PHY 303 / RCS 303

TERM: 202509 SEC: A01

http://astro.uvic.ca/~babul/AstroCourses/P303

A course intended for *non*-physicists, *non*-astronomers that will explore the Origins of Space, Time and Matter in the Universe, and our place within

We will explore the conceptual foundations of current physical theories as well as ideas animating bleeding-edge investigations.

Some of these may even be unfamiliar to Physics and Astronomy students, who are welcome to take this course as a general (but not a program) elective.

Finally, welcome to Religion, Culture and Society students who are taking this course as RCS 303

Galatea of the Spheres by Dali

PLEASE ENTER BY CLICKING ON THE IMAGE

This website is incomplete and under construction. The version currently available was developed by Deborah Rose and Alison Brown. It is partly based on the classroom lecture notes of the Instructor, Arif Babul. Financial support was provided by the Work Study program at University of Victoria

- # Course Information PHY 303 / RCS 303

  - PHYS 303 / RCS 303: An Introduction
  - Instructor Info and Course Requirements
  - Course Texts and References
  - Readings and Lecture Schedule
  - Reading Depository
  - Grading Scheme

- # Must watch movies over reading break: three 1-HR Videos:

  Some of the episodes are low-res. I am going to look for hi-res versions and replace these in due course.

  - Episode 1 Full (Medium Res)
  - Episode 2 First Half only (High Res)
  - Episode 2 Full (Low Res)
  - Episode 3 Full (High Res)

- # Class Notes

  For convenience, I am making copy of my basic overhead slide set available below. Please note that the information contained therein is subject to revision in that in any one year, I may choose to present only a subset of the material, change the emphasis and/or order of presentation, and add extra material not included in notes below depending on the developments and discoveries that have occurred over the past year. And, I may even add additional notes to the set below.

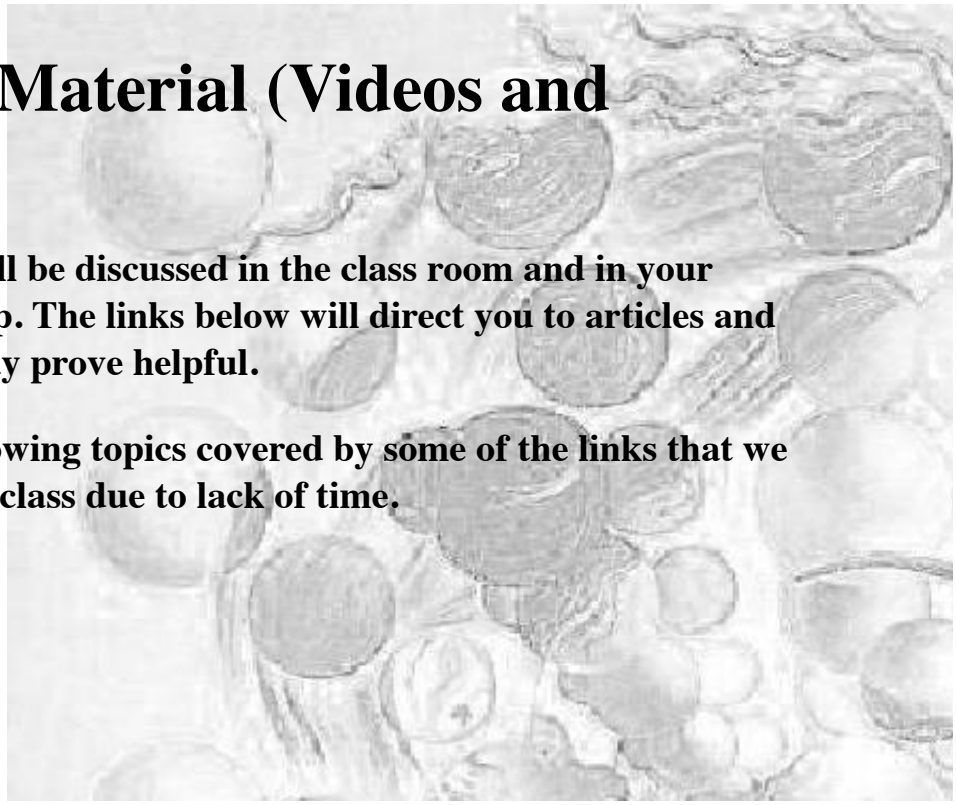
  Since it is very likely that the content of this website WILL BE UPDATED over the course of the semester, you should be aware that most browsers

will cache webpages. This means that when you return to webpage, you will generally see the old, cached page and any new changes will not show up. To see the updated content, you must clear browser cache and force reload the webpages. I have found that this is difficult to do on Safari but it is possible. For example, under Develop menu, you can "empty caches" and then reload the webpage. Generally, I have found Firefox and Chrome to be more user-friendly: You can explicitly "force reload the frame" on these browsers.

Finally, these notes should NOT be used as a reason for not attending the lectures since the considerable additional content introduced during the lectures is legitimate source of questions for midterms and final exams.

THESE ARE THE NOTES AS OF AUG 28TH 2025:

- **Set_I**
- **Set_II**
- **Set_III**
- **Set_IV**
- **Set_V**
- **Set_VI**
- **Set_VII**



• Supplementary Material (Videos and Articles)

Some of the concepts that will be discussed in the class room and in your readings are difficult to grasp. The links below will direct you to articles and videos with graphics that may prove helpful.

There are also some mindblowing topics covered by some of the links that we will only touch briefly in the class due to lack of time.

- **For Weeks 1-2: Introduction**
  - Why Physics 303?
  - TED Lecture: Truth and Beauty in Physics
  - The Humans and the Heavens: An Ancient Affair
  - On the Origins of the Zodiac
- **For Weeks 3: Pre-Einstein**
  - Kepler's Laws (animation)
  - Newton's Laws explained, with animation
- **For Weeks 4-5: Symmetry and Supersymmetry**
  - Symmetry: Key to Nature's Secrets
  - The Most Important Woman in the History of Mathematics
  - Symmetry in Physics: Part 1-Spacetime Symmetry
  - Symmetry in Physics: Part 2-Discreet Symmetries and Antimatter
  - Symmetry in Physics: Part 3-Internal Symmetries and Particle Physics
  - Symmetry in Physics: Part 4-Gauge Symmetries and Physical Interactions
  - Atoms, Spacetime and Unity of Physics
  - What is symmetry? What is supersymmetry?
  - Supersymmetry and Origin of Matter (Four videos)
  - The Origin of Mass
- **For Weeks 6-7: Einstein's Relativity**
  - Basics of Relativity (A student project)
  - A Neat Intro to Relativity, with animation
  - Intro to Relativity (A student project)
  - Time is an OBJECT...but see the next link (youtube video)
  - How To Build A Time Machine | Weird Science
  - Time Machines and Time Travel
  - Falling into a Black Hole (movies, animation, etc.)
  - Inside a Black Hole (movies, animation, etc.)
  - Gravity Waves: Ripples in Spacetime
  - What are Gravity Waves?
  - Pre-2016 Evidence for Gravity Waves?
- **For Weeks 8-9: Quantum Physics**

- **For Weeks 10-11: Big Bang and the Origin of the Universe**
  - WMAP Cosmology 101
  - Cosmic Voyage: A Journey Through the Universe
  - Dark Matter, Dark Energy the Invisible Universe HD Full Documentary
  - Observing the Beginning of Time
  - Back to the Beginning
  - National Geographic: Death of the Universe
- **For Weeks 12-13: Inflation and the Origins of the Universe**
  - Inflation Tutorial
  - Proof of Inflation? -- The BICEPS Detection
  - The Myth of the Beginning of Time
  - Universe or Multiverse - A Documentary
  - Does the Multiverse Really Exist?
  - Putting Multiverse Model to the Test
  - Parallel Universes FAQ
  - Primer on particles, strings & quantum spacetime foam

Problem Sets

There will be a total of 6 problem sets assigned over the course of the semester. Jointly these will comprise 40% of your final mark. The assignments (and their due dates as well as an outline of suitable responses) will be posted here. Please check this page regularly.

All students are expected to EITHER drop off their solutions to the assigned problems with the secretaries in the PHYSICS AND ASTRONOMY main office by 3pm of the posted due date OR email your solutions in PDF format directly to the course marking assistant.

If you email your solutions, the file must be PDF and the subject of the email must include YOUR NAME and "PHYS 303 / RCS 303" [PICK THE APPROPRIATE COURSE NAME] and "PROBLEM SET NUMBER XXXX" where XXX =1, 2, ... 6.

To receive a non-failing final course grade, students must - at the very least, submit the FOUR COURSE problem sets where majority of assigned questions have been attempted (NOTE: THE ASSIGNED QUESTIONS FOR PHYS 303 AND RCS 303 STUDENTS ARE NOT THE SAME) and sit for the final exam (PHYS 303/RCS 303) or submit a final essay (RCS 303). The actual course grade will depend on the scores received on the problem sets, midterms and the final exam/essay.

For further details about submission requirements etc., please see Grading Scheme

If you require assistance with the problem sets, I recommend - in the first instance - visiting the Physics Aid Service offered by the Department of Physics and Astronomy. Click on the link for information about the room and schedule information.

- **Problem-Set-1 Due SEPT 15TH**
- **Problem-Set-2 Due SEPT 29TH**
- **Problem-Set-3 Due OCT 10TH**

  NOTE: If you are having trouble with link in the Question 2, click here

  IMPORTANT: Some of the graphics use Adobe Flash, which is no longer supported. It is still possible to understand the article without these graphics (though less fun). We'll have to make do until I find a better alternative.

  PS: Mathematician Emily Noether was the first to realize that symmetries and conservation laws go hand in hand. This video explains that.

- **Problem-Set-4 Due OCT 31ST**
- **Problem-Set-5 Due NOV 15TH**
- **Problem-Set-6 Due NOV 25TH**

  For the first question, please use this website (you may need to temporarily

turn off JavaScript in your browser settings to view this website). Continue to "next" to read a total of 5 webpages.

YOU SHOULD ALSO READ SECTIONS UNDER "BASICS" AND "BLACK HOLES" FROM SIDE MENU.

- # Midterm Test

  The scores of the midterm exam will comprise 25% of the final course mark.

  - **DATE: MID-OCTOBER (see Class Schedule for date)**

- # Final Exam / End-of-Term Essay
  ## Latter is an option available to RCS 303 students

  The scores from the final exam or term-end essay (see Grading Scheme for details) will comprise 35% of the final course mark.

  To receive a non-failing final course grade, students must - at the very least, submit the FOUR COURSE problem sets where majority of assigned questions have been attempted (NOTE: THE ASSIGNED QUESTIONS FOR PHYS 303 AND RCS 303 STUDENTS ARE NOT THE SAME) and sit for the final exam (PHYS 303/RCS 303) or submit a final essay (RCS 303). The actual course grade will depend on the scores received on the problem sets, midterms and the final exam/essay.

  - **DATE: SEE UNIVERSITY EXAM SCHEDULE**

- # Academic Integrity, Course Material Copyright and Policy on use of AI

  ## University of Victoria course copyright Statement:

  All course content and materials are made available by instructors for educational purposes only and for the exclusive use of students registered in their class. The material is protected under copyright law, even if not marked with a ©. Any further use or distribution of materials to others (via email or posting on sites not under the instructor‘s direct editorial control) requires the written permission of the instructor. By accessing this website and by using the username and password to download the course material, you are agreeing to abide by the copyright statement. Violations may result in disciplinary action.

Academic Integrity:

This course is governed by the UVic policy on Academic Integrity Violations of this policy will be reported to the chair or delegate, who will apply appropriate sanctions. Examples of violations include: Plagiarism; Unauthorized use of an human editor or an editing service (paid or unpaid); Unacknowledged use of AI; Multiple submissions; Falsifying materials subject to academic evaluation; Cheating on work, tests and examinations; and Aiding others to cheat

Please note that this policy is not intended to prevent students from developing their academic skills through the exchange of ideas, seeking peer review or critique and using the resources available at the university to support learning. In fact, I personally think that this are important and often very effective modes of learning and skill development.

However, anything that you submit for marking must be prepared in your voice and in your words.

Course AI Policy:

Having an AI answer problem set questions and prepare your course submissions for marking is strictly prohibited. The content of these submissions and the organization of the material therein must the result of your own effort, and carry the imprint of your own unique voice and thoughts. You are welcome to use AI in an engaged iterative manner to find information but you must then explicitly acknowledge such use. If you do use AI in this fashion, I strongly encourage you to double-check the content -- verify the sources, confirm its accuracy, make sure it is sensible. In other words, make sure you have content knowledge and are able to review the information provided to you critically. You will be held accountable for anything that is submitted by you and lacks intellectual rigour, false information, hallucinations, etc.

- # Course Experience Survey

Towards the end of term, you will have the opportunity to complete an anonymous survey regarding your learning experience (CES). The survey is vital to providing feedback to me regarding the course, as well as to help the department improve the overall program for students in the future. In due

course, you will receive an email inviting you to do so.

To make sure you receive the invite, please ensure that your current email address is listed in MyPage (http://uvic.ca/mypage) . If you do not receive an email invitation, you can go directly to http://ces.uvic.ca . You will need to use your UVic netlink ID to access the survey, which can be done on your laptop, tablet, or mobile device. I will remind you and provide you with more detailed information nearer the time

IMPORTANT NOTE:

Physics and Astronomy majors (or potential majors) should note that this course cannot be used to satisfy their program credit requirements, but can be taken as one of their free (i.e. unrestricted) electives.

Please check with me or with the department administrator.

PHYS 303 / RCS 303: ORIGIN OF SPACE, TIME AND MATTER IN THE UNIVERSE


RCS 303 and PHYS 303 are cross-listed courses. Both courses are intended for *non*-science students interested in expanding their understanding of the physical universe, including current ideas regarding its origin (and the origin of all physical elements of our universe) and, its evolution over time. We will explore the concept of spacetime and the intertwined nature of matter and energy.

The course is intended for students with no prior formal (university-level) exposure to astronomy and astrophysics. And, the emphasis will be on conveying the current scientific understanding in a qualitative conceptual manner, making it especially ideal for curious students wanting to know about the Big Bang and related topics without having to grapple with complex mathematics as well as for RCS students wanting to explore various accounts of the universe's origin and development.

Over the course of the semester, we will build up insights using a variety of approaches: We will trace how our understanding of space, time, matter and energy has changed over the past 500, and especially the last 100 years, as well as the role of symmetries in nature. In the process, the course will also provide a glimpse into how physicists go about trying to comprehend the physical cosmos, touching upon issues such as the nature of scientific knowledge as well as the strengths and limitations of the scientific method. Although the course will largely eschew advanced mathematics, a few of the lectures may invoke Grade 11-level mathematics to illustrate and clarify ideas like why people in a fast-moving spaceships age slower than they would on earth.

Students enrolled in PHYS 303 are expected to be conversant with Grade 11 (high school) mathematics. Students enrolled in RCS 303 will not be expected to reproduce these calculations and in detail, will be evaluated differently than PHYS 303 students. For instance, RCS students will have an option of submitting an essay at the end of the term in lieu of sitting the final exam

Finally, students who have taken other astronomy courses should be forewarned that they may find some overlap with materials covered in those courses, at least in the first half of the semester, but things will get much more interesting thereafter.

Science students may find that the course is not as rigorous as they would like and may find the introductory material concerning the history of the subject and a brief survey of ancients attempts understanding the

Universe, superfluous. That being said, the course material, lectures and readings, will introduce concepts that even undergraduate specialist physics and astronomy students are unlikely to seen previously, much less thought of. **These ideas, stemming from on-going research at the very frontiers of our knowledge about the Universe, are guaranteed to stretch and bend the mind in unimaginable ways.**

A. Babul

WHY DEVELOP AND OFFER PHYSICS 303?

There are many reasons for developing a course such as PHYS 303. In my own particular case, I have been motivated by two principle considerations:

Since the dawn of civilization (literally), human beings have exhibited an unquenchable curiosity concerning our Cosmic Origins.

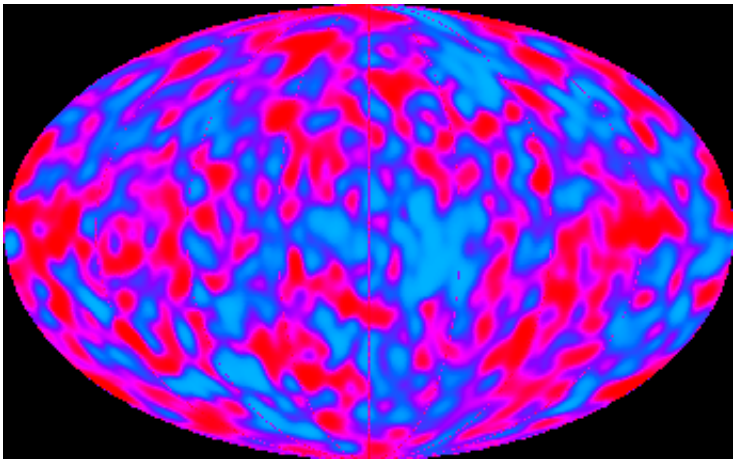
> How, when and why did the Universe come in existence?
> How did galaxies and frothy large-scale structure that they delineate form?
> How did the stars and the planets around them form?
> Is life unique to our solar system?
> What is our place in the Grand Scheme?

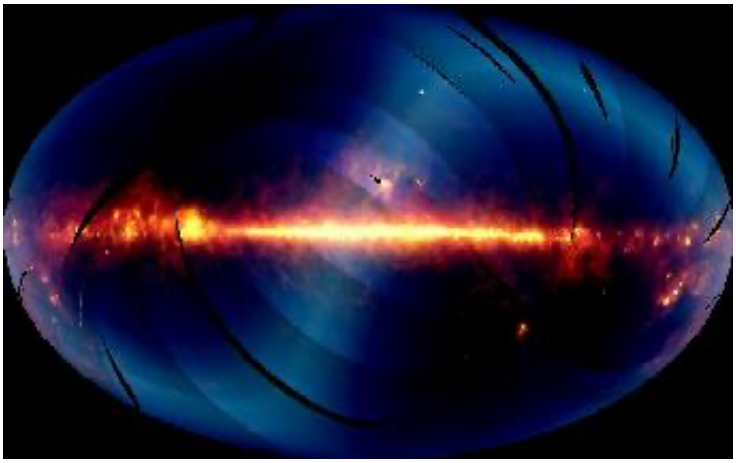
The questions have, in different forms, been pondered by mankind for centuries. They fire the imagination, ignites a sense of awe, touch something deep in the human psyche. It is therefore not surprising that astronomy, which in essence involves peering into the sky in search for answers, holds a favoured position in the public eye. As evidence, one only has to look at the popularity of the public lectures on the subject and the degree of coverage that astronomical discoveries and controversies receive in the popular media. It is, perhaps, not a coincidence that amateur astronomy is one of the two most popular hobby activities in the world.

The search for answers to the cosmic questions takes many forms: mysticism, philosophical, artistic, scientific, or any combination thereof. This course will focus on the scientific search.

The last half-century has seen astonishing progress towards answering these questions from a physical perspective and for the first time in the history of mankind, we are on the threshold of being able to address many of the age-old questions. Cosmology, the study of the Universe as a whole, is entering an exciting new phase when, as Sir Martin Rees the Astronomer Royal (who, by the way, gave a public lecture here in March of 1999) puts it, "*the big picture is coming into focus for the first time. The latest in technological advances are being incorporated into new telescopes and instruments, both land and space-based. And we can expect a crescendo of discoveries in the new millennium, clarifying how the cosmos has evolved, and the role that life plays in it*." In fact, we can now even begin to speculate that our Universe *may be only one of a family, even an infinity, of unique universes*.

This course is an attempt to share to share with you the discoveries, the excitement and the speculations that defines our rapidly receeding horizon.





Second, I would like to show you the exciting and richly layered nature of scientific endeavors. Most non-scientists, and even undergraduate science students, have a very myopic view of the world of science best represented by the following verses by Walt Whitman:

When I heard the learn'd astronomer,
When the proofs, the figures, were ranged in columns before me,
When I was shown the charts and diagrams, to add, divide,
and measure them,
When I sitting heard the astronomer where he lectured with much
applause in the lecture-room,
How soon unaccountably I became tired and sick,
Till rising and gliding out I wander'd off by myself,
In the mystical moist night-air, and from time to time,
Look'd up in perfect silence at the stars.

There is no question that there exists a large gulf that separates the scientists from the non-scientists, and in between flow the murky waters of misunderstanding and miscommunication. Much has been written about on this, starting with the famous essay titled *Two Cultures* by C.P. Snow. I recommend reading the following short essays and articles on the subject:

The Place of Science in a Liberal Education by R.A. Raimi
The Cultural Challenge to Scientific Knowledge by D.K. Dadachanji

In addition, I also recommend reading various articles and commentaries on a recent brouhaha often referred to as the The Sokal Affair and of these, I highly recommend the article titled: What the Social Text Affair Does and Does Not Prove by Alan D. Sokal Follow this link (caveat emptor) to Science Wars webpage to learn more about the subject.

Non-scientists hold many myths about science. There is the myth that the main function of science is to divide and compartmentalize. This, of course, ignores the fact that many of the great scientific theories are intrinsically unifying in nature, bringing together phenomena that were previously thought to be independent and distinct. There is also the commonly held misperception that science is simply an exercise in reducing natural phenomena to a few mathematical equations. Nothing can be further from the truth.

One of Richard Feynman's favourite metaphor will serve to illustrate what I mean. Suppose you came upon two people playing an unfamiliar game, chess. By observing the various moves, you would be able to deduce the rules of the game. The physicist likewise finds patterns in the natural world, and learns about what dynamics and transformations govern its basic elements. Sometimes, this understanding arises from repeated sets of carefully controlled experiments, something it is come upon by seredipity, sometimes as a result of intuition, and sometimes by appeal to aesthetic principles of "simplicity" and "beauty". In this process, mathematics is simply a language for describing the patterns in a manner that allows us to transcend our common-sense experience and limitations. A physical understanding of the phenomena, a narrative if you will, is just as important. But, as in chess, learning how the pieces move is a trivial element of the game. The essence of the game lies in the variety implicit in a few simple rules. Similarly, it may be that the rules governing the entire structure of the Universe, from the Big Bang to the origin and evolution of life, may be described by a few sets of equations and while discovering what these basic rules may be the primary goal of certain branches of physics, on the whole exploring the endless complexities and possibilities inherent in the few simple rules is what physics and science in general is all about.

At this point, it should be noted that the fact that science involves creating narratives has, over the past

decade or so, led some sociologists and literary intellectuals to mount attacks on the normative conception of scientific inquiry as a search for truths or approximate truths about the world; they have sought to reduce science to yet another social practice that produces ``narratives'' and ``myths'' which are no more valid than those produced by other social practices. In defence of science, Alan Sokal demonstrated that many of these commentators have little or no understanding of how science functions, or about the nature of scientific theories. While present and important, the narrative or rather the theoretical picture describing a phenomenon is not grounded in wishful thinking, superstition and demagoguery. Rather, it is a systematic attempt to understand the phenomenon, a product of observations, evidence and logic. Most importantly it is subject to incessant confrontation with the real world, with failure being fatal.

Such discussions are especially important in our increasingly polarized world. One aspect will be of interest to some of you is the relationship between science and religion. The two have co-existed for several millenia, some times in harmony and some times in acrimony. To have a meaningful discussion, it is important to understand what science is -- and what it isn't.



IMPORTANT NOTE:

Physics and Astronomy majors (or potential majors) should note that this course cannot be used to satisfy their program credit requirements, but can be taken as one of their free (i.e. unrestricted) electives.

COURSE REQUIREMENT:

This course does *not* require any university-level science background. In fact, it is suitable for students with no prior formal (university-level) exposure to physics or astronomy. And, the emphasis will be on conveying the current scientific understanding in a qualitative conceptual manner. However, while the course will largely eschew advanced mathematics, three or four of the lectures may invoke Grade 11-level mathematics to better clarify ideas like time dilation and space contraction.

As a cross-listed course, the requirements and expectations for PHYS 303 and RCS 303 are somewhat different:

Students enrolled in PHYS 303 are expected to be conversant with and able to manipulate algebraic equations involving at the most squares and square roots. PHYS 303 who require assistance or even a memory jog are encouraged to visit the Physics Aid Service offered by the Department of Physics and Astronomy. Click on the link for information about the room and schedule information.

Students enrolled in RCS 303 will not be expected to reproduce these calculations and in detail, will be evaluated differently than PHYS 303 students. For instance, RCS students will have an option of submitting an essay at the end of the term in lieu of sitting the final exam

Finally, note that this course IS a third year course and formally, enrolled students are expected to have a third year standing. This means that class will be managed as an upper level class. There will be assigned readings - some of which will be used to launch classroom discussions and others are there to help clarify discussed during the lectures. The lectures are not intended to review the assigned readings and often, will present a parallel but different way of thinking about the topics of interest.

INSTRUCTOR : Prof. Arif Babul **CONTACT INFO: babul@uvic.ca**

OFFICE HOURS: Contact me by email to set up an appointment

MARKING ASST: TO BE CONFIRMED **CONTACT INFO: TO BE CONFIRMED**

LECTURE SCHEDULE: ***Tuesday, Wednesday & Friday, 1:30-2:20pm in hybrid mode***

In-Person Lectures

Synchronous Online Lectures

LECTURE FORMAT:

FIRST WEEK: Wednesday, Friday (in-person)

REST OF SEPT: Tuesday, Wednesday (in-person); Friday (online)

ALL OF OCT: Tuesday, Wednesday (in-person); Friday (online)

ALL OF NOV: Tuesday, Wednesday (in-person) and Friday (TBD)

DECEMBER: Tuesday, Wednesday and Friday (in-person)

RECOMMENDED TEXTS AND REFERENCES

The following table lists various books and webcontent that will be used to augment and supplement the ideas and issues that will be discussed in the course.

I **highly recommend** that course participants establish a regular reading schedule schedule from the first two books and the recommended webcontent. A recommended schedule of readings is suggested HERE.

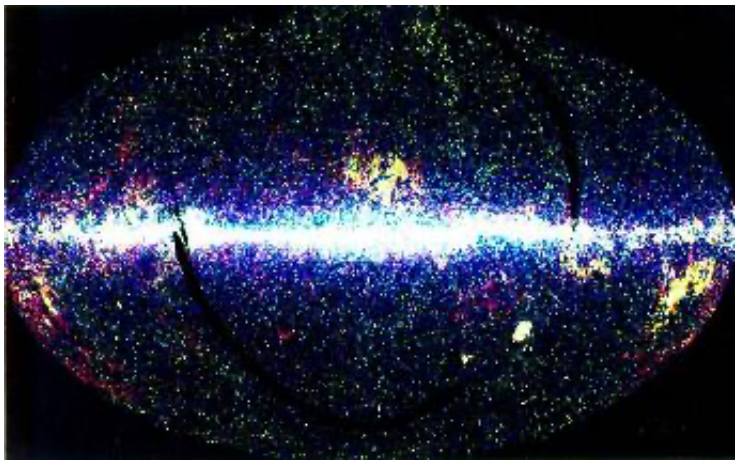
I have also provided a list of suggested reference books as well as amazingly interesting (and highly informative) supplemental books below that course participants will find very useful.

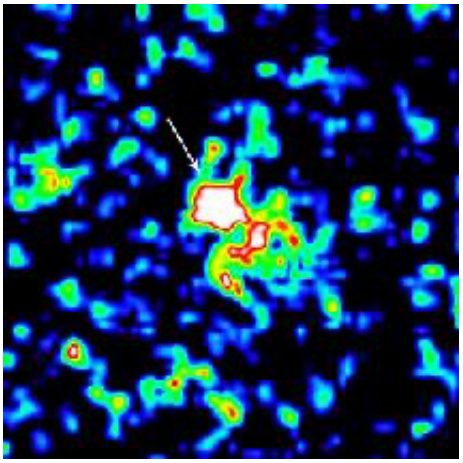
Finally, I have made available copies of my overhead slides HERE . Please note that these notes are rudimentary in that they only contain basic material that I use as a memory jog. They should not be used as a replacement to attending the lectures as I add a lot of content while I speak.

Required Text:	**The Elegant Universe**	**by Brian Greene**
Highly Recommended Reference:	**Black Holes & Time Warps**	**by Kip Thorne**
For Your Interest:	**Before The Beginning** **After The Beginning:**	**by Sir Martin Rees**

A Cosmic Journey Through Space and Time	**by Norman Glendenning**
Foundations of Modern Cosmology	**by Hawley & Holcomb**
Physics of Star Trek	**by Lawrence Krauss**
Black Holes and Baby Universes and Other Essays	**by Stephen Hawking**

Back Next





COURSE OUTLINE AND READING SCHEDULE

Given the nature of the subject matter, the ongoing revolutionary progress in our thinking, and the fact that this course is specifically aimed at *non-science students*, I will only attempt to convey a broad-brush sweep of the mind-boggling ideas that present-day cosmologists and early-Universe physicists discuss and carry around in their heads. To this end, I try to avoid unnecessary mathematics; I am more interested in conveying an insightful conceptual understanding. Student specializing in mathematics or engineering or other technical specializations should take note of this. Those interested in technical discussions should consider alternate courses. However, I do want to emphasize that this course will introduce even specialist physics and astronomy students to a way of thinking and to insights that are they are unlikely to have encountered previously.

As for this course itself: recent rapid developments necessitates a constant review of the course content and the manner in which the material is presented. I use a variety of resources, ranging from standard overheads and powerpoint presentations, to formal documentaries and interesting, illustrative videos. The approach is, by its very nature, fluid and even experimental. My aim is to convey what are often conceptually challenging ideas using as many different approaches as possible. To that end, the readings and my lectures should be seen as two complementary parallel streams that over the course of the semester will converge, diverge and jointly weave a tapestry offering a glimpse into the astounding physics animating our mind-boggling universe. No single textbook covers the material to be presented.

Finally, I cannot emphasize enough how important classroom discussions are to successfully accomplish the goals set out above. I encourage students to ask questions and participate in animated exchanges. It is my sincerest hope that animated classroom discussions will not only help assimilate the concepts to be discussed, but also key to weaving various ideas into a coherent whole.

The following is the required and the optional but highly recommended reading schedule:

>

WEEK OF		READINGS
1:	Sept 1st	REQUIRED: Webcontent for Weeks 1-2 on Course Website RECOMMENDED: BH & TW: Prologue
2:	Sept 8th	REQUIRED: Elegant Universe: Chp 1 and finish Webcontent for Weeks 1-2 on Course Website RECOMMENDED: BH & TW: Chp 1
3:	Sept 15th	REQUIRED: Elegant Universe: Chp 2 and Webcontent for Weeks 3 RECOMMENDED: BH & TW: Chp 2
4:	Sept 22nd	REQUIRED: Elegant Universe: Chp 3 and first four links of Webcontent for Week 4-5 RECOMMENDED: BH & TW: Chp 3 & 6 & Pages 281-286 of Chp 7 OPTIONAL: BH & TW: Chps 4 & 5 & 7

5:	Sept 29th	REQUIRED: Elegant Universe Chp 4 plus links 5,6,8,9,10 of Webcontent for Week 4-5 RECOMMENDED: BH & TW: Chp 10 OPTIONAL: BH & TW: Chps 8 & 9 (Discovery of Black Holes)
6:	Oct 6th	REQUIRED: Elegant Universe: Chp 5 plus first six links of Webcontent for Weeks 6-7 RECOMMENDED: BH & TW: Chps. 11
7:	Oct 13th	REQUIRED: Elegant Universe: Chp 6 plus links 7 to 11 of Webcontent for Weeks 6-7 RECOMMENDED: BH & TW: Chp 12 & 13
MIDTERM EXAM: WILL COVER ALL MATERIAL		**WEDNESDAY OCT 15TH TO END OF PREVIOUS CLASS**
8:	Oct 20th	REQUIRED: Elegant Universe: Chp 7 plus half of the links of Webcontent for Weeks 8-9 RECOMMENDED: BH & TW: Chp 14

9:	Oct 27th	REQUIRED: Elegant Universe: Chp 8 plus rest of the links of Webcontent for Weeks 8-9
10:	Nov 3rd	REQUIRED: Elegant Universe: Chp 9 plus the links of Webcontent for Weeks 10-11
11:	Nov 10th	**READING BREAK (NOV 13-15, INCUSIVE)** **Must watch three 1-HR Videos (Episodes 1-3 of Elegant Universe):** Some of the episodes are low-res. I will look for hi-res versions and replace these in due course. • Episode 1 Full (Medium Res) • Episode 2 First Half only (High Res) • Episode 2 Full (Low Res) • Episode 3 Full (High Res)
12:	Nov 17th	REQUIRED: Elegant Universe: Chp 10 plus some of the Webcontent for Weeks 12-13
13:	Nov 24th	REQUIRED: Elegant Universe: Chp 12 plus rest of the Webcontent for Weeks 12-13 OPTIONAL: Elegant Universe: Chp 13
14:	Dec 1st	Last Two Days of Classes


Cygnus Loop
HST - WFPC2


Planetary Nebula NGC 7027
HST - WFPC2

GRADING SCHEME

The "percent-to-letter-grade" conversion to be used in this course is specified HERE .

Students enrolled in RCS 303 can opt to submit a 3000 word (doublespaced) essay instead of the final exam. Students interested in this option must speak to me before the Reading Break week to discuss potential topics that speak to issues in science and religion, etc.

All handwritten submissions (problem sets, midterm, final exam, etc.) must be written clearly and legibly. If we cannot read your writing or have to devote an excessive amount of time to trying to make out what you have written, we will NOT mark the item in question. As a guide, make sure your writing is at least as large as a typical 12 pt font; use either ink or a dark pencil; etc.

Problem Sets: 40% of final grade

The term work for this course will comprise of 6 problem sets. The problem set questions will be drawn from lecture material, classroom discussions and assigned readings. **The problem sets and their due dates will be posted HERE** . Please check this website for assignments and due dates. Solutions to the problem sets will also be posted on the same page a few days after the due

date.

All students will EITHER drop off their solutions to the assigned problems with the secretaries in the PHYSICS AND ASTRONOMY main office by 3pm of the posted due date OR email your solutions in PDF format directly to the course marking assistant.

If you email your solutions, the file must be PDF and the subject of the email must include YOUR NAME and "PHYS 303 / RCS 303" [PICK THE APPROPRIATE COURSE NAME] and "PROBLEM SET NUMBER XXXX" where XXX =1, 2, ... 6.

To receive a non-failing final course grade, students must - at the very least, submit the FOUR COURSE problem sets where majority of assigned questions have been attempted (NOTE: THE ASSIGNED QUESTIONS FOR PHYS 303 AND RCS 303 STUDENTS ARE NOT THE SAME) and sit for the final exam (PHYS 303/RCS 303) or submit a final essay (RCS 303). The actual course grade will depend on the scores received on the problem sets, midterms and the final exam/essay.

Late assignments will NOT be accepted except in case of illness or other unavoidable circumstances accepted by the Faculty of Science as legitimate reasons. In these instances, independent supporting documentation will be required. Please note that in case of PLANNED absence (eg. sports meets, research travel, etc.) on the due date, students will be expected to complete and submit solutions in advance.

If you find that you require assistance with some of the calculations, you should - in the first instance - seek the assistance of the Physics Aid Service offered by the Department of Physics and Astronomy. The schedule and other pertinent information is available HERE .

The problem set solutions will be marked by the course Marking Assistant. All questions concerning the marking scheme, solutions, etc. ought to be directed to him/her in the first instance. I am happy to address questions once the marking assistant has had an opportunity to address the concerns.

Midterm Test: 25%

Sometime in the middle of second month (October or February, depending on the semester), there will be a midterm test that will be worth 25% of the final mark.The questions on this test

will be drawn from the problem sets, classroom presentations, as well as assigned readings. The questions will consist of simple work-through quantitative problems and/or short essay questions.

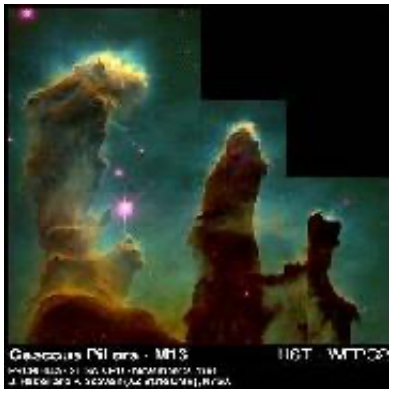
The test is designed to test the breadth of your understanding, not the depth. Long detailed answers (unless specifically requested) are neither necessary nor preferred. In fact, it is in your interest to practise answering questions in a concise and "to the point" manner, lest you run out of time.

Final Exam: 35%

(RCS students may submit a 3000-word essay instead. Speak to me before the Reading Break)

There will be a 2-to-2.5 hours long final exam at the end of the term. The exam will cover all the material discussed during the class lectures and in the assigned reading, with a slight focus on material covered after the mid-term. The exam will be similar in style to the midterm.

Please note that PHYS 303 students MUST sit the final exam otherwise a final grade of N will be assigned. RCS 303 students MUST either sit the final exam or submit a 3000-word essay after discussing the same with me prior to the reading break.



HST image: "Star Nursery"

Artwork: "Starbirth"