General Physics & Electronics

Lab Manual – Undergraduate Physics (Complementary) Programme

MALINI K A - MINI KRISHNA K
LAVEENA VARGHESE - SANTHOSH P JOSE

VIMALA PUBLICATIONS

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(Lab Manual for Undergraduate Physics – Complementary Programme)

Malini K A - Mini Krishna K – Laveena Varghese – Santhosh P Jose

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(Lab Manual for Undergraduate Physics – Complementary Programme)

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To our beloved students….

PREFACE

Post Graduate and Research Department of Physics, Vimala College is proud to come up with a lab manual for General Physics & Electronics, a practical paper for the Undergraduate Physics students of the complementary programme. This compilation aims to present the theory and procedures of the undergraduate experiments prescribed in the 2019 syllabus revision in a simplified manner. The manual is structured in a way to incorporate relevant theory, procedure, diagrams and graphical representations of each experiment. A brief idea on how to perform the calculations from the recorded observations is provided as and when required. Necessary tips, viva questions and model questions pertaining to each experiment have been included. The standard operating procedures (SOP) to be adopted while in laboratory, other relevant physical data and pictures of components are also incorporated as appendix to give the students further insight on lab experiments explained in the book.

We wish that the book unveils the joy of experimentation to the physics students at the under graduate level.

Department of Physics

Vimala College

ACKNOWLEDGEMENT

The authors would like to place on record their sincere appreciation to Dr Sr Beena Jose, Principal, Vimala College (Autonomous), Thrissur for the unstinted support extended for the successful completion of the Lab Manual for Undergraduate Physics – Core Programme. The authors heartfully acknowledge the financial support extended under DBT STAR college scheme for the publishing of the current lab manual. Special appreciation to Dr Sr Silvy Mathew, Co-ordinator, DBT STAR college Scheme, Vimala College (autonomous), Thrissur for the support and guidance. Special thanks to Sr Jisna Jose, Librarian, Vimala College (Autonomous), Thrissur for the support extended in regard to the publication of the lab manual. We express our gratitude to Union press and MMB (Malabar Missionary Brothers) offset printers for helping us with the printing of this book. The authors also remember with thanks the effort put in by our under-graduate and post-graduate students for their creative contributions. Special word of appreciation to Ms. Aswathy M, our M.Sc. student for sincerely rendering her effort towards the final compilation of the book. Finally, warm words of cheers to all the faculty of the Department for making genuine efforts to make this possible.

Department of Physics

Vimala College

Semester 1 to 4 - Complementary Course V

PHY4C05: PRACTICALS I

36 hours in each semester (Credit - 5)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Apply and illustrate the concepts of properties of matter through experiments	**AP**	**P**	**36**
CO2	Apply and illustrate the concepts of electricity and magnetism through experiments.	**AP**	**P**	**36**
CO3	Apply and illustrate the concepts of optics through experiments	**AP**	**P**	**36**
CO4	Apply and illustrate the principles of electronics through experiments	**AP**	**P**	**36**

List of experiments

1. Characteristics of Diode and Zener diode
2. Liquid lens - Refractive index of liquid and glass
3. Torsion pendulum - Rigidity modulus
4. Spectrometer - Refractive index of the material of prism
5. Deflection Magnetometer - Moment of a magnet (Tan A & Tan B positions)
6. Potentiometer - Measurement of resistance
7. Young's modulus – Uniform bending – using optic lever
8. Static torsion – Rigidity modulus
9. Spectrometer – Grating - Normal incidence
10. Melde's string - Frequency of fork (Transverse and Longitudinal mode) - (Mass determination by equal oscillation method / digital balance)
11. Half wave rectifier and Full wave rectifier
12. Field along the axis of a circular coil
13. Deflection Magnetometer - Moment of a magnet (Tan C)

14. Potentiometer - Conversion of Galvanometer in to voltmeter – calibration by standard voltmeter
15. Viscosity of liquid - Capillary flow - Variable pressure head method (Mass determination by equal oscillation method / digital balance)
16. Logic gates – Verification of truth table
17. Carey Fosters bridge - Resistivity of the material of wire
18. Surface Tension - Capillary rise method - Radius by microscope.
19. Young's modulus of a cantilever- Pin and microscope method
20. Potentiometer -Calibration of low range voltmeter
21. Moment of inertia of fly wheel
22. Tangent galvanometer – Reduction factor
23. Searle's vibration magneto meter – Comparison of moments
24. Newton's rings - Wavelength of sodium light

Books of Study:

1. Electronics lab manual - K A Navas (vol 1 & 2)
2. B.Sc Practical Physics - C L Arora

Reference book:

1. Practical Physics - S L Gupta & V Kumar

CONTENTS

Standard Operating Procedures (SOP) of the lab

General instructions regarding Practical Record

1. Attendance is must for all experiments. Students who miss 25% (or, as per the syllabus followed) experiments shall not be permitted to write the exam.
2. Make up labs are not promoted except under unforeseen circumstances.
3. No eating or drinking is allowed during class in laboratory.
4. The grading guidelines shall be strictly followed as per the syllabus followed for each batch.
5. Each student must submit an individual report for every lab paper.
6. Cover page must include title of every experiment, page number and date.
7. Aim, apparatus, theory and principle, relevant diagrams and procedure must be recorded along with the observations, graphs (optional) and result for every experiment.
8. The students must submit attested lab records for the exam.

SOP for the Safety measures to be followed in the lab

1. Be always alert and attentive in the lab. Follow all written and verbal instructions. Never hesitate to ask your doubts.
2. Do not waste electricity, consumables and water.
3. Do not work alone in the lab without prior permission from the teacher in charge / HoD.
4. Report all accidents, injuries or breakage to the teacher in charge/ lab attendant immediately. Also, report any equipment that you suspect is malfunctioning.
5. Avoid wearing overly-bulky or loose-fitting clothing, or dangling jewelry that may become entangled in your experimental apparatus. Pin or tie black long hair.
6. Use goggles:
   a. when heating anything.

b. when using any type of projectile or laser experiments
c. when instructed to do so.

7. Do not perform unauthorized experiments. Get the permission of teacher in charge before you try something original.
8. Be careful when working with apparatus that may be hot. If you must pick it up, use tongs, a wet paper towel, or other appropriate holder.
9. If a thermometer breaks, inform the teacher/lab attendant immediately. Do not touch either the broken glass or the mercury with your bare skin.
10. Ask the teacher to check all electrical circuits before you turn on the power.
11. When working with electrical circuits, be sure that the current is turned off before making adjustments in the circuit.
12. Do not connect the terminals of a battery or power supply to each other with a wire. Such a wire will become dangerously hot.
13. Return all equipment, clean and in good condition, to the designated location at the end of the lab to the concerned staff. Leave your lab area cleaner than you found it.
14. Know locations of laboratory eye wash stations, fire extinguishers and emergency exit routes.
15. Avoid skin and eye contact with all chemicals. Minimize all chemical exposures. Never leave containers of chemicals open.
16. Be vigilant of warning signs when unusual hazards, hazardous materials, hazardous equipment, or other special conditions are present.
17. Do not taste or intentionally sniff chemicals. Never consume and/or store food or beverages or apply cosmetics in areas where hazardous chemicals are used or stored.
18. Wash exposed areas of the skin prior to leaving the laboratory.
19. No cell phone or ear phone usage in the active portion of the laboratories, or during experimental operations.

Appendix

Electronic components are classified into passive and active components. Electronic components that are not capable of amplifying or processing an electronic signal are known as passive components. They conduct current in both the directions. Resistors, capacitors etc. are the examples for passive components.

1. Resistors

A resistor is an electronic component, which has been manufactured with a specified amount of resistance. The resistance value is marked on the resistor in codes using standard colour band. (Symbol used to represent a resistor and how it looks is given in figure 1)

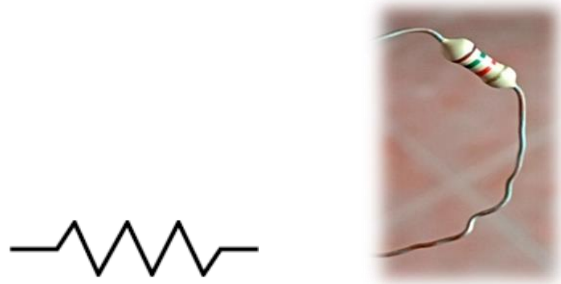
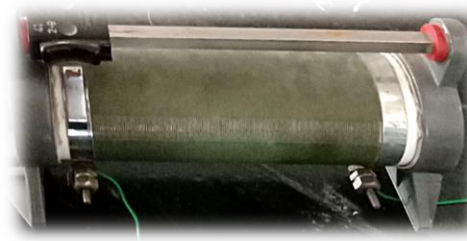


Figure 1. Symbol and photo of a resistor

Variable resistors are usually used in electronc circuits to adjust the values of currents and voltages. Rheostat, potentiometers, trimmers, rotary trimmers etc. some of the variable resistors.

Variable resistance



Rheostat

Figure 2. Variable resistors in use

The value of a resistor is usually identified by its color code. The coding used is depicted in figure 3. The color code can easily be remembered using the acronym: "BB ROY of Great Britain had a Very Good Wife". The way to use the color code is given in figure 4. The fourth ring is known as tolerance ring. This indicates the tolerance in %. Colours for indicating the tolerance value are gold and silver. The gold ring indicates 5% and silver ring indicates 10%.

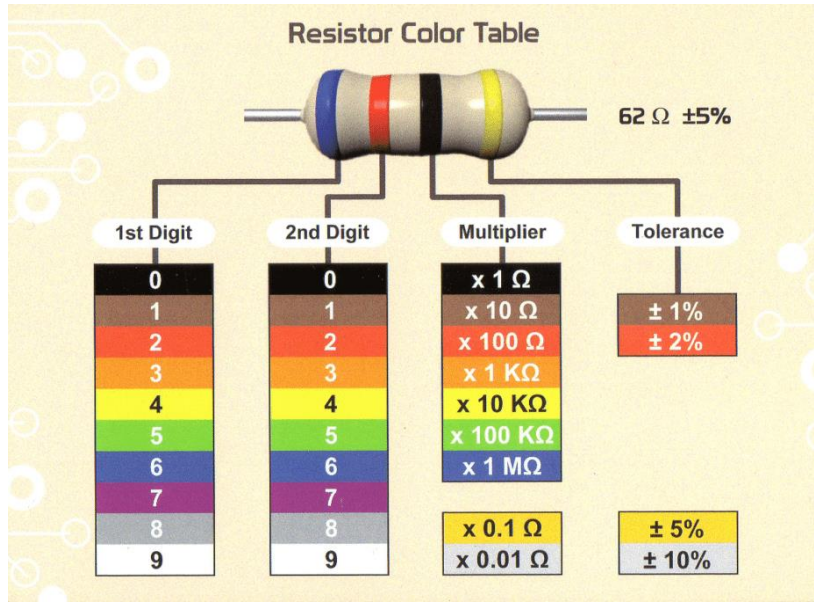
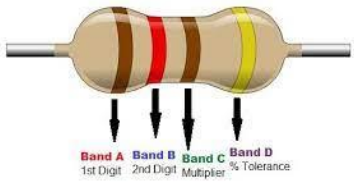


Figure 3. Color coding of a resistor

Consider following resistors

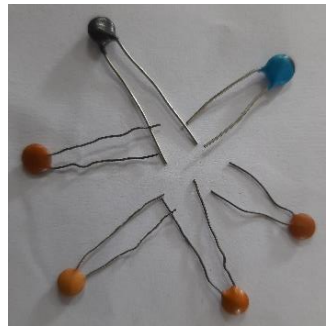


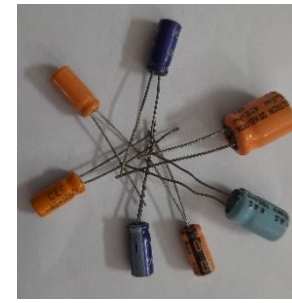
$12 \times 10^1 = 120\ \Omega$ $15 \times 10^2 = 1.5\ k\Omega$ $10 \times 10^3 = 10\ k\Omega$

Figure 4. Using the color code to read a resistor

For example, if a 200 kΩ resistor has a silver ring, the resistor can be used in the range of 180 kΩ to 220 kΩ.

2. Capacitors





Disc / Ceramic capacitor Electrolytic capacitor

Figure 5. Symbol of a capacitor and its various types

There are polar and non-polar capacitors. Example for polar capacitor is the electrolytic capacitor, also called the cylindrical capacitor. Ceramic capacitors are

non-polar capacitors. The coding used to identify the value of a ceramic capacitor is illustrated in figure 6.

$104 \cong 10 \times 10^4$ pF = 0.1 µF $103 \cong 10 \times 10^3$ pF = 0.01 µF $102 \cong 10 \times 10^2$ pF = 0.001 µF

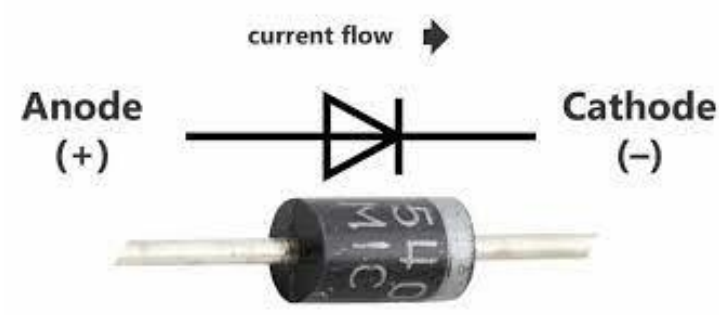
Figure 6. Using the code to read a capacitor

3. Inductor

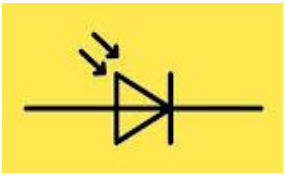
The inductor is a passive component which stores the electrical energy in the magnetic field when the electric current passes through it.

4. Diodes

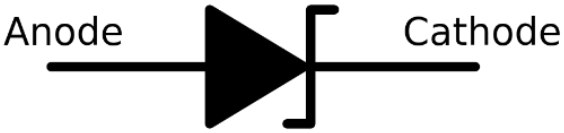
- Semiconductor diode



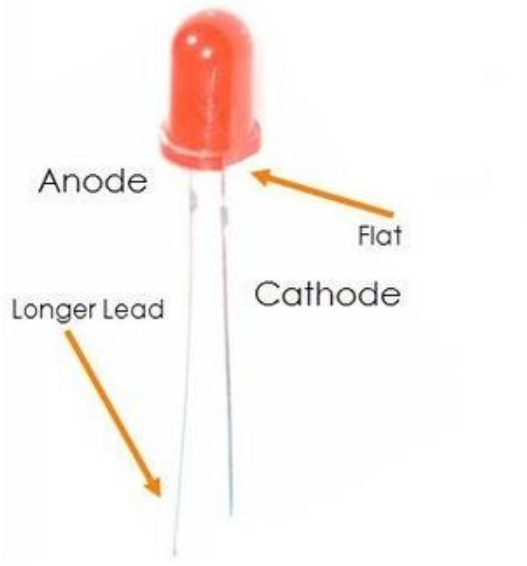
- Photo diode

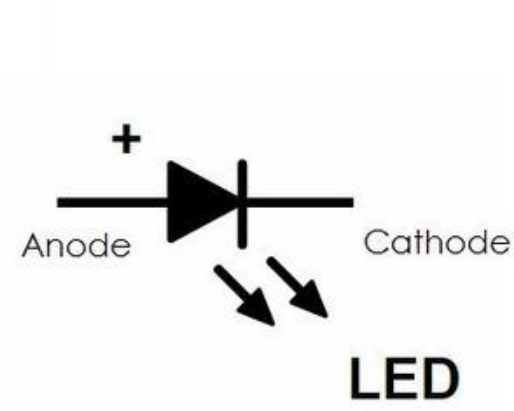


- Zener diode

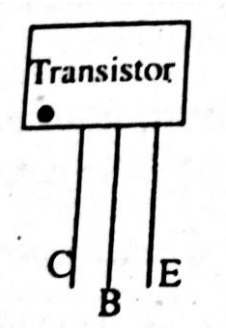


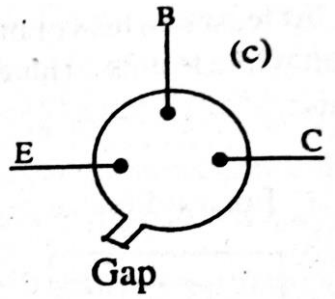
- LED





5. Transistor





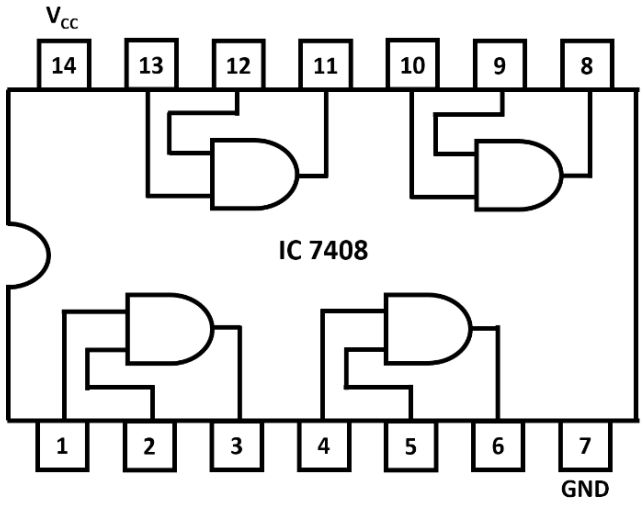
There are two types of transistors: npn and pnp. There are three leads for a transistor namely emitter, base and collector . BC 107 is a npn transistor that we use in our lab frequently.It has a metalcover with a small projection . The terminal near the projection is emitter . Next one is the base and then the collector taken in clockwise order as shown in the figure above.

6. Integrated Circuits (IC)

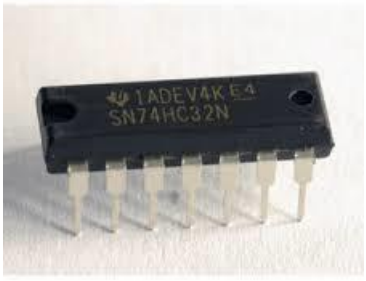
An integrated circuit is an electronic circuit, which contains thousands of diodes, transistor and capacitors in a single chip.

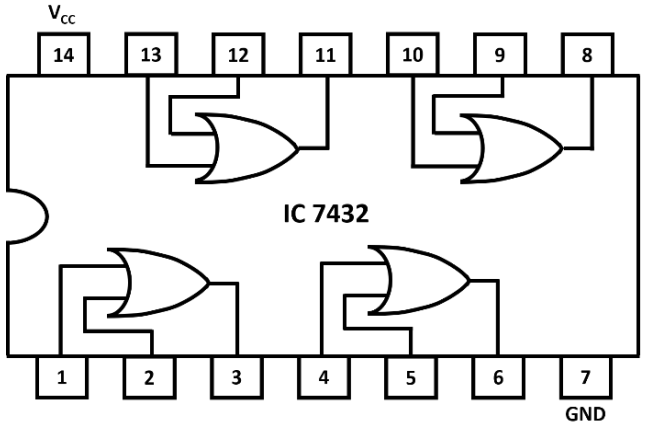
- LOGIC GATES

1. AND GATE (IC7408)

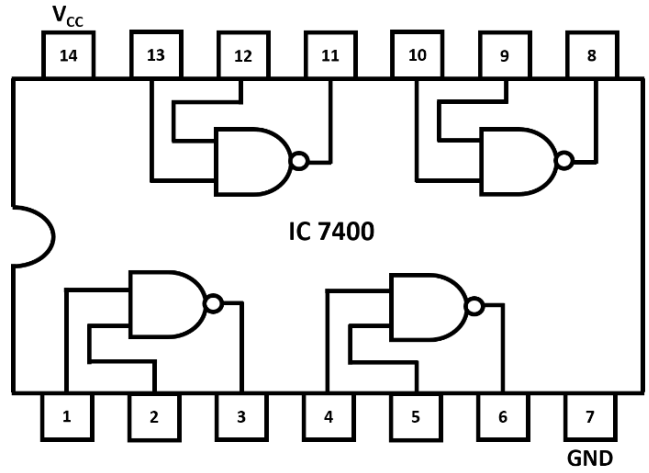


2. OR GATE (IC7432)

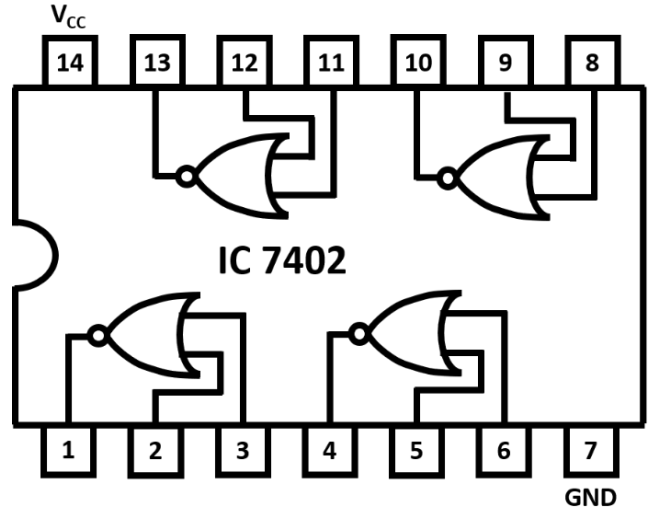




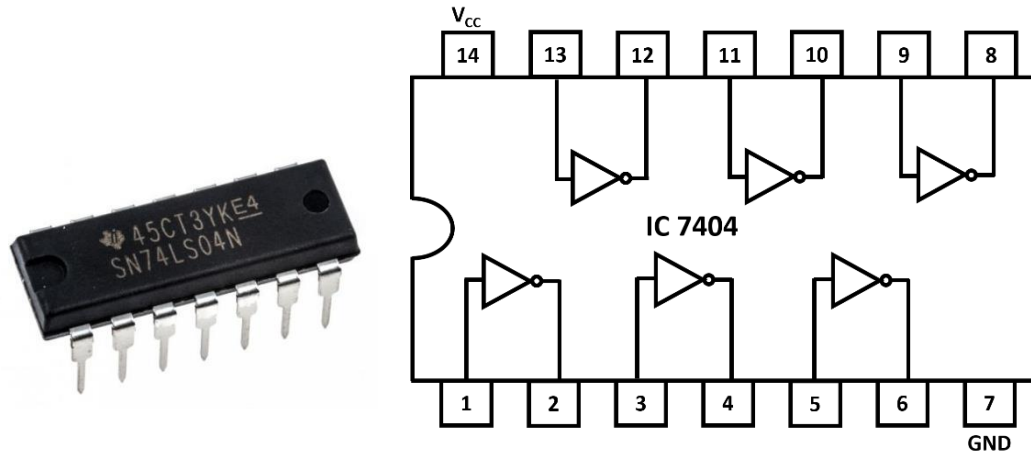
3. NAND GATE (IC7400)



4. NOR GATE (IC7402)



5. NOT GATE (IC7404)



7. Instruments

- **Digital Multimeter (DMM)**

Figure 7. Digital multimeters

- DC/AC Voltage measurement

Connect the red lead V / Ω terminal and the black lead to COM terminal. The range selector is set to DC V or AC V position and the leads of DMM are connected across the voltage source under measurement For safety its better to start from high range. There will be digital display of the voltage. The display 'I' indicates the selector should change to higher range for measurement.

NB: Do not change the selector switch when the test leads are connected to the measuring points.

- DC/AC Current measurement

Connect the red lead to the 'A' terminal and black lead to the COM terminal of the DMM for measurement of current up to 2A. For 2A to 20A range connect the red lead to '20A' terminal.

The range selector switch is set to DC or AC accordingly and connect the leads in series with the load under measurement .The digital display gives the value of current .The display 'I' indicates the selector switch should change to higher range for measurement.If the current is unknown set the range selector switch to high range.

- Resistance measurement

Connect the black lead to the COM terminal and red lead to the V/Ω terminal.Set the range selector switch to the required range and connect the test leads across the resistance to be measured.The digital display will give the value of the resistance.The display'I' indicates the range selector should be changed to higher range.

- Testing of a diode

The black lead is connected to the COM terminal red lead is connected to V/Ω terminal. The range selector switch is set to range and the leads are connected across the diode . DMM displays forward voltage drop in mV and 'OL'or 'I' when the diode is reversed.

- Testing of a transistor

The emitter to base junction and collector to base junction of a transistor have to be checked separately in the same way as the diodes are checked.

- Transistor hFE (hybrid parameter forward current gain, common emitter) checking

The range selector switch is set to the h_{fe} range. Identify the emitter, base and collector terminals of the npn or pnp transistor. Insert the leads into the proper holes in the socket in the front panel. Approximate h_{fe} values are displayed by DMM.

- Capacitor measurement.

The range selector switch is adjusted to the desired capacitance range and the capacitor leads are inserted into the proper holes in the front panel. The DMM will display the capacitor value.

- Continuity measurement.

To verify the shorts and opens in the circuit the selector switch is turned to the  or))) position. A beep sound will be heard if there is continuity or short between the lead tips.

PHYSICAL CONSTANTS

Table 1.1 Physical Constants of Solids

Substance	Density ($\times 10^3$ Kgm^{-3})	Specific heat capacity ($JKg^{-1}K^{-1}$)	Thermal Conductivity ($Wm^{-1}K^{-1}$)	Young's Modulus ($\times 10^{10}$ Nm^{-2})	Rigidity Modulus ($\times 10^{10}$ Nm^{-2})
Aluminium	2.71	913	201	7.1	2.4 – 2.7
Brass	8.5	370	110	10	3.5
Constantan	8.8	420	23	17	
Copper	8.93	385	385	11.7	3.6
Iron cast	7.15	500	75	11	5.3
Iron wrought	7.85	480	60	19.7	7.7 – 8.3
Lead	11.34	126	35	1.8	
Steel	7.86	420	63	21	7
Cork	0.24	2050	0.05		
Glass crown	2.6	670	1	7.1	
Ice	0.92	2100	2		
Paraffin wax	0.9	2900	0.25		
Ebonite	1.8	1674	0.17		
Rubber	0.91	1600	0.15 – 0.19	0.002	
Wood	0.65		0.15	0.12 – 0.18	
Cardboard	0.91		0.21		

Table 1.2 Physical Constants of Liquids

Substance	Density ($\times 10^3$ Kgm^{-3})	Specific heat capacity (JKg^{-1}K^{-1})	Surface Tension ($\times 10^{-3}$ Nm^{-1})	Coefficient of viscosity ($\times 10^{-3}$ Nsm^{-2})
Carbon tetrachloride	1.632	840	26.8	0.972
Coconut oil	0.91	2050		
Castor oil	0.97		33	9.86
Glycerol	1.262	2400	63	1.495
Kerosene	0.8	2093	30	2
Methyl alcohol	0.791	2500	22.6	0.594
Mercury	13.546	140	472	1.552
Water	0.998 – 1	4190	72.7	0.8 - 1
Sea water	1.025	3900		
Soap solution			20 - 40	

Table 1.3 Density of various substances

Substance	Density ($\times 10^3$ Kgm^{-3})	Substance	Density (Kgm^{-3})
Common salt	2.2	Air	1.293
Copper sulphate	2.28	Carbon dioxide	1.977
Granite	2.7	Hydrogen	0.09
Sand	2.6	Helium	0.179
Brick	2.3	Nitrogen	1.251
Sugar	1.6	Oxygen	1.429
Cork	0.24	Water vapour	0.8

Table 1.4 Wavelengths of spectral lines

Mercury spectrum		Colour	Wavelength (nm)
Colour	**Wavelength (nm)**		
Violet I	404.65	Sodium D_1	589.59
Violet II	407.78	Sodium D_2	589
Blue	435.83	H_α red	656.3
Greenish blue	491.6	H_β blue green	486.1
Green	546.07	H_γ blue	434
Yellow I	576.96	H_δ	410.2
Yellow II	579.06	K red	766.5

Table 1.5 Density of materials

Substance	**Density ($\times 10^3$ Kgm^{-3})**
Common salt	2.2
Copper sulphate	2.28
Granite	2.7
Sand	2.6
Brick	2.3
Sugar	1.6
Cork	0.24

Constants to Remember

1. Refractive index of water – 1.33
2. Refractive index of flint glass – 1.60 – 1.62
3. Refractive index of crown glass – 1.52
4. Velocity of light $c = 3 \times 10^8$ m/s
5. Planck's constant $h = 6.626 \times 10^{-34}$ Js
6. Resistivity of Nichrome = 1.1×10^{-6} Ωm
7. $B_h = 3.8 \times 10^{-5}$ T
8. $e/m = 1.758 \times 10^{11}$ C·kg^{-1}
9. Acceleration due to gravity $g = 9.8$ m/s^2
10. Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ H/m
11. Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
12. Ripple factor of half wave rectifier - 1.21
13. Ripple factor of full wave rectifier - 0.482

Conversions to Remember

1. 1 Kg = 1000 g
2. 1 g = 1000 mg
3. 1 cm = 0.01 m
4. 1 mm = 0.001 m
5. 1 pF = 10^{-12} F
6. 1 μF = 10^{-6} F
7. 1 nm = 10^{-9} m
8. 1 μm = 10^{-6} m

MODEL QUESTIONS

1. Draw the forward characteristics of PN junction diode and reverse characteristics of zener diode.
2. Determine the refractive index of the given liquid by forming a liquid lens of Plano-concave in nature.
3. Determine the refractive index of the material of the lens. Convex lens and mercury are given.
4. Determine the material index of the material of the lens. Convex lens and water are given.
5. Determine the rigidity modulus of the material of the given wire using torsion pendulum
6. Determine the refractive index of the material of the prism.
7. Determine the pole-strength of the given magnet using deflection magnetometer arranged in Tan A position. Take six readings.
8. Find out the magnetic moment of the magnet arranging the deflection magnetometer in Tan A position. Take three sets of readings.
9. Find out the magnetic moment of the magnet arranging the deflection magnetometer in Tan A position. Take three sets of readings.
10. Determine the resistance of the given wire using potentiometer. Also find the resistivity of the material of the wire.
11. Determine the Young's modulus of the material of the given bar by subjecting it to uniform bending using optic lever for measuring the elevation at the midpoint (2 sets).
12. Determine the rigidity modulus of the material of the given rod using static torsion apparatus (2 sets).
13. Standardize the given grating using the green line of mercury spectrum and hence determine the wavelength of other prominent lines in the mercury spectrum by normal incidence method.

14. Determine the frequency of a given tuning fork by Melde's arrangement. (Use both modes of vibration)
15. Construct a half wave rectifier and a full wave rectifier and measure the ripple factors for various (six) values of load resistance.
16. Study the variation of magnetic flux density along the axis of a circular coil carrying current.
17. Determine the pole-strength of the given magnet using deflection magnetometer arranged in Tan C position. Verify using Tan A position.
18. Convert the galvanometer into a voltmeter to read 0.1V per division and calibrate it using a voltmeter
19. Determine the coefficient of viscosity of the given liquid by variable pressure head method. Measure the radius using mercury pellet method and mass by common balance (sensibility method).
20. Compare the coefficient of viscosity of two given liquids by the capillary flow method using Poiseullie's formula.
21. Compare the radii of two capillary tubes by capillary flow method using Poiseullie's formula.
22. Construct OR,AND and NOT gates using diodes and transistors and verify the truth table.
23. Determine the resistivity of the material of the given wire by finding the resistance using Carey foster's bridge
24. Determine the surface tension of the given liquid by capillary rise method. The radius of capillary tube is measured by using microscope.
25. Compare the radii of two given capillary tubes by measuring the capillary rise.
26. Compare the surface tensions of the given two liquidsby capillary rise method.
27. Using load-extension curve, determine the Young's modulus of the material of the given bar subjecting it to non-uniform bending. (Pin and microscope are given.)

28. Calibrate the given ammeter and draw the calibration graph.
29. Determine the moment of inertia of a Flywheel.
30. Determine the reduction factor of the Tangent galvanometer for N= …….. turns using potentiometer
31. Calibrate the given low range voltmeter using potentiometer and draw the calibration graph.
32. Convert the galvanometer into a voltmeter to read 0.1 V per division and calibrate it using potentiometer.
33. Determine the Young's modulus of the material of the given bar using it as a cantilever (2 sets).
34. Calibrate the given low range voltmeter using potentiometer and draw the calibration graph.
35. Determine the moment of a given bar magnet using Searle's vibration magnetometer.
36. Compare the moments of the given two magnets using Searle's Vibration magnetometer.
37. Find the radius of curvature of a lens using Newton's rings method. Verify the result.

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Other books published by the authors

- **General Physics I** (Lab Manual for Undergraduate Physics – Core Programme)
- **General Physics II** (Lab Manual for Undergraduate Physics – Core Programme)
- **Electronics & Python** (Lab Manual for Undergraduate Physics – Core Programme)

General Physics & Electronics

Lab Manual – Undergraduate Physics (Complementary) Programme

MALINI K A - MINI KRISHNA K - LAVEENA VARGHESE - SANTHOSH P JOSE

ABOUT DBT STAR COLLEGE SCHEME

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