



COURSE OUTLINE

1. **Course:** PHYS 365, Acoustics, Optics and Modern Physics (for students in Engineering) - Fall 2022

Lecture 01 : TR 12:30 - 13:45 in ST 140

Instructor	Email	Phone	Office	Hours
Dr Timothy Andrew	timothy.andrew@ucalgary.ca	please email	SB 603	TR

Coordinator(s)

Name	Email	Phone	Office	Hours
Shahpoor Moradi	moradis@ucalgary.ca	403 220-3041	SB 130	By appointment

To account for any necessary transition to remote learning for the current semester, courses with in-person lectures, labs, or tutorials may be shifted to remote delivery for a certain period of time. In addition, adjustments may be made to the modality and format of assessments and deadlines, as well as to other course components and/or requirements, so that all coursework tasks are in line with the necessary and evolving health precautions for all involved (students and staff).

In Person Delivery Details:

This course will have in-person lectures, labs, and exams. Attendance at the lectures is optional but highly recommended as there are in-class activities for credit. Attendance at the labs and exams is compulsory. For information on missed labs and exams, see below. Safety protocols for in-person labs will be discussed during the first week of classes. Face masks are to be worn as per University policy.

Re-Entry Protocol for Labs and Classrooms:

To limit the spread of COVID-19 on campus, the University of Calgary has implemented safety measures to ensure the campus is a safe and welcoming space for students, faculty and staff. The most current safety information for campus can be found [here](#).

Course Site:

D2L for Lectures: PHYS 365 L01-(Fall 2022)-Acoustics, Optics and Modern Physics (for students in Engineering)

D2L for Labs: PHYS 365 B01 - B16 (Fall 2022) - Acoustics, Optics and Modern Physics (for students in Engineering)

Note: Students must use their U of C account for all course correspondence.

Equity Diversity & Inclusion:

The University of Calgary is committed to creating an equitable, diverse and inclusive campus, and condemns harm and discrimination of any form. We value all persons regardless of their race, gender, ethnicity, age, LGBTQIA2S+ identity and expression, disability, religion, spirituality, and socioeconomic status. The Faculty of Science strives to extend these values in every aspect of our courses, research, and teachings to better promote academic excellence and foster belonging for all.

The Physics and Astronomy EDI Committee acknowledges there are persistent barriers that prevent such accessibility and hinder our progress towards EDI. Our representatives (faculty, postdocs, graduate and undergraduate students) are committed to addressing any concerns and work towards proactive solutions that enact necessary change within the department. To submit anonymous questions, comments or concerns regarding EDI related issues, please reach out to our Associate Head EDI, Claudia Gomes da Rocha (claudia.gomesdarocha@ucalgary.ca)

2. **Requisites:**

See section [3.5.C](#) in the Faculty of Science section of the online Calendar.

Prerequisite(s):

Mathematics 277 and Physics 259 and admission to a program in Engineering.

Antirequisite(s):

Credit for Physics 365 and 369 will not be allowed. Not open to Geomatics Engineering students.

3. Grading:

The University policy on grading and related matters is described in [F.1](#) and [F.2](#) of the online University Calendar.

In determining the overall grade in the course the following weights will be used:

Course Component	Weight	Due Date (duration for exams)	Modality for exams	Location for exams
Assignments (online) ¹	12%	Ongoing		
Laboratory experiments ²	20%	Ongoing		
Top Hat ³	8%	Ongoing		
Midterm examination	25%	Nov 15 2022 at 12:30 pm (75 Minutes)	in-person	In class
Registrar Scheduled Final Exam	35%	Will be available when the final exam schedule is released by the Registrar	in person	Will be available when the final exam schedule is released by the Registrar

¹ 10 weekly (Wiley Plus) assignments, each will open on Wednesday at 5:00 PM and close on next Sunday at 11:59 PM.

² 5 Labs beginning in the second week of classes.

³ Questions asked during the lectures.

Each piece of work (reports, assignments, quizzes, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
Minimum % Required	95 %	90 %	85 %	80%	75%	70 %	65 %	60%	55%	50 %	45 %

This course will have a Registrar Scheduled Final exam that will be delivered on-line. [The Final Examination Schedule](#) will be published by the Registrar's Office approximately one month after the start of the term. The final exam for this course will be designed to be completed within hours.

The University of Calgary offers a [flexible grade option](#), Credit Granted (CG) to support student's breadth of learning and student wellness. Faculty units may have additional requirements or restrictions for the use of the CG grade at the faculty, degree or program level. To see the full list of Faculty of Science courses where CG is not eligible, please visit the following website: <https://science.ucalgary.ca/current-students/undergraduate/program-advising/flexible-grading-option-cg-grade>

4. Missed Components Of Term Work:

The university has suspended the requirement for students to provide evidence for absences. Please do not attend medical clinics for medical notes or Commissioners for Oaths for statutory declarations.

In the event that a student legitimately fails to submit any online assessment on time (e.g. due to illness etc...), please contact the course coordinator, or the course instructor if this course does not have a coordinator to arrange for a re-adjustment of a submission date. Absences not reported within 48 hours will not be accommodated. If an excused absence is approved, one possible arrangement is that the percentage weight of the legitimately missed assignment could also be pro-rated among the components of the course. This option is at the discretion of the coordinator and may not be a viable option based on the design of this course.

Missed Lab

Students are NOT allowed to attend a different lab section than the one in which they are registered. A make-up lab session will be scheduled in the last week of classes. You can make up one lab. Please fill in the *Make-up lab request form* (Excel file, should be saved as an Excel file) posted on D2L to the appropriate Dropbox. Requests submitted more than **2 days** after the date of the missed lab will not be considered.

Missed midterm

If a student misses the midterm, they must fill out the Missed Course Component form on D2L and submit it to the appropriate Dropbox within **2 days** of the missed midterm. If the request is approved, the weight of the missed midterm will be shifted to the final exam. A missed midterm that does not have an approved accommodation from the course coordinator will result in a zero for that midterm.

Missed WileyPlus assignments

The deadline for the online assignments will not be extended, instead, the best 9 grades of the assignments out of 10 will be counted toward the final grade accommodating for missing one assignment.

Missed Top Hat

There will be no make-up for the missed Top Hat. Instead, the final grade for Top Hat is adjusted at the end of the term in order to accommodate for any Top Hat questions you might occasionally miss due to different circumstances. Each grade (greater than 70%) is divided by 0.8 and capped at 100%. For example, if your grade is 85%, your adjusted grade will be 100% ($85\%/0.8 = 106\%$, capped at 100%). If your final grade is 76%, your adjusted final grade will be 95% ($76\%/0.8 = 95\%$).

5. Scheduled Out-of-Class Activities:

There are no scheduled out of class activities for this course.

6. Course Materials:

Recommended Textbook(s):

David Halliday, Robert Resnick, and Jearl Walker, *Fundamentals of Physics, 11th Edition*, : Wiley.

- WileyPLUS license (see information about online Assignments below)
- An extensive set of supplemental Extra Notes will be posted on D2L (free of charge).
- Relevant textbook sections from the free Openstax textbook will be included in the topic outline.

In order to successfully engage in their learning experiences at the University of Calgary, students taking online, remote and blended courses are required to have reliable access to the following technology:

- A computer with a supported operating system, as well as the latest security, and malware updates;
- A current and updated web browser;
- Webcam/Camera (built-in or external);
- Microphone and speaker (built-in or external), or headset with microphone;
- Current antivirus and/or firewall software enabled;
- Stable internet connection.

For more information please refer to the UofC [ELearning](#) online website.

7. Examination Policy:

No aids are allowed on tests or examinations.

Students should also read the Calendar, [Section G](#), on Examinations.

8. Approved Mandatory And Optional Course Supplemental Fees:

There are no mandatory or optional course supplemental fees for this course.

9. Writing Across The Curriculum Statement:

For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also [Section E.2](#) of the University Calendar.

10. Human Studies Statement:

Students will not participate as subjects or researchers in human studies.

See also [Section E.5](#) of the University Calendar.

11. Reappraisal Of Grades:

A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the

grade being reappraised may be raised, lowered or remain the same. See [Section I.3](#) of the University Calendar.

- a. **Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within **ten business days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall submit the Reappraisal of Graded Term work [form](#) to the department in which the course is offered within 2 business days of receiving the decision from the instructor. The Department will arrange for a reappraisal of the work within the next ten business days. The reappraisal will only be considered if the student provides a detailed rationale that outlines where and for what reason an error is suspected. See sections [I.1](#) and [I.2](#) of the University Calendar
- b. **Final Exam:** The student shall submit the request to Enrolment Services. See [Section I.3](#) of the University Calendar.

12. Other Important Information For Students:

- a. **Mental Health** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health and receive supports when needed. We encourage you to explore the mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 370, MacEwan Student Centre, [Mental Health Services Website](#)) and the Campus Mental Health Strategy website ([Mental Health](#)).
- b. **SU Wellness Services:** For more information, see their [website](#) or call [403-210-9355](#).
- c. **Sexual Violence:** The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email (svsa@ucalgary.ca) or phone at [403-220-2208](#). The complete University of Calgary policy on sexual violence can be viewed [here](#).
- d. **Misconduct:** Academic integrity is the foundation of the development and acquisition of knowledge and is based on values of honesty, trust, responsibility, and respect. We expect members of our community to act with integrity. Research integrity, ethics, and principles of conduct are key to academic integrity. Members of our campus community are required to abide by our institutional [Code of Conduct](#) and promote academic integrity in upholding the University of Calgary's reputation of excellence. Some examples of academic misconduct include but are not limited to: posting course material to online platforms or file sharing without the course instructor's consent; submitting or presenting work as if it were the student's own work; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; borrowing experimental values from others without the instructor's approval; falsification/fabrication of experimental values in a report. Please read the following to inform yourself more on academic integrity:

[Student Handbook on Academic Integrity](#)
[Student Academic Misconduct Policy](#) and [Procedure](#)
[Faculty of Science Academic Misconduct Process](#)
[Research Integrity Policy](#)

Additional information is available on the [Student Success Centre Academic Integrity page](#)

e. **Academic Accommodation Policy:**

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: <https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Student-Accommodation-Policy.pdf>

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities: <https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Accommodation-for-Students-with-Disabilities-Procedure.pdf>.

Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, by filling out the [Request for Academic Accommodation Form](#) and sending it to Dr. David Feder by email phas.ahugrd@ucalgary.ca preferably 10 business days before the due date of an assessment or scheduled absence.

- f. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of

Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see [Legal Services](#) website.

- g. **Student Union Information:** [SU contact](#), Email SU Science Rep: sciencerep1@su.ucalgary.ca, [Student Ombudsman](#)
- h. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction ([USRI](#)) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.
- i. **Copyright of Course Materials:** All course materials (including those posted on the course D2L site, a course website, or used in any teaching activity such as (but not limited to) examinations, quizzes, assignments, laboratory manuals, lecture slides or lecture materials and other course notes) are protected by law. These materials are for the sole use of students registered in this course and must not be redistributed. Sharing these materials with anyone else would be a breach of the terms and conditions governing student access to D2L, as well as a violation of the copyright in these materials, and may be pursued as a case of student academic or [non-academic misconduct](#), in addition to any other remedies available at law.

LABORATORIES

Laboratories begin during the week of September 12; check the timetable below for the dates of your labs. Labs take place in person in ST 36. You must attend your lab and contribute to your group's lab write-up in order to receive points for it. TAs offer assistance and guidance and check student understanding periodically throughout the session.

Lab schedule

Week #	Dates	B01 Tu 5:00PM - 7:50PM	B03 We 5:00PM - 7:50PM	B05 Tu 8:00AM - 10:50AM	B06 Tu 8:00AM - 10:50AM	B07 Tu 2:00PM - 4:50PM	B13 Th 8:00AM - 10:50AM	B14 Th 8:00AM - 10:50AM	B15 Th 2:00PM - 4:50PM	B16 Th 2:00PM - 4:50PM
1	Sept 06 - Sept 09	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs
2	Sept 12 - Sept 16				Lab 1			Lab 1		Lab 1
3	Sept 19 - Sept 23	Lab 1	Lab 1	Lab 1		Lab 1	Lab 1		Lab 1	
4	Sept 26 - Sept 30				Lab 2			Lab 2		Lab 2
5	Oct 03 - Oct 07	Lab 2	Lab 2	Lab 2		Lab 2	Lab 2		Lab 2	
6	Oct 10 - Oct 14				Lab 3			Lab 3		Lab 3
7	Oct 17 - Oct 21	Lab 3	Lab 3	Lab 3		Lab 3	Lab 3		Lab 3	
8	Oct 24 - Oct 28				Lab 4			Lab 4		Lab 4
9	Oct 31 - Nov 04	Lab 4	Lab 4	Lab 4		Lab 4	Lab 4		Lab 4	
10	Nov 7 - Nov 11	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs
11	Nov 14 - Nov 18	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs	No Labs
12	Nov 21 - Nov 25	Lab 5	Lab 5	Lab 5		Lab 5	Lab 5		Lab 5	
13	Nov 28 - Dec 02				Lab 5			Lab 5		Lab 5
14	Dec 05 - Dec 07	Make-up labs	Make-up labs	Make-up labs	Make-up labs	Make-up labs	Make-up labs	Make-up labs	Make-up labs	Make-up labs

List of experiments

Lab 1 Uncertainties

Lab 2 Simple harmonic oscillations

Lab 3 Standing waves

Lab 4 Balmer series

Lab 5 Electron diffraction

Lab Write-ups

Lab write-ups are prepared by the Department of Physics and Astronomy and will be posted on Desire2Learn. Each student should download their own copy of each lab. Before you come to your first lab session (see the schedule, above) make sure you have read the relevant sections of the Manual and completed any Preliminary Work (Pre-lab) required.

Pre-labs

Pre-labs are to be completed and submitted individually by each lab group member via D2L by 11:59 pm on Monday.

Lab Group work

When you come to the first lab session, your lab section will be organized into groups of 2 or 3 (3 is preferred). Your group will remain the same during the term. The group will work as a team, sharing tasks such as setting up apparatus, taking measurement data, and keeping a running record of the experiment. No group member should be an idle "third wheel" during the session. The intention is to finish the data taking in the 3-hour period, and also move ahead as much as possible with a single write-up for the group.

Raw Lab Data and Discussion points

All the data recorded in the lab should be recorded in the provided Excel file and submitted to the Lab report D2L Dropbox before the lab ends. Please note that all discussion points (especially for Lab 1) should also be recorded in the same file.

Lab reports

Final Laboratory reports are due at 11:59 pm, one week after the date of lab completion. Group members will meet during that week, perhaps electronically, to accomplish this. (It is possible for students to book group study space in the TFDL or EEEL.). Use a word processor to write your lab report and attach a scan of your raw lab notes to your write-up. Save the lab report as a PDF. Your group report saved as a PDF should be submitted to Dropbox (lab report). Your TA will download it and submit the feedback via D2L. Each member of the group will receive the same mark. A caution: Teamwork within a single lab group is expected. However, your group should work independently of other lab groups. Unduly similar reports received from different groups could result in charges of academic misconduct against the students involved.

TOP HAT

As a vehicle to encourage class participation and student interaction, as well as to provide instructors with rapid, real-time feedback, the Top Hat student response system will be employed. Detailed instructions on how to register for an account will be provided via D2L. Each lecture section will have its own Top Hat course name, which will be given to you by your instructor. The Top Hat questions are graded for 50% participation and 50% correctness. The type and number of questions asked over the semester are at the sole discretion of your instructor.

Make sure you are using your correct **UCID** and your **ucalgary.ca email address** for your Top Hat enrollment, otherwise the grade for TopHat will not be counted towards your final.

WileyPLUS ONLINE ASSIGNMENTS

Your textbook, "Fundamentals of Physics" by Halliday, Resnick, and Walker, is available in the bookstore. If you did purchase the book and WileyPLUS access last term for PHYS 259, you will not need another code as your access is still valid. A new textbook comes bundled with a code, which will give you access to the eBook and assignments. If you would like to purchase just WileyPLUS standalone (without the text), you can do so through the bookstore.

If you choose not to purchase a new book or the WileyPLUS standalone, you will be able to access the homework from an on-campus library computer (with no textbook or resources access). You need to register as directed below. When you click an assignment you will not be prompted to enter an access code if you are accessing from the on-campus library.

To register in WileyPLUS go to: www.wileyplus.com/go/login. If you have a WileyPLUS account already, login using the account you used previously. Once you have an account or you have logged into your existing account press "+Add Courses." Once in the course finder, enter the 6-digit Course ID provided by your instructor (find it on D2L) into the space provided. Once you enter your WileyPLUS course, click on one of the content links and you will be asked to verify your purchase using the code provided.

New users: If you are using WileyPLUS for the first time, please click Sign up and complete the form. Once you hit submit, check your email for an email from Noreply@wileyplus.com. The email will include a link titled "Click here." This link will take you to the password screen where you can create and set your WileyPLUS password. Once you create your password you will be taken to the course finder.

Assignment schedule

Assignment	Topics covered (HR textbook)	Available date (Wednesday 5:00 PM)	Due/Closing date (Sunday 11:59 PM)
Assignment 01	15.1, 15.2	September 07	September 18
Assignment 02	16.1, 16.6	September 14	September 25
Assignment 03	16.1,16.2 ,16.5 ,16.6	September 21	October 02
Assignment 04	17.4	September 28	October 09
Assignment 05	16.7	October 05	October 16
Assignment 06	17.3, 17.7	October 12	October 23
Assignment 07	17.7, 35.3, 36.1, 36.4	October 19	October 30
Assignment 08	38.1 - 38.3	November 02	November 13
Assignment 09	38.6, 38.6, 39.1	November 16	November 27
Assignment 10	39.3 - 39.5	November 23	December 04

COURSE SCHEDULE

Week#	Dates	Topics	Notes	Main textbook reference*	Supp. texts^
1	Sept 06 - Sept 09	Introduction; simple harmonic motion (SHM) of systems obeying Hooke's law; differential equation of SHM; superposition of SHMs of the same frequency.		HR 15.1, 15.4,16.6	EN1 OSv1 15.1, 16.5
2	Sept 12 - Sept 16	Phasors; phasor addition; phasor diagrams; phasors as complex quantities; traveling wave pulse: mathematical description and particle motion; partial derivatives; harmonic wave equation.		HR 16.1,16.4, 16.6	EN1, EN2 OSv1 16.2
3	Sept 19 - Sept 23	Principle of wave superposition; harmonic (sinusoidal) waves; mathematical description, particle motion, phase differences; complex representation of a traveling harmonic wave; speed of waves in real media: stretched string; sound waves as longitudinal waves in solids, liquids, and gases; speed of sound waves.		HR 16.2, 16.5,16.6, 17.1-2	EN2, EN3 OSv1 16.5, 17.1, 17.2
4	Sept 26 - Sept 30	Energy transport by a harmonic wave; mechanical impedance; power transported by a wave; acoustical impedance.		HR 16.3	EN4 OSv1 15.2, 16.4
5	Oct 03 - Oct 07	Sound intensity and sound intensity level (dB); sound field around point and line sources; inverse square law; acoustical attenuation; reflections at boundaries between two media; boundary conditions; amplitude reflection and transmission coefficients at a junction; energy reflection and transmission coefficients.		HR 17.4, 17.5,16.7	EN4, EN5 OSv1 16.5, 16.6, 17.3, 17.4
6	Oct 10 - Oct 14	Standing waves on a stretched string of fixed length: normal modes; acoustical standing waves: vibrations of air columns, normal modes; standing wave ratio; resonance.		HR 16.7	EN6 OSv1 16.5, 16.6, 17.4, 17.5
7	Oct 17 - Oct 21	Doppler effect; superposition of two harmonic waves of different frequencies: beats; coherent and incoherent sources; two-slit interference.		HR 17.6, 17.7, 33.4, 35.2, 35.3	EN7 OSv1 16.5, 17.6, 17.7 OSv3 3.1
8	Oct 24 - Oct 28	Thin film interference; multiple reflections in a thin film; diffraction pattern of a single slit; circular aperture; resolving power.		HR 35.4, 36.1, 36.2, 36.3	OSv3 3.4, 4.1, 4.5

9	Oct 31 - Nov 04	Emission and absorption of light; photoelectric effect; photon momentum and probability waves.		HR 38.1, 38.2, 38.4	OSv3 6.1, 6.2, 6.3, 7.1
10	Nov 07 - Nov 11		Winter break		
11	Nov 14 - Nov 18	De Broglie waves; electron diffraction.	Midterm on Tuesday, Nov 15	HR 38.5	OSv3 6.5
12	Nov 21 - Nov 25	Schrodinger's equation; Heisenberg's uncertainty principle; energy and wave functions of a trapped electron.		HR 38.6, 38.7, 39.1, 39.2	OSv3 7.2, 7.3, 7.6
13	Nov 28 - Dec 02	An electron in a potential well; the hydrogen atom: Bohr model.		HR 39.3, 39.5	OSv3 6.4, 7.5, 7.6
14	Dec 05 - Dec 07	The hydrogen atom: Schrodinger's equation; electrical properties of metals.		HR 39.5, 41.1	OSv3 6.2, 6.4, 7.3

*HR = Halliday Resnick (the course textbook)

^Supplementary texts: EN = Extra notes; OSv1 = Openstax University Physics Vol. 1; OSv3 = Openstax

University Physics Vol. 3. Access the Openstax books at <https://openstax.org/details/books/university-physics>

Course Incomes

- Students coming into PHYS 365 should be able to:
- Use trigonometric functions and identities as well as geometry to solve problems
- Employ algebraic manipulations (including solving the quadratic formula)
- Perform derivatives and integrals of functions as well as calculations using complex numbers
- Demonstrate ability to use vector algebra
- Exploit and use symmetry to simplify physical problems in electricity and magnetism
- Apply the principle of superposition to calculate the electric and magnetic fields of extended objects
- Develop mathematical models of physical situations
- Carry out calculations symbolically (in terms of physical variables) and numerically (using appropriate values and their units)
- Obtain experimental data and relate them to predicted physical laws governing electricity and magnetism

Course Outcomes:

- By the end of the course, students will be expected to:
- Exploit and use mathematical representations to predict the behaviour of physical systems exhibiting simple harmonic oscillations or containing waves.
- Analyze and describe the effect of a system's physical properties (density, temperature, mechanical impedance, motion) on wave propagation (speed, reflection, transmission, resonance, and interference.)
- Compute properties and effects of electromagnetic radiation emitted and absorbed by physical systems.
- Extend understanding of classical concepts of particles and waves to the quantum domain.
- Carry out calculations symbolically (in terms of physical variables) and numerically (using appropriate values and their units).
- Obtain experimental data, estimate uncertainties and relate the results to physical laws governing wave behaviour of oscillating systems and waves.
- Collaborate effectively within a team environment and communicate laboratory results in written scientific format.

Electronically Approved - Sep 02 2022 17:28

Department Approval