VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY, BALLARI

Department of Studies in Physics

BACHELOR OF SCIENCE

SYLLABUS

(I to VI Semester)

With effect from 2016-17

B. Sc. Physics Syllabus effective from 2016-17

Semester	Paper code	Title of the paper	Examination duration hours	Max. marks	IA marks	Teaching hours (per week)	Credits
I	PHY101	Paper 1: Mechanics & properties of matter	03	70	30	04	04
	PHYL1	Practical	03	40	10	3x2 = 6	02
II	PHY 201	Paper 2: Heat, thermodynamics, waves & oscillations	03	70	30	04	04
	PHYL2	Practical	03	40	10	3x2 = 6	02
	PHY OET 201	Mechanics and properties of matter	03	70	30	04	
III	PHY 301	Paper 3: Electricity, vector analysis & electromagnetic theory	03	70	30	04	04
	PHYL3	Practical	03	40	10	3x2 = 6	02
	PHY OET 301	Thermodynamics, waves and oscillations	03	70	30	04	
IV	PHY401	Paper 4: Physical Optics, Fibre Optics and computational Physics	03	70	30	04	04
	PHYL4	Practical	03	40	10	3x2 = 6	02
	PHY OET 401	Electronics and Theory of Relativity	03	70	30	04	
V	PHY501	Paper 5.1: Atomic & molecular Physics	03	70	30	04	04
	PHYL5.1	Practical	03	40	10	3x2 = 6	02
	PHY502	Paper 5.2:Statistical mechanic, quantum mechanics and Electronics I	03	70	30	04	04
	PHYL5.2	Practical	03	40	10	3x2 = 6	02
	PHY OET 501	Atomic, energy and astrophysics	03	70	30	04	
VI	PHY601	Paper 6.1: Nuclear physics, solid state physics, astrophysics & biophysics	03	70	30	04	04
	PHYL6.1	Practical	03	40	10	3x2 = 6	02
	PHY602	Paper 6.2: Materials science & Electronics-II	03	70	30	04	04
	PHYL6.2	Practical	03	40	10	3x2 = 6	02
						Total	**48**

C. INSTRUCTIONS TO TEACHERS

1 Lectures must be delivered on all the topics in the syllabus. Use only SI units.

2 The allotted hours for each chapter are only the teaching hours. If required, extra classes can also be engaged with the permission of the Head of the Department/Principal.

3 Complete teaching notes should not be dictated in the class. Notes in the form of highlights may be distributed.

4 A good number of problems must be solved on all possible topics in the syllabus so that the students can appreciate the concepts, phenomenon, ideas and theories and also get acquainted with physical quantities and their units.

5 Home work in the form of assignments/problems must be given to the students.

6 Class seminars by the students be conducted. Participation of students in the conferences, Science exhibitions etc., be encouraged.

7 A good number of problems must be solved on all possible topics in the syllabus so that the students can appreciate the concepts, phenomenon, ideas and theories and, get acquainted with physical quantities and units.

D. LABORATORY INSTRUCTIONS TO STUDENTS

1 Measurements and results must be written in SI units only.

2 Required number of experiments in each semester must be performed in order to be eligible for taking semester end examination.

3 Measurements, calculations and results must be recorded in the observations book first and get them verified and signed by the course teacher in the Laboratory. After that, they can be copied to the Practical Journal.

4 After completing all the experiments in the given semester and writing up the Journals, students have to get certify their Journals by the Head of the Department after due verification by the concerned teachers.

5 An internal practical test for 15 marks in each semester shall be conducted and all the students must have to appear for the test. For absentees, it cannot be conducted again under any circumstances.

6 Candidates will be permitted to take Semester end practical examinations only if they produce a certified Practical Journal. If the candidate fails produce the certified journal and produces a letter from the Head of the Department/Principal to the effect that he/she has completed the concerned practical course, then the candidate will be allowed for the examination. However, such candidates will loose marks prescribed for the journal.

E. SCHEME OF EXAMINATION

In each course (paper), there shall be an **Internal Test** and **Semester End Examination**. Internal Test (one hour duration) shall be conducted for **30** marks in theory courses and **10** marks (three hours duration) in practical courses. Similarly, Semester End Examination shall be conducted for **70** marks in theory courses and **40** marks in practical courses. Division of marks in practical examinations is detailed below.

Internal Practical Test			Semester End Practical Examination		
No.	Item	Max.marks	No.	Item	Max.marks
1	Journal	02	1	Journal	08
2	Experimental skill	02	2	Circuit diagram / ray diagram / Measurements	08
3	Measurements	02	3	Experimental skill	08
4	Graph/calculation/result	02	4	Graph/calculation/result	08
5	Viva	02	5	Viva	04
			6	Procedure	04
		10			**40**

B. Sc (Semester I) Examination
Optional-PHYSICS

Model Question Paper for Semester End Examination

Paper1: Mechanics and Properties of matter

Time: 3 hours **Max. Marks: 70**

Instructions: 1. Answers all the questions of Section A.
2**.** Answer any five questions from Section B and four questions from Section C.

SECTION-A

Marks

1. What kind of force is responsible for whirlwinds and cyclones? (1x15)

   Ans: Corioli's force.

2. Why centripetal and centrifugal forces do not constitute action and reaction pair?

   Ans: They cannot form action and reaction pair because both the force act on the same body.

3. Two similar spheres A and B suffer head-on elastic collision. If their respective velocities before the collision are $2ms^{-1}$ and $3ms^{-1}$, what is velocity of A just after the collision?

   Ans: The two bodies exchange their velocities during the elastic head-on collision. Therefore, the velocity of A soon after the collision becomes $3ms^{-1}$.

4. What is the force that controls the planetary motion.

   Ans: Gravitation.

5. Name the liquid for which liquid the angle of contact is obtuse.

   Ans: Mercury.

6. Give the limiting values of Poison's ratio.

   Ans: The limiting values of Poison's ratio, σ, is $-1<\sigma<1/2$

7. Why the race-tracks are saucer shaped?

   Ans: To provide essential centripetal force and thereby avoiding the vehicle Skidding

8. Mention the advantage of using I-section girders.

   Ans: To save the money and material without compromising quality.

9. State the condition for dynamic equilibrium of a body.

   Ans: The body must have a uniform velocity.

10. Mention the condition for a closed orbit.

    Ans: For a closed orbit such as elliptical path, the satellite must possess a net negative energy, E. i.e., E ‹ 1

11. Steel is more elastic than rubber- give justification for this statement.

    Ans: The elasticity is measured not by the amount of deformation suffered by the degree recovery. When the steel and rubber are deformed to the same extent,
    The steel regains its original shape and size more than that of rubber.
    Therefore, steel is considered to be more elastic than rubber.

12. What is multistage rocket?

    Ans: A multi-stage rocket is a combination of rockets joined one inside other so that it reaches its destiny in a more than one stage.

13. What is the weight of a body of mass 10kg on a lift falling under the action of gravity?

    Ans: Zero

14. If ‘a’ is the amplitude of the particle performing simple harmonic motion, then at what distance form the mean position the particle has its kinetic energy is equal to potential energy.?

    Ans: We have, $E_k = \frac{1}{2} m\omega^2 \left(a^2 - y^2\right)$ and $E_p = \frac{1}{2} m\omega^2 y^2$

    when, $E_p = E_k$ then we get $y = a/\sqrt{2}$

15. Write the general expression for the excess pressure inside a curved surface.

    Ans: $\Delta p = T(1/R_1 + 1/R_2)$

SECTON –B (Solve any five)

16.	Write a note on a geo-stationary satellite.	(5)
17.	State and prove parallel axes theorem.	(5)
18.	Derive an expression for couple per unit twist.	(5)
19.	Describe single stage rocket and derive an expression for its velocity neglecting the weight of the rocket.	(5)
20.	What is a frame of reference? Deduce Galilean transformation equations for length, velocity and acceleration.	(5)
21.	Derive a general expression for the pressure within the curved surface of a liquid.	(5)
22.	Show that the velocity after a perfect plastic collision between two bodies is zero in the centre of mass frame of reference.	(5)

SECTION-C (Solve any three)

23.	Deduce expressions for radial and transverse components of velocity and acceleration.	(10)
24.	a) Derive Poiseuille's equation for a steady flow of liquid through a capillary tube. b) A coin of 2gm is pushed down on a vertical spring compressing the spring by 1cm. The force constant for the spring is $40Nm^{-1}$.How far from this position will the coin go up if it is released?	(7+3)
25.	a)Describe Boy's method to determine the universal gravitational constant G. b) The earth is revolving around the sun in circle of radius 1.5×10^{11}m. Find the mass of the sun. Given; G =$6.67x10^{-11}$ SIU	(8+2)
26.	a) Give the theory of compound pendulum. b) A thin uniform bar of 1.20m is oscillating about one end in a vertical plane. Find the period of oscillation and locate the point of oscillation.	(7+3)
27.	a) Obtain an expression for the bending moment of a rectangular beam. b) The length of a wire increases by 8 mm when a load of 3kg is hung. If diameter of the wire is doubled and rest of the conditions are the same then what is the possible extension in the wire?	(7+3)

Instruction to the paper setter: The questions of Section A should not be of objective type. They must test the students for their understanding of Physics concepts/phenomenon/theory and Scientific reasoning. Each chapter in the syllabus must be represented in the question paper proportionate to the teaching hours prescribed against it.

VIJAYANAGAR SRI KRISHNADEVARAYA UNIVERSITY, BELLARY

Syllabus for B.Sc Semester I

Optional Physics

PHY101 : Paper 1: Mechanics & Properties of Matter

Total hours of teaching: 50

1. **Frames of Reference** **8 hrs**

Inertial frames. Galilean transformation equation for position, length,velocity, momentum, acceleration. Non inertial frames, fictitious force, Rotating frame of reference, concept of Corioli's force (derivation) and effects of Corioli's force. Centre of mass and it's characteristics. Motion of centre of mass and centre of mass as frame of reference.

2. **Conservation laws** **14 hrs**

Linear momentum

Law of conservation of linear momentum. Elastic collision; head-on collision. Newton's law of impact.Inelastic collision-expression for the loss of kinetic energy in one dimension.

Conservation of momentum in case of variable mass. Examples: single stage rocket,- expression for velocity and multi stage rocket.

Angularmomentum

Angular momentum-relation to angular velocity and torque. Conservation of angular momentum. Illustrative examples such as. Ballet dancer, skating motion of a planet around the sun (proof of Kepler's second law of planetary)

Energy

Conservation of energy as a basic principle. Illustrations with verification of law of conservation of energy for a particle executing Simple Harmonic Motion and spiral spring.

3. **Rigid bodies** **10 hrs**

Rotational motion about an axis, concept of moment of inertia (MI), radius of gyroton, $L = I\omega$, $\tau = I \times Mg$, Perpendicular and parallel axes theorems with proof. Calculation of moment of inertia of thin uniform rod, uniform bar of rectangular area of cross section, circular disc,

annular ring, solid sphere and hollow cylinder-extension to the solid cylinder as a special case of hollow cylinder. Theory of compound pendulum and its properties. Bar pendulum and fly wheel (theory and experiment).

4. **Elasticity** **10 hrs**

Review of elastic behavior of solids in general, origin of elastic forces, stress- strain diagram, elastic limit and hook's Law. Moduli of elasticity, Poisson's ratio, relation among elastic constants: $k = y/(1-2\sigma)$, $n = y/2(1+\sigma)$ & $3/y = (1/n) + (1/3k)$

Torsion; Expression for couple per unit twist. Torsion pendulum theory and experiment. Work done in stretching and twisting a wire. Bending: Bending moment, mention of expression for bending moment, theory of light cantilever, uniform bending –beam loaded at

the centre and I-section girder.

5. **Gravitation** **3 hrs**

Newton's law of gravitation, Kepler's laws of planetary motion explanation without derivations, elements of satellite motion and geostationary satellite.

6. **Viscosity** **5 hrs**

Streamline, turbulent motion, critical pressure and equation of continuity. Coefficient of viscosity. Poiseuille's equation (derivation). Motion of a body in a viscous medium, stokes' law, terminal velocity and its significance. Effect of temperature on viscosity of liquids (qualitative).

PHYL1: Practical Course for Semester I

Instructions

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 12 experiments from the list mentioned below should be performed in semester I. Of these, one experiment can be open ended type (Course teacher may develop a new innovative experiment and introduce into the course). Open ended experiment must also be considered for examination.

List of experiments

1. Bar pendulum- T versus L graph.
2. Bar pendulum- L^2 versus LT^2 graph.
3. M.I. of fly –wheel.
4. Moment of inertia of an irregular body.
5. Torsion pendulum –Rigidity modulus.
6. Verification of parallel axes theorem.
7. Verification of perpendicular axes theorem.
8. Y- by stretching – elongation versus load graph.
9. Verification of Hook's law and determination of unknown mass.
10. Y- by uniform bending – load depression method.
11. Y- by cantilever.
12. Y- by oscillation method.
13. Y- by Koenig's method and determination of unknown load.
14. Elastic constants by Searle's double bar.
15. Rigidity modulus by static torsion method.
16. Surface tension and interfacial tension by drop-weight method.
17. Surface tension and angle of contact by Quincke's drop method.
18. Coefficient of viscosity by Stokes' method.
19. Viscosity by poiseuille's method.
20. Determination of g and unknown mass by spiral spring.
21. Critical pressure for stream line flow.
22. Radius of capillary tube by mercury pellet method.

Reference books

1. Mechanics by D.S. Mathur
2. Mechanics by J.C. Upadhaya
3. Properties of matter by D.S. Mathur
4. Properties of matter by Brijlal & Subrmanyam
5. Physics for Degree Students (B.Sc. I year) by C.L. Arora and P.S Hemne
6. Physics Vol. I by Resnick by Halliday and krane
7. Berkely Physics Vol I

Syllabus for B. Sc. II Semester
Optional Physics
PHY 201: Paper 2: Heat & Thermodynamics, Waves & Oscillations

Total hours of teaching: 50

1. **Thermodynamics** **12 hrs**

First law of thermodynamics and its applications like C_p-C_v = R & L (latent heat).Work done in isothermal and adiabatic changes. Carnot's heat engine, Carnot's cycle and expression for its efficiency. Principle of refrigeration. Second law of thermodynamics (both Kelvin and clausius statements), Concept of entropy, entropy change in adiabatic and irreversible processes (during radiation and free expansion). Clausius & Clapeyron latent equations variation in melting and boiling points.

2. **Low temperatures** **8 hrs**

Ideal and real gases. Andrew's experiments, porous plug experiment. Expression for temperature of inversion. Principle of regenerative cooling, Linde's air liquefier, liquid nitrogen and liquid helium and their properties. Production of low temperatures by adiabatic demagnetization method. Concept of absolute zero temperature and third law of hermodynamics.

3. **Radiation** **8 hrs**

Black body radiation and the spectrum of energy distribution, Kirchhoff's law of radiation, Stefan's law, Statements of wien's displacement law and Rayleigh-Jeans law, Derivation of Planck's law of radiation, deduction of wien's, Rayleigh-jeans and Stefan's laws from the Planck's law. Radiation pressure (no derivation). Crookes' radiometer.

4. **Oscillations** **6 hrs**

Review of Simple Harmonic Motion (SHM) - derivations of K.E and P.E at any instant. Expression for frequency from the equation $F \propto -x$ (derivation). Theory of superposition of SHMs at right angles to each other- Lissajous' figures. Forced, free and damped vibrations- write their respective differential equations and discuss their solutions in exponential form (qualitative) Resonance (discus amplitude and phase at resonance).

5. **Waves** **6 hrs**

Wave motion, General equation for progressive wave in one dimension, differential form of wave equation, derive relation between amplitude and intensity. Wave groups –wave velocity and group velocity, relation between wave velocity and group velocity.

6. Sound **6 hrs**

Introduction to sound. Expression for the velocity of a longitudinal wave in a gas. Derivation of Newton's formula and discuss Laplace's correction. Effect of pressure, temperature, humidity and wind on the velocity of sound. Theory of stationary waves and beats. Longitudinal waves in a rod: expression for velocity and its harmonics in free- free rod and rod fixed at the middle (qualitative). Laws of stretched strings, transverse waves in a stretched string- expression for velocity and harmonics.

7. **Applied acoustics** **4 hrs**

Requisites of good auditorium. Absorption coefficient, reverberation time, Sabine's formula with derivation.

Reference Books

1. A text book of Heat by D.S. Mathur
2. A treatise on Heat by Shah and Srivastava
3. Heat and thermodynamics by J.B.Rajam
4. Heat and thermodynamics by Brijilal and Subramanyam.
5. A text book of sound by Braijilal and Subramanyam
6. Sound by Khanna and Bedi
7. Waves and Oscillations by A.P.French

PHYL2: Practical course for Semester II

Instructions

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 12 experiments from the list mentioned below should be performed in semester II. Of these, one experiment can be open ended type (Course teacher may develop a new innovative experiment and introduce into the course). Open ended experiment must also be considered for examination.

List of experiments

1. Thermal conductivity of poor conductor (rubber)
2. Thermal conductivity of good conductor by Searle's method.
3. Thermal conductivity of a bad conductor by Lee's method.
4. Emissivity of a surface.
5. Latent heat of steam.
6. Specific heat of liquid by cooling-graphical method.
7. J by electrical method.
8. Ratio of specific heats – Clement and Desorme method.
9. Stefan's constant.
10. Verification of Stefan- Boltzmann law.
11. J by continuous flow method.
12. Platinum resistance thermometer-Determination of boiling point of a liquid.
13. Helmholtz resonator.
14. Laws of transverse vibrations of stretched string using sonometer.
15. Determination of velocity of transverse wave in stretched string using sonometer.
16. Relative linear density using Melde's apparatus.
17. Frequency of electrically maintained tuning fork using Melde's apparatus.
18. Velocity of sound for higher model of vibrations or volume resonator using signal generator.

Syllabus for B.Sc. II Semester
Open Elective
PHY OET 201: Mechanics and Properties of Matter
Total hours of teaching time: 48 hrs

Unit-1 **12 hrs**

1. Units and dimensions **6 hrs**

Units-SI units, Fundamental and derived units, Principal system of unites, Dimensions, dimensional formulae and equations, uses of dimensional equations, Limitations of dimensional Analysis, examples. Precision of measurements, errors in the measurements, Significant figures.

2. Newton's law of motion **6 hrs**

Rest and motion Newton's first law of motion, second law of motion (with illustration) and third law of motion with examples. Limitations of Newton's laws of motion, frame of reference, inertial & non-inertial frames of reference with examples. Circular motion, centripetal and centrifugal forces (qualitative).

Unit-2 **12 hrs**

3. Rigid bodies

Rotational motion about an axis, concept of moment of inertia (MI), radius of gyration, $L = I\omega$, $\tau = I \times Mg$, Perpendicular and parallel axes theorems with proof. Theory of compound pendulum and its properties. Bar pendulum and fly wheel (theory and experiment).Precession, Gyrostat & its applications.

Unit-3 **12 hrs**

4. Surface Tension

Surface tension, cohesive and adhesive forces, Molecular theory of surface tension, angle of contact and surface energy. Effect of temperature on surface tension (qualitative). Interfacial tension and theory and experiment of drop weight method.

Unit-4 **12 hrs**

5. Viscosity

Streamline, turbulent motion, critical pressure and equation of continuity. Coefficient of viscosity. Poiseuille's equation (derivation). Motion of a body in a viscous medium, stokes' law, terminal velocity and its significance. Effect of temperature on viscosity of liquids (qualitative).

Reference books

1. Mechanics by D.S. Mathur
2. Mechanics by J.C. Upadhaya
3. Properties of matter by D.S. Mathur
4. Properties of matter by Brijlal & Subrmanyam
5. Physics for Degree Students (B.Sc. I year) by C.L. Arora and P.S Hemne
6. Physics Vol. I by Resnick by Halliday and krane
7. Berkely Physics Vol I

Syllabus for B.Sc. III Semester
Optional Physics
PHY 301: Paper 3: Electricity, Vector analysis & Electromagnetic theory

Total hours of teaching time:50

1. **Basic Electrical Components** **4 hrs**

Definitions of resistance, capacitance and inductance; colour code and ratings and their defining equations. Ideas of reactance and impedance.

2. **Network Theorems** **6 hrs**

Revision of Kirchhoff's current and voltage laws, Voltage and current divider circuits. Thevenin's, Norton's Reciprocity and Maximum power theorems with examples.

3. **Alternating Currents** **12 hrs**

Expression for mean and rms values. Response of LR, CR and LCR circuits to sinusoidal voltages using j-operator. Series & parallel resonant circuits, band width, Q-factor. Power in electrical circuits, Maxwell and Anderson bridges, Derive expression for L and discuss experimental determination of L by Anderson bridge. RC Filter circuits: High pass & low pass.

4. **Cathode Ray Oscilloscope** **5 hrs**

Construction and working of cathode ray oscilloscope, Expression for electrostatic and magnetic deflection sensitivity, Measurement of voltage, current, frequency and phase of the signals using CRO.

5. **Galvanometers** **5 hrs**

Construction, working and theory of Helmholtz galvanometer, moving coil galvanometer, Dead beat galvanometer and Ballistic galvanometer. Construction and study of simple Analog-multimeter.

6. **Vector Analysis:** **6 hrs**

Review of vector algebra, vector calculus, Scalars and vectors. Gradient, divergence and curl and their physical significance. Vector identities. Statements of Gauss, Stokes' and green's theorems.

7. **Electromagnetic Theory** **12 hrs**

Coulomb's law, electrostatic field, Gauss law, applications of Gauss law, electrostatic potential, poison's & Laplace's equations. Biot- Savart law, Ampere's circuit law and its applications. Concept of dipole, current loop as a dipole. Torque on a dipole. Concept of displacement current. Maxwell's electromagnetic field equations (no derivations). Modified Ampere's circuit law. Wave equation for field vectors. Statement of Pointing theorem and its physical significance. Equation for plane electromagnetic waves in free space. Production of electromagnetic waves. Hertz experiment.

Reference books

1. Electricity and magnetism by K. K Tewari
2. Electricity and magnetism by Sehigal and Chopra
3. Electricity and magnetism by Khare and Srivastav
4. Physics part-II by Halliday and Resnik
5. Electrodynamics by B.B.Laud
6. Fundamentals of Electronics by B.Basavaraj

PHYL3: Practical course for Semester III

Instructions

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 12 experiments from the list mentioned below should be performed in semester III. Of these, one experiment can be open ended type (Course teacher may develop a new innovative experiment and introduce into the course). Open ended experiment must also be considered for examination.

List of experiments

1. Verification of current divider theorem and voltage divider theorem.
2. Verification of Thevenin ‘s theorem and reciprocity theorem.
3. Verification of Norton’s theorem and maximum power transfer theorem.
4. Determination of time constant of an RC circuit (both charging and discharging).

14

5. Frequency of AC using Sonometer.
6. Determination of cut off frequency –RC low pass and high pass filters.
7. LCR series and parallel resonance –determination of resonant frequency, bandwidth and Q-factor.
8. Determination of time period, frequency, amplitude and phase of an ac signal using CRO.
9. Comparison of frequencies by Lissajous figures using CRO.
10. Determination of capacitance using de sauty’s dc bridge using spot galvanometer.
11. De sauty’s ac bridge – determination of capacitance of the given capacitor.
12. Study of variation of thermo emf with temperature.
13. Determination of B_H using Helmholtz galvanometer.
14. Measurement of low resistance.
15. Charge sensitivity of B.G.
16. Dispersive power of prism/grating.
17. Double refraction –determination of and
18. Dispersive power of plane diffraction grating.
19. Diffraction grating –minimum deviation method.
20. Resolving power of prism.
21. Verification of Newton’s formula for the equivalent focal length of two convex lenses separated by a distance (with principle plane, focal plane, nodal planes).

Syllabus for B.Sc. III Semester
Open Elective
PHY OET 301 : Thermodynamics, Waves and Oscillations

Total hours of teaching time: 48 hrs

Unit-1 **12 hrs**

1. Heat and Thermodynamics

First law of thermodynamics. Isothermal and adiabatic changes, work done in isothermal and adiabatic changes. Phase diagrams, heat engine, expression for efficiency of Carnot cycle, reversibility of Carnot's cycle , principle of refrigeration.

Second law of thermodynamics, Entropy, microscopic and macroscopic definitions, principle of increase of entropy in irreversible process. Classius and Clayperon equation for variation of melting and boiling points.

Unit-2 **12 hrs**

2. Radiation

Black body radiation, Stefan's law, distribution of energy in the black body spectrum, statement of Wein's law and Rayleigh-Jeans law. Plank's quantum theory of radiation, derivation of Plank's law. Radiation momentum and pressure, Crooke's radiometer.

Unit-3 **12 hrs**

3. Low temperature

Ideal and real gases, Andrew's experiment, porous plug experiment. Temperature of inversion air liquefaction by Linde's processes. Liquid nitrogen and liquid helium and their properties. Concept of absolute tempererature

Unit-4 **12 hrs**

4. Waves and oscillations

Progressive wave: equation for wave in one dimension (general formula) differential equation for wave motion expression for relation between amplitude and intensity. Newton's formula for velocity of sound in air (derivation) & Laplace's correction. Superposition of SHM: Lissajou's figures composition of two SHMs of equal periods at right angles (analytical treatment). Beats, expression for beat frequency.

Reference Books

1. A text book of Heat by D.S. Mathur
2. A treatise on Heat by Shah and Srivastava
3. Heat and thermodynamics by J.B.Rajam
4. Heat and thermodynamics by Brijilal and Subramanyam.
5. A text book of sound by Braijilal and Subramanyam
6. Sound by Khanna and Bedi
7. Waves and Oscillations by A.P.French

Syllabus for B.Sc. IV Semester
Optional Physics
PHY 401: Paper 4: Physical Optics, Fibre Optics and Computational Physics

Total hours of teaching: 50 hrs

.

1. Interference of Light 10 hrs

Wave theory of light: Interference, interference by division of wave front, young's double slit experiment, Fresnel's bi-prism (both theory and experiment). Interference by division of amplitude, thin film of uniform thickness and wedge shape, Newton's rings by reflection; theory and experiment, Michelson's interferometer and experimental determination of wavelength of sodium light and its doublet separation.

2. Diffraction of light 10 hrs

Diffraction, Concepts of Fresnel and Fraunhoffer diffractions. Rectilinear propagation of light. Theory of Zone plate, comparison between zone plate and convergent lens. Fresnel's diffraction at a straight edge and wire. Fraunhoffer diffraction at a single slit – derivation expression for intensity, with theory of double slit method. Transmission grating (both theory and experiment)- determination of wavelength of light. Dispersion and resolution of grating.

3. Polarization of light 10 hrs

Polarization, methods for obtaining polarized light. Double refraction in uniaxial crystals, Huygens' theory, positive and negative crystals and principal refractive indices. Huygens' construction of O and E rays in uniaxial crystals for plane wave front. Quarter and half wave
plates. Production and detection of plane, circularly and elliptically polarized light. Babinet compensator (qualitative). Optical activity; specific rotation, Fresnel's theory and Laurent's half shade polarimeter.

4. Optical Instruments 6 hrs

Cardinal points; Equivalent focal length of two thin convex lenses separated by a distance (derivation), tracing of cardinal points. Abberrations; Spherical and chromatic aberrations in lenses. Achromatic combination of lenses; in contact and separated by a distance. Huygens' and Ramsden's eye pieces

5. Optical fibres 4 hrs

Review of the idea total internal reflection. Optical fibres: structure, dispersion & propagation of light through optical fibres, angle of acceptance, expression for numerical aperture and refractive index, applications of optical fibres.

6. Special theory of relativity 10 hrs

Michelson–Morley experiment and explanation of its negative result. Postulates of special theory of relativity. Lorentz transformations, length contraction, time dilation–
illustrations with twin-paradox and μ -meson, relativity of simultaneity, addition of velocities, variation of mass with velocity. Derivation of Einstein's mass–energy relation. Minkowski;s space.

Reference books

1. A Text Book of Optics by Brijilal and Subramanyam
2. Optics by Ajay Ghatak
3. A Text Book of Optics by D.S. Mathur

4. Optics & Spectrosecopy by R. Murugeshan- S Chand & Co.

PHYL4: Practical course for Semester IV

Instructions

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 12 experiments from the list mentioned below should be performed in Semester IV. Of these, one experiment can be open ended type (Course teacher may develop a new innovative experiment and introduce into the course). Open ended experiment must also be considered for examination.

List of experiments

1. Interference at a wedge – Measurement of the thickness of paper separator.
2. Determination of wavelength of momochromatic light using biprism.
3. Newton's rings –Determination of radius of curvature and its verification by telescope method.
4. Diffraction at a wire – Diameter of wire.
5. Diffraction grating – Normal incidence method.
6. Diffraction of Cauchy's constants.
7. Conductivity of an electrolyte using Kohlrausch bridge
8. Brewster's law.
9. Resolving power of grating using spectrometer.
10. Resolving power of telescope.
11. Specific rotation of sugar solution using polarimeter.
12. Searle's Goniometer- Determination of equivalent focal length of combination of lenses for at least three separations and its verification.
13. Liquid lens –Determination of refractive index of liquid.
14. Measurement of numerical aperture of an optical fiber using LASER.
15. Measurement of fiber attenuation by cut beck method using LASER.
16. Determination of mutual inductance of a pair of coils using BG.
17. Turn table –equivalent focal length and cardinal points.
18. Sextant – height of an inaccessible object such as hill, tree ete.
19. Determination of coefficient of damping, relaxation time and quality factor of a damped oscillator.
20. Construction of simple multimeter (Single versatile circuit)
21. Field along the axis of the circular coil

Syllabus for B.Sc. IV Semester
Open Elective
PHY OET 401 : Electronics and Theory of Relativity
Total hours of teaching time: 48 hrs

Unit-1 **12 hrs**

1. Basic electrical components

Definitions of resistance, capacitance and inductance; color code and ratings and their defining equations. Ideas of reactance and impedance. Alternating current, Expression for mean and rms values. Response of LR, CR and LCR circuits using phasor diagram.

Unit-2 **12 hrs**

2. Wave optics

Theories of light. Huygens' principle. Interference, interference by division of wave front, young's double slit experiment, Fresnel's bi-prism (qualitative). Interference by division of amplitude, thin film of uniform thickness and wedge shape. Newton's rings by reflection; theory and experiment.

Diffraction, Concepts of Fresnel and Fraunhoffer diffractions. Rectilinear propagation of light.

Polarization, methods for obtaining polarized light. Double refraction in uniaxial crystals, Huygens' theory, positive and negative crystals.

Unit-3 **12 hrs**

3. Optical fibers

Review of the idea total internal reflection. Optical fibers: structure, dispersion & propagation of light through optical fibers, angle of acceptance, applications of optical fibers.

4. Display devices and LED and LCD

Photo diode, Solar Cell, LED, application of LED in display, liquid crystal, type of liquid crystals, liquid crystal display (LCD), comparison between LED and LCD. 7-Segment display.

Unit-4 **12 hrs**

5. Special theory of relativity

Michelson–Morley experiment and explanation of its negative result. Postulates of special theory of relativity. Lorentz transformations, length contraction, time dilation–illustrations with twin-paradox. Relativity of simultaneity. Variation of mass with velocity. And $E = mc^{2.}$

Reference books

1. Electricity and magnetism by K. K Tewari
2. Fundamentals of optics Brijla and subramanyam
3. Electricity and magnetism by Khare and Srivastav
4. Modren Physics by R Murgeshan.
5. Physical Optics by A Ghatak

Syllabus for B.Sc. Semester V
Optional Physics
PHY 501: Paper -5.1: Atomic & Molecular Physics

Total hours of teaching : 42hrs

1. **Basic Properties of Atom** **8 hrs**

Constitution of atom and its properties, Determination of charge of the electron by Millikan's oil drop method. Determination of specific charge of the electron by J.J. Thomson's method. Atomic mass determination by Dempster's method and atomic mass unit.

2. **Atomic models** **8 hrs**

Review of Thompson and Rutherford models, alpha scattering experiment – concept of impact parameter (qualitative). Bohr's theory of hydrogen atom and its inadequacies, effect of nuclear mass, Somerfield model – qualitative. Excitation and ionization energies and their potentials. Frank –Hertz experiment.

3. **Vector atom model** **10 hrs**

Concept of spatial quantization, spinning electron hypothesis, quantum number. Pauli's exclusion principle. Fine structure of spectral lines; Stern and Gerlach experiment; degeneracy associated with magnetic quantum number. Selection rules. Coupling schemes LS and JJ-coupling for a pair of electrons. Zeeman effect; experimental study, quantum theory of normal and anomalous zeeman effect, Stark effect (qualitative).

4. **Molecular spectra** **6 hrs**

Introduction to molecular spectra. Classification of molecular spectra. Eigen value expressions for rotational, vibrational and electronic spectra of diatomic molecules. Band structure of diatomic molecules. Fluorescence and phosphorescence phenomenon.

5. **Raman effect** **4 hrs**

Coherent and incoherent scattering, Rayleigh scattering, Raman effect Experimental study, classical and quantum theory. application of Raman effect- determination of force constant, bond length of diatomic molecule and structure of tri-atomic molecule.

6. **LASERS** **6 hrs**

Definition of laser, properties of lasers, Ideas of Induced absorption, spontaneous emission and stimulated emission. Expression for Einstein's coefficients. population inversion, electrical and optical pumping techniques used to achieve population inversion,construction and working of solid state laser (Ruby), Gas laser (He-Ne), Semiconductor lasers (intrinsic and doped). Applications of lasers. Principle of Holography.

Reference books

1. Statistical Mechanics by K Huang.
2. Statistical Mechanics by S.L.Gupta & V. Kumar
3. Concepts of Modern Physics by Arthur Beiser, Tata McGraw-Hill pubs.
4. Modern Physics by B.V.N. Rao
5. Modern Physics by Murugeshan
6. Electronic devices and circuits by Jacob Millman & Halkias
7. Fundamentals of Electronics by B. Basavaraj
8. Modern Physics, Vol-II B by Basavaraj, Omkar Publications
9. Concept of Modern Physics by S.L Gupta and S.Gupta

PHYL5.1: Practical course for Semester V

Instructions

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 6 experiments should be performed in semester V.

List of experiments

1. Determination of energy band gap of a semiconductor.
2. Forward and reverse biased characteristics of a PN –junction diodedetermination of forward resistance and Reverse
3. Characteristics of a zener diode-determine Zener breakdown voltage
4. Half wave and full rectifiers- study input and output waveforms and determine ripple factors.
5. Unregulated power supply –shunt capacitor filter. Series inductor filter and comparison of ripple factors.
6. Regulated power supply using Zener diode. - Line regulation and load regulation.
7. Characteristics of LED (three different colours).
8. Characteristics of photodiode.
9. Characteristics of a solar cell – determination of fill factor.
10. Input, output and transfer characteristics of a transistor in CB Configuration.
11. Determination of Rydberg constant using H_2-source and spectrometer
12. Temperature of flame by line reversal method.
13. Capacitance of reverse biased semiconductor diode.
14. Estimation of chlorophil in plant cell
15. Mapping of H-R diagrams
16. Fermi energy of copper by four –probe point method.

Syllabus for B. Sc Semester V
Optional Physics
PHY 502: Paper -5.2 Statistical mechanics, Quantum mechanics & Electronics-I

Total teaching time: 42 hours

.

1. Statistical Mechanics 6 hrs

Statistical ideas in physics, Phase space, ensemble, ensemble average, probable and most probable distributions, Boltzman equipartition theorem (derivation), Gibb's paradox (no derivation) Stirling's approximation, Maxwell- Boltzmann, Bose-Einstein and Fermi-Dirac distribution functions and their comparison (qualitative- no derivations).

2. Elements of Quantum mechanics 8 hrs

Origin of quantum theory –Compton effect –expression for Compton shift. Concept of de Broglie's matter waves. Expression for de Broglie's wavelength, Davisson & Germer experiment. Heisenberg uncertainty principle–illustrations of Gamma ray microscope & diffraction at a single slit.

3. Wave mechanics 8 hrs

Wave function and its physical interpretation, Schrodinger time– independent wave equation, Eigen values and Eigen functions. Problems: particle in one-dimensional box (derive Eigen values and Eigen functions), linear harmonic oscillator (derive Eigen values and Eigen functions), concept of zero point energy.

4. Band theory of solids 8 hrs

Formation of energy bands in bands, the concepts of valence band, conduction band and energy gap in semiconductors, electrical conductivity of conductors, semiconductors and insulators (qualitative). Intrinsic and extrinsic semiconductors. Deviation of expression for electrical conductivity and energy gap in semiconductors. Hall effect, Hall coefficient.

5. Semiconductor devices 6 hrs

PN junction, rectifiers (half wave, full wave & bridge). Filters (Land pi-section filters), Zener breakdown and avalanche breakdown, Zener diode as voltage regulator. Transistor action,

configurations (CE, CB & CC) and relation between α & β.Transistor amplifier in CE-mode.

6. Special purpose Diodes and Display Devices 6 hrs

Photo diode, Solar Cell, LED, application of LED in display, liquid crystal, type of liquid crystals, liquid crystal display (LCD), comparison between LED and LCD. 7- Segment display.

PHYL5.2: Practical course for Semester V

Instructions

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 6 experiments should be performed in semester V.

LIST OF EXPERIMENTS

1. Charge of electron by dispersion method.
2. Specific charge of electron by Thomson's method.
3. Co-efficient of linear expansion of material of razor (blade) by LASER diffraction method.
4. Determination of refractive index using LASER.
5. Determination of $_{o}\mu$ and $_{e}\mu$ using LASER
6. Diffraction grating using LASER- determination of wavelength of laser light.
7. Determination of temperature coefficient of resistance of a wire.
8. Calibration of thermistor and determination of temperature coefficient of resistance and unknown temperature.
9. Planck's constant – using photocell.
10. Thermionic emission – Verification of Child's law.
11. Input, output and transfer characteristics of a transistor in CE Configuration.
12. Spectral response of a LDR.
13. Ionization potential of Xenon / Mercury.
14. Excitation and ionization potentials.
15. Hall Coefficient.

Syllabus for B.Sc. V Semester
Open Elective
PHY OET 501 : Atomic, Energy and Astrophysics
Total hours of teaching time: 48 hrs

Unit-1 **12 hrs**

1. Atomic Models

Constitution of atom and its properties, Review of Thompson and Rutherford models, alpha scattering experiment – concept of impact parameter (qualitative). Bohr's theory of hydrogen atom and its inadequacies, effect of nuclear mass, Somerfield model – qualitative. Excitation and ionization energies and their potentials. Frank –Hertz experiment.

Unit-2 **12 hrs**

2. Laser and Raman Effect

Definition of laser, properties of lasers, Ideas of Induced absorption, spontaneous emission and stimulated emission. Population inversion, electrical and optical pumping techniques used to achieve population inversion, construction and working of solid state laser (Ruby), Gas laser (He-Ne).

Coherent and incoherent scattering, Rayleigh scattering, scattering as a spectacular phenomena of light- blue sky, deep blue sea, red sunset and white clouds. Raman effect, Experimental study. Applications of Raman effect.

Unit-3 **12 hrs**

3. Superconductivity

Discovery of superconductivity, zero resistivity, Meissner effect, give examples of metals exhibiting superconductivity, persistent current, critical fields, type I and type II of superconductors, Results of BCS theory. High temperature superconductors, applications of superconductors.

Unit-4 **12 hrs**

4. **Energy Physics** & **Astrophysics:**

Conventional and non conventional energy sources, Solar radiation, Use of solar energy , Wind energy, Tidal energy, Bio energy. Nuclear energy: Nuclear fission, Nuclear reactor, Nuclear fusion Thermonuclear reaction

Solar system, evolution of stars: stars birth, white dwarf, neutron stars, supernova and black holes. Keplar's laws of planetary motion. Basics of satellites.

Reference

1. Modren Physics by R Murgeshan.
2.Non conventional energy sources by G.D.Rai.
3. Non conventional energy sources by Rajesh prasad & TP Ojha.
4. Text book on spherical Astronomy by Smart W M.
5. Gravitational Astronomy by Binney Scott D.

Syllabus for B.Sc. VI Semester
Optional Physics
PHY 601: Paper 6.1: Nuclear physics, Solid State Physics, Astrophysics & Biophysics

Total hours of teaching: 42 hrs

1. **Nuclear Physics** **4 hrs**

Nucleus composition; mass, charge, size, density, spin and magnetic moment. Binding energy of nucleus. nuclear force; characteristics of nuclear forces, Yukawa theory – qualitative. Nuclear models; liquid drop model and shell model (qualitative).

2. Radioactivity **4 hrs**

Radioactivity decay law, half life and mean life with derivations Radioactive particles α, β and γ and their characteristics, Alpha decay - Gamow's theory (brief description), Beta decay- Fermi theory (brief description), neutrino hypothesis and Gamma-decay.

3. **Nuclear Instruments** **4 hrs**

Detectors of nuclear radiation: Geiger –Muller Counter and Scintillation Counters. Particle accelerators: Construction and theory of Cyclotron and Betatron.

4. **Alternate energy Sources** **6 hrs**

Conventional and non-conventional energy sources, ecological and sociological perspective. Wind energy, tidal energy and bio-energy (qualitative). Nuclear energy: Nuclear reaction,
Q – value. Nuclear fission, nuclear reactors, nuclear fusion, thermonuclear reaction.

5. **Crystal Structure** **4 hrs**

Concept of lattice, unit cell, Bravais lattice, crystal, crystal planes and Miller indices, structure of NaC1. X-ray diffraction-Bragg's law derivation, types of X-ray diffraction techniques (qualitative),

6. **Electrical and thermal properties of solids** **6 hrs**

Free electron theory of metals, Expression for electrical and thermal conductivities.
Concept of Fermi energy and its variation with temperature (qualitative). Specific heats of solids: Dulong and Petit law, Einstein and Debye theories (main features and results).

7. Magnetic properties of solids **4 hrs**

Define magnetic moment. Diamagnetism (explain origin) - Langevin classical theory,
Paramagnetism - curies law, ferromagnetism, hysteresis loop, Weiss theory (main features).

8. Superconductivity **5 hrs**

Discovery of superconductivity, zero resistivity, Meissner effect, give examples of metals exhibiting superconductivity, persistent current, critical fields, type I and type II of superconductors, London's penetration depth, Results of BCS theory. High temperature superconductors, applications of superconductors.

9. **Astrophysics** **5 hrs**

Light year and parsec; luminosity of stars, apparent & absolute magnitudes. Colour and surface temperature of stars. spectrall classification of stars, HR diagram, Formation and

evolution of stars (qualitative); end stages of stars – white dwarfs, neutron stars and black holes (qualitative).

Reference books

1. Introduction to solid state physics by C Kittel.
2. Solid State physics by A J Dekkar.
3. Introduction to solid state physics by J S Blackmore
4. Modern physics by R Murugeshan.
5. Nuclear physics by D C Tayal.
6. Non –Conventional Energy Source by G D Rai.
7. Energy Technology by S Rao and B B Rarulekar.
8. Introductory Nuclear physics by Kenneth Crane (john Wiley).
9. An Introduction to Astrophysics by Baidyanath Basu.
10. Astronomy by Fundamentals and Frontiers –R jastrow and M H Thompson.
11. Biophysics by Vasanth Pattabhi and N Gautham.
12. Essentials of Biophysics by P Narayanan.

PHYL6.1: Practical course for Semester VI

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 6 experiments should be performed in semester VI.

List of experiments

1. Analysis of random error: Poisson distribution, statistics of nuclear counting.
2. Characteristics of GM tube.
3. Verification of inverse square law using GM tube.
4. Determination of half life using GM tube.
5. Study of 4 bit binary counter (Using IC 7483)
6. Maping of Constallations.
7. Field Effect Transistor.
8. Phase shift oscillator using transistor.
9. Astable multivibrator using transistor.
10. Determination of self inductance of a coil using Anderson’s bridge.
11. Frequency response of an RC coupled single stage CE amplifier.- determination of bandwidth.
12. Frequency response of emitter follower.- determination of bandwidth.
13. Determination of voltage gain, current gain, input impedance, output impedance of an emitter follower.
14. Hartley oscillator using transistor
15. Seven segment display using LED.

Syllabus for B. Sc. VI Semester
Optional Physics
PHY 602: Paper -6.2 Material Science & Electronics-II

Total hours of teaching : 42 hrs

1. **Materials Science** **4 hrs**

Scope of Materials science, engineering classification of materials, engineering requirement of materials, crystalline and non-crystalline states of materials.

2. **Bonding in materials** **4 hrs**

Covalent bonding, ionic bonding and metallic bonding. Give examples and discuss covalent solids, ionic solids and metallic solids.

3. **Mechanical properties of materials** **4 hrs**

Strength, elasticity and hardness (give examples and compare properties of different materials), fatigue, creep and fracture.

4. **Electrical and thermal properties of materials** **4 hrs**

Conductivity of metals, semiconductors and superconductors. Dielectric properties of insulators (dielectric properties), thermal conductivity and thermal expansion

5. **Thin films** **3 hrs**

Definition, methods of preparation: physical and chemical, thermal evaporation in vacuum (describe experiment),Sputtering Technique applications of thin films.

6. **Nanophysics & nanomaterials:** **4 hrs**

Nanoscale systems, size effect, correlation with quantum mechanical particle in a box, quantum structures, quantum wells.Synthesis of nano materials, characterization and applications (qualitative).

7. Oscillators: **6 hrs**

Concept of Feedback Positive , negative feedback Sinusoidal oscillators: Tuned oscillators-Barkhausen criterion for oscillations, Hartly and Colpitt's oscillators. RC oscillators – Phase shift oscillator and Wien Bridge oscillator. Non- sinusoidal oscillators: Astable, Monostable and Bi- stable multivibrators.

8. **Digital Electronics:** **6 hrs**

Number systems: Decimal, Binary, Hexadecimal and their inter –conversion. Boolean algebra, K- maps, basic theorems, Logic gates; OR, AND, NOT, NAND and XOR gates. Half adder, full adder and adder. Flif flops; RS, D, JK and M/S filp flops, counters – Serial and Parallel counters, modified counter, shift register, ring counter, shift counter and
mod – 16 counter.

9. **Radio Communication:** **7 hrs**

Radio – wave propagation, need for modulation, Amplitude modulation, modulation factor, side band. band width, power in AM wave, Frequency modulation, de-modulation, super-hetrodynes. Block diagrams of AM & FM receivers. Selectivity, sensitivity, dynamic range, image frequency and image rejection(Qualitative).

Reference books

1. Materials Science and processes by S.K.Hajra Choudhury
2. Materials Science by Raghavan V
3. Material Science, M.Arunugam, Anuradha agencies, Kumbakonam (2002)
3. Applied electronics by R.S. Sedha
4. Operational Amplifiers and linear integrated Circuits by Ramakanth Gayakawad
5. Digital Principles and Applications by Malvino and Leach.
6. Digital Electronics by Gathmann
7. Electronics Communication by Sanjeev Gupta.
8. Integrated Circuits by K R Botkar, Khanna Publilshers.
9. Introduction to Solid State physics by C Kittel.
10. Solid State Physics by A J Dekkar.
11. Introduction to Solid State Physics by J S Blackmore.
26

PHYL6.2: Practical course for Semester VI

Instructions

1. Two experiments (3 hours duration each) per week should be performed.
2. One practical internal test of 3 hours duration for 15 marks be conducted at the end of practical course in the semester.
3. Minimum of 6 experiments should be performed in semester VI.

List of experiments

1. Determination of capacitance of capacitor using Maxwell's bridge.
2. Colpitt's oscillator using transistor.
3. Construction of OR, AND, NOT, NOR & NAND gates using diodes/transistor/IC and verification of their truth tables.

27

4. Verification of de Morgan's theorem. (using ICs)
5. Verification of truth table of half adder and full adder. (using ICs)
6. Absorption coefficient of aluminum for β - rays.
7. Attenuation coefficient of γ - rays.
8. Construction and verification of RS and JK flip- flops.
9. Study Op-Amp characteristics: Determine Offset voltage and CMMR
10. Operational Amplifier: voltage to current and current to voltage converter
11. Operational Amplifiers – Inverting and Non- inverting.
12. Measurement of resistance of thin films by four- probe method.
13. Interplanar Spacing – X-ray diffraction.
14. Maping of HR diagram**.**
15. Estimation of Cholorophill in plant cel