for each grade; however, this order is not intended to imply a required sequence of instruction and assessment.



STUDENT ACHIEVEMENT

Grade 11

KEY ELEMENTS: MECHANICAL SYSTEMS

Vocabulary

constant acceleration, constant velocity, deformation, efficiency, energy, elastic force, force direction, force on an object, lever arm, magnitude, mechanical advantage, mechanical system, motion, power, rotation, torque, translation, work

Knowledge

- importance of force direction and magnitude
- elastic force
- relationship between force, lever arm, and torque
- motion with constant velocity (uniform motion)
- motion with constant acceleration (non-uniform motion)
- Newton's second law of motion (acceleration occurring as a result of unbalanced force)
- difference between linear and rotational motion
- nature and transfer of energy in a mechanical system
- efficiency of a mechanical system
- concept of power as it relates to mechanical systems
- causes and effects of resistive forces in a mechanical system

Skills and Attitudes

- calculating force, work, displacement, energy, torque, efficiency, power, mechanical advantage
- manipulating formulae
- measuring (using appropriate units), converting units
- designing and calibrating measuring devices
- constructing vector diagrams, scale diagrams
- collecting, organizing, graphing, and interpreting data
- confidence
- appreciating the value of mathematics and physics in trades and technology

GRADE 11: MECHANICAL SYSTEMS (FORCE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
A1 explain the importance of force direction and magnitude	❑ define *force on an object* ❑ identify units appropriate for measuring force ❑ describe the role of force in common situations ❑ identify common forces (e.g., gravity, friction, normal force) ❑ identify the effects of forces on objects (translation, rotation, and/ordeformation) ❑ describe the effects of balanced and unbalanced forces on objects ❑ design, construct, and calibrate devices capable of measuring force ❑ distinguish between scalar and vector quantities ❑ use parallel or right-angle vectors to solve problems
A2 demonstrate understanding of elastic force	❑ apply different forces to elastic objects, measure the extension, plot the data, and interpret the results ❑ calculate the spring constant (constant of elasticity) ❑ solve problems using $F_{SpringonObject} = -kx$
A3 describe the relationship between force, lever arm, and torque	❑ identify units appropriate for measuring torque ❑ describe the effects of balanced and unbalanced torques on a rotational system

GRADE 11: MECHANICAL SYSTEMS (RATE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
A4 analyse motion with constant velocity (uniform motion)	❑ measure the displacement of a moving object at several time intervals and graph the results ❑ calculate velocity in a linear system (e.g., as slope of a position vs. time graph; using the formula $v = \frac{\Delta d}{\Delta t}$, where v=velocity, d=displacement and t=time ❑ express velocity using appropriate units
A5 analyse motion with constant acceleration (non-uniform motion)	❑ distinguish between velocity and acceleration in linear motion ❑ determine the acceleration of an object in linear motion ❑ determine the relationship between net force and acceleration ❑ identify linear displacement, linear velocity, and linear acceleration as vector quantities ❑ use kinematics formulas to solve common problems involving - linear displacement - initial linear velocity - final linear velocity - linear acceleration - time interval
A6 explain acceleration that occurs as a result of unbalanced force (Newton's second law of motion)	❑ determine the relationship between mass, acceleration, and net force ❑ explain inertia as it relates to linear acceleration ❑ solve common problems involving net force, mass, and motion in a linear system, using the formula $F_{net} = ma$
A7 explain the basic difference between linear and rotational motion	❑ create vector drawings to illustrate that an object moving at constant speed in a circular path is accelerating ❑ recognize the relationship between centripetal force and centripetal acceleration (i.e., centripetal acceleration implies the existence of a centripetal force) ❑ use a stroboscope to measure rotational frequency of an object in circular motion (e.g., in RPM or radians per second) ❑ explain the purpose of a flywheel (i.e., inertia)

GRADE 11: MECHANICAL SYSTEMS (ENERGY)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
A8 solve common problems involving work, force, and distance	❑ use $W = (F)(s)\cos\theta$ to calculate work done by a constant force *F*, when given force and displacement *s* ❑ identify workplace applications in which work in mechanical systems occurs ❑ convert from one set of work units to another
A9 analyse the nature and transformation of energy in a mechanical system	❑ identify various forms of energy (e.g., kinetic, gravitational potential, elastic potential, thermal) ❑ describe the relationship between work and mechanical energy ❑ identify practical examples of mechanical kinetic energy in the community ❑ measure input and output force/distancein simple machines ❑ calculate - the potential energy of an object (i.e., gravitational or elastic), using $E_P = mgh$ or $E_P = \frac{1}{2}kx^2$ - the kinetic energy of a moving object, using $E_k = \frac{1}{2}mv^2$ - actual and ideal mechanical advantage in the six simple machines, using appropriate variants of $AMA = \frac{F_{out}}{F_{in}}$ or $IMA = \frac{d_{in}}{d_{out}}$ ❑ explain the law of conservation of energy
A10 analyse the efficiency of a mechanical system	❑ define efficiency ❑ calculate the efficiency of a simple mechanical device, using $eff = \frac{W_{out}}{W_{in}}$ ❑ describe ways in which mechanical energy is lost during the operation of a mechanical system ❑ describe different methods of minimizing or utilizing energy lost from a mechanical system during its operation ❑ compare the advantages and disadvantages of different methods of utilizing energy

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
A11 demonstrate understanding of power as it relates to mechanical systems	❑ identify units used to measure power in mechanical systems ❑ calculate the power in a mechanical system, using $P = \frac{W}{\Delta t} or \frac{\Delta E}{\Delta t}$ ❑ calculate the efficiency of a mechanical system using power input and output values, using $eff = \frac{P_{out}}{P_{in}}$

GRADE 11: MECHANICAL SYSTEMS (RESISTANCE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
A12 analyse causes and effects of resistive forces in a mechanical system	❑ define friction (as resistance), and identify advantages and disadvantages of friction in a mechanical system ❑ demonstrate the relationship between frictional force, normal force, and the coefficient of friction for a body on a surface ❑ calculate the effects of friction on static and moving (sliding, rolling) objects, using $F_{fs} \leq \mu_s F_N$ and $F_{fk} = \mu_k F_N$ ❑ construct a model of a mechanical system and describe the methods used to reduce or increase friction ❑ collect the data and determine the coefficient of friction for objects on a horizontal surface

KEY ELEMENTS: FLUID SYSTEMS

Vocabulary

Archimedes' principle, area, buoyancy, density, efficiency, fluid displacement, force, hydraulics, kinetic energy, mechanical advantage, pneumatics, potential energy, power, pressure, resistive force, volume, work

Knowledge

- characteristics of fluids
- relationship between pressure, force, and area
- hydraulics and pneumatics
- buoyancy and fluid displacement (Archimedes' principle)
- significance of rate with respect to fluid systems
- control and use of the energy stored in fluid systems
- efficiency of a fluid system
- concept of power as it relates to fluid systems
- resistive forces in a fluid system

Skills and Attitudes

- measuring (using appropriate units); converting units
- performing calculations involving pressure, force, density, area, volume, displacement, buoyancy, mechanical advantage, kinetic energy, potential energy, efficiency, power, work
- manipulating formulae
- designing and calibrating devices to measure specific gravity
- constructing model fluid systems
- collecting, organizing, graphing, and interpreting data
- appreciating the value of mathematics and physics in trades and technology

GRADE 11: FLUID SYSTEMS (PRESSURE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
B1 explain characteristics of fluids	❑ define a fluid and explain how it acts ❑ show how liquids are incompressible and gases are compressible ❑ recognize the relationship between density, mass, and volume as expressed in $\rho = \frac{m}{V}$ ❑ distinguish between the mass density and weight density of a substance ❑ design, construct, and calibrate a device capable of measuring specific gravity ❑ determine the specific gravity of a substance, given its density and the density of water
B2 demonstrate understanding of the relationship between pressure, force, and area	❑ identify units used to measure pressure ❑ convert pressure values from one unit to another ❑ explain the relationships between atmospheric pressure, gauge pressure, and absolute pressure ❑ solve common problems involving pressure, force, and area, using $P = \frac{F}{A}$ ❑ explain the cause of pressure exerted by a column of liquid ❑ solve common problems involving pressure, density, and height of liquid, using $P_1 + \rho g h_1 = P_2 + \rho g h_2$ (e.g., calculate the pressure exerted by a column of liquid) ❑ use a manometer to measure pressure in an open fluid system
B3 compare hydraulics and pneumatics	❑ explain Pascal's principle ❑ describe the effects of pressure difference in a fluid system ❑ compare methods and devices used to measure pressure and pressure difference ❑ give examples of applications of fluid pressure (e.g., brake systems, hydraulic lifts, tires)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
B4 explain buoyancy and fluid displacement (Archimedes' principle)	❑ identify the forces acting on an object that is immersed or floating in a fluid ❑ explain the relationship between the volume of fluid displaced and the buoyant force exerted on a partially or completely immersed object ❑ demonstrate Archimedes' principle ❑ perform calculations involving buoyancy and fluid displacement (e.g., calculate the weight of a boat by knowing the volume of water displaced)

GRADE 11: FLUID SYSTEMS (RATE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
B5 explain the significance of rate with respect to fluid systems	❑ distinguish between mass flow rate and volume flow rate ❑ identify various units used to measure fluid flow rates ❑ convert flow rate values in a fluid system from one system of units to another ❑ construct a system in which fluid flow occurs and is controlled ❑ explain how the pressure in a fluid relates to flow rate (Bernoulli's Law) ❑ give examples of the application of Bernoulli's Law (e.g., situations in which fluid flow exists and is controlled by technology)

GRADE 11: FLUID SYSTEMS (ENERGY)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
B6 demonstrate understanding of how the energy stored in fluid systems can be controlled and used	❑ identify circumstances in which fluid systems are used to store energy ❑ identify and describe examples of work done by fluid in a system ❑ calculate the work done when a pressure difference exists in a fluid, using $W = PV$ ❑ calculate the quantity of potential energy stored for a volume

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
	of fluid, using $E_P = mgh = (\rho V)gh$ ❑ calculate the quantity of kinetic energy for a volume of fluid, using $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(\rho V)v^2$ ❑ design and construct a simple fluid system that performs mechanical work
B7 analyse the efficiency of a fluid system	❑ define efficiency ❑ calculate the efficiency of a fluid system, using $eff = \frac{W_{out}}{W_{in}}$ ❑ describe ways in which mechanical energy is lost during the operation of a fluid system ❑ describe different methods of minimizing mechanical energy lost during the operation of a fluid system (e.g., by reducing turbulence)
B8 demonstrate understanding of power as it relates to fluid systems	❑ identify units used to measure power in fluid systems ❑ calculate the power in a fluid system, using $P = \frac{W}{\Delta t} or \frac{\Delta E}{\Delta t}$ ❑ calculate the efficiency of a fluid system using power input and output values, using $eff = \frac{P_{out}}{P_{in}}$

GRADE 11: FLUID SYSTEMS (RESISTANCE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
B9 analyse resistive forces in a fluid system	❑ identify various units used to measure resistance in a fluid system ❑ identify resistance in a fluid system as the ratio of pressure difference to rate of flow ❑ identify the advantages (e.g., slipstreaming, efficiency of combustion, lift) and disadvantages (e.g., slower speeds, catastrophic vibration, loss of suction power) of drag in a fluid system ❑ construct a model of a fluid system and describe factors (e.g., eddy currents, surface characteristics, shape) that affect the drag of an object moving through a fluid ❑ describe methods used to reduce and increase turbulence and resistance in a fluid system (e.g., dimpling on a golf ball, boat hull design)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
	❑ explain resistance in a pipe in terms of length of the pipe, cross-sectional area of the flow, interior surface characteristics of the pipe, volume of fluid, velocity of fluid, and type of fluid ❑ recognize the need for a pressure difference in order to maintain a viscous fluid's flow, due to the fluid's "resistance" ❑ design and construct a system that can be used to gather data on pressure difference and flow rate so that resistance can be calculated ❑ describe the differences between laminar and turbulent flow

KEY ELEMENTS: THERMAL SYSTEMS

Vocabulary

change of state, heat, heat flow, latent heating, latent heat of fusion, power, specific heat capacity, temperature, temperature differences, thermal energy, thermal resistance, thermal system

Knowledge

- significance of temperature and temperature differences in thermal systems
- methods of measuring temperature and temperature difference
- transfer of thermal energy
- change of state in a thermal system
- concept of power as it relates to thermal systems
- relationship between thermal resistance, temperature difference, and rate of heat flow in a thermal system
- relationship between the transfer of thermal energy and the physical attributes of the material through which it is transferred

Skills and Attitudes

- measuring temperature and thermal heat capacity (using appropriate units and methods); converting units
- performing calculations involving transfer of thermal energy, specific heat capacity, change of state, thermal energy transfer, efficiency and power of thermal systems
- manipulating formulae
- calibrating devices to measure temperature and temperature difference
- collecting, organizing, graphing, and interpreting data
- appreciating the value of mathematics and physics in trades and technology

GRADE 11: THERMAL SYSTEMS (TEMPERATURE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
C1 explain the significance of temperature and temperature differences in thermal systems	❑ define and clearly distinguish among *temperature*, *thermal energy*, and *heat* ❑ explain the relationship between molecular motion and temperature ❑ explain the relationship between temperature and volume in solids, liquids, and gases ❑ identify circumstances in which a knowledge of temperature and temperature difference is important
C2 analyse various methods of measuring temperature and temperature difference	❑ convert temperature measurements among Celsius, Fahrenheit, and Kelvin ❑ calibrate a device capable of indicating temperature and temperature difference ❑ compare several methods and devices used to determine temperature and temperature difference

GRADE 11: THERMAL SYSTEMS (ENERGY)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
C3 analyse the transfer of thermal energy	❑ define *conduction, convection*, *radiation* and *specific heat capacity* ❑ identify various units used to measure energy in thermal systems (e.g., calorie, btu, and joule) ❑ convert values from one system of units used in a thermal system to another ❑ relate thermal energy transferred to or from an object to the change in the object's temperature, its mass, and its specific heat capacity ❑ determine the specific heat capacities of several different metals, using experimentally collected data ❑ solve common problems involving the transfer of thermal energy between substances having different specific heat capacities, using $Q = mc\Delta T$

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
C4 analyse change of state in a thermal system	❑ define *latent heating*, *latent heat of fusion* and *vaporization* ❑ solve common problems to determine the quantity of heat involved in changing the state of a substance, when given values for latent heat of fusion and vaporization, and using $Q = ml_f$ and $Q = ml_v$ ❑ explain how the zeroth and first laws of thermodynamics apply to heating and cooling systems (e.g., heat pumps, refrigeration systems, air conditioning systems)
C5 demonstrate understanding of power as it relates to thermal systems	❑ identify units used to measure power in thermal systems ❑ calculate the efficiency and power of a thermal system

GRADE 11: THERMAL SYSTEMS (RATE AND RESISTANCE)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
C6 explain the relationship between thermal resistance, temperature difference, and rate of heat flow in a thermal system	❑ identify factors causing resistance to heat conduction in a thermal system ❑ describe the advantages and disadvantages of resistance in a thermal system ❑ explain the significance of rate in thermal systems ❑ identify methods used to reduce and increase thermal resistance ❑ identify circumstances in which heat flow exists and is controlled by technology ❑ describe R-value as used to indicate the relative insulating value of materials
C7 analyse the relationship between the transfer of thermal energy and the physical attributes of the material through which it is transferred	❑ apply appropriate variants of $\frac{Q}{\Delta t} = \frac{kA\Delta T}{l}$ to calculate the thermal energy transferred through a material, using given values for - temperature, ΔT - time interval, Δt - heat flow rate, $Q/\Delta t$ - thickness, l - area, A - thermal conductivity, k

KEY ELEMENTS: ELECTRICAL SYSTEMS

Vocabulary

AC circuit, charge, circuit breaker, conventional current, current, DC circuit, electron flow, efficiency, grounding, resistance, overload, short circuit, voltage (emf)

Knowledge

- safety principles when working with electricity
- significance of charge, voltage (emf), current, resistance, grounding, short circuit, overload, and circuit breakers
- symbols used in electrical schematics
- appropriate units (amperes, volts, ohms) for expressing electrical quantities
- difference between electron flow and conventional current
- resistance in electrical systems
- DC circuits
- AC circuits
- functioning and efficiency of electrical devices
- comparison of electrical systems, fluid systems, mechanical systems, and thermal systems

Skills and Attitudes

- safely using tools, equipment, and materials related to electrical systems
- using a multimeter (analog and digital)
- measuring (using appropriate units) and converting units
- performing calculations involving current, charge, voltage, voltage drop, resistance, equivalent resistance, power, energy
- manipulating formulae
- connection techniques (e.g., soldering, insulating, crimping, grounding, switching, wire connecting)
- constructing circuits and models
- collecting, organizing, graphing, and interpreting data
- appreciating the value of mathematics and physics in trades and technology

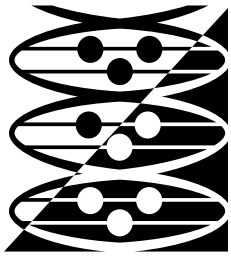
GRADE 11: ELECTRICAL SYSTEMS (FUNDAMENTALS)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
D1 apply basic principles of safety when working with electricity	❑ identify potential hazards when working with electricity ❑ demonstrate the safely using tools, equipment, and materials ❑ describe electrical safety and emergency response procedures ❑ explain the significance of electrical codes
D2 apply basic terms, concepts, and skills related to electrical systems	❑ explain the significance of *charge transferred*, *time interval*, *voltage* (*emf*), *current*, *resistance, grounding, short circuit, overload,* and *circuit breakers* (e.g., fuse, GFCI) ❑ recognize, use, and interpret symbols used in electrical schematics ❑ use appropriate connection techniques, such as soldering, insulating, crimping, grounding, switching, and wire connecting ❑ correctly use a multimeter (analog and digital), identifying appropriate units (amperes, volts, ohms) ❑ distinguish between electron flow and conventional current ❑ solve common problems involving the relationship between current, charge transferred, and time interval, using $I = \frac{\Delta q}{\Delta t}$
D3 determine resistance in electrical systems	❑ define resistance and equivalent resistance, and explain their significance ❑ determine the value of resistors used in electrical circuits by referring to colour-code charts ❑ determine the resistance of an ohmic resistor using voltage and current data (Ohm's law) ❑ describe the characteristics of conductors and insulators ❑ calculate and compare the equivalent resistance when at least three resistors are placed in series combinations (using $R_{Tseries} = R_1 + R_2 + \ldots$) and parallel combinations (using $\frac{1}{R_{Tparallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$) ❑ identify factors affecting the resistance of a conductor ❑ calculate the resistance of conductors using resistivity, length, and cross-sectional area, using $R = \rho \frac{l}{A}$

GRADE 11: ELECTRICAL SYSTEMS (CIRCUITS)

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
D4 analyse DC circuits	❑ define *series circuit, parallel circuit,* and *combination circuit* ❑ identify the basic components of a circuit, including loads, conductors, switches, and sources ❑ construct simple DC circuits from a schematic drawing (e.g., circuits with two or more resistors in series and in parallel) ❑ measure and compare current and voltage drops for various applied voltages in a simple DC circuit ❑ use the following laws to calculate voltage, current, resistance, and power in series, parallel, and combination resistive circuits: - Ohm's Law, $V = IR$ - $P = VI$, power dissipated in a circuit element (resistor), as derived from Joule's Law - Kirchhoff's Laws, $\Sigma I_{in} = \Sigma I_{out}$ and $\Sigma V_{increase} = \Sigma V_{drop}$
D5 analyse AC circuits	❑ explain the similarities and differences between DC and AC circuits ❑ solve common problems involving voltage, energy, charge transferred, current, and time interval ❑ determine the energy usage of various devices and express values in kWh ❑ use the following laws to calculate voltage, current, resistance, and power in AC circuits: - Ohm's Law, $V = IR$ - $P = VI$, power dissipated in a circuit element (resistor), as derived from Joule's Law - Kirchhoff's Laws, $\Sigma I_{in} = \Sigma I_{out}$ and $\Sigma V_{increase} = \Sigma V_{drop}$ ❑ describe the function of *capacitors*, *resistors*, *diodes*, *variable resistors*, *switching devices*, and *transformers* ❑ construct a simple household circuit model, including - two- and three-way switches - loads - circuit-breaker

PRESCRIBED LEARNING OUTCOMES		SUGGESTED ACHIEVEMENT INDICATORS
D6	analyse electric devices with respect to function and efficiency	❑ explain the function of various electric devices, including - generators - alternators - electric motors - transformers - inverters ❑ explain the efficiency of an electrical system using power input and output values ❑ explain why AC transmission systems are used rather than DC systems
D7	compare electrical systems with fluid systems, mechanical systems, and thermal systems	❑ identify and describe similarities among electrical systems, fluid systems, mechanical systems, and thermal systems, with respect to - force-like quantities (e.g., torque, pressure difference, temperature difference, voltage difference) - rate (e.g., acceleration, rpm, volume or mass flow rate, thermal energy transfer, current) - resistance (e.g., friction, drag, insulation, electrical resistance) - energy (as measured by Joules, calories, BTUs, watts, kWh, hp)



STUDENT ACHIEVEMENT

Grade 12

GRADE 12

KEY ELEMENTS: TRANSFORMERS

Vocabulary

current, displacement, fluid system, force, mechanical system, transformer, voltage

Knowledge

- displacement and changes of force within a mechanical system
- ideal and actual mechanical advantage
- displacement and changes of force within a fluid system
- changes of voltage and current within an electrical system (how electrical transformers work)
- transfer of energy from one form to another

Skills and Attitudes

- measuring (using appropriate units), converting units
- performing calculations involving mechanical advantage, input and output current, efficiency
- designing and constructing energy conversion systems, mechanical and fluid systems, devices to measure force and distance
- collecting, organizing, graphing, and interpreting data
- appreciating the value of mathematics and physics in trades and technology

GRADE 12 TRANSFORMERS

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
A1 demonstrate the conversion of force and distance within a mechanical system	❑ describe how force can be amplified at the expense of displacement (or vice-versa) within a mechanical system ❑ describe the three classes of levers and explain the advantage of each ❑ determine the mechanical advantage and efficiency of: - a wheel and axle - a pulley system - an inclined plane - a belt-and/or gear-driven system ❑ distinguish between ideal and actual mechanical advantage ❑ distinguish between efficiency and mechanical advantage ❑ design and construct a device that alters force and distance, and explain where it could be applied within a mechanical system
A2 demonstrate the changes of force and linear displacement within a fluid system	❑ describe how force can be amplified within a fluid system ❑ calculate the mechanical advantage of a hydraulic jack ❑ construct a device that uses mechanical advantage in a fluid system
A3 demonstrate changes of voltage and current within an electrical system	❑ describe the operation of an electrical transformer ❑ relate voltage in and voltage out to the number of windings in an electrical transformer ❑ describe the advantages and disadvantages of a laminated core in a transformer ❑ describe the operation of an induction coil ❑ determine input (primary) or output (secondary) voltage of a transformer, given the turn ratio ❑ determine input or output current for an ideal transformer, given the turn ratio ❑ describe situations that require step-up or step-down voltages
A4 evaluate transfers of energy from one form to another	❑ identify and describe energy transfer in given applications (e.g., a vacuum cleaner involves change of electrical energy to kinetic rotational to fluid/pneumatic) ❑ construct a system that performs three consecutive energy transfers ❑ determine the efficiency of an energy transfer system

KEY ELEMENTS: MOMENTUM

Vocabulary

angular momentum, conservation of energy, conservation of momentum, drive shaft, fluid momentum, impulse, inertia, flywheel, law of conservation of momentum, linear momentum, rotor

Knowledge

- relationship between impulse and linear momentum
- conservation of momentum in collisions in two dimensions
- conservation of energy in collisions in two dimensions
- factors affecting angular momentum
- law of conservation of momentum as it relates to angular momentum
- law of conservation of momentum as it relates to fluid momentum

Skills and Attitudes

- performing calculations involving linear momentum, change in momentum, angular momentum
- manipulating formulae
- vector addition
- constructing devices that use angular momentum
- collecting, organizing, graphing, and interpreting data
- appreciating the value of mathematics and physics in trades and technology

GRADE 12 MOMENTUM

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
B1 analyse the relationship between impulse and linear momentum	❑ define *impulse, momentum,* and *inertia* ❑ describe impulse and factors affecting it ❑ calculate linear momentum using $\vec{p} = m\vec{v}$ ❑ describe the relationship between impulse and change in momentum ❑ calculate changes in momentum using $\vec{F}\Delta t = \Delta\vec{p}$
B2 analyse collisions in two dimensions using the concepts of - conservation of momentum - conservation of energy	❑ explain the law of conservation of momentum ❑ describe how the concept of conservation of momentum applies to linear and oblique collisions ❑ distinguish between elastic collision and inelastic collision ❑ analyse collisions in one and two dimensions to determine whether they are elastic or inelastic (e.g., using vector addition)
B3 analyse angular momentum and factors affecting it	❑ relate angular momentum to angular impulse ❑ describe the vector nature of angular momentum ❑ given axis of rotation and the appropriate formula, calculate angular momentum for the following common shapes: – flywheel, $I = \frac{1}{2}mr^2$ – drive shaft (hollow thin wall), $I = mr^2$ – rotor, $I = \frac{1}{12}ml^2$ – ball, $I = \frac{2}{5}mr^2$ – (non-rotating) object in orbit, $I = mr^2$ ❑ construct a device that uses angular momentum in its operation
B4 explain the law of conservation of momentum as it relates to - angular momentum - fluid momentum	❑ describe systems that involve conversions between linear and angular momentum ❑ describe systems involving the momentum of a fluid (e.g., torque converter, water hammer, tornado) ❑ describe two-dimensional situations in which conservation of angular momentum is involved

KEY ELEMENTS: TRANSDUCERS

Vocabulary

anemometer, barometer, Bourdon tube, bimetallic strip, electrical transducer, fluid transducer, mechanical transducer, moving coil meter, multimeter, pitot tube, platinum resistance thermometer, thermal expansion valve, thermal transducer, thermistor, thermocouple

Knowledge

- application and functioning of mechanical transducers
- application and functioning of fluid transducers
- application of thermal transducers and how they work
- application and functioning of electrical transducers

Skills and Attitudes

- measuring various quantities (e.g., applied force, pressure, speed, fluid levels) using appropriate units; converting units
- calibrating and using mechanical transducers, multimeters, sphygmomanometers
- selecting appropriate transducer for the purpose
- interpreting transducer output
- appreciating the value of mathematics and physics in trades and technology

GRADE 12 TRANSDUCERS

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
C1 evaluate the application and functioning of mechanical transducers	❑ describe the purpose of a transducer ❑ identify and describe common situations in which mechanical transducers are used ❑ explain how various mechanical transducers work (e.g., piezoelectric accelerometer, strain gauge, Hall-effect force probe) ❑ calibrate and use a mechanical transducer to measure applied force (e.g., a digital bathroom scale)
C2 evaluate the application and functioning of fluid transducers	❑ identify and describe common situations in which fluid transducers are used ❑ describe how barometers, including Bourdon tubes, indicate pressure ❑ describe how a pitot tube indicates speed ❑ describe how an anemometer measures wind speed ❑ demonstrate how a float can be used to measure fluid level ❑ demonstrate the measurement of blood pressure using a sphygmomanometer (blood pressure cuff) ❑ use given calibration values to solve common problems involving fluid transducers
C3 explain the application of thermal transducers and how they work	❑ identify and describe common situations in which thermal transducers are used ❑ describe the operation of a liquid-in-glass thermometer ❑ explain how thermistors, thermocouples, thermal expansion valves, bimetallic strips, and platinum resistance thermometers indicate temperature
C4 evaluate the application and functioning of electrical transducers	❑ identify and describe common situations in which electrical transducers are used ❑ explain how a moving coil meter works ❑ explain how a moving coil meter can be used as a multimeter ❑ calibrate a multimeter

KEY ELEMENTS: WAVES AND VIBRATIONS

Vocabulary

AM wave, amplitude, Doppler effect, diffraction, electromagnetic, FM wave, frequency, interference (superposition principle), natural frequency, oscilloscope, phase, period, reflection, refraction, resonance, Snell's law, wave, wavelength, universal wave equation, vibration

Knowledge

- properties of waves
- universal wave equation
- Snell's Law
- wave interactions and their applications (sonic ranging, lasers, fibre optics, AM & FM transmission)
- effects of vibrations in various systems

Skills and Attitudes

- measuring (using appropriate units), converting units
- classifying wave types
- using an oscilloscope
- performing calculations involving wave speed, velocity, angle of refraction
- manipulating formulae
- designing and conducting an experiment to measure the speed of a wave
- collecting, organizing, graphing, and interpreting data
- appreciating the value of mathematics and physics in trades and technology

GRADE 12 WAVES AND VIBRATIONS

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
D1 analyse waves with reference to their properties and using the universal wave equation	❑ describe the two basic types of wave motion: transverse and longitudinal ❑ describe the properties associated with waves, including - amplitude - frequency - wavelength - period - phase - speed - types of waves ❑ use the universal wave equation, $v = f\lambda$, to determine wave speed, given frequency, period, and wavelength ❑ use an oscilloscope to measure the period of a wave ❑ describe the characteristics of electromagnetic waves and sound waves ❑ classify electromagnetic waves and sound waves according to frequency

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
D2 analyse wave interactions and their applications	❑ describe and give examples of the following wave phenomena and the conditions that produce them: - reflection - refraction - diffraction - interference (superposition principle) - Doppler effect ❑ determine the refractive index of several materials (e.g., using prisms, using Snell's law) ❑ use Snell's law to determine the angle of refraction at an interface $\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$ ❑ explain how sonic ranging can be used to determine position and relative speed of an object ❑ describe the relationship between the speed of electromagnetic waves and the transmission medium ❑ explain how light is transmitted through optic fibres ❑ describe the characteristics and uses of laser light ❑ explain how a gas laser works ❑ design and perform an experiment to measure the speed of a wave ❑ explain the purpose of modulating a wave ❑ distinguish between AM and FM waves
D3 explain the effects of vibrations in various systems	❑ determine the period and frequency of a vibrating object (e.g., using a stopwatch to time a pendulum; using an oscilloscope and microphone to measure the frequency of a tuning fork) ❑ identify and describe several effects of vibrations ❑ relate natural frequency of an object to resonance ❑ determine the resonant frequency or frequencies of a system by experimental measurements ❑ identify methods of reducing vibrational motion in a system (e.g., the use of bracing or structural members to move the natural resonances of structures such as bridges away from low-frequency environmental vibrations such as those caused by pedestrian and auto traffic)

KEY ELEMENTS: ELECTRICITY AND MAGNETISM

Vocabulary

AC current, alternator, capacitor, DC current, electrical circuit, electromagnetic induction, generator, Kirchhoff's laws, load, magnetism, motor, power supply, resistance, servo motor, stepper motor, voltage

Knowledge

- safety principles when working with electricity; electrical codes
- principles and applications of electromagnetic induction (back emf, Lenz's Law, right-hand rule)
- principles involved in electrical circuits (Kirchhoff's laws)
- operation and applications of motors, alternators, and generators
- role and operation of capacitors

Skills and Attitudes

- safely using tools, equipment, and materials related to electricity
- measuring (using appropriate units), converting units
- performing calculations involving current, charge, voltage
- determining magnetic field lines
- manipulating formulae
- calibrating and using devices to measure electrical quantities
- interpreting electrical schematic (circuit) diagrams
- designing and constructing circuits
- constructing or creating diagrams of power supplies and DC motors
- collecting, organizing, graphing, and interpreting data
- appreciating the value of mathematics and physics in trades and technology

GRADE 12 ELECTRICITY AND MAGNETISM

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding Prescribed Learning Outcome.* *Students who have fully met the Prescribed Learning Outcome are able to:*
E1 apply basic principles of safety when working with electricity	❑ identify potential hazards when working with electricity ❑ demonstrate the safely using tools, equipment, and materials ❑ describe electrical safety and emergency response procedures ❑ explain the significance of electrical codes
E2 demonstrate principles of electromagnetic induction	❑ explain the relationship between magnetism and electric current ❑ create a diagram of or construct a power supply (transformer + rectifier + capacitor) ❑ describe applications of electromagnetic induction (e.g., alternators, generators, motors, magneto ignition systems) ❑ explain the significance of back emf, with reference to Lenz's law ❑ use the right-hand rule to determine magnetic induction field lines around a conductor ❑ use the right-hand rule to determine the magnetic induction field in a solenoid
E3 demonstrate the principles involved in electrical circuits	❑ define *voltage (electric potential)*, *current*, *resistance*, *power, AC current,* and *DC current* ❑ measure current and voltage in multi-resistor DC circuits using a multimeter ❑ use an oscilloscope to - determine period, frequency, and voltage of an AC source - observe the effect of a diode in an AC current ❑ construct single and multi-load circuits from schematic diagrams ❑ explain the function of a potentiometer in a circuit ❑ use Kirchhoff's laws to determine voltage and current in multi-resistor DC circuits ❑ explain the operation of a ground fault interrupter ❑ design a simple household circuit to code, including - various 120 and 240 V loads - two-way and three-way switches - receptacles - grounding - circuit-breakers

PRESCRIBED LEARNING OUTCOMES	SUGGESTED ACHIEVEMENT INDICATORS
E4 analyse the operation and applications of motors, alternators, and generators	❑ describe the operation and application of - DC motors - AC motors - stepper motors - servo motors - generators - alternators ❑ compare the operation of an electric motor and a generator ❑ construct a DC motor
E5 explain the role and operation of capacitors	❑ define *capacitance* ❑ explain how capacitors work ❑ identify several common applications of capacitors in circuitry (e.g., point ignition system [condenser], camera flash, strobe light, CRT television, cap-start motor) ❑ describe the function of capacitors in timing circuits