Term: 202509 Course: ASTR403 Section: A01

Welcome to the ASTR 403 course: Radiative Processes in Astrophysics

http://astro.uvic.ca/~babul/AstroCourses/A403

Important: You will need a username and password to access the lecture notes

University of Victoria Course Copyright Statement:

University of Victoria Policy on Academic Integrity:

https://www.uvic.ca/calendar/undergrad/index.php#/policy/Sk_0xsM_V

Academic integrity requires commitment to the values of honesty, trust, fairness, respect, and responsibility. It is expected that students, faculty members and staff at the University of Victoria, as members of an intellectual community, will adhere to these ethical values in all activities related to learning, teaching, research and service. Any action that contravenes this standard, including misrepresentation, falsification or deception, undermines the intention and worth of scholarly work and violates the fundamental academic rights of members of our community. This policy is designed to ensure that the university's standards are upheld in a fair and transparent fashion.

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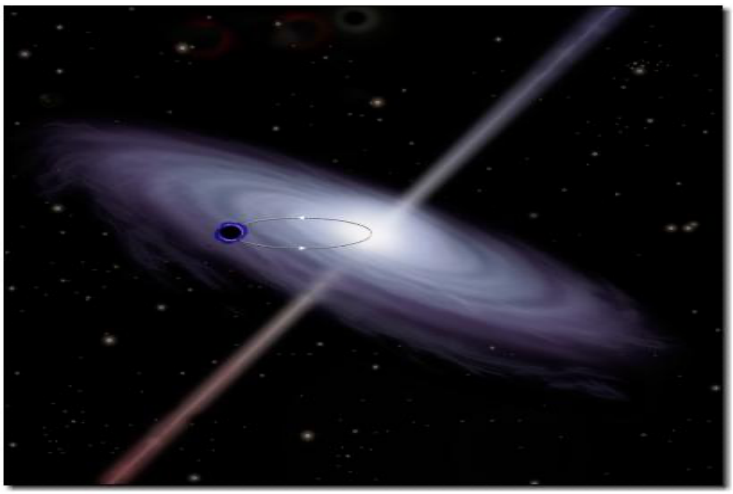
Examples of violations include:

Plagiarism; Unauthorized use of an editor; Multiple submission; Falsifying materials subject to academic evaluation; Cheating on work, tests and examinations; and Aiding others to cheat

ASTR 403 course webpage!

Important information regarding devices and browsers



These webpages are designed to be viewed on a computer screen with a wide browser window. You may be able to view it on a tablet. As for a mobile, how well the pages render will depend on your device.

Please note that each page comprises two frames, a fixed top frame and a scrollable bottom frame. This is in addition to the fact that your browser window itself can scroll. Please make sure you scroll both the frame window and the browser window to see all of the text.

Finally, I will be updating the webpage content throughout 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 force reload the frames,** especially the bottom frame. 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.

Welcome to the "AST403" course webpage!

http://astro.uvic.ca/~babul/AstroCourses/A403

This course will offer a combined quantitative-qualitative introduction to important radiative processes and associated concepts that one often encounters in astrophysical settings.

Radiative processes can be thought of as our windows into the universe. The radiation observed and an understanding of the mechanisms that give rise to this observed radiation allows us to determine conditions present in regions as diverse as the interstellar and intergalactic medium, and to probe processes underlying galaxy formation to active galactic nuclei.

This course will touch upon topics like thermal and non-thermal radiation, radiative transfer, Bremsstrahlung, Compton scattering, etc. Given the time constraints, the course will only skim over some of these concepts.

The emphasis will be on introducing the basic processes and exploring how they are used in astrophysics.

Important: You will need a username and password to access the lecture notes and other protected course content. This information will be given to you in class.

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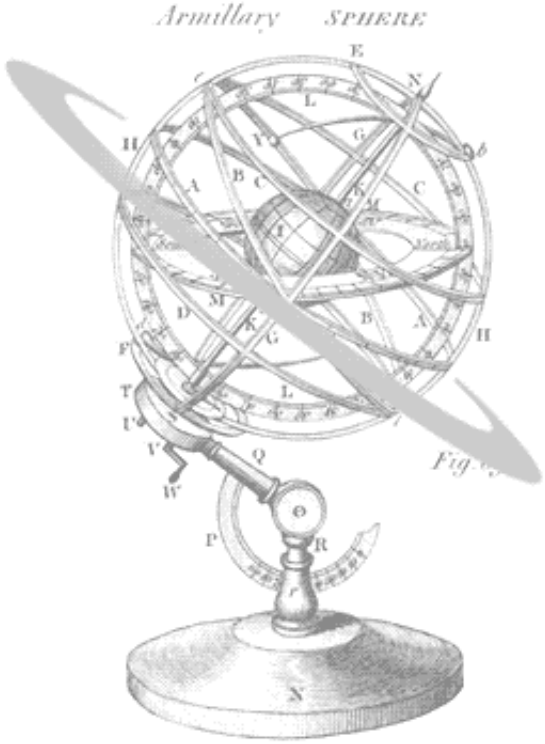
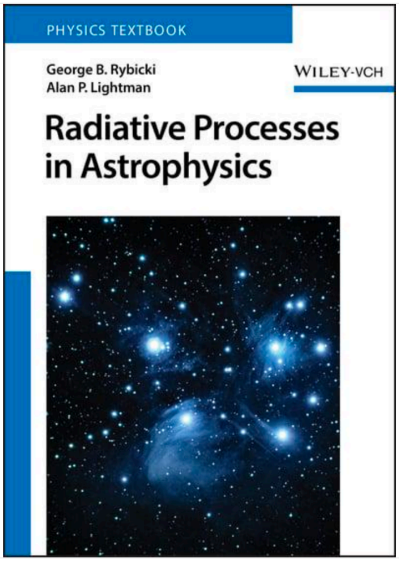


Information

Instructor:	Professor Arif Babul
Lecture Schedule:	*Tuesday, Wednesday & Friday, 12:30-1:20pm* *In-Person Lectures in **MacLaurin Building, Room A326 (MAC A326)*** *Synchronous Online Lectures: **ZOOM LINK***
Lecture Format:	**Unless otherwise announced:** *FIRST WEEK (SEPTEMBER): Wednesday and Friday lectures (**in-person**)* *REST OF SEPTEMBER: Tuesday, Wednesday (**in-person**); Friday **(online)*** ****** NO CLASS on Wednesday September 24th*** *ALL OF OCTOBER: Tuesday, Wednesday (**in-person**); Friday **(online)*** *NOV & DEC: Tuesday, Wednesday (**in-person**); Friday (**TBD**)*

Required Text



Radiative Processes in Astrophysics
by Rybicki & Lightman.

Please make sure that you purchase the 2nd Edition, which has blue and white cover.

According to UVic Bookstore, the hardcopy is out of print though some second-hand sellers likely still have it. I have also placed an electronic copy on reserve. This copy can be accessed **HERE** or via Course Tools tab in Brightspace for 202509 ASTR 403.

You may also want to check **HERE** or **HERE**.

Course readings and the problem set questions will be assigned from this textbook.

The publishers describe this book as a "clear, straightforward, and fundamental introduction is designed to present-from a physicist's point of view-radiation processes and their applications to astrophysical phenomena and space science. It covers such topics as radiative transfer theory, relativistic covariance and kinematics, bremsstrahlung radiation, synchrotron radiation, Compton scattering, some plasma effects, and radiative transitions in atoms. Discussion begins with first principles, physically motivating and deriving all results rather than merely presenting finished formulae. However, a reasonably good physics background (introductory quantum mechanics, intermediate electromagnetic theory, special relativity, and some statistical mechanics) is required. Much of this prerequisite material is provided by brief reviews, making the book a self-contained

reference for workers in the field as well as the ideal text for senior or first-year graduate students of astronomy, astrophysics, and related physics courses. Radiative Processes in Astrophysics also contains about 75 problems, with solutions, illustrating applications of the material and methods for calculating results. This important and integral section emphasizes physical intuition by presenting important results that are used throughout the main text; it is here that most of the practical astrophysical applications become apparent."

My take: I agree with most of what is written here. This is one of the few books from my student days that I still go back to every so often. I learnt radiative processes and radiation transfer theory by reading this book and working through the problems. However, I personally think that the book would definitely benefit from more problems applying the concepts and theory to more realistic astrophysics problems.

There are two additional things to note:

(1) There are errors in this second edition. A list of some of these can be found here: ERRATA

2) We will work exclusively in astronomical cgs units. In other words, we will use cgs units to do the calculations and then for a handful of units (e.g. solar masses, solar luminosities, etc.), we will convert to these if the question requires. Here is a convenient reference:

CONSTANT	SYMBOL	VALUE IN GAUSSIAN CGS UNITS		
		Coefficient		Units
Speed of light	c	3.00×10^{10}		cm / s
Elementary unit charge	e	4.80×10^{-10}		statcoulomb or esu
Electron mass	m_e	9.13×10^{-28}		g
Proton mass	m_p	1.67×10^{-24}		g
Boltzmann constant	k_B	1.38×10^{-16}		erg / K
Gravitational constant	G	6.67×10^{-8}		$cm^3 / g / s^2$
Planck constant	h	6.62×10^{-27}		erg s
Thompson cross-section	σ_T	6.65×10^{-25}		cm^2
Stefan-Boltzmann constant	σ	5.67×10^{-5}		$erg / cm^2 / K^4 / s$

In Astrophysics, it often convenient to use: $G \approx 4.302 \times 10^{-3}\ \mathrm{pc}\, M_\odot^{-1}\, (\mathrm{km/s})^2$.

Quantity	Symbol	Value in Gaussian-CGS units		
		Coefficient		Units
Astronomical Unit	AU	1.5×10^{13}		cm
Parsec	pc	3.1×10^{18}		cm
Light-year	ly	0.95×10^{18}		cm
Angstrom	Å	10^{-8}		cm
Solar Radius	$R_\odot$	7.0×10^{10}		cm
Neutron Star Radius		$\sim 10^6$		cm (~10 km)
Solar Mass	$M_\odot$	2.0×10^{33}		g
Solar Luminosity	$L_\odot$	3.9×10^{33}		erg / s
Electron Volt	eV	1.6×10^{-12}		erg
1 eV is equivalent to $\sim 1.1 \times 10^7$ K (temperature)				

Errata in Second Printing of
Radiative Processes in Astrophysics
by Rybicki & Lightman

- p. 1: Improved value of Planck's constant is 6.626×10^{-27} erg s.
- p. 22, Figure 1.11: This figure does not correctly represent B_λ. Ignore the right scale and the two top scales.
- p. 23, first sentence: Change to "A plot of B_ν versus ν for a range of values of T ($1\text{K} \leq T \leq 10^8\text{K}$) is given in Fig. 1.11".
- p. 50: Part **b.** of problem 1.10 should read:
  Show that $J_\nu(\tau)$ approaches the blackbody intensity at an effective optical depth $\tau_* = \sqrt{3\tau_a(\tau_a + \tau_s)}$ of order unity.
- p. 53, line before Eq. (2.9): Equation referred to should be (2.5).
- p. 61, Figure 2.2a: sine wave should go through (0,0).
- P. 62: Change the last two lines to:
  Then the electric vector **E** is the real part of

$$(\hat{\mathbf{x}}E_1 + \hat{\mathbf{y}}E_2)e^{-i\omega t} \equiv \mathbf{E}_0 e^{-i\omega t}$$

- p. 63, first sentence: Replace E_1 by E_0.
- p. 66, Eq. (2.45), last line: Change λ_{12} to λ_{22}.
- p. 68, Eq. (2.52): LHS should read "$\langle E_1 E_2^* \rangle$."
- p. 69: Second from last line in §2.4. Change "plane" to "linear."
- p. 88, line before Eq. (3.27a): Equation referred to should be Eq. (2.27).
- p. 93, under point "1.": change "$\theta \to -\theta$" to "$\theta \to \pi - \theta$."
- p. 100, Eq. (3.61): LHS should be $dP/d\omega$. Eq. 3.62: $(\omega^2 - \omega_0^2) \to (\omega^2 - \omega_0^2)^2$
- p. 103, Problem 3.2, second line: change "v_1" to "$v_\perp$."
- p. 123, line 8: Delete the phrase "transformation of."
- p. 146, Eq. (4.109) and following line: Replace U_ν by u_ν.
- p. 154, last sentence of Problem 4.14: Change "that" to "than."
- p. 160, Figure 5.2: Error in "Small-angle, classical region": The exponent 1/2 on the bracket is misplaced. The bracket should be

$$\left[\frac{4}{\zeta^{5/2}}\left(\frac{kT}{h\nu}\right)\left(\frac{kT}{Z^2 R_y}\right)^{1/2}\right]$$

  Also ζ should be defined in the caption: "Here $\zeta \equiv e^C$, where $C = 0.5771\ldots$ is Euler's constant."
- p. 161, caption of Figure 5.3: Expand and correct definitions of u and γ: "$u = h\nu/kT = 4.8 \times 10^{-11}\nu/T$" and "$\gamma^2 = Z^2 R_y/kT = 1.58 \times 10^5 Z^2/T$."
- p. 164, Eq. (5.23): K_1 should be K_1^2.
- p. 174, line 4: Change "has" to "have."
- p. 174, Eq. (6.21b): Interchange x_1 and x_2 in the limits of integration. Also in the paragraph after this equation, the limits should be "$x_2 \approx 0$, $x_1 \approx \infty$."
- p. 174, Eq. (6.22a): Add condition

$$\omega_c(\gamma_1) \ll \omega \ll \omega_c(\gamma_2)$$

- p. 179, Sentence before Eq. (6.34): Change to: "Asymptotic forms for $F(x)$ and $G(x)$ for small and large values of x are:" Add the following to Eq. (6.34):

$$G(x) \sim \Gamma\left(\frac{2}{3}\right)\left(\frac{x}{2}\right)^{1/3}, \qquad x \ll 1, \tag{6.34c}$$

$$G(x) \sim \left(\frac{\pi}{2}\right)^{1/2} e^{-x} x^{1/2}, \qquad x \gg 1, \tag{6.34d}$$

- p. 180: Add the restiction $\mu > -4/3$, to both Eqs. (6.35a) and (6.35b).
- pp. 180–181: Add the restriction $p > 1/3$ to Eqs. (6.36) and (6.38).
- p. 186, sentence before Eq. (6.41): Change "(1.74)" to "(1.75)."

- p. 187, sentence after Eq. (6.42): Change "(1.71b)" to "(1.72b)."
- p. 190, Eq. (6.54): Replace $P(\nu)$ by $n_e P(\nu)$.
- p. 199: Eliminate Eq. (7.9) and the preceding sentence.
- p. 199: Replace Eq. (7.10) and its preceding sentence with: Thus d^3p/ϵ is a Lorentz invariant:

$$\frac{d^3p}{\epsilon} = \frac{d^3p'}{\epsilon'}$$

- pp. 199–200: Starting with Eq. (7.11) and extending through the unlabeled equation after (7.15a), make the following replacements in subsequent equations and text:

$$v'\,d\epsilon' \rightarrow n'\,d^3p', \qquad \text{3 occurrences}$$

$$v\,d\epsilon \rightarrow n\,d^3p, \qquad \text{4 occurrences}$$

- p. 201, last paragraph, first sentence: Change "(7.16)" to "(7.16a)."
- p. 203, Eq. (7.23): The γ on the extreme RHS of the "if" clause should be γ^2.
- p. 226, sentence after Eq. (8.9): Change "(8.5)" to "(8.7)."
- p. 232, Eq. (8.32): Insert minus sign before term

$$\frac{1}{c}\frac{\partial \mathbf{B}}{\partial t}$$

- p. 239: Equation (9.2). Replace i by $-i$ in exponential.
- p. 239: Replace Eq. (9.7) with

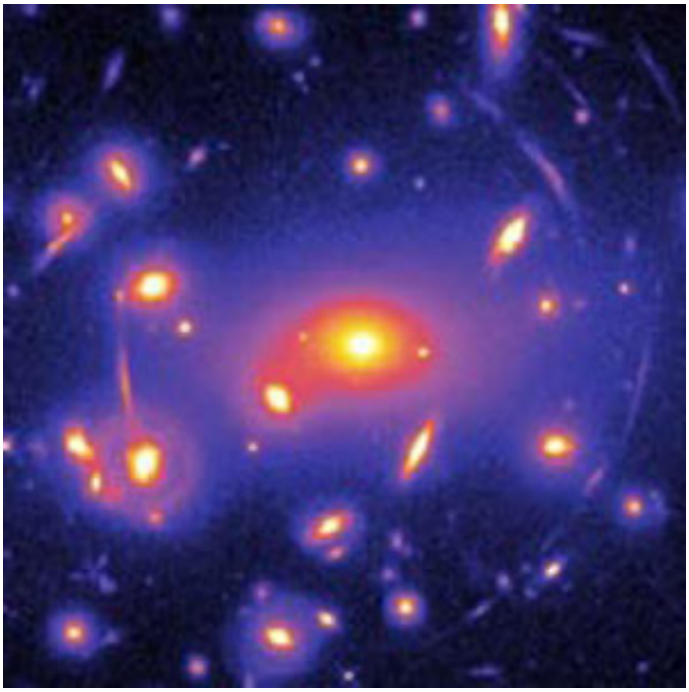
$$\frac{e^2}{a_0} = \frac{me^4}{\hbar^2} = 4.36 \times 10^{-11}\ \text{erg} = 27.2\ \text{eV}$$

- p. 240, first equation: RHS should have an overall minus sign.
- p. 243, line after Eq. (9.16c): Replace "R_{nl}^2" by "$R_{nl}^2 dr$"
- p. 249, line 4: change "in the closed shells" to "outside of the closed shells."
- p. 249, paragraph 3, sentence 2: change "sample" to "example."
- p. 250, paragraph after Eq. (9.22b): Replace by:
  Since the combination $m_L = \pm 2$, $m_S = \pm 1$ does not occur, the ^3D term can be ruled out. On the other hand, state 5 requires a ^3P term, and state 2 requires a ^1D term. These two terms take up $3 \times 3 + 1 \times 5 = 14$ of the 15 distinguishable states. The only remaining term can be ^1S, with one associated state. Thus the allowed terms for two equivalent p electrons are
- p. 252, paragraph 1, last sentence: Replace "configuration" with "terms generated by the configuration."
- p. 257, Eq. (9.35b): Change "$(S + L)$" to "$(S + 1)$."
- P. 268, Eq. (10.3): Change "ϕ" to "$\dot{\phi}$."
- P. 269, last sentence before section "The Transition Probability": Change "ϕ" to "$\dot{\phi}$."
- p. 271, line before Eq. (10.15): Delete minus sign in equation for $E(\omega)$.
- p. 275, line 3: "(3.65)" should be "(3.65b)," and "(1.66)" should be "(1.65)."
- p. 281, Eq. (10.47): exponent of denominator in first line should be $2n + 4$ instead of $2n - 4$.
- p. 326, line 7: Should be carat over $\mathbf{y}$.
- p. 337, line 3 of part "e.": Change "part (a)" to "part (c)."
- p. 347, line 1 of solution 6.1: Change "d/dt" to "(d/dt)."
- p. 361, line 5 of solution 9.5a: In equation for ρ, the extreme RHS should have factor "m_H."

Course Expectations

In teaching ASTR 403: Introduction to Astrophysical Processes, I will expect that students are familiar with calculus-based electromagnetic theory and calculus-based classical mechanics, including familiarity with computing the mass profile M(r) given a density profile (and vice versa), the relationship between rotation (or circular) velocity and mass, for any general spherically symmetric mass profile M(r), etc. If you need to refresh your memory, please see:

(a) The text associated with Eq. 13.3 of Frank Shu's "The Physical Universe"
(b) Work thru Problem 13.5 of Shu,
(c) Review section 2.3 and 2.4 of Carroll and Ostlie's "An Introduction to Modern Astrophysics"



I will also assume a background in basic quantum mechanics, and special relativity. This is necessary if I am to cover the required material in the allocated time. If you need a memory jog, I would recommend reviewing your course notes for prior classes in these subjects. You may also want to peruse the book "The Physical Universe" by Frank shu for some basic review.

The general expectation for this course is that the students will read the assigned chapters from the course textbook (all this is specified in the section titled "Topics") and familiarize themselves with the material presented there.

I will highlight some of the questions at the end of the chapter and specify a subset to be handed in. I strongly recommend that you solve ALL the highlighted questions **as seriously and as rigorously as you would if you were handing them in** **One or more of these questions will appear verbatim on the midterm and the final.** .

All this information, including the problem set due dates, is specified in the section titled "Topics".

The problem sets must be handed by 5pm on the specified date. I will only accept problem sets emailed to me at babul@uvic.ca in PDF format and when you email it to me put YOUR NAME and "ASTR 403 Problem Set # XXX" as the subject.

I strongly recommend getting an app that will allow you to take a picture of your pages and automatically convert these in PDF pages.

Late problem sets will not be accepted without prior approval or official documentation. If you are going to be away, I would recommend planning ahead and handing in the problem set ahead of the due date. Since the problem sets are worth a significant fraction of the final mark, handing in a partially completed problem set is better than not turning one in at all.

I do not have an issue with students discussing the highlighted/assigned questions with - and learning from - each other. However, I expect that each person will then go back and work through the problems independently and write out their own solutions. Plagerism will result in a score of "0". I should also note that the answers to the problems are given at the back of the textbook. If you are stuck, you are welcome to glance at the final answer and see if that offers a direction. Similarly, I don't have an issue with you using ChatGPT or other AI to get hints but I strongly recommend that you work through the questions by yourself so that you are prepared for the midterm/final.

More importantly, I expect that the solutions submitted for grading will be detailed (much more detailed than the terse explanation at the back of the book) and show full reasoning in a step-by-step manner. Please explain your reasoning, highlight (and if necessary) justify any assumptions you need to make, etc. Do not assume that anything is obvious: explain and clarify. Full marks will only be given if the solutions are explicit and allow me to see how you have thought things through.

The lectures WILL NOT reproduce the text. The text is very well written and the concepts are very well explained. I expect you will read carefully and thoroughly the assigned sections as per the course schedule. Sometimes, you may find that you need to look up an idea or an explanation to get a different perspective. I encourage you to do that. There is an abundance of relevant material on the web. The book does have a weakness. It does not do enough problems and that is where I will focus my attention. I will use the lectures to show how the processes and concepts discussed in the book are used in an astrophysical setting through supplementary and much more realistic problems.

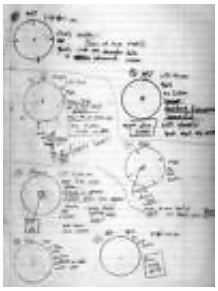
Please see the webpage titled "Grading Scheme" for more details

Topics, Readings, Lecture Notes and Assignments

Week of 2025-09-01 (Monday); first class on 2025-09-03

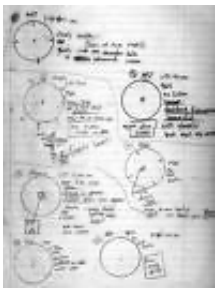
Introduction and Overview to the Course

Readings: Think Physics (Watch the video)
Back of the Envelope Calculations
R&L: Sections 1.1 to 1.3 inclusive



Class Schedule: Wednesday and Friday lectures in-person

Lecture Notes: Lecture notes for the semester are posted here. Please do not download them all at once. I will be fine-tuning these over the course of the semester. Download these as needed.



WEEK0 (also see above material) : This covers basic course info

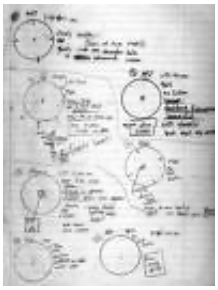
PART_1A, PART_1B, PART_1C : These cover lecture material up to and including Bremstrahlung

PART_2A, PART_2B, PART_2C : These cover the balance of the lecture material.

Please note that the lecture material DOES NOT replace textbook material. It is intended to augment the latter. Please ensure that you read the assigned sections of the textbook and make notes as appropriate.

A: Week of 2025-09-08
Fundamentals of Radiative Transfer

Readings: R&L 1.4 to 1.7 inclusive



Class Schedule: Tuesday and Wednesday lectures in-person; Friday via zoom (synchronous)

Problems: Recommended to work through and understand: 1.1, 1.3, 1.4, 1.5, 1.7, 1.8, 1.9

HAND-IN FOR MARKING: 1.4, 1.7, 1.9 ONLY
DUE DATE: by 5pm (always) on 2025-09-16

NOTE: PROBLEM SETS MUST BE EMAILED TO ME (babul@uvic.ca).

The subject line of the email should have YOUR NAME followed by

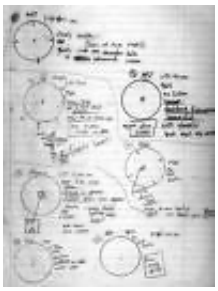
"ASTR 403 Problem Set # XXX" where XXX = 1, 2, 3, ...

FILES MUST BE IN PDF FORMAT.

B: Week of 2025-09-15
Radiation Fields

Readings: R&L 2.1 to 2.6 inclusive (in 2.4 focus on polarization!)

While you don't need to know about stokes parameters, you should know know how to write down the wave equation for plane polarized waves (in a specified direction) as well as left and right circularly polarized waves.



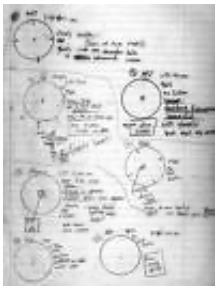
Class Schedule: Tuesday and Wednesday lectures in-person; Friday via zoom (synchronous)

Problems: Recommended to work through and understand: 2.1, 2.2, 2.3

HAND-IN FOR MARKING: 2.2
DUE DATE: 2025-09-25

C: Week of 2025-09-22
Moving Charges (Non-Relativistic)

Readings: R&L 3.1 to 3.5 inclusive



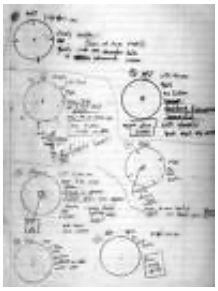
Class Schedule: Tuesday lecture in-person; Wednesday (**no class**); Friday (**TBD**)

Problems: Recommended to work through and understand: 3.1, 3.2, 3.3, 3.5, 3.6, 3.7

HAND-IN FOR MARKING: 3.1, 3.3
DUE DATE: 2025-10-03

D: Week of 2025-09-29
Bremsstrahlung (Non-Relativistic)

Readings: 5.1 to 5.3 inclusive



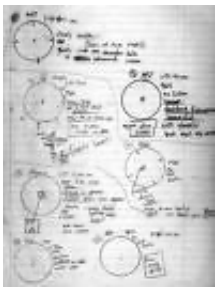
Class Schedule: Tuesday and Wednesday lectures in-person; Friday via zoom (synchronous)

Problems: Recommended to work through and understand: 5.1, 5.2

HAND-IN FOR MARKING: 5.2 ONLY
DUE DATE: 2025-10-10

E: Week of 2025-10-06
Catch-up Week and/or Start of Relativistic Motion

Readings: Catch-up week for Chapters 1-3; and 5 Midterm will cover these four chapters



Class Schedule: Tuesday and Wednesday lectures in-person; Friday via zoom (synchronous)

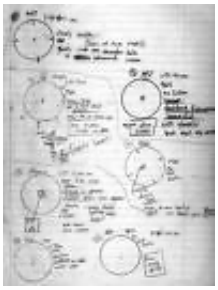
REMINDER: MIDTERM NEXT WEEK

F: MIDTERM ON WEDNESDAY 2025-10-15

G: Week of 2025-10-13
Relativistic Motion

Readings: R&L 4.1 and 4.5 to 4.9 inclusive (4.2-4.4 is optional)

In this class, we will not use tensors or four-vectors. We will make do with algebraic expressions for the transformations -- but you should know the conversation laws and how E and B fields transform.



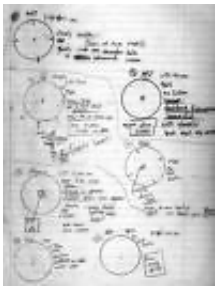
Class Schedule: **In-person Midterm on Wednesday**
Tuesday and Wednesday lectures in-person; Friday via zoom (synchronous)

Problems: Recommended to work through and understand: 4.1, 4.2, 4.4, 4.7, 4.10, 4.11, 4.12, 4.13

HAND-IN FOR MARKING: 4.1, 4.7, 4.13 ONLY
DUE DATE: 2025-10-28

H: Week of 2025-10-20
Synchrotron Radiation A

Readings: R&L 6.1 to 6.4 inclusive



Class Schedule: Tuesday and Wednesday lectures in-person; Friday via zoom (synchronous)

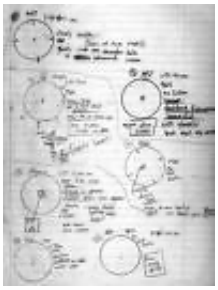
Problems: Recommended to work through and

understand: See next week's entry

HAND-IN FOR MARKING: See next week's entry
DUE DATE: See next week's entry

I: Week of 2025-10-27
Synchrotron Radiation B

Readings: R&L 6.5 to 6.8 inclusive



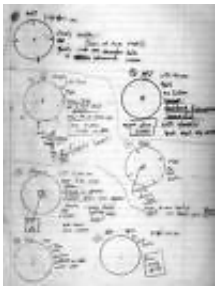
Class Schedule: Tuesday and Wednesday lectures in-person; Friday via zoom (synchronous)

Problems: Recommended to work through and understand: 6.1, 6.2, 6.3, 6.4

HAND-IN FOR MARKING: 6.1 ONLY
DUE DATE: 2025-11-11

J: Week of 2025-11-03
Compton Scattering A

Readings: R&L 7.1 to 7.4 inclusive See last week & next week



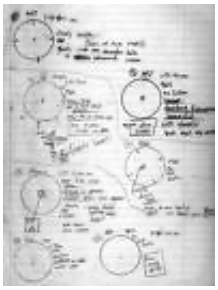
Class Schedule: Tuesday and Wednesday lectures in-person; Friday (TBD)

Problems: See entry for week after Reading Break.

K: Week of 2025-11-10

READING BREAK: MONDAY NOVEMBER 10TH TO WEDNESDAY NOVERMBER 12TH

Readings: See last week & next week



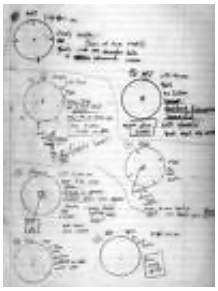
Class Schedule: Tuesday and Wednesday lectures in-person; Friday (TBD)

Problems: Use this time to work the Synchrotron problem set, and and get a jump on studying for the exam by ensuring that you fully understand the material covered to date.

HAND-IN FOR MARKING: See next week's entry
DUE DATE: See next week's entry

L: Week of 2025-11-17
Compton Scattering B

Readings: R&L 7.6 to 7.7 inclusive



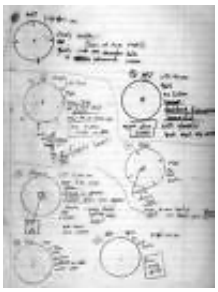
Class Schedule: Tuesday and Wednesday lectures in-person; Friday (TBD)

Problems: Recommended to work through and understand: 7.1, 7.2, 7.3

HAND-IN FOR MARKING: 7.1, 7.3 ONLY
DUE DATE: 2025-11-25

M: Week of 2025-11-24

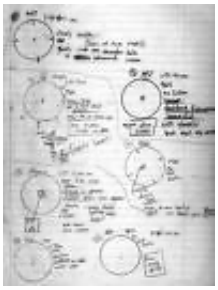
Catch-up Week



Class Schedule: Tuesday and Wednesday lectures in-person; Friday (TBD)

N: Week of 2025-12-01

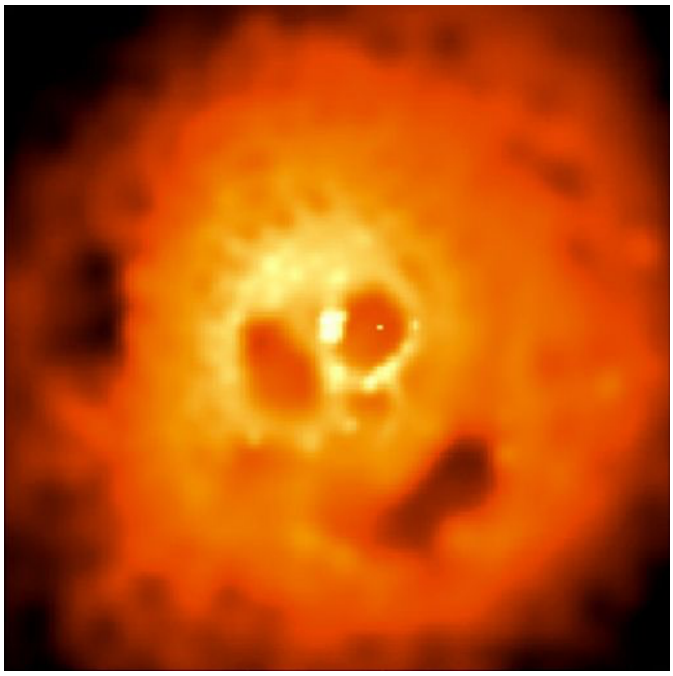
LAST TWO DAYS OF CLASSES (DEC 3RD IS THE LAST DAY OF CLASSES)



Class Schedule: Tuesday and Wednesday lectures in-person

Course Grading Scheme

Problem Sets (see below):	30%
Midterm Test (see below):	30%
Final Exam (see below)	40%



UVIC Grading Scheme and Percent-to-Letter Grade Conversion
(will open in new window)

*Problems Sets

The problem sets must be handed by 5pm on the specified date. Late problem sets will not be accepted without prior approval or official documentation. In the event of forseeable absence, it is the student's responsibility to make arrangements to ensure that the problem set is received before the due date. If the deadline is missed due to medical or other "emergencies" of similar stature, a formal note will be required. Please note that since the problem sets are worth a significant fraction of the final mark, handing in a partially completed problem set is better than not turning one in at all.

Please see the **TOPICS section** for due dates and the **EXPECTATIONS section** for additional instructions regarding the assigned problems and the problem sets. The most important of these are:

The problem sets must be handed by 5pm on the specified date. I will only accept problem sets emailed to me at babul@uvic.ca in PDF format and when you email it to me put YOUR NAME and "ASTR 403 Problem Set # XXX" as the subject.

I do not have an issue with students discussing the highlighted/assigned questions with - and learning from - each other. However, I expect that each person will then go back and work through the problems independently and write out their own solutions. Plagerism will result in a score of "0". I should also note that the answers to the problems are given at the back of the textbook. If you are stuck, you are welcome to glance at the final answer and see if that offers a direction. Similarly, I don't have an issue with you using ChatGPT or other AI to get hints but I strongly recommend that you work through the questions by yourself so that you are prepared for the midterm/final.

Finally and most importantly, I expect that the solutions submitted for

grading will be detailed (much more detailed than the terse explanation at the back of the book) and show full reasoning in a step-by-step manner. Please explain your reasoning, highlight (and if necessary) justify any assumptions you need to make, etc. Do not assume that anything is obvious: explain and clarify. Full marks will only be given if the solutions are explicit and allow me to see how you have thought things through.

*Midterm and Final Exam Schedule

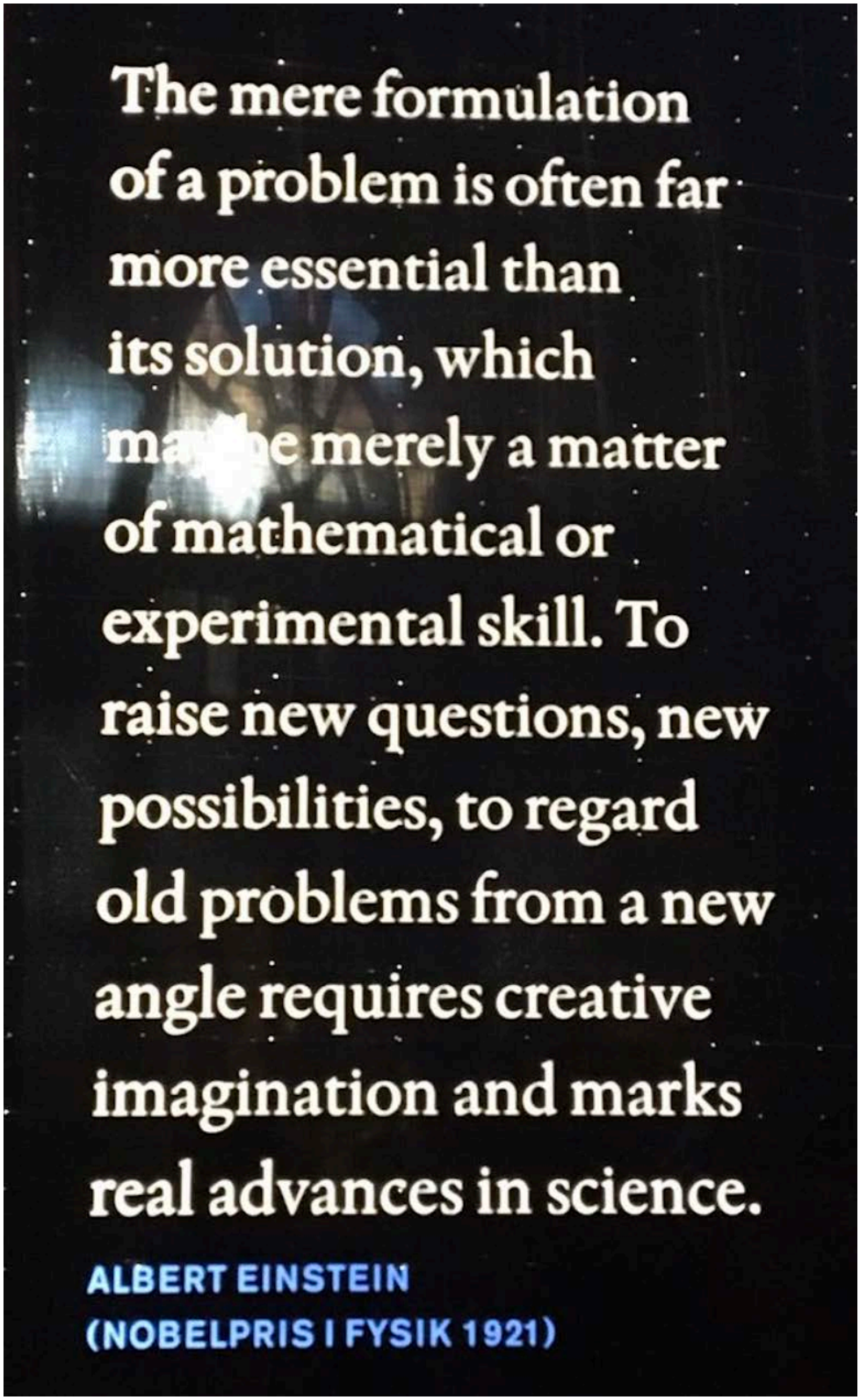
The midterm exam is usually scheduled in mid-october. It will be an in-class, in-person event unless otherwise announced. You will find the exact date in **TOPICS section** .

The date of the final exam will be announced by the UNIVERSITY closer to the end of term. Please check the final exam schedule when available.

Questions on the midterm and the final will be a mix of questions similar to those in your textbook and those worked out in class.

"Cheat Sheet" policy: For both the midterm and the exam, you are allowed to bring cheat sheet (unless informed otherwise). It cannot be bigger than a 8.5" X 11" sheet of paper. You may write on both sides but it most definitely should be handwritten and in your own handwriting.

Calculator Restrictions on Midterms and Final Tests: According to recently adopted Department of Physics and Astronomy policy, in cases where the use of a calculator is allowed on a test or an exam (as in this course), the standard, and only, calculator that may be used is the Sharp EL-510R or Sharp EL-510RNB. For updates to allowed models (and departmental policy), please see FAQ page on department webpage for current undergraduate students. Allowed calculators are available for purchase from the Bookstore (for example) for about $10, plus taxes.


The mere formulation of a problem is often far more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle requires creative imagination and marks real advances in science.
ALBERT EINSTEIN
(NOBELPRIS I FYSIK 1921)