G.C.E. (Advanced Level)

Physics

Practical Instructional Manual

(for the syllabus implemented from 2009)

Department of Science, Health and Physical Education

Faculty of Science and Technology

National Institute of Education

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Department of Science, Health and Physical Education
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Contents

Introduction

Provided inside is a set of instructions for teachers on conducting of practical experiments under the Physics syllabus (2009) for G.C.E. (Advanced Level), grades 12 and 13. Printed in thick black letters under the contents of this syllabus are the recommended minimum quota of laboratory experiments and the teacher demonstrations. A brief guidance of only the laboratory experiments is included here.

Contents herein include some learning outcomes the student could basically achieve by performing each experiment. Also included are the minimum apparatus required for each experiment at laboratory level and instructions for the teacher to guide the students through the experiment. It is expected from the teacher to feed the students with the relevant theoretical knowledge prior to performing the experiment, during the learning - teaching process in the classroom. Other experiments / demonstrations mentioned in the Teacher's Instructional Manual can be utilized to further enhance the practical skills of the students.

However, the teachers have the freedom of constructing other relevant experiments and activities using their own experiences to enlighten the students on the concepts and principles of Physics, without being confined to the instructions provided here.

Experiment No. 1

Measurements using the Vernier calipers

Learning outcomes

- Determines the least count and the zero error of Vernier calipers.
- Uses relevant parts of the Vernier to obtain various measurements.
- Appreciates the importance of using the Vernier calipers to measure small lengths.
- Achieves the skill of using other instruments consisting of Verniers.

Materials and equipments

Vernier calipers, a block of wood of size about 4 x 3 x 2 cm, a PVC pipe of length about 5 cm, a sphere of diameter about 3cm, a hollow cylinder of suitable size

Teaching instructions

Provide instructions to:

- find out the least count and the zero error of the Vernier calipers.
- measure the length, breadth and thickness of the block of wood using the Vernier calipers.
- use the relevant components of the calipers to measure the internal and external diameters and also the length of the PVC pipe.
- obtain relevant measurements to find out the mean diameter of the sphere
- Obtain relevant measurements to find the mean internal diameter and also the mean depth of the cavity of the hollow cylinder.
- tabulate the readings, carry out calculations correctly and also to record the results clearly

and

- Examine the readings recorded and the calculations.

Experiment No. 2

Measurements using the micrometer screw – gauge

Learning outcomes

- Finds the least count and zero error of a micrometer screw gauge.
- Uses micrometer screw gauge correctly taking relevant measurements minimizing the percentage error of measurement.
- Appreciates the importance of micrometer screw guage for taking measurements as small as those of the order $1/100^{th}$ of a millimetre.
- Makes an arrangement using constructive thinking in taking a measurement such as the thickness of a sheet of paper, in order to minimize errors according to the least count of the instrument.

Materials and equipments

A micrometer screw gauge, a thin wire, a small metal ball, a razor blade, a photocopy paper

Teaching instructions

- Provide instructions to students about the way of obtaining the least count of the micrometer screw gauge.
- Enquire about ways of minimizing errors of measurements of given materials and provide necessary instructions.
- Provide instructions for a proper arrangement in measuring the thickness of a sheet of paper, minimizing the error in comparison with the least count of the instrument.
- Check how the readings are recorded and instruct to reveal the least count of the instrument in the recording.

Experiment No. 3

Measurements using the spherometer

Learning outcomes

- Finds the least count of the spherometer.
- Takes measurements correctly using the spherometer.
- Appreciates the importance of the spherometer in determining the radius of curvature of a spherical surface.
- Develops the skill of adjusting the tip of the middle screw to just touch the surface of the relevant surface, when taking measurements.

Materials and equipments

A spherometer, a microscope slide, a watch glass, a piece of flat glass

Teaching instructions

- Instruct students on finding the least count of the spherometer.
- Give instructions to keep the spherometer on the flat glass surface and to take the reading by adjusting the tip of the middle screw to just touch that surface.
- Give instructions to keep microscope slide among the legs of the spherometer and adjust the tip of the middle screw to just touch the surface of the slide and then take the reading.
- Provide instructions to find the radius of curvature of a given curved surface.
- Give instructions to raise the tip of the middle screw before keeping it on the curved surface.
- Instruct as to how to check whether the tip of the middle screw is lowered too much in the adjustment of just touching the relevant surface.
- Provide relevant expression in finding the radius of curvature of the spherical surface.

Experiment No. 4

Measurements using the travelling microscope

Learning outcomes:

- Names the components of the travelling microscope.
- Uses the vertical and horizontal scales of the microscope, to obtain measurements.
- Develops the practical skill of focusing the travelling microscope.
- Develops the skill of obtaining small measurements using a Vernier scale.

Materials and equipments

A travelling microscope, a capillary tube, a rubber tube, a stand

Teaching instructions

- Instruct the students to find the least count of the travelling microscope
- Also instruct them to fix the capillary tube horizontally to be co - axial with the travelling microscope.
- Provide relevant instructions to measure two mutually perpendicular diameters of the capillary tube using the horizontal and vertical scales of the travelling microscope.
- Explain the students how to utilize the cross wires and also the Venire of the travelling microscope in taking measurements.
- Emphasize the special importance of using the travelling microscope in the measurements of the internal diameter and the external diameter of a rubber tube.

Experiment No. 5

Verification of the law of parallelogram of forces and hence determination of the weight of a given body

Learning outcomes

- Takes remedial measures to eliminate any defects such as friction in the pulleys of the parallelogram of forces apparatus, and uses the apparatus appropriately.
- Checks practically the correctness of the equilibrium position obtained
- Marks correctly the perpendicular projection of strings on the paper by using the supplied devices.
- Verifies the law of parallelogram of forces and determines the weight of a given object using the parallelogram of forces apparatus.

Materials and equipments

A parallelogram of forces apparatus, an object of unknown weight (w), three weights of known values (w_1. w_2. w_3), a set square or a short strip of a plane mirror, a half metre ruler, four drawing pins, a white sheet of paper (A 4).

Teaching instructions

- Check the parallelogram of forces apparatus for defects such as friction in the pulleys and give instructions on eliminating them.
- Give instructions as to how to check the accuracy of the equilibrium position after obtaining it.
- Check the ways of obtaining perpendicular projections of strings and provide necessary instructions.
- Check whether appropriate scales are selected in completing parallelogram of forces and give necessary instructions.
- Check the interpretation of the results of the experiment.

Experiment No.6

Determination of the weight of a body using the principle of moments

Learning outcomes

- Develops the skill of balancing the metre ruler on the knife edge.
- Takes distances to masses from the knife edge such that there is a good distribution among readings.
- Appreciates the accuracy of this method compared with the other methods of determining weights.
- Determines the weight of the object using a suitable graph.

Materials and equipments

A metre ruler, a knife edge, an object of unknown weight (glass stopper), a weight of known mass (nearly equal to that of the object), a stand, a piece of light string

Teaching instructions

- Check the way of balancing the metre ruler on the knife edge.
- Check the balancing of metre ruler again after suspending weights from its arms and instruct to keep the knife edge in the same position of the metre ruler as at the beginning.
- Give instructions to select the spread of readings by checking the maximum and minimum values.
- Give instructions to determine the weight of the object by a suitable graph.

Experiment No. 7

Determination of the relative density of a liquid using the U- tube

Learning outcomes

- Sets up the apparatus so that readings can be taken accurately.
- Uses instruments such as the set square to measure accurately readings corresponding to the liquid meniscus and the interface.
- Selects water and liquid volumes so that a better distribution between height of the liquid column and water column can be obtained.
- Compares densities of liquids using a suitable graph.

Materials and equipments

A U - tube, two half metre rulers, coconut oil, water, stands

Teaching instructions

- Check the setup of apparatus and give necessary instructions
- Give instructions to admit a certain amount of water first from one limb of the U - tube and admit coconut oil next from the other limb.
- Check how the readings corresponding to liquid meniscus and interface are taken and give necessary instructions.
- Direct students to compare densities of liquids using a suitable graph.

Experiment No. 8

Determination of the relative density of a liquid using the Hare's apparatus

Learning outcomes

- Determines the relative density of a liquid after a correct understanding of the principle of Hare's apparatus.
- Achieves the skill of obtaining correct measurements in using the same apparatus.
- Appreciates the usage of Hare's apparatus in determining the relative densities of liquids.

Materials and equipments

A Hare's apparatus, water, a solution of Copper Sulphate or any other suitable solution

Teaching instructions

- Enquire whether the students have correctly understood the principle of Hare's apparatus.
- Instruct how to set up the apparatus properly with relevant liquids, to perform the experiment.
- Observe whether the relevant measurements are taken correctly and correct any mistakes.
- Examine the practical record and the final calculations.

Experiment No. 9

Determination of the density of a liquid using a weighted test tube

Learning outcomes

- States that this experiment is based on the principle of floatation.
- Selects the suitable material and the quantity of the material to make the test tube float vertically in the liquid.
- Develops the skill of measuring the diameter of a test tube using the Venier calipers.
- Calculates the gradient and intercept using a suitable graph.

Materials and apparatus

A boiling tube, a tall jar, a box of weights, Vernier calipers, a strip of graph paper with milli- metre markings, a sufficient quantity of the liquid and a quantity of thin sand

Teaching instructions

- Enquire whether the students have understood the theory related to the experiment.
- Observe whether the students take the relevant measurements correctly.
- Direct students to calculate the gradient and the intercept of the graph.
- Discuss the results obtained by students.

Experiment No.10

Determination of the acceleration due to gravity using the simple pendulum

Learning outcomes

- Measures the length of the pendulum correctly up to the centre of the bob
- Fixes the reference pin at the lowest position of the pendulum close to its path
- Selects the number of oscillations according to the least count of the stop-watch in order to minimize the percentage error.
- Oscillates the pendulum by a small angle and measures the time correctly corresponding to the number of oscillations, using stop watch.
- Selects the values of the length of pendulum to obtain a better distribution of readings.
- Finds the acceleration due to gravity using a suitable graph.

Materials and equipments

A simple pendulum, a metre ruler, a stop watch, a reference pin, stands

Teaching instructions

- Check the setup of instruments, and provide necessary instructions.
- Give instructions about the selection of the number of oscillations in order to minimize the percentage error.
- Observe the ways of measuring the time of oscillations and give necessary instructions.
- Direct the students to find acceleration due to gravity using a satiable graph.

Experiment No. 11

Verification of the relationship between a mass suspended from a helical spring and its period of oscillation

Learning outcomes

- Sets up the instruments enabling the time of oscillations to be measured accurately.
- Selects the number of oscillations so that the percentage error of the measured time is minimized.
- Obtains the relevant period of oscillations correctly corresponding to the mass suspended.
- Verifies the relationship between the mass and the period of oscillation using a suitable graph.

Materials and equipments

A helical spring, a set of 50 g weight, a stopwatch, a reference pin, stands

Teaching instructions

- Observe the setup of instruments and give the necessary instructions.
- Direct students to decide by calculation, the number of oscillations which would minimize the percentage error of the time measurement in accordance with the rigidity of the helical spring and the least count of the stop watch.
- Direct the students to take relevant readings for about six values of the suspended mass.
- Give instructions to verify the relationship between the mass and the period of oscillation using a suitable graph.

Experiment No.12

Determination of the frequency of a tuning fork using the sonometer

Learning outcomes

- Decides the variables according to the supplied apparatus to find the relevant quantity
- Develops the skill of tuning the sonometer wire to a given frequency.
- Accepts the importance of the sonometer in the study of the vibrations in strings.
- Finds the frequency of the tuning fork using a suitable graph.

Materials and equipments

A sonometer, a tuning fork of unknown frequency, a set of ½ kg weights, a piece of sonometer wire used, a metre ruler, a triple beam balance

Teaching instructions

- Give necessary instructions on planning the experiment.
- Observe how the gap between the bridges is adjusted to obtain the first state of resonance and provide necessary instructions.
- Direct the students to find the frequency of the tuning fork using a suitable graph.

Experiment No. 13

Verification of the relationship between the vibrating length and the frequency of a stretched wire using the sonometer

Learning outcomes

- Selects from the given set of tuning forks, the one of suitable frequency to be used as the first one.
- Adjusts at the beginning the separation between the bridges to obtain the fundamental note first.
- Obtains accurately the resonance lengths of the sonometer wire for different tuning forks in the descending order of frequencies.
- Verifies the relationship between frequency and vibrating length using a suitable graph.

Materials and equipments

A sonometer, a set of tuning forks, a 2 kg weight

Teaching instructions

- Check whether the tuning fork with suitable frequency is selected to obtain the first reading and give necessary instructions.
- Check whether the resonance state has been obtained correctly.
- Check whether the gap between the bridges has been adjusted to obtain the fundamental state of resonance first, and provide necessary instructions.
- Direct the students to verify the relationship between the frequency and the vibrating length using a suitable graph.

Experiment No. 14

Determination of the velocity of sound in air and the end correction of the tube using a closed tube and one tuning fork

Learning outcomes

- Obtains practically the state of resonance of the air column in a closed resonance tube with a source of sound.
- States that the maximum sound level is produced when the air column in a closed tube resonates with a vibrating tuning fork.
- Calculates the velocity of sound in air and the end correction of the tube.

Materials and equipments

A tube of diameter about 2.5 cm and of length about 50 cm, a tuning fork of known frequency, a half metre ruler, a tall jar, a stand, water

Teaching instructions

- Direct students to prepare a closed resonance a tube out of tube immersed in a jar of water.
- Direct students to vibrate the tuning fork of known frequency and from it obtain the fundamental state of resonance of the closed resonance tube.
- Instruct students to obtain the next state of resonance by increasing the length of the air column.
- Provide relevant instructions to calculate the velocity of sound in air using the corresponding resonance lengths.
- Direct students to calculate the end correction of the tube.
- Examine the results obtained and the calculations.

Experiment No. 15

Determination of the velocity of sound in air and the end correction of the tube using a closed tube and a set of tuning forks

Learning outcomes

- Obtains the state of fundamental resonance of an air column with each vibrating tuning fork out of s set of forks
- Calculates the velocity of sound in air and the end corrections of the tube using a suitable graph.

Materials and equipments

A tube of diameter about 2.5 cm and of length about 50 cm, a set of tuning forks, a half metre ruler, a tall jar, water, a stand.

Teaching instructions

- Direct students to select the tuning fork of the highest frequency from the set, obtain the fundamental stat e of resonance with the air column and then to measure the length of the air column.
- Also direct them to select the other tuning forks in the descending order of frequencies, obtain corresponding fundamental resonance states and measure the resonating lengths.
- Instruct students to construct a suitable graph and to find from it the velocity of sound in air and also the end correction of the tube.
- Advise students to find the percentage error of the variation of the experimentally determined value from the standard value of the velocity of sound.

Experiment No. 16

Determination of refractive index of glass using a rectangular glass block and the travelling microscope

Learning outcomes

- Determines the refractive index of glass using a glass block , making use of the knowledge of finding refractive index from the real depth and apparent depth.
- Develops the skill of correct usage of the travelling microscope.
- Appreciates the utility of the travelling microscope in very accurate measurements of various lengths.

Materials and equipments

A rectangular block of glass, a white sheet of paper, a travelling microscope

Teaching instructions

- Test students' knowledge of the principle of the experiment.
- Observe whether the procedure is followed correctly and adjust any faulty steps.
- Examine the recorded results.

Experiment No. 17

Investigation of the deviation of a ray of light through a prism and hence determination of its angle of minimum deviation

Learning outcomes

- Represents graphically, the variation of deviation of a ray of light refracting thought a prism, with its angle of incidence
- Achieves the skill of locating the paths of rays of lights by means of pins
- Accepts that several methodologies could be employed in determining the refractive index of a material.

Materials and equipments

A glass prism, a drawing board, drawing pins, a while sheet of paper, a ruler , a protractor, a few object pins

Teaching instructions

- Test students' knowledge of the theory of the experiment.
- Explain a suitable method of constructing angles to represent various angles of incidence
- Explain the location of the paths of rays using pins
- Examine the construction of rays after the experiment
- Examine the construction of the graph and calculations recorded.

Experiment No. 18

Determination of the refractive index of the material of a prism by the critical angle method

Learning outcomes

- Presents an alternative method to determine the refractive index of the material of a prism
- Determines the refractive index of that material by so identified method.
- Develops the skill of finding the paths of light rays using pins
- Compares and evaluates various methods of determining refractive indices.

Materials and equipments

A glass prism, a drawing board and drawing pins, Object pins, a white sheet of paper

Teaching instructions

- Test whether the students are thorough with the principle of the experiment.
- Instruct to perform the experiment and do the relevant constructions.
- Examine the ray diagram of the experiment performed
- Examine and comment on the practical record.

Experiment No. 19

Adjustment of a spectrometer and hence determination of the angle of a prism using it

Learning outcomes

- Names the components of the spectrometer.
- Adjusts the telescope for parallel light.
- Adjusts the collimator and the slit properly.
- Levels the prism table accordingly.
- Places the prism on the prism table correctly.
- Records the readings of the Vernier scale that corresponds to the images of the slit formed by reflection at relevant faces of the prism.
- Calculates the angle of the prism from the measurements obtained.

Materials and equipments

A spectrometer, an equilateral prism, a source of light (a filament lamp)

Teaching instructions

- Provide instructions to adjust the telescope for parallel light.
- Examine the adjustment of the collimator and provide necessary instructions.
- Instruct and guide to level the prism table.
- Direct students to observe Vernier scale readings correctly.
- Provide necessary instructions to calculate the prism angle from the measurements obtained and examine the final calculations.

Experiment No. 20

Determination of the angle of minimum deviation of a prism using the spectrometer and finding the refractive index of the material of the prism

Learning outcomes

- Describes the way, the angle of deviation of a ray refracting through a prism varies with the angle of incidence.
- Acquires the skill of determining the angle of minimum deviation of a prism using an adjusted spectrometer.
- Uses correctly the relevant theories to calculate the refractive index of the material of the prism from the angle of minimum deviation thus found and the angle of the prism.

Materials and equipments

An adjusted spectrometer, an equilateral prism, a sodium flame or a sodium vapour lamp

Teaching instructions

- Instruct to place the prism on the spectrometer table accordingly, and to turn the prism table and the telescope simultaneously to find the angle of minimum deviation.
- Direct students to measure accurately, the positions of the image of the slit at the minimum deviation situation and also when the prism is removed, from the scale on the spectrometer.
- Examine the results and the calculations recorded.

Experiment 21 (I)

Location of images formed by a convex lens by the method of no - parallax, and hence determination of the focal length of the lens

Learning outcomes

- Explains how to distinguish between real images and virtual images formed by a convex lens.
- Locates real images by the method of no – parallax
- Locates virtual images by the method of no- parallax (using a plane mirror strip)
- Finds out image distances corresponding to various object distances and using a suitable graph determines the focal length of the lens
- Evaluates the accuracy of the results obtained.

Materials and equipments

A convex lens mounted on a stand, two optical pins, a plane mirror strip and a metre ruler

Teaching instructions

- Provide instructions to set up the apparatus and to identify real / virtual images
- Help to correct any difficulties that occur in obtaining coincidence during the experiment
- Inspect the practical record and guide to correct any errors.

Experiment 21(II)

Location of the images formed by a concave lens and hence determination of its focal length

Learning outcomes

- Explains about the position and nature of the image formed by a concave lens.
- Finds the positions of images by the method of no-parallax (using a plane mirror strip)
- Determines the focal length of the lens by means of a graph after finding the image distances corresponding to various objects distances.
- Evaluates the accuracy of the results obtained.

Materials and equipments

A concave lens, a plane mirror strip, two optical pins, a metre ruler, stands

Teaching instructions

- Provide necessary instructions to set up the apparatus and to identify and observe images.
- Solve any difficulties that would arise in obtaining coincidence during the experiment.
- Examine the practical record, point shortcomings and get them corrected.

Experiment No. 22

Determination of the atmospheric pressure using the Quill tube

Learning outcomes

- Sets up the apparatus so as to obtain readings easily.
- Obtains readings enabling a good distribution among variables.
- Accepts that a small quantity of mercury at a low cost makes this experiment possible.
- Determines the atmospheric pressure from a suitable straight line graph constructed by manipulating the variables.

Materials and equipments

A quill tube, a metre ruler, a clamp stand

Teaching instructions

- Observe whether the instruments are set up correctly and provide necessary instructions.
- Observe how the readings are taken and correct any defects.
- Direct the students to find atmospheric pressure using a suitable graph.

Experiment No. 23

Investigation of the relationship between the volume and temperatures of a gas at constant pressure

Learning outcomes

- Sets up the apparatus appropriately so that the air column stays under water throughout the temperature range within which readings are expected to be taken.
- Obtains the skill of maintaining a constant temperature before taking a reading.
- Obtains the relationship between volume and temperature of the gas using a suitable graph.

Materials and equipments

A thin uniform narrow tube closed at one end with a dry air column trapped by a mercury pellet, a linear scale, a thermometer, a tall beaker with water, a stirrer, a tripod stand, a Bunsen burner, a clamp stand

Teaching instructions

- Check whether all readings are possible with the apparatus set up and provide any instructions if necessary.
- Check whether correct procedures are followed in taking readings and give necessary instructions.
- Direct the students to obtain the relationship between volume and temperature of the gas using a suitable graph.

Experiment No.24

Verification of the relationship between the pressure and temperature of a gas at constant volume

Learning outcomes

- Sets up the apparatus with the bulb of the constant volume gas apparatus completely immersed in water.
- Achieves the skill of maintaining the temperature of water at a constant value before taking readings.
- Achieves the skill of keeping the volume of air inside the bulb constant.
- Verifies the relationship between the pressure and temperature of the gas using a suitable graph.

Materials and equipments

A constant volume gas apparatus, a thermometer, a tall beaker with water, a stirrer, a tripod stand, a Bunsen burner

Teaching instructions

- Check whether the instruments are set up so that readings can be taken easily and give necessary instructions.
- Check whether correct procedures are followed in taking readings and give necessary instructions.
- Direct the students to verify the relationship between the pressure and temperature of a gas using a suitable graph.

Experiment No. 25

Determination of the specific heat capacity of a solid by the method of mixtures

Learning outcomes

- Explains the exchange of heat that takes place when a hot substance is mixed with a cold substance.
- Determines the specific heat capacity of a solid substance using this heat exchange
- Carries out precautions satisfactorily to minimize experimental errors that occur in the above determination.
- Evaluates the accuracy of the final result as due to above precautions.

Materials and equipments

A calorimeter, a stirrer, a Nicholson's heater or any other steam heater (or a boiling tube with a water bath), a quantity of lead shots, water, a balance and a box of weights.

Teaching instructions

- Test whether the students have a clear knowledge of the experimental steps.
- Provide instructions regarding measures of minimizing errors, with special concern on minimizing the heat loss to the surroundings during mixing.
- When marking the practical record, examine especially the correctness of the equation equating the heat gain to heat loss.
- Instruct to find out the percentage error of the value of the specific heat capacity of the substance obtained by the student.

Experiment No. 26

Determination of the specific heat capacity of a liquid by the method of cooling

Learning outcomes

- Constructs the temperature /time graph using suitable scales.
- Explains the importance of uniform stirring of the liquid in the calorimeter.
- States that in this method the rate of loss of heat depends on convection as well as on radiation.
- Calculates the specific heat capacity of the liquid with the help of graphs.

Materials and equipments

A calorimeter (with a lid and a stirrer) having a blackened outer surface, two outer metal vessels (of different sizes), a beaker of water, a beaker of liquid, a thermometer, a stop clock, a triple beam balance, a piece of cardboard with holes drilled at a distance equal to that between the two holes in the calorimeter lid.

Teaching instructions

- Test whether the students have realized the importance of having constant environmental conditions
- Stress the need to have a blackened outer surface of the calorimeter and also the need to have equal volumes of liquid and water.

Experiment No. 27

Determination of the specific latent heat of fusion of ice by the method of mixtures

Learning outcomes

- Explains the exchange of heat that takes place when ice is mixed with water.
- Determines the specific latent heat of ice using the above heat exchange
- Applies satisfactorily precautionary methods to minimize experimental errors in the above determination.
- Compares the determined value of specific latent heat of fusion of ice with its standard value.

Materials and equipments

A calorimeter, a stirrer, a thermometer, water, a quantity of ice ,a few filter papers, a balance, a box of weights

Teaching instructions

- Observe whether the students, having realized the sources of error in the experiment are taking precautionary steps to minimize them.
- Examine the recorded results and check the accuracy of the calculations.
- Instruct to compare the value of the specific latent heat of ice obtained in the experiment with its standard value.

Experiment No. 28

Determination of the specific latent heat of vapourization of water by the method of mixtures

Learning outcomes

- Explains the exchange of heat that takes place when steam is mixed with water
- Determines experimentally the specific latent heat of vapourization of water making use of the above heat exchange.
- Employs satisfactorily precautionary methods to minimize experimental errors that occur during the above determination.
- Compares the value of specific latent heat of vapourization of water obtained in the experiment with its standard value.

Materials and equipments

A calorimeter, a stirrer, a thermometer, water, a steam generator, a steam trap, a triple beam balance (or a chemical balance and a box of weights)

Teaching instructions

- Observe whether the students, being aware of the sources of experimental error, take precautionary steps to minimize them.
- Examine recorded results and check the accuracy of the calculations.
- Instruct to compare the value obtained in the experiment, with the standard value of the specific latent heat of vapourization of water.

Experiment No. 29

Determination of relative humidity of air using a polished calorimeter

Learning outcomes

- Explains the conditions necessary for the formation of dew
- Observes correctly the instant at which the dew begins to form and that at which the dew begins to disappear.
- Calculates the relative humidity of air making use of the dew point.

Materials and equipments

Two polished calorimeters, ice chips, a stirrer, two 0^0 C- 50^0 C thermometers, two stands

Teaching instructions

- Instruct how to lower slowly the temperature of water in the calorimeter by using ice.
- Also instruct to observe correctly the instant at which dew deposits and that at which dew disappears by comparing with the surface of the other calorimeter.
- Direct students to find the relative humidity making use of a S.V.P table and the readings obtained.

Experiment No. 30

Determination of thermal conductivity of a metal by Searle's method

Learning outcomes

- Achieves the ability of practically identifying the thermal steady state.
- Succeeds in controlling the temperature as needed in the thermal steady state with the help of a constant pressure head.
- Determines experimentally the thermal conductivity of a good conductor.

Materials and equipments

A Searle's apparatus of determining thermal conductivity, four mercury – in-glass thermometers, a steam generator, a constant pressure head, Verneir calipers, a stop clock, a beaker, a triple beam balance

Teaching instructions

Provide instructions to

- set up the apparatus correctly.
- identify the thermal steady state by observing the readings of the thermometers.
- utilize the constant pressure - head to control the readings of the thermometers suitably
- obtain and tabulate relevant readings and calculate the thermal conductivity of the metal.

  and
- Examine the results and calculations recorded.

Experiment No. 31

Determination of the internal resistance and the electromotive force of a dry cell

Learning outcomes

- Affects the variation of the current in a circuit by varying its total resistance.
- Connects the voltmeter and the ammeter correctly in a circuit.
- Obtains needed results by plotting the variables suitably in a graph.

Materials and equipments

A dry cell a milli- ammeter, a voltmeter, a rheostat

Teaching instructions

- Supply a circuit diagram as suitable for the experiment.
- Give instructions to connect the circuit correctly.
- Examine and approve the connected circuit.
- Provide instructions to obtain readings by proper adjustments of components and to determine the electromotive force and the internal resistance of the cell with the aid of a graph.

Experiment No.32

Comparison of two resistances using the metre bridge

Learning outcomes

- Connects correctly a circuit according to a given circuit diagram
- Explains the need of and the way of operating a safety device for the galvanometer
- Explains the effect of a series resistance to the sensitivity of the galvanometer
- Uses the metre bridge to compare the values of two resistances.

Materials and equipments

A metre bridge, a sliding key, an accumulator of electromotive about 2 V, a centre zero galvanometer, the two resistances to be compared, a rheostat, a 1000 Ω resistor, two plug keys

Teaching instructions

- Instruct to keep the plug keys open, when connecting the circuit.
- Examine the connected circuit and advise to proceed with the experiment.
- Instruct to use the safety circuit correctly.
- Instruct to find the ratio of the two resistances from the results obtained.

Experiment No. 33

Determination of the temperature coefficient of resistance of a metal using the metre bridge

Learning outcomes

- Connects correctly a circuit relevant to a given circuit diagram.
- Describes how the temperature of a water bath could be controlled.
- Explains the usage of a safety circuit to protect the galvanometer.
- Describes the ways of using the terminals of the resistance box and the plugs.
- Obtains readings suited to construct a graph and from the graph thus constructed determines the temperature coefficient of resistance of the metal.

Materials and equipments

A coil of insulated wire of about 100 Ω , a centre zero galvanometer, a sliding key, two plug keys, an accumulator of electromotive force about 2 V, a thermometer, a calorimeter with a stirrer, a water bath, a tripod, a Bunsen burner., a metre bridge, a 1000 Ω resistor, a 0 – 500 Ω resistance box

Teaching instructions

- Advise to keep all plug keys open when connecting the apparatus.
- Examine whether the supplied apparatus are connected correctly according to the given circuit diagram and make any corrections.
- Guide students to obtain readings necessary for a graph and to determine the temperature coefficient of resistance from a suitable graph.

Experiment No. 34

Comparison of electromotive forces using the potentiometers

Learning outcomes

- Appreciates the importance of the potentiometer in the comparison of electromotive forces.
- Achieves the ability to compare using the potentiometer.
- Achieves the skill of utilizing sensitive equipment with safety.

Materials and equipments

A potentiometer, a 2V accumulator, a Leclanche cell, a Daniel cell , a centre zero galvanometer, a two - way key, a plug key, a 1000 resistor and connecting wires

Teaching instructions

- Supply the circuit diagram relevant to the experiment.
- Provide instructions to set up the potentiometer circuit correctly.
- Provide instructions to be followed to ensure the safety of the galvanometer.
- Examine and approve the circuit set up by the students.
- Instruct to compare the electromotive forces from the relevant readings.

Experiment No. 35

Comparison of resistances using the potentiometer

Learning outcomes

- Sets up a potential dividing circuit to obtain a suitable potential difference
- Uses two way keys as desired.
- Compares resistances using experimental results.

Materials and equipments

A potentiometer, two 2 V accumulators, two resistors to be compared, a two-way key, a 0 - 5 Ω resistance box, three plug keys, a safety resistor of about 1000 Ω which could be short circuited by a plug, a sliding key, a centre zero galvanometer, connecting wires

Teaching instructions

- Supply a circuit diagram to be used for the comparison of resistances.
- Examine the accuracy of the circuit set up by students.
- Examine the record of the results of the experiment.

Experiment No.36

Determination of the internal resistance of a cell using the potentiometer

Learning outcomes

- Explains that the terminal potential difference of a cell with an internal resistance varies according to the current flowing from the cell.
- Derives an expression to represent graphically the relationship between the variables.
- Obtains the required result from the graph drawn between the variables.

Materials and equipments

A potentiometer, a 2V accumulator, a dry cell, a 0 - 5 Ω resistance box, two plug keys, a safety resistor (of about 1000 Ω) which could be short circuited by a plug, a sliding key, a centre zero galvanometer, connecting wires

Teaching instructions

- Supply the circuit diagram required for the experiment.
- Provide instructions to vary the resistance of the resistance box to obtain a suitable balance length.
- Give instructions to derive the expression to be used in the construction of the graph.
- Examine the practical record.

Experiment No. 37

Determination of very small electro- motive forces (of thermo-couples) using the potentiometer

Learning outcomes

- Explains why the normal potentiometer is not suitable to measure very small electro-motive forces.
- Re-adjusts the potentiometer to measure very small electromotive forces and calibrates it.
- Sets up the potentiometer along with the thermo-couple and obtains necessary measurements.
- Exhibits skills of utilizing methodologies of obtaining more accurate results from the materials and apparatus supplied.

Materials and equipments

A potentiometer (the resistance of the wire being known), a 2 V accumulator, a thermo-couple, a standard cell, two resistance boxes, a centre zero galvanometer, a sliding key, two plug keys, a safety resistor of about $1000\,\Omega$, connecting wires

Teaching instructions

- Enquire from students about reasons as to why the normal potentiometer is unsuitable to measure very small electromotive forces.
- Explain with the help of a circuit how to re-adjust and calibrate a potentiometer to measure very small electromotive forces.
- Advice to adjust the values of the resistances of the boxes so that the balance point during the calibration would be close to the midpoint of the wire. Enquire the reason for this adjustment.
- Supply a circuit diagram for the measurement of the electro-motive force of a thermo-couple.
- Examine the accuracy of the circuit set up by the students.
- Examine the results recorded by students.

Experiment No. 38

Construction of the *I-V* curve of a semiconductor diode

Learning outcomes

- Connects diode, ammeter, voltmeter, rheostat, cells and resistance correctly according to a given circuit
- Uses rheostat as a potential divider.
- Uses a milli-ammeter to measure a small current and voltmeter to measure potential differences.
- Identifies knee voltage/ cut in voltage of a diode using the *I -V* curve.

Materials and equipments

A 1N4001 doide, a 7.5 V storage cell, a 0-1V voltmeter, a 1000 Ω rheostat, a 100 Ω 1 W resistor, a 0-50 mA milli-ammeter, connecting wires

Teaching instructions

- Provide a suitable circuit diagram to students for obtaining *I-V* curve of a diode.
- Direct the students to connect the components correctly in a circuit according to the relevant circuit diagram.
- Check the circuit connected by the students.
- Give instructions to students about the voltage range within which the voltage should be changed when taking readings after exceeding the knee voltage / cut-in- voltage.
- Guide the student to obtain *I - V* curve practically and using that curve to identify the knee voltage /cut-in voltage.

Experiment No. 39

Construction of the transfer characteristics curve between I_B and I_C using a transistor as an amplifier in the common emitter configuration

Learning outcomes

- Explains the way in which a variable resistance can be used as a potential divider.
- Identifies the terminals of a transistor and connects up correctly in a circuit.
- Explains using the graph that a transistor acts as an amplifier due to a large variation of I_C by a small variation of I_B.

Materials and equipments

A 0-5 V voltmeter, a 2 kΩ variable resistor, a 1 kΩ variable resistor, a 56 kΩ resistance, a 0-100 μA ammeter, a 0-10 mA ammeter, two 6 V storage cells, a 2SD400 transistor

Teaching instructions

- Provide needed circuit diagram.
- Check whether the circuit is connected correctly and correct if necessary
- Give instructions to take data for I_B and I_C by changing I_B in μA until the value of I_C is 5 mA.
- Give instructions to draw the graph after recording the results for I_B and I_C.
- Examine the graph drawn.

Experiment No. 40

Experimental investigation of the truth tables of simple logic gates

Learning outcomes

- Identifies and states the truth tables of basic logic gates NOT, AND, OR, NAND and NOR by obtaining them practically.
- Obtains the ability of identifying the pins of integrated logic circuits and using them practically in circuits.
- Describes the differences in the practical usages of gates of TTL (7400) series and CMOS (4000) series in integrated circuits.

Materials and equipments

Four TTL IC's of 7400, 7402, 7408, 7432 (or four CMOS IC's of 4001, 4011, 4071, 4081), three red LED's, four 330 Ω $\frac{1}{2}$ W carbon resistor, two 100 kΩ $\frac{1}{8}$ W carbon resistors, a circuit board, a +5V regulated power supply, connecting wires.

Teaching instructions

- Supply the relevant circuit diagram.
- Give instructions to build up the circuit on the circuit board by fixing integrated circuits and relevant instruments correctly.
- Give instructions about the voltage to be supplied to the circuit according to the integrated circuit used TTL (7400) or CMOS (4000).
- After completing the circuit, check it, give instructions for correction if needed and approve it.
- Give instructions to build up practically the truth tables of the gates according to the given instructions
- After recording the inferences check and approve it.

Experiment No. 41

Determination of the Young's modulus of a metal (steel) in the form of a wire

Learning outcomes

- States that the principle of the Vernier is being used to measure small extensions in this experiment.
- Appreciates the value of the micrometer screw gauge in the measurement of the diameter of the wire.
- Explains the necessity of using two wires to minimize errors arising due to changes of temperature.
- States the importance of suspending the wires from a rigid bar.

Materials and equipments

Two thin uniform wires of length about 3 m and diameter about 0.5 mm each and suspended from the same rigid bar, a metre ruler, a micrometer screw gauge, a millimetre main scale with a Vernier scale, a pan and a set of ½ kg weights

Teaching instructions

- Instruct to select a suitable initial weight to maintain the wire used in the experiment rid of kinks.
- Instruct to take readings of the Vernier while adding weights as well as while removing weights.
- Instruct to obtain the mean extension of the wire.
- Examine the record of the experiment.
- Compare the value obtained for Young's modulus of steel with its standard value.

Experiment No. 42

Determination of the coefficient of viscosity of a liquid (water) by the capillary flow method using Poiseuille's formula

Learning outcomes

- Uses a constant pressure apparatus to maintain a uniform liquid flow.
- Measures very accurately the internal diameter of a capillary tube.
- States the necessity of suspending a piece of a string at the end of the capillary tube.
- Calculates the viscosity of water using Poiseuille's formula.

Materials and equipments

A capillary tube of length about 25 cm, a constant pressure apparatus, a measuring cylinder of 100 ml, a wooden stand, a stop clock, a travelling microscope, a piece of a string, a piece of rubber tubing (of same radius as capillary tube), dilute Nitric acid and dilute solution of Sodium Hydroxide.

Teaching instructions

- Instruct to clean the capillary tube.
- Instruct to adjust the constant pressure apparatus to maintain a streamline flow.
- Instruct to fix the capillary tube horizontally.
- Instruct to use the travelling microscope to measure the internal diameter of the capillary tube.
- Examine the recorded results.

Experiment No. 43

Determination of surface tension of water using a microscope slide

Learning outcomes

- Explains how to clean the glass slide.
- Measures accurately the length and thickness of the glass slide using the Vernier caliper and micrometer screw gauge.
- Uses suitable methodology to determine the force due to surface tension acting on a microscope slide touching a water surface.
- Calculates the surface tension of water from the relevant readings obtained.

Materials and equipments

A microscope slide, a beaker, a chemical balance (or a three beam balance), Vernier calipers, a micrometer screw gauge, a piece of thin thread, a suitable gum for fastening, dilute Nitric acid , dilute solution of Sodium Hydroxide, pure water

Teaching instructions

- Instruct students to clean the glass slide.
- Instruct students to hang the slide vertically from the balance using the thread and to balance it.
- Instruct next to make the lengthy edge of the slide to touch the water surface and then to find out the excess weight required to pull the slide out of the water.
- Also instruct to measure the length and the thickness of the glass slide using suitable instruments.
- Direct students to calculate the surface tension of water using relevant measurements.
- Examine the practical record.

Experiment No. 44

Determination of the surface tension of a soap solution using a wire frame

Learning outcomes

- Attains the competency of forming the correct set up from the given equipment.
- Describes how the surface tensional forces act on the wire frame.
- Develops the skill of measuring a small force from a suitable balance.
- Calculates the surface tension of the solution from the results obtained.

Materials and apparatus

A piece of thin wire, a cotton thread, a Petri dish, a chemical balance (or a three beam balance), a travelling microscope, a soap solution

Teaching instructions

- Instruct students to form the soap solution film on the wire frame and balance it on the balance.
- Emphasize on how to use the balance correctly.
- Instruct on how to use correctly the travelling microscope to measure the length of the horizontal portion of the wire frame.
- Direct students to find the surface tension of the solution from the results obtained and examine final results.

Experiment No. 45

Determination of surface tension of water by capillary rise method

Learning outcomes

- Develops the competency of preparing a given experimental setup.
- Develops the competency of more accurate length measurements using the travelling microscope.
- Develops the skill of cleaning a capillary tube.
- Determines experimentally the surface tension of water making use of the phenomenon of capillary rise.

Materials and equipments

A capillary tube of length about 15 cm, a travelling microscope, a beaker, an adjustable bench stand, a bent pin (to be used as an index), dilute Nitric acid, dilute solution of Sodium Hydroxide, a stand, thin rubber loops

Teaching instructions

- Instruct students to clean the capillary tube.
- Provide instructions to students to set up the apparatus for the determination of surface tension.
- Explain to students the steps to follow in the measurement of the capillary rise of the liquid using the travelling microscope.
- Examine the record of results and conclusions of the experiment.

Experiment No. 46

Determination of surface tension of a liquid by Jaeger's method

Learning outcomes

- Sets up the components of Jaeger's apparatus properly
- Uses the travelling microscope to measure correctly the internal diameter and the height immersed in the liquid of the capillary tube.
- Measures the difference in heights of the liquid columns of a manometer.
- Determines the surface tension of a given liquid utilizing the readings and data obtained from Jaeger's method.

Materials and equipments

A Jaeger's apparatus, a beaker, the liquid of which surface tension is required, a manometer liquid of low density, a travelling microscope, two stands, a block of wood or a bench of variable height.

Teaching instructions

- Instruct students to set up properly the Jaeger's apparatus to determine surface tension
- Instruct students to control the rate of formation of air bubbles at the end of the capillary tube immersed in the given liquid, in order to take measurements conveniently.
- Instruct students to measure the maximum pressure produced during the formation of the air bubble at the end of the capillary tube using the manometer.
- Also instruct to measure using the travelling microscope, the height of the tube immersed in the liquid.
- Examine the practical record.