APPRENTICESHIP TRAINING

ENTRANCE LEVEL COMPETENCIES FOR ALBERTA APPRENTICESHIP PROGRAMS

Government of Alberta

ENTRANCE LEVEL COMPETENCIES FOR ALBERTA APPRENTICESHIP PROGRAMS

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ENTRANCE EXAMINATIONS ARRAY

ENTRANCE 1 77/01/12/10

Barber
Construction Craft Labourer
Hairstylist

ENTRANCE 2 77/02/12/10

Baker
Boilermaker
Bricklayer
Cabinetmaker
Carpenter
Concrete Finisher
Cook
Crane and Hoisting Equipment Operator
Floorcovering Installer
Glazier
Insulator
Ironworker
Lather - Interior Systems Mechanic
Locksmith
Painter and Decorator
Parts Technician
Roofer
Sheet Metal Worker
Structural Steel and Plate Fitter
Welder

ENTRANCE 3 77/03/12/10

Agricultural Equipment Technician
Auto Body Technician
Automotive Service Technician
Heavy Equipment Technician
Landscape Gardener
Motorcycle Mechanic
Outdoor Power Equipment Technician
Recreation Vehicle Service Technician
Transport Refrigeration Technician
Water Well Driller

ENTRANCE 4 77/04/12/10

Elevator Constructor
Gas Utility Operator
Gasfitter
Machinist
Millwright
Plumber
Sprinkler Systems Installer
Steamfitter – Pipefitter

ENTRANCE 5 77/05/12/10

Appliance Service Technician
Communication Technician
Electrical Motor Systems Technician
Electrician
Instrument Technician
Powerline Technician
Power System Electrician
Refrigeration and Air Conditioning Mechanic

NOTE: A pass mark earned on Entrance Exam 5 = deemed to have also passed Entrance Exams 4, 3, 2 and 1.

A pass mark earned on Entrance Exam 4 = deemed to have also passed Entrance Exams 3, 2 and 1.

A pass mark earned on Entrance Exam 3 = deemed to have also passed Entrance Exam 1 (due to the significant differential in math/science content, a pass mark on Entrance Exam 3 does NOT allow a pass mark on Entrance Exam 2).

A pass mark earned on Entrance Exam 2 = deemed to have also passed Entrance Exam 1.

Alberta entrance exams are also used for entrance into apprenticeship programs in the Yukon, Northwest and Nunavut territories. Applicants to an Alberta apprenticeship program who have successfully completed an Alberta entrance exam in any of these jurisdictions have met the minimum entrance requirements of the relevant trade in Alberta.

ENTRANCE LEVEL COMPETENCIES IN MATHEMATICS
(Numbers in parentheses indicate which Entrance Examination(s) test for this competency)

SECTION ONE: .....NUMBER CONCEPTS AND OPERATIONS

A. Decimals And Integers Including Whole Numbers

Outcome: Demonstrate a number sense for decimals and integers, including whole numbers. (1,2,3,4,5)

1. Define and use power, base and exponent to represent repeated multiplication.
2. Write a whole number as an expanded numeral; using powers of 10, scientific notation, and vice versa.
3. Use divisibility rules to determine if a number is divisible by 2, 3, 4, 5, 6, 9, and 10.
4. Read and write numbers to any number of decimal places.
5. Demonstrate and describe equivalent mixed numbers and improper fractions concretely, pictorially and symbolically.
6. Compare and/or order improper fractions, mixed numbers and decimals to thousandths.
7. Recognize and illustrate that all fractions and mixed numbers can be represented in decimal form.
8. Convert from terminating decimals to fractions.
9. Convert from single-digit repeater decimal numbers to fractions, using patterns.
10. Demonstrate, concretely and pictorially, that the sum of opposite integers is zero.
11. Represent integers in a variety of concrete, pictorial and symbolic ways.
12. Compare and order integers.

B. Rational Numbers, Common Fractions, Integers And Whole Numbers

Outcome: Demonstrate a number sense for rational numbers, including common fractions, integers and whole numbers. (1,2,3,4,5)

1. Demonstrate and explain the meaning of a negative exponent, using patterns (limit to base 10).
2. Represent any number in scientific notation.
3. Define, compare and order any rational numbers.
4. Demonstrate concretely, pictorially and symbolically that the product of reciprocals is equal to 1.
5. Express 3-term ratios in equivalent forms.
6. Represent and apply fractional percent, and percent greater than 100, in fraction or decimal form, and vice versa.
7. Represent square roots concretely, pictorially and symbolically.
8. Distinguish between a square root and its decimal approximation as it appears on a calculator.

C. Structure And Interrelationship Of Rational Numbers

Outcome: ***Explain and illustrate the structure and the interrelationship of the sets of numbers within the rational number system. (1,2,3,4,5)***

1. Give examples of numbers that satisfy the conditions of natural, whole, integral and rational numbers, and show that these numbers comprise the rational number system.
2. Describe, orally and in writing, whether or not a number is rational.
3. Give examples of situations where answers would involve the positive (principal) square root, or both positive and negative square roots of a number.

D. Exponents And Rational Bases

Outcome: ***Develop a number sense of powers with integral exponents and rational bases. (1,2,3,4,5)***

1. Illustrate power, base, coefficient and exponent, using rational numbers or variables as bases or coefficients
2. Explain and apply the exponent laws for powers with integral exponents.
3. Determine the value of powers with integral exponents, using the exponent laws.

SECTION TWO .....NUMBER OPERATIONS

A. Arithmetic Operations Using Decimals And Integers

Outcome: ***Apply arithmetic operations on decimals and integers, and illustrate their use in solving problems. (1,2,3,4,5)***

1. Use patterns, manipulatives and diagrams to demonstrate the concepts of multiplication and division by a decimal.
2. Use estimation strategies to justify or assess the reasonableness of calculations.
3. Add, subtract, multiply and divide decimals (for more than 2-digit divisors or multipliers; the use of technology is expected).
4. Add, subtract, multiply and divide integers concretely, pictorially and symbolically.
5. Illustrate and explain the order of operations, using paper and pencil or a calculator.

B. Problem Solving Using Rates, Ratios, Percentages And Decimals

Outcome: ***Illustrate the use of rates, ratios, percentages and decimals in solving problems. (1,2,3,4,5)***

1. Estimate and calculate percentages.
2. Distinguish between rate and ratio, and use them to solve problems.
3. Explain, demonstrate and use proportion in solving problems.
4. Solve problems by mentally converting, among fractions, decimals and percent.

C. Problem Solving Using Whole Numbers And Decimals

Outcome: ***Apply arithmetic operations on whole numbers and decimals in solving problems. (1,2,3,4,5)***

1. Add, subtract, multiply and divide fractions concretely, pictorially and symbolically.
2. Estimate, compute and verify the sum, difference, product and quotient of rational numbers, using only decimal representations of negative rational numbers.
3. Estimate, compute (using a calculator) and verify approximate square roots of whole numbers and of decimals.

D. Problem Solving In Meaningful Context

Outcome: ***Apply the concepts of rate, ratio, percentage and proportion to solve problems in meaningful contexts. (1,2,3,4,5)***

1. Use concepts of rate, ratio, proportion and percent to solve problems in meaningful contexts.
2. Calculate combined percentages in a variety of meaningful contexts.
3. Derive and apply unit rates.
4. Express rates and ratios in equivalent forms.

E. Using A Calculator

Outcome: ***Use a scientific calculator or a computer to solve problems involving rational numbers. (1,2,3,4,5)***

1. Document and explain the calculator keying sequences used to perform calculations involving rational numbers.
2. Solve problems, using rational numbers in meaningful contexts.

F. Using Exponents

Outcome: ***Explain how exponents can be used to bring meaning to large and small numbers, and use calculators or computers to perform calculations involving these numbers. (1,2,3,4,5)***

1. Understand and use the exponent laws to simplify expressions with variable bases, and evaluate expressions with numerical bases.
2. Use a calculator to perform calculations involving scientific notation and exponent laws.

G. Analysing Data

Outcome: ***Analyze the numerical data in a table for trends, patterns and interrelationships. (5)***

1. Use words and algebraic expressions to describe data and interrelationships in a table with rows that are not related recursively (not calculated from previous data).
2. Use words and algebraic expressions to describe data and interrelationships in a table with rows that are related recursively (calculated from previous data).

SECTION THREE: ..... PATTERNS AND RELATIONS

A. Patterns

Outcome: ***Express patterns, including those used in business and industry, in terms of variables, and use expressions containing variables to make predictions. (1,2,3,4,5)***

1. Predict and justify possible nth values of a number pattern.
2. Interpolate and extrapolate number values from a given graph.
3. Graph relations, analyze the result and draw a conclusion from a pattern.

4. Use patterns and relations to represent simple oral and written expressions as mathematical symbols, and vice versa.

B. Problem Solving Using Patterns

Outcome: ***Use patterns, variables and expressions, together with their graphs, to solve problems. (1,2,3,4,5)***

1. Generalize a pattern arising from a problem-solving context, using mathematical expressions and equations, and verify by substitution.
2. Substitute numbers for variables in expressions, and graph and analyze the relation.
3. Translate between an oral or written expression and an equivalent algebraic expression.

C. Design And Justify Mathematical Procedures

Outcome: ***Generalize, design and justify mathematical procedures, using appropriate patterns, models and technology. (1,2,3,4,5)***

1. Use logic and divergent thinking to present mathematical arguments in solving problems.
2. Model situations that can be represented by first-degree expressions.
3. Write equivalent forms of algebraic expressions, or equations, with rational coefficients.

D. Cyclic Patterns

Outcome: ***Generate and analyze cyclic patterns. (5)***

1. Produce a periodic graph from cyclic data.
2. Predict results from graphs that represent periodic events.
3. Describe periodic events using sinusoidal curves using correct terminology.
4. Collect sinusoidal data; sketch the graph of the data; and, using degrees, represent the data with an equation of the form $y = a \sin(kt) + c$ or $y = a \cos(kt) + c$.
5. Develop sinusoidal equations using degrees to represent periodic behaviour.

SECTION FOUR..... VARIABLES AND EQUATIONS

A. Problem Solving Using Variables And Equations

Outcome: ***Use variables and equations to express, summarize and apply relationships as problem-solving tools in a restricted range of contexts. (1,2,3,4,5)***

1. Write mathematical expressions that arise from problem-solving contexts.
2. Evaluate expressions with and without concrete models.
3. Illustrate the solution process for a one-step, single-variable, first-degree equation, using concrete materials or diagrams.
4. Solve and verify one-step linear equations, using a variety of techniques.
5. Explain how to solve simple problems, using informal algebraic methods.

B. One And Two Step Linear Equations

Outcome: ***Solve and verify one-step and two-step linear equations with rational number solutions. (1,2,3,4,5)***

1. Illustrate the solution process for a two-step, single-variable, first-degree equation, using concrete materials or diagrams.
2. Solve and verify one- and two-step, first-degree equations with integer coefficients.
3. Create and solve problems, using first-degree equations.

C. Linear Equations And Inequalities In One Variable

Outcome: ***Solve and verify linear equations and inequalities in one variable. (1,2,3,4,5)***

1. Illustrate the solution process for a first-degree, single-variable equation, using concrete materials or diagrams.
2. Solve and verify first-degree, single-variable equations with rational coefficients (with a focus on integers), and use equations of this type to model and solve problem situations.
3. Solve, algebraically, first-degree inequalities in one variable, display the solutions on a number line and test the solutions.

D. Generalize Arithmetic Operations From Rational Numbers To Polynomials

Outcome: ***Generalize arithmetic operations from the set of rational numbers to the set of polynomials. (1,2,3,4,5)***

1. Identify constant terms, coefficients and variables in polynomial expressions.
2. Evaluate polynomial expressions, given the value(s) of the variable(s).
3. Represent and justify the addition and subtraction of polynomial expressions, using concrete materials and diagrams.
4. Perform the operations of addition and subtraction on polynomial expressions.
5. Represent multiplication, division and factoring of monomials, binomials, and trinomials using concrete materials and diagrams.
6. Find the product of two monomials, a monomial and a polynomial, and two binomials.
7. Determine equivalent forms of algebraic expressions by identifying common factors and factoring trinomials.
8. Find the quotient when a polynomial is divided by a monomial.

E. Exponential, Logarithmic And Trigonometric Equations And Identities

Outcome: Solve exponential, logarithmic and trigonometric equations and identities. (5)

1. Solve exponential equations having bases that are powers of one another.
2. Solve and verify exponential and logarithmic equations and identities.
3. Distinguish between degree and radian measure and solve problems using both.
4. Determine the exact and approximate values of trigonometric ratios for any multiples of 0, 30, 45, 60, and 90 degrees.
5. Solve first and second degree trigonometric equations over a domain of length 2pi algebraically and graphically.
6. Determine the general solution to trigonometric equations where the domain is the set of real numbers.
7. Verify trigonometric identities: numerically for any particular case; algebraically for general cases; and graphically.
8. Use sum difference and double angle identities for sine and cosine to verify and simplify trigonometric expressions.

SECTION FIVE ..... RELATIONS AND FUNCTIONS

A. Exponential And Logarithmic Functions Using Appropriate Technology

Outcome: Represent and analyze exponential and logarithmic functions, using technology as appropriate. (5)

1. Graph and analyze an exponential function using technology.
2. Model, graph and apply exponential functions to solve problems.
3. Change functions from exponential form to logarithmic form and vice versa.
4. Use logarithms to model practical problems.
5. Explain the relationship between the laws of logarithms and the laws of exponents.
6. Graph and analyze logarithmic functions with and without technology.

B. Trigonometric Functions Using Appropriate Technology

Outcome: Represent and analyze trigonometric functions, using technology as appropriate. (5)

1. Describe the three primary trigonometric functions as circular functions with reference to the unit circle and an angle in standard position.
2. Draw using technology, sketch and analyze graphs of sine, cosine and tangent functions for amplitude, period, domain and range, asymptotes, behaviour under transformations.
3. Draw using technology, sketch and analyze graphs of secant, cosecant and cotangent functions for amplitude, period, domain and range, asymptotes, behaviour under transformations.
4. Use trigonometric functions to model and solve problems.

SECTION SIX .. .. MEASUREMENT OF SHAPE AND SPACE

A. Properties Of Circles, Angles And Time Zones

Outcome: ***Solve problems involving the properties of circles and their connections with angles and time zones. (1,2,3,4,5)***

1. Measure the diameters, radii and circumferences of circles, and establish the relationships among them.
2. Solve problems involving the radii, diameters and circumferences of circles.
3. Explain how time zones are determined.
4. Research and report how measurement instruments are used in the community.

B. Metric And Imperial Measure

Outcome: Solve problems involving Metric and Imperial measure. (1,2,3,4,5)

1. Identify commonly used metric units of measurement.
2. Convert between units of measurement.
3. Convert imperial units:
   a. feet to inches and vice versa.
   b. square inches to square feet and vice versa.
   c. cubic inches to cubic feet and vice versa.
   d. cubic measures to gallons.

C. Indirect Measurement Procedures

Outcome: Apply indirect measurement procedures to solve problems. (1,2,3,4,5)

1. Use concrete materials and diagrams to develop the Pythagorean relationship.
2. Use the Pythagorean relationship to calculate the measure of the third side, of a right triangle, given the other two sides in 2-D applications.

D. Area, Perimeter, Surface Area And Volume

Outcome: ***Generalize measurement patterns and procedures, and solve problems involving area, perimeter, surface area and volume. (1,2,3,4,5)***

1. Describe patterns, and generalize the relationships by determining the areas and perimeters of quadrilaterals and the areas and circumferences of circles.
2. Estimate, measure and calculate the surface area and volume of any right prism or cylinder.
3. Estimate and calculate the area of composite figures.
4. Estimate, measure and calculate the surface area of composite 3-D objects.
5. Estimate, measure and calculate the volume of composite 3-D objects.

E. Trigonometric Ratios

Outcome: Use trigonometric ratios to solve problems involving a right triangle. (1,2,3,4,5)

1. Explain the meaning of sine, cosine and tangent ratios in right triangles.

2. Demonstrate the use of trigonometric ratios (sine, cosine and tangent) in solving right triangles.
3. Calculate an unknown side or an unknown angle in a right triangle, using appropriate technology.
4. Model and then solve given problem situations involving only one right triangle.

F. Problem Solving Involving Dimension Changes In Two And Three Dimensional Objects

Outcome: Describe the effects of dimension changes in related 2-D shapes and 3-D objects in solving problems involving area, perimeter, surface area and volume. (1,2,3,4,5)

1. Relate expressions for volumes of pyramids to volumes of prisms, and volumes of cones to volumes of cylinders.
2. Calculate and apply the rate of volume to surface area to solve design problems in three dimensions.
3. Calculate and apply the rate of area to perimeter to solve design problems in two dimensions.

SECTION SEVEN..... 3-D OBJECTS AND 2-D SHAPES

A. Angle Measures And Properties Of Parallel Lines

Outcome: Link angle measures to the properties of parallel lines. (1,2,3,4,5)

1. Measure and classify pairs of angles as complementary or supplementary angles.
2. Investigate, identify and name pairs of angles pertaining to parallel lines and transversals, including: corresponding, vertically opposite, interior on the same side of the transversal, and exterior on the same side of the transversal.)
3. Describe the relationships between the pairs of angles pertaining to parallel lines and transversals.
4. Explain, in more than one way, why the sum of the measures of the angles of a triangle is $180°$.
5. Use mathematical reasoning to determine the measures of angles in a diagram.
6. Construct angle bisectors and perpendicular Bisectors.

B. Angle Measures., Properties Of Parallel Lines And Properties Of Quadrilaterals

Outcome: Link angle measures and the properties of parallel lines to the classification and properties of quadrilaterals. (1,2,3,4,5)

1. Identify, investigate and classify quadrilaterals, regular polygons and circles, according to their properties.
2. Build 3-D objects from a variety of representations (nets, skeletons).

C. Similar And Congruent Triangles

Outcome: Specify conditions under which triangles may be similar or congruent, and use these conditions to solve problems. (1,2,3,4,5)

1. Recognize when, and explain why, two triangles are similar, and use the properties of similar triangles to solve problems.
2. Recognize when, and explain why, two triangles are congruent, and use the properties of congruent triangles to solve problems.
3. Relate congruence to similarity in the context of triangles.

D. Describe And Analyze Geometric Shapes

Outcome: ***Use spatial problem solving in building, describing and analyzing geometric shapes. (1,2,3,4,5)***

1. Draw the plan and elevations of a 3-D object from sketches and models.
2. Sketch or build a 3-D object, given its plan and elevation views.
3. Recognize and draw the locus of points in solving practical problems.

E. Problem Solving Using Polygons And Vectors

Outcome: ***Solve problems involving polygons and vectors, including both 3-D and 2-D applications. (5)***

1. Use and give 2D and 3D examples of vector terminology and notation including: vector direction & magnitude, scalar, unit vector, collinear vectors, opposite vectors, parallel vectors, resultant vectors.
2. Assign meaning to the multiplication of a vector by a scalar.
3. Perform vector addition and subtraction using triangle or parallelogram methods.
4. Determine the magnitude and direction of a resultant vector, using triangle, parallelogram or component methods.
5. Use vector diagrams and trigonometry to analyze and solve practical problems in 2D and 3D.

SECTION EIGHT .....TRANSFORMATIONS

A. Create And Analyse Patterns And Designs

Outcome: ***Create and analyze patterns and designs, using congruence, symmetry, translation, rotation and reflection. (1,2,3,4,5)***

1. Create, analyze and describe designs, using translations (slides), rotations (turns) and reflections (flips).
2. Use informal concepts of congruence to describe images after translations, rotations and reflections.
3. Draw designs, using ordered pairs, in all four quadrants of the coordinate grid, together with translation and reflection images.
4. Relate reflections to lines and planes of symmetry.

B. Architectural Patterns

Outcome: ***Create and analyze design problems and architectural patterns, using the properties of scaling, proportion and networks. (1,2,3,4,5)***

1. Represent, analyze and describe enlargements and reductions.
2. Draw and interpret scale diagrams and colouring problems.
3. Describe, analyze and solve network problems.

C. Geometry And Pattern Recognition

Outcome: ***Apply coordinate geometry and pattern recognition to predict the effects of translations, rotations, reflections and dilatations on 1-D lines and 2-D shapes. (1,2,3,4,5)***

1. Draw the image of a 2-D shape as a result of a single transformation, dilatation, combinations of translations, and/or reflections.
2. Identify the single transformation that connects a shape with its image.
3. Demonstrate that a triangle and its dilatation image are similar.
4. Demonstrate the congruence of a triangle with its translation image, rotation image, and reflection image.

SECTION NINE ..... STATISTICS AND PROBABILITY

A. Data Analysis

Outcome: Develop and implement a plan for the collection, display and analysis of data, using measures of variability and central tendency. (5)

1. Formulate questions for investigation, from a real-world context.
2. Select, defend and use appropriate methods of collecting data; designing and using questionnaires, interviews, experiments, research.
3. Describe issues to be considered when collecting data.
4. Display data by hand or by computer in a variety of ways, including circle graphs.
5. Read and interpret graphs.
6. Determine measures of central tendency for a set of data: mode, median, mean.
7. Determine measures of the distribution of a set of data: range, extremes, gaps and clusters, quartiles.
8. Interpolate from data to make predictions.

B. Plan For The Collection, Display And Analysis Of Data

Outcome: Develop and implement a plan for the collection, display and analysis of data, using technology, as required. (5)

1. Formulate questions for investigation, using existing data.
2. Select, use and defend appropriate methods of collecting data; designing and using surveys, research, using electronic media.
3. Display data by hand or by computer in a variety of ways, including box and whisker plots.

C. Evaluate And Use Measures

Outcome: Evaluate and use measures of central tendency and variability. (5)

1. Determine and use the most appropriate measure of central tendency in a given context.
2. Describe the variability of data sets, using such techniques as range, and box and whisker plots.
3. Construct sets of data given measures of central tendency and variability.
4. Determine the effect on the mean, median and/or mode when a constant is added or subtracted from each value; each value is multiplied or divided by the same constant; and a significantly different value is included.

D. Collect And Analyse Experimental Data

Outcome: Collect and analyze experimental results expressed in two variables, using technology, as required. (5)

1. Design, conduct and report on an experiment to investigate a relationship between two variables.
2. Create scatter plots for discrete and continuous variables.
3. Interpret a scatterplot to determine if there is an apparent relationship.
4. Determine the lines of best fit from a scatterplot for an apparent linear relationship, by inspection and using technology (equations are not expected).
5. Draw and justify conclusions from the line of best fit.
6. Assess the strengths, weaknesses and biases of samples and data collection methods.
7. Critique ways in which statistical information and conclusions are presented by the media and other sources.

E. Chance And Uncertainty

Outcome: Create and solve problems, using probability. (5)

1. Use a table to identify all possible outcomes of two independent events.
2. Create and solve problems, using the numerical definition of probability as favourable outcomes divided by possible outcomes.
3. Use the Monte Carlo simulation method to solve probability problems. (5)

F. Theoretical And Experimental Probability

Outcome: Compare theoretical and experimental probability of independent events. (5)

1. Use computer or other simulations to solve probability and data collection problems.
2. Recognize that if n events are equally likely the probability of any one of them occurring is 1/n.
3. Determine the probability of two independent events where the combined sample space has 52 or fewer elements.
4. Predict population characteristics from sample data.

G. Complex Problems Using Probability And Statistics

Outcome: Explain the use of probability and statistics in the solution of complex problems. (5)

1. Recognize that decisions based on probability may be a combination of theoretical calculations, experimental results and subjective judgments.
2. Demonstrate an understanding of the role of probability and statistics in society.
3. Solve problems involving the probability of independent events.

ENTRANCE LEVEL COMPETENCIES IN SCIENCE
(Numbers in parentheses indicate which Entrance Examination(s) test for this competency)

SECTION ONE: ..... PHYSICS

A. Electricity And Magnetism Materials And Safety

Outcome: ***Demonstrate safe methods for the study of magnetism and electricity, identify methods for measurement and control, and apply techniques for evaluating magnetic and electrical properties of materials. (1,2)***

1. Recognize and appreciate the potential dangers involved in using sources of electrical currents; understand that household electrical currents are potentially dangerous and not a suitable source for experimentation; understand that small batteries are a relatively safe source of electricity, for experimentation and study, but that care should be taken to avoid short circuits; understand that short circuits may cause wires to heat up, as well as waste the limited amount of energy in batteries.
2. Describe and demonstrate example activities that show that electricity and magnetism are related; demonstrate that electricity can be used to create magnetism; demonstrate that a moving magnet can be used to generate electricity.
3. Demonstrate and interpret evidence of magnetic fields around magnets and around current-carrying wires, by use of iron filings or by use of one or more compasses.
4. Demonstrate that a continuous loop of conducting material is needed for an uninterrupted flow of current in a circuit.
5. Distinguish electrical conductors from insulators.
6. Recognize and demonstrate that some materials, including resistors, are partial conductors of electricity.
7. Predict the effect of placing an electrical resistance in a simple circuit.
8. Recognize that the amount of electricity we use is measured in kilowatt-hours.
9. Interpret and explain the reading on a household electrical meter and efficiency labels on electrical appliances.
10. Draw and interpret, with guidance, circuit diagrams that include symbols for switches, power sources, resistors, lights and motors.

B. Simple Circuits And Motorized Devices

Outcome: ***Construct simple circuits, and apply an understanding of circuits to the construction and control of motorized devices. (1,2)***

1. Identify example applications of electrical devices in the home and work environment, and classify the kinds of uses. Categories of electrical use may include such things as heating, lighting, communicating, moving, and computing.
2. Design and construct circuits that operate lights and other electrical devices.
3. Recognize the importance of switches and other control mechanisms to the design and operation of electrical devices, and identify purposes of switches in particular applications.

4. Construct and use a variety of switches.
5. Design and construct devices that use a battery-powered electric motor to produce motion.
6. Design and construct a burglar alarm.
7. Demonstrate different ways of lighting two lights from a single power source, and compare the results. Learner should recognize that wiring two bulbs in series makes both bulbs glow less brightly than if the bulbs are wired in parallel. Learners may demonstrate this knowledge operationally and do not need to use the terms series and parallel.
8. Demonstrate different ways of using two batteries to light a bulb, and compare the results. Students should recognize that wiring the batteries in series causes the bulb to glow brighter than it would if parallel wiring were used.
9. Given a design task and appropriate materials, invent and construct an electrical device that meets the task requirements.

C. Potential Dangers Of Electricity.

Outcome: Recognise the potential dangers of electricity. (3,4)

1. Assess the potential danger of an electrical device by referring to the voltage and amperage of the device.
2. Distinguish between devices that might be used safely in experimental studies and those that would not be appropriate.
3. Recognize dangerous procedures.
4. Recognize equipment that is in an unsafe condition for use.

D. The Production Of Current Electricity Based On Chemical, Photoelectric Or Thermoelectric Principles.

Outcome: Describe specialized technologies for the production of current electricity based on chemical, photoelectric or thermoelectric principles. (3,4)

1. Describe the general design and function of a simple wet cell.
2. Describe a process for testing the effectiveness of different materials for use within a wet cell.
3. Describe the design of cells and batteries in common usage.
4. Identify practical problems that designers of batteries have attempted to solve, and describe approaches that have been used to solve these problems
5. Construct a thermocouple and demonstrate its effectiveness.
6. Identify practical applications appropriate for the use of photoelectric or thermoelectric devices.

E. Conversion Of Energy

Outcome: Demonstrate how electromagnetic effects provide a means for conversion of mechanical energy to electrical energy, or electrical energy to mechanical energy. (3,4)

1. Describe evidence of electromagnetic effects.
2. Construct a simple galvanometer using a compass and wire.
3. Use a meter to measure voltages and amperages within a circuit.
4. Demonstrate the generation of electricity by movement of a magnet through a coil.

5. Interpret the operation of a simple generator.
6. Describe the design of a simple electric motor.
7. Interpret the operation of an electric motor.
8. Design and construct a device that operates on the basis of electromagnetic force.

F. Electrical Devices Are Based On Circuits

Outcome: ***Demonstrate that electrical devices are based on circuits.(3,4)***

1. Construct a simple circuit using materials provided.
2. Design and construct series and parallel circuits.
3. Predict the effects of linking electrical loads in series and in parallel.
4. Use materials provided to design a circuit that will perform a given function.
5. Construct and interpret circuit diagrams.
6. Identify short circuits in a sketch of a circuit or in an actual circuit.

G. Electrical Resistance

Outcome: ***Explain how electrical resistance can be used to control the flow of electricity in a circuit or to produce heat and light. (3,4)***

1. Construct and use a simple variable resistor with materials provided.
2. Describe the effect of resistance on electron flow in a simple circuit.
3. Predict the effects of resistors on electron flow in series and parallel circuits.
4. Interpret the design of devices that produce heat and light based on electrical resistance.

H. Electromechanical Systems

Outcome: ***Describe how electromechanical systems can be designed to perform simple or complex functions. (3,4)***

1. Describe the operation of various kinds of switches and control devices; use these in a simple circuit
2. Design a circuit that will perform a function then shut off when the function has been completed.
3. Design a circuit that will perform one function and proceed to a second function when the first is completed.
4. Design a circuit that will respond to a changing environmental condition.
5. Recognize systems and subsystems within household electromechanical devices.
6. Interpret the function and operation of electronic control devices in common domestic applications.

I. Field Theory As An Important Idea In Modern Science

Outcome: ***Describe field theory as one of the most important ideas in modern science. (5)***

1. Define a field as the value of a quantity by virtue of position.
2. Describe the basic characteristics of all vector fields, source, direction and strength of field, as determined by a test object.
3. Compare gravitational, electric and magnetic fields in terms of basic characteristics.

J. Applications of Field Theory

Outcome: ***Explain the operation of many important electric devices using field theory. (5)***

1. Describe the relationships among current, voltage and resistance, using Ohm's law.
2. Describe the relationships among power, current, voltage and resistance.
3. Compare the resistances in series and parallel circuits.
4. Distinguish between alternating current and direct current in terms of electron movement and electric field.
5. Describe the advantages of alternating current over direct current for transmitting and using electrical energy.
6. Explain the operation of a transformer in terms of the relationship among current, voltage, and the number of turns in the primary and secondary coils.
7. Use a mechanical (collision) model to illustrate electric current and resistance in conductors.
8. Calculate any variable in the equation V=IR, given the other two variables.
9. Calculate any variable in the equation P=VI, given the other two variables.
10. Calculate any variable in the equation P=I2R, given the other two variables.
11. Calculate simple series and parallel circuits involving up to three resistors, and measuring the voltage, current and resistance.
12. Calculate resistance for series and parallel circuits involving up to three resistors.
13. Investigate the effect of a conductor moving through a magnetic field.
14. Build or demonstrate a simple electric motor.
15. Compare electric motors and generators.
16. Investigate the relationships among the current, voltage and number of turns in the primary and secondary coils of a transformer.

SECTION TWO ..... FORCE, WORK, ENERGY AND MOTION

A. Indirect Observation Of Force

Outcome: ***Describe how the presence of a force can be inferred from its effects. (1,2,3,4)***

1. Infer the application of a force based on observed movements.
2. Describe the direction of a force.
3. Identify examples of mechanical, frictional, electrostatic, magnetic and gravitational forces.
4. Describe the effects of these forces.

B. Measurement And Comparison Of Forces

Outcome: ***Identify the various ways forces can be compared and measured. (1,2,3,4)***

1. Identify appropriate means for detection and measurement of different kinds of forces.
2. Identify and describe the principles on which various kinds of force measurement devices are based.
3. Recognize and use units of force.

C. Gravitational Force

Outcome: ***Describe how the weight of an object (the gravitational force on it) can vary according to the gravitational field in which the weight of the object is measured. (1,2,3,4)***

1. Recognize and describe the effects of gravitational force.
2. Describe changes in gravitational force that result from a change of position in space.

D. Mass

Outcome: ***Explain the concept of mass as a constant characteristic for an object, regardless of its gravitational frame of reference. (1,2,3,4)***

1. Identify appropriate means of measuring mass.
2. Distinguish between mass and weight.
3. Recognize and use units of mass.
4. Identify differences in scientific and everyday approaches to identifying the mass of an object.

E. Relative Motion Of Objects

Outcome: ***Describe how the relative motion of objects is affected by forces that act between those objects. Motion of objects can be interpreted or predicted based on knowledge of forces. (1,2,3,4)***

1. Describe and predict the pathways of moving objects.
2. Describe and predict changes in movement that result from the application of force.
3. Identify evidence and effects of friction.
4. Identify factors that affect friction.
5. Describe methods of increasing or decreasing frictional forces.
6. Describe movement of materials in space environments.
7. Identify action–reaction pairs.
8. Identify forces in action–reaction pairs.

F. Motion Of Objects

Outcome: ***Describe motion of objects in terms of displacement, time, velocity and acceleration. (5)***

1. Compare scalar and vector quantities.
2. Compare distance and displacement, and speed and velocity.
3. Define velocity as a change in position during a time interval.
4. Define acceleration as a change in velocity during a time interval.
5. Use scale diagrams to solve displacement problems in two dimensions.

G. Newton’s Laws Of Motion

Outcome: ***Explain how Newton’s laws of motion relate force to the motion of objects. (5)***

1. Compare mass and weight, qualitatively.

2. Explain how a force effects a change in motion.
3. Apply Newton's first law of motion to explain an object's state of rest or uniform motion.
4. Apply Newton's second law of motion, and using it to relate force, mass and motion.
5. Apply Newton's third law of motion to explain situations where objects interact.

H. Uniform Circular Motion

Outcome: ***Describe how an object moving in a circular path, with a constant speed, undergoes acceleration toward the centre of the circle. (5)***

1. Describe uniform circular motion as a special case of two-dimensional motion.
2. Describe a centripetal force as having one of several sources.
3. Apply the centripetal force and acceleration equations to uniform circular motion.
4. Illustrate, qualitatively, Newton's universal law of gravitation as it applies to planetary and satellite motion.

I. Conservation Of Momentum

Outcome: ***Explain how momentum is conserved in physical interactions. (5)***

1. Define momentum as a quantity of motion equal to the product of the mass and the velocity of an object.
2. Relate the role of change in momentum to acceleration.
3. Apply the law of conservation of momentum to linear collisions and explosions.
4. Explain one-dimensional collisions and explosions, using scale diagrams and numerical means.

J. Energy Waves

Outcome: ***Explain how waves are a means of transmitting* energ*y. (5)***

1. Describe medium particle vibrations as the source of mechanical waves.
2. Compare and contrasting energy transmission by matter that moves and by waves that move.
3. Explain the characteristics of waves in terms of the direction of vibration of the medium particles in relation to the direction of propagation of the disturbance.
4. Define and using the terms wavelength, amplitude, transverse and longitudinal, in describing waves.
5. Explain how a wave travels with a speed determined by the characteristics of the medium.
6. Relate the frequency of a wave to the period of the source, and the speed of propagation to the frequency and wavelength.
7. Predict, quantitatively, and verify, the effects of changing one, or a combination, of the variables in the relationship v = f □.
8. Explain the behaviour of waves at the boundaries between mediums.
9. Predict the resultant displacement when two waves interfere.
10. Explain the Doppler effect on a stationary observer with a moving source, and a moving observer with a stationary source.

SECTION THREE..... STATICS (STRUCTURES)

A. Structural Design

Outcome: ***Identify structural design in both natural and manufactured materials. (1,2,3,4,5)***

1. Recognize stems and skeletons as structural components of living things.
2. Infer the function of plant and animal structures.
3. Identify patterns of organization in manufactured materials.
4. Recognize similarities between natural and manufactured structures.

B. Purpose Of Structures

Outcome: ***Describe how structures are designed in response to human needs, purposes and aspirations. (1,2,3,4,5)***

1. Infer and describe the function of structures.
2. Recognize examples of ways in which human aspirations have been achieved through the design and construction of structures.

C. Alternative Design Approaches

Outcome: ***Explain how alternative approaches are considered in the design of structures. (1,2,3,4,5)***

1. Recognize common approaches to the design of bridges and buildings
2. Distinguish between rigid and non-rigid structures.
3. Infer the purpose of components in structures.
4. Recognize examples of various materials being used for the same design function.
5. Recognize the relationship between choice of materials and the design used.

D. Material Properties And Structural Principles

Outcome: ***Explain the contribution of knowledge of materials and structural principles to the design process. (1,2,3,4,5)***

1. Describe processes for testing the strength of materials.
2. Measure and compare the strength of materials.
3. Distinguish between tensile and compressive forces.
4. Identify points of tension and compression in a structure.
5. Describe the potential effects of tensile and compressive forces on different components of a structure.
6. Recognize the role of ties and linkages in adding to the overall strength and stability of a structure.
7. Describe the effects of the use of different shapes on the strength and stability of materials.
8. Identify the function of hinged components in natural and manufactured materials.
9. Describe the function of different kinds of hinged components.

E. Selection Of Materials And Design

Outcome: Identify the factors affecting the selection of materials and design. (1,2,3,4,5)

1. Identify environmental implications of design decisions.
2. Recognize costs to be considered in design decisions.
3. Recognize the need to balance functional, esthetic, economic and environmental concerns.

F. Accommodating Design For Specialized Needs And Environmental Conditions

Outcome: ***Identify design accommodations for specialized needs or environmental conditions. (1,2,3,4,5)***

1. Identify differences in requirements of structures built on earth and in space.
2. Recognize similarities and differences in approaches to construction used on earth and in space.

SECTION FOUR..... DYNAMICS (MACHINES)

A. Wheels, Gears And Levers

Outcome: ***Demonstrate a practical understanding of wheels, gears and levers by constructing devices in which energy is transferred to produce motion. (1,2)***

1. Explain how rollers can be used to move an object, and demonstrate the use of rollers in a practical situation.
2. Compare the wheel and the roller, and identify examples where each is used.
3. Construct devices that use wheels and axles and demonstrate and describe their use in model vehicles, pulley systems, and gear systems.
4. Construct and explain the operation of a drive system that uses one or more of the following: wheel-to-wheel contact, a belt or elastic, a chain, cogs or gears.
5. Construct and explain the operation of a drive system that transfers motion from one shaft to a second shaft, where the second shaft is parallel to the first, at a 90° angle to the first. Demonstrate ways to use a lever that: applies a small force to create a large force, applies a small movement to create a large movement.
6. Predict how changes in the size of a lever or the position of the fulcrum will affect the forces and movements involved.
7. Construct models of levers and explain how levers are involved in such devices as: teeter-totters, scissors, pliers, pry bars, tongs, nutcrackers, fishing rods, and wheelbarrows.

B. Construction Of A Mechanical Device

Outcome: ***Construct a mechanical device for a designated purpose, using materials and design suggestions provided. (1,2)***

1. Design and construct devices and vehicles that move or have moving parts—linkages, wheels and axles.
2. Use simple forces to power or propel a device.
3. Design and construct devices and vehicles that employ energy-storing or energy-consuming components that will cause motion.
4. Recognize the need for control in mechanical devices, and apply control mechanisms where necessary.
5. Compare two designs, identifying the relative strengths and weaknesses of each.
6. Identify steps to be used in constructing a device or vehicle, and work cooperatively with other students to construct the device or vehicle.
7. Design and construct several different models of a device and evaluate each model, working cooperatively with other students.

C. Understanding Mechanical Devices

Outcome: ***Explain how mechanical devices are systems made up of subsystems and components. (1,2,3,4,5)***

1. Identify parts or components of some simple mechanical devices.
2. Identify parts of a mechanical device that work together as a subsystem.

D. Mechanical Systems

Outcome: ***Explain how mechanical systems are designed to perform one or more functions. (1,2,3,4,5)***

1. Identify the functions of some common mechanical devices.
2. Identify the contribution of subsystems to the overall function of a mechanical device.
3. Identify the contribution of individual components to the function of a mechanical device.
4. Identify components that operate as simple machines within a mechanical device.
5. Describe the operation and application of simple machines.
6. Describe the bicycle as an example of a mechanical system.
7. Compare alternative designs of a mechanical device.

E. Power Transmission Within A System

Outcome: ***Describe the various kinds of linkages used to transmit power between different parts of a system. (3,4,5)***

1. Identify the source of power in some familiar mechanical devices.
2. Identify power linkages within a mechanical system.
3. Analyze a gear system to identify the effect of different gear ratios on relative speeds of a driving and driven shaft.
4. Build or adapt a mechanical system to provide for different turning ratios between a driving and a driven shaft.

F. Energy Conversion

Outcome: ***Explain how mechanical systems convert energy from one form to another. (3,4,5)***

1. Identify examples of energy conversion.
2. Identify modifications to a device that would enable it to use more than one form of energy input.

G. Mechanical Efficiency

Outcome: ***Identify ways to improve the efficiency of mechanical devices often through changes in design and by alterations that reduce friction. (3,4,5)***

1. Construct a device that makes efficient use of energy.
2. Identify changes in the design of a mechanical device that would improve its overall efficiency.
3. Identify improvements in the design of a mechanical device that would improve its safety and ease of operation.
4. Improve the efficiency of a device by troubleshooting.

5. Interpret information on energy efficiency of different devices or products.
6. Identify impacts of inefficient energy use on environments and resources.

SECTION FIVE ..... HEAT & TEMPERATURE

A. Temperature

Outcome: ***Explain how the temperature of a substance provides a measure of its relative hotness or coldness compared with an arbitrary temperature scale. (1,2)***

1. Infer temperatures based on physical properties of materials.
2. Describe temperatures of materials in descriptive, non-quantitative terms.

B. Temperature Measurement

Outcome: ***Describe how the need for precision in temperature measurement has led to the development of thermometers and temperature scales. (1,2)***

1. Infer the need for precise temperature measurement in given applications.
2. Infer the accuracy of a temperature-measuring device.
3. Describe the Celsius temperature scale and identify significant temperatures on that scale Calibrate a thermometer.
4. Estimate temperatures of materials in degrees Celsius.

C. Expansion and Contraction

Outcome: ***Describe how thermal expansion and contraction provides the basis for thermometry. (1,2)***

1. Predict changes in materials due to heating and cooling.
2. Compare the amount of thermal expansion for different materials.
3. Describe the components of liquid thermometers and the functions of those components.
4. Describe the operation of liquid and air thermometers in relation to the design of the devices and the principles by which they operate.
5. Describe the operation of various specialized thermometers in relation to their design and the principles by which they operate.

D. Heat

Outcome: ***Explain the scientific concept of heat as used to describe the thermal energy in a material. (1,2)***

1. Recognize that when the temperature of a substance increases, the substance has absorbed heat; when the temperature of a substance decreases, the substance has lost heat.
2. Estimate final temperature of a mixture of equal quantities of a liquid of different temperatures.
3. Recognize that the final temperature of liquid mixtures is affected by the mass and heat-related characteristics of the original components.
4. Distinguish between the concept of temperature and the concept of heat.
5. Describe temperature and heat in terms of particle motion.

E. Sources Of Heat Energy

Outcome: ***Identify Sources Of Heat Energy. (1,2)***

1. Identify sources and methods of generating heat.
2. Identify advantages and disadvantages of the use of various heat sources.
3. Recognize that different fuels may have different heat energy content.
4. Compare the energy content of different fuels.
5. Compare energy content of different foods.

F. Heat As Energy Gain Or Loss

Outcome: ***Define the term "heat" as used in reference to energy gained or lost by a material as it interacts with other materials. (3,4,5)***

1. Recognize heat gain or heat loss in practical activities.
2. Distinguish between heat and temperature.
3. Interpret temperature changes in terms of particle theory
4. Identify heat losses or gains in terms of number of joules.

G. Movement Of Heat

Outcome: ***Explain the movement of heat energy from hot bodies to cooler ones. (3,4,5)***

1. Predict temperature changes that will result from mixing various quantities of water of different temperatures.
2. Interpret information regarding the specific heats of materials.
3. Compare the specific heat of solids, liquids and gases.

H. Heat Transfer

Outcome: ***Describe heat transfer by conduction, convection and radiation. (3,4,5)***

1. Interpret conduction and convection in terms of particle theory.
2. Compare conduction rates of materials based on experimental data.
3. Identify and interpret applications of heat conduction.
4. Predict the flow pattern of a fluid as it is heated.
5. Identify and interpret applications of heat convection.
6. Identify factors that affect rates of radiation.
7. Identify and interpret examples of heat radiation.

I. Control Of Heat Transfer

Outcome: ***Describe how heat transfer can be controlled through selection of appropriate materials and by use of appropriate design. (3,4)***

1. Identify applications in which heat transfer is controlled.
2. Design and construct an insulated container.

3. Compare the effectiveness of alternative materials and designs for heat transfer in domestic applications.
4. Compare the effectiveness of alternative materials and approaches to insulation in domestic applications.
5. Interpret the effect of clothing materials and design on the retention or transfer of heat.
6. Describe and demonstrate a technique for comparing the effectiveness of different kinds of insulating materials.
7. Identify effective insulating materials.

J. Solar Heat

Outcome: ***Explain the absorption and transfer of energy from solar radiation. (3,4)***

1. Describe general principles of passive and active solar heating.
2. Identify functions of components used in a solar heating system.
3. Design and construct a model solar heating device.

K. Energy Transfer

Outcome: ***Describe how* energy *can be transformed from one form to another. (5)***

1. Recognize that potential energy is only useful when it is transformed to some form of kinetic energy.
2. Illustrate, by use of examples, that energy transfers produce measurable changes in motion, shape or temperature of matter.
3. Define gravitational potential energy as the work done on a mass against gravity, and quantifying gravitational potential energy.
4. Quantify kinetic energy.
5. Recognize chemical energy as a form of potential energy.
6. Quantify electrical energy.
7. Analyze units to describe the kilowatt-hour as a unit of energy, and the watt as a unit of rate of energy transfer or a unit of rate of doing work.

L. Conservation Of Energy

Outcome: ***Illustrate The Law Of The Conservation Of Energy. (5)***

1. State the law of conservation of energy, as “the sum of initial energies is equal to the sum of final energies”.
2. Recognize the first law of thermodynamics as a statement of the law of conservation of energy.
3. Describe by use of examples, that thermal energy will, of its own accord, flow from a hotter body to a cooler body, and recognizing this as a formal statement of the second law of thermodynamics.
4. Compare the mechanism of diffusion to thermal energy transfer according to the second law of thermodynamics.

M. Energy Efficiency

Outcome: ***Explain how useful* energy *diminishes during any* energy *transformation. (5)***

1. Interpret empirical data from a study of energy conversions.

2. Explain that energy conversion processes have different efficiencies, based on total energy input compared to the net useful energy output.
3. Define efficiency as a measure of the useful work compared to the total energy put into an energy conversion process.
4. Define inefficiency as the fraction of energy lost as wasted heat in the conversion process.
5. Describe techniques for reducing waste of energy, in a common household device.

SECTION.SIX .. ..FLUIDS AND PRESSURE

A. Properties Of Air

Outcome: Describe properties of air and the interactions of air with objects in flight. (1,2)

1. Provide evidence that air takes up space and exerts pressure, and identify examples of these properties in everyday applications.
2. Provide evidence that air is a fluid and is capable of being compressed, and identify examples of these properties in everyday applications.
3. Describe and demonstrate instances in which air movement across a surface results in lift – Bernoulli's principle.
4. Recognize that in order for devices or living things to fly, they must have sufficient lift to overcome the downward force of gravity.
5. Identify adaptations that enable birds and insects to fly.
6. Describe the means of propulsion for flying animals and for aircraft.
7. Recognize that streamlining reduces drag, and predict the effects of specific design changes on the drag of a model aircraft or aircraft components.
8. Recognize that air is composed of different gases, and identify evidence for different gases.

B. Properties Of Liquids And Gases

Outcome: List the fluid properties liquids and gases exhibit that are significant to their application in technological devices. (3,4,5)

1. Describe the compressibility of liquids and gases.
2. Interpret the compressibility of liquids and gases in terms of particle theory.
3. Compare the viscosity of different liquids by use of a simple lab test.
4. Predict the effects of temperature changes on viscosity of fluids.
5. Recognize flow rates as an indicator of the viscosity of liquids.
6. Identify applications where viscosity of fluids is a significant.
7. Distinguish between applications that require a compressible fluid (gas) and applications that require a non-compressible fluid.

C. Forces Within Fluids

Outcome: Explain how forces within fluids are transferred in all directions. (3,4,5)

1. Describe the response of fluids to gravity.
2. Predict the response of fluids to external pressure.

3. Recognize the relationship between gravity and buoyancy.
4. Measure a buoyant force.
5. Construct and calibrate a simple hydrometer.
6. Use a hydrometer in measuring the density of a liquid.
7. Predict changes in liquid density that result from temperature changes and from changes in solution concentration.
8. Predict changes in buoyant force that result from changes in fluid density.
9. Identify and interpret technologies that are based on buoyant.

D. Hydraulic Systems

Outcome: ***Explain how hydraulic systems provide the basis for the application and transfer of forces. (3,4,5)***

1. Determine the force exerted on a surface based on knowledge of pressure and surface area.
2. Predict changes in force exerted resulting from an increase in the surface area over which pressure acts.
3. Explain the need for strength in pressurized vessels.

E. Technologies Used In The Movement And Control Of Fluids

Outcome: ***Describe various technologies used in the movement and control of fluids. (3,4,5)***

1. Identify fluid systems in living things and manufactured devices.
2. Interpret the function of fluid systems within living things and manufactured devices.
3. Construct a diagram to illustrate components in a fluid system.
4. Construct a functional fluid system using materials provided.
5. Interpret the operation of various kinds of valves.
6. Interpret the operation of valves in the human heart.
7. Interpret and explain the operation of pumps.

F. Aerodynamic And Hydrodynamic Design

Outcome: ***Explain how the study of fluid movement has led to development of aerodynamic and hydrodynamic design. (3,4,5)***

1. Predict the effect of design on drag around an object travelling through a fluid.
2. Design a streamlined device.

SECTION SEVEN ..... OPTICS AND LIGHT

A. Light

Outcome: ***Identify sources of light, describe the interaction of light with different materials, and infer the pathway of a light beam. (1,2,3,4)***

1. Recognize that bright lights can damage eyes and that one should not look at the Sun—either directly or with binoculars or telescopes.

2. Identify a wide range of sources of light, including the Sun, various forms of electric lights, flames, and materials that glow.
3. Distinguish objects that emit their own light from those that require an external source of light in order to be seen.
4. Demonstrate that light travels outward from a source and continues unless blocked by an opaque material.
5. Describe changes in the size and location of Sun shadows during the day—early morning, to midday, to late afternoon.
6. Recognize that opaque materials cast shadows, and predict changes in the size and location of shadows resulting from the movement of a light source or from the movement of a shade-casting object.
7. Distinguish transparent materials from opaque materials by determining if light passes through them and by examining their shadows.
8. Classify materials as transparent, translucent or opaque.
9. Recognize that light can be reflected and that shiny surfaces such as polished metals and mirrors, are good reflectors.
10. Recognize that light can be bent (refracted) and that such objects as aquaria, prisms and lenses can be used to show that light beams can be bent.
11. Recognize that light can be broken into colours and that different colours of light can be combined to form a new colour.
12. Demonstrate the ability to use a variety of optical devices, describe how they are used, and describe their general structure.

B. Geometric Optics

Outcome: Explain the nature and behaviour of light using the geometric optics model. (5)

1. Cite evidence for the linear propagation of light.
2. Explain a method of measuring the speed of light.
3. Calculate given experimental data of various methods employed to measure the speed of light.
4. Define a ray as a straight line representing the rectilinear propagation of light.
5. Explain, using ray diagrams, the phenomena of dispersion, reflection and refraction at plane and uniformly curved surfaces.
6. State and use Snell's law.
7. Derive the curved mirror equation from empirical data.
8. Solve reflection and refraction problems, using algebraic, trigonometric and graphical methods.
9. Analyze simple optical systems, consisting of no more than two lenses or one mirror and one lens, using algebraic and/or graphical methods.

C. Light Waves

Outcome: Describe how the wave model of light improves our understanding of the behaviour of light. (5)

1. Compare the explanations of reflection and refraction by the particle theory and by the wave theory of light.
2. Explain, using the wave theory of light, the phenomena of reflection and refraction.

3. Explain why geometric optics fail to adequately account for the phenomena of diffraction, interference and polarization.
4. Explain, qualitatively, diffraction and interference, using the wave model of light.
5. Explain how the results of Young's double-slit experiment support the wave theory of light.
6. Solve double-slit problems and diffraction grating problems.
7. Explain, qualitatively, polarization in terms of the wave model of light.
8. Demonstrate how Snell's law offers support for the wave model of light.

D. Electromagnetic Spectrum

Outcome: ***Describe the electromagnetic spectrum as a continuous range of electromagnetic waves with specific characteristics and similar properties. (5)***

1. Predict the effects of changing one, or a combination, of variables in the relationship v = *f* □□on any one of the remaining variables.
2. Describe the range of the electromagnetic spectrum from long, low frequency radio waves, through microwaves, infrared, visible, ultraviolet and X-rays, to very short, high frequency gamma rays.
3. Explain the difference between AM and FM radio waves in terms of amplitude and frequency modulation.
4. Compare, to each other, the various constituents of the electromagnetic spectrum on the basis of source, frequency, wavelength, energy and effect on living tissue.
5. Describe, qualitatively, the phenomena of reflection, refraction and polarization of visible light.
6. Compare, the characteristics of radiation from any region of the electromagnetic spectrum with those of visible light.
7. Calculate any variable in the equation v = f□, given two of the three variables of frequency, wavelength and speed of electromagnetic propagation.
8. Perform and evaluating experiments that investigate reflection and refraction of visible light.
9. Perform an experiment to demonstrate total internal reflection.
10. Perform an experiment to demonstrate the polarization of visible light.
11. Draw diagrams to illustrate amplitude and frequency modulated radio waves.

ENTRANCE LEVEL COMPETENCIES IN READING COMPREHENSION
(Numbers in parentheses indicate which Entrance Examination(s) test for this competency)

A Literal Comprehension

Outcome: ***Identify facts in a written passage. (1,2,3,4,5)***

B Comprehension Of Concepts

Outcome: ***Identify the concepts in a written passage.*** **(1,2,3,4,5)**

C. Application Of Concepts

Outcome: ***Apply the concepts in a written passage to practical situations.*** **(1,2,3,4,5)**

D. Analysis Of Concepts

Outcome: ***Analyse the concepts contained in a written passage.*** **(1,2,3,4,5)**

E. Making Judgements

Outcome: ***Make judgements based on information contained in a written passage.*** **(1,2,3,4,5)**

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