Programme	SBCS Assured Certificate in Advanced Refrigeration and Air Conditioning
Course Title	**Refrigeration and Air Conditioning Fundamentals**
Guided Learning Hours	**120**

Aims

This unit gives learners the opportunity to learn the fundamentals of Mathematics, science, safety and blueprint reading and to apply this knowledge when carrying out refrigeration and air conditioning works.

Learning Outcomes

On completing this course successfully, learners will be able to:

1. Mathematics
2. Applied Science
3. Drawing and Blueprint Reading
4. Safety at work

Indicative Content

1. Mathematics

Basic arithmetic calculations: Add, subtract, multiply and divide whole numbers, fractions and decimals; Convert fractions to decimals, percentages and vice versa; Application of "BODMAS" Rule; Discounts, percentages, profit and loss, Value added tax (VAT) and averages; SI units (Length, Mass, Time, Volume); Change between prefixes (giga (G), mega (M), kilo (k), micro (μ), nano (η), pico (ρ)).

Areas and volumes: Determine areas and volumes of various regular shaped objects (including circles, cuboids, cylinders, cones and spheres); Solve problems relating to refrigeration work.

Ratios and proportions: Direct and Indirect proportions; Determination of various ratios (Materials to tools, materials to labor, tools to labor etc.).

Transposition: Transpose simple formulae in which the subject is equal to an expression whose terms are connected by (+)of (-) sign; Transpose simple formulae in which the subject is equal to an expression

composed of two or more factors); Transpose formulae which contain a root or power; Transpose formulae in which the subject appears in more than one term.

Indices: Perform calculations applying the rules of indices where (m) and (n) are positive and negative integers ($a^m a^n = a^{m+n}$, $a^m/a^n = a^{m-n}$, $(a^m)^n = a^{mn}$); Apply the rules of fractional indices where (m) and (n) are positive integers and recognize that $a^{1/n} = \sqrt[n]{a}$ and that $a^{m/n} = \sqrt[n]{a^m}$; Convert values to standard forms.

Factorization: Distinguish between an algebraic expression, an equation and an identity; Factorize expressions by using the following methods (grouping, extraction of common factors, completing the square and using the quadratic formula).

Linear and Simultaneous Equations: Form and solve linear equations; Maintain the equality of a given equation whilst applying any arithmetic operation; Solve linear equations in one unknown including those involving brackets and fractions; Solve a pair of simultaneous linear equations in two unknowns by substitution, elimination and using the quadratic formula.

Radian Measure: Express angular rotations in multiples of radians. One rotation is 2π radians, n rotations is 2πn radians; Use the relationship s = r θ to determine the length of arc of a circle.

Triangles: Identify the types and properties of triangles (Types: acute-angled, right-angled, obtuse-angled, equilateral, isosceles); Calculate the length of any third side of a right-angled triangle; given the length of the other two sides, using the theorem of Pythagoras.

Trigonometry: Define trigonometrical ratios and solve problems involving right-angled triangles (Ratios: sine, cosine, tangent); Obtain values for the three trigonometric functions for angles of any magnitude from tables and from a calculator; Surds (30^0, 45^0 and 60^0), Sine Rule = $(\frac{a}{Sin\ A} + \frac{b}{Sin\ B} + \frac{c}{Sin\ C})$; Cosine Rule: $a^2 = b^2 + c^2 - 2bcCosA$; Identities (Sin (A+B), Sin (A-B), Cos (A+B), Cos (A-B)).

Graphs: Choose suitable scales and plot graphs from experimental data (Graphs: y = mx + c, y = 1/x, $y = x^2$, trigonometric ratios); Read values from graphs and interpolate values between points; Determine the Gradient and y-intercept of a straight line graph; Determine the roots of a quadratic equation; Find the gradient of a curve at a point

Vectors: Resolving into horizontal and vertical component; Calculating resultant (direction and magnitude)

2. Applied Science

Units: Identify base units for length, mass and time, stating their letter symbols. Change between prefixes (giga (G), mega (M), kilo (k), micro (μ), nano (η), pico (ρ)); Derive quantities in terms of base quantities (e.g. Volume, velocity); Explain the difference between density and relative density

Forces: Represent a force as a vector; Distinguish between different types of forces (types: centrifugal, centripetal, compression, tension); Explain the parallelogram of forces theorem and solve graphically and by calculation, problems involving the resultant and equilibrium of two inclined forces; Explain the polygon of forces Theorem; Determine the resultant of a set of co-planar forces (up to four forces) acting at a common point; Define the moment of a force about a point; Define torque and apply to hand tools such as wrenches, spanners, screw-drivers; Explain the principle of moments and solve problems involving straight levers.

Laws of motion: Define the following terms (distance, displacement, speed, velocity, acceleration); State Newton's (3) Laws of Motion; Sketch graphs of distance/time and speed/time, solve question using equations of motion.

Stress and strain: Define stress and its unit (N/m^2 or Pa (Stress: direct tensile and compression, single shear); Define direct strain; Explain Hook's Law and define Young's modulus; Solve problems involving direct stress, strain, Young's modulus and factors of safety; Explain the behaviors of steel and copper when stretched (Tensile tests)

Simple Machines: Explain the function of a machine and the term simple machine; Define the terms velocity ratio (VR), mechanical advantage (MA) and efficiency and solve problems on a range of machines (Machines: belt drives, gear trains, pulley blocks); Explain the operation of the wheel and axle; Explain the operation of belt and chain drives; Discuss forces , torque, tension and friction in relation to belt drives; Discuss gear ratios, pulley sizes and speeds; Define angular Displacement and angular velocity of a rotating shaft.

Work, Power and Energy: Define the terms (work, power, energy) in relation to machines; Solve problems involving work, power and energy in relation to machines.

Friction: Define friction, Effects of friction; Explain friction in relation to forces acting on a body (at rest, moving along a smooth horizontal surface, inclined plane).

Heat: Distinguish between heat and temperature; Explain thermometry and state the fundamentals of calorimetry; Convert between Kelvin and degree Celsius; List the (3) states of matter; Describe the changes of the state of water, Discuss the effect of heat on conducting and insulating materials; Explain the (3) methods of heat transfer (conduction, convection and radiation); Explain natural convection and Forced convection; Define the term Linear Expansion and give examples where it is useful (bimetallic strip); Define the following (Heat capacity, Latent Heat of Fusion, Latent heat of vaporization); Explain what is meant by tempering, hardening and annealing; Explain the effects of joining dissimilar metals.

Lubrication: Explain the types of oil used in refrigeration systems; Explain the function of refrigeration lubrication systems; Explain the effects of adding too much oil, oil starvation and oil entrainment; Explain the function of oil separators.

Pressure and Gas Laws: State and apply principles of pressure and pressure measurements; Explain pressure scales (atmospheric, gauge and absolute); Conversion form imperial to S.I. units; Operation of manometers and gauges (Bourdon tube type); State and apply the gas laws to solve related problems.

Metering Devices: Identify types of metering devices such as the thermostatic expansion valve, capillary tube and automatic expansion valve; explain the operation of the thermostatic expansion valve and the capillary tube; Explain what is meant by critical charge.

3. Drawing and Blueprint Reading

Basics: Identify instruments and equipment used for the production of good quality drawings (set square, T-square, protractor, scale rules); Practice lettering and dimensioning.

Drawing exercises: Draw and bisect various angles; Draw circles and escribe and inscribe triangles and squares; Draw assorted polygon figures; Draw ellipse concentric circles; Draw a parabola; Draw analog scales of various measuring instruments.

Isometric and Orthographic Projection: Introduction to isometric and orthographic projections; Draw sectional illustrations of cables; Prepare a free–hand sketch showing the internal cut-away profile of a standard refrigeration service valve. Diagram should show clearly the method of operation, machined surfaces, seals and threads. Sketch should be properly labelled, clearly showing the direction of refrigerant flow in the normal operating position, parked position, charging position; Mechanical engineering detail drawings; Draw isometric and orthographic views of various electrical and pipework components and fixtures.

Refrigeration arrangements: Identify pipework valves and control symbols; Read and interpret basic electrical circuit drawings (Electrical symbols, wiring diagrams, schematic diagrams, building wiring); Draw common types of pipes used in piping; Draw graphical symbols used for pipe fitting, valves etc; Produces drawings to show the installation of meters and gauges.

Equipment: Draw and understand the graphical symbols for the different types of condensers (Water-cooled, shell and coil, air-cooled); Draw and understand graphical symbols for evaporator systems (Circular, ceiling type, manifold finned forced air, manifold base tube gravity air); Draw the installation of intake and expel air fans; Draw a simple fan motor electrical circuit.

Fault detection: Read and draw diagrams used in troubleshooting faults; Read and draw diagrams for current and voltage operated earth leakage circuit breaker; Interpret drawings of various earthing and grounding arrangements in buildings.

4. Safety at Work

State the methods used to prevent hazards to ensure the safety of working personnel and members of the public: Methods (warning notices, insulate/enclose live electrical parts, barriers).

State the methods used to protect surrounding work areas from infringement or contamination: Methods (dust sheets, shields (boards)).

Explain the safe use of scaffold platforms less than 2m high: Scaffolding (trestles, folding trestles, hop-up stools, scaffold boards); Safe use (manufacturers' instructions, nationally/locally applied regulations).

Explain the safe use of scaffold platforms over 2m high: Scaffolding (quick assembly towers, scaffold boards, toe boards, hand rails, stabilizers/outriggers); Safe use (manufacturers' instructions, nationally/locally applied regulations).

State the faults, possible hazards and dangerous practices when using steps and ladders: Faults (metal components (corrosion), timber components (deterioration, splits, cracks)); Hazards (base fixing/stabilizing, clip/lash at platform level, clear space around base); Dangerous practices (uneven/lose ground).

Explain the purpose and use of barriers and warning signs/lights to protect working personnel and members of the public from possible accidents: Barriers (security tape, barrier material (timber, metal, plastic), safety/warning (signs, lights)); Purpose (segregation of different work activities, segregation of work from members of the public, prevention of falls from heights above 2m).

Describe the correct use of protective clothing and safety equipment for a range of applications: Use (own safety, regulations); Equipment/clothing (goggles, face mask, ear defenders/plugs, safety helmet (hard hat), overalls, safety shoes, residual current device, electrically insulated hand tools); Applications (pipe cutting/bending, brazing, using power tools, use of hazardous substances (refrigerants, solvents, fluxes, oils), use of insulating materials).

Identify the dangers associated with the use of refrigeration equipment: Dangers (electrical shock, fire, burns).

Identify the means of isolating refrigerant circuits: Means of isolation (compressor service valves, pump down systems, liquid receiver/line stop valves).

Identify the dangers associated with the release of refrigerant from a system: Dangers (frostbite, asphyxiation, toxic products of decomposition, harmful to environment).

State the toxic effect of materials used in refrigeration installations: Effect (eyes, skin, breathing); Materials (refrigerants, brazing material, fluxes, solvents).

Describe the preventative and remedial actions to be taken in the case of exposure to toxic materials: Exposure (ingested, contact with skin, inhaled); Preventative action (ventilation, masks, protective clothing/equipment); Remedial action (immediate first aid, report to supervisor); Materials (solvents, PVC compounds (burning).

Explain the method by which a risk assessment is carried out: Method (identify task procedure, identify hazards, identify control actions to reduce hazard, assess final risk).

Practical Competences

Candidates will be able to:

1. Mathematics

1.1 Perform simple calculations involving addition, subtraction, multiplication and division of whole numbers, fractions and decimals.
1.2 Solve problems related to practical applications of fractions, decimals and percentages.
1.3 Apply "BODMAS" Rule to perform arithmetic sequence operations.
1.4 Calculate the total cost of materials for a given project.
1.5 Calculate work hours, wages and salaries.
1.6 Calculate total and average cost of electrical energy consumed over a particular period of time (T&TEC Tariff).
1.7 Calculate profit and loss as percentages.
1.8 Identify basic SI units and change between different prefixes.
1.9 Solve problems involving Areas, Volumes, Speed, and Density.
1.10 Solve problems involving circles (circumference, segments, and sectors).
1.11 Calculate cross-sectional areas for conductors.
1.12 Calculate volume of rectangular solids, cylinders, cones, spheres related to electrical work (E.g. excavation of trenches, quantity of oil required for a transformer tank etc.)
1.13 Express ratios in its simplest form.
1.14 Solve problems involving direct and indirect proportions.
1.15 Know the laws of transposition.
1.16 Transpose formulae and evaluate using given data ($I = \frac{V}{R}$, $V = E + I_{\alpha}R_{\alpha}$, $\frac{R_1}{R_2} = \frac{1+ \alpha t_1}{1+ \alpha t_2}$)
1.17 Know the laws of indices.
1.18 Evaluate expressions, which combine positive, negative and fractional indices.
1.19 Write expressions in standard forms.
1.20 Distinguish between an algebraic expression, an equation and an identity.
1.21 Solve quadratic problems by factorizing, completing the square and by using the quadratic formula.
1.22 Solve linear equations in one unknown including those involving brackets and fractions.
1.23 Solve a pair of simultaneous linear equations in two unknowns by both substitution and elimination.
1.24 Convert between radian measure and degrees.
1.25 Determine the length of and arc given its radius and angle.

1.26 Use Pythagoras Theorem to solve various problems (e.g. Height of a lamp pole, length of guide wire).
1.27 Use trigonometric ratios to solve problems involving right-angled triangles.

1.28 Solve problems involving surds.
1.29 Apply the sine and cosine rules to solve problems involving triangles.
1.30 Use identities to solve problems.
1.31 Calculate without using tables or calculators the values of angles greater or less than 90^0 (e.g. Sin 105^0 = Sin (60^0 + 45^0)).
1.32 Draw graphs from given data
1.33 Evaluate the law of a straight-line graph in the form y = mx + c.
1.34 Determine the roots of a quadratic equation using the graphical method.
1.35 Approximate the gradient of a non-linear graph by defining the slope of a secant line between two points on the curve.
1.36 Resolve a vector into its horizontal and vertical components.
1.37 Calculate the resultant of two or more vectors
1.38 Calculate the angle of the resultant vector
1.39 Determine the resultant vector using the graphical method.

2. Applied Science

2.1 Identify base units, change between prefixes and derive quantities in terms of base units.
2.2 Explain the properties and uses of insulators and conductors (silver, copper, aluminum, PVC).
2.3 Solve problems involving density and relative density.
2.4 Perform calculations involving torque.
2.5 Perform calculations involving moments for a uniform straight lever.
2.6 Resolve forces into its horizontal and vertical vectors.
2.7 Determine the resultant of a set of co-planar forces acting at a common point using calculations and drawing.
2.8 Solve problems using Newton's Laws of Motion.
2.9 Determine, distance, speed and acceleration graphically.
2.10 Define the following terms (stress, strain, Hook's Law and Young's modulus.
2.11 Solve problems involving direct stress, strain, Young's modulus and factors of safety.
2.12 Calculate the mechanical advantage, velocity ratio and efficiency of a simple machine.
2.13 Solve problems involving gear ratios, pulley sizes and speeds.
2.14 Solve problems involving angular displacement and angular velocity of a rotating shaft.
2.15 Solve problems involving work, power and energy in relation to machines.
2.16 Define and state the effects of friction.
2.17 Solve problems involving friction on a body moving along a horizontal plane.
2.18 Solve problems involving friction on a body moving along an inclined plane.
2.19 Discuss the effects of heat on conducting and insulating materials.
2.20 Solve problems relating to the quantity of heat generated.

2.21 Solve related problems on linear expansion.
2.22 Explain the function of refrigeration lubrication systems.
2.23 Explain the operation of manometers and gauges.
2.24 Solve problems using the gas laws.
2.25 Identify and explain the operation of various types of metering devices.

3. Drawing and Blueprint Reading

3.1 Draw various geometric shapes.
3.2 Identify pipe work valves and control symbols.
3.3 Draw isometric and orthographic views of various components and fixtures.
3.4 Draw floor plans inserting electrical, lighting and switching symbols.
3.5 Draw condensing unit layouts.
3.6 Draw sketches of evaporator systems.
3.7 Make alterations to existing refrigeration plans.
3.8 Use plans to prepare estimates for materials.

4. Safety at work

4.1 Carry out safe working practices to prevent hazards and to ensure the safety of working personnel and members of the public.
4.2 Carry out safe working practices using various equipment/materials to protect surrounding work areas from damage.
4.3 Carry out the safe erection, use and dismantling of scaffold platforms less than 2m high and over 2m high.
4.4 Inspect for faults, set up and safely use steps and ladders in general use.
4.5 Set up safety barriers around refrigeration and air conditioning hazards to protect working personnel and members of the public.
4.6 Select and use protective clothing and safety equipment for specific tasks.
4.7 Locate and manually operate the isolating switch to disconnect a refrigeration/air conditioning system/circuit from the electrical supply.
4.8 Locate and manually operate refrigeration and air conditioning systems service valves to isolate components/fluid circuits for service /maintenance.
4.9 Use and store toxic, hazardous and environmentally unfriendly materials in a safe manner.
4.10 Carry out a risk assessment and prepare a report identifying the potential hazards.

Assessment Details

Methods of Assessment	**End of Term Examination**
Grading Mode	Numeric
Weighting %	100
Pass Mark%	50
Outline Details	2 hrs. Closed book examination. Learners must also compile and maintain a portfolio of evidence to demonstration that all practical competences relating to the learning outcomes were successfully completed. Photographic evidence must be included, showing the learner participating in the various activities. The portfolio should also contain all assessor and internal verification reports