ORIGINAL COURSE IMPLEMENTATION DATE:	January 2003
REVISED COURSE IMPLEMENTATION DATE:	September 2015
COURSE TO BE REVIEWED: (six years after UEC approval)	October 2020

Course outline form version: 07/07/14

OFFICIAL UNDERGRADUATE COURSE OUTLINE FORM

Note: The University reserves the right to amend course outlines as needed without notice.

Course Code and Number: PHYS 452 **Number of Credits: 3** Course credit policy (105)

Course Full Title: Introduction to General Relativity
Course Short Title (if title exceeds 30 characters):

Faculty: Faculty of Science **Department (or program if no department):** Physics

Calendar Description:

Einstein's theory of general relativity; a description of gravity as a consequence of the curvature of spacetime; introduction to differential geometry and geodesics; Schwarzschild metric, gravitational waves, and FLRW cosmology.

Prerequisites (or NONE):	PHYS 352
Corequisites (if applicable, or NONE):	NONE
Pre/corequisites (if applicable, or NONE):	

Equivalent Courses (cannot be taken for additional credit)
Former course code/number: **N/A**
Cross-listed with:
Equivalent course(s): **N/A**
Note: Equivalent course(s) should be included in the calendar description by way of a note that students with credit for the equivalent course(s) cannot take this course for further credit.

Transfer Credit
Transfer credit already exists: ☐ Yes ☒ No
Transfer credit requested (OReg to submit to BCCAT):
☐ Yes ☒ No (if yes, fill in transfer credit form)
Resubmit revised outline for articulation: ☐ Yes ☐ No
To find out how this course transfers, see **bctransferguide.ca.**

Total Hours: 75
Typical structure of instructional hours:

Lecture hours	75
Seminars/tutorials/workshops	
Laboratory hours	
Field experience hours	
Experiential (practicum, internship, etc.)	
Online learning activities	
Other contact hours:	
Total	**75**

Special Topics
Will the course be offered with different topics?
☐ Yes ☐ No
If yes, different lettered courses may be taken for credit:
☐ No ☐ Yes, repeat(s) ☐ Yes, no limit
Note: The specific topic will be recorded when offered.

Maximum enrolment (for information only): 24
Expected frequency of course offerings (every semester, annually, every other year, etc.): Once every two years

Department / Program Head or Director: Derek Harnett	**Date approved:**	August 27, 2014
Campus-Wide Consultation (CWC)	**Date of posting:**	n/a
Faculty Council approval	**Date approved:**	October 3, 2014
Dean/Associate VP: Lucy Lee	**Date approved:**	October 3, 2014
Undergraduate Education Committee (UEC) approval	**Date of meeting:**	October 24, 2014

Learning Outcomes

Upon successful completion of this course, students will be able to:

- compute geometric quantites such as length, area, volume, and proper time given a line element in an arbitrary Riemannian space or Lorentzian spacetime
- transform line elements between coordinate systems
- define timelike and null geodesics
- compute Christoffel symbols from line elements
- sketch local lightcones in an effort to identify event horizons
- determine two-dimensional embeddings in flat three-dimensional space corresponding to spherically symmetric spacetimes
- solve relativistic kinematics problems in the exterior Schwarzschild geometry
- explain the phenomenon of gravitational lensing
- explain the key principles underlying direct detection of gravitational radiation
- relate the rate of the universe's expansion to the gravitational red shift and the age of the universe

Prior Learning Assessment and Recognition (PLAR)

☒ Yes ☐ No, PLAR cannot be awarded for this course because

Typical Instructional Methods (guest lecturers, presentations, online instruction, field trips, etc.; may vary at department's discretion)

Lectures, computer simulations, projects

NOTE: The following sections may vary by instructor. Please see course syllabus available from the instructor.

Typical Text(s) and Resource Materials (if more space is required, download Supplemental Texts and Resource Materials form)

	Author (surname, initials)	Title (article, book, journal, etc.)	Current ed.	Publisher	Year
1.	Schultz, B.F.	A First Course in General Relativity	☒	Cambridge	2009
2.	Wald, R.M.	General Relativity	☒	Chicago	1984
3.	Misner, Thorne, Wheeler	Gravitation	☒	Freeman	1973
4.	Hartle, James B.	Gravity: An Introduction to Einstein's General Relativity	☒	Addison-Wesley	2003
5.	Carroll, Sean	Spacetime and Geometry: An Introduction to General Relativity	☒	Addison-Wesley	2003

Required Additional Supplies and Materials (software, hardware, tools, specialized clothing, etc.)

Use this section for supplies and materials for all sections of this course.

Typical Evaluation Methods and Weighting

Final exam:	40%	Assignments:	15%	Midterm exam:	0%	Practicum:	%
Quizzes/tests:	**30%**	Lab work:	%	Field experience:	%	Shop work:	%
Project::	15%	Other:	%	Other:	%	Total:	100%

Details (if necessary):

Grading system: Letter Grades: ☒ Credit/No Credit: ☐ Labs to be scheduled independent of lecture hours: Yes ☐ No ☒

Typical Course Content and Topics

1. Introductory differential geometry
2. Newtonian gravity
3. Special relativity review
4. Gravity as geometry
5. Geodesics
6. The Schwarzschild metric
7. Gravitational waves
8. Cosmology