



COURSE OUTLINE

1. **Course:** PHYS 369, Acoustics, Optics and Radiation (for students in Engineering) - Fall 2019

Lecture 01: TR 12:30 - 13:45 in MFH 162

Instructor	Email	Phone	Office	Hours
Dr Christopher Cully	cmcully@ucalgary.ca	403 220-6088	SB 631	TR 14:00-15:00

Coordinator(s)

Name	Email	Phone	Office	Hours
Dr. Marzena Kastyk-Ibrahim	phascrscoord@ucalgary.ca	403 220-8073	SB 527A	Fridays 10:00-11:00

When communicating with the instructors and course coordinator please allow 2 work days for a response to messages and e-mail inquiries.

Course Site:

D2L: PHYS 369 L01-(Fall 2019)-Acoustics, Optics & Radiation

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

2. **Requisites:**

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

Prerequisite(s):

Mathematics 277 and Physics 259.

Antirequisite(s):

Credit for Physics 369 and 365 will not be allowed.

Note(s):

- a. Required for Geomatics Engineering students. Open to all other engineering students, excluding electrical.

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:

Component(s)	Weighting %	Date
Electronic response (TopHat)	3	
Assignments (Wiley Plus)	12	
Laboratory experiments	20	
In-class quiz	5	Thu Oct 10, 2019; 12:45 - 1:30 pm
Midterm test	20	Tue Nov 5, 2019, 7:00 - 8:30 pm
Final examination	40	To be scheduled by the Registrar

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 %

A weighted course percentage will be calculated for each student after the final exam is written. Values in the table above indicate the minimum percent required to achieve the given grade.

This course has a registrar scheduled final exam.

4. Missed Components Of Term Work:

In the event that a student misses the midterm or any course work due to illness, supporting documentation, such as a medical note or a statutory declaration will be required (see [Section M.1](#); for more information regarding the use of statutory declaration/medical notes, see [FAQ](#)). Absences must be reported within 48 hrs.

The regulations of the Faculty of Science pertaining to this matter are found in the Faculty of Science area of the Calendar in [Section 3.6](#). It is the student's responsibility to familiarize themselves with these regulations. See also [Section E.3](#) of the University Calendar.

Missed labs

Please fill in the [Make-up lab request form](#) (should be saved as an Excel file) posted on D2L (Folder: Missed course components) and submit it to the Dropbox: Missed Labs. Priority for scheduling a make-up lab will be given to students who can provide supporting documentation e.g. statutory declaration, a note from a physician/counsellor. Requests submitted more than 7 days after the date of the missed lab will not be considered.

Students are NOT allowed to come to a lab section different than their own. Make-ups for all labs will be scheduled during the 13th week of classes. You can make up one lab. In case of special circumstances, please contact the Course Coordinator (preferably come for office hours to discuss the issue).

Missed assignments

Please contact the the Course Coordinator if you have a legitimate reason for missing a deadline for an assignment. Sleeping in, forgetting about the deadline etc. is NOT considered a legitimate reason.

Missed In-class Quiz

Students who miss the In-class quiz because of ill health, or for other valid reasons, will be granted an excused absence by the Course Coordinator provided that alleged problems are supported in writing (e.g. statutory declaration, a note from a physician/counsellor). In the case of a missed In-class quiz students must notify the Course Coordinator by submitting the form: Missed quiz (Folder: Missed course components) to the D2L Dropbox: Misses quiz the day after the In-class quiz, at the latest. Once the claim of illness is substantiated, the weight of the In-class quiz will be shifted to the midterm exam.

Missed Midterm

Students who miss the midterm because of ill health, or for other valid reasons, will be granted an excused absence by the Course Coordinator provided that alleged problems are supported in writing (e.g. statutory declaration, a note from a physician/counsellor). In the case of a missed exam students must notify the Course Coordinator by submitting the form: Missed quiz (Folder: Missed course components) to the D2L Dropbox: Misses quiz the day after the In-class quiz, at the latest. Once the claim of illness is substantiated, the weight of the midterm will be shifted to the final exam.

5. Scheduled Out-of-Class Activities:

The following out of class activities are scheduled for this course.

Activity	Location	Date and Time	Duration
Midterm Exam	Will be posted in D2L the week before the Midterm Exam.	Tuesday, November 5, 2019 at 7:00 pm	1.5 Hours

REGULARLY SCHEDULED CLASSES HAVE PRECEDENCE OVER ANY OUT-OF-CLASS-TIME-ACTIVITY. If you have a conflict with the out-of-class-time-activity, please contact your course coordinator/instructor no later than **14 days prior** to the date of the out-of-class activity so that alternative arrangements may be made.

Students are expected to make every effort to attend the midterm exam. If you have a legitimate conflict, you must inform the course coordinator at least 2 weeks prior to the exam dates so that alternative arrangements may be made.

6. Course Materials:

Recommended Textbook(s):

Jearl Walker, *"Fundamentals of Physics, Halliday, Resnick", 10th Edition* Wiley.

- WileyPlus license (see information about on-line Assignments below).
- A TopHat license (free for UC students at tophat.com) and a response device such as a phone, laptop or tablet.
- An extensive set of supplemental Extra Notes will be posted on D2L (free of charge).

7. Examination Policy:

The In-class quiz, midterm and final examinations in Physics 369 are multiple choice questions, closed-book exams, although a formula sheet will be provided with the question paper.

You are required to use the Schulich School of Engineering approved calculator in these examinations. Students should also read the Calendar, Section G, "Examinations and Tests" (<https://www.ucalgary.ca/pubs/calendar/current/g.html>).

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.

- Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within **10 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 immediately submit the Reappraisal of Graded Term work form to the department in which the course is offered. The department will arrange for a re-assessment of the work if, and only if, the student has sufficient academic grounds. See sections [I.1](#) and [I.2](#) of the University Calendar
- 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:

- 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](#)).
- SU Wellness Center:** The Students Union Wellness Centre provides health and wellness support for students including information and counselling on physical health, mental health and nutrition. For more information, see www.ucalgary.ca/wellnesscentre or call [403-210-9355](tel:403-210-9355).
- Sexual Violence:** The University of Calgary is committed to fostering a safe, productive learning environment. The Sexual Violence Policy (<https://www.ucalgary.ca/policies/files/policies/sexual-violence->

[policy.pdf](#)) is a fundamental element in creating and sustaining a safer campus environment for all community members. We understand that sexual violence can undermine students' academic success and we encourage students who have experienced some form of sexual misconduct to talk to someone about their experience, so they can get the support they need. 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](tel:403-220-2208).

- d. **Misconduct:** Academic misconduct (cheating, plagiarism, or any other form) is a very serious offence that will be dealt with rigorously in all cases. A single offence may lead to disciplinary probation or suspension or expulsion. The Faculty of Science follows a zero tolerance policy regarding dishonesty. Please read the sections of the University Calendar under [Section K](#). Student Misconduct to inform yourself of definitions, processes and penalties. Examples of academic misconduct may include: submitting or presenting work as if it were the student's own work when it is not; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; collaborating in whole or in part without prior agreement of the instructor; borrowing experimental values from others without the instructor's approval; falsification/ fabrication of experimental values in a report. **These are only examples.**
- e. **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on [assembly points](#).
- f. **Academic Accommodation Policy:** Students needing an accommodation because of a disability or medical condition should contact Student Accessibility Services in accordance with the procedure for accommodations for students with disabilities available at [procedure-for-accommodations-for-students-with-disabilities.pdf](#).

Students needing an accommodation in relation to their coursework or to fulfill requirements for a graduate degree, based on a protected ground other than disability, should communicate this need, preferably in writing, to the Associate Head of the Department of Physics & Astronomy, Dr. David Feder by email phas.ahugrd@ucalgary.ca or phone 403-220-8127. Religious accommodation requests relating to class, test or exam scheduling or absences must be submitted no later than **14 days** prior to the date in question. See [Section E.4](#) of the University Calendar.
- g. **Safewalk:** Campus Security will escort individuals day or night (See the [Campus Safewalk](#) website). Call [403-220-5333](tel:403-220-5333) for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.
- h. **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.
- i. **Student Union Information:** [VP Academic](#), Phone: [403-220-3911](tel:403-220-3911) Email: suvpaca@ucalgary.ca. SU Faculty Rep., Phone: [403-220-3913](tel:403-220-3913) Email: sciencerep@su.ucalgary.ca. [Student Ombudsman](#), Email: ombuds@ucalgary.ca.
- j. **Internet and Electronic Device Information:** Unless instructed otherwise, cell phones should be turned off during class. All communication with other individuals via laptop, tablet, smart phone or other device is prohibited during class unless specifically permitted by the instructor. Students that violate this policy may be asked to leave the classroom. Repeated violations may result in a charge of misconduct.
- k. **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.
- l. **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.

LABATORIES

Laboratories begin during the week of September 9, 2019. Check the timetable below for the dates of your labs. Labs take place in ST 036 and ST 038, as indicated in your Student Centre. Make-up labs will be during the last week of classes.

Lab schedule

Week	Dates	Odd-numbered lab sections	Even-numbered lab sections
1	Sep 5 - Sep 6	NO LABS	NO LABS
2	Sep 9 - Sep 13	Lab 1	NO LABS
3	Sep 16 - Sep 20	NO LABS	Lab 1
4	Sep 23 - Sep 27	Lab 2	NO LABS
5	Sep 30 - Oct 4	NO LABS	Lab 2
6	Oct 7 - Oct 11	Lab 3	NO LABS
7	Oct 14 - Oct 18	NO LABS	Lab 3
8	Oct 21 - Oct 25	Tutorial	NO LABS
9	Oct 28 - Nov 1	NO LABS	Tutorial
10	Nov 4 - Nov 8	Lab 4	NO LABS
11	Nov 18 - Nov 22	NO LABS	Lab 4
12	Nov 25 - Nov 29	Lab 5	NO LABS
13	Dec 2 - Dec 6	NO LABS	Lab 5

List of Experiments

- Lab 1** Uncertainties
- Lab 2** Simple Harmonic Oscillations
- Lab 3** Standing Waves on a Wire
- Tutorial** Interference and Diffraction
- Lab 4** Concave Mirrors
- Lab 5** Thin Lenses & Optical Instruments

The weight of laboratory experiments (Lab 1, Lab 2, Lab 3, Lab 4 and Lab 5) adds up to the total of 18% (3.6% per experiment), with 10% of each lab assigned to the pre-lab exercise. Tutorial is worth 2% of the total grade.

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 his/her 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 required. Lab preliminary work is to be submitted individually by each lab group member via D2L by 11:59 pm before the day of the lab.

Pre-labs

Pre-labs are to be completed and submitted individually.

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 the 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.

Lab grades

As your term work items (labs, electronic response scores and midterm test) accumulate, your marks will be posted on the Physics 369 grades website. Check this posting regularly by going to the Physics 369 D2L site. Missing or incorrectly posted term work scores should be reported to your TA not later than two weeks after they have been posted. If the problem could not be resolved the Course Coordinator should be contacted. You should be prepared to produce the original work to verify the requested correction.

WileyPLUS On-line ASSIGNMENTS

Your text, Fundamentals of Physics by Halliday, Resnick and Walker is available in the bookstore bundled with a WileyPLUS code. If you did not take PHYS 259, you must obtain the book or WileyPLUS standalone and keep this code, as it will be used to access the online homework system. If you did buy the book last term and used your code, you will **not** need another code as it is still valid.

To register, please go to www.wileyplus.com and logon with your U of C email address and your password, which is your student ID. If you changed your password to something different than your student ID last year, the change will remain intact. For any technical support issues, go to www.wileyplus.com/support and choose the live chat option.

A new text comes bundled with a code, which will give you access to the eBook, Assignments, Tutorials, Videos, Animations and Orion, an adaptive learning self-practice system.

If you would like to purchase just WileyPLUS by itself (without the text), you can do so through the bookstore or else from www.wileyplus.com.

If you are not able to purchase a new book or the WileyPLUS standalone, you will be able to access the homework in Taylor Library. You will not have access to any of the e-text or other WileyPLUS materials, and must do your homework in the lab, but can upgrade at any time. You will need to register as directed above, and choose the free option.

Assignment Schedule

Assignment	Available	Due Date
Assignment 1	September 11, 2019	September 19, 2019
Assignment 2	September 18, 2019	September 26, 2019
Assignment 3	September 25, 2019	October 3, 2019
Assignment 4	October 2, 2019	October 10, 2019
Assignment 5	October 9, 2019	October 17, 2019
Assignment 6	October 16, 2019	October 24, 2019
Assignment 7	October 23, 2019	October 31, 2019
Midterm practice	October 30, 2019	No due date, practice
Assignment 8	November 6, 2019	November 21, 2019
Assignment 9	November 20, 2019	November 28, 2019
Assignment 10	November 27, 2019	December 5, 2019
Final practice	December 4, 2019	No due date, practice

TopHat

As a vehicle to encourage class participation and student interaction, the TopHat system will be employed. This is the same response system used in Physics 259. Each lecture section will have its own TopHat course name which will be given to you by your instructor.

The type and number of response questions you will encounter over the semester is at the sole discretion of your instructor. If students make any attempt to answer a question they get 1 mark, and if they get the answer correct they get 1 more mark. Such questions are worth 2 marks. Some of the questions asked will not have a specific correct answer and are worth 1 mark. The TopHat marks are worth 3% of the total course grade.

COURSE SCHEDULE (APPROXIMATE)

Lecture-by-lecture Course Schedule PHYS 365/369 Part 1

Week	Dates	Day	Topic	Text reference*
1	Sep 5 - Sep 6	R	Introduction	EN1, HR15.1, HR15.4
			Uncertainties in measurements	
			SHM of systems obeying Hooke's Law	
2	Sep 9 - Sep 13	T	Differential equation of simple harmonic motion Superposition of SHMs of the same frequency	EN1, HR15.1, HR 16.6
		R	Phasors, phasor addition; phasor diagrams	EN1, HR 16.6
			Phasors as complex quantities	
3	Sep 16 - Sep 20	T	Travelling wave pulse: mathematical description, particle motion Partial derivatives; harmonic wave equation	HR 16.1, EN2, HR 16.4
		R	Principle of wave superposition	HR 16.5, EN2, HR 16.6
			Harmonic (sinusoidal) waves	
			Mathematical description, particle motion, phase differences Complex representation of a traveling harmonic wave	
4	Sep 23 - Sep 27	T	Speed of waves in real media: stretched string Sound waves as longitudinal waves in solids, liquids, and gases Speed of sound waves	EN3, HR 16.2, HR 17.1-2
		R	Energy transport by a harmonic wave	
			Mechanical impedance; Power transported by a wave	
			Acoustical impedance; Sound intensity and sound intensity level (dB)	
5	Oct 30 - Oct 4	T	Sound field around point and line sources; inverse square law Acoustical attenuation Reflections at boundaries between two media; boundary conditions	EN4, HR 17.4, HR 17.5
		R	Amplitude reflection and transmission coefficients at a junction	EN4
			Energy reflection and transmission coefficients	
		6	Oct 7 - Oct 11	T
R	In-class quiz			
7	Oct 14 - Oct 18			T
		R	Coherent and incoherent sources	HR 33.4 HR 35.2-3
			Two-slit interference	
8	Oct 21 - Oct 25	T	Thin film interference; Multiple reflections in a thin film	HR 35.4
		R	Diffraction pattern of a single slit	HR 36.1-2, HR 36.3
			Circular aperture, resolving power	

Lecture-by-lecture Course Schedule Part 2 PHYS 369

Week	Dates	Day	Topic	Text reference*
9	Oct 28 - Nov 1	T	Midterm Review	
		T	Nature of light	HR 33.1, HR 33.5
		T	Wavefronts, ray approximation	
		T	Laws of reflection and refraction, index of refraction	
		R	Total internal reflection	HR 33.6, HR 34.1-2
		R	Fibre optics and waveguides	
R	Imaging by reflection at a spherical surface			
10	Nov 4 - Nov 8	T	Midterm Review	
		R	Graphical methods for spherical mirrors	HR 34.2, HR 34.3
		R	Lateral magnification	
R	Imaging by refraction at a spherical interface			
11	Nov 18 - Nov 22	T	Multi-surface problems; virtual object	HR 34.4, HR 38.4-5
		T	Derivation of thin lens equation	
		T	Graphical methods for thin lenses	
		R	Multi-lens systems, cameras, the eye	HR 34.5
R	Magnifiers, microscopes, telescopes			
12	Nov 25 - Nov 29	T	Light as a transverse electromagnetic wave	EN9, HR 35.1, HR 33.4
		T	Plane and circular polarization; Malus' Law Elliptical and Circular Polarization	
		T	Polarization by Reflection: Brewster's Angle	
		R	Doubly Refracting Materials	HR 35.1
R	Huygen's Principle			
13	Dec 2 - Dec 6	T	Resolving Power. Irradiance	EN10
		T	Radiometric quantities; solid angle; point sources	
		T	Irradiance due to an extended source: Lambert's law	
		R	Plane source surfaces; radiance	EN10
		R	Absorptance, reflectance; thermal equilibrium	
		R	Blackbody radiation, Planck's Law	
R	Stefan-Boltzmann law; emissivity; heat transfer			
R	Wien displacement law			

FAQs (Frequently asked questions):

- 1. What do we cover in this course?** See Detailed Course Outline above.
- 2. Where do I get the Extra Notes?** Download them in small chunks from the course Desire2Learn site (free). These notes deal with material included in the course but not covered in sufficient depth in the textbook.
- 3. When do labs start?** Week starting Monday, Sep 9, 2019 for ODD-numbered lab sections (This is in the FIRST week of lectures in the course.) Week starting Monday Sep 16, 2019 for EVEN-numbered sections.
- 4. Where do I get my lab manual?** Lab Manuals are posted on D2L. You must read the labs and answer pre-lab questions before coming to each lab.
- 5. Where do I get the first assignment?** Information for accessing WileyPlus is provided on the previous page
- 6. My instructor said he posted their lecture notes...where is that?** Your instructor will post lecture notes in the Content section on Desire2Learn.
- 7. Who do I contact if something is wrong with my grades, or I have any other problem with the course?** For an incorrectly entered lab grade, talk to your own lab TA at your next scheduled lab. For all other inquiries, send an e-mail to the Course Coordinator. IMPORTANT: include the course number, your name and ID number in the subject line. Keep messages brief and to the point.

COURSE INCOMES

Students coming into PHYS 369 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 behavior 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.
- Solve problems in geometric optics, incorporating reflection and refraction from multiple curved surfaces.
- 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 predicted physical laws governing wave behavior of oscillating systems and waves.
- Collaborate effectively within a team environment and communicate laboratory results in written scientific format.

Department Approval:

Electronically Approved

Date: 2019-08-24 10:55

Associate Dean's Approval for out of
regular class-time activity:

Electronically Approved

Date: 2019-08-25 20:10