PHY320 Astrophysics

Gustavus Adolphus College Spring 2022

Instructor: Dr. Steven Mellema

Office: Olin Hall 210 **Office Hours:** MTWRF 8:30-9:50am

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Textbooks:

Fundamentals of Astrophysics, by Stan Owocki, Cambridge University Press, ©2021

Mathematical Handbook of Formulas and Tables, by Murray R. Spiegel (Schaum's Outline Series)

Course Policy and Evaluation:

1. **Class Meetings and Reading Assignments**: The class will meet Monday, Wednesday and Friday from 9:00-9:50AM for lecture, small-group problem solving, homework review and, occasionally, for exams. Attached is a daily calendar of activities for the course. When reading assignments are made for a class session, the reading is expected to be completed **before** coming to the class.

2. **Homework**: Homework problems will be assigned according to topics from the textbook, and are due at the beginning of class on the due date given by the instructor. Late homework may be accepted at the discretion of the instructor with a reduction in credit.

3. **Group Problems**: Frequently in class, students will work cooperatively to solve problems. A group solution will be submitted, with all group members receiving the same grade. There will be no make-up for group problems missed due to absence.

4. **Laboratory**: The laboratory work consists of the observing exercises described on page 3 below. Students will work as a group on these experiments. The group will maintain a single laboratory notebook for these experiments, which will be collected and graded periodically. A formal report in the style of a short "scientific letter" will be prepared by each group for labs 2-4.

5. **Project**: Each laboratory group will select a project to be completed in the second half of the semester. Suggestions are included on the following page. The group will collaborate to make a presentation and to write a formal report on the project.

6. **Attendance**: Regular attendance at all class meetings is expected. Students will be held responsible for informing themselves of all announcements/assignments made in class.

7. **Exams:** There will be three hour exams and a two-hour, comprehensive final exam (see the calendar below). Students must arrange **in advance** to take an exam at other than the scheduled

time, and may do so **only** for a valid health or school-related reason. Exams missed without pre-arrangement are entered as zero credit and cannot be made up.

8. **Evaluation**:

Homework	25%
Laboratory	20%
Group Problems	10%
Hour Exams	10% each
Final Exam	15%

Assignment of final letter grades will be based upon the following guidelines:

	B+ = 86-90%	C+ = 74-78%	D+ = 62-66%
A = 94-100%	B = 82-86%	C = 70-74%	D = 58-62%
A- = 90-94%	B- = 78-82%	C- = 66-70%	

9. **Incompletes**: A grade of incomplete will **only** be given for work not completed due to circumstances beyond the control of the student (*this is the College policy*).

10. **Academic Honesty**: Having signed and agreed to abide by the College's Honor Code, students thereby pledge that, in all academic exercises, examinations, papers, and reports, they shall submit their own work. In the context of this course, students are expected to collaborate and to discuss their out-of-class assignments. However, submitting under one's own name work that is merely copied from another is a violation of the Honor Code. (The full text of the Gustavus Academic Honor Code Policy may be found at: https://gustavus.edu/general_catalog/current/acainfo).

11. **Disability Services**: Gustavus Adolphus College is committed to ensuring the full participation of all students in its programs. If you have a documented disability (or you think you may have a disability of any nature) and, as a result, need reasonable academic accommodation to participate in class, take tests or benefit from the College's services, then you should speak with the Disability Services Coordinator, for a confidential discussion of your needs and appropriate plans. Course requirements cannot be waived, but reasonable accommodations may be provided based on disability documentation and course outcomes. Accommodations cannot be made retroactively; therefore, to maximize your academic success at Gustavus, please contact Disability Services as early as possible. Disability Services (https://gustavus.edu/advising/disability/) is located in the Center for Academic Resources & Enhancement (CARE). Disability Services Coordinator Kelly Karstad (mailto:kkarstad@gustavus.edu or x7138) can provide further information.

12. **Help for Students Whose First Language is not English**: Support for Multilingual students is available via the Multilingual and Intercultural Program Coordinator. Please schedule appointments by phone at x7545 or by email to Carly Overfelt (coverfel@gustavus.edu).

Astrophysics Laboratory Schedule

Lab 1 Finding and Viewing Celestial Objects – Due 2/28

Lab 1 involves the use of the Meade LX-600 telescope to reliably locate and view objects of interest.

A complete lab notebook must be kept for all lab work, but no formal report is required.

Lab 2 Imaging Celestial Objects – Due 3/18

Lab 2 will combine the use of the LX-600 with available imaging hardware (including CCD cameras). Images should be recorded of the Sun, Moon, planet(s) (if possible) and a variety of deep-sky objects.

A complete lab notebook must be kept for all lab work, but no formal report is required.

Lab 3 Project 1: Photometry – Due 4/13

Lab 3 will combine the imaging capabilities of lab 2 with image analysis software in order to extract photometric information about celestial objects. This will involve the student choice of a project (e.g. brightness measurements of variable stars or measurements of stellar magnitudes, with comparison of results to known values.)

A complete lab notebook must be kept for all lab work.

A formal project report, in scientific-letter format, must also be submitted.

Lab 4 Project 2: Spectroscopy – Due 5/6

Lab 4 will combine the use of the LX-600 with available spectrometers to extract spectral information about celestial objects. This will involve the student choice of a project (e.g. stellar spectra of known stars (or the Sun), planets, or nebulae, with comparison of results to known values.

A complete lab notebook must be kept for all lab work.

A formal project report, in scientific-letter format, must also be submitted.

Astrophysics Laboratory Reports

INTRODUCTION:

You are a research physicist during the 21st century. Your job is to conduct experiments, make discoveries, and publish results. You hope to become famous and win a Nobel Prize before the age of thirty, so the quality of your publications is very important. The results of your research are to be published in Astrophysics Journal or a similar journal. Most journals accepts results published in "scientific letter" style (described below). Good luck making history!

INSTRUCTOR'S NOTES:

Philosophy of Reports - I want you to take your role as a research physicist seriously. I am the editor of the journal in which you are trying to get your papers published. Whether or not your papers are accepted for publication (and your lab grade) depend on how well the paper is written and the quality of the scientific evidence you present to support your findings. You must convince me that your results are real and not just experimental noise!

Final Project - Each group will do a laboratory project during the final half of the semester. The results of this project will be submitted in letter format and defended orally (see below).

I. Scientific Letter Format - The scientific letter style of presenting experimental results is a short paper used to announce significant new findings or discoveries.

- The paper should be no longer than three typed pages or its equivalent and should contain the following items.
- The paper should have a title, statement of authorship, abstract, body, and a reference list. The abstract is a brief, summary statement explaining what was done and the significance of the results that were obtained.
- The body of the paper should contain an introductory paragraph that places the work in context and states why it is important. Next the experimental setup (no procedure information), results, data analysis, and theory are described. You are trying to convince the reader that you know what you are talking about. Include anything that you feel supports your conclusions, for example, data tables, diagrams, graphs with captions, and equations. Finally, the body of the text should include a concluding paragraph, which restates the most important results or findings. Any references used should then be listed.
- All figures should have complete captions so that the reader can understand what is being shown without referring back to the main text.

II. Oral Presentation of Experimental Results - Due to the large number of scientists working today a brief oral presentation style has been developed, called "the 10 minute talk". This is an oral presentation in which the scientist is given 10 minutes to state his or her case and the audience is then given 5 minutes for questions. The presentations usually include very short text, graphs, tables, and equations as appropriate. These talks are usually given using overhead transparencies. Practice your talk before giving it to the class since ten minutes goes by very quickly and you will therefore only have time to include the most essential things (8 to 12 slides is usually appropriate).

FEBRUARY2022

subject: Astrophysics period: 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 1		1	2 Classes begin; Syllabus and Introduction	3	4 Astrophysical Distances	5/6
Read:			Chapter 1		Chapter 2	
WEEK 2	7 Stellar Luminosity	8	9 Stellar Temperatures	10	11 Stellar Radii	12/13
Read:	Chapter 3		Chapter 4		Chapter 5	
WEEK 3	14 Stellar Composition	15	16 Surface Gravity and Orbital Speeds	17	18 Stellar Lifetimes	19/20
Read:	Chapter 6		Chapter 7		Chapter 8	
WEEK 4	21 Stellar Velocities	22	23 Binary Star Systems	24	25 Stellar Rotation	26/27
Read:	Chapter 9		Chapter 10		Chapter 11	
WEEK 5	28 Light Intensity and Absorption					
Read:	Chapter 12					

MARCH2022

subject Astrophysics period 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 5		1	2 Observational Methods	3	4 **Hour Exam 1 (Chapters 1-11)**	5/6
	Read:		Chapter 13			
WEEK 6	7 The Sun	8	9 Hydrostatic Equilibrium	10	11 Radiation Transport	12/13
	Read: Chapter 14		Chapter 15		Chapter 16	
WEEK 7	14 Radiative vs. Convective Stellar Envelopes	15	16 Fusion and Stellar Masses	17	18 Evolution of Low-Mass Stars	19/20
	Read: Chapter 17		Chapter 18		Chapter 19	
	21 **No Class: Spring Break**	22 **No Class: Spring Break**	23 **No Class: Spring Break**	24 **No Class: Spring Break**	25 **No Class: Spring Break**	26/27
WEEK 8	28 Evolution of High-Mass Stars	29	30 The Interstellar Medium	31		
	Read:: Chapter 20		Chapter 21			

APRIL2022

subject Astrophysics period 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
WEEK 8					1 **Hour Exam 2: (Chapters 12-20)**	2/3
	:					
WEEK 9	4 Star Formation	5	6 Planetary Systems	7	8 Earth and Water	9/10
	Read: Chapter 22		Chapter 23		Chapter 24	
WEEK 10	11 Extra-Solar Planets	12	13 The Milky Way	14	15 **No Class: Easter Recess**	16/17
	Read: Chapter 25		Chapter 26			
WEEK 11	18 Galaxies	19	20 Active Galaxies	21	22 Large-Scale Structures and Galactic Evolution	23/24
	Read: Chapter 27		Chapter 28		Chapter 29	
WEEK 12	25 Expansion of the Universe	26	27 **Hour Exam 3: (Chapters 21-29)**	28	29 Accelerating Universe	30
	Read:: Chapter 30				Chapter 31	

MAY2022

subject Astrophysics period 2

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
						1
WEEK 13	2 The Hot Big Bang Read: Chapter 32	3	4 Evolution of the Universe Chapter 33	5	6 **Hour Exam 4: (Chapters 30-33)**	7/8
WEEK 14	9 Guest Lecture: Dr. Alex Filippenko Read:	10	11 Observing Project Presentations	12	13 **No Class: Reading Day**	14/15
	16 **Final Exam: 3:30-5:30 pm**	17	18	19	20	21/22
	23	24	25	26	27	28/29