UNIVERSITY OF CALGARY
DEPARTMENT OF PHYSICS AND ASTRONOMY
COURSE OUTLINE

1. **Course:** Physics 501, The Theory of Relativity Winter 2017

   Instructor: Dr. Sean Stotyn | SA 101C | 403.210.7594 | sean.stotyn@ucalgary.ca | Office Hours: TBA

   Lecture Sections: LEC 1 | MWF 15:00-15:50 | SA 147

   Course Website: d2l.ucalgary.ca

   Departmental Office: SB 605, 403-220-5385, phasugrd@ucalgary.ca

2. **Prerequisites:** Physics 325 and 457 and Mathematics 353 or Applied Mathematics 309.
   Note: The Faculty of Science policy on pre- and co-requisite checking is outlined in the UofC Calendar. A student may not register in a course unless a grade at least" C-" has been obtained in each pre-requisite course; it is the responsibility of students to ensure that their registrations are in order. See http://www.ucalgary.ca/pubs/calendar/current/sc-3-5.html for details.

3. **Grading:** The University policy on grading and related matters is described sections F.1 and F.2 of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Assignments	30%	(6 in total at 5% each)
In-class Midterms	30%	(2 midterms at 15% each)
Worksheets	10%	(In class activities)
Final Examination	30%	(To be scheduled by the Registrar)

   All class work will be graded numerically (e.g. 7/10) which can directly be converted to a percent. The final course mark will be calculated as a percent then converted to a grade using the following scale:

> = 92 %	A +	> = 76 %	B +	> = 63 %	C +	> = 50 %	D
> = 86 %	A	> = 72 %	B	> = 59 %	C	< 50 %	F
> = 80 %	A -	> = 68 %	B -	> = 55 %	C -		

4. **Missed Components of Term Work:** 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 himself/herself with these regulations. See also Section E.6 of the University Calendar

5. **Scheduled out-of-class activities:** none

6. **Course Materials:** Official textbook: "*Dynamics and Relativity,*" J.R. Forshaw and A.G. Smith, Wiley, 2009.
   + supplemental material from "*Gravity: An Introduction to Einstein's General Relativity,*" Hartle (to be provided by instructor)

7. **Examination Policy**: All worksheets, midterms, and final examinations will be open book and a calculator is allowed. For both midterms and the final exam, a formula sheet (prepared by the student) is encouraged. Students should also read the Calendar, Section G, on Examinations.

8. **Course fees**: none

9. **Writing across the curriculum statement:** In this course, the quality of the student's writing in quizzes, tests and examinations will be a factor in their evaluation. See also Section E.2 of the University Calendar.

10. **Human studies statement**: Students in this course are not expected to participate as subjects or researchers. See also Section E.5 of the University Calendar.

11. OTHER IMPORTANT INFORMATION FOR STUDENTS:

(a) **Academic 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.

(b) **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on assembly points.

(c) **Student Accommodations:** 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 http://www.ucalgary.ca/policies/files/policies/procedure-for-accommodations-for-students-with-disabilities_0.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, preferably in writing, to the Associate Head of the Department of Physics and Astronomy, Dr. Michael Wieser, by email (mailto:mwieser@ucalgary.ca) or by phone (403.220.3641).

(d) **Safewalk:** Campus Security will escort individuals day or night (http://www.ucalgary.ca/security/safewalk/). Call 220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.

(e) **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). As one consequence, 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 also http://www.ucalgary.ca/secretariat/privacy.

(f) **Student Union Information:** VP Academic Phone: 220-3911 Email: suvpaca@ucagary.ca.
SU Faculty Rep: Phone: 220-3913
Email: science1@su.ucalgary.ca, science2@su.ucalgary.ca and science3@su.ucalgary.ca
Student Ombuds Office: 403 220-6420 Email: ombuds@ucalgary.ca; http://ucalgary.ca/provost/students/ombuds

(g) **Internet and Electronic Device Information:** You can assume that in all classes that you attend, your cell phone should be turned off unless instructed otherwise. Also, communication with other individuals, via laptop computers, Blackberries or other devices connectable to the Internet is not allowed in class time unless specifically permitted by the instructor. If you violate this policy you may be asked to leave the classroom. Repeated abuse may result in a charge of misconduct.

(h) **U.S.R.I.:** At the University of Calgary, feedback provided by students through the Universal Student Ratings of Instruction (USRI) survey provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses (www.ucalgary.ca/usri). Your responses make a difference - please participate in USRI Surveys.

1. OTHER COURSE RELATED INFORMATION:

(a) Course Description

This course on a modern approach to Einstein's theory of Special Relativity will begin with Lorentz transformations in classical mechanics and relativistic energy and momentum. These will be applied to relativistic kinematics and relativistic electrodynamics. Throughout the course, a geometrical interpretation will be developed via space-time diagrams and causal structure. Moving beyond the restrictive formulation in terms of inertial frames, four-vectors and tensors will be introduced, leading finally to an introduction to General Relativity and the Schwarzschild black hole.

(b) Course Learning Outcomes

By the end of the course, students should be able to:

1. Describe the Lorentz transformation laws of space-time and apply them to resolve apparent paradoxes.
2. Describe how energy and momentum of null and time-like particles transform between frames and use these to explain observational data from particle accelerators.
3. Express classical electromagnetism as a Special Relativistic theory.
4. Use the symmetries of space-time to construct the 4-velocity of a generic time-like observer, and the wave 4-vector of a null particle.
5. Interpret and draw conclusions about causal structure from space-time diagrams
6. Identify the key properties of black holes, including event horizons, singularities, and (un)stable orbits

(c) Course Learning Incomes

Coming into the course, students should be able to:

1. Construct the laws of Newtonian physics in inertial frames in cartesian, cylindrical, and spherical coordinates.
2. Utilize available symmetry to make a given problem tractable.
3. Perform basic vector calculus (Green's theorem, Stokes' theorem, etc.) using unit vector notation.
4. Express electrodynamics in terms of fields that exert forces on charged particles.
5. Use the Euler-Lagrange equations to find equations of motion (this will also be reviewed in the course).

(d) Syllabus

Midterm 1: Chapters 1, 5, 6, and 7
Midterm 2: Chapters 11, 12, 13, and 14
Final: Chapters 1, 5, 6, 7, 11, 12, 13, 14 + additional material from Hartle

Week	Class Dates	Reading	Homework	Exam
1	Jan 9-13	Ch. 1		
2	Jan 16-20	Ch. 5		
3	Jan 23-27	Ch. 6	Assignment 1	
4	Jan 30-Feb 3	Ch. 6,7		
5	Feb 6-10	Ch. 7	Assignment 2	
6	Feb 13-17	Ch. 11		Midterm 1
Feb 20-24: Reading Week, University Closed				
7	Feb 27-Mar 3	Ch. 12	Assignment 3	
8	Mar 6-10	Ch. 12,13		
9	Mar 13-17	Ch. 14	Assignment 4	
10	Mar 20-24	Ch. 14		Midterm 2
11	Mar 27-31	Hartle (Ch. 9)	Assignment 5	
12	Apr 3-7	Hartle (Ch. 12)		
13	Apr 10-12	Hartle (Ch. 12)	Assignment 6	

Topics that will be covered in this course include:

- Physics in inertial frames of reference
- Transforming between inertial frames *(Lorentz transformations)*
- Length contraction, time dilation, unification of energy and momentum
- Resolving paradoxes and the relativity of simultaneity
- Transformation of mass and energy
- Minkowski space-time, light cones, and causal structure
- Special Relativity in non-inertial frames (4-vectors and tensors)
- Null and time-like geodesics

- Space-time symmetries: Killing vectors and conserved quantities
- Curved space-times: General Relativity, gravitational time dilation, and black holes

Department Approval_____Date_____