

# **Astronomy 102:**

## **Introductory Astronomy: Stars, Galaxies, and the Universe**

University of Michigan, Winter 2020

**Description:** This concept-focused course invites students to explore the nature of stars, black holes, nebulae, supernovae, galaxies, and the ultimate fate of the Universe. We will explore the roles of light, energy, and gravity in astronomy. There are three hours of weekly lectures and a weekly discussion/lab period.

**Background:** A basic high school math (up to algebra and geometry) and science background is assumed. No previous astronomy courses are required or expected.

**Credits:** 4 (meets BS, NS, and QR/2 requirements)

**Credit disclaimers:** This course may not be repeated for credit. No credit is granted to students enrolled in or who have completed Astro 104, 142, or 201. Please consider Astro 101, 105, 106, or 115, or a higher level astro class if you took 201.

### **Course Materials (both are required):**

- Bennett et al., “The Cosmic Perspective: Stars, Galaxies & Cosmology” (publisher: Pearson)
  - Any of the 7th, 8th, or 9th editions are okay.
  - There are also several variants of each edition available. You will want to avoid “The Cosmic Perspective: The Solar System,” “The Essential Cosmic Perspective,” and “Cosmic Perspective Fundamentals.” Books titled simply “The Cosmic Perspective” are okay, although they contain more chapters than you need for this course.
  - A copy of this book has been placed on reserve in the Shapiro Undergraduate Library.
- Prather et al., “Lecture-Tutorials for Introductory Astronomy,” 3<sup>rd</sup> Edition (publisher: Pearson)

## Who are we?

<b>Instructors:</b>	Dr. Ian U. Roederer	<a href="#">Dr. Michael C. Lo Presto</a>
<b>Email:</b>	iur@umich.edu	lopresto@umich.edu
<b>Office:</b>	West Hall 306-H	West Hall 306-D ( <a href="#">Angell Hall 3118 M</a> )
<b>Free help sessions / office hours:</b>	Wednesday 12:00-3:00 PM in West Hall 306-A (“Cygnus”) (next to the copy machine)*	When <a href="#">Dr. LoPresto</a> is teaching the class- Fri 1-2 ( <a href="#">MW 1-2</a> ) Other times- Tues 1-4 pm

\* There will be no regularly-scheduled help sessions with Dr. Roederer on 02/26, 03/04, 04/01, 04/08, 04/15, and 04/22. If you would like to meet with Dr. Roederer on any of those weeks, please send an email to arrange a mutually-convenient time.

The instructors will handle matters related to the lecture sections, and they are responsible for the overall structure of the course and decisions about course policies.

<b>GSIs:</b>	Anne Blackwell	Ryan Farber	Lena Komarova
<b>Email:</b>	aebblackw@umich.edu	rjfarber@umich.edu	komarova@umich.edu
<b>Office:</b>	West Hall 401 (“Grus”)	West Hall 401 (“Grus”)	West Hall 401 (“Grus”)
<b>Free help sessions / office hours:</b>	Thursday 1:00-2:00 PM	Tuesday 12:00-1:00 PM	Monday 3:00-4:00 PM, Friday 1:00-2:00 PM

The GSIs will handle all matters related to the discussion sections. (Note that we will use the terms “discussion sections” and “lab sections” interchangeably in this course.)

Department of Astronomy general phone for all instructors and GSIs: (734) 764-3440

**Other Free Help Sessions:** There will also be a free help session for all introductory astronomy courses, including Astro 102, that takes place in West Hall 302 from 10AM to 3PM each Wednesday.

## Learning objectives

By the end of the course, you should be able to...

- Apply the scientific method by making observations of physical phenomena and interpreting your findings.
- State examples of how the scientific method has led humans to revise our understanding of the Universe and our place in it.
- Apply known physical principles (including Newton's laws of motion and universal law of gravitation, Kepler's laws of planetary motion, properties of light/radiation, and others) to predict the behavior and characteristics of objects in the Solar System and beyond.
- Recognize that basic motions and characteristics of matter and radiation observed in the Universe can be readily predicted from relatively simple mathematics.
- Explain the fundamental astrophysical principles that limit our ability to study everything in the Universe in infinite detail.
- Articulate the history of the development of the Universe from the Big Bang until today, citing evidence, identifying uncertainties, and describing why these uncertainties do not undermine the overall picture.
- Evaluate and articulate the extent to which your worldview has changed in response to the concepts and information covered in this course.

## Class Meetings

Section	Room	Day/Time	Dates
<b>Section-101 LECTURE</b>	182 Weiser Hall	Tues/Thurs 1:00-2:20	Jan. 9 - April 21
<b>Section-107 LECTURE</b>	182 Weiser Hall	Tues/Thurs 2:30-3:50	Jan. 9 - April 21
<b>DISCUSSIONS (Sections 102-106; 108-112)</b>	5179 Angell Hall	(see detailed schedule below)	Jan. 14 - April 16
<b>FINAL EXAM</b>	182 Weiser Hall	Tues 1:30-3:30 Tues 4-6	April 28, April 28

**You may attend EITHER LECTURE section, but you MUST attend the DISCUSSION SECTION for which you signed up .**

### Discussion Section Schedule (All sections meet in 5179 AH)

Section #	Day	Time	GSI
002	Thursday	1-2	LK
003	Thursday	10-11	AB
004	Thursday	11-12	LK
005	Tuesday	10-11	RF
006	Tuesday	3-4	AB
008	Tuesday	4-5	LK
009	Tuesday	5-6	LK
010	Tuesday	12-1	AB
011	Tuesday	11-12	RF
012	Tuesday	1-2	AB

There are no lecture or discussion/lab sections on March 2-6 (spring break). The discussion/lab sections do not meet during the first or last half-weeks of the semester.

## Evaluation/Grades

We use high standards to evaluate your work in this course. We do so because we believe that each of you is capable of meeting those standards. This is a four-credit course, and we expect a commensurate level of out-of-class effort (i.e., ~8 hours per week) on your part. Grades will be tabulated in CANVAS, and they are determined as follows:

Portion	Points Per	Frequency	Points
Exams	50/unit	x 3 units	= 150
Discussion Activities (including telescope observing)	10/activity	x 12 activities (lowest grade dropped)	= 110
Review Questions Homework	5/chapter	x 15 chapters (lowest grade dropped)	= 70
Quantitative Problems Homework	15/unit	x First 2 units	= 30
		<b>TOTAL</b>	<b>= 360</b>

Grade	Points	Percentage	+/- Modifiers
<b>A</b>	324-350	90-100	A+: $\geq 98$ ; A: $\geq 93$ ; A-: $\geq 90$
<b>B</b>	288-323	80-90	B+: $\geq 88$ ; B: $\geq 83$ ; B-: $\geq 80$
<b>C</b>	252-287	70-80	C+: $\geq 78$ ; C: $\geq 73$ ; C-: $\geq 70$
<b>D</b>	216-251	60-70	D+: $\geq 68$ ; D: $\geq 63$ ; D-: $\geq 60$
<b>E</b>	$\leq 215$	$< 60$	None

If you wish to contest a score on an assignment or exam (for example, you think something was graded incorrectly), let one of the instructors know of your intent to contest the score within 1 week of the assignment being returned to you. We can later find a mutually-convenient time to discuss the matter.

A special note for seniors taking Astro 102 in their final term to satisfy the QR/2 requirement: The “pass/fail” option requires a C- to pass, while one can still get credit with a “D” if taking the course for a letter grade. Please consider discussing with your academic advisor whether one option or the other may work better for you.

## In-Class Activities and Other Assignments

**Lecture Tutorials** are collaborative, in-class, activities designed to help you learn important concepts. These will be used during most class meetings. Participation is required, and you must have the necessary course materials (the Prather et al. textbook) with you. Please plan to bring the Prather et al. textbook with you to each lecture session.

**Discussion Activities (sometimes referred to as “Labs”)** will be done during all Discussion Sections, and they are listed on the course schedule. They are available as PDF documents under the ASSIGNMENTS tab on the course CANVAS site. Please read the activity before coming to the discussion meeting. Also, please print and bring each week’s PDF with you; you will not be able to print them in the discussion sections, and you must have these with you to complete the activities. There are 11 Discussion Activities (plus the Observation Activity; see below). Your one lowest grade will be dropped, and that includes a 0 if you miss a discussion for any reason. It MAY be possible (although it is difficult because most discussion sections are full) to make up a discussion by attending a different section the same week, but BOTH GSIs involved must agree to this change in advance. Policies and procedures for discussion sections will be set by your GSI during the first discussion section.

**Observation Activity:** Astronomers’ main laboratory is the sky, so as part of this course you will observe the sky through a telescope. On the University of Michigan campus, there are telescopes located on the roof of Angell Hall, and they are operated by members of the Student Astronomical Society. The observation activity counts as one of the 12 discussion activities. It is posted as a PDF under the ASSIGNMENTS tab on the course CANVAS site. To complete this activity, print the PDF before going to the telescope, fill out the PDF while at the telescope, and submit it to your GSI for grading during any of your discussion sections. This activity will be accepted any time before 4 PM on April 16. The dates and times when you can go to the telescope, including instructions for finding your way to the Angell Hall roof, are listed on the following website:

<https://sites.google.com/a/umich.edu/sas/openhouse>

Additional dates and times will be announced in class, in discussion sections, and/or via email. Please be aware that Michigan skies tend to be cloudy during the winter term, and of course the telescopes are not open if the sky is cloudy. Given the challenges with weather, please plan to go observing as early in the semester as possible.

**Homework** will consist of selected **Review Questions** and **Quantitative Problems** from the end of the textbook (Bennett et al.) chapters in the *Exercises and Problems* sections. You are encouraged to work together on the homework, but each student should write up their solutions in their own words.

- **Review Questions** are used to help prepare you to think about the material that will be covered during each class lecture. They are due on the dates marked on the Course Schedule (see below). Review Questions will be submitted by uploading a file to CANVAS by 1 PM on the day they are due. There are no penalties for late submissions of Review Questions, but they

will only be accepted up to 1 PM the class-day BEFORE the unit test of which their chapter is a part. (For example, if an exam is scheduled for Tuesday, any remaining Review Questions for that unit would be due on the previous Thursday at 1 PM.) No credit is given for Review Questions submitted after 1 PM on the class-day before that unit's exam. Review Questions should be typed, not hand-written.

- **Quantitative Problems** are used to help you practice and think more deeply about the ideas covered in lecture and discussion sections. The Quantitative Problems for all chapters of each unit will be due all together to your GSI during your discussion section on the weeks indicated on the Course Schedule. Your answers/responses must conform to high standards, because we believe you are capable of meeting those standards. Calculation exercises must show the steps involved to derive the final answer and include physical units throughout. Graphs must be drawn carefully using a ruler or computer software, and the axes must be labeled and include values and units. Written exercises must conform to the standards of an English class for grammar and punctuation. Please remember to include your name and section number on all submitted work; assignments without these components may not be graded. Quantitative Problems may be either typed or hand-written.

## Exams

There are three written exams in this course. The goal of the exams is to provide an opportunity for you to demonstrate what you have learned. The exam format is multiple choice. The first two exams take place during the normal lecture sections, and the last exam has two dates/times during the Final Exam period. All exams are held in the normal lecture room, Weiser 182. No calculators are permitted (or needed) on the exams.

Our aim is that you engage with the material in such a way that you accomplish the learning goals we have for you for this course. In that spirit, if you demonstrate learning (at least to the extent that learning can be measured with these exams) by the end of the course, we consider that a success. To incentivize this, if your grade on Exam Three exceeds your grade on either Exam One or Exam Two (or both), we will replace those earlier, lower scores with your grade on Exam Three. For example:

<b>Exam One (out of 50)</b>	<b>Exam Two (out of 50)</b>	<b>Exam Three (out of 50)</b>	<b>Total exam score (out of 150)</b>
40	45	50	$50+50+50 = 150$
50	45	40	$50+45+40 = 135$
35	45	40	$40+45+40 = 125$
40	0	30	$40+30+30 = 100$
40	30	0	$40+30+0 = 70$

If you are absent on either day that Exam One or Exam Two is given (e.g., you are ill, representing the University off-campus, etc.), there is no make-up exam. In this case, your score from Exam Three will also count for the exam you missed. If you know you will be absent for Exam Three, please inform one of the instructors at least three weeks in advance so that we can make alternate arrangements.



## Course Schedule (subject to possible revision)

Class Meeting	Day	Date	Subject	RQ DUE (via Canvas)	Lecture Tutorial (in class)	DISCUSSION ACTIVITY
1	R	1/9	Introduction			
2	T	1/14	CH 1 Scales	CH 1 RQ	113	Starry Night
3	R	1/16	CH 2 Motions of Stars		3	
4	T	1/21	Motions of Sun & Seasons	CH 2 RQ	7	Phases of Venus
5	R	1/23	CH 3 Geocentric & Heliocentric Systems	CH 3 RQ	37 (part 1)	
6	T	1/28	CH 4 Kepler's Laws, Gravity	CH 4 RQ	21, 25, 29	Moons of Jupiter QP CH 1-4
7	R	1/30	(more CH 4) CH 5 Light	CH 5 RQ		
8	T	2/4	Spectra, part 1			Spectroscopy
9	R	2/6	Spectra, part 2		59 (?)	
10	T	2/11	EXAM ONE (CH 1-5)			(no discussion sections this week)
11	R	2/13	CH 14 The Sun	CH 14 RQ		
12	T	2/18	CH 15 Properties of Stars: Magnitude		33	The Sun
13	R	2/20	Parallax & Distance	CH 15 RQ	37, 41	
14	T	2/25	Temperature & Size		55	Spectra Classification
15	R	2/27	HR Diagram		117	

16	T	3/10	CH 16 Stellar Birth & Life	CH 16 RQ		HR Diagram QP 14-18
17	R	3/12	Stellar Masses & Lifetimes		119	
18	T	3/17	CH 17 Life & Death of Stars	CH 17 RQ	133	Star Clusters
19	R	3/19	CH 18 Stellar Corpses	CH 18 RQ		
20	T	3/24	<b>EXAM TWO (CH 14-18)</b>			(no discussion sections this week)
21	R	3/26	CH 19 The Milky Way	CH 19 RQ	135	
22	T	3/31	CH 20 Galaxies	CH 20 RQ	139	Cepheids
23	R	4/2	CH 21 Galaxy Evolution		155	
24	T	4/7	Hubble's Law	CH 21 RQ	161	Galaxy Zoo
25	R	4/9	The Expanding Universe		151	
26	T	4/14	CH 22 The Big Bang	CH 22 RQ	165	Active Galaxies
27	R	4/16	CH 23 Dark Matter & Energy	CH 23 RQ	143	Observation Assignment due
28	T	4/21	Fate of the Universe & Wrap up			
29-A	T	4/28	<b>EXAM THREE (CH 19-23) 1:30-3:30 pm</b>			You may attend either one
29-B	T	4/28	<b>EXAM THREE (CH 19-23) 4-6 pm</b>			You may attend either one

NOTES: QP = Quantitative Problems, RQ = Review Questions

M=Monday, T=Tuesday, W=Wednesday, R=Thursday, F=Friday.

The highlighting on assignments that are due also corresponds to the exam where that material will be tested. Green refers to material covered by Exam One, yellow refers to material covered by Exam Two, and aqua refers to material covered by Exam Three.

## Homework Schedule (if using the Bennett et al. 9<sup>th</sup> Ed.)

Bennett et al. Chapter	Review Questions (RQ)	Quantitative Problems (QP)
1	1-12 (omit 5)	45, 46
2	1-16 (omit 2, 3, 15)	
3	2, 3, 5, 7-9, 11	51-54
4	3, 9, 11, 13	
5	3-5, 7, 8, 12, 13	
14	2, 4-7, 9-18	
15	1-17 (omit 2, 7, 15)	52, 58
16	1-3, 6, 9, 14-16	
17	1-15 (omit 2, 5, 7)	
18	2, 4-7, 10-13	54-56
19	1-4	
20	1-15 (omit 5, 7)	
21	1-6, 9, 11	
22	1-14	
23	1-3, 5-11, 14-16, 18	

## Homework Schedule (if using the Bennett et al. 7<sup>th</sup> or 8<sup>th</sup> Ed.)

Bennett et al. Chapter	Review Questions (RQ)	Quantitative Problems (QP)
1	1-12 (omit 5)	41, 42
2	1-16 (omit 2, 3, 15)	
3	2, 3, 5, 7-9, 11	47-50
4	3, 9, 11, 13	
5	3-5, 7, 8, 12, 13	
14	2, 4-7, 9-18	
15	1-17 (omit 2, 7, 15)	49, 55
16	1-3, 6, 9, 14-16	
17	1-15 (omit 2, 5, 7)	
18	2, 4-7, 10-13	48-50 (7 <sup>th</sup> ed), 49-51 (8 <sup>th</sup> ed)
19	1-4	
20	1-16 (omit 5, 6, 8)	
21	1-6, 11, 12 (7 <sup>th</sup> ed), 13 (8 <sup>th</sup> ed)	
22	1-14	
23	1-3, 5-11, 14-16, 18	

## Other Tips To Help You Succeed in This Course

**Drop/add deadline:** January 28 is the last day to withdraw for regular drop/add or to change to pass/fail status. Enrollment after January 20 will require instructor permission.

**Free tutoring available:** The Student Astronomical Society (SAS) offers free tutoring for 100- and 200-level courses. Please see their website for times and locations: <https://sites.google.com/a/umich.edu/sas/>

**Class discussion on Piazza:** We will be using the Piazza platform for class discussion. This platform caters to providing you help, quickly and efficiently, from your classmates, the GSIs, and instructors. Rather than emailing your questions to the instructors or GSIs, we encourage you to post your questions on Piazza. The Piazza platform is linked as a tab on the CANVAS site.

**Make-up and Missed Work Policies:** In general, the strategies and consequences for missing lectures, discussion sections, or exams are dealt with in the relevant text above. These policies apply to classes missed for any reason, including illness, athletic or other university-related activities, job interviews, vacations, etc. If you anticipate missing more than a few classes, please talk to us in advance.

**Devices in the classroom:** You are more than welcome to use laptops, smart phones, or other devices in class if they are used responsibly and do not pose a distraction to the instructors, you, or your neighbor. These devices must remain silent. In the interest of common courtesy, if you find yourself in need of your phone (perhaps in the case of an emergency), please quietly excuse yourself from class and do what you need to do in the hallway.

**Other contact notes:** The free help sessions (sometimes called “office hours”) are a time that we reserve for you. Please feel free to stop by, ask questions about the classes, course materials, homework assignments, discussion activities, etc., or anything else of interest. If you cannot attend the posted times (perhaps because you have another class that meets then), send an email, and we will schedule a meeting time that works for each of us. We have other responsibilities in our schedules, so we may not always be present in our offices at other times of the day. As a matter of policy, we decline social media networking requests (e.g., LinkedIn or facebook) from students.

**Academic integrity:** The College of LSA is a community in which personal responsibility, honesty, fairness, respect, and mutual trust are maintained. You are expected to practice the highest possible standards of academic integrity. Any deviation from this expectation will result in a minimum academic penalty of your failing the assignment, and will result in additional disciplinary measures. This includes, but not limited to, cheating, using unauthorized material during exams, using or copying another student’s work, and any other form of academic misrepresentation. For a list of actions that constitute misconduct, and possible sanctions for

those actions, please see the Code of Conduct at <https://lsa.umich.edu/lsa/academics/academic-integrity.html>.

**Commitment to equal opportunity:** We are committed to a policy of equal opportunity for all persons and do not discriminate on the basis of race, color, national origin, age, marital status, sex, sexual orientation, gender identity, gender expression, disability, religion, height, weight, or veteran status. Please feel free to contact us with any problem, concern, or suggestion. We ask that all students treat each other with respect.

**Accommodations for Students with Disabilities:** If you think you need an accommodation for a disability, please let us know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way the course is usually taught may be modified to facilitate your participation and progress. As soon as you make us aware of your needs, we can work with the Services for Students with Disabilities (SSD) office to help us determine appropriate academic accommodations. SSD (734-763-3000; <http://ssd.umich.edu>) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. If obtaining a VISA form presents an undue burden, for any reason, please reach out to us, and we can discuss accommodations for your individual situation. Any information you provide is private and confidential and will be treated as such.

**Student Mental Health and Wellbeing:** University of Michigan is committed to advancing the mental health and wellbeing of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, contact Counseling and Psychological Services (CAPS) at (734) 764-8312 and <https://caps.umich.edu/> during and after hours, on weekends and holidays, or through its counselors physically located in schools on both North and Central Campus. You may also consult University Health Service (UHS) at (734) 764-8320 and <https://www.uhs.umich.edu/mentalhealthsvcs>, or for alcohol or drug concerns, see [www.uhs.umich.edu/aodresources](http://www.uhs.umich.edu/aodresources). For a listing of other mental health resources available on and off campus, visit: <http://umich.edu/~mhealth/>.



This course is taught by members of the Lecturers' Employee Organization, AFT Michigan Local 6244, AFL-CIO.